NBER WORKING PAPER SERIES

INSIDE MONEY AND MONETARY NEUTRALITY

Peter R. Hartley

Carl E. Walsh

Working Paper No. 1890

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

The opinions expressed herein are those of the authors and do not necessarily reflect the views of the Bank of San Francisco or of the Board of Governors of the Federal Reserve System. Walsh's research was partially supported by the National Science Foundation under Grant No. SES-8408603. The research reported here is part of the NBER's research program in Financial Markets and Monetary Economics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #1890
April 1986

Inside Money and Monetary Neutrality

ABSTRACT

This paper examines the interaction between the financial and real sectors of the economy within the framework of a stochastic, rational expectation model that distinguishes between inside and outside money. The model also can be used to study the impact of variations in the degree of intermediation, measured by the elasticity of bank deposit supply. In contrast to earlier work which emphasized confusion between monetary and real shocks, we focus on the role played by confusion between inside and outside money and temporary and permanent base money disturbances. Financial sector disturbances, as well as temporary shocks to the monetary base, are shown to have real effects even when private agents have complete information. When contemporaneous information on economic disturbances is incomplete, permanent shocks to the monetary base also have real effects. If our model is correct, it is invalid to reject equilibrium models of the business cycle on the grounds that anticipated money affects output. We argue that this result is robust in the sense that many "reasonable" models which incorporate inside money would yield a non-neutrality of portfolio and temporary base money supply shocks.

Peter R. Hartley
Department of Economics
Princeton University
Princeton, NJ 08544
(609) 452-4032

Carl E. Walsh
Research Department
Federal Reserve Bank of
San Francisco
101 Market Street
San Francisco, CA 94105
(415) 974-2397

Recent trends towards the deregulation of the financial services industry have generated a growing literature on the role of monetary policy in an unregulated financial environment. The works of Black [1970], Fama [1980], Wallace [1983], and Bryant and Wallace [1984] have focused on the role of legal restrictions and regulations in determining the effectiveness of monetary policy. Less emphasized, but of equal importance in recent years, is the impact of technological innovations that affect the ability of financial institutions to intermediate between borrowers and lenders. Many of these same issues were also the subject of a large literature that developed in the early 1960's. For example, Gurley and Shaw [1960], Tobin and Brainard [1963] and Patinkin [1961, 1965] analyzed the role of financial intermediaries in general equilibrium models. This earlier literature employed static, deterministic models -- models which cannot be used to study the effects of expectations and imperfect information that have been emphasized in recent work on business cycles (Lucas [1975], Barro (1981]).

The purpose of the present paper is to examine the interaction between the financial and real sectors of an economy within the framework of a stochastic, rational expectation model that distinguishes between inside and outside money. The model also allows the impact of variations in the degree of intermediation, measured by the elasticity of bank deposit supply, to be studied. In contrast to earlier work that has emphasized the role of confusion between monetary and real shocks, the model developed in the present paper can also examine the role played by a confusion between inside and outside money disturbances. Even when private agents have complete information, financial sector disturbances, as well as temporary shocks to the monetary base, are shown to have real effects. When contemporaneous information on economic disturbances is incomplete, permanent base money shocks also have real effects.

The model we develop helps to provide an understanding of recent empirical work that distinguishes between unperceived and unanticipated monetary shocks (Boschen and Grossman [1982]) and recent work on the real interest rate effects of money announcements (Roley and Walsh [1985]). In particular, our model does not imply that output movements should be uncorrelated with known money supply changes (or noisy signals of such changes) unless agents also know whether those changes are permanent or temporary. In the latter case, known permanent changes in base money would be neutral. But, known temporary changes in base money would not be. This result contrasts with models such as that of Brunner, Cukierman, and Meltzer [1980] which incorporate only outside money and find that both temporary and permanent changes in money are neutral. Regression results which reject equilibrium models of the business cycle on the grounds that anticipated money affects output are invalid if our model is correct. In fact, we argue that the specific details of our model are not required to make such tests invalid. Many "reasonable" models which incorporate inside money would yield a non-neutrality of portfolio and temporary base money supply shocks.

The paper is organized as follows. Section II develops a simple model of the financial sector and carries out some comparative static exercises. These help to fix the intuition on how interest rates adjust to financial shocks. Section III incorporates the goods market and examines general equilibrium with complete information. The case in which full, current information is unavailable is studied in Section IV. In order to motivate the emphasis we place on the distinction between inside money and outside money, the next section presents some simple empirical evidence that suggests these two types of money may have independent and distinct roles in macroeconomic fluctuations.

I. Empirical Background

Summary statistics for two measures of outside money -- the monetary base and currency -- and two measures of inside money -- M1 and M2, both excluding currency -- are presented in Table 1. Monthly data are used for the period January 1960 to September 1985. Because of the shift in Federal Reserve operating procedures in October, 1979, Table 1A presents means, standard deviations, and sample autocorrelations for the period January 1960 to September 1979, while those for the period January 1980 to September 1985 are presented in Table 1B.

An examination of the means and standard deviations show them to be generally similar for both inside and outside money. However, the autocorrelations show somewhat different patterns. This suggests that the distinction between inside money and outside money is a meaningful one; the two types of money display quite different time series behavior. In fact, the correlation between the monetary base and M2 excluding currency was only 0.31 in the pre-October 1979 period and 0.21 in the 1980:01-1985:09 period.

To examine whether inside and outside money display different correlations with other macroeconomic variables, a five variable VAR system was estimated over the 1960:01-1979:09 period. The variables included were the logs of real personal income (Y), the price deflator for personal income (P), M2, the monetary base (B), and, in level form, the 3-month Treasury bill interest rate (R). Table 2 presents the marginal significance levels for tests of Granger causality and the correlation matrix of the contemporaneous residuals. In each case, the null hypothesis is that the row variable does not cause the column variable.

Several interesting results emerge from Table 2. First, M2, the inside measure of money, apears to Granger causes Y, while the base does not appear to. However, the residuals from the equation for the base are more highly correlated with the contemporaneous income residuals than are the M2 residuals. Conversely, the base

Granger causes P but M2 does not. Table 2 also shows that the base does not Granger cause M2, but M2 Granger causes the base. This last finding is hardly surprising since the Federal Reserve has never adopted a policy of controlling the monetary base.

Table 2 strongly suggests that inside money and outside money have very different correlations with other macroeconomic variables. There is no evidence to support the view that it is sufficient to consider only one monetary aggregate, a view implicit in almost all current macroeconomic models.

Further evidence against this standard view is found in Table 3 which uses the estimated VAR to construct a variance decomposition. The ordering of the variables was Y, P, R, M2 and B. Other orderings were tried, with little effect on the general results -- those in Table 3 are quite representative. Even though it appears last in the ordering, the base explains a much higher fraction of the forecast error variance of Y and P than does M2. However, the base accounts for little of the M2 forecast error variance.

This brief examination of the data indicates that inside and outside money bear different relationships to basic macroeconomic variables. This conclusion is consistent with the work of King and Plosser [1984) who also find inside and outside money to exhibit different correlations with income and prices. This suggests that, particularly for empirical work, it may be important to distinguish between inside and outside money. A theoretical framework for evaluating the different roles played by central bank liabilities and private bank liabilities is developed in the next two sections.

Table 1A: Summary of Statistics, Monetary Data: 1960:01 - 1979:09

Series	Mean	Standard Deviation	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}
First Difference in Log of:														
Monetary Base	.005	.003	.36	.33	.44	.30	.28	.39	.26	.28	.33	.31	.33	.22
Currency	.005	.003	.32	.40	.53	.32	.41	.40	.33	.40	.36	.28	.40	.30
M1 excluding currency	.004	.004	.15	.08	.25	-.02	.10	.18	-.08	.06	.14	-.02	.14	-.03
M2 excluding currency	.007	.003	.73	.57	.50	.40	.35	.32	.23	.22	.21	.15	.11	-.00

Note: ρ_i is the sample autocorrelation coefficient at lag i. The large sample standard error is 0.06.

Table 1B: Summary of Statistics, Monetary Data: 1980:01 - 1985:09

Series	Mean	Standard Deviation	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}
First Difference in Log of:														
Monetary Base	.006	.003	.20	-.14	.04	.05	.13	.16	.05	.03	.09	-.04	-.13	-.10
Currency	.007	.002	.17	.04	.14	-.01	.23	.11	-.12	.14	.30	-.23	-.18	-.19
M1 excluding currency	.007	.009	.29	.01	-.06	-.27	-.06	-.06	.07	.11	.14	-.05	-.21	-.17
M2 excluding currency	.008	.004	.38	-.06	-.17	-.10	-.01	-.09	-.05	.05	.10	-.12	-.28	-.10

Note: The large sample standard error of ρ_i is 0.12.

Table 2

Tests of Granger Causality, Marginal Significance Levels†

	Y	P	R	M2	B
Y	.000*	.058	.001*	.261	.008*
P	.247	.000*	.000*	.495	.121
R	.796	.074	.000*	.000*	.298
M2	.003*	.535	.085	.000*	.034*
B	.195	.000*	.236	.463	.000*

Correlation Matrix of Residuals

	Y	P	R	M2	B
Y	1.0	-0.34	-0.09	0.05	0.18
P		1.0	0.21	0.00	-0.02
R			1.0	-0.09	0.01
M2				1.0	0.18
B					1.0

† Marginal significance levels for test that the row variable does not cause the column variables. Results are from a 5-variable VAR system with 6 lags, estimated with monthly data, 1960:01-1979:09.

* Significant at the 5 percent level.

Table 3

Decomposition of Variance*

Forecast Horizon (months)	Real Personal Income Y	Price Deflator for Personal Income P	3-month Bill Rate R	M2	Monetary Base B
Real Personal Income (Y)					
1	100.0	0.0	0.0	0.0	0.0
6	84.7	7.5	0.4	0.3	7.0
12	59.7	21.9	2.3	0.2	15.9
18	36.5	33.9	9.8	0.3	19.5
24	22.6	40.2	16.7	0.3	20.2
Price Deflator for Personal Income (P)					
1	11.9	88.1	0.0	0.0	0.0
6	2.62	81.8	1.6	2.8	11.1
12	0.8	68.5	5.6	4.8	20.3
18	0.4	62.4	8.6	5.9	22.6
24	0.3	59.0	9.8	7.4	23.6
3-Month Treasury Bill Rate (R)					
1	0.8	3.7	95.5	0.0	0.0
6	4.8	23.2	69.4	1.8	0.7
12	0.6	20.5	41.5	34.6	2.8
18	0.5	24.9	43.8	26.0	4.8
24	0.4	26.8	44.4	22.2	6.2
M2					
1	0.3	0.1	0.8	98.8	0.0
6	0.4	9.6	29.6	59.8	0.7
12	0.6	20.5	41.5	34.6	2.8
18	0.5	24.9	43.8	26.0	4.8
24	0.4	26.8	44.4	22.2	6.2
Monetary Base (B)					
1	3.1	0.2	0.1	2.9	93.8
6	10.0	3.1	5.3	13.6	68.0
12	8.0	1.7	12.6	22.8	54.9
18	7.0	1.8	17.9	29.8	43.4
24	6.5	3.13	22.7	33.8	33.9

* Entries give the percentage of the forecast error variance accounted for by orthogonalized innovations in the column variables.

II. The Financial Sector

Financial institutions, banks for short, are assumed to intermediate between firms and households. Firms directly hold the economy's stock of physical capital, while households, the economy's ultimate wealthholders, hold claims against both the financial intermediaries and the central bank. The financial structure can be seen by considering the simplified balance sheets of each sector. The value of capital held by firms is balanced by their liabilities in the form of loans from banks. Banks hold loans and reserves as assets, and issue liabilities in the form of deposits. Household's hold deposits and currency, balanced on the liability side by their net worth. Finally, currency plus reserves are the liabilities of the central bank. The model thus incorporates four financial assets: loans, deposits, reserves, and currency. The remainder of this section sets out a simple model of the financial sector, and examines some of the properties of financial sector equilibrium. The next section expands the model to endogenize price expectations and to allow real output to respond to real interest rates.

The banking industry is assumed to be competitive; each individual bank maximizes profits, taking interest rates on loans and deposits as given. The profits of a representative bank are equal to interest income from loans minus interest paid on deposits minus real costs associated with providing loans and deposits. In addition, banks hold currency to meet legal reserve requirements imposed by the monetary authority. If excess reserves are zero, and the required reserve ratio is ρ, the bank's budget constraint implies that its loans in period t are equal to $(1 - \rho)D_t$, where D_t equals its deposit liabilities. Hence, real bank profits can be written as

$$[\tilde{i}_t(1-\rho) - \tilde{r}_t](D_t/P_t) - c(D_t/P_t)$$

where $\tilde{i}$ is the nominal interest rate on loans, $\tilde{r}$ is the nominal rate paid on deposits, and $c(\cdot)$ is the bank's convex cost function. The first order condition for profit maximization[1] by a "representative bank" implies that

$$\tilde{i}_t(1-\rho) - \tilde{r}_t = c'(D_t/P_t) \tag{2.1}$$

Now let i_t and r_t denote actual deviations of interest rates about their (known) trend levels, and d_t and p_t proportional deviations of deposits and the price level about their (known) trends. Equation (2.1) can then be approximated by

$$d_t - p_t = \tau\,[\,i_t(1-\rho) - r_t] + u_t \tag{2.2}$$

where we have appended a banking sector deposit supply shock u_t. The parameter τ in (2.2) equals $1 / c'(\overline{D}/\overline{P})e$, where $\overline{D}$ and $\overline{P}$ are the trend values of D and P, and e is the elasticity of $c'(\cdot)$. This parameter will play a key role in the subsequent analysis and will serve as an index of the degree of financial intermediation. As $e \to o$ $(\tau \to \infty)$, the supply of deposits becomes perfectly elastic. This is the case considered by Fama [1980], Fischer [1983], and Romer [1985] in their analyses of unregulated financial sectors. We can interpret (2.2) as implying that so long as banks incur non-constant marginal costs in transforming deposits into loans, a positive spread between $i\,(1 - \rho)$ and r is required. In the limit as $\tau \to \infty$, a positive spread between i and r exists only if $\rho > 0$.

From the balance sheet constraint, the representative bank's nominal supply of loans is just $(1-\rho)D_t$. In terms of <u>proportional</u> deviations about trend,

$$l_t - p_t = (d_t - p_t) = \tau[i_t(1-\rho) - r_t] + u_t, \tag{2.3}$$

where l_t is the proportional deviation of nominal loans about trend and use has been made of (2.2).

The demand for loans is a derived demand arising from the investment demand by firms for physical capital. Assuming the demand for capital is a decreasing function of the expected real interest rate on loans, $i_t + p_t - E_t p_{t+1}$, the real demand for loans will be written as

$$(l_t - p_t) = -\beta(i_t + p_t - E_t p_{t+1}) + \varepsilon_t \tag{2.4}$$

with ε_t a real loan demand shock (or equivalently, a shock to desired investment). Using (2.3) and (2.4), the nominal loan rate that clears the loan market is

$$i_t = [\tau r_t - u_t + \varepsilon_t - \beta(p_t - E_t p_{t+1})]/(\beta + \tau(1-\rho)) \tag{2.5}$$

Equation (2.5) shows that as $\tau \to \infty$, the loan rate approaches a constant markup over the deposit interest rate, with the markup factor equal to $(1-\rho)^{-1}$. For τ finite, the spread between the loan and deposit rates will depend on the expected rate of inflation and the two disturbances ε_t and u_t.

To complete the financial sector, it is necessary to specify household demands for deposits and currency. We follow standard specifications:

$$c_t - p_t = y_t - \psi r_t - w_t \tag{2.6}$$

$$d_t - p_t = y_t + \gamma r_t + k w_t \tag{2.7}$$

where c_t is the proportional deviation of household currency holdings about trend, y_t is the proportional deviation of income about trend, and w_t is a portfolio disturbance that affects household demand for deposits relative to currency. For convenience, the income elasticities of demand for currency and deposits are set equal to one. Also, both theoretical (see, for example, Hartley [1985]) and empirical analyses (Goldfeld [1973]) suggest that the semi-elasticity of currency demand with respect to interest paid on deposits (ψ) is lower (in absolute value) than the semi-elasticity of demand for deposits (γ).[2] The factor $k = \bar{C}/\bar{D}$ (with $\bar{C}$ trend currency holdings) arises in (2.7) since the left hand sides in (2.6) and (2.7) are expressed in terms of proportional deviations about trend. For U.S. data, k has been roughly 0.4 in the last decade, although it is much closer to 1.0 if we restrict ourselves to household money holdings alone. On the other hand, if we think of d as representing a wider range of assets (including time deposits, saving and loan deposits, mutual funds and even insurance policies and pension funds), k would be much smaller.

Deposit market equilibrium requires that deposit supply given by (2.2) equal deposit demand given by (2.7). This condition can be written

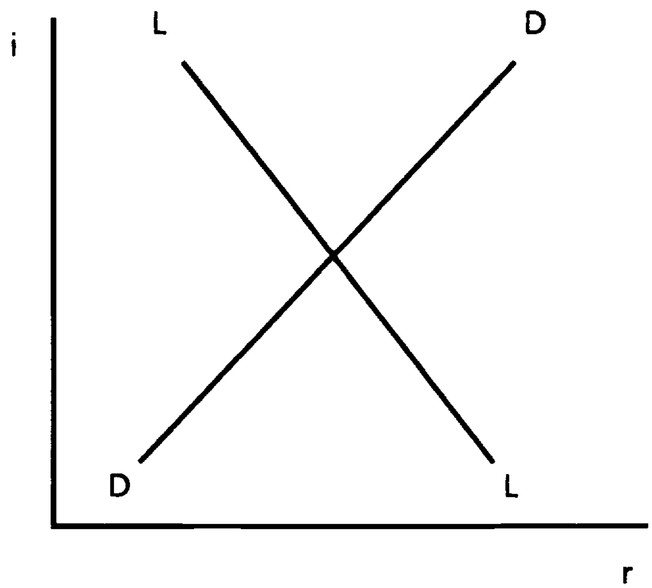
$$r_t = [\tau(1-\rho)i_t - y_t - kw_t + u_t]/(\gamma+\tau) \ . \tag{2.8}$$

This relationship defines a locus in (i, r) space consistent with deposit market equilibrium for given y, w, and u. This locus has slope

$$\frac{\gamma+\tau}{\tau(1-\rho)} > 1$$

and is labeled DD in Figure 1. A rise in r increases deposit demand. A rise in i

Figure 1



restores equilibrium by increasing banks' desired supply of deposits.

Equilibrium in the financial sector also requires that currency demand, both by households and by banks via their demand for reserves, equal the monetary authority's supply of high-powered money. The equilibrium condition for currency can be written

$$\delta c_t + (1-\delta) d_t = m_t \tag{2.9}$$

where m_t is the proportional deviation of high-powered money about a deterministic trend and δ is the ratio of trend currency in the hands of the nonbank public to total trend high-powered money. For later purposes, it is useful to note that $\rho\delta = k(1-\delta)$. In later sections of the paper, it will be assumed that we can write

$$m_t = v_t + \sum_{i=0} x_{t-i} \tag{2.10}$$

where v_t is a white noise shock to m_t and $\Sigma_i x_{t-i}$ is a random walk with innovation x_t. Thus, x_t represents a permanent shock to the base money supply, while v_t is a transitory shock.[3]

Combining (2.6) and (2.7) with (2.9), the reserve market equilibrium condition can be written as

$$p_t - \phi r_t = m_t - y_t + \delta(1-\rho) w_t \tag{2.11}$$

where $\phi = \delta\psi - (1-\delta)\gamma$. The parameter ϕ is the interest semi-elasticity of the excess supply of high-powered money. A rise in r reduces the demand for currency, and this increases the excess supply of high-powered money. However, a rise in r also increases deposit demand and banks' demand for reserves. We will assume that the net effect of a rise in r is a reduction in the demand for high-powered money: $\phi > 0$.[4]

Substituting (2.7) into (2.4) and using (2.11) to eliminate p_t, the condition for equilibrium in the loans market can be written as

$$-\beta i_t - (\gamma + \beta\phi) r_t = \beta m_t + (1-\beta) y_t - \beta E_t p_{t+1} + [k + \beta\delta(1-\rho)] w_t - \varepsilon_t \tag{2.12}$$

This defines a locus with slope di/dr = $-(\gamma + \beta\phi) / \beta < 0$ in (i, r) space. This locus is labeled LL in Figure 1. A rise in i reduces loan demand and creates excess supply in the loan market. A fall in r is required to reduce deposit demand and cause loan supply to decline.

Figure 1 can be used to examine the effects of various disturbances to the financial markets, holding y_t and $E_t\, p_{t+1}$ constant. A rise in m_t shifts the LL locus down but does not directly affect the DD locus. Both nominal interest rates fall, but, since the slope of DD exceeds one, the loan rate decreases more than the deposit rate. Thus, the spread between loan and deposit rates falls in response to a monetary expansion. Using (2.11), it can be shown that p_t rises.

A positive shock to deposit supply ($u_t > 0$) leaves LL unaffected, but shifts DD to the right. The deposit rate rises and the loan rate declines. Again, the spread between loan and deposit rates declines. Equation (2.11) can, with some manipulation, be used to show that p rises.

A positive portfolio shift disturbance w shifts the LL curve down and the DD curve to the left. The deposit rate falls, but the effect on i is ambiguous. A positive w increases the demand for deposits relative to currency. This tends to reduce r and induce banks to increase their supply of loans, causing i to fall. However, the initial fall in the demand for currency is also offset by the fall in r. If the offset is more than complete, the price level could fall. Given $E_t p_{t+1}$, such a fall in p_t increases the expected rate of inflation and reduces the real rate of interest on loans. If the resulting rise in loan demand is larger than the rise in loan supply induced by the fall in r, the nominal loan rate could rise. Sufficient conditions to insure that a portfolio shift out of currency reduces both interest rates and leads to a rise in the price level are that *either* $\gamma > k\psi$ *or* $\tau > \beta\phi$. The first condition, which implies that a rise in the interest rate paid on deposits raises the demand for currency *plus* deposits, follows from $\gamma > \psi$ and $k < 1$. The second just requires that the degree of financial intermediation not be "too small." Either condition is sufficient to insure that both rates decline in response to a positive w.

A positive shock to loan demand ($\varepsilon_t > 0$) shifts the LL curve up. Both nominal interest rates rise, and, because the slope of DD is greater than 1, the spread between loan and deposit rates rises. Using (2.11), the price level can be shown to rise.

A positive income shock shifts both curves. The direction of the shift in LL is ambiguous unless we can sign $1-\beta$. This ambiguity arises because an increase in income increases deposit demand for each r. This increase in the demand for the banks' liabilities allows banks to increase loan supply. On the other hand, in the high-powered money market, the rise in y for given r, requires a fall in p to maintain market equilibrium. The fall in p reduces the *ex ante* real loan rate and increases loan demand by β times the rise in y. If $\beta > 1$, this second channel dominates and a higher i is required to clear the loan market: LL shifts up. The DD locus shifts up as well since the demand for deposits has risen. Thus, $\beta > 1$ is sufficient to insure that the loan rate increases. However, an additional condition is required to sign the effect on r. It can be shown that if τ is sufficiently large, r will also rise. Using (2.11), it can be shown that p must unambiguously fall in response to a positive supply shock. These results are summarized in Table 4.

An increase in the degree of financial intermediation is represented by an increase in τ. As equation (2.12) shows, the LL locus is independent of τ, but, from (2.8), a rise in τ shifts DD to the right. The loan rate falls and the deposit rate rises. Hence, the gains to more efficient intermediation accrue to both borrowers and lenders. Since the spread $(i-\rho)$ i-r falls as τ increases, the equilibrium real quantities of both loans and deposits are increasing in τ.

Table 4
Results of Comparative Static Experiments
(y_t and $E_t p_{t+1}$ fixed)

	i_t	r_t	p_t
m_t	$-$	$-$	$+$
u_t	$-$	$+$	$+$
w_t	$-$[a]	$-$	$+$[a]
ε_t	$+$	$+$	$+$
y_t	$+$[c]	$+$[b]	$-$

a. Sufficient conditions to obtain these signs are $\gamma > k\psi$ *or* $\tau > \beta\phi$.

b. Sufficient conditions to obtain this sign are $\beta > 1$ and $\tau > \beta/[(\beta-1)(1-\rho)]$.

c. Sufficent condition to obtain this sign is $\beta > 1$.

As the degree of financial intermediation goes to infinity, $(1-\rho)i-r$ converges to zero and the equilibrium loan rate is given by

$$i_t = \{\varepsilon_t + \beta E_t p_{t+1} - \beta m_t - (1-\beta)y_t - (\beta\delta(1-\rho)+k)w_t\} / (\beta + (1-\rho)(\gamma + \beta\phi)). \tag{2.14}$$

It is interesting to note that the reserve ratio appears only in the denominator, multiplied by $\gamma + \beta\phi > 0$, and in the coefficient on the portfolio shock, w_t. If neither currency nor deposit holdings by households are interest sensitive ($\psi = \gamma = 0$), then $\gamma + \beta\phi = 0$ and the *expected* value of i is independent of ρ. Consequently, the expected reserve tax is borne completely by deposit holders. If either ψ or γ are non-zero, then the banks' borrowers also bear part of the tax.[5] Even when $\psi = \gamma = 0$, the variance of i will depend on ρ since the coefficient of w_t becomes $\delta(1-\rho)$. Thus, the reserve requirement tends to dampen the effect on the loan rate of shifts between deposits and currency.

With costless intermediation, r approaches i as the reserve requirement goes to zero. If $\rho \rightarrow 0$ and $\tau \rightarrow \infty$, equation (2.14) shows that i_t becomes less sensitive to all disturbances with the possible exception of w.

The analysis of this section has taken as given the level of income and the expected future price level, using the three asset market equilibrium conditions, (2.5), (2.8), and (2.11), to solve for the two interest rates and the price level.[6] The complete rational expectations solution requires the specification of the information structure and an assumption concerning aggregate supply in the goods market. These are discussed in the next section.

III. General Equilibrium with Complete Information

In this section we allow y_t and $E_t p_{t+1}$ to respond endogenously to the interest rate and price movements produced by the ε, w, u, v and x shocks. Specifically, in line with other equilibrium models of the business cycle, we assume intertemporal substitution by households makes current output a positive function of the real interest rate available to households:

$$y_t = \alpha(r_t + p_t - E_t p_{t+1}) + \xi_t \tag{3.1}$$

where ξ_t is an exogenous supply shock. Also in line with virtually all other macroeconomic models, we ignore the effect on aggregate supply arising through effects of $(i_t + p_t - E_t p_{t+1})$ on investment and hence the capital stock. We adopt this specification in order to focus on the consequences of including inside money in a model which is in other respects very similar to models previously analyzed. The dynamics introduced by accounting for capital accumulation would complicate the solution of the model and obscure the interpretation of the main results.

The equilibrium conditions for the loan, deposit, and reserve markets can now be written:

$$-\beta(i_t + p_t - E_t p_{t+1}) + \varepsilon_t = \alpha(r_t + p_t - E_t p_{t+1}) + \xi_t + \gamma r_t + k w_t \tag{3.2}$$

$$\tau[i_t(1-\rho) - r_t] - \alpha(r_t + p_t - E_t p_{t+1}) - \gamma r_t = k w_t - u_t + \xi_t \tag{3.3}$$

$$p_t + \alpha(r_t + p_t - E_t p_{t+1}) - \phi r_t = \sum_i x_{t-i} + v_t - \xi_t + \delta(1-\rho) w_t \tag{3.4}$$

Equations (3.2) - (3.4) can be solved for p_t, i_t and r_t as functions of the shocks ε_t, ξ_t, w_t, u_t, x_t, and v_t. Let those solutions be

$$p_t = \sum_{i=0} x_{t-i} + \Pi_{11}\varepsilon_t + \Pi_{12}\xi_t + \Pi_{13}w_t + \Pi_{14}u_t + \Pi_{15}\upsilon_t \tag{3.5}$$

$$i_t = \Pi_{21}\varepsilon_t + \Pi_{22}\xi_t + \Pi_{23}w_t + \Pi_{24}u_t + \Pi_{25}\upsilon_t \tag{3.6}$$

$$r_t = \Pi_{31}\varepsilon_t + \Pi_{32}\xi_t + \Pi_{33}w_t + \Pi_{34}u_t + \Pi_{25}\upsilon_t \tag{3.7}$$

Then

$$E_t p_{t+1} = \sum_{i=0} x_{t-i}$$

since each of the shocks is assumed to be white noise. We can define

$$P_t \equiv p_t - E_t p_{t+1} = p_t - \sum_{i=0} x_{t-i} = \Pi_{11}\varepsilon_t + \Pi_{12}\xi_t + \Pi_{13}w_t + \Pi_{14}u_t + \Pi_{15}\upsilon_t$$

and rewrite equations (3.2) - (3.4) in matrix notation as

$$\begin{bmatrix} \alpha+\beta & \beta & \alpha+\gamma \\ -\alpha & \iota(1-\rho) & -(\iota+\gamma+\alpha) \\ 1+\alpha & 0 & \alpha-\phi \end{bmatrix} \begin{bmatrix} P_t \\ i_t \\ r_t \end{bmatrix} =$$

$$\begin{bmatrix} 1 & -1 & -k & 0 & 0 \\ 0 & 1 & k & -1 & 0 \\ 0 & -1 & \delta(1-\rho) & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t \\ \xi_t \\ w_t \\ u_t \\ v_t \end{bmatrix} \qquad (3.8)$$

Using (3.8) we can solve for the π_{ij}'s in (3.5) - (3.7). The algebraic expressions are given in Appendix 1, while numerical values corresponding to plausible values for α, β, γ, ψ, κ, δ and τ are presented in the next section. In that section, we also discuss the sensitivity of the solution to changes in the parameter values. In the remainder of this section we shall investigate the qualitative results by comparing the solution to (3.8) with the solution discussed in Section II.

The signs of the partial derivatives of each of the endogenous variables with respect to each of the shocks (i.e., the signs of the π_{ij} coefficients in (3.5) - (3.7)) are presented in Table 5 (corresponding to Table 4 in Section II). The main change from Section II is that the effects on P_t of a banking sector shock (u_t) and a loan demand shock (ε_t) change sign (to become negative). The reason for this is that nominal income is the factor determining asset demands. Hence, while the effect of shocks on nominal income $p_t + y_t$, does not change from Section II to Section III, the effect on prices can differ when real output is allowed to move. Otherwise, the signs of the effects of the shocks on the endogenous variables are similar to those found in Section II. For the signs which are ambiguous, the conditions on parameter values which would remove the ambiguity are also similar to those presented and discussed in Section II.

Table 5
Results of Comparative Static Experiments
(y_t and $E_t\, p_{t+1}$ endogenous)

	i_t	r_t	P_t
v_t	−	−	+
u_t	?	+	−[a]
w_t	−[b]	−	+[c]
ε_t	+	+	−[a]
ξ_t	+[d]	+[e]	−

a. A necessary and sufficient condition to obtain these signs is $\alpha > \phi$.

b. A sufficent condition to obtain this sign is $\gamma > k\psi$ *or* $\iota > \beta\delta[k\psi - \gamma - \alpha(1+k)] / [\alpha\delta(1+k) + k + \beta\delta(1-\rho)]$.

c. A sufficient condition to obtain this sign is $\gamma > k\psi$ *or* $\alpha(1+k) + \beta + \gamma - k\psi > 0$ and $\tau > \beta[\gamma - k\psi + \alpha(1+k)] / (1-\rho)[\beta + \gamma + \alpha(1+k) - k\psi]$.

d. A sufficient condition to obtain this sign is $\beta > 1$.

e. Sufficient conditions to obtain this sign are $\beta > 1$ and $\iota > \beta / [(\beta-1)(1-\rho)]$.

We demonstrate in Appendix 1 that real output responds positively to all shocks. This result does not depend on assumptions with respect to relative parameter values except for $\partial y_t / \partial w_t$, in which case $\gamma > k\psi + k / \delta$ is sufficent to ensure $\partial y_t / \partial w_t > 0$.

In particular, financial sector shocks w_t, u_t, and v_t are non-neutral even when there is no uncertainty about the source of shocks. A positive base supply shock v_t raises the current price level relative to the expected future price level. This more than offsets the fall in the nominal deposit rate, raising the anticipated real interest rate faced by households, and leading to a rise in output. Thus, known temporary innovations in the money base, v_t, have real effects. They cannot merely produce offsetting price and nominal interest rate movements because of the operation of the banking sector. More explicitly, if temporary base money innovations are not to have real effects, from (3.1) they must not alter the real interest rate $(r_t+p_t\text{-}Ep_{t+1})$. But equilibrium between the demand and supply of base money (3.4) requires r_t and p_t to move to increase the demand for currency. The two conditions $\Delta\ (r_t+p_t\text{-}E_tp_{t+1})=0$ and $\Delta\ (p_t\text{-}E_tp_{t+1}\text{-}\phi r_t)=1$ then completely determine the effect of v_t on r_t and p_t. Turning to (3.2) and (3.3), equilibrium in the markets for deposits and loans then imposes two further conditions while introducing only one additional variable i_t. In general, this will yield an inconsistency, leading us to reject the hypothesis $\Delta\ (r_t+p_t\text{-}Ep_{t+1})=0$. In short, if temporary base money shocks are not to have real effects, deposit rates r_t and prices p_t have to move equal non-zero amounts in opposite directions. But changes in r_t alter the demand for deposits. Any movement in the loan interest rate, i_t, which would restore equilibrium to the deposit market would cause disequilibrium in the loan market (holding r_t and p_t fixed).

By contrast, note that a permanent innovation in base money, x_t, produces a proportional movement in current and all future prices while leaving interest rates and output unaffected.

Our results on the differing impact of temporary and permanent base money supply shocks can be contrasted with the remarks of Barro [1981, p.51]:

> ...One conclusion from these models with endogenous nominal interest rates is that the stress on confusions between temporary and permanent monetary shocks has been overdone. The real effects of temporary, but perceived, money shocks would be eliminated by the appropriate adjustment in the nominal rate of return....

We cannot have offsetting price and interest rate movements in our model (and thereby avoid real effects), because the demand for deposits and hence the supply of loans would be affected. One or both real interst rates *must* be affected by temporary money supply shocks. In our model they are both affected.

There are some modifications of our model which would cause *all* base money innovations to be neutral. For example, suppose monetary injections take the form of transfers proportional to each individual's or branch's existing base holdings as in Lucas [1972]. In this case, base money innovations have no effect on the opportunity cost of holding base money. Household's demands for deposits and currency would then depend on real rather than nominal interest rates. Banks' supply of deposits would similarly be a function of the difference between the real loan interest rate, adjusted for the reserve ratio, minus the real deposit rate. Both temporary and permanent base money shocks would then be neutral. However, empirical tests of monetary neutrality have not been based on data generated by economies in which money supply changes have taken the form of interest payments on existing money holdings.

Portfolio shifts, w_t, and supply shocks originating in the banking sector, u_t, are two sources of output movements in a model with inside money which, of course, cannot be present in models which have just one (outside) monetary asset. A positive innovation in w_t increases the demand for bank deposits relative to currency, producing an excess supply of high-powered money. This excess supply is eliminated by a combination of a fall in r and a rise in p. For reasonable parameter values (i.e., $\gamma > k\psi + k/\delta$), this adjustment leads to a rise in the *real* deposit rate and, hence, a rise in output. A positive u shock raises both the supply of loans and the supply of deposits. This results in a rise in the real return on deposits and produces a rise in output.

It is also worth noting that u_t, w_t, and v_t shocks will in general all be reflected in movements of money supply measures which include inside money, such as M1. In this model, deviations about trend of an aggregate like M1 are given by

$$M1_t = \frac{1}{1+k} d_t + \frac{k}{1+k} c_t = p_t + y_t + \frac{\gamma - k\psi}{1+k} r_t .$$

Even if there is no uncertainty about the sources of shocks and the monetary base is exogenous, the presence of inside money and temporary shocks to the base can easily explain positive correlations between $M1_t$ and current output y_t.

Looking at the implications of the model for co-movements between other variables, it can be seen from the solution in Appendix 1 that (consistent with the results of Section II) temporary base money and banking sector shocks decrease the spread, $i(1-\rho)-r$, between the borrowing and lending rates of financial intermediaries. On the other hand, real demand and supply shocks increase the spread between borrowing and lending rates of interest. Also, while supply shocks unambiguously decrease current prices and temporary innovations in the base money supply unambiguously increase current prices, the effects of demand, financial sector, and portfolio shocks on current prices are all ambiguous.

Real supply and investment (or loan demand) shocks produce real interest rate movements which partially offset their initial effect on output. This result follows because the effects of ε, ξ, u and v shocks on real output are all bounded between zero and one, as can easily be seen by considering a uniform innovation in ε, ξ, u and v. An equivalent movement in ε_t and ξ_t implies, from (3.2), that real interest rates need not vary to maintain loan market equilibrium. But in that case, supply and demand would adjust in proportion to the ε_t (and ξ_t) shock. This in turn would produce a proportionate increase in demand for currency and bank deposits. The consequent increase in demand for base money could be completely accommodated by the v_t shock (equation 3.4). The increased demand for bank deposits could be accommodated by the deposit supply shock u_t (3.3). Given that a uniform increase in ε_t, ξ_t, u_t, and v_t produces an equivalent increase in y_t, and also given, from Appendix 1, that each of these shocks has a positive impact on y_t, it follows that the effect of each shock on y_t is in fact bounded between zero and one.

Finally, it is of interest to note the effect of increasing the degree to which intermediation is effective in preventing a spread between i_t and r_t from arising. As $\tau \to \infty$, the supply of intermediation services becomes infinitely elastic, and borrowing and lending rates net of the effect of reserve requirements cannot diverge. Hence, the effects of u_t, w_t, and v_t on $i_t(1-\rho) - r_t$ will fall to zero. Banking supply disturbances, u_t, in fact have no effects on any variables as $\tau \to \infty$. Temporary innovations in base money supply and portfolio shifts both continue to affect prices and real interest rates. As $\tau \to \infty$, we know that i and r have to move together. In fact, from the algebraic expression for the full information solution given in the appendix, we can see that as $\tau \to \infty$, the effect of real shocks on both i and r will be positive (only if $\beta > 1$ for ξ) and the effect of w and v shocks on i and r both tend to zero. As for y_t, as $\tau \to \infty$

$$\frac{\partial y_t}{\partial w_t} \to \frac{-\alpha(1-\rho)[k - \beta\delta\rho - \gamma\delta + k\delta\psi]}{(1-\rho)[\alpha + \alpha\phi + \alpha\gamma + \gamma] - \beta[1 + \phi(1-\rho) + \alpha\rho]}$$

$$and \quad \frac{\partial y_t}{\partial v_t} \to \frac{\alpha\beta\rho - \alpha\gamma(1-\rho)}{(1-\rho)[\alpha + \alpha\phi + \gamma(1+\alpha)] + \beta[1 + \alpha\rho + \phi(1-\rho)]}.$$

Also

$$\frac{\partial y_t}{\partial \varepsilon_t} \to \frac{\alpha(1-\rho)[1+\phi]}{(1-\rho)[\alpha + \alpha\phi + \gamma(1+\alpha)] + \beta[1 + \alpha(1-\rho) + \alpha\rho]} > 0$$

and it is easy to show $\partial y / \partial \varepsilon$ is monotonically increasing in τ, while

$$\frac{\partial y_t}{\partial \xi_t} \to \frac{(1-\rho)[\gamma + \beta\phi] + \beta}{(1-\rho)[\alpha(1-\rho) + \gamma(1+\alpha)] + \beta[1 + \phi(1-\rho) + \alpha\rho]} > 0 \ as \ \tau \to \infty.$$

This section has demonstrated that even within the framework of an equilibrium, rational expectations model in which current information is complete, portfolio shifts between currency and deposits, as well as temporary innovations in the monetary base, will lead to real interest rate and output movements. These effects depend importantly on the presence of real costs of intermediation. Since the assumption of complete cotemporaneous information is very restrictive, the next section studies the behavior of real interest rates and output when current information is incomplete. Permanent innovations in base money will no longer be neutral in this case, since they will be confused with temporary innovations and portfolio shifts.

IV. Incomplete Current Information

In this section of the paper we assume that, while agents know the lagged values of all shocks, they do not have complete information on the sources of current shocks. In order to model the rapid availability of monetary data, we assume that noisy measures of the monetary base and the money multiplier are observed. Thus, the public is assumed to know the current values of i_t, r_t, and p_t and two noisy measures (signals) of the monetary base and the money multiplier:

$$s_{1t} = \sum_{i=0} x_{t-i} + v_t + n_{1t} \tag{4.1}$$

and

$$s_{2t} = p_t + y_t + \frac{\gamma - k\Psi}{1+k} r_t - \sum_{i=0} x_{t-1} - v_t + n_{2t} \tag{4.2}$$

with n_{1t}, n_{2t} white noise.[7]

There are two motivations for studying this example. First, while the models examined in Section III result in real effects of "financial sector" (u, v and w) shocks, known permanent movements, x_t, in base money supply would still be neutral with respect to real variables and result in proportional movements in all prices. The model in this section will imply that current x_t shocks also will be non-neutral.[8] The second motivation for introducing uncertainty about the source of current shocks is the evidence, presented by Lucas [1973], Alberro [1981] and Kormendi and Maguire [1984] among others, that the real effects of monetary disturbances depend on the variance of monetary shocks. These results suggest that the incomplete information signal processing model of business cycle disturbances pioneered by Lucas [1972] has some merit. However, a major difference in the implications of our model and that of Lucas [1972] and subsequent authors is that, because *known* monetary sector disturbances are not neutral, current signals on such disturbances (such as 4.1 and 4.2) also will not be neutral. More explicitly, insofar as 4.1 and 4.2

reveal information about current *temporary* movements in base money supply, or portfolio or banking sector shocks, they will lead to real output movements. Thus our model can reconcile the cross-sectional empirical evidence, favorable to the "misperceived money shocks" view of business cycles, with the findings of Boschen and Grossman [1982] and Barro and Hercowitz [1980] that money announcements appear to be correlated with real output movements. It also is consistent with the empirical evidence that money announcements affect real interest rates (Roley and Walsh [1984]).

The equilibrium conditions are still given by (3.2) - (3.4). Now, however, in forming their expectations of future prices, agents will have five sources of information (i_t, r_t, p_t and (4.1) and (4.2)) on the eight variables:

$$\Omega_t = \begin{bmatrix} \varepsilon_t & \xi_t & w_t & u_t & x_t & v_t & n_{1t} & n_{2t} \end{bmatrix} \tag{4.3}$$

We need to solve for p_t, i_t and r_t in terms of the underlying shocks (4.3) so that we can determine the information provided to agents from observation of p_t, i_t and r_t.

Explicitly, we guess a solution of the form

$$p_t = \sum_{i=1} x_{t-1} + \pi_{11}\varepsilon_t + \pi_{12}\xi_t + \pi_{13}w_t + \pi_{14}u_t + \pi_{15}(v_t + x_t) + \pi_{16}n_{1t} + \pi_{17}n_{2t} \tag{4.4}$$

$$i_t = \pi_{21}\varepsilon_t + \pi_{22}\xi_t + \pi_{23}w_t + \pi_{24}u_t + \pi_{25}(v_t + x_t) + \pi_{26}n_{1t} + \pi_{27}n_{2t} \tag{4.5}$$

$$r_t = \pi_{31}\varepsilon_t + \pi_{32}\xi_t + \pi_{33}w_t + \pi_{34}u_t + \pi_{35}(v_t + x_t) + \pi_{36}n_{1t} + \pi_{37}n_{2t} \tag{4.6}$$

$$s_{2t} = \pi_{41}\varepsilon_t + \pi_{42}\xi_t + \pi_{43}w_t + \pi_{44}u_t + \pi_{45}(v_t + x_t) + \pi_{46}n_{1t} + \pi_{47}n_{2t} \tag{4.7}$$

Under the informational assumptions of this section, all *lagged* values of x are known. As in Section III, these shocks will merely affect nominal prices, leaving interest rates and real variables unchanged. Note that the proportional effect of lagged x's on s_{2t} (the money multiplier signal) through their effect on p is offset by their effect on the money base. In all equations, current x and v appear in the form $v_t + x_t$. Agents have no basis for distinguishing the effects of contemporaneous x from those of v. Hence, the conjectured solutions (4.4) - (4.7) include $v_t + x_t$ with a common coefficient.

In forming their expectations, $E_t p_{t+1}$, agents will use (4.4) to obtain

$$E_t p_{t+1} = \sum_{i=1} x_{t-1} + E_t x_t \tag{4.8}$$

with $E_t x_t$ formed using a linear projection onto the information variables (4.5) - (4.7) together with

$$P_t^* = \pi_{11} \varepsilon_t + \pi_{12} \xi_t + \pi_{13} w_t + \pi_{14} u_t + \pi_{15}(v_t + x_t) + \pi_{16} n_{1t} + \pi_{17} n_{2t}$$

and

$$s_{1t}^* = x_t + v_t + n_{1t} \equiv s_{1t} - \sum_{i=1} x_{t-i}$$

Thus

$$E_t x_t = B_1 P_t^* + B_2 i_t + B_3 r_t + B_4 s_{1t}^* + B_5 s_{2t} \equiv [B_i] Q_t \tag{4.9}$$

The projection equation (4.9) yields normal equations

$$[B_i] = \sigma_x^2 [\pi_{15}\ \pi_{25}\ \pi_{35}\ \pi_{45}\ 1]\, \Gamma^{-1} \tag{4.10}$$

where

$$\Gamma = E[Q_t' Q_t].$$

Γ will be a nonlinear function of the π coefficients and the variance-covariance matrix $\Sigma = E[\,\Omega_t'\,\Omega_t\,]$. This makes the solution analytically intractable. However, one important implication of the model is immediate. Permanent innovations in the monetary base will no longer be neutral but will have effects on real output and real interest rates. This follows since known temporary base money innovations have real effects and, with incomplete information, permanent innovations will be confused with temporary innovations. Similarly, perceived innovations to the monetary signal will have real effects.

To solve the model, we specify some values for the elasticity parameters, together with a variance-covariance matrix Σ. Solving the model for plausible parameter values will help to determine whether portfolio disturbances and temporary base shocks can have effects which are not just of theoretical interest but are of potential empirical significance as well. So that we may fix some plausible parameter values, note that α is a semi-elasticity of supply with respect to the real deposit interest rate (since y_t is the *proportional* variation in output) and β is the semi-elasticity of loan demand with respect to the real loan interest rate. If real interest rates are on the order of 4 percent, values of α and β around 8.0 will yield elasticities of 0.3. Similarly, γ and ψ represent semi-elasticities of asset demands with respect to nominal interest rates. As we noted in Section II of the paper, on the basis of both theory and empirical evidence we would expect γ to exceed ψ. The estimates reported in Goldfeld [1973] suggest a value for γ of about 5 and for ψ of about 3. In summary, we used as our "base case" parameter values:

$$\alpha = \beta = 8.0; \quad \partial = 5.00; \quad \psi = 3.0 .$$

Similarly, the parameter τ represents a semi-elasticity of deposit supply with respect to the interest differential adjusted for the reserve requirement. We set $\tau = 8.0$ for the "base case."

The value of δ, the share of currency in high-powered money, was set to 3/4 (its approximate value in the U.S.), while k, the ratio of currency to bank deposits, was set to 1/2 (also its approximate value in the U.S.). As we noted above, the value of ρ is then determined by the identity

$$\rho \quad = \; k\,(1.0 - \delta)\,/\,\delta$$

(so that in the United States ρ is approximately equal to 1/6 for banks). When we think about "deposits" in our model as representing a wider range of assets than demand deposits, both k and the corresponding value of ρ will be smaller, but the value of δ will be no different. Accordingly, we examined the effect on the numerical solution of reducing k to a smaller value.

With the above "base case" parameter values, we will have the following values for two of the expressions needed to sign effects in Table 5:

$$\phi = \delta\psi - [1.0 - \delta]\,\gamma = 1.0 > 0$$

$$\alpha - \phi = 7.0 > 0$$

To calculate the incomplete information solution, we also need to specify the *relative* variances for the different shocks. Examination of the normal equation (4.10) implies that the absolute values of the variances are irrelevant. We take the variance of permanent money supply shocks, $\sigma^2{}_x$, to be the smallest. Measured as a ratio to $\sigma^2{}_x$ the remaining variances were set at:

$$\sigma^2_u = \sigma^2_v = \sigma^2_w = \sigma^2_\varepsilon = \sigma^2_\xi = 2$$

$$\sigma^2_{NM} = \sigma^2_{NB} = 1 \qquad (4.15)$$

for the "base case."

Table 6 presents the numerical solution for the "base case" parameter values. Looking first at the full information solution, which was explicitly derived in the Appendix and discussed in the previous section, it is of some interest to note the magnitudes of the coefficients. Temporary base money supply shocks have the largest effect on output, followed by portfolio shocks, output supply shocks, banking sector shocks and, lastly, loan demand or investment shocks ε. A 5 percent temporary deviation of base money about trend would, under full information and given the "base" parameter values, result in a 3.1 percent deviation of output about trend. Similarly, a 5 percent shift out of currency and into deposits would increase output about 1.4 percent. Both of these shocks affect output positively because they raise current prices,[9] but reduce deposit and loan interest rates by lesser amounts.[10] Supply shocks significantly reduce prices and raise nominal interest rates by a lesser amount, and thus increase output by less than the size of the shock. On the other hand, while loan demand (or investment) shocks also decrease prices, they increase deposit rates to a greater extent and so expand output.

When we compare the incomplete and full information solutions in Table 6, we see the effect of the confusion between temporary and permanent shocks to the base money supply produced by uncertainty. Temporary base money supply shocks now have a larger effect on prices (a 5 percent shock leading to a 2.2 percent movement in prices), but permanent shocks have a smaller effect, than under full information. Similarly, the effect of both temporary and permanent base money supply shocks on interest rates is between the effects of each shock under full information. A 5 percent temporary *or* permanent base money supply shock increases output roughly 2.2 percent above trend. If we look at the row of coefficients for $E_t p_{+1}$ (in effect, $E_t x_t$) we see that a permanent base money supply shock is also confused to a significant extent with a movement in base measurement error (n_1), a positive portfolio shock, and a negative supply shock. The confusion with base measurement error arises

Table 6
Solution for "base case" parameter values

Variable	Shock							
	ε (Invest.)	ξ (Supply)	w (P'folio)	u (Bank)	v (Temp.)	x (Perm.)	n_1 (Bnoise)	n_2 (Mnoise)
Full Information								
p_t	-.043	-.139	.192	-.051	.232	1.0	0.0	0.0
i_t	.121	.095	-.190	-.005	-.211	0.0	0.0	0.0
r_t	.055	.035	-.157	.066	-.156	0.0	0.0	0.0
y_t	.097	.174	.276	.117	.612	0.0	0.0	0.0
Incomplete Information								
p_t	-.063	-.179	.232	-.072	.444	.444	.131	-.050
i_t	.116	.084	-.179	-.010	-.153	-.153	.036	-.014
r_t	.051	.027	-.149	.062	-.113	-.113	.027	-.010
$E_t p_{t+1}$	-.027	-.053	.052	-.027	.277	.277	.171	-.065
y_t	.114	.206	.244	.133	.443	.443	-.105	.040

since the measure of the base observed by individuals is $x_t + v_t + n_{1t}$. Confusion with portfolio and negative supply shocks arises since these have an effect on prices and interest rates that is similar to that of a temporary base supply shock. By contrast, ε and u shocks have a different effect on prices and interest rates and are therefore confused less for money shocks. The effect of real and banking sector shocks on output ends up being higher under incomplete than full information, while the effect of temporary base money shocks and portfolio shocks is lower. Permanent base money supply shocks of course have a larger effect on output under uncertainty than when current information is complete. Finally, note that the correlation between output movements and *announced* money base movements is a little over

0.66. Given that *known* temporary money base movements have a large effect on output, it is not surprising that the present model also results in a large positive correlation between money announcements and real output (and real interest rate) movements when information is incomplete.[11]

Table 7 illustrates the effects of varying some of the key parameter values. The effect of each of the shocks on output is little changed from one set of parameter values to the next. This remains true even when many of the parameters are varied over quite a large range. Prices and interest rates can be noticeably affected by parameter changes, but real output (α times real deposit interest rates) appears much less sensitive.

The upper half of Table 7 illustrates the effects of increasing the elasticity of deposit supply. These effects are consistent with the discussion of the previous section on the full information solution. In both the full and incomplete information cases, raising τ increases the real effects of real shocks (ε and ξ) and reduces the real effects of monetary shocks.

In the lower half of Table 7 we reduced k from 0.5 to 0.2. This solution corresponds to the assumption that D represents a broader range of assets than just demand deposits. With D larger, both k ($= C / D$) and ρ ($=$ reserves $/$ D) will fall, but δ ($= C / M$) will remain unchanged. The major consequence of reducing k (and the corresponding value of ρ) is that the effect of portfolio shocks on deposit interest rates is reduced. A given sized shock w represents a smaller increase in demand for inside assets D, and hence produces less of a reduction in r_t. The smaller fall in r_t translates into a larger rise in output.

Table 8 illustrates the effect of changing the relative variances of the shocks. Comparing the top panel of Table 3 with Table 5, we can see that increasing the variance of real (ε and ξ) shocks relative to money shocks raises the real effect of

Table 7
Changes in deposit supply elasticity and C / D

Variable	Shock							
	ε (Invest.)	ξ (Supply)	w (P'folio)	u (Bank)	v (Temp.)	x (Perm.)	n_1 (Bnoise)	n_2 (Mnoise)
τ = 15.0 Full Information								
p_t	-.054	-.149	.192	-.034	.237	1.0	0.0	0.0
i_t	.120	.094	-.190	-.003	-.211	0.0	0.0	0.0
r_t	.069	.049	-.158	.044	-.162	0.0	0.0	0.0
y_t	.123	.198	.275	.079	.601	0.0	0.0	0.0
Incomplete Information								
p_t	-.074	-.189	.232	-.055	.448	.448	.130	-.050
i_t	.115	.083	-.179	-.009	-.153	-.153	.036	-.014
r_t	.065	.040	-.149	.040	-.117	-.117	.028	-.011
E_tp_{t+1}	-.027	-.053	.052	-.027	.277	.277	.171	-.065
y_t	.138	.230	.244	.094	.435	.435	-.102	.039
k = 0.2 Full Information								
p_t	-.047	-.142	.188	-.051	.241	1.0	0.0	0.0
i_t	.121	.094	-.171	-.005	-.211	0.0	0.0	0.0
r_t	.061	.040	-.142	.065	-.167	0.0	0.0	0.0
y_t	.108	.183	.370	.116	.593	0.0	0.0	0.0
Incomplete Information								
p_t	-.075	-.177	.226	-.078	.453	.453	.122	-.052
i_t	.113	.085	-.160	-.012	-.152	-.152	.034	-.015
r_t	.055	.033	-.134	.059	-.120	-.120	.027	-.012
E_tp_{t+1}	-.036	-.046	.049	-.036	.280	.280	.161	-.069
y_t	.130	.210	.341	.138	.427	.427	-.095	.041

Table 8

Changes in relative variances (Incomplete information solutions only)

Variable	Shock							
	ε (Invest.)	ξ (Supply)	w (P'folio)	u (Bank)	v (Temp.)	x (Perm.)	n_1 (Bnoise)	n_2 (Mnoise)
$\sigma^2_\varepsilon = \sigma^2_\xi = 4\sigma^2_x$								
p_t	-.057	-.162	.228	-.081	.441	.441	.141	-.045
i_t	.117	.088	-.181	-.013	-.154	-.154	.039	-.013
r_t	.052	.030	-.150	.060	-.113	-.113	.029	-.009
$E_t p_{t+1}$	-.019	-.031	.047	-.039	.272	.272	.183	-.059
y_t	.109	.193	.247	.140	.446	.446	-.112	.036
$\sigma^2_\varepsilon = \sigma^2_\xi = \sigma^2_u = \sigma^2_w = 4\sigma^2_x$								
p_t	-.058	-.164	.212	-.066	.438	.438	.150	-.049
i_t	.117	.088	-.185	-.009	-.155	-.155	.041	-.014
r_t	.052	.030	-.153	.063	-.114	-.114	.030	-.010
$E_t p_{t+1}$	-.020	-.033	.026	-.020	.268	.268	.195	-.064
y_t	.110	.194	.260	.129	.448	.448	-.120	.039
$\sigma^2_\varepsilon = \sigma^2_\xi = \sigma^2_u = \sigma^2_w = \sigma^2_v = 4\sigma^2_x$								
p_t	-.053	-.155	.205	-.061	.366	.366	.098	-.032
i_t	.118	.090	-.187	-.007	-.175	-.175	.027	-.009
r_t	.053	.032	-.155	.064	-.128	-.128	.020	-.007
$E_t p_{t+1}$	-.013	-.021	.017	-.013	.175	.175	.127	-.042
y_t	.105	.187	.266	.125	.506	.506	-.078	.026
$\sigma^2_\varepsilon = \sigma^2_\xi = \sigma^2_u = \sigma^2_w = \sigma^2_v = 4\sigma^2_x$ $\sigma^2_{NB} = \sigma^2_{NM} = 2\sigma^2_x$								
p_t	-.054	-.162	.215	-.063	.355	.355	.076	-.029
i_t	.118	.088	-.184	-.008	-.178	-.178	.021	-.008
r_t	.052	.031	-.153	.063	-.131	-.131	.015	-.006
$E_t p_{t+1}$	-.016	-.031	.030	-.016	.160	.160	.099	-.038
y_t	.106	.193	.258	.126	.514	.514	-.061	.023

money disturbances on output in line with the results of previous rational expectations equilibrium business cycle models (e.g., Lucas [1973], Barro [1976]).

The second panel of Table 8 shows the results when the variances of portfolio and banking sector shocks are also raised. Here, perhaps somewhat contrary to previous models (which did not really include such shocks), the real effects of portfolio and base money supply shocks continue to increase. The basic reason is that the increase in σ^2_w and σ^2_u relative to σ^2_x reduces the extent to which movements in endogenous variables are interpreted as the result of a permanent base money supply shock x. Hence, E_tp_{t+1} is not as affected. This parallels the result of reducing the relative variance of money shocks in earlier models. There, the reduction in the variance of money relative to real shocks increases the extent to which shocks are interpreted as real, and so reduces the effect of a money shock on E_tp_{t+1}.

In the third panel of Table 8, the variance of temporary base money supply shocks is also increased relative to permanent base money supply shocks. This further increases the real effects of portfolio and base money shocks and lowers the real effects of real and banking sector shocks (ε, ξ and u). The rise in σ^2_v increases the extent to which base money shocks are interpreted as temporary shocks and therefore increases the real effect of such shocks.

Finally, the bottom panel of Table 8 also doubles the two noise variances relative to σ^2_x. Thus, the bottom panel of Table 8 can equivalently be interpreted as a halving of the variance of x shocks relative to all other variances in the model. Comparing the bottom panel of Table 8 with Table 6, we see that a reduction in the variance of permanent base money supply shocks relative to all other variances increases the real effects of w, v and x shocks, and reduces the real effects of ε, ξ and u shocks. Movements in endogenous variables (and the *measured* base and money multipliers) will be interpreted less as reflecting x shocks, and therefore actual x shocks will have larger real effects. Comparing the final panel of Table 5 with the third panel of Table 7, we see that raising the noise variances holding all other variances constant increases the real effects of x and v shocks but *reduces* the real effects of w shocks. This result appears to hold more generally.[12] An explanation may be that as the variances of the noise terms rise we have two effects operating. First, as the noise terms come to dominate both the base and multiplier measures, and the endogenous price and nominal interest rate variables, the coefficients of all shocks in E_tp_{t+1} would tend to fall toward zero. Second, the noise terms have coefficients equal to or close to unity in the base and multiplier measures, but much smaller coefficients in the endogenous price and interest rate variables. Hence, as the noise variances increase, the weight of the endogenous variables in E_tx_t will tend to rise, increasing the degree of confusion between w and x+v shocks. These two effects might explain the non-monotonic behavior of the coefficient of w_t in E_tp_{t+1} as the relative variances of the noise terms are increased.

In any analysis of this type, there always exists the danger that the results may be highly sensitive to the particular parameter values chosen. We have repeated the experiments reported in Tables 6-8 for a wide range of values for the elasticities α and β since these are the ones for which existing empirical work provides the least guidance. The general conclusions we have reported were found to be quite robust.

V. Conclusions and Extension

The conclusions of this paper can perhaps be best summarized by reviewing the range of recent empirical findings in macroeconomics which are consistent with our model. First, because temporary base money innovations have real effects even when perfectly observed, our model is consistent with the empirical results reported by Barro and Hercowitz [1980] and Boschen and Grossman [1982] who found that perceived, but unpredicted, monetary innovations were non-neutral. When information is incomplete and private agents are unable to determine whether a base money innovation is permanent or temporary, even permanent innovations will have real effects.

Second, monetary signals affect real and nominal rates of interest. This is consistent with the empirical results reported by Roley and Walsh [1985] and Hardouvelis [1985], among others, who have shown that weekly announcements of the money supply affect interest rates. Siegel [1985] has shown that money announcements may affect interest rates by providing information about the real economy even if money is neutral. In our model, announcements provide information about non-neutral financial and base money shocks as well.

Third, changes in the variance of either temporary or permanent base money innovations relative to the variance of real shocks alters money-output correlations. This is consistent with other equilibrium business cycle models which stress the role of incomplete information, and with the empirical work of Lucas [1973], Alberro [1981], and Kormendi and Maquire [1984]. In addition, our model predicts that money-output correlations will be altered if the variance of base money innovations changes relative to the variance of portfolio and banking sector disturbances.

Fourth, the work of Rush [1985] and Hardouvelis [1985] shows that innovations in the base and innovations in the money multiplier have different correlations with interest rates. This also is an implication of our model.

Finally, by explicitly incorporating a role for portfolio disturbances, our model provides a stochastic framework for evaluating the role of such shocks in producing business cycle fluctuations. Shifts between bank deposits and currency have been emphasized in many discussions of the Great Depression (Friedman and Schwartz [1963]).

The model we have studied treats the monetary base as an exogenous process. Previous work by King and Trehan [1984] has emphasized that it is inappropriate to use a monetary aggregate that is at least partially endogenous when testing for monetary neutrality. However, the present model shows that innovations in an exogenous monetary aggregate can also be correlated with output even if permanent changes in the level of the aggregate are neutral.

The empirical evidence presented in Section I showed that innovations in the base are correlated with innovations in real income and that lagged M2 helps predict future real income. There are a number of reasons, however, why these, and other summary statistics reported in Section I cannot directly be compared with the implications of our model. First, the monetary base has not been an exogenous variables in the U.S. Except for a period from late 1979 to late 1981, the Federal Reserve has tended to focus on interest rates, letting the monetary base endogenously respond to economic disturbances. A more complete model would need to provide a description of policy behavior. Second, even when the base is exogenous, the correlation between base innovations and income will depend on the relative variances of the permanent and transitory components of base money innovations. Third, our model ignored general money demand disturbances which seem, empirically, to be relatively important. Fourth, we have ignored dynamics in our model in the interests of tractability. Finally, our model suggests that empirical work may need to incorporate more than one interest rate. These points all suggest areas of future research, but the model of this paper represents a useful starting point for understanding the effects of financial sector disturbances in an economy with both inside and outside money.

There are many other dimensions along which the model analyzed here could be extended. For instance, we have assumed that only base money innovations contain a permanent component. Other sorts of permanent shocks could easily be incorporated. For simplicity, we assumed that the permanent and temporary innovations to base money could be distinguished after one period. If individuals only observe past values of the base and not its decomposition into permanent and temporary components, then a source of persistence to monetary disturbances would be introduced. Base money shocks will have real effects for several periods as private agents try to infer whether the shocks are permanent or temporary.

Temporary base money shocks have real effects because the financial sector in our model plays a real role in channeling loans to firms. Financial disturbances which affect the size of the banking industry can produce changes in real loan supply which require real interest rates to adjust in order to maintain equilibrium. This result remains true even in the limit as financial intermediation becomes costless.

More generally, the results obtained here will be robust to a wide range of variations in the model structure because the results depend ultimately on a property of the model which is likely to characterize any rational expectations, multi-asset model that recognizes a role for both inside and outside money. That property is the dependence of equilibrium in the markets for output and physical capital on *ex ante* real rates of return while financial market equilibrium depends on nominal interest rates. A change in expected inflation will leave real rates unaffected only if all nominal interest rates move by the same amount. Such parallel movements in nominal rates, however, will be consistent with financial market equilibrium only in very special cases.

Appendix

<u>Solution to Equation (3.8) in the Text:</u>

Write equation (3.8) as

$$H s_t = J z_t$$

where

$$s_t' \equiv [P_t \; i_t \; r_t]$$

and

$$z_t' \equiv [\varepsilon_t \;\; \xi_t \;\; w_t \;\; u_t \;\; v_t]$$

First observe that

$$\det H = -\tau(1-\rho)[\alpha(1+\phi)+\gamma(1+\alpha)+\beta\phi]-\beta[\tau+\alpha+\gamma+\alpha\phi+\alpha\gamma+\alpha\tau\rho]<0$$

for $\phi > 0$ as we have assumed. Then inverting H we can solve (3.8):

$$s_t \equiv \frac{1}{\det H}\begin{bmatrix} \tau(1-\rho)(\alpha-\phi) & \tau(1-\rho)(\phi+\gamma)+\beta(\phi+\tau+\gamma) & -\delta[\gamma-k\psi+\alpha(1+k)][\tau(1-\rho)+\beta]-\beta\tau\delta(1-\rho) & \beta(\alpha-\phi) & -\tau(1-\rho)(\alpha+\gamma)-\beta(\tau+\gamma+\alpha) \\ -[\tau+\gamma+\alpha(1+\tau+\gamma+\phi)] & \tau-\beta(\phi+\tau+\gamma) & \tau[\alpha\delta(1+k)+k+\beta\delta(1-\rho)]+\beta\delta[\gamma-k\psi+\alpha(1+k)] & \gamma+\beta\phi+\alpha(1+\gamma+\phi-\beta) & \alpha\tau+\beta(\tau+\gamma+\alpha) \\ -\tau(1-\rho)(1+\alpha) & \tau(1-\rho)(1-\beta)+\beta & \tau(1-\rho)[k+\beta\delta(1-\rho)+\alpha\delta(1+k)]+\beta\delta\alpha(1+k)+\beta k & -\beta(1+\alpha) & \alpha\beta+\tau(1-\rho)(\alpha+\beta) \end{bmatrix} z_t$$

The solution for the effect of shocks on real output y_t is

$$y_t \equiv \frac{1}{\det H}\begin{bmatrix} -\alpha\tau(1-\rho)(1+\phi) & -\tau(1-\rho)(\gamma+\beta\phi)-\beta(\tau+\gamma) & \alpha(k+k\delta\psi-\delta\gamma)[\beta+\tau(1-\rho)]-\tau\alpha\beta\delta\rho(1-\rho) & -\alpha\beta(1+\phi) & -\alpha\beta(\gamma+\tau\rho)-\alpha\tau(1-\rho)\gamma \end{bmatrix}$$

Footnotes

1. We assume the short-run supply of deposits is determined by profit maximization, holding fixed the capital invested in the banking sector. In the long-run equilibrium, the number of banks would be determined by a requirement that entry occurs until capital invested in the banking sector earns the competitive rate of return given the risks (see, for example, Walsh [1983]). Since we analyze small deviations around the long-run equilibrium, any changes in bank profits are of second order.

2. It might be thought that ψ and γ should be related to each other via a wealth constraint. If total wealth is independent of r, the requirement that the sum of all assets equal total wealth would place adding up restrictions on the elasticities of demand for each asset. In our model, however, both consumption and labor supply will respond to variations in r so that the relevant adding up constraints will apply to a more complicated intertemporal budget constraint and not just the asset demands (2.6) and (2.7). The main issue from our present point of view is that γ and ψ are not related to each other in a simple way.

3. A reader uncomfortable with the assumption that there is a known deterministic trend in addition to a permanent stochastic component to deviations about trend can instead interpret the quantities denoted by lower case letters as proportional deviations about some initial levels. It would be possible to allow permanent and transitory components to other shocks. We focus on permanent money supply shocks to show how the model can yield neutral and non-neutral responses to money shocks under full information.

4. See Tobin and Brainard [1963] who discuss the effects a change in the sign of ϕ has on the comparative statics of a fixed-price financial sector model.

5. See Romer [1985].

6. By Walras' Law, equilibrium in the loan, deposits and currency markets will also imply equilibrium in the goods market. In effect, this requires that total household wealth minus the value of currency plus reserves equal the value of the capital stock held by firms, or in flow terms that savings equal investment. For an earlier example of a model which uses the asset market equilibrium conditions (in a model with capital and outside money only) see Lucas [1975].

7. Equation (4.1) is consistent with the empirical results of Mankiw, Runkle, and Shapiro [1984], who show that preliminary money stock numbers are noisy signals, as opposed to rational forecasts of the money stock.

8. The body of empirical work initiated by Barro [1977] does not distinguish between temporary and permanent innovations in the money supply. If agents only observe $x_t + v_t, x_{t-1} + v_{t-1}, \ldots$, lagged monetary innovations will have real effects. In addition to distinguishing between permanent and temporary base innovations, the results of the previous section imply innovations to the base multiplier (due to w or u) have different effects than innovations to the base. Rush [1985] finds that during the Gold Standard period, only multiplier innovations were associated with output.

9. The rise is about 1.2 percent for a 5 percent base money shock and 0.96 percent for a 5 percent portfolio shock.

10. Deposit rates fall about 0.8 percentage points for either a 5 percent base money or portfolio shock, while loan rates fall about 1.1 percentage points for a 5 percent base money shock and 1.0 percentage points for a 5 percent portfolio shock.

11. It is worth mentioning that money multiplier innovations (n_2) have a negative effect on nominal interest rates since innovations in the multiplier signal seem to be interpreted mainly as an opposite movement in the base. In part, this is due to the absence of a common money demand shock, as can be seen from (2.6) and (2.7): conditional on p, y, and r, the demand for "money" (kc + d) is deterministic. Introducing a common asset demand shock in (2.6) and (2.7) is likely to produce a positive effect of n_2 on interest rates.

12. It is true for other variations in σ^2_{NB} and σ^2_{NM} which we have examined.

References

Alberro, José, "The Lucas Hypothesis on the Phillips Curve: Further International Evidence," *Journal of Monetary Economics* 7 (March 1981): 239-250.

Barro, R.J., "Rational Expectations and the Role of Monetary Policy," *Journal of Monetary Economics*, 2 (January 1976), 1-32.

Barro, R.J., "The Equilibrium Approach to Business Cycles," in R.J. Barro, ed., *Money, Expectations, and Business Cycles*, Academic Press, 1981.

Barro, R.J., "Unanticipated Money Growth and Unemployment in the United States", *American Economic Review*, 67 (March 1977), 101-115.

Barro, R.J. and Z. Hercowitz, "Money Stock Revisions and Unanticipated Money Growth," *Journal of Monetary Economics*, 6 (1980), 257-267.

Black, F., "Banking and Interest Rates in a World Without Money," *Journal of Bank Research*, 1 (Autumn 1970), 8-20.

Boschen, J.F. and H.J. Grossman, "Tests of Equilibrium Macroeconomics Using Contemporaneous Monetary Data," *Journal of Monetary Economics*, 10 (1982), 309-333.

Brunner, K.A. Cukierman and A.H. Meltzer, "Stagflation, Persistent Unemployment, and the Permanence of Economic Shocks," *Journal of Monetary Economics*, 6 (1980), 467-492.

Bryant, J.B. and N. Wallace, "Price Discrimination Analysis of Monetary Policy," *Review of Economic Studies*, 51 (April 1984).

Fama, E., "Banking in the Theory of Finance," *Journal of Monetary Economics*, 6 (November 1980), 39-57.

Fischer, S., "A Framework for Monetary and Banking Analysis," *Economic Journal - Conference Papers* (1983), 1-16.

Friedman, M. and A. Schwartz, *A Monetary History of the United States, 1857-1960*, Princeton University Press, 1963.

Goldfeld, S.M., "The Demand for Money Revisited," *Brookings Papers on Economic Activity*, 1973:3, 577-638.

Gurley, J.G. and E.S. Shaw, *Money in a Theory of Finance*, The Brookings Institution, 1960.

Hardouvelis, G., "Reserve Announcements and Interest Rates: Does Monetary Policy Matter?" mimeo, 1985.

Hartley, P.R., "The Liquidity Services of Money," unpublished working paper, Princeton University, 1985.

King, R.G., "Monetary Information and Monetary Neutrality," *Journal of Monetary Economics*, 3 (1981), 145-206.

King, R.G., and C.I. Plosser, "Money, Credit and Prices in a Real Business Cycle," *American Economic Review*, 24 (1984), 363-380.

King, R.G. and B. Trehan, "Money: Endogeneity and Neutrality," *Journal of Monetary Economics*, 14 No. 3 (November 1984), 385-393.

Kormendi, P.C. and P.G. Maguire, "Cross-Regime Evidence of Macroeconomic Rationality," *Journal of Political Economy*, 92 No. 5 (October 1984), 875-908.

Lucas, R.E., Jr., "Expectations and the Neutrality of Money," *Journal of Economic Theory*, 4 (April 1972), 103-124.

Lucas, R.E., Jr., "An Equilibrium Model of the Business Cycle," *Journal of Political Economy*, 83 (December 1975), 1113-1144.

Lucas, R.E., Jr., "Some International Evidence on Output-Inflation Tradeoffs," *American Economic Review*, 63 (June 1973), 326-334.

Mankiw, N.G., D.E. Runkle, and M.D. Shapiro, "Are Preliminary Announcements of the Money Stock Rational Forecasts?" *Journal of Monetary Economics*, 14 No. 1 (July 1984), 15-27.

Patinkin, D., "Financial Intermediaries and the Logical Structure of Monetary Theory", *American Economic Review*, 51 No. 1 (March 1961), 95-116.

Patinkin, D., *Money, Interest, and Prices: An Integration of Monetary and Value Theory*, 2nd ed. Harper and Row, 1965.

Roley, V.V. and C.E. Walsh, "Unanticipated Money and Interest Rates," *American Economic Review*, 74 No. 2 (May 1984), 49-54.

Roley, V.V. and C.E. Walsh, "Monetary Policy Regimes, Expected Inflation, and the Response of Interest Rates to Money Announcements," *Quarterly Journal of Economics*, 100, Supplement 1985, 1011-1039.

Romer, D., "Financial Intermediation, Reserve Requirements, and Inside Money: A General Equilibrium Analysis," *Journal of Monetary Economics*, 16 No. 2 (September 1985), 175-194.

Rush, M., "Unexpected Monetary Disturbances During the Gold Standard," *Journal of Monetary Economics*, 15 No. 3 (May 1985), 309-321.

Siegel, J., "Money Supply Announcements and Interest Rates: Does Monetary Policy Matter?" *Journal of Monetary Economics, 15*, (March 1985).

Tobin, J. and W.C. Brainard, "Financial Intermediaries and the Effectiveness of Monetary Controls," *American Economic Review*, 53 No. 2 (May 1963), 383-400.

Waldo, D.G., "Rational Expectations and the Role of Countercyclical Monetary Policy," *Journal of Monetary Economics*, 10 (1982), 101-109.

Wallace, N., "A Legal Restrictions Theory of the Demand for 'Money' and the Role of Monetary Policy," Federal Reserve Bank of Minneapolis, *Quarterly Review*, Winter 1983, 1-7.

Walsh, C.E., "Taxation of Interest Income, Deregulation and the Banking Industry," *Journal of Finance*, 28 No. 5 (December 1983), 1529-1542.