Monetary Aggregates and Output

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We ask whether the following observations may result from endogenously determined fluctuations in the money multiplier rather than a causal influence of money on output: (i) $M1$ is positively correlated with real output; (ii) the money multiplier and deposit-to-currency ratio are positively correlated with output; (iii) the price level is negatively correlated with output; (iv) the correlation of $M1$ with contemporaneous prices is substantially weaker than the correlation of $M1$ with real output; (v) correlations among real variables are essentially unchanged under different monetary-policy regimes; and (vi) real money balances are smoother than money-demand equations would predict. (*JEL* E300, E510)

In this paper we ask whether the endogenous nature of monetary aggregates may account in a quantitatively plausible way for the observed procyclical movement of the nominal money stock, reported most influentially by Milton Friedman and Anna J. Schwartz (1963). To this end we adapt the endogenous money-multiplier model of Freeman and Gregory W. Huffman (1991) into an otherwise standard model of a business cycle set off by real disturbances. In deliberate contrast to monetary models that create a money-output link using sticky prices or fixed money holdings, all prices and quantities are assumed to be fully flexible. Following the business-cycle analysis of Kydland and Edward C. Prescott (1982), the model will be calibrated to meet long-run features of the U.S. economy (but now including also monetary features) and then subjected to shocks to the technology level following a random process like that observed in U.S. data. The model's predicted business-cycle frequency correlations, of both real and nominal variables, are then compared to those of the U.S. data. We find that the model's predicted business-cycle frequency correlations share the following features with U.S. data: (i) $M1$ is positively correlated with real output; (ii) the money multiplier and deposit-to-currency ratio are positively correlated with real output; (iii) the price level is negatively correlated with output [in spite of (i) and (ii)]; (iv) the correlation of $M1$ with contemporaneous prices is substantially weaker than the correlation of $M1$ with real output; (v) correlations among real variables are essentially unchanged under different monetary-policy regimes; and (vi) real money balances are smoother than money-demand equations would predict.

Of earlier efforts Wilbur John Coleman II (1996) takes an approach closest to ours.[1] He employs a model featuring an endogenous money multiplier in which he postulates separate transactions costs for consumption and investment purchases. To examine a variety of lead-lag relationships, the model includes 28 parameters of which 12 are calibrated and 16, including 9 of the 12 transaction-cost parameters, are estimated for the period 1959Q1–1994Q2 using simulated moments estimation.

In this paper, we take an approach that is more parsimonious and thus, we hope, more transparent and more generally adaptable. We assume that consumption goods can be

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[1] Notable prior efforts to introduce money into an equilibrium business-cycle model include Robert G. King and Charles I. Plosser (1984; endogenous supply costs of "producing" inside money), Thomas F. Cooley and Gary D. Hansen (1989; seigniorage), Ayşe İmrohoroğlu (1989; money as insurance), and V. V. Chari et al. (1995; liquidity effects with an endogenous money multiplier). A useful survey is to be found in Cooley and Hansen (1995).

purchased using either currency or bank deposits. Only the minimal number (two) of transaction costs are assumed. One is a William J. Baumol (1952)-James Tobin (1956) cost of acquiring money balances, necessary to determine the demand for money and make endogenous the velocity of money. The other is a fixed cost of using deposits, necessary to determine the division of money balances into currency and interest-bearing deposits. Faced with these two costs and other factors that may vary over the business cycle, households make decisions that determine the velocity of money and the money multiplier. These decisions can be tractably introduced into a variety of business-cycle models addressing issues in addition to those in this first illustration of the model's usefulness.

I. The Theoretical Framework

A. *The Environment*

Each of a large number of infinitely lived identical households is endowed with a stock of capital in the initial period (period 0) and one unit of time in each period $t \geq 0$. Time can be used for leisure, labor, or the conducting of transactions.

There is a continuum of good types indexed by j with $0 \leq j \leq 1$. The utility of the representative household is the following function of its consumption of goods of each type $[c_t(j)]$ and of leisure (d_t) in each period $t \geq 0$:

$$(1) \qquad E \sum_{t=0}^{\infty} \beta^t u\left[\min\left(\frac{c_t(j)}{2j}\right), d_t\right].$$

The function $u(.,.)$ is assumed to satisfy the Inada conditions and to be increasing in each argument, quasi-concave, and twice continuously differentiable.

A single production process produces capital and consumption goods of every type j. Output at t is a constant-returns-to-scale function of the two inputs to production at t—capital (k_t) and labor (l_t): $z_t f(k_t, l_t)$, where z_t denotes the technology level. In every period fraction δ of the existing capital stock depreciates after production $(0 < \delta < 1)$, i.e., $k_t = i_{t-1} + (1 - \delta)k_{t-1}$, where i_{t-1} equals the sum of capital created in period $t - 1$. The technology level evolves according to $z_t = \rho z_{t-1} + \varepsilon_t$, where the ε's are normally distributed with positive mean, and with standard deviation σ.

In addition to capital, two other assets are available to households: fiat money and bank deposits. Fiat money, uniquely issued by the government, is unbacked, intrinsically useless, and costless to exchange. The stock of fiat money (in units called dollars) at the end of any period t is M_t, with $M_t = \xi_t M_{t-1}$. Changes in the stock of fiat money are financed by lump-sum subsidies of x_t units of fiat money to each household. The government budget constraint is

$$(2) \qquad x_t = (\xi_t - 1)M_{t-1}.$$

Bank deposits are loans to competitive financial intermediaries that use the proceeds to invest in capital and reserves of fiat money. The government requires that financial intermediaries hold reserves of at least θ dollars worth of fiat money for each dollar held in deposits. The use of deposits to make a purchase incurs a fixed cost of γ goods for each type of good purchased using deposits.[2] (This might be thought of as a check-clearing cost or a cost of verifying the identity of the person writing a check or making a withdrawal.) Deposits made in period t pay competitively determined interest in period $t + 1$.

The consumption of each household must be purchased with money balances chosen at the beginning of the period. Any combination of deposits and fiat money may be chosen to satisfy this requirement, but the ratio of deposits to currency chosen at the beginning of the period must be maintained throughout the period. We make a simplifying assumption of symmetric purchases: the household must purchase the same combination of goods after each trip to the bank within a single period. If these money balances are replenished n_t times in period t, then n_t dollars worth of consumption goods can be purchased for each dollar of balances held. The replenishment of money

[2] The assumption of a fixed cost of deposits is taken from Prescott (1987). In a growing economy the assumption that the cost is fixed in goods implies a gradual shift from currency to deposits.

balances (a trip to the asset market) uses ϕ units of time so that the total time spent on transactions equals ϕn_t. A household begins each period with the money balances it chose in the previous period. Essentially this transactions technology is that introduced by Baumol (1952) and Tobin (1956) but with a transaction cost payable in time as proposed by Edi Karni (1973) and money balances that are a mix of deposits and currency.

B. *Equilibrium*

Let us examine household choices in several steps, starting with the choices of the composition of consumption and money balances. For a given desired level of total period t consumption c_t^*, the Leontief-type instantaneous utility function, $u[\min(c_t(j)/2j),\ d_t]$, induces agents to distribute consumption over the various goods types according to the optimizing rule

$$c_t(j) = 2jc_t^*. \tag{3}$$

Integrating (3) from $j = 0$ to 1 will verify that total consumption equals c_t^*. Substitution of this optimal rule (3) into the household's utility function (1) yields the standard representative–agent objective function $\sum_{t=0}^{\infty} \beta^t u(c_t^*, d_t)$.

Consider next the household's choice of the composition of money balances for a given c_t^*. For each type of good purchased, a household must decide whether deposits or fiat money offer the more attractive rate of return, net of transaction costs. Deposits, however, have a fixed cost of use so that, defining $\tilde{r}_{t+1}$ as the real gross rate of return paid by banks in period $t + 1$ on deposits made in period t and r_{t+1} as the real gross rate of return on nonintermediated assets acquired at t, the real rate of return net of transaction costs on funds to be used for n_t purchases of size $c_t(j)$ is

$$\tilde{r}_{t+1} - \frac{\gamma r_{t+1} n_t}{c_t(j)}, \tag{4}$$

an increasing function of the size of the purchase (an increasing function of j). Because of the fixed cost of using deposits, the deposit rate of return net of transaction costs goes to negative infinity as j goes to zero; i.e., deposits become less desirable as the purchase size decreases. In contrast, the nominal gross rate of return of fiat money is always unity no matter how many units are purchased because it incurs no fixed cost per transaction. This implies that there exists some j^* below which currency is preferred to deposits. In the case of perfect foresight (or certainty equivalence), this j^* is given by the value of j at which currency and deposits offer the same rate of return:

$$\tilde{r}_{t+1} - \frac{\gamma r_{t+1} n_t}{2jc_t^*} = \frac{p_t}{p_{t+1}}. \tag{5}$$

We concentrate on the case in which both currency and deposits are used as money ($j^* < 1$).

Recall that money balances are replenished n_t times each period. Then, denoting nominal household deposits by h_t and nominal fiat-money balances by m_t, we can use j^* to express the demand for each type of money as the values of h_t and m_t satisfying

$$n_t \frac{h_t}{p_t} = \int_{j^*}^{1} c_t(j)\, dj = \int_{j^*}^{1} 2jc_t^*\, dj \tag{6}$$

$$= (1 - j^{*2})c_t^*,$$

$$n_t \frac{m_t}{p_t} = \int_{0}^{j^*} c_t(j)\, dj \tag{7}$$

$$= \int_{0}^{j^*} 2jc_t^*\, dj = j^{*2}c_t^*.$$

Let us now turn to the constraints on the household's decision. The time constraint is

$$1 = l_t + d_t + n_t\phi, \tag{8}$$

which divides the available time into labor (l_t), leisure (d_t), and the number of trips to the bank (n_t). Let us define w_t as the (real) wage paid to a unit of labor, and a_t as the level of nonmonetary assets acquired by the end of period t. We can now write the agent's goods budget constraint:

$$(9)\quad w_t l_t + r_t a_{t-1} + \frac{\tilde{r}_t h_{t-1}}{p_{t-1}} + \frac{m_{t-1} + x_t}{p_t} = c_t^* + a_t + \frac{h_t}{p_t} + \frac{m_t}{p_t} + \gamma(1 - j_t^*).$$

The (nonmonetary) decisions of labor supply, consumption, and capital are identical to those in the standard real-business-cycle model. In equilibrium the marginal intertemporal rate of substitution equals the marginal product of capital, and the marginal rate of substitution between leisure and consumption equals the marginal product of labor. Also, in an equilibrium in which all assets are held, the assets with the lowest transaction costs must have the lowest equilibrium returns; i.e., $r_{t+1} > \tilde{r}_{t+1} > p_t/p_{t+1}$.

The bank's problem is easy to describe. Banks accept deposits, investing them in a portfolio of capital and fiat-money reserves. In equilibrium, capital's rate of return exceeds that of fiat money $[r_{t+1} > p_t/p_{t+1}]$, ensuring that banks will not hold more than the legal minimum requirement of reserves (θ for each dollar of deposits). Free entry among zero-cost, zero-net-worth banks requires that depositors are offered the rate of return received by the banks' assets:

$$(10)\qquad \tilde{r}_{t+1} = (1 - \theta) r_{t+1} + \theta \frac{p_t}{p_{t+1}},$$

where the effective gross real rate of return on capital, r_t, equals $\pi_t + (1 - \delta)$.

The clearing of the asset market for capital requires that the capital stock per household must equal the sum of capital held directly by each household and capital held by banks on behalf of each household:

$$(11)\qquad k_{t+1} = a_t + (1 - \theta) \frac{h_t}{p_t}.$$

The clearing of the market for fiat money requires that the stock of fiat money equal the combined stocks of currency and reserves:

$$(12)\qquad M_t = m_t + \theta h_t.$$

The total money stock, the sum of nominal deposits and currency, is $M1_t$, which, using (12), can also be written as the product of the monetary base and the money multiplier:

$$(13)\quad M1_t = m_t + h_t = M_t \left[1 + \frac{h_t(1 - \theta)}{m_t + \theta h_t} \right].$$

The money multiplier is closely related to the deposit-to-currency ratio, h_t/m_t, but with an adjustment for that part of the base that serves as reserves.

A positive technology shock affects the composition of money balances. The resulting increase in desired consumption increases the size of all purchases. Because the deposits are preferred for larger purchases, households increase the ratio of deposits to currency.[3] This increases the money multiplier and thus $M1$. To the extent that it reduces the demand for currency, this switch in the composition of money balances also increases the price level, other things equal.

II. Quantitative Analysis

A. *Model Calibration*

The parameters of preferences and productive technology are calibrated to satisfy certain steady-state relations. In the steady state, investment is one-quarter of output, so that, with a depreciation rate of 0.025, the ratio of capital to annual output is 2.5. The production function is assumed to have a Cobb-Douglas form $z_t k_t^{\alpha} l_t^{1-\alpha}$. The parameter α is calibrated so that the labor share of national income is 0.64. The autocorrelation coefficient ρ in the technology-level process is set equal to 0.95 with a standard deviation σ of its innovations of 0.0076. The utility function is assumed to have the form $(1/(1 - \nu))[(c_t^*)^{\zeta}(d_t)^{1-\zeta}]^{1-\nu}$, with $0 < \zeta < 1$, $\nu > 0$. Setting the average allocation of households' time (net of sleep and personal care) to market activity equal to 0.30 restricts the value of the utility function's share param-

[3] One might loosely think of these large purchases as purchases of durable goods, which are generally large and thus purchased using deposits.

TABLE 1—CONTEMPORANEOUS CORRELATIONS WITH OUTPUT FOR TWO SERIALLY UNCORRELATED MONETARY POLICIES

	$M1$	P	$M1/M0$	$M1/P$	$PY/M1$	R_{nom}	C	I	L
Policy A	1	−0.49	1	0.98	0.52	−0.18	0.96	0.99	0.99
Policy B	0.87	−0.13	1	0.98	0.52	−0.18	0.95	0.99	0.99

eter, ζ, to be 0.33. We choose $\nu = 2$. The reserve-requirement ratio, θ, is set equal to 0.10.

We make no attempt here to obtain independent values of the key parameters γ and ϕ. Instead, we calibrate them to steady-state values of the deposit-to-currency ratio and the share of capital that is intermediated. In determining the deposit-to-currency ratio, we exclude a rough estimate of the currency held abroad or associated with unlawful activities. Estimates of the former currently range from two-thirds to three-quarters. An indication is that high-denomination currency (100- and 50-dollar bills) by 1995 had risen to over 70 percent of the outstanding currency. If we divide the deposits portion of $M1$ by one-third of currency, the resulting figures range from about 12, early in our sample, to about 7, late in the sample. The figure one-third used in that calculation surely is too low for the early period but probably too high for recent years. As a compromise, we selected a deposit-to-currency ratio of 9 for our computational experiments. Dividing the nonreserve portion of $M1$ by the capital stock (about 2.5 times annual GDP) yields values ranging from about 4 to 6 percent. We chose 0.05 as our steady-state value. The resulting parameter values are $\gamma = 0.0060$ and $\varphi = 0.00076$. In our computational experiments, the average aggregate resource use associated with the fixed cost γ works out to be 0.41 percent of the model's GDP. The time per replenishment implied by the value of ϕ is approximately one hour. (Note that ϕ represents not the cost of going to the ATM but the cost of replenishing all deposit and cash balances from nonmonetary assets.)

B. *Quantitative Findings*

We start by examining the model's behavior under two simple monetary policies, each with an average annual inflation rate of 3 percent. Under the first, Policy A, the growth rate of fiat money is fixed at 3 percent in every period. Under the second, Policy B, serially uncorrelated shocks have been added to the supply of fiat money, with a standard deviation of 0.5 percent.

The model's time series and the actual data are detrended using the Hodrick-Prescott filter. The model displays interesting comovements among its variables. Table 1 presents contemporaneous correlations with output.

Notice first that $M1$ is positively correlated with real output. Under Policy A, in which there is no randomness in the growth rate of fiat money, it is obvious that the movement of $M1$ comes from the reaction of the deposit-to-currency ratio to the technology shock. A positive technology shock encourages the use of deposits because it increases both the return to the capital backing deposits and the size of consumption purchases. Because technology shocks are assumed to be the only source of randomness, the correlation is very high. Under Policy B, with randomness in the monetary base, $M1$ and the price level are less tightly correlated with real output, although output's correlations with the money multiplier and real sector variables are essentially unchanged.

A second interesting pattern is the countercyclical behavior of prices. Although a procyclical increase in the money multiplier implies a decrease in the demand for fiat money which, other things equal, implies a higher price level, the increase in desired consumption from a positive technology shock increases the demand for both forms of money, decreasing the price level. In these computational experiments, as in the actual data [see Cooley and Lee E. Ohanian (1991) and William T. Gavin and Kydland (1999)], this second effect dominates.

In Table 2 we present correlations between $M1$ and other endogenous variables for Policy B, with serially uncorrelated randomness in the growth rate of the monetary base.

Several patterns observed here are consistent with a business cycle driven by monetary fluctuations. Nominal money balances are positively correlated with contemporaneous

TABLE 2—CONTEMPORANEOUS CORRELATIONS WITH $M1$ FOR A RANDOM BUT SERIALLY UNCORRELATED MONETARY POLICY

	GDP	P	C	I	$M1/M0$	R_{nom}
Policy B	0.87	0.34	0.87	0.85	0.87	−0.20

consumption and investment as well as labor and future capital. Notice too that the correlation of $M1$ with contemporaneous prices (0.34) is substantially weaker than the correlation of $M1$ with real output (0.87). Looking at these correlations without knowing the underlying economic structure, one might be tempted to imagine that they come from an economy in which monetary shocks are not offset by price-level changes but have a causal effect on output. These correlations, however, are found in a model driven by technology shocks featuring complete flexibility in prices and money balances.

Consider now the more realistic assumption that shocks to the growth rate of the monetary base are serially correlated. Consider in particular a first-order autoregressive process with an autoregression parameter of 0.7 and a standard deviation of 0.2, which we will call Policy C. In this case, positive innovations to the current rate of growth of the monetary base signal an increased probability of high growth in next period's monetary base. As a result, agents will anticipate a high rate of inflation, inducing them to switch some of their money balances from currency to capital-backed deposits, stimulating output.[4] This stimulus is negligible, however. The standard deviation of output is the same (1.33) under both policies. Comparing Policies B and C in Table 3 we do not find much of a difference in the correlations with output of real variables, despite some differences in the correlations of nominal variables.

Figures 1 and 2 provide some additional insight on how the model works. Figure 1 displays the responses of the key variables to a 1-percent positive shock to the technology level in period one, shown in the graphs as percentage deviations from the steady state (the nominal interest rate as percentage-point deviations), while Figure 2 contains the corresponding responses to a 1-percent shock to the process for the monetary base under Policy C. In the former case, we see the procyclical movement of $M1$, associated with the resulting change in the money multiplier, and the countercyclical price level. In the latter case, there are sizable movements in all the nominal variables, with only the tiniest of movement in output and a slight temporary change in its composition.

The correlations are sensitive to the deposit-to-currency ratio. We present in Table 4 the correlations found under Policy C with three different deposit-to-currency ratios. The lowest of these is the extreme one that would result if all currency were used only in domestic legal transactions. The middle one is our best estimate, the one we used originally (lower-denomination currency). The highest is the deposit-to-currency ratio that would result from a 10-percent reduction in the cost of using deposits. This last may be thought of as arising from an improvement in the computer or communications technologies used by banks or from a general increase in output that makes the costs of using deposits a smaller fraction of output.

In Tables 5 and 6 we compare the model's correlations with output and with $M1$ respectively to those of the United States before and after 1980.[5]

Our simple model generally matches the signs of these correlations of the real data. In particular, we see in Table 5 that output is positively correlated with output and real balances even though prices are countercyclical.

The model also displays a correlation of $M1$ with contemporaneous prices that is substantially weaker than the correlation of $M1$ with

[4] This effect of serially correlated monetary expansions was proposed by Jeffrey M. Lacker (1988) and Freeman and Huffman (1991).

[5] The correlations are calculated from Citibase data. Labor, L, is hours from the establishment survey. The price level, P, is the GNP deflator. Consumption, C, is total consumption and investment; I, is total investment. A case could be made that, to be consistent with our calibration, high-denomination currency should be subtracted from $M1$. As its movements are largely uncorrelated with the U.S. business cycle, however, and our focus is on correlations between money and output, we made no attempt to do so. Our sample starting in 1959:I is based on availability of quarterly monetary aggregates.

TABLE 3—CORRELATIONS WITH OUTPUT, WITH AND WITHOUT SERIAL CORRELATION IN MONETARY-BASE GROWTH

	$M1$	P	$M1/M0$	$M1/P$	$PY/M1$	R_{nom}	C	I	L
Policy B	0.87	−0.13	1	0.98	0.52	−0.18	0.95	0.99	0.99
Policy C	0.81	−0.1	0.92	0.98	0.52	−0.06	0.94	0.99	0.99

real output. The model does not go as far as the actual data, however, which displays in Table 6 a negative correlation between $M1$ and the price level. A negative correlation is a possibility consistent with the mechanics of our theory: positive output shocks can drive $M1$ up (through an increase in the money multiplier) while it drives the price level down (through an increased demand for money). As calibrated, however, our simple model displays a price level that is not sufficiently countercyclical for this outcome (see Table 5).

From Table 5 we see that the correlation of output and the money multiplier is much greater in the model than in the data. An assumption of the model made for tractability is that the same number of purchases are made regardless of the desired level of consumption. When more consumption is desired, a household simply makes larger purchases, increasing the use of deposits and the money multiplier. The response of the money multiplier (and thus the price level) to output fluctuations would therefore be less (more like the data) if agents increased both the size and quantity of purchases when consumption increases.

The model's correlations (and, we believe, its assumptions about monetary structures) are much closer in magnitude to those in the real U.S. economy before 1980 (the period of much of the empirical work on money-output correlations) than to those after 1980. The financial deregulation of the 1980's brought large changes in what could be used as money and a major change in monetary policy. Most relevant to our story about the money multiplier are the large and fluctuating flows of U.S. currency to foreign countries, especially the former Soviet Union, in this period.[6] As Gavin and Kydland (1999) point out, the various monetary changes in the post-1980 era led to dramatic changes in the variance and correlations of $M1$ and other monetary variables (though not to real behavior). Explaining the changes brought by the 1980's is an important project for future work by monetary economists of all persuasions but is beyond the scope of a model with only a single type of intermediated asset, a monetary policy without targeting, and no foreign demand for dollars.

Another area for exploration is the possible endogeneity of the monetary base. It is clear from Table 5 that even in the period before 1980 the correlation of the monetary base and output is stronger in the data than in our experimental economy with its exogenous random monetary base (although in both the pre-1980 data and the model it is weaker than the correlation of $M1$ and output). A policy by the Federal Reserve of changing the monetary base in reaction to economic events (for example, a policy of stabilizing the price level) might account for this correlation. We wish, however, to keep the focus of this present paper squarely on the endogeneity of the money multiplier.

C. *The Excessive Smoothness of Real Money Balances*

A puzzle for monetary theory is the observed persistence of money holdings in the face of fluctuations in income and nominal interest rates. Robert E. Lucas, Jr. (1994) presents the puzzle in the following way. He first shows that unitary income elasticity accounts well for the trend of $M1$ since 1900. Plotting the money-to-income ratio versus a nominal interest rate, he finds that an interest elasticity of −0.5 fits the data better than either −0.3 or −0.7. Using time-series data on nominal output and interest rates, Lucas then calculates predicted $M1$ from the relation $m/p = Ayr^{-1/2}$, where m, p, y, r, and A represent respectively nominal money balances ($M1$), the price level, real output, the nominal interest rate, and a scale parameter. Lucas finds that the actual time series of $M1$ is much smoother than the predicted time series.

[6] See Richard D. Porter and Ruth A. Judson (1996) for evidence concerning the flows of currency to the former Soviet Union. We thank Philip Jefferson for bringing this to our attention.

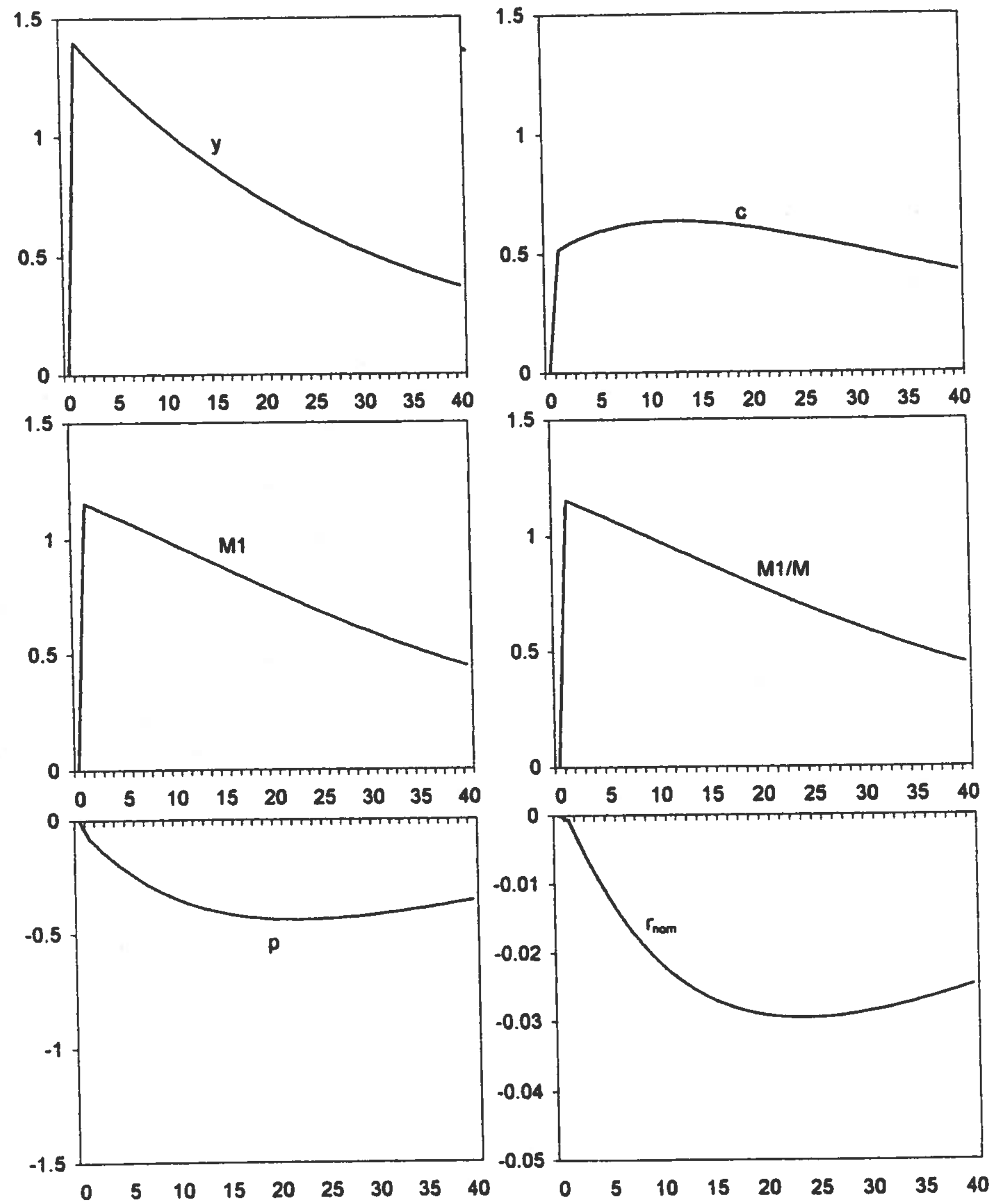

FIGURE 1. RESPONSES TO A 1-PERCENT POSITIVE SHOCK TO THE TECHNOLOGY LEVEL UNDER POLICY C

For our economy under Policy C, the average percentage standard deviation of cyclical real $M1$ is 1.21, while that predicted by the relation used by Lucas is 1.36. The artificial time series generated by our model thus display more smoothness than would be predicted by a conventional money-demand function. This apparent "stickiness" of money demand is observed even though money balances are completely flexible in the model. What looks like stickiness of money demand comes from the endogeneity of $M1$ through the money multiplier. Using the Lucas notation, m/py fails to fluctuate as much as would be predicted from long-run behavior

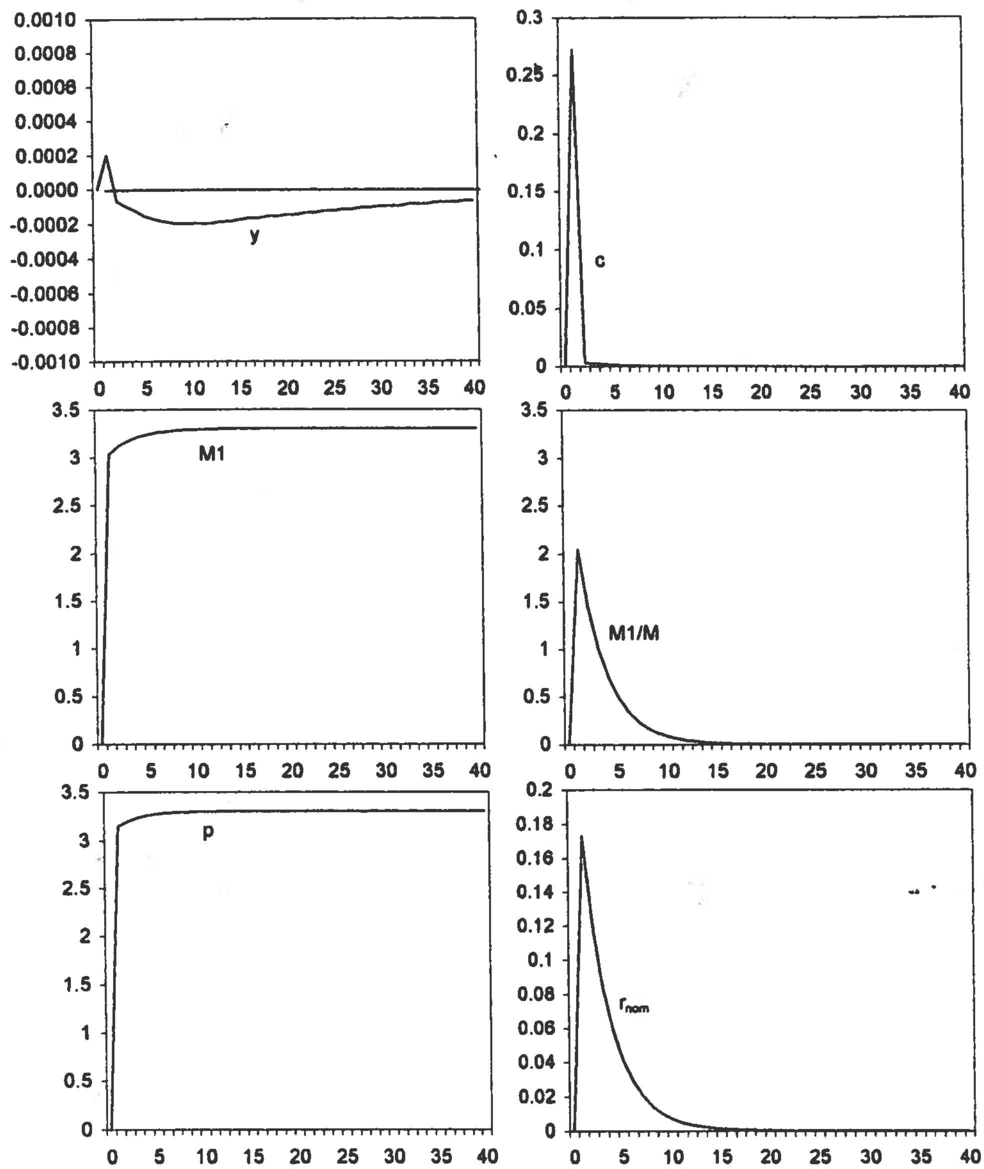

FIGURE 2. RESPONSES TO A 1-PERCENT POSITIVE SHOCK TO THE MONETARY BASE UNDER POLICY C

because endogenous changes in the total money supply (m) offset fluctuations in nominal income (py) at the business-cycle frequency.

III. Conclusion

Motivated by observed correlations between real output and nominal variables like the total money supply, two lines of work have been developed that assume that either nominal prices or nominal money balances are unchangeable for some period.

In this paper we attempt to address the observed correlations of nominal money balances and real output while imposing no rigidity in prices or agent choices. This intentionally

TABLE 4—CORRELATIONS WITH OUTPUT UNDER POLICY C

Deposit/Currency	$M1$	P	$M1/M0$	$M1/P$	$PY/M1$	R_{nom}	C	I	L
3	0.89	0.20	0.94	0.98	−0.81	−0.72	0.93	0.99	0.99
9	0.81	−0.1	0.92	0.98	0.52	−0.06	0.96	0.99	0.99
13.38	0.75	−0.19	0.91	0.97	0.81	0.12	0.96	0.99	0.99

TABLE 5—CORRELATIONS WITH OUTPUT

	$M1$	P	$M1/P$	$PY/M1$	$M0$	$M1/M0$	C	I	R_{nom}
Policy C	0.81	−0.1	0.98	0.52	0.01	0.92	0.94	0.99	−0.05
U.S. 59:1–79:3	0.70	−0.78	0.81	0.45	0.46	0.46	0.89	0.90	0.29
U.S. 79:4–95:4	0.09	−0.56	0.26	0.51	0.34	0.02	0.89	0.89	0.48

TABLE 6—CORRELATIONS WITH $M1$

	C	I	P	$M1/M0$	R_{nom}
Policy C	0.82	0.78	0.47	0.91	0.33
U.S. data 59:1–79:3	0.63	0.66	−0.50	0.67	0.37
U.S. data 79:4–95:4	0.27	0.13	−0.42	0.94	−0.48

simple equilibrium model demonstrates that one may observe correlations between nominal monetary aggregates and real output even in economies in which rigidities are not imposed.

The key feature of the model is the endogeneity of the money supply that results from the households' choices of the composition of their money balances in response to variables that fluctuate over the business cycle. These endogenous monetary responses yield not only the sought-after money-output correlation but also the sticky prices and money balances that other models of money and output impose by assumption.

We do not offer this analysis as a definitive affirmation of complete monetary neutrality. Indeed, in our model economy, shocks to required reserves or serially correlated shocks to the monetary base have an influence on output. Other real effects of monetary policies are certainly conceivable. We offer a rather tractable way in which an endogenous money multiplier can be introduced into models considering a variety of monetary phenomena, policies, or links to the real sector.

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