Short-run Monetary Control

An Analysis of Some Possible Dangers

While the Federal Reserve has been setting annual targets for several years, there continues to be a question of the time horizon the Federal Reserve should use in attempting to control money. Some analysts contend that the Federal Open Market Committee (FOMC) can and should extend control to the very short run. But there could be costs in so doing: the pursuit of monthly monetary targets could transmit an unacceptable degree of instability to the financial markets and to economic activity The purpose of this article is to show under what circumstances such considerations are important and then to review some empirical evidence relevant to these matters.

Currently, the Federal Reserve's monetary targets are set on an annual basis, measured from the fourth quarter of one year to the fourth quarter of the next. During the course of the year, the FOMC also sets shorter run monetary objectives consistent with attaining the annual targets. These shorter run targets usually extend over a period of a few months, for example, December to March

Some analysts argue that tight control over such short periods or even shorter periods is both desirable and feasible Others are concerned that sharp movements in nonborrowed reserves would be required to achieve such precise control. To hit the monetary targets in the very short run it might become necessary to adjust the level of nonborrowed reserves substantially every period to offset the lagged effects of the Federal Reserve's own policy actions in previous periods This is because the total response of the public's money holdings to a change in nonborrowed reserves occurs partly in the same period as the change in nonborrowed reserves and partly in the next and succeeding periods. Consequently, a change in nonborrowed reserves bringing the money stock quickly back to target from, for instance, a level below target may later cause the money stock to rise *above* target, as the lagged effects take hold It would thus be necessary to make further adjustments to the level of nonborrowed reserves to keep the money stock on target in every period.

Roughly speaking, if the lagged effects of past actions are large, the movements in nonborrowed reserves from period to period required to keep the money stock on target in each period could turn out to be sizable initially and diminish only slowly through time. If the lagged effects are particularly large, the required offsetting movements in subsequent periods could increase through time; such a situation is known as "instrument instability".[1] Explosive oscillations in the movement of the policy instrument would be untenable. Furthermore, even substantial although gradually moderating oscillations in nonborrowed reserves might be judged to be undesirable, not because of the required shifts in open market operations *per se*, but because

[1] See Robert S Holbrook, "Optimal Economic Policy and the Problem of Instrument Instability", *American Economic Review* (March 1972), pages 57-65

of the associated effects on financial markets and the general economy.[2]

In the first section of this article, the timing of the public's adjustment of its money holdings to changes in interest rates is shown to be important in selecting a control horizon for the monetary aggregates that will avoid or minimize such problems. This is true even though interest rates are not controlled by the Federal Reserve under the new operating procedures. In the second section, empirical estimates of the demand for money from previous research are examined. The evidence indicates the possibility that monetary control over periods of less than six months could have destabilizing effects. Some readers may wish to pass over the mathematical treatment of the problem in the first section and proceed directly to the review of earlier empirical research and its implications, beginning on page 4.

Simulations of the monetary sector under monetary targeting

In this section, some simple examples are used to illustrate how strict short-run monetary targeting can precipitate cycles in nonborrowed reserves and interest rates. Initially, it is assumed for simplicity that the level of income is given and is invariant to changes in the money stock and interest rates; therefore, only the monetary sector of the economy is relevant Later this assumption will be dropped; changes in the money stock and interest rates will then be allowed to affect aggregate demand, which in turn will have feedback on the demand for money. At that time, the model will be expanded to include an equation representing aggregate demand.

To begin, let the monetary sector consist of the demand and supply of money, which are specified as:

(demand) $M(t) = a - b_0 r(t) - b_1 r(t-1) + cY(t)$

(supply) $M(t) = d + eNBR(t) + f[r(t) - DISC(t)]$

where M = the money stock,
r = the interest rate,
Y = income,
NBR = nonborrowed reserves,
$DISC$ = the discount rate, and
t represents a specific period of time.

That is, the quantity of money demanded is determined by the current period's income and the current and previous period's interest rate, so that the total response to a change in the interest rate occurs partly in the same period and partly in the following period. The quantity of money supplied is determined by the current period's level of nonborrowed reserves and the spread between the interest rate and the Federal Reserve's discount rate Banks are assumed to respond completely in the same period to changes in these factors. Hence, no lagged effects are included in the supply-of-money equation.

If the goal of monetary policy is to keep the money stock on target in every period, the level of nonborrowed reserves—the Federal Reserve's main policy instrument—must be changed every period (at least early on) after a change in income or a shift in the demand for money.[3] Nonborrowed reserves must be changed enough in the first period to offset the effect of the income or money demand disturbance on money holdings. In the second period and all periods thereafter, nonborrowed reserves must be adjusted to offset the lagged effects of earlier changes in nonborrowed reserves.

The relative magnitude of the current and the one-period lagged interest rate effects on money demand determines whether the oscillations of nonborrowed reserves and the interest rate will be explosive or stable if period-by-period control over the money stock is maintained It can be shown that the cycles are explosive—the case of instrument instability—if the lagged effect (b_1) is greater than the current effect (b_0). If the current effect is greater than the lagged effect, the cycles eventually die out. Generally the greater the current effect is relative to the lagged effect, the more rapidly the cycles dampen.[4]

Chart 1 shows the simulated behavior of nonborrowed reserves and the interest rate when a targeted value of the money stock is to be maintained despite a permanent 4 percent reduction of income. Three sets of values for the current and lagged interest rate effects were selected to illustrate explosive, slowly damped, and rapidly damped cycles. The qualitative

[2] Attention was called to these potential problems first by Richard G Davis, "Implementing Open Market Policy with Monetary Aggregate Objectives", *Monetary Aggregates and Monetary Policy* (Federal Reserve Bank of New York, 1974), pages 7-19, and more recently by Bryon Higgins, "Should the Federal Reserve Fine Tune Monetary Growth?", *Economic Review* (Federal Reserve Bank of Kansas City, January 1982), pages 3-16 Also see John H Ciccolo, "Is Short-run Monetary Control Feasible?", *Monetary Aggregates and Monetary Policy* (Federal Reserve Bank of New York, 1974), pages 82-91

[3] Recognizing that the Federal Reserve does not have perfect control over either the Federal funds rate or nonborrowed reserves, some economists refer to one or the other as the operating target rather than the policy instrument The term "policy instrument" then refers to open market operations, the discount rate, and reserve requirements For example, see Gordon H Sellon, Jr , and Ronald L Teigen, "The Choice of Short-run Targets for Monetary Policy Part One", *Economic Review* (Federal Reserve Bank of Kansas City, April 1981), pages 3-16

[4] If the current and lagged effects are exactly equal, constant oscillations occur, however, this special case will not be considered See William J Baumol, *Economic Dynamics* (New York Macmillan, 1970), page 164

character of the cycles would be the same if the income disturbance is transitory, provided the ratio between the current and lagged effects of the interest rate on money demand is kept constant.

In the example shown in Chart 1, the lagged interest rate effects on money are confined to the previous period, but lagged interest rate effects on the demand for money may in the real world extend for several periods. If so, the resulting cycles will be one of two types: (a) cycles repeating themselves every two periods or (b) cycles taking longer than two periods to repeat themselves To distinguish between these two cases, it is customary to refer to (a) as oscillations and to (b) as fluctuations or trigonometric oscillations. Whether they are oscillations or fluctuations, the cycles can be either explosive or damped.[5]

Besides lagged interest rate effects on the quantity of money demanded, there may be lagged income effects. Their presence generally does not change the character of the cycles, although it does affect the particular path For example, suppose a lagged income effect is introduced so that the quantity of money demanded is determined by the current and previous period's level of income, as well as the current and previous period's interest rate. The demand-for-money equation therefore becomes:

$$M(t) = a - b_0r(t) - b_1r(t-1) + c_0Y(t) + c_1Y(t-1).$$

Let the weights of the interest rate effects be the same as those used to produce the slowly damped cycles shown in Chart 1. In the first four columns of Table 1, a comparison is made between the paths that nonborrowed reserves and the interest rate take when the demand for money does and does not have a lagged income effect, the long-run income elasticity is the same, however. In both cases, slowly damped cycles occur; with the lagged income effect present, the amplitude of the cycles is smaller.

Although the character of the cycles is generally the same whether lagged income effects are present or not, there is an important exception. No cycles whatsoever occur following a change in income if the current and lagged effects from income and the interest rate are exactly parallel, that is:

$$(b_0/c_0) = (b_1/c_1) = (b_2/c_2) = \cdots$$

If income decreases in period 1 when money demand is in equilibrium, nonborrowed reserves will be moved in period 1 to its new equilibrium level if the money stock is to be kept on target, and nonborrowed reserves will be kept at that new equilibrium level in all subsequent periods. The last two columns of Table 1 are an example of this. What happens is that the level of nonborrowed reserves is moved in period 1 to offset exactly the change in the quantity of money demanded due to the change in income. No further adjustments of the policy instrument are necessary to keep the money stock on target, because the lagged interest rate effects precisely cancel the lagged income effects in subsequent periods.

Exactly parallel income and interest rate effects may seem to be a very special case, but this restriction often appears in empirical studies of the demand for money. One way this restriction is imposed is through the "partial adjustment" model, which is frequently assumed, mostly for convenience, as the mechanism determining the lagged income and interest rate effects in the demand for money.[6] Implicit in the partial adjustment model is the way all factors influencing the long-run demand for money have parallel lagged effects in the short run.

Looser short-run monetary targeting

The simulation results (Chart 1) illustrate how lags in the demand for money can cause troublesome cycles in nonborrowed reserves and interest rates when the money stock is immediately brought back to target following a disturbance. The problem can be averted by relinquishing some control over the money stock in the short run. Suppose that only the current and previous period's interest rate affects the quantity of money demanded; again let the weights of these two effects equal those used to generate the slowly damped cycles in Chart 1 In period 1, let income decrease permanently by 4 percent If the level of nonborrowed reserves is changed so that the interest rate is moved to its new equilibrium value in period 1 and kept there subsequently, the money stock will be back on target in period 2 and will remain there. Cycles are thus avoided but at the cost of having the money stock below target for one period.

This result can be generalized for more complicated cases. If the quantity of money demanded is affected by the level of the interest rate as far back as n periods ago, the money stock will be back on target in period n + 1, provided the interest rate is moved to

[5] With a two-period lag, fluctuations will occur rather than oscillations if $(b_1/b_0)^2 < (4b_2/b_0)$ With a two-period lag, the conditions for damped cycles are

$(b_2/b_0)^2 < 1$ and

$(b_1/b_0)^2 < [1 + (b_2/b_0)]^2$

These conditions are derived in Baumol, *op cit*, page 248

[6] The partial adjustment model is discussed in detail by Stephen M Goldfeld, "The Demand for Money Revisited", *Brookings Papers on Economic Activity* (1973, 3), pages 576-638

its new equilibrium value in period 1 and subsequently kept there. The money stock, however, will be off target from period 1 through period n.[7]

Another strategy, that of bringing the money stock back to target gradually, would also mitigate cycles, provided they were damped to start with. In Table 2, a comparison is made between the paths nonborrowed reserves and the interest rate take with the immediate and gradual return of the money stock to target. If the money stock is brought one half of the way back to target in the first period and completely back to target in the second period, the amplitude of the damped cycles is greatly reduced. This strategy fails nevertheless in the case of instrument instability; if immediate return of the money stock to target causes explosive cycles, likewise gradual return to target causes explosive cycles. This occurs because the money stock must eventually be put on target in one period.[8]

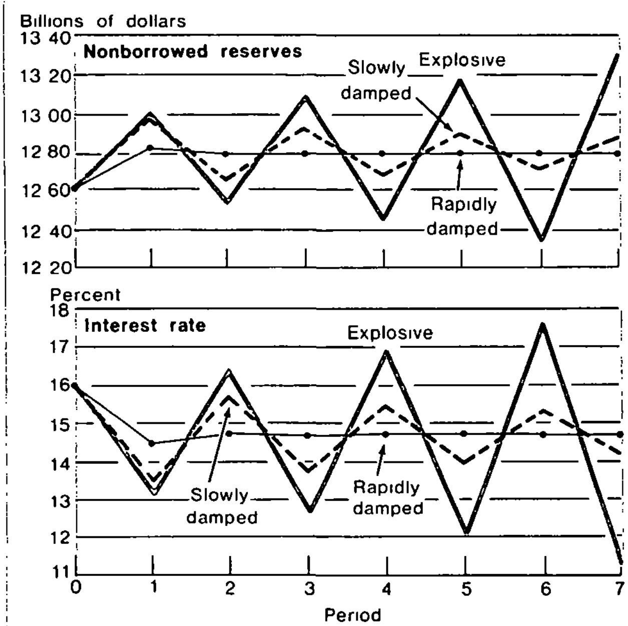
Results from empirical research on the demand for money

The simulations presented earlier suggest that the lag structure in the demand for money is critical for the behavior of nonborrowed reserves and the interest rate under monetary targeting. In this section, the results from three econometric studies of the demand-for-money equation are examined to see what types of cycles are implied according to the analysis in the previous section. Although the models are based on the same general theory of money demand, there are differences in the ways they are formulated and then estimated, so that the implications of tight monetary targeting vary considerably.

Chart 1

Simulated Paths of Nonborrowed Reserves and the Interest Rate

Assuming Period-by-Period Control of Money



Demand for money $M(t) = a - b_0 r(t) - b_1 r(t-1) + cY(t)$

Explosive case $b_0 = 0.7$, $b_1 = 0.8$

Slowly damped case $b_0 = 0.8$, $b_1 = 0.7$

Rapidly damped case $b_0 = 1.3$, $b_1 = 0.2$

Goldfeld. Stephen Goldfeld formulated and estimated a model of the demand for money using quarterly data.[9] He found that the quantity of money demanded in a particular quarter was determined by the level of the commercial paper rate as far back as six quarters previous and by the level of income as far back as eleven quarters previous. The mean lag—the time it takes for one half of the long-run effect resulting from a change in income or interest rates to occur—was calculated to be 9.2 months for the commercial paper rate and 6.8 months for income. The estimates of the regression equation's coefficients imply that adjusting the policy instrument to keep the money stock on target every quarter would precipitate cycles that dampen rather rapidly. For example, starting in equilibrium with the money stock on target and the interest rate

[7] This was pointed out by Holbrook, *op cit*, page 60.

[8] This can be shown with the example below. The demand for money is $M(t) = 19 - (0.5)r(t) - (1.0)r(t-1) + (0.5)Y(t)$; this specification leads to instrument instability if period-by-period control is attempted. If the money stock is gradually returned to target after four periods, however, instrument instability still occurs because the money stock must be put back on target in period 4.

Simulated Paths of Nonborrowed Reserves and the Interest Rate
In billions of dollars

Period	Y	M	NBR	r (percent)
0	100	45.0	12.60	16
1	96	43.5	12.75	15
2	96	44.0	12.60	16
3	96	44.5	13.05	13
4	96	45.0	12.30	18
5	96	45.0	13.80	8
6	96	45.0	10.80	28
7	96	45.0	16.80	−12
∞	96	45.0	—	—

[9] See Goldfeld, *op cit*, pages 604-5.

Table 1

Simulated Paths of Nonborrowed Reserves and the Interest Rate

Assuming Period-by-Period Control of Money

In billions of dollars

Period	No income lag ($c_0 = 0.5, c_1 = 0.0$)		Nonparallel income and interest rate lags ($c_0 = 0.35, c_1 = 0.15$)		Parallel income and interest rate lags ($c_0 = 0.267, c_1 = 0.233$)	
	Non-borrowed reserves	Interest rate (percent)	Non-borrowed reserves	Interest rate (percent)	Non-borrowed reserves	Interest rate (percent)
0	12 60	16 00	12 60	16 00	12 60	16 00
1	12 98	13 50	12 86	14 25	12 80	14 67
2	12 65	15 69	12 75	15 03	12 80	14 67
3	12 93	13 77	12 85	14 35	12 80	14 67
4	12 68	15 45	12 76	14 95	12 80	14 67
5	12 90	13 98	12 84	14 42	12 80	14 67
6	12 71	15 27	12 77	14 88	12 80	14 67
7	12 88	14 14	12 83	14 48	12 80	14 67
∞	12 80	14 67	12 80	14 67	12 80	14 67

Income equals $100 billion in period 0, $96 billion in subsequent periods.

Demand for money $M(t) = a - (0\ 8)r(t) - (0\ 7)r(t-1) + c_0Y(t) + c_1Y(t-1)$

Supply of money $M(t) = d + eNBR(t) + f[r(t) - DISC(t)]$.

Table 2

Simulated Paths of Nonborrowed Reserves and the Interest Rate

Immediate Versus Gradual Return of the Money Stock to Target

In billions of dollars

Period	Immediate return			Gradual return		
	Money stock	Non-borrowed reserves	Interest rate (percent)	Money stock	Non-borrowed reserves	Interest rate (percent)
0	45	12 60	16 00	45	12 60	16 00
1	45	12 98	13 50	44	12 79	14 75
2	45	12 65	15 69	45	12 81	14 59
3	45	12 93	13 77	45	12 79	14 73
4	45	12 68	15 45	45	12 81	14 61
5	45	12 90	13 98	45	12 79	14 72
6	45	12 71	15 27	45	12 81	14 62
7	45	12 88	14 14	45	12 80	14 70
∞	45	12 80	14 67	45	12 80	14 67

Income equals $100 billion in period 0, $96 billion in subsequent periods.

Demand for money: $M(t) = a - (0\ 8)r(t) - (0\ 7)r(t-1) + cY(t)$.

Supply of money. $M(t) = d + eNBR(t) + f[r(t) - DISC(t)]$

Target for money stock $45 billion

Chart 2

Simulated Paths of the Interest Rate under Monetary Targeting: Goldfeld Equation

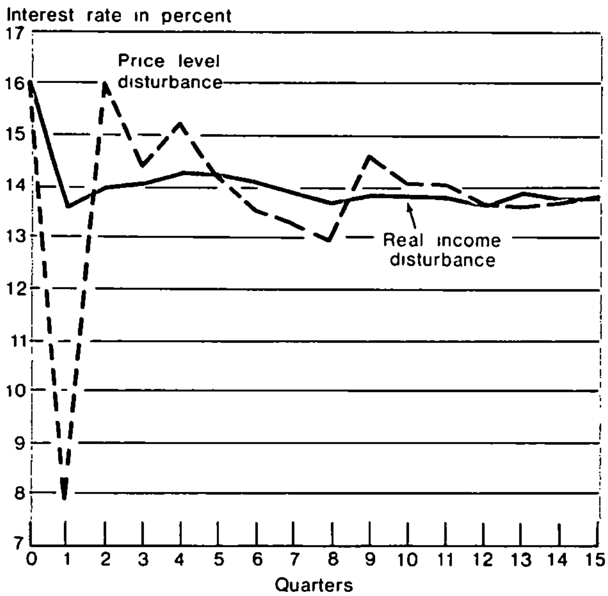
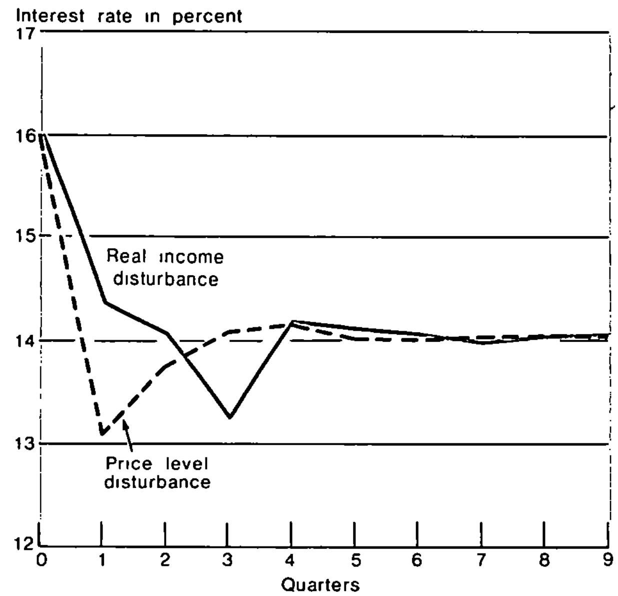


Chart 3

Simulated Paths of the Interest Rate under Monetary Targeting: MPS Equation



at 16 percent, suppose the demand for money falls by 1 percent (A 1 percent deviation of the money stock from its targeted value would seem to characterize some of the problems the FOMC confronts) Chart 2 shows the values of the interest rate that result quarter by quarter when the target is attained by changing nonborrowed reserves. Two cases are examined: (a) a fall in money demand due to a drop in the price level and (b) a fall due to a decline in real income. (These two cases are different since a change in the price level, unlike a change in real income, has no lagged effects.) Because the interest rate elasticity in the current quarter was estimated to be rather small, a very sharp rise in nonborrowed reserves—and a concurrent fall in the short-term interest rate—is necessary in the first period to offset a price level disturbance.

MPS. A second equation examined is that used in the MPS model of the macroeconomy.[10] This regression equation was also estimated using quarterly data; however, the dependent variable is demand deposits. The lagged effects of short-term interest rates were estimated to go back three quarters; the mean lag is only 1 8 months, considerably shorter than Goldfeld's estimate. The interest rate elasticity for the current quarter was constrained to −0.05, which is about 3.5 times as great as Goldfeld's estimate. The lagged effects from income were also estimated to go back three quarters. Since the interest rate's current period effect is large relative to its lagged effects, the estimated coefficients of the MPS equation imply very rapidly damped cycles if the money stock is kept on target every quarter following either a price level or real GNP disturbance. Chart 3 shows the values of the interest rate obtained when the two simulations performed with the Goldfeld equation are repeated with the MPS equation.

Thomson-Pierce. This equation representing money demand was estimated using monthly, instead of quarterly data.[11] The lagged effects of the short-term interest rate were estimated to go back nine months and for income four months. In contrast to the two models already investigated, the estimates of this regression

[10] This equation is described in a mimeograph obtained from the Board of Governors of the Federal Reserve System MPS refers to the MIT-Penn-Social Science Council econometric model

[11] The Thomson-Pierce model is described in Robert S Pindyck and Steven M Roberts, "Optimal Policies for Monetary Control", *Annals of Economic and Social Measurement* (January 1974), pages 207-38

equation's coefficients imply that hitting monetary targets either month by month or quarter by quarter would cause explosive cycles. This result is obtained, in part, because it was estimated that the interest rate from five months previous had the greatest effect on the current month's money demand. The shortest time period over which monetary targeting would be feasible without explosive cycles appears to be six months

In summary, the estimates of these three models have vastly different implications for monetary targeting: *i.e.*, rapidly damped cycles in nonborrowed reserves and interest rates if monetary targets are hit quarterly in contrast to explosive cycles if monetary targets are hit on anything shorter than a semiannual basis. The wide range in findings is not so surprising, given the wide variation in estimates of the lagged effects that changes in income and interest rates have on the demand for money. To illustrate how diverse the estimates of the lagged effects are, the mean lag has been computed from several studies on the demand for money (or demand deposits). According to these estimates (Table 3), the mean lag in some cases is less than a month, and in other cases more than 2½ years. The mean lag by itself is insufficient to determine the implied behavior of nonborrowed reserves and the interest rate under monetary targeting since the pattern in the relative sizes of the lagged effects is also important. Still, from this wide range of estimates of the lagged effects (as characterized by the mean lag), a wide variation in the implied behavior of the monetary sector under monetary targeting could be expected.

Furthermore, very small changes in the estimates of the lagged effects can significantly influence the behavior of nonborrowed reserves and the interest rate under precise monetary targeting. Consider, for example, an alteration of the Goldfeld equation in which the long-run interest rate elasticity remains unchanged, but the mean lag is lengthened from the existing 6.8 months to 7.3 months. To do this, let the elasticities take on the values shown on page 8; these hypothetical values are all within one standard deviation of Goldfeld's estimates.

Table 3

Estimates of the Mean Lag in the Demand for Money

Name	Lag structure	Mean lag (in months) Income	Market interest rate
Quarterly models:			
Goldfeld	geometric	7 6	7 6
Goldfeld	polynomial	9 2	6 8
MPS*	geometric	10 0	10 0
MPS	polynomial	†	1 6
Hamburger‡	geometric	31 0	31 0
Lieberman§	geometric	0 9	0 9
Monthly models:			
Board of Governors‖	polynomial	2 5	1 9
Thomson-Pierce	polynomial	1 3	4 8

* See Jared Enzler, Lewis Johnson, and John Paulus, "Some Problems in Money Demand", *Brookings Papers on Economic Activity* (1976,1), pages 261-80. MPS refers to the MIT-Penn-Social Science Research Council econometric model

† Cannot be computed

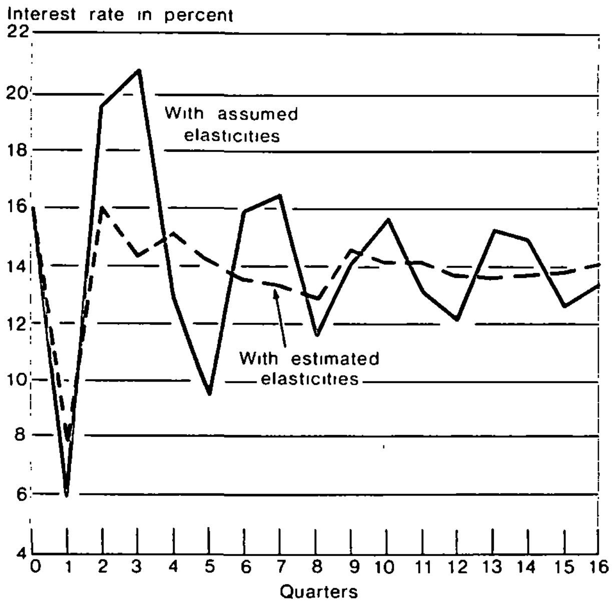
‡ Michael J Hamburger, "Behavior of the Money Stock Is There a Puzzle?", *Journal of Monetary Economics* (July 1977), pages 265-88.

§ Charles Lieberman, "The Transactions Demand for Money and Technological Change", *Review of Economics and Statistics* (August 1977), pages 307-17

‖ See Helen T Farr, "The Monthly Money Model", mimeograph (Washington, D C · Board of Governors of the Federal Reserve System, 1980)

Chart 4

Simulations of the Interest Rate with Goldfeld's Estimates and Assumed Values



Interest rate elasticities

Lag (in quarters)	0	1	2	3	4	5	6
Goldfeld's estimates	0 014	0 014	0 012	0 011	0 009	0 006	0 003
Hypothetical values	0 010	0 012	0 014	0 014	0 010	0 006	0 003

This slight change in the interest rate's lagged effects from what Goldfeld estimated causes the cycles to dampen much more slowly (Chart 4).

In a paper written for the Federal Reserve staff study of the *New Monetary Control Procedures*, Tinsley and Others [1981] make a similar observation. The coefficient estimates of the model they investigate imply that damped, rather than explosive, cycles would result from tight monetary targeting. They note, though, "the margin between stability and instability is extremely small, especially in light of the standard errors of the coefficients".[12]

Thus, the high sensitivity of interest rate behavior to the estimates of lagged effects, combined with the wide variation in the estimates of lagged effects, leads to vastly different implications Despite all the effort expended in empirical research on the demand for money, no firm conclusion can be made concerning the precise cyclical behavior of nonborrowed reserves and short-term interest rates under quarter-by-quarter or month-by-month monetary targeting. According to this analysis, slowly damped cycles are a distinct possibility and explosive cycles cannot be eliminated entirely from the set of potential outcomes

Simulations of the monetary sectpr and aggregate demand under monetary targeting

In this section, a simple three equation model of the economy is constructed. The model is used to illustrate how, under fairly believable conditions, feedback on the money market from the production side of the economy can reinforce the lagged interest rate effects on the demand for money, thereby aggravating the cycles in nonborrowed reserves and the interest rate caused by period-by-period monetary control and, at the same time, creating cycles in income itself

Model simulations

The model consists of three equations: (1) the demand for money, (2) the supply of money, and (3) aggregate demand:

$$(1)\ M(t) = a - b_0r(t) - b_1r(t-1) + cY(t)$$
$$(2)\ M(t) = d + eNBR(t) + f[r(t) - DISC(t)]$$
$$(3)\ Y(t) = g - h_0r(t) - h_1r(t-1)$$

The demand and supply of money are formulated in the same manner as before Aggregate demand is affected by the current and previous period's interest rate The relative magnitudes of the current and lagged interest rate effects in the demand for money and aggregate demand, as well as the sensitivity of the demand for money to changes in income, determine the type of oscillations nonborrowed reserves, income, and the interest rate will exhibit if absolute control over the money stock is maintained. Specifically, the cycles will be explosive if $(b_0 + ch_0) < (b_1 + ch_1)$ and damped if $(b_0 + ch_0) > (b_1 + ch_1)$[13] Thus, the more the current period's interest rate affects money demand and aggregate spending, the more likely the cycles will be stable; the more the previous period's interest rate affects money demand and aggregate spending, the more likely the cycles will be unstable.

Table 4 reports the simulated behavior of the model

[12] See Appendix C of Peter Tinsley and Others, "Money Market Impacts of Alternative Operating Procedures", *New Monetary Control Procedures*, Federal Reserve staff study, Volume 2 (Washington, D C Board of Governors of the Federal Reserve System, 1981)

[13] Constant oscillations occur if $(b_0 + ch_0) = (b_1 + ch_1)$, as before, this special case will not be considered Another special case occurs if $b_0h_1 = b_1h_0$, then income exhibits no cycles whatsoever

Table 4

Simulated Paths of Nonborrowed Reserves, the Interest Rate, and Income

Assuming Period-by-Period Control of Money

In billions of dollars

Period	Explosive ($h_0 = 0.5$, $h_1 = 4.0$)			Slowly damped ($h_0 = 1.5$, $h_1 = 3.0$)			Rapidly damped ($h_0 = 4.0$, $h_1 = 0.5$)		
	Non-borrowed reserves	Interest rate (percent)	Income	Non-borrowed reserves	Interest rate (percent)	Income	Non-borrowed reserves	Interest rate (percent)	Income
0	12 60	16 00	100 00	12 60	16 00	100 00	12 60	16 00	100 00
1	12 79	14 71	97 65	12 75	15 02	97 46	12 69	15 39	98 42
2	12 52	16 54	101 81	12 63	15 83	99 18	12 68	15 48	98 40
3	12 91	13 94	94 86	12 73	15 16	97 76	12 68	15 47	98 40
4	12 36	17 63	103 42	12 64	15 72	98 93	12 68	15 47	98 40
5	13 14	12 39	91 28	12 71	15 26	97 96	12 68	15 47	98 40
6	12 03	19 83	108 51	12 65	15 64	98 77	12 68	15.47	98 40
7	13 61	9 28	84 05	12.70	15 34	98 10	12 68	15 47	98 40
∞	—	—	—	12 68	15 47	98.40	12.68	15.47	98 40

Demand for money. $M(t) = a - (1\ 3)r(t) - (0\ 2)r(t-1) + cY(t)$.
Supply of money $M(t) = d + eNBR(t) + f[r(t) - DISC(t)]$
Aggregate demand $Y(t) = g - h_0r(t) - h_1r(t-1)$

when the targeted value of the money stock is to be maintained despite shifts in aggregate demand. Three simulations are conducted. The demand-for-money function is the same in each of the three cases; if looked at in isolation, a relatively large current period effect ($b_0 = 1.3$, $b_1 = 0.2$) would imply rapidly damped cycles. The purpose of these simulations is to reveal how critical are the sizes of the current and previous period's interest rate effects on aggregate demand.

The procedure used to perform the simulation is similar to what was followed in the simulation of the monetary sector alone. Initially the money stock is on target Then, aggregate demand (rather than income) decreases permanently by 4 percent, and the level of nonborrowed reserves is adjusted period by period to keep the money stock on target. Given a demand-for-money equation, the interest rate effects on aggregate demand determine the type of cycles that occur. Thus, concentrating on the current and lagged interest rate effects in the demand for money by themselves could lead to the wrong conclusion concerning the outcome of period-by-period control of the money stock.

With this model as with the model consisting solely of the monetary sector, explosive or slowly damped cycles can be avoided by relinquishing some control over the money supply and setting the interest rate at its new equilibrium value. Slowly damped cycles can also be mitigated by bringing the money stock back to target only gradually.[14]

The lagged effects on aggregate demand

It is beyond the scope of this article to survey the large volume of empirical work on the lagged effects on aggregate demand, particularly investment spending. It is fair to say, however, that all macroeconomic models of the economy feature lagged interest rate effects on residential construction and business fixed investment. Current rates alone may influence the decision to begin construction of housing units or expansion of plant capacity, but actual expenditures follow with a lag.

Although it seems certain that the lagged effects on investment spending exist, there is no consensus on the pattern of the lagged effects or the number of periods they extend beyond the previous period. There does seem to be a considerable impact on residential housing construction one and two quarters after a change in the level of interest rates. (In terms of the model used in this section, this delayed impact would be reflected by h_1 being equal to or greater than h_0.)

14 Many of these same points were illustrated with a similar model by Kevin Hurley in "How a Tight Monetary Policy Can Destabilize the Economy", *Money Manager* (March 9, 1981), page 3

Thus, the pattern of lagged interest rate effects on aggregate demand could to some extent intensify cycles caused by tight control of the money supply.

In another paper written for the Federal Reserve staff study of the *New Monetary Control Procedures,* Enzler and Johnson construct a consensus model of the macroeconomy that would give results which are "qualitatively representative of a wide range of models of similar but more elaborate structure (for example, the MPS model)".[15] This model consists of four equations; besides aggregate demand and the demand for money, they include an equation describing FOMC behavior and a "Phillips curve" inflation rate equation. They then use this model to perform a series of simulations of the economy's performance. In several simulations, explosive or slowly damped cycles with a period of fourteen quarters are obtained for income; these simulations imply explosive or damped cycles for the interest rate and nonborrowed reserves as well.

[15] Jared Enzler and Lewis Johnson, "Cycles under Monetary Targeting", *New Monetary Control Procedures,* Federal Reserve staff study, Volume 1 (Washington, D C Board of Governors of the Federal Reserve System, 1981)

Concluding remarks

Some critics of monetary policy assert that the FOMC should control the money stock in the very short run. These critics generally do not confront the possibility that overly close monetary control could destabilize the economy. In fact, empirical research suggests that the adoption of a very short control horizon could inject instability into financial markets and the level of economic activity.

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