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Optimal Control of the Money Supply

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Since the Federal Reserve changed its monetary control procedures in late 1979, many observers have given the Fed credit for reducing the average rate of growth of the money supply. Some, however, have criticized the Fed for allowing interest rates to swing widely and the money supply to move far from its trend in the short run (from month to month, for example). These criticisms have challenged economists by raising the question of whether, by further modifying its monetary control procedures, the Fed could achieve all that its critics would like: less short-run volatility in both money and interest rates as well as its desired long-run growth of money.

This is really a question about the efficiency of the Fed's current procedures. In most models of short-run movements in monetary policy variables, interest rates are the link between the Fed's actions to control money and the growth of money soon thereafter. So, under any particular monetary control procedures, the more the Fed intervenes in money markets in an attempt to tighten control of money, the more interest rates fluctuate. These models indicate that changes in procedures can improve the Fed's ability to both control money and stabilize interest rates. But, according to the models, such changes are limited; ultimately the Fed faces a tradeoff between its short-run goals. When the Fed is using *optimal* procedures—those that produce the best possible combinations of money and interest rate volatility—the Fed cannot simultaneously reduce the short-run volatility of both variables. It must accept more of one to produce less of the other. Only if the Fed is currently using inefficient procedures, that is, can it improve its short-run performance by changing its procedures.

The theoretical limit on the Fed's ability to improve its short-run monetary control procedures could be represented as a graph of all the combinations of money and interest rate volatility the Fed can achieve with efficient procedures. Economists refer to such a graph as a *tradeoff curve* because its shape tells the rate at which one good or goal can be exchanged for another. In this case, of course, it tells the rate at which the Fed could exchange better (or worse) short-run money control for larger (or smaller) interest rate movements by switching from one efficient control procedure to another.

At any point in time, then, the question of whether new monetary control procedures could reduce short-run volatility while still keeping average money growth on target can be answered by using actual data to estimate this tradeoff curve as well as the Fed's current position on or off it. If the combination of money and interest rate volatility the Fed has been achieving lately is not on the tradeoff curve, then the Fed's monetary control procedures are inefficient and both forms of volatility could be reduced by improving the procedures enough to move onto the curve. If the recent combination of volatilities is on the tradeoff curve, the Fed is already using efficient procedures, and the best it can do by altering its procedures is to exchange one form of volatility for the other by moving along the curve. Whether or not that sort of change is desirable depends on the relative importance the Fed attaches to short-run money control versus short-run interest rate smoothness. Nonetheless, an estimate of the shape of the tradeoff curve would provide a useful summary of the Fed's options.

Despite the relevance of this sort of analysis to the current monetary policy controversy, few economists have attempted to determine what the Fed's tradeoff curve really looks like and where it is in relation to recent levels of short-run money control and interest rate volatility. And, until now, no one has attempted to do that with *optimal control theory,* a mathematical technique designed to handle just this sort of problem of balancing competing goals. I applied optimal control theory to a statistical model of the linkages between weekly movements in the money supply and interest rates during the last seven years and found the model's implicit tradeoff between short-run money control and short-run interest rate smoothness since late 1979. I also measured the actual degree of short-run money control and interest rate smoothness associated with the Fed's monetary control procedures in the last few years.[1]

My estimates indicate that recently the Fed's procedures have been fairly efficient. In other words, simultaneous improvements in both short-run money control and interest rate volatility are not likely because the Fed appears to have been operating near the tradeoff curve already. My estimates also show, however, that the tradeoff curve is almost flat: very small changes in the Fed's degree of money control are associated with large opposing changes in interest rate volatility. This means that the Fed could keep average money growth on target while reducing short-run interest rate volatility considerably from recent levels with at most a minor loss of short-run money control. But it also means that a significant increase in the degree of money control, from recent levels, would require a degree of interest rate volatility unprecedented even by recent experience.

A Way to Balance the Fed's Competing Goals

The Fed recognizes that moving closer to its goals for both money and interest rates can require changes in its operating procedures. Since the early 1970s, as concern about inflation has increased and more public attention has been focused on money growth, the Fed has slowly shifted its attention from controlling interest rates to controlling the money supply.[2] Starting early in 1970, the Fed began to produce targets for money growth to guide short-run policy. The instrument actually used to control money, however was the federal funds rate, the interest rate on short-term loans of the reserves of depository institutions. Because this rate tended to change slowly, money growth targets were often missed. Since 1975, Congress has required the Fed to report annual targets for money growth, and in October 1979, after several years in which money growth exceeded annual targets, the Fed announced a change in operating procedures which was designed to acquire better short-run (and, therefore, long-run) control of money growth at the risk of introducing more interest rate volatility.

Today even many of the Fed's critics admit that it has brought the trend growth of money closer to targeted levels since 1979. In recent years the center of controversy over monetary control has shifted from how well the Fed hits its long-run targets for money to how volatile money and interest rates are in the short run. Milton Friedman (1982), for instance, acknowledges that "the Federal Reserve . . . did succeed in bringing down the *average* rate of growth in the quantity of money," but he argues that it must "recognize the importance of curbing the erratic ups and downs in monetary growth" over short periods. At the same time, interest rate volatility has clearly been an important concern of the Fed's primary policymaking body, the Federal Open Market Committee (FOMC). Members of the FOMC have often expressed concern with the possibility of whipsawing the markets (see, for example, Volcker 1977, p. 26). This concern appears to have something to do with the Fed's role as a lender of last resort. Apparently, the fear is that increased rate volatility will increase the probability of a financial panic. This concern with money market conditions is discussed by Jack Guttentag (1972, p. 71), who defends it, arguing that "a good open-market strategy will permit adequate control over aggregates *and* have strong panic-prevention properties as well."

Despite the Fed's recent experience, much research on improving monetary control procedures has been directed not at finding the Fed's best obtainable combinations of money control and interest rate volatility, but rather at a narrower issue: how to bring money closer to a chosen target without destabilizing interest rates.

This issue appears to have arisen from a consideration

[1]A more detailed description of this work is given in Litterman 1982.

[2]Actually, before 1970, the Fed targeted money market conditions, a policy which basically involved holding short-term interest rates constant and accommodating fluctuations in money demand. A large literature has developed addressing the issue of whether a central bank should try to control interest rates or money. A well-known article by Poole (1970) shows that the answer may depend on the source of shocks to the economy. A more recent analysis by Kareken, Muench, and Wallace (1973) questions whether it is ever desirable to target money. I do not address this issue; I take as given the Fed's decision to try to control money growth.

The Federal Funds Rate's Role in Monetary Control

There are some obvious differences between my discussion, in which the federal funds rate is the Fed's instrument for controlling money, and the usual discussion of current Fed operating procedures, which stresses nonborrowed reserves (that is, the total reserves of depository institutions less those borrowed from the Fed). Nonetheless, even under current Fed policy, there is an implicit role for the funds rate, and that role is the same as the one it plays in my discussion.

Under current Fed policy, the causal chain which connects changes in the nonborrowed reserves path to changes in money holdings clearly includes the level of borrowings from the Fed. That level affects the federal funds rate and causes financial firms and the public to make portfolio decisions which return money holdings to the desired level. (See FRBNY 1981, 1982 and FR Board 1981.) Thus, whether the focus is directly on the federal funds rate, as in my discussion, or on nonborrowed reserves, the fundamental link between the Fed's open market operations and the money supply is the effect of the Fed's actions on the funds rate.

Although there is a good deal of uncertainty over what causes money to respond to changes in the funds rate, there is general agreement that an important role is played by banks, which respond rapidly to changes in the price of reserve credit. In the first several weeks after a change in the funds rate, it is banks' decisions to make or refuse commercial loans and to buy or sell assets which transmit changes in the funds rate to changes in deposits and money. Banks do not respond directly to the level of reserves in the system, but rather to the current and expected future prices for reserves. At the margin, when deciding whether or not to make a loan, a bank compares the risk-adjusted rate of return on that loan with its alternative return from supplying those funds to the federal funds market. If other things don't change, when the funds rate goes up, for example, the level of bank loans and deposits, and hence the money supply, will go down.

The Fed has not kept secret the fact that it will occasionally modify the growth in nonborrowed reserves to change the funds rate and affect the speed of monetary adjustment. But any consideration of how much to adjust the nonborrowed reserves path must face the following questions: What is the effect of the resulting change in borrowings on the funds rate? What is the response of money to changes in the funds rate? And, implicitly, what level of the funds rate is consistent with the desired path for money? Unless the Fed wants to instantaneously offset each unexpected deviation in money growth from that path, the use of the nonborrowed reserves targeting procedure does not eliminate the tradeoff between short-run money supply deviations and interest rate fluctuations. In this context, a policy prescription which suggests fixing the supply of reserves, no matter what happens to the money supply, amounts to telling the Fed to worry only about hitting money targets each week and to ignore the effects of interest rate fluctuations—fluctuations which might in fact be considerably sharper than those we have seen to date.

of the lags inherent in the money control process. It is widely recognized that the Fed does not directly control the quantity of money. What the Fed does control is the supply of reserves to the financial system. Open market operations, by increasing or decreasing the supply of reserves, cause the federal funds rate, which is the price of reserves, to go down or up, respectively. These movements in the federal funds rate cause banks and other economic agents to adjust their portfolios in ways that, other things unchanged, lead to predictable but somewhat delayed movements in the stock of money (see box).

According to a number of Fed economists, these lags have restricted the Fed's actions to keep money growth on target in the short run because they imply that such actions can lead to drastic movements in interest rates.[3] The arguments made by these economists are basically the same. Consider what happens when, for some reason, monetary growth accelerates sharply for a week or two. Because movements in interest rates have long-lasting delayed effects on money demand, action by the Fed to raise interest rates enough to quickly bring the money supply back to its target would continue to affect financial

[3]A partial list includes Davis 1974a,b; Ciccolo 1974; Pindyck and Roberts 1974, 1976; Tinsley et al. 1981; Higgins 1982; and Radecki 1982. Davis (1974b, p. 50), for example, suggests that if the Fed tried to exert tight control over money, "sharp week-to-week fluctuations in demand for bank credit and deposits . . . would lead to erratic and large movements in the Federal funds rate and related rates. . . ." Pindyck and Roberts (1974, p. 224) argue that tight control over M1 would cause interest rates to "behave wildly" and to "oscillate between extreme values." The others all reach similar conclusions.

markets for some time afterward, eventually pushing the money stock below its target and thus requiring offsetting actions by the Fed to lower interest rates. Depending on the lag in the response of money and the speed with which money was to be returned to its target, the required offsetting movement in rates could be larger than the initial change, thus leading to an explosive cycle of interest rate oscillations. Since interest rates are the instrument the Fed uses to control the money supply, Robert Holbrook (1972), who first discussed this problem, called it *instrument instability.*

Attempts to determine how slowly the Fed should act to correct money deviations from a target in order to avoid instrument instability are misguided. Since the Fed faces an ultimate tradeoff between short-run money control and interest rate volatility, what it needs to know is where that tradeoff is, what are the best combinations of short-run money control and interest rate volatility it could possibly reach. Analyses of instrument instability merely tell the Fed how close it can come to one of its goals (short-run money control) without completely missing the other (smooth interest rate movements). Because these analyses ignore the question of what is optimal, they may be mistaken in concluding that, at any point in time, close short-run control of money necessarily requires excessive interest rate volatility.

Gregory Chow (1973) was the first to point this out, and he also pointed out that there is a mathematical technique which can address the Fed's problem of competing goals. That technique, *optimal control theory,* was developed and is used most often by engineers, but it has many powers economists find helpful. The one Chow referred to is its ability to define the best balance between competing objectives in a system that evolves over time (like an economy). Several economists besides Chow have recognized the applicability of this theory to short-run money control questions (see Davis 1974b and Pindyck and Roberts 1974, 1976). So far, however, no one has used it to calculate the Fed's tradeoff curve.

Applying Optimal Control to Monetary Control

In order to determine the best combinations of short-run money and interest rate volatility the Fed can achieve, I have applied optimal control theory to a simple time series model of U.S. money markets.[4] Once the Fed has chosen the relative weight it attaches to its competing goals of money control and stable interest rates, my optimal control technique tells the Fed how to best balance these goals by setting the federal funds rate each week according to an *optimal feedback rule,* which is a linear function of current and past data on money, interest rates, and any other variables which help to predict future movements in the money stock.[5] Once calculated, this rule determines the probability laws of the model, which allow me to estimate the expected money deviations from target and interest rate volatility associated with the optimal control procedures.[6] For any given degree of monetary control, that is, I can find the operating procedures which minimize the model's interest rate fluctuations.

As discussed earlier, the best possible combinations of money control and interest rate volatility that these procedures allow the Fed to achieve can be summarized graphically in a curve. This curve is a possibility frontier, or tradeoff curve, that not only defines the best levels of money and interest rate movements the Fed can achieve. It also illustrates, by its shape, the fact that, once inefficient control procedures are superseded by optimal control procedures, the Fed can only trade increased money control for decreased interest rate stability, and vice versa.[7]

4Because of the controversy surrounding the question of whether the Fed can or should peg interest rates, it is important to address this question. What optimal control procedures produce is a suggested level for the funds rate at a given point in time. The level next period will depend on what information is observed this period. In contrast to the suggestions of Pindyck and Roberts (1974, 1976) and other control schemes, my procedures include no target for future interest rates. In my control scheme, if money deviates from its target, then the funds rate will eventually adjust as much as is necessary to bring money back to its desired path. Only within the shortest time interval—a week, in my model—is the funds rate held fixed, and even this degree of interest rate control is not necessary.

5It would also be possible to use the feedback rule defined here under a reserves targeting procedure that would not be much different from current procedures. Today the FOMC picks a target for money growth, which the Federal Reserve Board and the Fed's Trading Desk translate into reserves path targets. Under an optimal control approach, the Board and the Desk could compute weekly reserves targets consistent with the funds rate given by the feedback rule. As long as the Fed is willing to cause the federal funds rate to move as needed to control the money supply, the difference between a funds and a reserves targeting procedure is not sharp.

6Technical details of the computation of the optimal feedback rule are described in Litterman 1982. Along with the standard considerations, my rule takes into account the uncertainty in the coefficient estimates and the two-week lag between when we observe money and when we observe interest rates.

7The Tinsley et al. (1981) study, involving simulations of the Board's monthly money market model, reached conclusions similar to those reached here, although its approach differs in that Tinsley et al. did not adopt an explicit control-theoretic framework, nor did they try to model the week-to-week dynamics of the money market. They found that there exists "a well-behaved trade-off between the volatility of deviations of M-1A from long-run targets and the volatility of short-term interest rates under current and alternative operating procedures that may be exploited by short-run monetary policy" (p.1). Similar conclusions were also reached by Pindyck and Roberts (1974, 1976) in earlier studies which did use optimal control but did not directly penalize interest rate volatility.

A critical element in any application of optimal control theory to an economy is knowledge of how the economy evolves over time, or the *dynamic* behavior of the economic system. I used time series analysis to estimate the dynamic relationships between weekly movements in money (defined as seasonally adjusted M1, which basically includes currency and checkable accounts) and the federal funds rate in the period 1976–late 1982.[8] See Litterman 1982 for the details of my *specification* of the time series representation for these variables, that is, for the details on how I chose the variables and determined how to relate them in equations. Very briefly, I first searched for any variables besides the federal funds rate which would help forecast weekly movements in M1. Having found that other variables help very little, I chose to include only M1 and the federal funds rate in the model. Several specifications were considered. The final choice, which included 12 lags of both variables in each equation, was based on maximizing the (out-of-sample) forecasting accuracy of the model.

For the purpose of short-run monetary control, the important aspect of my estimated time series model is the response of M1 to movements in the federal funds rate. M1 responds to many different and usually unpredictable events, but the Fed's input can be viewed as being based on its response to the federal funds rate. Because this response appears to be relatively strong, stable across time periods, and insensitive to different specifications of the time series representation, my results can be considered relatively good indicators of what the Fed really can and cannot achieve. (Again, for evidence on this point, see Litterman 1982.)

It is important to note as well, however, that despite the strong statistical relationship between money and the funds rate and the additional fact that much of the long-run behavior of money is attributable to movements in this rate, very little of the weekly variability of money is explained by these movements. The existence of a large amount of unexplainable noise in the weekly money stock series is an important factor in reducing the Fed's ability to use interest rates to achieve better short-run control of the money supply.

My optimal control approach to monetary control outlined above is an attempt to formalize the Fed's operating procedures and its problem of how to best balance the goals of short-run money control and interest rate smoothness. Applying time series techniques to estimate the dynamics of the M1, federal funds process formalizes the FOMC's attention to the lags inherent in that process. Because the FOMC is, in effect, attempting to solve the same problem I am, but without the benefit of optimal control theory or time series analysis, its solution might be suboptimal.

My Estimates of the Best the Fed Can Do

The tradeoff between the Fed's two goals can be more easily understood by visualizing the costs of aiming at each. The cost to the Fed of striving to smooth interest rates is larger deviations of money from its target. For simplicity, I have used seasonally adjusted M1's long-run (1976–late 1982) trend as its target. Using this trend does not necessarily represent actual Fed policy; it assumes the Fed was always basically hitting its long-run targets, an assumption which presumably overstates the true situation, at least before October 1979. For my purposes, which focus on short-run control, however, this is an adequate approximation. My estimates of the growth in the long-run trend support this assertion. Over the last several years, its growth has been slowly declining, which is quite consistent with the Fed's stated intentions. Chart 1 shows this long-run trend along with the actual weekly levels of M1 between late 1979 and late 1982. Notice that a graph which focuses only on deviations from trend, as Chart 2 does, tends to exaggerate the importance of these movements: during this period they averaged only about 1 percent of the level of M1. The average size of these deviations, as measured by their root mean square value, is the measure of monetary control which I assume the Fed wants to minimize as it tries to smooth interest rates.

The cost to the Fed of trying to eliminate money stock fluctuations is more volatility in interest rates. Chart 3 shows the weekly levels of the federal funds rate from late 1979 to late 1982 and Chart 4 the corresponding values of my measure of interest rate volatility. Notice that when

[8]The use of a time series representation as the basis for the dynamic structure of a control exercise is a departure from the standard econometric approach, which uses structural models. I decided not to estimate a structural model in this study because doing so would have greatly increased the cost and complexity of the exercise and probably would not have led to improved estimates. The usual identifying restrictions of a structural model are likely to be false, and their application would lead to misspecification and therefore bias in the estimation of the crucial response function. Given the strength of the evidence in the data, as seen in the lack of sensitivity to alternative specifications, the results from using a reasonable structural model would presumably be similar to those I obtain with a time series representation. However, the risks of biasing results by imposing false restrictions and inappropriate specification of dynamic structures appear to far outweigh the expected benefit of possibly reducing the variance of the estimates.

Charts 1–4

Measuring the Costs of Short-Run Money Deviation and Interest Rate Volatility

October 3, 1979–November 3, 1982

Seasonally Adjusted M1

Chart 1 Weekly Levels ___ and Long-Run Trend* ___

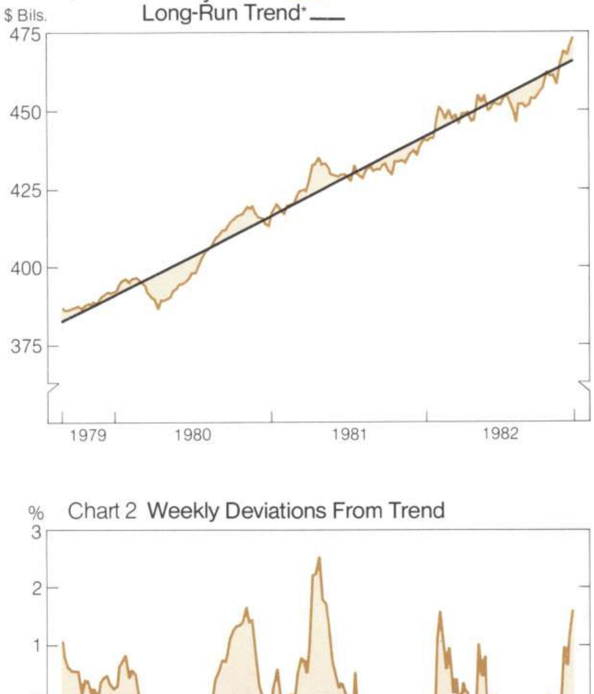
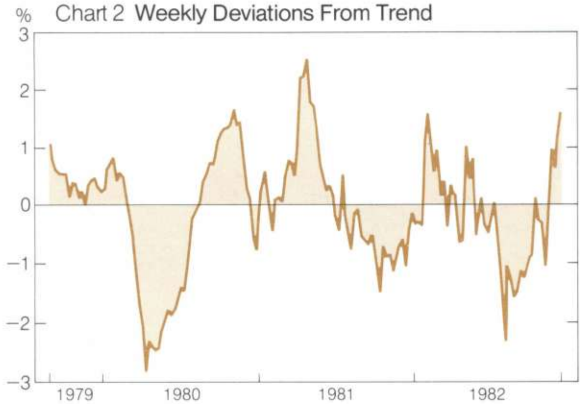


Chart 2 Weekly Deviations From Trend



The Federal Funds Rate

Chart 3 Weekly Levels

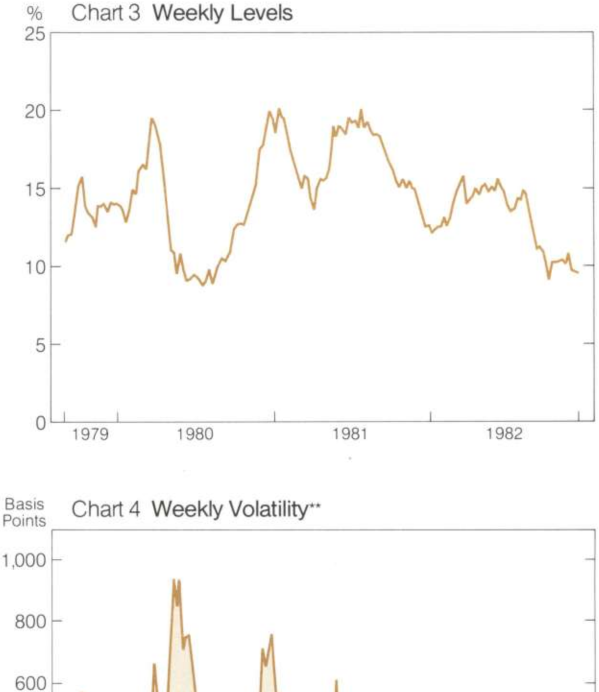
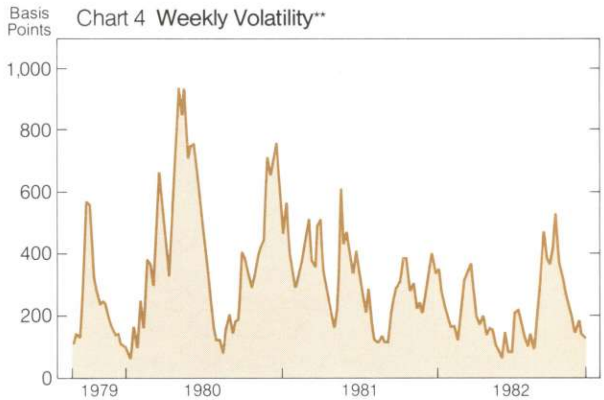


Chart 4 Weekly Volatility**



*M1's long-run trend is based on weekly data from January 7, 1976, to November 3, 1982.

**The measure of volatility is the square root of a declining weighted average of squared changes in the federal funds rate from each of the 12 previous weeks.

Source of basic data: Federal Reserve Board of Governors interest rates move quickly in either direction, the volatility measure is large. My measure is the square root of a declining weighted average of squared changes in the federal funds rate from each of the 12 previous weeks. I assume that the expected value of this measure of interest rate volatility is the cost the Fed wants to minimize as it attempts to control money.

Using these measures of costs in my model, I can present estimates of the minimum obtainable cost combinations in a graph. Different relative weights attached to the goals of money control and interest rate smoothness will lead to different optimal feedback rules and thus to different points on the graph. Again, by connecting these points, I trace out the tradeoff curve, or possibility frontier, from which the Fed can choose optimal procedures.

It should be clear that a tradeoff curve defines a broad set of possible feedback rules. Each point on the curve represents a feedback rule which is optimal for a particular weighting of the Fed's goals.[9] Deciding which rule should be chosen from this set means deciding how relatively important are the goals of money control and interest rate stability; that is beyond the scope of this analysis. What this analysis does tell the Fed is how costly, in terms of interest rate volatility, closer control of the money supply is (and vice versa).

My estimates of both the tradeoff curve, based on the data since early October 1979, and the actual costs in this period are shown in Chart 5.[10] Note that the curve is fairly flat and the actual is fairly close to it. Together these estimates imply two main results:

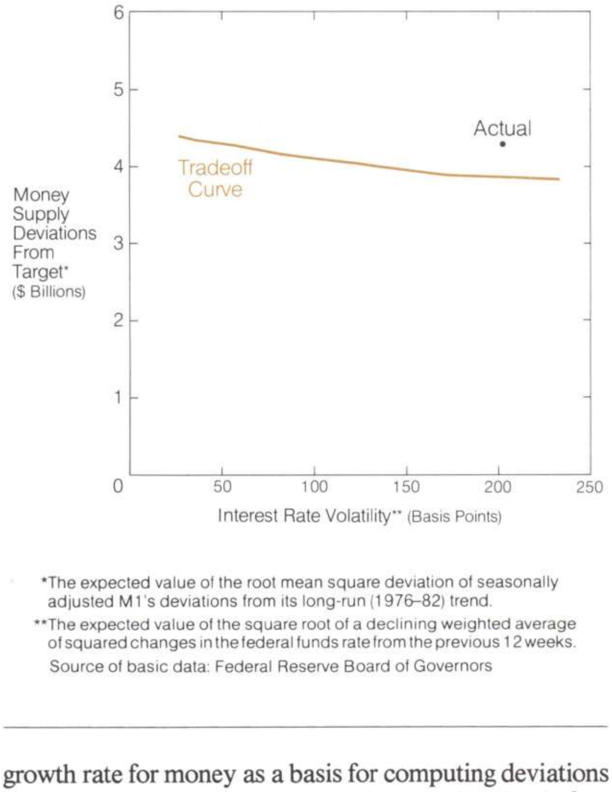
- Short-run money deviations from target cannot be reduced much from recent levels without incurring large increases in interest rate volatility.
- Short-run interest rate volatility can be reduced quite a bit from recent levels without reducing the degree of money control.

Readers familiar with the behavior of money and interest rates before October 1979 may find an apparent discrepancy between that behavior and my tradeoff curve. The tradeoff curve implies that more interest rate volatility is associated with closer control of the money supply. Since October 1979, however, both money deviations from trend and interest rate volatility have increased. This discrepancy does not refute the existence of the tradeoff curve. The tradeoff penalizes money deviations from target, not money growth volatility. The use of a trend growth rate for money as a basis for computing deviations from target badly underestimates the true situation before October 1979. Although there is no exact measure of how close the Fed has come to hitting its target, all indications

Chart 5

Money Control vs. Interest Rate Volatility in the Short Run

Estimates of the Fed's Possibility Frontier and Actual Achievement Since October 1979



*The expected value of the root mean square deviation of seasonally adjusted M1's deviations from its long-run (1976–82) trend.

**The expected value of the square root of a declining weighted average of squared changes in the federal funds rate from the previous 12 weeks.

Source of basic data: Federal Reserve Board of Governors

9When there are innovations in the types of financial assets available, the behavior of M1 is sometimes less predictable than usual and the Fed then puts less weight on M1 targets. In my analysis, such times would suggest moving along the tradeoff curve toward less money control and more interest rate stabilization. Another possible response would be to attempt to control a different monetary or credit aggregate. Whether or not a different aggregate is controllable, however, and what the nature of that control would be are open questions.

10The costs associated with points on the curve are measured by simulating the weekly time series model with the Fed following an optimal control procedure. The shocks in the simulation are taken to be those which actually occurred. By using these actual shocks, I can meaningfully compare the costs using optimal control with the actual costs in the historical period.

are that the Fed has been closer to its desired trend growth path recently than it was several years ago.

Even given the above qualifications, however, there is still a large increase in money stock volatility in recent years which my model does not account for. Some possible explanations include the increase in financial innovations, such as the nationwide introduction of checkable interest-earning accounts in January 1981; the credit controls of spring 1980; the more general tightening of policy over the whole period; and finally, the fact that seasonal effects are harder to remove from recent data than from data around which there are several years of observations. In my analysis, these effects end up as unexplained shocks to money. Since the tradeoff curve I have estimated is based on shocks of the size experienced between late 1979 and late 1982, it does not apply to other periods. Whenever shocks to money are larger (or smaller), the tradeoff curve for that period will be higher (or lower) than the one in Chart 5.

The model I used to calculate the tradeoff curve can also demonstrate how different the weekly history of money and interest rates might have been if the Fed had chosen an optimal procedure suggested by my results. Charts 6 and 7 compare the actual history of M1 and the federal funds rate during 1980–82 with what the model suggests could have been accomplished under an optimal control procedure which weighted stabilizing interest rates more highly than actual results imply the Fed did. The comparison suggests that the funds rate could have been smoothed considerably with little or no adverse effect on money control. Clearly, though, this particular optimal control solution does not promise to reduce money deviations from their current levels. Also, note that, while in this simulation the smoothed interest rate is usually lower than the actual rate, that will not generally be true. For example, in a period of falling rates, a smoothed rate will usually be higher than otherwise.

A Closing Remark

There is no guarantee that adopting optimal monetary control procedures would leave unaffected the important dynamics of the money market on which these procedures depend. In fact, there are good reasons to expect changes in government policy to affect market behavior.[11] Since the Fed has recently been operating close to the tradeoff curve, however, the use of optimal control is appropriately viewed as a minor fine tuning of the Fed's current operating procedures rather than as a change in policy.

Charts 6–7

How Optimal Control Might Have Helped the Fed

Weekly, April 23, 1980–November 3, 1982

Chart 6 Seasonally Adjusted M1's Deviations From Long-Run Trend*

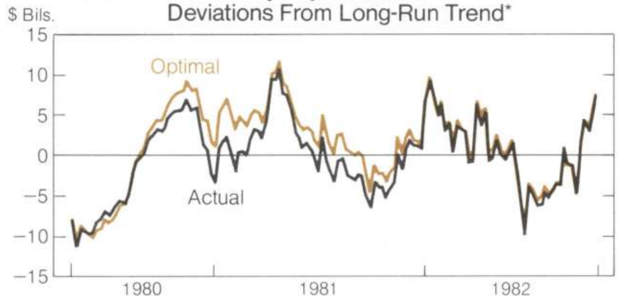
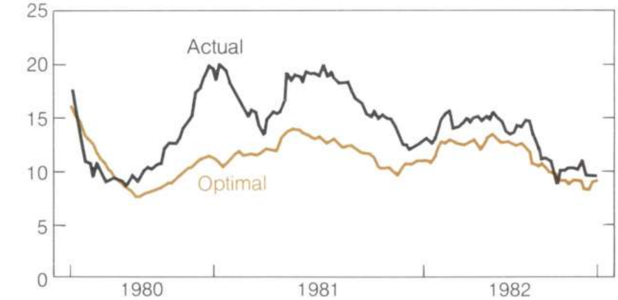


Chart 7 The Federal Funds Rate



*M1's long-run trend is based on weekly data from January 7, 1976, to November 3, 1982.

Source of basic data: Federal Reserve Board of Governors

Furthermore, there is evidence, described in Litterman 1982, that the important response of money to interest rate movements did not change significantly when the Fed's operating procedures changed in October 1979. Money control procedures aimed simply at reducing interest rate fluctuations may be viewed as a compromise between the pre– and post–October 1979 regimes. With that as a goal, therefore, the impact on market behavior of switching to these procedures probably would not be large.

[11]See Lucas 1976 for a forceful attack on the type of analysis described here. See Sims 1982 for a forceful defense of it.

References

Chow, Gregory C. 1973. Problems of economic policy from the viewpoint of optimal control. *American Economic Review* 63 (December): 825–37.

Ciccolo, John H. 1974. Is short-run monetary control feasible? In *Monetary aggregates and monetary policy*, pp. 82–91. New York: Federal Reserve Bank of New York.

Davis, Richard G. 1974a. Implementing open market policy with monetary aggregate objectives. In *Monetary aggregates and monetary policy*, pp. 7–19. New York: Federal Reserve Bank of New York.

__________. 1974b. Short-run targets for open market operations. In *Monetary aggregates and monetary policy*, pp. 40–59. New York: Federal Reserve Bank of New York.

Federal Reserve Bank of New York (FRBNY). 1981. Monetary policy and open market operations in 1980. *Federal Reserve Bank of New York Quarterly Review* 6 (summer): 56–75.

__________. 1982. Monetary policy and open market operations in 1981. *Federal Reserve Bank of New York Quarterly Review* 7 (spring): 34–53.

Federal Reserve Board of Governors (FR Board). 1981. *New monetary control procedures.* Federal Reserve Staff Study. Washington, D.C.: Federal Reserve Board of Governors.

Friedman, Milton. 1982. An aborted recovery? *Newsweek* (August 23): 59.

Guttentag, Jack M. 1972. Discussion of The problems of the open market manager, by Alan R. Holmes. In *Controlling monetary aggregates II: The implementation.* Federal Reserve Bank of Boston Conference Series 9: 69–79.

Higgins, Bryon. 1982. Should the Federal Reserve fine tune monetary growth? *Economic Review* 67 (January): 3–16. Federal Reserve Bank of Kansas City.

Holbrook, Robert S. 1972. Optimal economic policy and the problem of instrument instability. *American Economic Review* 62 (March): 57–65.

Kareken, John H.; Muench, Thomas; and Wallace, Neil. 1973. Optimal open market strategy: The use of information variables. *American Economic Review* 63 (March): 156–72.

Litterman, Robert B. 1982. Optimal control of the money supply. Research Department Staff Report 82. Federal Reserve Bank of Minneapolis.

Lucas, Robert E., Jr. 1976. Econometric policy evaluation: A critique. In *The Phillips curve and labor markets*, ed. Karl Brunner and Allan H. Meltzer. Carnegie-Rochester Conference Series on Public Policy 1: 19–46. Amsterdam: North-Holland.

Pindyck, Robert S., and Roberts, Steven M. 1974. Optimal policies for monetary control. *Annals of Economic and Social Measurement* 3 (no.1): 207–37.

__________. 1976. Instruments, intermediate targets, and monetary controllability. *International Economic Review* 17 (October): 627–50.

Poole, William. 1970. Optimal choice of monetary policy instruments in a simple stochastic macro model. *Quarterly Journal of Economics* 84 (May): 197–216.

__________. 1982. Federal Reserve operating procedures: A survey and evaluation of the historical record since October 1979. *Journal of Money, Credit, and Banking* 14 (November, part 2): 575–96.

Radecki, Lawrence. 1982. Short-run monetary control: An analysis of some possible dangers. *Federal Reserve Bank of New York Quarterly Review* 7 (spring): 1–10.

Sims, Christopher A. 1982. Policy analysis with econometric models. In *Brooking Papers on Economic Activity*, ed. William C. Brainard and George L. Perry, 1: 107–52. Washington, D.C.: Brookings Institution.

Tinsley, Peter A.; von zur Muehlen, Peter; Trepeta, Warren; and Fries, Gerhard. 1981. Money market impacts of alternative operating procedures. In *New monetary control procedures*, vol. II. Federal Reserve Staff Study. Washington, D.C.: Federal Reserve Board of Governors.

Volcker, Paul A. 1977. A broader role for monetary targets. *Federal Reserve Bank of New York Quarterly Review* 2 (spring): 23–28.