Commentary

Athanasios Orphanides

John Taylor is well known as a teacher of macroeconomics, and time and again he has challenged academics and practitioners alike to focus attention on how monetary policy should be formulated and analyzed in terms that are useful and practical.

Until perhaps a decade ago, most academic discussions of monetary policy were formulated in terms of the money stock, despite the fact that central banks invariably implemented monetary policy decisions through control of money market interest rates—the federal funds rate in the United States. Taylor's work, especially since his widely cited 1993 Carnegie-Rochester conference article, has been instrumental in shifting academic discussions closer to what is practically relevant for central banks. In large part, as a result, a substantial volume of useful research has been generated on how the Federal Reserve does or should set the federal funds rate to achieve and maintain good macroeconomic performance.

In this paper, Taylor goes a step further and examines the mechanics of open market operations and the day-to-day determination of the federal funds rate. The primary objective, once again, is to bring theory and academic discussion closer to practice. The standard textbook treatment of the mechanics of monetary policy implementation suggests that the Federal Reserve may need to perform some open market operations in order to change the federal funds rate. It also abstracts from open market operations when no change in the federal funds rate is desired. In practice, the Federal Reserve performs open market operations almost every day. But contrary to the standard textbook treatment, an open market operation may not be necessary to bring about a change in the intended federal funds rate. Once the Federal Open Market Committee (FOMC) announces a change in its target, market reaction moves the federal funds rate from trading around the old target to trading around the new one, most often without any action beyond the announcement, at least not right away.[1]

Athanasios Orphanides is a member of the research staff at the Board of Governors of the Federal Reserve System.

I read the paper as an attempt to move towards a new textbook treatment of open market operations. It presents a simple model of the supply and demand for reserve balances. The model emphasizes expectations and is capable of explaining how the Federal Reserve appears to be able to change the federal funds rate simply by announcing its target for the rate, that is with "open mouth" operations instead of open market operations. Of course, detailed models of the supply and demand for reserve balances and the determination of the federal funds rate already exist, and Taylor points to some of them. The objective of this paper, in my view, is not to break new ground in developing detailed models. Instead, Taylor tries to distill key features of existing models in a stylized fashion that can serve as a new analytical framework for describing the reserves market. This effort deserves a lot of praise.

The paper begins with a clear summary of institutional features of the federal funds market and examines in some detail the daily differences between the Federal Reserve's target rate and the effective rate at which federal funds are actually traded. There have been a number of changes in these institutional details over the past few years and it is of great value to have a summary such as the one presented by Taylor in one place.

To better understand the need for a new textbook treatment of the reserves market, it is useful to review a couple of pertinent institutional developments that are only briefly mentioned in the paper. Reserves serve two important functions for depository institutions. The traditional use of reserve holdings by depository institutions is to meet reserve requirements. Reserve requirements have historically served a very useful role for implementing policy and have provided the primary motivation for earlier textbook treatments of the reserves market. Reserve requirements must be met on an average basis over a two-week maintenance period that ends every other Wednesday. As a result, they provide some scope for intertemporal substitution and adjustment in the daily demand for reserves that

[1] I follow Taylor's usage of the word "target" for the intended or expected level of the federal funds rate, but note that this usage provides an accurate description of the Committee's intent only in the past few years. The FOMC has made announcements immediately following a change in its policy stance since February 1994, but has explicitly announced changes in the federal funds rate expected to prevail following a policy action only since July 6, 1995. Prior to the 1990s, in particular, identification of the Committee's policy intent with a "target'' for the federal funds rate can be misleading.

Figure 1

Required Reserves and Applied Vault Cash

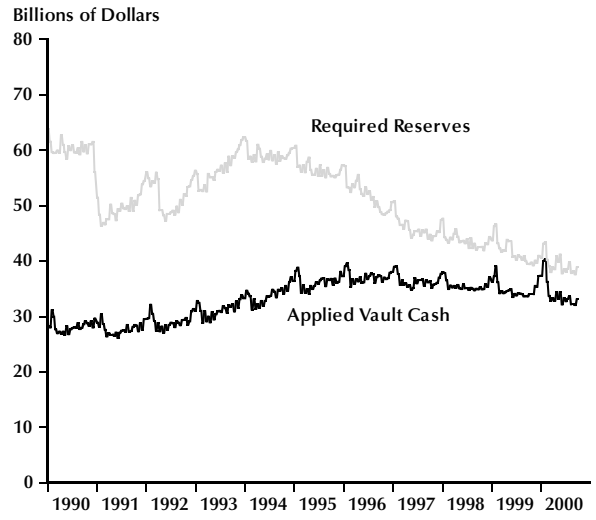
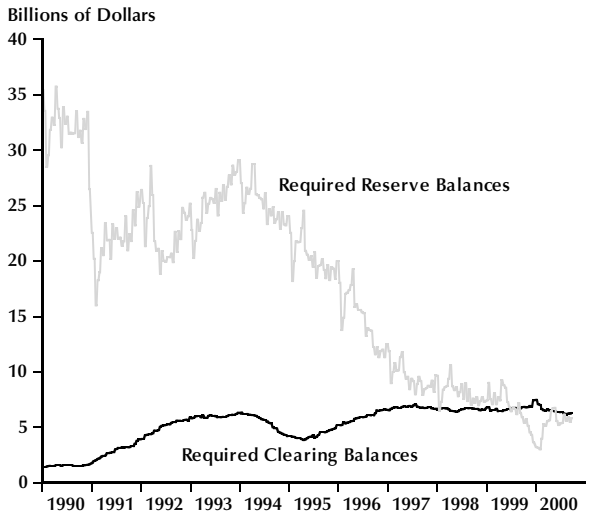


Figure 2

Required Reserve and Clearing Balances



help stabilize the federal funds rate.[2] The potential for this stabilizing role has diminished in the 1990s, however. During this decade, reductions in reserve requirements and improvements in technology that allowed depository institutions to sweep consumer transactions deposits into nonreservable accounts have resulted in significant reductions in required reserves. Depository institutions can meet reserve requirements by holding vault cash and by maintaining reserve balances at the Federal Reserve. As a result of the reductions in reserve requirements, many institutions can now satisfy their reserve requirements with vault cash alone with no need to maintain additional balances at the Federal Reserve. As shown in Figure 1, in the aggregate, the wedge between required reserves and vault cash that can be applied against reserve requirements, has diminished from over $30 billion in 1990 to about $5 billion in 2000.[3] As this wedge represents the amount of required reserve balances that depository institutions must hold at the Federal Reserve against reserve requirements, its significant reduction was one of factors that raised concerns about the potential for volatility in the reserves market over the past several years.[4]

The second, and increasingly more important function of reserve balances held by depository institutions in their accounts at Federal Reserve Banks, is to serve as a buffer against clearing needs. The Federal Reserve strongly discourages overnight overdrafts, which can result if an institution faces a payment order without sufficient funds in its account to cover it when the order is received. As a precaution against such overdrafts, depository institutions choose to maintain some overnight balances with the Federal Reserve even if the balances are not needed for satisfying reserve requirements. This consideration was of much less importance in the past when depository institutions needed to maintain greater required reserve balances as those balances could also serve this precautionary role, when needed. With required reserve balances diminishing, however, the role of such precautionary balances has been amplified.

Maintaining excess reserve balances is costly to depository institutions since these balances earn no interest. One way in which depository institutions can reduce this burden, to some degree, is by establishing so-called required clearing balances with the Federal Reserve. These provide some compensation in the form of credits that can be used to

[2] Carryover provisions that allow some excess reserve holdings in a maintenance period to be counted against requirements in the following (or previous) period ensure that some intertemporal substitution is possible across maintenance periods as well.

[3] Vault cash held in excess of reserve requirements is not counted as part of aggregate reserves as it cannot be used to meet reserve requirements. The applied vault cash series shown in Figure 1 does not include this surplus. Maintenance period averages are shown.

[4] See Clouse and Elmendorf (1997) and Bennett and Hilton (1997).

pay for Federal Reserve priced services. During the 1990s, depository institutions have negotiated higher levels of clearing balances and these balances have become much more important than they had been in providing a predictable demand for the total reserves that the Federal Reserve needs to supply through open market operations to achieve its federal funds target. As can be seen in Figure 2, as of 2000, required clearing balances have in fact surpassed required reserve balances. Despite the increase in required clearing balances, however, the total of required reserve balances and required clearing balances has been falling during the 1990s. With required balances falling, the Federal Reserve has been concerned that it may become more difficult to determine each morning the appropriate daily quantity of reserves to supply to the market, especially on days with increased clearing activity when the precautionary demand for reserve balances may rise significantly relative to other days. In light of these concerns, the Federal Reserve has taken some measures to foster stability and help reduce volatility in the federal funds market and this is the reason for some of the recent institutional changes surveyed in the paper. As confirmed by the detailed discussion in the paper, the Open Market Desk (the Desk) has not experienced difficulties implementing monetary policy in recent years, suggesting that these steps have been successful.

Taylor presents a disarmingly simple model for the supply and demand of reserve balances. The demand for reserve balances is

$$b_t = -\alpha\left(r_t - \gamma E_t r_{t+1}\right) + \varepsilon_t,$$

and the supply for reserve balances (Desk reaction function) is

$$b_t = b_{t-1} + \beta\left(r_{t-1} - \rho_{t-1}\right).$$

Here b_t is the supply of reserve balances, r_t is the daily effective federal funds rate, and ρ_t is the target federal funds rate, all on day t.

Concentrating first on demand, the theoretical background is provided by work on the management of reserves in a stochastic environment.[5] To motivate Taylor's specification of the demand function, I prefer to consider separately two implications for the daily management of reserves that arise from the two key functions of reserves mentioned earlier.

The first is the desire and ability to arbitrage at least some of the demand for reserve balances across days. To meet an average reserve requirement over a two-week maintenance period, for example, it does not matter much whether a depository institution holds the reserves on day t or day $t+1$. If the rate on federal funds is expected to fall tomorrow, demand for reserves will fall today. Thus, the demand for reserves will be decreasing in the spread, $r_t - E_t r_{t+1}$. The ability to intertemporally substitute reserve holdings across time is limited, of course, and consequently the elasticity of demand with respect to this spread between the rate at t and the expected rate at $t+1$ cannot be infinite. This reasoning implies that the parameter α in the demand equation is finite, as Taylor posits. The same motivation suggests that this elasticity should also be present in another margin available to depository institutions for reserve management, namely discount window borrowing. When reserve holdings are expensive relative to their expected cost in subsequent days, depository institutions will be more willing to resort to the discount window when they face a shortfall in their reserve positions. Indeed, Hanes (2000) presents convincing empirical evidence for this mechanism, which lends support on this aspect of Taylor's simple demand specification.

The second motive relevant for the daily demand equation is the precautionary motive to hold reserves for clearing needs—particularly towards the end of the day after the closing of the FedWire. Since excess reserve holdings reduce the probability of costly overnight overdrafts, their demand is akin to the demand for insurance, with the usual implication that more insurance will be purchased when its price is relatively lower. This suggests that, other things equal, the precautionary demand for reserves is somewhat inversely related to the cost of holding reserves, that is, today's rate, r_t.

Combined, the two motives suggest a demand equation:

$$b_t = -\theta\left(r_t - E_t r_{t-1}\right) - \delta r_t + \varepsilon_t,$$

with $\theta, \delta > 0$. Trivially, this collapses to Taylor's equation and also satisfies his imposed restriction that the partial elasticity with respect to today's rate, $\alpha = \theta + \delta$, is somewhat greater that the partial elasticity with respect to the expectation of tomorrow's rate, $\alpha\gamma = \theta$.

My reaction to the demand function as a text-

[5] This is based on the intuition from the work Taylor reviews, though similar features are also present in other recent work, such as Bartolini, Bertola, and Prati (2000), Clouse and Dow (2000), and Hanes (2000). The grandparent of research on reserve management in a stochastic environment, of course, is Bill Poole's 1968 classic.

book treatment of the demand for reserves is very positive. It is elegant. It nicely captures the element that appears important for understanding "open mouth" operations—namely, the expectation of tomorrow's rate. And it abstracts from a number of elements that, although they may be important, are not essential for understanding the market at an elementary level.

I am afraid I cannot be as positive for the second key equation in Taylor's model, regarding the supply of reserves. Taylor models the Desk's operations as a mechanical reaction function that relies exclusively on the previous day's miss of the effective federal funds rate from the Desk's target rate to guide open market operations in the morning of the current day. As motivation, Taylor suggests that effective implementation of monetary policy in this model requires credibility that the Desk will do its best to achieve the FOMC's target for the federal funds rate. This credibility, Taylor argues, can be achieved if the Desk follows a simple mechanical reaction function such as the one he posits.

To be clear, I agree with Taylor's motivation. Effective implementation of monetary policy, when the daily demand for reserves is sensitive to expectations regarding the federal funds rate on subsequent days, requires a credible commitment that the Desk will do its best to achieve the FOMC's target rate for federal funds, thereby stabilizing expectations for the federal funds rate on subsequent days. However, I do not find the reaction function Taylor posits consistent with this motivation. Taylor's mechanical reaction function is far from the best way to achieve the Desk's objective. It is also a rather poor description of what the Desk actually does.

To evaluate Taylor's Trading Desk reaction function as a description of Desk operations and contrast it with possible alternatives, it is useful to examine how the members of the Markets Group at the Federal Reserve Bank of New York (the people behind the Desk) have described the Desk's operations in the recent past. A useful source for this is the annual report of open market operations prepared by the Markets Group. For example, the second paragraph on the first page of the report for 1997 states[6]:

> The Committee's directives instruct the Trading Desk to maintain the federal funds rate on average around a specified level. Open market operations are used to provide a level of nonborrowed reserves that will allow the federal funds market to clear at the indicated level. Each day, the Desk aims to keep the rate as close to the targeted level as possible with a minimum of volatility. But in deciding each day's operations, the Desk also considers how its flexibility for arranging operations in upcoming days might be affected by that day's course of action as well as how the behavior of the funds rate that day might influence rates in subsequent days.

In stark contrast to the emphasis on outcomes during the previous day in Taylor's Trading Desk reaction function, this description points towards a forward looking approach to Desk operations and indicates that in selecting its early morning open market operation the Desk "*each day*…aims to keep the rate as close to the targeted level as possible with a minimum of volatility" (emphasis added). The description also suggests alternatives to Taylor's Trading Desk reaction function that could arguably offer better characterizations of the Desk's operations. For instance, one could simply posit that the Desk sets the supply of reserves each morning so that the effective rate during the day is expected to be as close as possible to the target rate. Letting E_{t_m} reflect the expectation operator with information available in early morning of day t, t_m, this suggests a supply function implicitly determined by the expectation

$$E_{t_m} r_t = \rho_{t_m}$$

and market clearing conditions. This characterization offers considerable and realistic flexibility. For instance, it recognizes that each morning the Desk takes account of anticipated variations in the daily demand and supply of reserves from normal patterns and attempts to offset known shocks that may be expected to influence the market during the day.[7]

To appreciate the Desk's task and its approach in performing daily operations, it is instructive to

[6] Similar paragraphs appear in the reports for 1998 and 1999 as well.

[7] On the other hand, this is also somewhat simplistic as it ignores the influence of the choice of operations during one day on the degree of success with which the Desk could achieve its target on subsequent days—a consideration suggested in the last sentence of the quoted paragraph. One implication alluded to in this sentence is that the Desk might opt for an operation consistent with an expected deviation of the federal funds rate from its target during a day if doing so could be expected to significantly reduce the likely volatility of the federal funds rate on subsequent days. (Footnote 11 offers one example where such considerations may have been relevant in early 2000.)

revisit Taylor's detailed analysis of recent policy changes. The analysis suggests that the Desk has been quite successful in implementing changes in the federal funds rate in the recent past. Federal funds have traded close to the new rate virtually immediately following a change in policy. And trading has tended to closely reflect the old rate before a change in policy.

One feature *not* emphasized in the paper, which I believe is important for the analysis, is that this has been the case even though a policy move may have been expected with high probability by market participants. For example, *it is not the case* if market participants expect a tightening on, say, Tuesday, that this tightening is reflected in trading a week earlier. This would be inconsistent with the Desk's objectives and Desk operations would actively seek to counteract it.[8]

To see this, in Figure 3 I reproduced the effective and target rates shown in Taylor's paper for the last three policy moves: February 2, March 21, and May 16, 2000.[9] On these series I superimposed the rate on the federal funds futures contract for February, April, and June, respectively. These months correspond, as closely as possible but obviously not perfectly, to the month following the FOMC meeting at which each tightening was decided but preceding the subsequent FOMC meeting. For each move, the figure shows four weeks of business-daily data centered around the two-week reserve maintenance period during which the policy move occurred. (The two vertical lines in each panel indicate maintenance-period ending Wednesdays.)

Consider first the March 21, 2000, policy move shown in the middle panel. The federal funds future contract for April 2000 can be viewed as a bet on the average level of the federal funds rate that the market expected to prevail during April 2000. But since no FOMC meeting was scheduled during April, it would be reasonable to expect that the FOMC's target rate during April would be the one decided during the March meeting. Thus, the rate implied in the April contract on any given day prior to the March meeting reflected market expectations of the FOMC decision at that meeting.

As can be seen, the April contract was consistently trading around 6 percent for weeks before the March meeting and on this occasion correctly anticipated the move to a 6 percent target rate that was decided at the meeting. At the same time, the effective rate on federal funds remained around 5.75 percent and one could not possibly detect the market's near certain expectation of the policy change in that rate prior to the policy move.

Likewise, with the May policy move (lower panel), trading of the June 2000 futures contract suggested that the 50 basis points increase in the target rate was widely anticipated before it materialized, though a small probability that the increase could be only 25 basis points appears to have been priced in the contract until just prior to the meeting.[10]

Similarly, with the February policy move (top panel), the futures contract for February anticipated that a tightening would likely take place on February 2. The contract traded consistently somewhat above 5.75 percent prior to the meeting, suggesting that although the 25 basis points tightening that took place was considered the most likely decision, a small probability of a 50 basis points tightening was also priced in the contract.[11]

Daily tracking of the FOMC's target rate, during a maintenance period when a change in the target is anticipated, poses special challenges for Desk operations as efforts by depository institutions to

---

[8] In general, the behavior of the federal funds rate during days preceding an FOMC meeting primarily reflects the Desk's constant efforts to track its target and is a rather poor indicator of market beliefs regarding the likelihood of a policy change at the meeting. One consequence of this is that Granger causality tests, such as those reported in Table 2 of the paper, are not particularly informative.

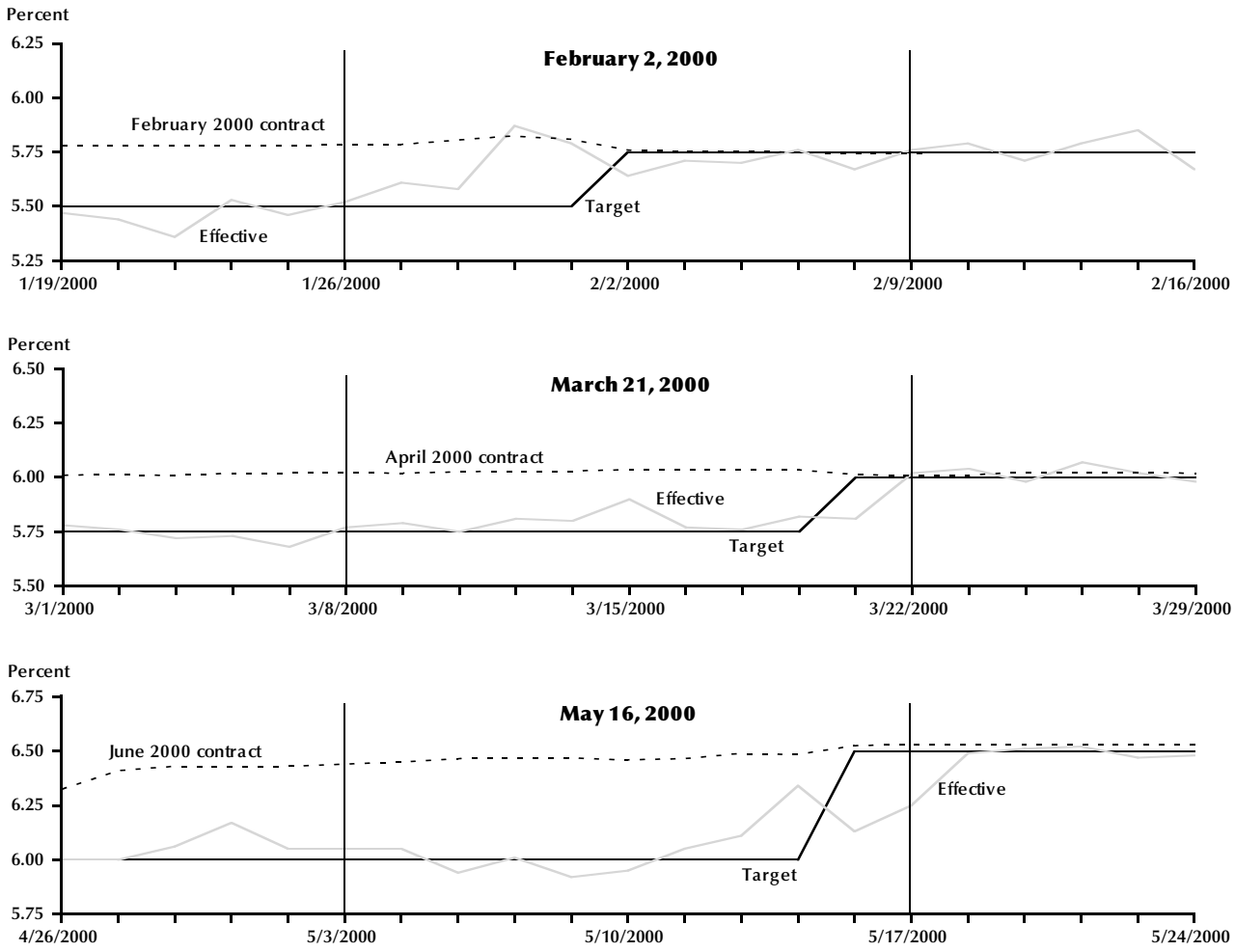
[9] These were the first three meetings of 2000. The federal funds rate target was left unchanged following the fourth meeting of the year, which took place June 27-28.

[10] The next policy decision was scheduled for June 28 (the second day of the June 27-28 FOMC meeting). As a result, the June contract could be roughly interpreted as a weighted average of the May decision (28/30 of the contract) and the June decision (2/30 of the contract). The fact that the contract for June traded a bit above 6.5 percent following the May meeting reflected the influence of expectations of another possible tightening move at the end of June.

[11] Unlike in March and May, the effective federal funds rate prior to the February 2 tightening, on Monday, January 31 and Tuesday, February 1, was significantly higher than the target and closer to the expected rate following the policy action. As is clear from the data, however, this did not reflect a major change in expectations regarding the tightening from the previous Friday, January 28. One explanation of the higher rates on January 31 and February 1 is larger than expected increases in the demand for reserves associated with the greater clearing needs often seen on the first and last day of a month. Another (and complementary) explanation is that, although the Desk may have correctly perceived the increase in demand during those days, it may have been reluctant to fully counteract it because doing so might have raised the volatility of the market on subsequent days. (This is the possibility raised in footnote 7). Such a concern may arise when the Desk perceives that adding the level of reserves required to keep the rate close to its target early in a maintenance period may significantly reduce the need for reserve balances later during the same period. The combination of end-of-month and expected tightening pressures just prior to the February 2 move could have justified such a concern on this occasion.

Figure 3

Federal Funds Rate and Futures Contracts

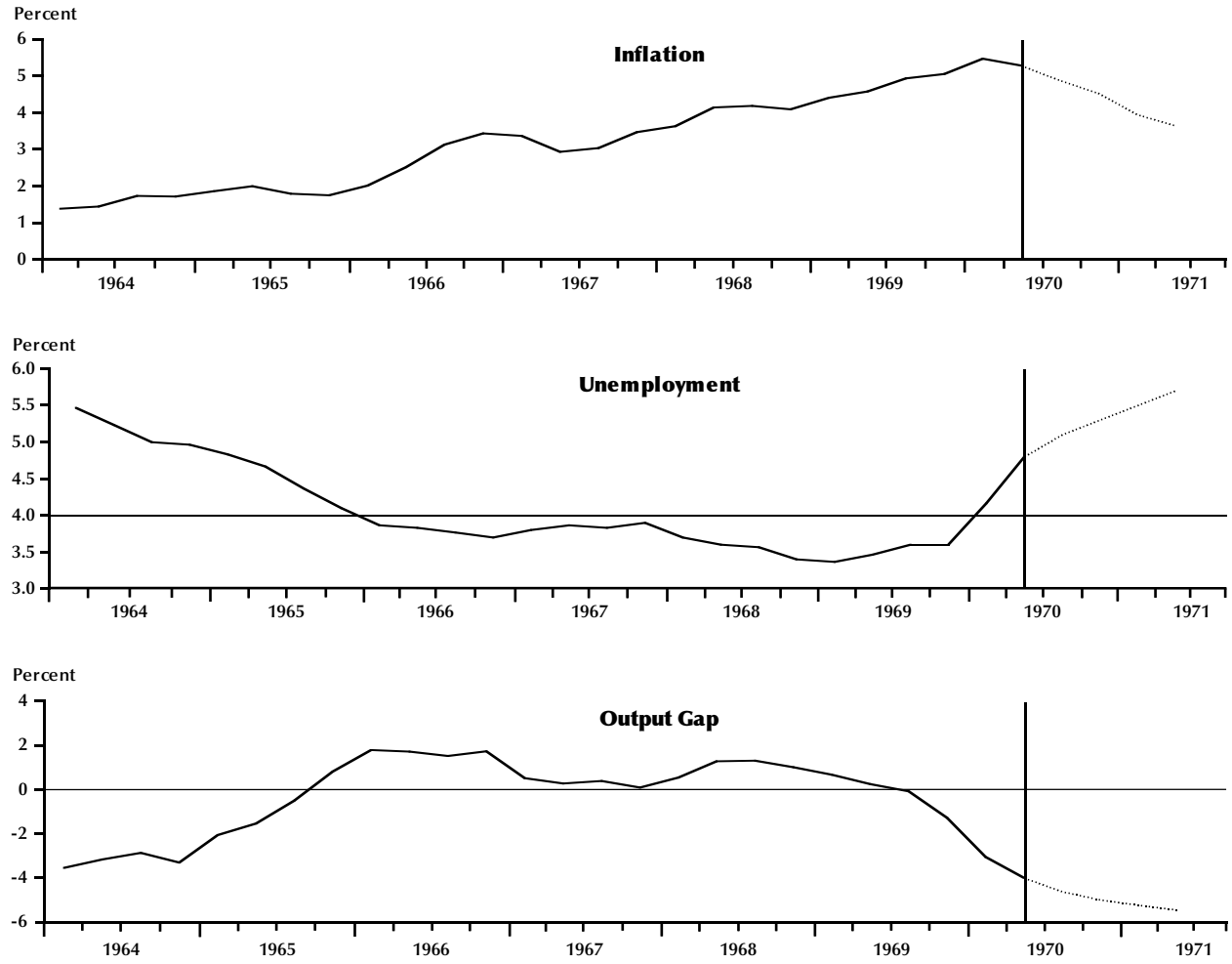


economize their cost of maintaining average reserve balances during the period tend to distort the normal daily intra-period pattern of reserve demand. Obviously, assessment of such relative changes in intra-period demand can be quite difficult and likely not very accurate. Viewed in this light, the apparent success of the Desk in tracking the FOMC's target relatively closely around the three anticipated tightenings, shown in Figure 3, offers a striking illustration of the Desk's credibility and its ability to adjust reserves on a daily basis to achieve its objective.

Similar success would have been unlikely had the Desk implemented policy by mechanically reacting to the previous day's miss of the effective federal funds rate from the Desk's target. Of course, to the extent the previous day's miss, $(r_{t-1}-\rho_{t-1})$, is an important summary statistic of stochastic supply and demand conditions that might influence the market on day t, it might be useful for determining the appropriate open market operation during day t. The previous day's miss could sometimes summarize information regarding demand and supply shocks that influenced the market during day t–1, and some of these shocks might persist during day t. In this sense, the previous day's miss is part of the information set the Desk employs in determining its operation during day t. As with any other variable that might provide useful information about market conditions, a response to this miss could be included in a mechanical reaction function for the Desk. The

Figure 4

Data and Forecasts at the August 1970 FOMC Meeting



difficulty is that not all variables are always equally useful as indicators. Statistical relationships change over time and so do our perceptions about such relationships and their usefulness for the future. Consequently it is practically impossible for a simple mechanical reaction function to reasonably capture the appropriate reaction at all times. And suggesting that the Desk follow a specific simple backward-looking rule at all times could quickly prove inadequate as a guide.

There are parallels to this and the analysis of how the FOMC should set its target for the federal funds rate to achieve its objectives of price stability and maximum sustainable growth over time (although the Committee's problem is arguably much more complex). The FOMC could follow a simple rule and adjust the interest rate mechanically to past inflation, for example. When inflation picks up, the rate could be raised and vice versa. This strategy could achieve price stability and reasonably stable growth on average, but it is unnecessarily crude and would leave scope for improvement. Allowing for judgment and flexibility in policy decisions is one approach. Alternatively, one could try to suggest an "improved" policy rule, specify that the FOMC follow a rule that mechanically reacts to the output gap or its close cousin, the unemployment gap, in addition to inflation. Indeed, as Taylor points out in footnote 12 of his paper, some modern research has emphasized that such a response may

be optimal. Perhaps the best-known example of such a rule is the one Taylor proposed in his 1993 Carnegie-Rochester conference article. As Taylor showed at the time, this rule described policy in the late 1980s and early 1990s rather well. This period was one in which monetary policy is generally believed to have been successful, so one could conclude that this rule would have provided reasonable guidance to monetary policy during that time. But there is no guarantee that the same rule would have provided good advice in other settings. Indeed, as shown in Orphanides (2000), the very same rule also appears to describe monetary policy during the early 1970s, a period during which monetary policy is generally considered to have been much less successful—if not outright disastrous.

Since this conference is in honor of Darryl Francis, I think it is most appropriate to illustrate what can go wrong with an example from a fascinating FOMC meeting in which he participated as a voting member, on August 18, 1970. To set the stage, recall that a recession earlier that year had shifted policy towards ease, while inflation, which had risen in the previous two years, remained a serious concern. This was the first of the "stagflation" years in the United States. By the August FOMC meeting, available data indicated a small increase in second quarter gross national product (GNP), suggesting the economy was turning around. However, the unemployment rate had risen to nearly 5 percent and Federal Reserve staff projected a further increase, well above the widely held at the time 4 percent estimate of the natural rate of unemployment. Similarly, available estimates of the output gap showed a continued deterioration. And it appeared quite reasonable to expect an improvement to the inflationary problem.[12] Based on this information, application of the Taylor rule would have suggested that a further policy easing was appropriate. Indeed a policy easing was adopted at the meeting and policy remained easy (and broadly consistent with the Taylor rule) for several quarters.

Darryl Francis dissented at this meeting. In his view, easing policy further would have been a mistake. His words, as reflected in the Memorandum of Discussion (1970) for the meeting, would prove prophetic:

> Mr Francis said that much of the current unemployment was structural and could not be obviated except temporarily and with adverse price effects by stimulation of total spending. In view of the strong inflationary actions, quick results in obtaining relatively stable prices and a reduction of transitional unemployment should not be expected. Attempts directed at rapid cures or fine tuning had usually caused more serious problems later on.

Mechanical reliance and response to past data always runs the risk of providing misleading advice at times, however well intentioned the design of a simple rule may be. For Desk operations, it is unnecessarily crude to adopt such a mechanical rule for determining daily open market operations each morning. So in my view, there is scope for improvement in the half of Taylor's model that deals with the daily supply of reserves. But the other half of the model could hardly be more elegant as a description of the daily demand for reserves. Overall, this is a very valuable paper to read.

[12] Quarterly historical data and staff projections for inflation (measured as the percent change in the GNP deflator over four quarters), unemployment, and the output gap as available at the meeting are shown in Figure 4. The vertical lines in the figure identify the last quarter of available historical data, 1970:Q2.

REFERENCES

Bartolini, Leonardo; Bertola, Giuseppe and Prati, Allessandro. "Bank's Reserve Management, Transaction Costs, and the Timing of Federal Reserve Intervention." Federal Reserve Bank of New York *Staff Report 109*, September 2000.

Bennett, Paul and Hilton, Spence. "Falling Reserve Balances and the Federal Funds Rate." Federal Reserve Bank of New York *Current Issues in Economics and Finance*, April 1997, *3*(5), pp. 1-6.

Clouse, James A. and Dow, James. "A Computational Model of Bank's Optimal Reserve Management Policy." Working Paper, February 2000.

Clouse, James A. and Elmendorf, Douglas W. "Declining Required Reserves and the Volatility of the Federal Funds Rate." Finance and Economics Discussion Series, 1997-30, Federal Reserve Board, June 1997.

Federal Open Market Committee. *Memorandum of Discussion*. Federal Reserve Board, August 1970.

Federal Reserve Bank of New York, Markets Group. "Open Market Operations During 1997." Federal Reserve Bank of New York, 1998.

Hanes, Christopher. "Open-Mouth Operations and the Disappearance of the Borrowing Function." Working Paper, November 2000.

Orphanides, Athanasios. "Activist Stabilization Policy and Inflation: The Taylor Rule in the 1970s." Finance and Economics Discussion Series, 2000-13, Federal Reserve Board, February 2000.

Poole, William. "Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy." *Journal of Finance*, December 1968, *23*(5), pp. 769-91.

Taylor, John B. "Discretion Versus Policy Rules in Practice." Carnegie-Rochester Conference Series on Public Policy, December 1993, *39*, pp. 195-214.