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MONETARY POLICY, SECRECY, AND FEDERAL
FUNDS RATE BEHAVIOR

by

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ABSTRACT:

The behavior of the Federal Reserve System can be characterized as
secretive with respect to its control of monetary aggregates. One
common justification for this secrecy is that markets will overreact
to information, causing undue variability in interest rates.
However, the consequences of keeping policy objectives hidden has
received little formal attention. This paper takes an initial step
by examining the variability of the federal funds rate and total
reserves under nonborrowed reserve targeting. The major result is
that the disclosure of operating procedures will generally increase
the unconditional variability of both the funds rate and total
reserves, but will decrease the variance of the forecasting error
of the federal funds rate.

The behavior of the Federal Reserve System can be characterized as secretive with respect to its control of monetary aggregates. Specifically, under various reserve targeting procedures, the Fed does not announce its total reserve paths, borrowed reserve assumptions, or nonborrowed reserve paths. Also, under a regime of federal funds rate targeting, the Fed does not announce its funds rate objectives. One common justification for this secrecy is that markets will overreact to information, causing undue variability in interest rates.[1] However, the consequences of keeping policy objectives hidden has received little formal attention.[2] For evaluating the desirability of this policy one needs to know how the distribution of output, prices, and interest rates varies under various money supply rules and different information sets.[3]

This paper takes an initial step in this direction by examining the variability of the federal funds rate and total reserves under nonborrowed reserve targeting and different information sets. Although the Fed has currently moved away from using nonborrowed reserves as an instrument, a nonborrowed reserve targeting scheme is useful in examining the effects of releasing information. Accordingly, the analysis focuses on the effects of announcing the total reserve path and the borrowing assumption on the behavior of the funds rate and total reserves. The proceeding analysis should be regarded as an investigation of the effects of secrecy on the behavior of the federal funds rate. A nonborrowed reserve targeting regime is used merely to highlight what appears to be a general property; that secrecy can reduce the unconditional variability of the funds rate and total reserves, but increase the variance of the federal funds rate forecast error.

The paper concentrates on the behavior of the federal funds rate since there is a good deal of evidence that this is an important variable in the Fed's objective function. Total reserves are also examined since the behavior of money has important implications in many macro models and the Federal Reserve also places some weight on monetary behavior. In order to perform the analysis, a model of the funds rate under a regime of nonborrowed reserve targeting is developed. The model is constructed to capture the essential features of nonborrowed reserve targeting, as it was employed in post-October, 1979. The only departure from the modelling of actual procedures is the use of contemporaneous reserve requirements (CRR) rather than lagged reserve requirements (LRR). This is done for both mathematical convenience and to make the analysis correspond to current regulations. The use of CRR does not change the essential aspects of the paper.

The organization of the paper is as follows. Section 2 gives a brief discussion providing evidence that the Federal Reserve is concerned with the unconditional variance of the funds rate and that this concern is related to secrecy regarding the Domestic Policy Directive. Section 3 describes funds rate behavior under CRR and nonborrowed reserve targeting. Section 4 discusses the solution of the model under different information sets and examines the conditional variance of both the funds rate and total reserves. Section 5 considers the behavior of the unconditional variance of the funds rate and total reserves, while Section 6 contains a summary and some possible extensions.

2. The Relationship Between Secrecy and the
   Unconditional Variance of the Funds Rate

Some of the motivation for Federal Reserve secrecy with respect to operating procedures can be linked with concern for the unconditional variance of the funds rate. A detailed analysis of the Fed's desire for secrecy can be found

in Goodfriend (1984b) and the discussion in this section is largely drawn from the portions of that paper which are relevant to the ensuing analysis. The primary source containing the Federal Reserve's arguments for secrecy is the Federal Reserve's defense in the case of Merrill vs. FOMC.

The relevant portions of that defense are those contained under Goodfriend's category (5), which addresses the question of interest rate smoothing. In this area, the Federal Reserve basically argued that the release of information concerning the operating procedures used in conducting monetary policy would make interest rates more variable. This is clearly indicated by two of the attorneys' statements, statements that are based on an affidavit by Governor Partee (see Goodfriend (1984, p. 24)). The attorneys stated that "One reason why the FOMC seeks to keep its directive secret is to prevent wild short-term swings in interest rates." The attorneys also argued, "To the extent that different conclusions are drawn about the FOMC's short-term policy from differing interpretations of the significance of the Manager's actions, there is a buffering force which moderates the reaction of the market to perceived changes in FOMC policy. . . ."

A reasonable interpretation of both statements suggests that the Federal Reserve is concerned with the variance of interest rates and that this variance can be reduced by withholding information from the marketplace. It also appears that the Federal Reserve is concerned with the behavior of interest rates per se and not on errors in forecasts. This implies that the unconditional variance of the funds rate is important to the Fed and that the decision to withhold certain pieces of information is linked to this unconditional variance.

3. The Model

3a. Fed behavior

The model developed in this section is based on the procedures used in post-October, 1979 with appropriate modification for the use of CRR. Under nonborrowed reserve targeting, the Federal Reserve sets a path for nonborrowed reserves that is consistent with desired growth in the monetary aggregates. This is done by first calculating a required reserve path that is consistent with the desired level of money growth and then adding an estimate of excess reserves to arrive at a target for total reserves. The mix of total reserves between borrowed and nonborrowed reserves is obtained by subtracting off a borrowed reserve assumption.[4] This yields an average level of nonborrowed reserves to be supplied by the Desk over an intermeeting period. (An inter-meeting period is the period between FOMC meetings.)

If money begins to grow too fast, the Fed reacts by forcing more discount window borrowing. This places upward pressure on the funds rate, slowing the growth in money. However, the Federal Reserve generally accommodates some of the increased reserve demand and only attempts to bring money back on path gradually.[5] The nonborrowed reserve supply rule given in (1) captures these essential features of nonborrowed reserve targeting.

$$(1) \quad NBR_t^s = -BR_t^* + E_t^F TR_t^d - n(E_t^F TR_t^d - TR_t^*) + u_t$$

Notationally, NBR, BR, and TR are nonborrowed, borrowed, and total reserves, respectively. E_t^F indicates the expectation of the Federal Reserve conditioned on information it possesses at time t and u_t is a disturbance term incorporating other factors (such as float and Treasury balances) that affect nonborrowed reserves. The superscripts s and d indicate supply and demand, respectively, while "*" denotes a targeted level.

Equation (1) states that the Fed supplies nonborrowed reserves equal to
its expectation of total reserve demand minus a borrowing assumption and minus
an amount that is sensitive to the expected deviation in total reserves from
path. An extreme form of this rule occurs when n = 1. In this case the Fed
does not respond to deviations in money from target gradually, but supplies
nonborrowed reserves based solely on its borrowing assumption and its total
reserve target (i.e., $NBR_t^s = -BR_t^* + TR_t^*$).

3b. Bank behavior

The demand for total reserves is given by

$$(2) \quad TR_t^d = a_0 - a_1 i_{f,t} + tr_t + ER_t^d$$

where $i_{f,t}$ is the federal funds rate, tr_t is a random disturbance and ER_t^d is
the demand for excess reserves. This formulation explicitly ignores any
effects of income other than random disturbances that may be incorporated into
tr_t. Further, this formulation also eliminates any discussion of the relation-
ship between the funds rate and other interest rates as well as any direct
linkage between the funds market and economic activity.[6] While an examination
of the effects of information dissemination on output and prices is of
considerable interest, analytical considerations make concentrating on weekly
funds rate variability an attractive initial step in exploring the effects
of secrecy.

The demand for borrowed reserves is expressed as

$$(3) \quad BR_t^d = b_0 + b_1(i_{f,t} - i_{d,t}) - b_2(E_t i_{f,t+1} - E_t i_{d,t+1}) - b_3 BR_{t-1} + br_t$$

where $i_{d,t}$ is the rate charged on discount window borrowing and br_t is a
random shock to borrowed reserves demand perhaps induced by an increase in

currency demand. E_t indicates the expectation of a variable conditioned on the information set of banks at date t.[7] Equation (3) is motivated by the work of Goodfriend (1983) in which a bank's demand for discount window borrowing originates from an intertemporal maximization of profits. Banks attempt to borrow from the discount window when the spread between the funds and the discount rate is relatively high. This behavior is a consequence of the non-price rationing scheme used by the discount window, in which banks can only take advantage of their borrowing privilege a certain number of times in any quarter and face an increasing marginal cost with respect to the amount borrowed. Therefore, past borrowing behavior and current and expected spreads will be important components of the decision to borrow.

The demand for nonborrowed reserves can be expressed by subtracting (3) from (2). This yields

$$(4) \quad NBR_t^d = TR_t^d - b_0 - b_1(i_{f,t} - i_{d,t}) + b_2(E_t i_{f,t+1} - E_t i_{d,t+1}) + b_3 BR_{t-1} - br_t.$$

3c. Equilibrium in the funds market

The equilibrium level of the funds rate can be calculated by equating (1) and (4). The funds rate is given by

$$(5) \quad i_{f,t} = \frac{1}{b_1}[R_t^* - b_0 + (TR_t^d - E_t^F TR_t^d) + nE_t^F TR_t^d + b_3 BR_{t-1} + b_1 i_{d,t} - b_2 E_t i_{d,t+1}$$
$$+ b_2 E_t i_{f,t+1} - u_t - br_t]$$

where

$$R_t^* \equiv BR_t^* - nTR_t^*$$

is a convenient expression summarizing changes in monetary policy under nonborrowed reserve targeting. Equation (5) is not strictly a reduced

form solution since it contains the endogenous expectations terms $E_t^F TR_t^d$, $E_t i_{f,t+1}$, and $E_t i_{d,t+1}$. To simplify the forthcoming analysis both ER_t^d and u_t are assumed to be zero.[8] Also, to avoid dealing with the effects of incorporating forecasting the forecasts of others (see Townsend (1983)), it is assumed that $E_t^F TR_t^d = TR_t^d$.[9]

Using the preceding assumptions and equation (2), (5) may be rewritten as

$$(6) \quad i_{f,t} = \frac{1}{b_1 + na_1} [(na_0 - b_0) + R_t^* + b_3 BR_{t-1} + b_1 i_{d,t} - b_2 E_t i_{d,t+1} + b_2 E_t i_{f,t+1} + ntr_t - br_t].$$

Equation (6) may be interpreted graphically for the case where $n = 1$[10] (figure 1). The amount of reserves demanded is determined by the demand for money and is negatively related to the funds rate. The amount of reserves supplied is given by the sum of nonborrowed reserves plus frictional borrowing[11] and the amount of reserves borrowed from the discount window. For $n = 1$, nonborrowed reserves are unaffected by the funds rate, while borrowed reserves are positively related to the funds rate. At levels of the funds rate below the discount rate, only frictional borrowing occurs. The level of the funds rate that equilibrates the reserves market is $i_{f,t}^o$.

An increase in the level of frictional borrowing or a positive shock to borrowed reserves demand shifts the $NBR_t^s + BR_t^d$ rightward lowering the equilibrium value of the funds rate. Also, an increase in the past history of borrowings summarized by BR_{t-1} or an increase in the expected value of next period's spread between the funds and discount rates shifts the borrowed reserve demand portion of $NBR_t^s + BR_t^d$ leftward, raising the equilibrium level of the funds rate. That is, both types of changes result in a decrease in the demand for borrowed reserves at any given funds rate. A decrease in the discount rate lowers the
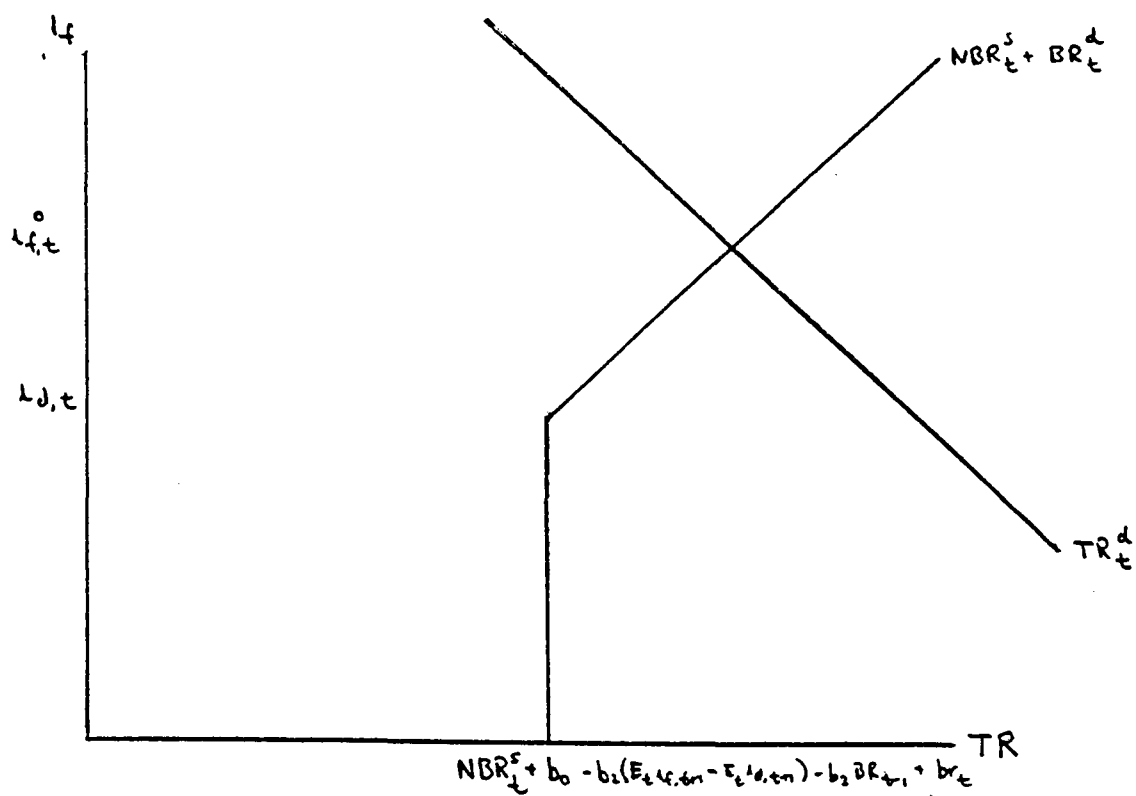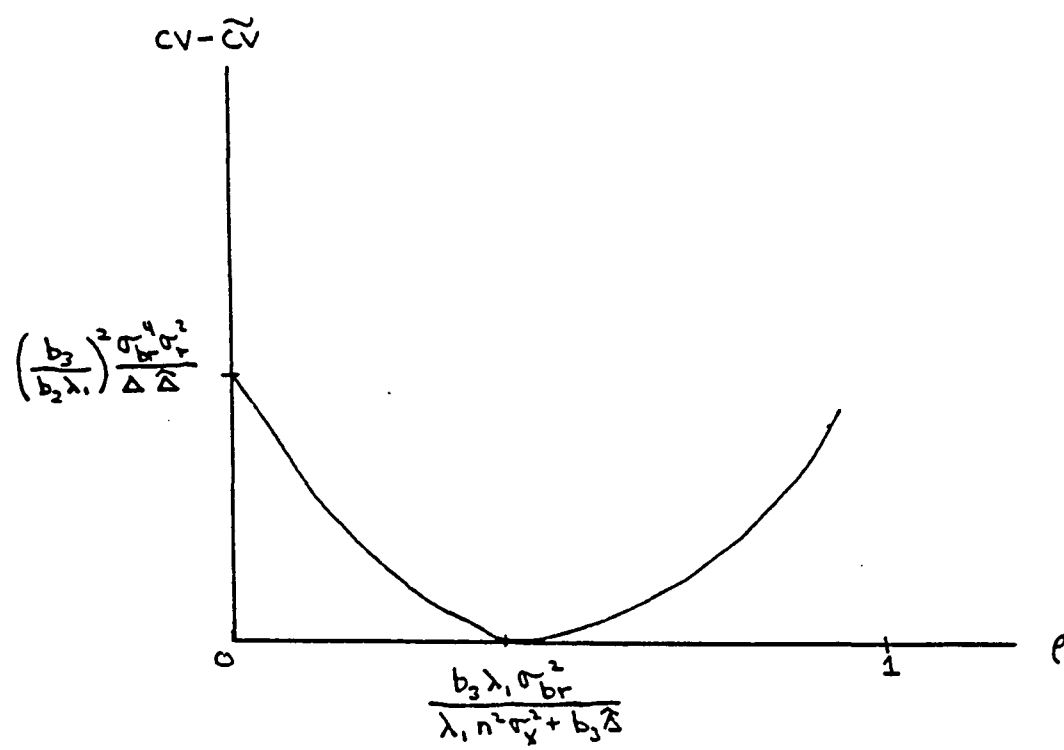
figure 1

figure 2

position of the BR_t^d portion of $NBR_t^s + BR_t^d$ and lowers the equilibrium value of the funds rate, while an increase in total reserve demand (a_0 or tr_t) raises the equilibrium value of the funds rate.

Using the equilibrium condition that $BR_{t-1} = TR_{t-1} - NBR_{t-1} = R_{t-1}^* + nTR_{t-1} = R_{t-1}^* + na_0 - na_1 i_{f,t-1} + ntr_{t-1}$, equation (6) can be written as a second order difference equation. Following the procedures outlined in Sargent (1979), along with considerable algebra (see appendix), the reduced form equation for the funds rate can be expressed as

$$(7) \quad i_{f,t} = \frac{b_0\lambda_1 - na_0(\lambda_1 + b_3)}{(1 - \lambda_1)b_2\lambda_1} + \frac{b_3}{b_2\lambda_1} BR_{t-1} + \frac{\lambda_1 + b_3}{b_2\lambda_1^2} R_t^*$$

$$- \frac{b_3}{b_2\lambda^2}(R_t^* - E_t R_t^*) + \frac{\lambda_1 + b_3}{b_2\lambda_1^3} \sum_{j=0}^{\infty} (\frac{1}{\lambda_1})^j E_t R_{t+j+1}^* + \frac{b_1}{b_2\lambda_1} i_{d,t}$$

$$+ \frac{b_1 - b_2\lambda_1}{b_2\lambda_1^2} \sum_{j=0}^{\infty} (\frac{1}{\lambda_1})^j E_t i_{d,t+j+1} + \frac{n(\lambda_1 + b_3)}{b_2\lambda_1^2} tr_t - \frac{nb_3}{b_2\lambda_1^2}(tr_t - E_t tr_t)$$

$$+ \frac{n(\lambda_1 + b_3)}{b_2\lambda_1^3} \sum_{j=0}^{\infty} (\frac{1}{\lambda_1})^j E_t tr_{t+j+1} - \frac{1}{b_2\lambda_1} br_t - \frac{1}{b_2\lambda_1^2} \sum_{j=0}^{\infty} (\frac{1}{\lambda_1})^j E_t br_{t+j+1}$$

where λ_1 is one of the roots of the difference equation and is greater than unity. The current funds rate is therefore a function of the paths and expected paths of all the relevant exogenous variables over time.

With respect to current and past variables, it is observed that an increase in "forced borrowing," BR_t^*, raises the funds rate as does a decrease in the targeted level of total reserves TR_t^* (recall $R_t^* = BR_t^* - nTR_t^*$). Also, an increase in last period's borrowing, because it increases the demand for nonborrowed reserves raises the funds rate as does an increase in the current discount rate. Also, an increase in borrowing through movements in b_0 or br_t cause the demand

for nonborrowed reserves and the funds rate to decline, while increases in the demand for total reserves through movements in a_0 or tr_t cause the funds rate to rise.

One also observes that increases in expected future levels of the borrowing assumption or decreases in the expected future path of targeted total reserves result in a higher current funds rate. This occurs because these shifts indicate a decline in future nonborrowed reserves supplied and hence a higher expected future funds rate. This implies that banks will postpone borrowing to the future, reducing current borrowing and raising this period's demand for nonborrowed reserves. Thus the current funds rate rises.[12] Similarly increases in expected future money demand or decreases in expected future borrowing result in an upward movement in the funds rate. Both of these movements yield an increase in future nonborrowed reserve demand and a higher expected future funds rate. The higher expected future funds rate causes current nonborrowed reserve demand to rise through movements in current borrowing. This rise in the current demand for nonborrowed reserves forces an increase in the funds rate. Further, expected increases in the discount rate lower today's funds rate ($b_1 - b_2\lambda_1 < 0$) since they make future discount window borrowing less attractive and thus increase the current demand for borrowed reserves.

4. A Specific Solution of the Model

4a. The stochastic environment

Equation (7) represents a very general solution to the model. In order to analyze the effects of different information sets on funds rate behavior some additional assumptions must be made. Specifically, the stochastic properties of R_t^*, i_d, tr_t and br_t must be specified. For simplicity, it will be assumed that $E_t i_{d,t+j} = i_d$ for all t, and that $R_t^* = R^* + r_t$ where r_t is a

zero mean independently normally distributed random variable with variance σ_r^2. The Fed may vary R_t^* for a number of reasons. Foremost is the desire to alter the level of the funds rate. Second, the targeted level of money growth may be adjusted over time as the Fed tries to reduce inflation. Third, to the extent that the Fed is concerned with price level stability it would change its targeted level of total reserves in response to permanent shifts in the demand for money.[13] The above reasons do not preclude modelling R_t^* as a rule based upon currently observed variables. This would imply that if rational agents had the same information set as the Fed, they would know R_t^* with or without some form of announcement by the Fed. The disturbance r_t can be thought of as that portion of R_t^* that cannot be deduced by the market due to the fact that the Fed possesses information not readily available to the market.

To capture the permanence of the money demand disturbance, let $tr_t = \rho tr_{t-1} + x_t$ where $0 \leq \rho \leq 1$. For simplicity x_t and br_t are assumed to be zero mean independently normally distributed random variables with variances σ_x^2 and σ_{br}^2 respectively. Given these assumptions, (7) can be rewritten as

$$(8) \quad i_{f,t} = k + \frac{b_3}{b_2\lambda_1} BR_{t-1} + \frac{1}{b_2\lambda_1} r_t + \frac{b_3}{b_2\lambda_1^2} E_t r_t + \frac{b_1 - b_2}{\lambda_1 - 1} i_d + \frac{n}{b_2\lambda_1} tr_t$$

$$+ \frac{n(b_3 + \rho)}{b_2\lambda_1(\lambda_1 - \rho)} E_t tr_t - \frac{1}{b_2\lambda_1} br_t$$

where $k = \dfrac{-b_0\lambda_1^2 + \lambda_1 n a_0(\lambda_1 + b_3) + (\lambda_1^2 + b_3)R^*}{b_2\lambda_1^2(\lambda_1 - 1)}$

4b. Information and its effect on the variance of the funds rate forecast error

The funds rate is generally an important variable affecting the investment decisions of banks (and possibly other financial market participants). Therefore,

errors in forecasting future levels of the funds rate are costly and improved
forecasting is beneficial to the banking industry. Some insight into the effect
of information on the conditional variances of the model can be gained by
examining the forecast error $i_{f,t} - E_{t-1}i_{f,t}$, where $E_{t-1}i_{f,t}$ is the conditional
expectation of the current funds rate based on an as yet unspecified $t-1$
information set. The value of this expression is given in equation (9), which
uses the fact that $BR_{t-1} = R^* + r_{t-1} + na_0 - na_1 i_{f,t-1} + ntr_{t-1}$ and that
$tr_t = \rho tr_{t-1} + x_t$.

$$(9) \quad i_{f,t} - E_{t-1}i_{f,t} = \frac{b_3}{b_2\lambda_1} (r_{t-1} - E_{t-1}r_{t-1}) + \frac{b_3 + \rho}{b_2(\lambda_1 - \rho)} n(x_{t-1} - E_{t-1}x_{t-1})$$

$$+ \frac{1}{b_2\lambda_1} (r_t + nx_t - br_t) + \frac{b_3}{b_2\lambda_1^2} E_t r_t + \frac{b_3 + \rho}{b_2\lambda_1(\lambda_1 - \rho)} nE_t x_t$$

For example, consider the two polar cases of full current information (which
implies that $E_{t-1}r_{t-1} = r_{t-1}$, etc.) as opposed to fixed or predetermined expec-
tations. On the one hand, full current information lowers the expectational
error (and therefore the conditional variance of the forecast error) due to
misperceptions about last period's borrowing. This is embodied in the first two
terms on the right-hand side of (9). However, full current information will
increase the conditional variance of the forecast error relative to fixed
expectations since $E_t r_t$ and $E_t x_t$ will then be random variables. Therefore, there
is a tradeoff concerning an improvement in information and its effect on the
conditional variance of the funds rate forecast error.

With regard to the specific problem addressed in this paper, the information
set under secrecy is $I_t = (i_{f,t}, i_{d,t}, BR_{t-1}, TR_{t-1}, r_{t-1}, tr_{t-1}, br_{t-1})$ and
all past values of these variables. The signal that can be extracted from the
funds rate is $S_{it} = r_t + nx_t - br_t$. This implies that the conditional

expectation of the disturbances r_t and nx_t may be expressed as

$$(10) \quad Er_t | I_t = \frac{\sigma_r^2}{\Delta}(r_t + nx_t - br_t) \quad \text{and} \quad nEx_t | I_t = \frac{n^2\sigma_x^2}{\Delta}(r_t + nx_t - br_t)$$

where $\Delta = \sigma_r^2 + n^2\sigma_x^2 + \sigma_{br}^2$. When the Fed releases R_t^*, the banking sector's

information set is $\hat{I}_t = I_t + R_t^*$. In this case, the funds rate reveals the

linear combination of disturbances equal to $nx_t - br_t$. Therefore,

$$(11) \quad Er_t | \hat{I}_t = r_t \quad \text{and} \quad nEx_t | \hat{I}_t = \frac{n^2\sigma_x^2}{\hat{\Delta}}(nx_t - br_t)$$

where $\hat{\Delta} = n^2\sigma_x^2 + \sigma_{br}^2$.

The comparison of the conditional variance of the forecast error under

secrecy and disclosure will involve comparisons of the variances of the

expectational errors $r_{t-1} - E_{t-1}r_{t-1}$ and $x_{t-1} - E_{t-1}x_{t-1}$ as well as the

variances of the expectations $E_t r_t$ and $E_t x_t$. (Covariances of the disturbances

and their expectations will also be involved.) Since $\hat{\Delta} \leq \Delta$ it is straight-

forward to show that the variance of $Ex_t | I_t$ is less than the variance of $Ex_t | \hat{I}_t$.

However, the variances of the expectational errors of r_{t-1} and x_{t-1} are larger

under secrecy. This implies the existence of a tradeoff in terms of the

conditional variance of the funds rate forecast error concerning the release

of information.

The specific outcome concerning the effects of revealing policy intentions

is that the variance of the forecast error can always be improved through the

release of information. That is, although there is a cost in terms of greater

variance of the conditional expectations of x_t and r_t, more information improves

the quality of the funds rate forecast.[14] In particular, the difference between

the conditional variances of the forecast errors under secrecy and disclosure is

$$(12) \quad CV_t - \hat{CV}_t = \frac{\sigma_r^2}{b_2^2 \lambda_1^2 (\lambda_1 - \rho) \Delta \hat{\Delta}} [\hat{\Delta} b_3 (\lambda_1 - \rho) - (b_3 + \rho) \lambda_1 n^2 \sigma_x^2]^2 (1 - \frac{1}{\lambda_1^2}).$$

Since $\lambda_1 > 1$, this is always positive. This implies that banks would like to know the Fed's objective with respect to monetary policy.

4c. The value of R_t^* to an individual bank

The previous section demonstrated that knowledge of R_t^* can improve the accuracy of the funds rate forecast for the banking system as a whole. It is therefore not surprising that under a policy of secrecy banks can generally improve their forecasts by uncovering Federal Reserve objectives. That is, if an individual bank can learn about the path of R_t^* it will be better off. This provides an incentive for banks to invest resources in uncovering R_t^*. Using (8), the conditional forecast of the funds rate for a bank that knows R_{t-1}^* at date t-1 is

$$(13) \quad \tilde{E}_{t-1} i_{f,t} = k + \frac{b_3}{b_2 \lambda_1} \tilde{E}_{t-1} BR_{t-1} + \frac{b_1 - b_2}{\lambda_1 - 1} i_{d,t} + \frac{(b_3 + \rho)n}{b_2 \lambda_1 (\lambda_1 - \rho)} [\rho^2 tr_{t-2} + \rho \tilde{E}_{t-1} x_{t-1}]$$

where $\tilde{E}_{t-1}$ refers to the expectation of a bank whose information set is $\hat{I}_{t-1}$ and where the rest of the market only has the information contained in I_{t-1}. Therefore its forecast error is

$$(14) \quad i_{f,t} - \tilde{E}_{t-1} i_{f,t} = \frac{b_2 + \rho}{b_2 \lambda_1} n(x_{t-1} - \tilde{E}_{t-1} x_{t-1}) + \frac{1}{b_2 \lambda_1} (r_t + nx_t - br_t)$$

$$+ \frac{b_3}{b_2 \lambda_1^2} E_t r_t + \frac{b_3 + \rho}{b_2 \lambda_1^2 (\lambda_1 - \rho)} n E_t x_t$$

The bank's forecast error is generally improved by uncovering Federal Reserve intentions because the variance of the forecast error with respect to

$r_{t-1} - E_{t-1}r_{t-1}$ and $x_{t-1} - E_{t-1}x_{t-1}$ is improved. However when a bank does not

have information concerning R_{t-1}^*, the covariance of these forecast errors

is negative, reducing the potential value of the information. For $\rho = 0$

the bank is better off, with a gain in forecasting efficiency equal to

$(\frac{b_3}{b_2\lambda_1})^2 \frac{\sigma_{br}^4\sigma_r^2}{\Delta\hat{\Delta}}$. However, when $\rho = \frac{b_3\lambda_1\sigma_{br}^2}{\lambda_1 n^2\sigma_x^2 + b_3\hat{\Delta}}$ the variance of the forecast

error with knowledge of R_{t-1}^*, $\tilde{CV}$, is equal to the variance of the forecast

error without this knowledge. This occurs because this particular value of ρ

implies that the coefficient on r_t in the funds rate equation attains its full

information value despite the fact that banks are not fully informed. The

value of $CV - \tilde{CV}$ is depicted in figure 2. Therefore it will almost always

be in a bank's interest to uncover information concerning the direction of

monetary policy.

The fact that information concerning r_t is valuable to banks is a necessary

condition for banks to invest resources in trying to uncover r_t. The model as

specified does not consider what an equilibrium would be like if banks could

sharpen their forecasts of r_t by engaging in what is typically referred to as

"Fed watching." As mentioned, the disturbance r_t is the value of R_t that

can not be discerned by banks given an exogenous amount of free information.

Therefore, the model implicitly assumes that additional information concerning

r_t is too costly to obtain or process. In a more general setting, an

equilibrium along the lines of Grossman-Stiglitz (1980) would involve a

proportion of banks obtaining more information than others, with the marginal

cost of acquiring this information equalling its marginal benefit. The signal

obtained from the funds rate would then reflect this behavior. However, the

main result of the preceding section, that full disclosure of r_t reduces the

conditional variance of the funds rate forecast error should not be affected by

this more complicated framework.

4d. Information and its effect on the variance
     of the total reserves forecast error

Given the analysis of the preceding section, it is straightforward to examine the effect that information has on the conditional variance of the forecast error for total reserves. Using the expression for total reserve demand (2) and the fact that $tr_t = \rho tr_{t-1} + x_t$ the forecast error for total reserve demand can be written as

$$(15) \quad TR_t - E_{t-1}TR_t = -a_1(i_{f,t} - E_{t-1}i_{f,t}) + \rho(x_{t-1} - E_{t-1}x_{t-1}) + x_t.$$

The conditional variance of this forecast error will therefore be

$$(16) \quad CV_{TR} = a_1^2 CV + \rho^2 CV_x + \sigma_x^2 - 2\rho a_1 COV(i_{f,t} - E_{t-1}i_{f,t}, x_{t-1} - E_{t-1}x_{t-1})$$

$$- 2a_1 COV(i_{f,t} - E_{t-1}i_{f,t}, x_t)$$

where $CV_x = Var(x_{t-1} - E_{t-1}x_{t-1})$. A similar expression can be obtained for the case where the Fed releases information regarding its operating procedures. The difference between the two conditional variances is given by

$$(17) \quad CV_{TR} - \hat{CV}_{TR} = \frac{a_1^2 \sigma_r^2}{b_2^2 \lambda_1^2 (\lambda_1 - \rho)\Delta\hat{\Delta}} Z^2 (1 - \frac{1}{\lambda_1^2}) + \rho^2 \sigma_x^2 \left[\frac{n^2 \sigma_x^2 \sigma_r^2}{\Delta\hat{\Delta}} \right]$$

$$+ \frac{2a_1 \rho \sigma_r^2}{b_2 \lambda_1 (\lambda_1 - \rho)\Delta\hat{\Delta}} Zn\sigma_x^2 - \frac{2a_1 \sigma_r^2}{b_2 \lambda_1^2 (\lambda_1 - \rho)\Delta\hat{\Delta}} Zn\sigma_x^2$$

where $Z = b_3(\lambda_1 - \rho)\hat{\Delta} - \lambda_1(b_3 + \rho)n^2\sigma_x^2$. The first term represents the improvement in forecasting the funds rate under disclosure (as can be seen from (12)). The second term represents the improvement in forecasting past money demand disturbances. The last two terms represent the covariances between the funds rate forecast error and the forecast error of last period's money demand disturbance and the current

money demand disturbance, respectively. In general their net contribution is hard to determine. For example, if $\rho = 0$ the expression in (17) is likely to be negative for reasonable parameter values.[15] However, as ρ increases the expression is likely to become positive reflecting the increasing importance of the effect of forecasting last period's money demand disturbance correctly.

## 5. Analysis of Unconditional Variances

5a. The unconditional variance of the funds rate

Before analytically determining the effects that secrecy has on the unconditional variance of the funds rate it will be instructive to further investigate the forecasting problem facing banks. For simplicity, tr_t is now assumed to be a white noise. Banks are concerned with forecasting next period's funds rate, since this is an important consideration in determining current borrowing and hence affects the current funds rate. In order to forecast the future funds rate banks attempt to uncover aggregate borrowing levels. Indeed it is the nature of borrowing that serves as the propagation mechanism in this model and gives the model its dynamic characteristics. In order to optimally forecast current borrowing, banks wish to separate the sum of the combined disturbances $r_t + ntr_t$ from the shock to borrowing br_t. They attempt to do this because under full information both sets of disturbances differentially affect borrowing, the future funds rate, and therefore the current funds rate. The differential effect on the disturbance is depicted in figure 3 (where n = 1).

In panel (a) an increase in $r_t + tr_t$ raises $RR_t^d - NBR_t^s$. It also increases expectations of the future funds rate, thereby lowering the demand for borrowed reserves for any funds rate. On net, the funds rate rises (a movement from point A to point B) and borrowing increases. In panel (b), the effect of a
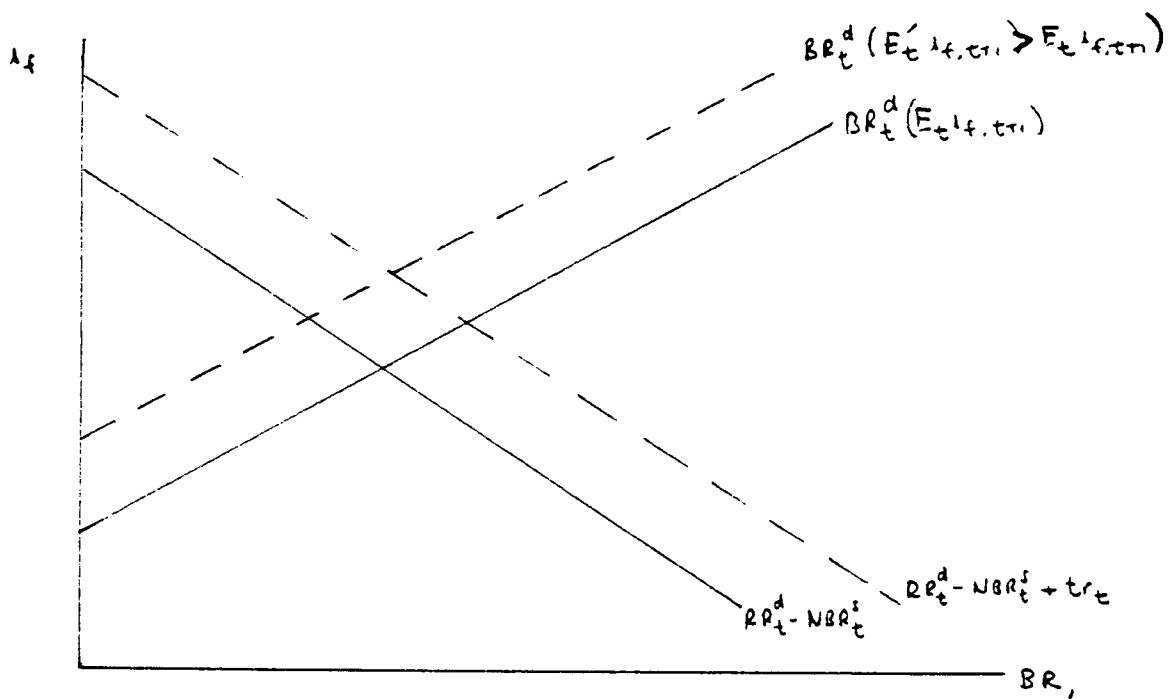
panel a
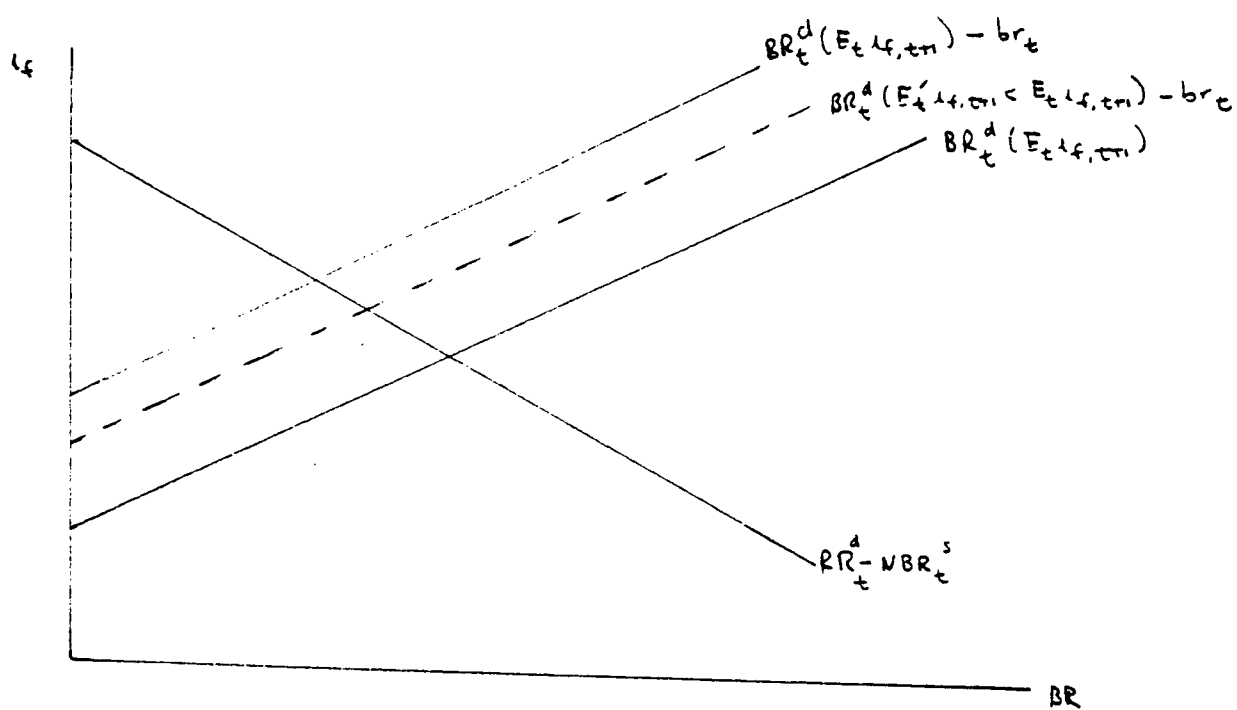
panel b

figure 3

negative shock to borrowing is analyzed. For a given expectation of next period's funds rate, the borrowed reserve demand function shifts back. However next period's expected funds rate decreases, offsetting some of the initial shift in the curve. On net the funds rate rises, but by less than for an equivalent increase in $r_t + tr_t$, and borrowing declines.

Banks do not generally know the breakdown between $r_t + ntr_t - br_t$, which is signalled by the funds rate. Instead they must forecast $r_t + ntr_t$ and br_t. The forecasts of these disturbances involve a weighting of their relative variances and on net will generally dampen the overall response of the funds rates to the various disturbances. By supplying information concerning r_t the solution for the funds rate moves closer to its full information solution and the unconditional variance rises.

The analytics can be conveniently carried out using an undetermined coefficients expression for the funds rate. The funds rate can be expressed as

(18) $\quad i_{f,t} = \pi_0 + \pi_1 BR_{t-1} + \pi_2 r_t + \pi_3 tr_t + \pi_4 br_t + \pi_5 i_{d,t}$

under secrecy, and as

(19) $\quad i_{f,t} = \hat{\pi}_0 + \hat{\pi}_1 BR_{t-1} + \hat{\pi}_2 r_t + \hat{\pi}_3 tr_t + \hat{\pi}_4 br_t + \hat{\pi}_5 i_{d,t}$

under disclosure. The solutions for the undetermined coefficients can be expressed as

$$\pi_0 = k \qquad\qquad \hat{\pi}_0 = k$$

$$\pi_1 = \frac{b_3}{b_2 \lambda_1} \qquad\qquad \hat{\pi}_1 = \frac{b_3}{b_2 \lambda_1}$$

$$\pi_2 = \frac{\lambda_1 + b_3 \psi}{b_2 \lambda_1^2} \qquad\qquad \hat{\pi}_2 = \frac{\lambda_1 + b_3}{b_2 \lambda_1^2}$$

$$\pi_3 = \frac{n(\lambda_1 + b_3\psi)}{b_2\lambda_1^2} \qquad\qquad \hat{\pi}_3 = \frac{n(\lambda_1 + b_3\hat{\psi})}{b_2\lambda_1^2}$$

$$\pi_4 = -\frac{\lambda_1 + b_3\psi}{b_2\lambda_1^2} \qquad\qquad \hat{\pi}_4 = -\frac{\lambda_1 + b_3\hat{\psi}}{b_2\lambda_1^2}$$

$$\pi_5 = \frac{b_1 - b_2}{\lambda_1 - 1} \qquad\qquad \hat{\pi}_5 = \frac{b_1 - b_2}{\lambda_1 - 1}$$

where $\psi = \dfrac{\sigma_r^2 + n^2\sigma_{tr}^2}{\sigma_r^2 + n^2\sigma_{tr}^2 + \sigma_{br}^2}$ and $\hat{\psi} = \dfrac{n^2\sigma_{tr}^2}{n^2\sigma_{tr}^2 + \sigma_{br}^2}$.

Since $0 \leq \hat{\psi} \leq \psi \leq 1$, $\pi_2 < \hat{\pi}_2$ $\pi_3 > \hat{\pi}_3$ and $|\pi_4| > |\hat{\pi}_4|$.

The unconditional variance of the funds rate under secrecy is

(20) $\quad UV = \pi_1^2\sigma_{BR}^2 + \pi_2^2\sigma_r^2 + \pi_3^2\sigma_{tr}^2 + \pi_4^2\sigma_{br}^2.$

Using the equilibrium condition $BR_{t-1} = na_0 + R^* - na_1 i_{f,t-1} + r_{t-1} + ntr_{t-1}$

equation (20) can be expressed as

(21) $\quad UV = \dfrac{1}{1 - n_1^2 a_1^2 \pi_1^2} [(\pi_1^2 - 2\pi_1^2 na_1\pi_2 + \pi_2^2)\sigma_r^2 + (n^2\pi_1^2 - 2\pi_1^2 na_1\pi_3 + \pi_3^2)\sigma_{tr}^2 + \pi_4^2\sigma_{br}^2].$

A similar expression obtains under disclosure. The difference between the two

unconditional variances can be derived using the undetermined coefficients

solutions and is given by

(22) $\quad UV - \hat{UV} = \left(\dfrac{1}{1 - n_1^2 a_1^2 \pi_1^2}\right) \dfrac{\pi_1^2\sigma_r^2\sigma_{br}^4}{\lambda_1^2\Delta\hat{\Delta}} \left(\dfrac{2na_1 b_3}{b_2} - 1\right) .$

This will be negative if $a_1 < \dfrac{b_2}{2nb_3}$, which is likely to be the case empirically.

Some intuition can be gained regarding this solution by examining the

response of the funds rate to various disturbances under full information and

incomplete information. This is done in figures (4a) and (4b). For future

reference, the full information solution to the funds rate is

$$(23) \quad i_{f,t} = k + \frac{b_3}{b_2\lambda_1} BR_{t-1} + \frac{\lambda_1 + b_3}{b_2\lambda_1^2}(r_t + ntr_t) - \frac{1}{b_2\lambda_1} br_t.$$

Figure (4a) compares the response of the funds rate to a money demand

disturbance under full and incomplete information. The initial equilibrium is

at point A. Now suppose there is a positive money demand disturbance. Updating

(23), the expected change in the future funds rate is $\frac{b_3}{b_2\lambda_1} d(E_t BR_t)$, where

$d(E_t BR_t)$ represent the expected change in current borrowing. Using the equilibrium

relationship for borrowing one sees that under full information the expected

future funds rate shifts up by $-na_1\left(\frac{\lambda_1 + b_3}{b_2\lambda_1^2}\right)d(tr_t) + d(tr_t) = \frac{b_1}{b_2\lambda_1} d(tr_t).$

This leads to a decrease in borrowing of $\frac{b_1}{\lambda_1} d(tr_t)$ and is depicted by the dotted

line as $BR_t^d(E_t^* i_{f,t+1})$. Under full information the equilibrium point is given

by B.

Now suppose banks have incomplete information and can not fully discriminate

between a positive money demand disturbance and a negative shock to borrowing.

In this case expected current borrowing will not rise by as much and neither will

the expected future funds rate. Hence, current borrowing will decline by less

than under full information, shifting the curve for borrowed reserves back by a

portion of the shift that occurred under full information. This is depicted by

the dashed line $BR_t^d(E_t i_{f,t+1})$ and the equilibrium is at point C. Therefore,

under incomplete information the funds rate response to a money demand disturbance

(similarly for a policy disturbance, r_t) is mitigated.

The analysis regarding a negative shock to borrowing produces the opposite

result. This is shown in figure (4b). Under full information expected borrowing

declines by $-na_1 d(i_{f,t})$ which equals $-na_1\left(\frac{-1}{b_2\lambda_1}\right)d(br_t) = \frac{na_1}{b_2\lambda_1} d(br_t).$ Therefore,

22
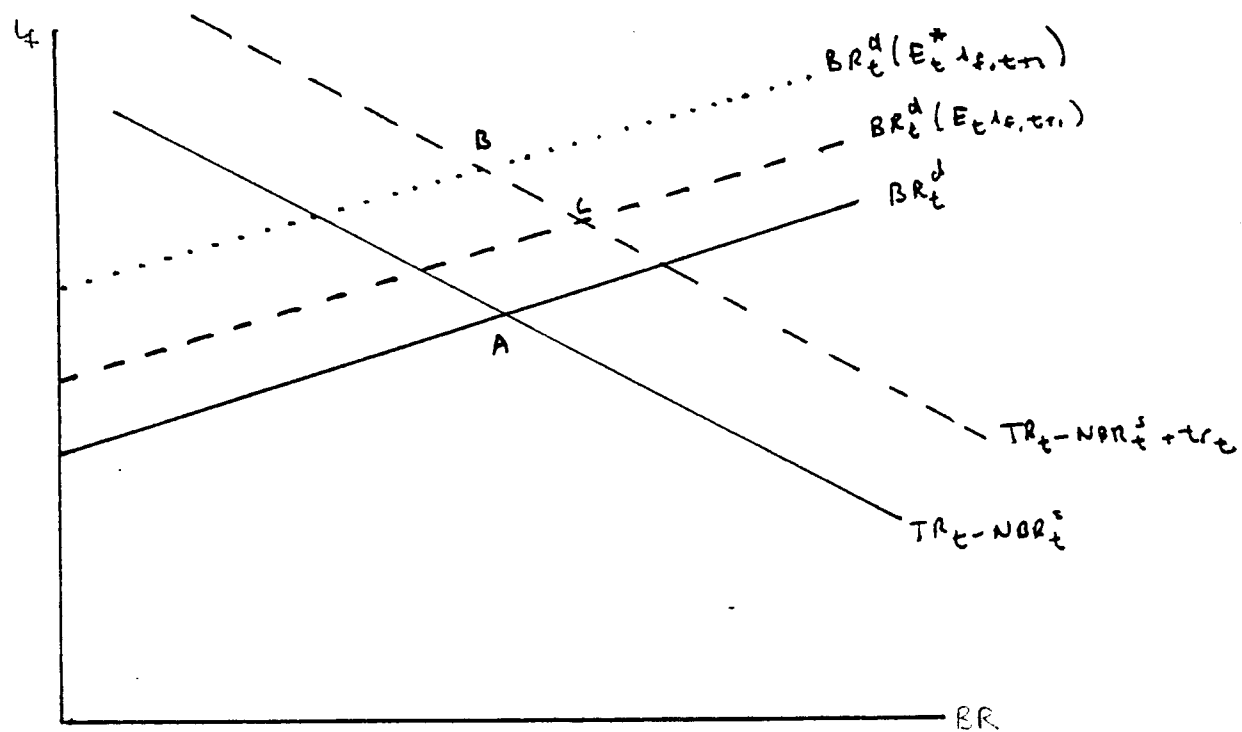
(4a)
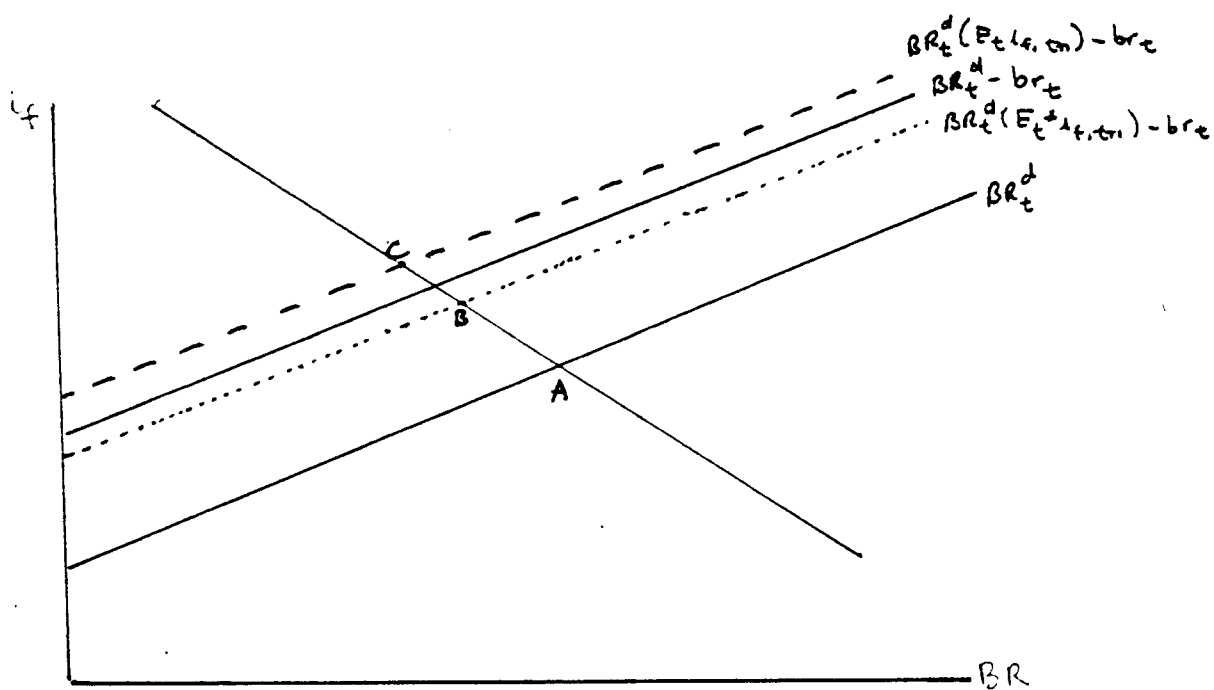
(4b)

the expected future funds rate falls by $\frac{b_3 na_1}{b_2^2 \lambda_1^2}$ $d(br_t)$ and the borrowed reserve

demand curve shifts partially back to its original position. This is shown by

the dotted line $BR_t^d(E_t^* i_{f,t+1}) - br_t$ and equilibrium occurs at point B. If banks

had incomplete information they would confuse some of the negative borrowing

shock with a positive money demand disturbance. Therefore, the expected future

funds rate will be higher than under incomplete information and borrowed reserve

demand will not shift back as much. In fact, banks would generally expect an

increase in the expected future funds rate causing BR_t^d to shift further leftward.[16]

This is shown by the dashed line $BR_t^d(E_t i_{f,t+1}) - br_t$. Hence, incomplete

information exacerbates the response of the funds rate to borrowing shocks.

Therefore, there exists a tradeoff regarding the effect that information

has on the unconditional variance of the funds rate. From (22) it is seen that

this tradeoff is sensitive to the relative size of the interest elasticity of

money demand. In figure (4a), it is clear that a steeper money demand curve

(a fall in a_1) implies a greater net benefit to secrecy in terms of the

unconditional variability of the funds rate. In figure 4b, the results are

more complicated since changes in a_1 directly affect expectations and the shift

in the demand for borrowing. Under full information as $a_1 \to 0$, there is no

change in expectations and the funds rate rises by enough to exactly offset the

disturbance to borrowing. Under incomplete information, the borrowed reserve

demand curve still shifts to the left, but the relative movement between the

full information case and incomplete information falls as a_1 goes to zero.

On net a smaller value of a_1 makes it likely that the unconditional variance of

the funds rate will rise with increases in information.

Some empirical verification that this is the case in practice can be found

in Moore, Porter, and Anderson (1985). In that paper the authors investigate

the impulse response function of the funds rate to various shocks in the money

market and find that the impulse response rises when agents have more information.

Given the apparent concern of the Fed with respect to the unconditional

variance of the funds rate, secrecy regarding the key elements of its operating

procedure is a consistent policy.

5b. The unconditional variance of total reserves

The unconditional variance of total reserves under secrecy, UV_{TR}, is

given by

$$(24) \quad UV_{TR} = a_1^2 UV + \sigma_{tr}^2 - 2a_1 COV(i_{f,t}, tr_t).$$

The difference in unconditional variances is

$$(25) \quad UV_{TR} - \hat{UV}_{TR} = a_1^2 (UV - \hat{UV}) - \frac{2a_1 n\pi_1}{\lambda \Delta \hat{\Delta}} \sigma_r^2 \sigma_{br}^2 \sigma_{tr}^2.$$

Therefore, the unconditional variance of total reserves is likely to be less

under secrecy. This implies that the total reserve series will appear smoother

and perhaps under greater control when information regarding operating

procedures is withheld.

6. Summary and Conclusion

This paper indicates that secrecy with respect to monetary objectives can

lower the unconditional variance of both the funds rate and total reserves.

Given that the Federal Reserve cares about funds rate and total reserves

variability, this lack of disclosure makes sense from the monetary authority's

point of view. From this standpoint the analysis provides one reason why the

Fed is reluctant to let the public know what it is doing. However, a policy of

secrecy is not without cost, since it increases the variance of the forecast

error of the federal funds rate. Banks and other financial institutions devote resources in trying to uncover the direction of monetary policy in order to reduce the costs associated with inaccurate predictions of the funds rate. From the market's point of view disclosure would be beneficial.

An extension of this model should consider the effects of secrecy on output variability and hence examine how social welfare is influenced. This type of exercise would allow for an assessment of the cost of allowing the Fed to withhold information.

APPENDIX

The reduced form equation for the funds rate (equation 7 in the text) is derived using the method outlined in Sargent (1979). Using (6) and substituting $BR_{t-1} = R^*_{t-1} + na_0 - na_1 i_{f,t-1} + ntr_{t-1}$ yields

$$\text{(A1)} \quad i_{f,t} = \frac{1}{b_1 + na_1} [na_0(1 + b_3) - b_0 + b_3 R^*_{t-1} + R^*_t - b_3 na_1 i_{f,t-1}$$

$$+ b_2 E_t i_{f,t+1} + b_1 i_{d,t} - b_2 E_t i_{d,t+1} + b_3 ntr_{t-1} + ntr_t - br_t]$$

(A1) can be explicitly rewritten as a second order stochastic difference equation

$$\text{(A2)} \quad (1 - \frac{b_1 + na_1}{b_2} B - \frac{b_3 na_1}{b_2} B^2) E_t i_{f,t+1} = -\frac{1}{b_2} [na_0(1 + b_3) - b_0 + b_3 R^*_{t-1} + R^*_t$$

$$+ b_1 i_{d,t} - b_2 E_t i_{d,t+1} + b_3 ntr_{t-1} + ntr_t - br_t]$$

where B is the backshift operator (i.e., $BE_t x_{t+1} = E_t x_t$). The left-hand side of (A2) can be reformulated as $(1 - \lambda_1 B)(1 - \lambda_2 B) E_t i_{f,t+1}$ where λ_1 and λ_2 satisfy the following two conditions

$$(\lambda_1 + \lambda_2) = \frac{b_1 + na_1}{b_2}$$

$$\lambda_1 \lambda_2 = -\frac{b_3 na_1}{b_2}$$

The solutions for λ_1 and λ_2 are therefore

$$\text{(A3)} \quad \lambda_1 = 1/2 \{ \frac{b_1 + na_1}{b_2} + [(\frac{b_1 + na_1}{b_2})^2 + \frac{4 b_3 na_1}{b_2}]^{\frac{1}{2}} \}$$

$$\text{(A4)} \quad \lambda_2 = 1/2 \{ \frac{b_1 + na_1}{b_2} - [(\frac{b_1 + na_1}{b_2})^2 + \frac{4 b_3 na_1}{b_2}]^{\frac{1}{2}} \}$$

Assuming that $b_3 < 1$ and $b_2 < b_1$, it can be shown that $\lambda_1 > 1$ and $0 < \lambda_2 < -1$. The condition $b_3 < 1$ guarantees that borrowing is stable and $b_2 < b_1$ indicates that banks are more responsive to current subsidies at the discount window.

Solving in the forward direction (A2) may be rewritten as

$$(A5) \quad E_t i_{f,t+1} = \lambda_2 i_{f,t} + \frac{na_0(1 + b_3) - b_0}{b_2(\lambda_1 - 1)} + \frac{b_3}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t R^*_{t+j}$$

$$+ \frac{1}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t R^*_{t+j+1} + \frac{b_1}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t i_{d,t+j+1}$$

$$- \frac{b_2}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t i_{d,t+j+2} + \frac{b_3 n}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t tr_{t+j}$$

$$+ \frac{n}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_i}\right)^j E_t tr_{t+j+1} - \frac{1}{b_2\lambda_1} \sum_{j=0}^{\infty} \left(\frac{1}{\lambda_1}\right)^j E_t br_{t+j+1}$$

Substituting (A5) into (A1) and rearranging terms yields equation (7) in the text.

REFERENCES

1. Axilrod, Stephen, and Lindsey, David E. "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach." A.E.R. Papers and Proc. 71 (May 1981): 246-52.

2. Dotsey, Michael, and King, Robert G. "Informational Implications of Interest Rate Rules." Working Paper no. 84-8. Federal Reserve Bank of Richmond, September 1984.

3. Goodfriend, Marvin. "Discount Window Borrowing, Monetary Policy, and the Post-October 6, 1979 Federal Reserve Operating Procedures." J. Monetary Econ. 12 (September 1983): 343-56.

4. _____. "Rational Expectations, Interest Rate Smoothing, and the 'Optimality' of a Non Trend Stationary Money Supply Rule." Federal Reserve Bank of Richmond, February 1984a, processed.

5. _____. "Secrecy and the Central Bank." Federal Reserve Bank of Richmond, December 1984b, processed.

6. Grossman, Sanford J., and Stiglitz, Joseph E. "On the Impossibility of Informationally Efficient Markets." A.E.R. 70 (June 1980): 393-408.

7. Hetzel, Robert L. "The Formulation of Monetary Policy." Federal Reserve Bank of Richmond, May 1984, processed.

8. _____. "The October 1979 Regime of Monetary Control and the Behavior of the Money Supply in 1980." J. Money, Credit and Banking 14 (May 1982): 234-51.

9. King, Robert G. "Secrecy, Speculation and Policy." Univ. of Rochester, October 1984, processed.

10. Meulendyke, Anne Marie. "Issues in Implementing Monetary Base Targeting." Federal Reserve Bank of New York, 1980, processed.

11. Moore, George; Porter, Richard; and Anderson, Gary. "Money Market Modelling in a Rational Expectations Framework with Staggered Information: Specification, Calibration, and Information Experiments." Board of Governors of the Federal Reserve System, 1985, processed.

12. Sargent, Thomas. Macroeconomic Theory. Academic Press, 1979.

13. Townsend, Robert M. "Forecasting the Forecasts of Others." J.P.E. 91 (August 1983): 546-88.

FOOTNOTES

1. For a detailed investigation of the Federal Reserve's justification for
secrecy, see Goodfriend (1984b). This line of reasoning implicitly assumes
that interest rate volatility is bad per se. This may be true from the stand-
point of the Fed, if interest rate smoothing is part of its objective function
(see Goodfriend (1984a)), but movements in interest rates may communicate
valuable information to agents in terms of optimally allocating resources
over time.

2. King (1984) has examined cases where secrecy concerning future govern-
ment spending may be optimal in a world with distorting taxes. His type of
analysis could be relevant for analyzing Fed behavior if one can isolate
distortionary aspects of monetary policy.

3. The effects of information on the behavior of agents is likely to vary
under different operating procedures. For instance, aggregate borrowing
numbers would be of little value under an interest rate targeting regime.

4. The mix between borrowed and nonborrowed reserves seems to depend on
the level of interest rates as well as deviations of money from target.

5. This seems to have been the procedure under the Fed's brief experiment
with nonborrowed reserve targeting under LRR.

6. The demand for money and hence total reserves could depend directly on
the funds rate for the following reason. Increases in the funds rate would
raise one source of funds for banks. This would affect the equilibrium value
of the rate on loans and hence affect both loans and deposits.

7. One could extend the model by allowing banks to have differential infor-mation, say with respect to tr_t and br_t. This would be especially important in analyzing the effects of optimal feedback policies. However, this extension would only complicate the model without affecting the qualitative results.

8. This does not affect the analysis in any substantive way.

9. Adding this aspect to the model might produce some interesting results. However, performing the analysis would make the problem much more difficult, the difficulty depending on the difference between information sets of banks and the Fed.

10. For more detailed analysis along these lines, see Hetzel (1980).

11. Frictional borrowing is that portion of borrowed reserves that banks would have liked to have acquired in the funds market but didn't due to denominational constraints or funds market trades or errors in calculating reserve positions.

12. This result occurs because prices are implicitly assumed to be fixed. In an extended model, a lower total reserve path would imply a reduction in inflation and a lower nominal interest rate. The assumption of rigid prices does not however affect the nature of the results concerning the consequences of secrecy.

13. One would typically expect the Fed to react differently to permanent and temporary money demand disturbances. An interesting extension would be to include this distinction.

14. Problems involving the addition of information do not trivially improve forecasts in a rational expectations environment, since the additional information also changes the covariance structure of the model. Therefore, including an additional piece of information is not simply

analogous to adding another regressor to an estimating equation. For

more detail, see Dotsey and King (1984).

    15.   For example let $n = 1/2$, $a_1 = 1/5$, $b_1 = 3/4$, $b_2 = b_3 = 1/2$. Then

$\lambda_1 = 1.75$ and $Z = b_3 \lambda_1 \sigma_{br}^2$. It can then be seen that unless σ_{br}^2 is 3 1/3 times

as great as σ_x^2 than $CV_{TR} < \hat{CV}_{TR}$.

    16.   The change in $d(E_t BR_t)$ is given by $-\psi d(br_t) - na_1 \pi_3 d(br_t)$ which

equals $[(na_1 \lambda_1 (1 - \psi) - b_1 \lambda_1 \psi)/b_2 \lambda_1^2] d(br_t)$. Since $a_1 < b_1$, then unless ψ is

small $d(E_t BR_t)$ will be positive and the expression in brackets is likely to

be negative. Hence the expected future funds rate is likely to rise.