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A Micro Model of the Federal Funds Market

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ABSTRACT

This paper demonstrates that valuable insights into the determination of Federal funds rates can be gained through modeling the micro-decisions of market participants. Fed fund demand functions are derived for different bank valuation functions and several implications are discussed. Specifically, it is: (i) possible to rationalize the observation that large banks are net purchasers and small banks net sellers of Fed funds; (ii) to explain the positive spread of Fed funds rates over other short-term money market rates; and (iii) to link the size of this spread to the Federal Reserve's underlying monetary policy strategy.

THERE IS NOW A considerable literature on the pricing of securities in both the equity and bond markets. However, to date, theoretical research into the pricing of instruments traded on the short-term money markets has been rather meager and incomplete. For example, the Federal funds market is the largest of the domestic money markets (Garbade et al. [7]) yet few attempts have been made to analyze conceptually the underlying, or micro, determinants of the Federal funds rate or how this rate is set relative to other money market rates.

One possible reason for the paucity of research is the difficulty involved in modeling a market which is so intimately linked to banks' (and other depository institutions') reserve management decisions and therefore to monetary policy uncertainty. Nevertheless, it is the very centrality of this market to the transmission of monetary policy which makes modeling important, especially if the consequences of alternative strategies for conducting monetary policy are to be rigorously compared. Apart from the reserve management-monetary policy reason, analyzing rate determination in the funds market is important simply because it is the shortest maturity instrument in the term structure (Dothan [5]; Cox et al. [4]). Hence, any changes in the Federal funds rate can be expected to feed through to the whole term structure of interest rates. For this reason alone, an understanding of the determinants of the funds rate is essential.

The objective of this paper is to develop a micro model of the Federal funds market (hereafter Fed funds) which incorporates the major institutional characteristics of this market. It will be shown that the model provides a number of valuable insights into the determinants of individual participant's demands for

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Fed funds and ultimately into the determinants of the market clearing rate. The model is additionally useful in that it provides some economic explanations for various observed characteristics of the funds market such as large banks as *net* purchasers (with small banks as *net* suppliers) and the positive interest spread between the funds rate and other short-term money market rates such as RPs and Treasury bills. Specifically, it is shown that a *timing* or liquidity premium exists in the Fed funds market which reflects: (i) the degree of monetary policy uncertainty faced by banks and (ii) the degree of (bank) risk aversion to reserve over (under)-shooting.

I. Assumptions of the Model

It is assumed that the Fed funds market is organized by money market brokers. These brokers do not trade on their own account but rather act in a manner analogous to a "Walrasian" auctioneer, continuously striving to match, buy, and sell orders as they arrive. Because of this brokerage function, it is possible to view the broker-arranged funds market as comprising a continuum of separately clearing call markets (see Ho et al. [13]), with brokers reducing the information and transaction costs that otherwise would be borne by market participants. Each bank in the model is assumed to face a *short-term* reserve management problem and wishes to optimize its participation in the funds market.

To focus attention on this problem, banks' decision period (i.e., day) is divided into: (i) *a banking-day*—a period from when the bank is open for business (t_0) until it closes its books that evening (t_2) and (ii) *overnight*—the period between closing its books (t_2) and opening the bank the next calendar day (t_3).

At the beginning of the banking day (t_0), the bank is assumed to have achieved its previous day's reserve target and to know the (new) end of *banking* day reserve target (at t_2) which is assumed to be binding. Over the course of the banking day, between t_0 and t_2, the bank's reserve position will change in response to stochastic deposit drains and inflows. Thus in this paradigm, the existence of a Fed funds market allows banks to borrow and lend to each other at points in time, say t_1, prior to t_2.

To capture this timing or flexibility aspect of the funds market more precisely, it is assumed that the funds market involves only banks and takes the form of a call market which clears just once a day. While actual market clearing is viewed as taking place at the end of the banking day (t_2), each bank can submit a demand function for Fed funds to market brokers just *before* the end of the day. In this framework, bank demands for Fed funds are submitted at t_1. Since the timing interval t_1 to t_2 is very small (by assumption), the bank cannot use other market methods to adjust reserves (RPs, T-bills, etc.). These instruments could only have been used prior to t_1.

However, the existence of the funds market provides no guarantee that an individual bank's reserve target will be met at t_2. The *actual* quantity of Fed funds a bank receives or supplies to other banks at t_2 (i.e., the position each bank finds itself on its demand function) will depend on the market clearing funds rate and the (stochastic) deposit drains and inflows that occur between t_1 and t_2.

It is then assumed that any excess reserves held at t_2 will count towards reserve requirements in the following week (the 3% carryover rule under the current contemporaneous reserve accounting system) and therefore will earn the bank an *opportunity* return equal to the daily rate expected in the next reserve maintenance period on short-term securities (Treasury bills or RPs) and that any shortfall, net of funds borrowing, is met by overnight loans from the discount window.

Specifically, let $\tilde{R}$ be the stochastic *deviation* of reserves from the target position (or excess reserves) at t_2, r the expected return (cost) on holding (borrowing) reserves, and k the expected return on marginal excess reserves at the target reserve level. In this framework, k can be thought of as the marginal expected daily return (at the target level) on investments in risk-free securities in the subsequent reserve maintenance period (i.e., the following week). For purposes of generality, the reserve adjustment opportunity curve (RAC) facing a bank at t_2 is assumed to slope downwards, i.e., the expected returns from holding excess reserves are less than the expected costs of borrowing from the discount window to meet a reserve deficiency. Such a slope will result if market demand and supply curves for short-term securities are imperfectly elastic, due, e.g., to preferred habitat considerations (see Roley [29]). The cost of discount window borrowing is viewed as "penal" after allowing for both the explicit and implicit costs of such borrowing.

II. Model Analysis

The demand function for Fed funds is derived by maximizing the bank's expected utility of (terminal) profit ($\tilde{\pi}$) from Fed funds participation. Expected utility maximization is assumed for purposes of generality, with risk neutrality analyzed as a special case (see [1], [15], [32]). Following [11], the $EU(\tilde{\pi})$ function is assumed to take the form (1) below:

$$EU(\tilde{\pi}) = E(\tilde{\pi}) - \tfrac{1}{2}Z\,\mathrm{Var}(\tilde{\pi}) \tag{1}$$

where Z is a measure of risk aversion.

Now, at t_2, when the market for Fed funds clears the banks total excess reserves available is given by,

$$\tilde{\Omega} = \tilde{R} + Q \tag{2}$$

where $\tilde{R}$ is the stochastic *excess* reserve position at t_2 with an expected value of excess reserves equal to R such that

$$\tilde{R} = R + \tilde{U}_R \quad \text{and} \quad \tilde{U}_R \sim N(0,\, \sigma_R^2)$$

Since r is the return (cost) of holding an excess (deficient) reserve position, we can specify that

$$\tilde{r} = \tilde{k} - e\tilde{\Omega} \tag{3}$$

where $\tilde{k} = \mathrm{k} + \tilde{U}_k$ and $\tilde{U}_k \sim N(0,\, \sigma^2)$, and e is the slope of the RAC when Fed funds are included in the reserve adjustment opportunity set. For simplicity, it is assumed that e is nonstochastic, although it would be possible to allow e to be stochastic.

Consequently, end of period (t_3) profit from Fed funds participation is

$$\tilde{\pi} = \tilde{\Omega}\tilde{r} - Q\rho \tag{4}$$

where ρ is the rate on Fed funds. Substituting (2) and (3) into (4), we find

$$\begin{aligned}\tilde{\pi} &= (Q + \tilde{R})(\tilde{k} - eQ - e\tilde{R}) - Q\rho \\ &= \tilde{R}(\tilde{k} - e\tilde{R}) + Q(\tilde{k} - e\tilde{R}) - eQ(Q + \tilde{R}) - Q\rho.\end{aligned} \tag{5}$$

Therefore, expected profit from Fed funds participation will be

$$E(\tilde{\pi}) = E[\tilde{R}(k - e\tilde{R})] + Q(k - eR) - eQ(Q + R) - Q\rho. \tag{6}$$

For the case when the bank *does not* participate in the market, then $Q = 0$, and the bank's expected profit, defined as $E(\tilde{\pi}_0)$, is equal to

$$E(\tilde{\pi}_0) = E[\tilde{R}(\tilde{k} - e\tilde{R})] \tag{7}$$

which is the first term on the right-hand side of Equation (6).

Hence, substituting (7) into (6), the profit at t_3, when the bank does participate in the funds market may also be expressed as

$$E(\tilde{\pi}) = E(\tilde{\pi}_0) + Q(k - eR) - eQ(Q + R) - Q\rho. \tag{8}$$

Since it is assumed that the bank is concerned with $EU(\tilde{\pi})$, the variance of profit from participation and nonparticipation in the funds market is also derived.

Using Equation (6) and calculating the variance, we find

$$\begin{aligned}\mathrm{Var}(\tilde{\pi}) = \mathrm{Var}[&(R + \tilde{U}_R)(k + \tilde{U}_k - eR - e\tilde{U}_R) + Q(k \\ &+ \tilde{U}_k - eR - e\tilde{U}_R) - eQ(Q + R + \tilde{U}_R) - Q\rho].\end{aligned} \tag{9}$$

If $\mathrm{Var}(\tilde{\pi}_0)$ is defined as the variance of profit from reserve adjustment when $Q = 0$ (i.e., when the bank does not participate in the funds market), then Equation (9) can also be expressed as

$$\mathrm{Var}(\tilde{\pi}) = \mathrm{Var}(\tilde{\pi}_0) + Q^2\sigma_k^2 + 4e^2Q^2\sigma_R^2 - 4eQ^2\sigma_{kR} + 2Q\Psi \tag{10}$$

where

$$\Psi = R\sigma_k^2 + \sigma_{Rk}\,(k - 4eR) + 2e\sigma_R^2(2eR - k). \tag{11}$$

The optimal transaction size (Q) for each Fed funds rate (ρ) is related by the demand function derived by:

$$\max_{Q} \mathrm{EU}(\tilde{\pi} \mid \text{for a fixed rate } \rho). \tag{12}$$

Substituting (8) and (10) into (1) and solving, the Fed funds demand function is derived as

$$\rho = (ak - bR) - bQ$$

where

$$\begin{aligned} a &= (1 - Z\sigma_{Rk} + 2Ze\sigma_R^2) \\ b &= 2e + Z(\sigma_k^2 - 4e\sigma_{Rk} + 4e^2\sigma_R^2) > 0.\end{aligned} \tag{13}$$

The first term in parentheses in Equation (13) is the intercept of the individual bank's demand function for Fed funds, and the second term, b, is the slope of that function. Hence, we have shown that a bank's demand for Fed funds is a linear function of the size of transactions (Q), where the slope and intercept of that function depends on: the variance of short-term security rates (σ_k^2), the variance of reserves (σ_R^2), the covariance between security rates and reserves (σ_{kR}), bank management's degree of risk aversion (Z), the slope of the RAC curve (e), and the bank's expected reserve position (R).

A. Fed Funds Demand by a Risk-Neutral Bank ($Z = 0$)

In the risk-neutral case, the Fed funds demand function in Equation (13) reduces to

$$\rho = (k - 2eR) - 2eQ. \tag{14}$$

First, note that (14) leads to the important result that if there are no costs or returns to reserve target short-falls or overruns (e.g., the costs of discount window loans are nonpenal and equal to k) so that $e = 0$ and the RAC is horizontal, while the bank is also risk-neutral, then $Q = 0$ and $\rho = k$. This result seems intuitively reasonable, implying that for the Fed funds market to have a unique function and demand that is distinct from other securities, there has to be either some economic costs (returns) of not meeting reserve targets ($e \neq 0$, the RAC is *not* perfectly horizontal) and/or banks have to be risk-averse ($Z > 0$). If neither condition holds, there is no obvious economic rationale for the existence of the Fed funds market.

B. Fed Funds Demand by a Risk-Averse Bank

In the risk-averse case (consider Figure 1), if the bank expects (at t_1) that it will meet its reserve target at the end of the banking day, i.e., $R = 0$ at t_2, the demand function becomes (14)—see FF_4 in Figure 1.

$$\rho = k(1 - Z\sigma_{kR} + 2Ze\sigma_R^2) - [2e + Z(\sigma_k^2 - 4e\sigma_{kR} + 4e^2\sigma_R^2)]Q. \tag{14a}$$

It seems reasonable on *a priori* grounds to suppose that the covariance (σ_{kR}) between $\tilde{k}$ and $\tilde{R}$ is negative. That is, the normal short-term effect of an open market sale of securities or an RP by the Fed with government security dealers (see [2]) is to increase these rates and reduce the quantity of immediately available funds and bank reserves, as purchasers of securities wire funds to the Fed's accounts at the Reserve banks. Given that $\sigma_{kR} < 0$, the demand function for a bank that expects $R = 0$, but is risk-averse ($Z > 0$), will take the form of FF_4, having a larger intercept and steeper slope than the risk-neutral case (FF_1). This result can be explained intuitively by the fact that the steeper slope of the Fed funds demand function reduces the uncertainty of reserve adjustment profit (loss). In particular, to reduce the risk of reserve deficiencies, even when the funds rate is high, the bank prefers to hold excess reserves and is less willing to sell Fed funds. Moreover, the more risk-averse the bank, and the greater the variances of rates on securities (σ_k^2) and reserve flows (σ_R^2), the more rate in elastic is its demand function.

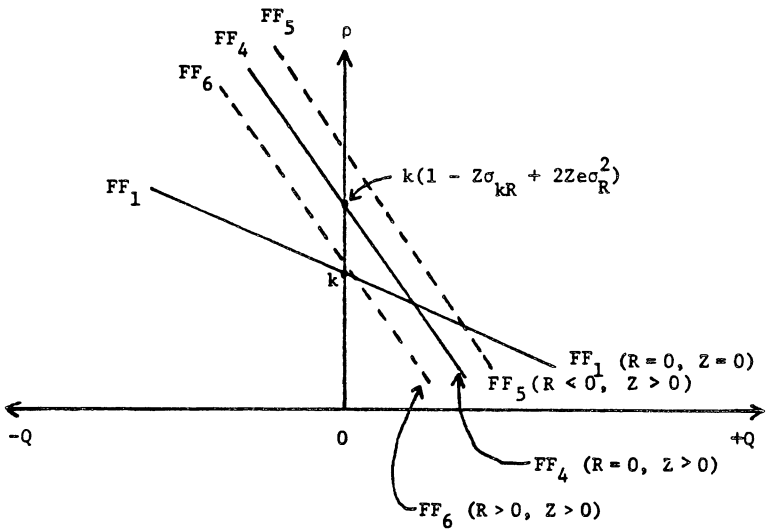

Figure 1. The Demand Function for Fed Funds by the Risk-Averse Bank

The effect of expectations at t_1 that $R \gtrless 0$ will shift the $R = 0$ schedule (FF_4) up or down in a parallel fashion. In the case where the bank expects $R < 0$, FF_4 shifts upward to FF_5 and where $R > 0$, FF_4 shifts downward to FF_6. The reason for this result is straightforward, the greater are a bank's expected excess reserves at t_2 the lower is the whole schedule of rates it is willing to demand for Fed funds at t_1 and vice-versa for an expected reserve shortfall in reserves.

C. The Derivation of the Market Clearing Rate

In Equation (13), an *individual* bank's demand for Fed funds is derived. In order to determine the equilibrium or *market* clearing rate, Equation (13) is rewritten in simplified form as (14b) below with i to denote the i^{th} bank

$$\rho_i = (a_i k_i - b_i R_i) - b_i Q_i \tag{14b}$$

where:

$$a_i = (1 - Z_i \sigma_{kR} + 2Z_i e_i \sigma_R^2),$$

$$b_i = 2e_i + Z_i(\sigma_k^2 - 4e_i \sigma_{Rk} + 4e_i^2 \sigma_R^2)$$

and

$$i = 1, \cdots, n.$$

To derive the market clearing rate, we know that in equilibrium

$$\textstyle\sum_{i=1}^{n} Q_i = 0. \tag{15}$$

Let:

$$w_i = \frac{b_i^{-1}}{\sum_{i=1}^{n} b_i^{-1}} \tag{16}$$

such that:

$$\sum_{i=1}^{n} w_i = 1 \tag{17}$$

where w_i's can be called *price-sensitivity* weights dependent on the price elasticity of the i^{th} bank's Fed funds demand function. Then aggregating (14b), the market clearing rate for Fed funds $\tilde{\rho}$ will be,

$$\tilde{\rho} = \sum_{i=1}^{n} a_i w_i k_i - \sum_{i=1}^{n} R_i. \tag{18}$$

The larger a bank's w_i the greater the influence it has on the market clearing rate.

III. Some Implications of the Model

A. Market Trading Between Large and Small Banks

The model developed in Sections I and II is useful for deriving insights into the observation that large banks are persistent *net* purchasers and small banks persistent *net* sellers in the broker-arranged market for Fed funds (see [19], [20], for example). Specifically, if it is assumed that large banks (especially money center banks) are more rate sensitive than small banks, since they are better able to diversify their risk exposure, the slopes' $(2e + Z(\sigma_k^2 - 4e\sigma_{kR} + 4e^2\sigma_R^2))$ of large bank Fed funds demand functions will be more price-elastic than those of small banks. Furthermore, the impact of a Federal Reserve open market purchase/sale of government securities (or RPs) will tend to have its primary impact on the deposits and reserves of larger banks [2]. As a result, covariance risk, or $|\sigma_{kR}|$, will tend to be greater for larger banks, thereby increasing the relative size of their intercept terms $k(1 - Z\sigma_{kR} + 2Ze\sigma_R^2)$ in their demand functions [see Equation (14a)]. Hence, assuming *ceteris paribus* (e.g., $R = 0$), large and small bank demand functions will look similar to those presented in Figure 2.

Consider, for simplicity, a trade of size Q in the funds market between one large and one small bank. The market clearing requirement of no net excess

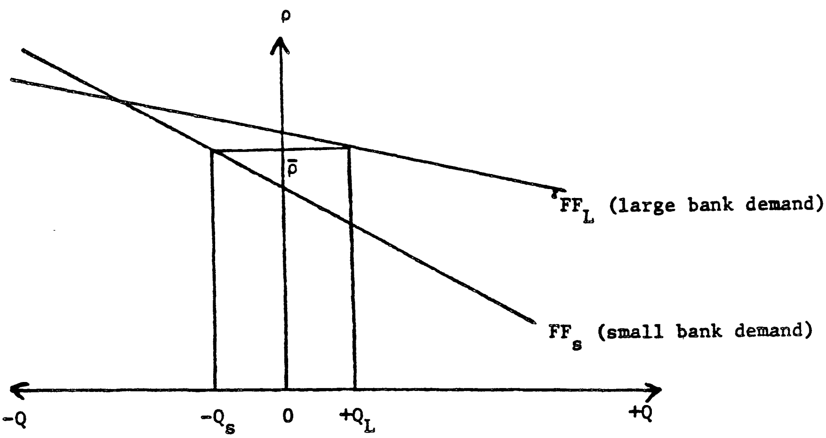

Figure 2. Large and Small Bank Demand Functions

supply, or $\sum_{i=1}^{n} Q_i = 0$, results in $\bar{\rho}$ as the clearing rate, with the larger bank purchasing $+Q_L$ and the small bank selling $-Q_s$. In this paradigm, large banks would be persistent net purchasers of Fed funds and small banks net sellers.

B. The Relationship Between the Fed Funds Rate and the Rate on Short-term Securities

In Equation (13), demand functions were derived for the i^{th} bank *for a given day* at t_1 given expectations regarding the rate on short-term securities ($\tilde{k}_1$) and expectations regarding excess reserve positions ($\tilde{R}_i$) at t_2 so that the daily market clearing rate, Equation (18), is conditional on those expectations. In this subsection, the model is extended beyond the day to analyze the *interday* behavior of the funds rate using a repeated market setting. This allows a better understanding of the factors which determine the spread between the funds rate (ρ) and the short-term securities rate (k). In a repeated market setting, $\tilde{k}$ and $\tilde{R}_i$ will tend to change from one period (day) to another (i.e., over time) with their stochastic nature being determined partly by the Fed's open market strategy.

To focus attention on this intertemporal relationship between ρ and k, it is assumed that market participants have homogeneous expectations regarding k_i. Since from (14b), $a_i = 1 - Z_i\sigma_{kR} + Z_i e_i \sigma_R^2$, then Equation (18) can be rewritten as:

$$\tilde{\rho} = \tilde{k}(1 - \sigma_{kR} \textstyle\sum_{i=1}^{n} Z_i w_i + 2\sigma_R^2 \sum_{i=1}^{n} Z_i e_i w_i) - \sum_{i=1}^{n} \tilde{R}_i \tag{19}$$

That is, we can view our period (day) as being repeated over and over again with the daily value of $\tilde{\rho}$ being conditional on the values of $\tilde{k}$ and $\tilde{R}_i$. However, *over time* it can be assumed that,

$$E(\tilde{R}_i) = 0.$$

Thus,

$$E(\tilde{\rho}) = \bar{\rho} = k(1 - \sigma_{kR} \textstyle\sum_{i=1}^{n} Z_i w_i + 2\sigma_R^2 \sum_{i=1}^{n} Z_i e_i w_i) \tag{20}$$

where in Equation (20), $\bar{\rho}$ is viewed as the average funds rate, and k is the average rate on short-term securities over time.

Equation (20) can be redefined in the form of a percentage rate spread in order to gain insights into the relationship between the funds rate and the expected rate on short-term securities, i.e.,

$$\frac{\bar{\rho} - k}{k} = -\sigma_{kR} \textstyle\sum_{i=1}^{n} Z_i w_i + 2\sigma_R^2 \sum_{i=1}^{n} Z_i e_i w_i. \tag{21}$$

Equation (21) implies that the average rate on Fed funds ($\bar{\rho}$) will always be above the rate on short-term securities of equivalent maturity (k) as long as $Z_i > 0$ and $\sigma_{kR} < 0$. The right-hand side of (21) might be thought of as the equilibrium value of the timing or reserve adjustment flexibility premium discussed in Section II, with the value of this premium depending on the risk aversion of market participants, the variance of reserves (σ_R^2), and the covariance between market interest rates and reserves (σ_{kR}). Since σ_{kR} and σ_R^2 are directly related to open market operating strategy, or monetary policy risk, Equation (21) implies that the Fed has the ability to influence the spread (or premium) between the funds rate and the rate on short-term securities such as RP's and Treasury bills of equivalent maturity.

In particular, on October 6, 1979, the Fed changed its short-run monetary policy target from short-term interest rates to unborrowed reserves (see Lindsey [17]). Under interest rate targets, unborrowed reserves are largely endogenously determined (see [24], [27]), and bank reserve management uncertainty (measured by σ_{kR} and σ_R^2) is likely to be small. By comparison, a Fed strategy of active reserve targeting associated with wide or no bounds on interest fluctuations should result in larger absolute values for both σ_{kR} and σ_R^2. Hence, under reserve targets the value of the timing (or reserve adjustment flexibility) premium in Equation (21) should have increased. Indeed, evidence from the money markets tends to support the existence of a monetary-regime dependent timing premium for Fed funds. Over the interest-rate target period, January 3, 1978 to October 6, 1979, the average daily spread between ρ (the Fed funds rate) and k (the rate on the nearest to maturity Treasury bill) was 0.83%. This increased to an average of 2.48% in the period immediately following the switch to unborrowed reserves targeting (October 7, 1979 to June 26, 1981). Moreover, this increase in the timing premium is robust to reasonable assumptions made about the size of (any) default premiums reflected in this $\rho - k$ spread.

C. The Variance of the Fed Funds Rate

Using Equation (20) it is also possible to derive the determinants of the variance of the funds rate. This is of particular interest since, as noted in the introduction, the funds rate can be viewed as the shortest rate in the whole term structure, and any increase in its variance can be expected to feed through to the whole term structure.

Assuming that participants have homogeneous expectations regarding the future course of short-term interest rates (k), then (19) can be rewritten as

$$\tilde{\rho} = A\tilde{k} - \textstyle\sum_i^n \tilde{R}_i \tag{22}$$

where

$$A = (1 - \sigma_{kR} \textstyle\sum_i^n Z_i w_i + 2\sigma_R^2 \sum_i^n Z_i e_i w_i).$$

Then,

$$\mathrm{Var}(\tilde{\rho}) = A^2\sigma_k^2 - 2 \textstyle\sum_i^n A \,\mathrm{Cov}(\tilde{k}, \tilde{R}_i) + \mathrm{Var}(\sum_i^n R_i). \tag{23}$$

If, for clarity of exposition, it is further assumed that $\mathrm{Cov}(\tilde{k}\ \tilde{R}_i) = \sigma_{kR}$, then it follows that,

$$\mathrm{Var}(\tilde{\rho}) = A^2\sigma_k^2 - 2An\sigma_{kR} + \mathrm{Var}(\textstyle\sum_i^n \tilde{R}_i). \tag{24}$$

The first term in (24) indicates that there is a direct and positive relationship between the variance of the rate on short-term securities (σ_k^2) and the variance of the funds rate. Moreover, the more negative *ceteris paribus*, the covariance between the short-term rate and reserves (σ_{kR}), the larger the first term. The size and sign of the second term also depends crucially on σ_{kR}. If σ_{kR} is negative, then the second term will be positive. Again the more negative σ_{kR}, the greater the (positive) effect on the variance of the funds rate. The third term in (24) is the *variance* of the sum of individual bank excess reserve positions which must be nonnegative by definition.

We can use Equation (24) to gain insights into the likely effects of different monetary policy target regimes on Fed funds rate variance. If the Fed followed a policy of active reserve targeting over time, such as occurred in the October 1979–October 1982 period, σ_k^2 should be greater than under interest rate targets (where by definition $\sigma_k^2 \sim 0$). Thus, the size of the first term in (24) will be larger. Moreover, if reserve targeting results in a more negative σ_{kR}, then the second term in (24) will also be larger than under a (passive) interest target regime. Finally, the $\mathrm{Var}(\sum_{i=1}^{n} \tilde{R}_i)$ term should also be smaller under interest rate targets, since under this regime R_i is largely endogenously determined by the banks in the system.

Using a high-low estimator (see [5], [23]) over the same subperiods used to measure spreads, it was found that the average daily variance of the funds rate increased from 2.36% (under interest-rate targets) to 10.27% (under reserve targets). Thus the micro-model developed above provides important insights into the underlying causes of this substantial increase in variance. Such insights cannot be derived from the standard aggregative financial market models which pervade the macro and micro-finance literature (see [3], [9], [10], [21], and [25]).

IV. Summary and Conclusions

The objective of this paper has been to demonstrate that valuable insights into the determinants of the Fed fund rate can be gained through an analysis of market participants micro-decisions. Using a micro-framework, Fed funds were shown to have a timing or flexibility advantage over other forms of reserve adjustment. Given this timing advantage, Fed fund demand functions were derived for representative market participants under conditions of managerial risk neutrality and risk aversion. These were shown to be linear functions of funds traded with intercept and slope parameters dependent on: a bank's expected reserve position relative to its reserve targets; the expected rates on short-term securities (and on discount window loans); the variance of the rate on short-term securities; and the covariance between the short-term security rate and reserves. Moreover, once these demand functions were specified, a method of aggregating the individual demand functions to derive the market clearing Fed funds rate was developed.

From this basic model, a number of interesting implications were derived. Specifically, it was possible to rationalize the observation that large banks tend to be *net* purchasers and small banks *net* suppliers of funds in the broker organized market for Fed funds. Perhaps more importantly, it was shown that the spread of the Fed funds rate over other short-term security rates could be directly related to the monetary policy (reserve adjustment) uncertainty facing the bank. The greater this uncertainty, the more valuable the timing or flexibility characteristic of the funds market and the greater the premium that agents are willing to pay (or going to demand) to participate in this market. Further, it was shown how the size of this premium, or the size of the Fed funds spread, would be directly affected by monetary policy strategy. Finally, the underlying determinants of Fed funds rate volatility (variance) were derived. These were also shown to be sensitive to the Fed's monetary policy strategy.

In conclusion, the main contribution of this paper is two-fold. First, by analyzing micro behavior in the funds market, this paper provides some useful insights into the actual formation, and time-varying characteristics, of the funds rate. Since the funds rate has been viewed as the shortest rate in the whole term-structure of rates (see Dothan [5]), an understanding of this rate formation process is crucial to sophisticated term-structure modeling or testing. Second, and equally important, is that this type of model allows for a far better understanding of how monetary policy strategy affects individual bank reserves management decisions and how these decisions in aggregate affect market rates. In so doing, better insights into the transmission mechanism of monetary policy can be derived as well as the costs and benefits of alternative monetary policy strategies.

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DISCUSSION

PAUL A. SPINDT*: The paper by Messrs. Ho and Saunders rationalizes the determination of the Federal funds rate in the context of a micro theoretic model that is relatively rich in institutional detail. For several reasons, I believe that the line of inquiry developed in the paper is of basic significance for the study and modeling of capital markets. In the first place, because it is the closest thing to an instantaneous spot rate that we observe in the actual capital market, the (overnight) funds rate is pivotal in the term structure if expectations matter. Then too, the particular role played by the funds rate in the conduct and interpretation of monetary policy gives it a unique significance in the capital market. It is therefore important that we thoroughly understand the mechanism whereby this rate is determined. Secondly, the funds rate is typically explained

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