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Lifting the Veil of Secrecy from Monetary Policy:
Evidence From the Fed's Early Discount Rate Policy.

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Lifting The Veil of Secrecy From Monetary Policy: Evidence From The Fed's Early Discount Rate Policy

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Abstract

Traditionally, monetary policy has been conducted under a veil of secrecy. In its landmark Freedom of Information Act case, the Federal Reserve argued that it needed to delay the disclosure of its policy decisions, claiming that immediate disclosure would cause the market to react in a way that was inconsistent with the Fed's intentions. Based on this argument and others, the Fed was permitted to delay the release of FOMC policy decisions. Most economists, however, believe that market forces would work to keep equilibrium outcomes more in line with policy maker's intentions if policy makers would announce their intentions and establish a reputation for behaving in a manner consistent with them. This paper tests the hypothesis that the market responds more closely to the Fed's intentions when the Fed makes its intentions known by investigating the market's reaction to a change in discount rate policy in the early 1960s. We find that the market responded in a manner inconsistent with the Fed's intentions when they were unknown, and responded in a manner consistent with them when the Fed made its intentions known.

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Historically, monetary policy has been conducted under a veil of secrecy. The economic rationale for secrecy is weak, however. Most economists believe that market forces will reinforce the policymakers' objective if they announce their intentions and establish a reputation for behaving in a manner consistent with achieving them. Economic theory's success in altering policymakers' view of how best to conduct monetary policy is evidenced by the number of central banks that have established explicit inflation targets.¹

While reluctant to go this far, the Fed has lifted the veil of secrecy from monetary policy in a variety of ways, such as, making formal and public the text of the Federal Open Market Committee's (FOMC's) policy directive and becoming more explicit about its short-run operating target, the federal funds rate.² At its February 1994 meeting, the FOMC began the practice of announcing its decision immediately upon making them.³ This procedural change is especially dramatic because it marks a reversal of the Fed's position in its landmark Freedom of Information Act case, *Merrill vs. FOMC*, [Goodfriend (1986)]. In *Merrill*, the Fed vigorously defended the need to delay the release of its policy directive.

The *Merrill* case was ultimately decided when the U.S. Supreme Court established the criterion that the FOMC must immediately disclose information unless immediate disclosure

¹Countries with explicit inflation targets are: Australia, Canada, Finland, Israel, New Zealand, Spain, Sweden and the United Kingdom. In addition, France, Germany, Italy and Switzerland have medium-term inflation objectives.

²The latest of such moves occurred at the August 1997 meeting of the FOMC, when the FOMC changed the wording of its policy directive to include a specific federal funds rate target.

³The FOMC remains reluctant to release verbatim minutes in a timely fashion or to establish explicit quantitative objects as a number of other central banks have done.

would “significantly harm the Government’s monetary functions or commercial interests.” The Supreme Court’s ruling forced the FOMC to explain its economic rationale for secrecy. The Fed defended its practice of delayed disclosure, arguing that immediate disclosure would cause financial markets to react in a way that is contrary to the Fed’s intentions. Goodfriend (1986) has pointed out that rational expectations implies that were the Fed to announce them, the market’s response would be more closely tied to the Fed’s intentions.⁴ Although widely accepted, empirical evidence of this proposition is scant because central banks have been reluctant to make their intentions known.

The purpose of this paper is to test the hypothesis that *the market’s response is more closely tied to the Fed’s intentions when the Fed makes its intentions known* by investigating the market’s reaction to the Federal Reserve’s change in discount rate policy in the early 1960s. In the early 1960s, the Fed began the practice of issuing a *statement of intent* when it announced a change in the discount rate. Previously, the Fed simply announced a discount rate change without stating the reason for the action. Because the Fed subsequently indicated what its intentions were, it is possible to test whether the market’s reaction was inconsistent with the Fed’s intentions before the Fed made them known.

The paper begins by briefly reviewing the developments that led to the marked change in discount rate policy. In the second section, the methodology for testing the hypothesis is specified. In the third section, the tests are performed and the results are analyzed. The final

⁴In advocating greater openness in the conduct of monetary policy, Blinder (1998, p. 70) has even suggested that “greater openness might actually improve the efficiency of monetary policy as a macroeconomic stabilizer.”

section presents the conclusions.

I. The Emergence of a New Discount Rate Policy

Starting in 1933, throughout World War II and during most of the immediate post-War period, discounting was virtually nonexistent. In the sixteen years from 1933 to 1949, discounts and advances were below their levels of the 1920s. Discount rate policy was likewise dormant. The discount rate was changed only once between February 1934 and December 1947.

With the Accord between the Federal Reserve and the Treasury on March 3, 1951, discounting resumed an important role in monetary policy. Indeed, the Fed elevated discounting to the point of suggesting that open market operations would supplement it.⁵ Initially, the Fed relied on what Roosa (1952, 1959) and others described as banks' *reluctance to borrow* to regulate the level of borrowing; however, borrowing increased significantly under nonprice rationing.⁶ By December 1952, discount window borrowing had increased to \$1.6 billion — about 7.5 percent of total reserves. Concerned about the level of borrowing and the frequency of borrowing by some institutions, the Fed undertook a comprehensive re-examination of discounting in 1953. Discount rate policy reemerged.⁷ The discount rate, which was changed

⁵In its 1952 Annual Report, the Board of Governors stated that "...the System contemplated that principal reliance for additional Federal Reserve credit, to support increased bank loans and investments, would be placed on member bank borrowings from Federal Reserve Banks and that open market operations would be limited as much as possible to supplying such additional demands as might be necessary to avoid undue restraint." Board of Governors of the Federal Reserve (1952), p. 91.

⁶This experience was consistent with Simmons' (1956) criticism of the Fed's discount rate policy.

⁷See Ahearn (1963) for a discussion of the revived use of the discount rate during this period.

only once between March 1951 and December 1953, was changed ten times between February 1954 and December 1957.

Prior to the early 1960s, the Fed simply announced discount rate changes. No reason for the action was given. Although the Fed did not state its intent, it believed that the market looked at changes in the discount rate as a signal of policy. In the 1954 edition of *The Federal Reserve System: Purposes and Functions*, the Fed notes:

“To the business community, the discount rate in effect at the Federal Reserve Banks, and particularly a change in this rate, serves as an objective index of Federal Reserve policy.” (p. 36)

Because the Fed’s intentions were not announced, the market was left to determine whether a particular discount rate change signaled a change in policy. Early critics of the Fed’s discount rate policy [Friedman (1960), Smith (1956, 1958), Young (1964)] argued that by failing to make its intentions known, it was likely as not that the market would misconstrue the Fed’s intentions. By 1961, the Fed acknowledged that discount rate changes were difficult to interpret, noting in the 1961 edition of *Purposes and Functions*:

“There are no simple rules for interpreting changes in discount rates, however. In some circumstances a change in discount rates may express a shift in direction of Federal Reserve policy toward restraint or ease. In other instances it may reflect a further step in the same direction. In still other cases,...a change in the level of rates may represent merely a technical adjustment of discount rates to market rates....” (pp. 46-7)

In acknowledging discount rate changes are difficult interpret, the Fed also acknowledged that technical discount rate changes had no policy significance. Apparently, the Fed neither wanted nor expected the market to respond to such discount rate changes.

It is not clear whether the Fed acquiesced to its critics,⁸ but beginning with the discount rate change made on July 16, 1963, the Fed began the practice of issuing a statement of intent, stating the reason for the discount rate change.⁹ Since then, all Fed Chairmen have followed this practice. Thornton (1982, 1986, 1994, 1998), Smirlock and Yawitz (1985), Cook and Hahn (1988) and Batten and Thornton (1984, 1985) have shown that the Fed's *statement of intent* is crucial for the markets' reaction to discount rate announcements.¹⁰ Specifically, financial and foreign exchange markets do not respond to discount rate changes that the Fed announces are made solely to realign the discount rate with market rates, i.e., *technical* changes. Financial and foreign exchange markets respond only to discount rate changes that the Fed announces are made for other, policy-related reasons, i.e., *nontechnical* changes.

Hence, when informed that particular actions have no policy significance, the market behaves in a manner consistent with the Fed's intentions and does not respond.¹¹ When informed

⁸The 1954 edition of *Purposes and Functions* made no mention of the difficulties associated with interpreting discount rate changes. Therefore, it is possible that both the wording of the 1961 edition of *Purposes and Functions*, to explicitly recognize this difficulty, and the change in discount rate policy itself might be attributable, at least in part, to criticisms by Friedman, Smith, Young and others.

⁹ The Board of Governors no longer has a copy of the press release for the discount rate change made on July 16, 1963, but according to the announcement published in the *Federal Reserve Bulletin* (July 1963), page 946, this change was made to "aid the United States' efforts to combat its international balance of payments problem."

¹⁰For other evidence that the financial, stock and foreign exchange markets respond significantly to announcements of discount rate changes see Waud (1970), Froyen (1975), Mudd (1979), Brown (1981), Roley and Troll (1984), Hakkio and Pearce (1992) Dueker (1992) and Wagster (1993).

¹¹An alternative explanation for the difference in reaction to technical and nontechnical discount rate changes is that the former are anticipated, while the latter are not. However,

that particular actions have policy significance, however, the market responds. The important question that we now turn to is whether the market responds inappropriately when the Fed did not state its intentions.

II. Testing For The Distorting Effects of Secrecy

Just prior to changing its discount rate policy, the Fed acknowledged that “Most commonly...changes in discount rates are of a routine nature, designed merely to keep discount rates in line with market rates.”¹² This admission is critical because previous research suggests that had the Fed announced which of these discount rate changes were technical, the market would not have responded to them. Hence, the Fed’s acknowledgment that most discount rate changes made prior to July 1963 were technical provides the basis to test whether the market responded in a manner inconsistent with the Fed’s intentions when the Fed did not make its intentions known.

To see how this hypothesis can be tested, consider the equation:

$$\Delta i_t = \alpha + \delta \Delta DR_{T,t} + \beta \Delta DR_{NT,t} + \mu \Delta DR_{ID,t} + \varepsilon_t \quad (1)$$

Following Thornton (1982), discount rate changes made after the Fed’s change in discount rate policy are classified as *technical*, ΔDR_T , if the Fed announced that the change was made solely to bring the discount rate into alignment with market rates and *nontechnical*, ΔDR_{NT} , if any other

Thornton (1998) presents considerable evidence rejecting this explanation for the differential response to these types of discount rate changes.

¹²Board of Governors (1963b), p. 123. See Rush, Sellon and Zhu (1994) for a discussion of some reasons why the Fed might make technical adjustments to the discount rate.

reason for the action was given.¹³ Discount rate changes prior to the change in discount rate policy are denoted *information-deficient* changes, ΔDR_{ID} , because the Fed did not provide information about its intentions.

If information deficit discount rate changes are partitioned into those which the Fed intended to be technical changes, ΔDR_{IDT} , and those which the Fed intended to have policy significance, ΔDR_{IDNT} , Equation 1 can be rewritten as

$$\Delta i_t = \alpha + \delta \Delta DR_{T,t} + \beta \Delta DR_{NT,t} + \mu \Delta DR_{IDT,t} + \gamma \Delta DR_{IDNT,t} + \varepsilon_t \quad (2)$$

Previous research has established that δ is close to and not significantly different from zero. This result is robust in that the market never responds to discount rate changes that the Fed has indicated are technical.¹⁴ In contrast, the market responds significantly to nontechnical discount rate changes, i.e., estimates of β are positive and statistically significant. If information-deficient discount rate changes are correctly partitioned into technical and nontechnical changes and if the market correctly perceived the Fed's intentions, estimates of μ should be insignificantly different from zero. However, estimates of γ should be statistically significant and the hypothesis that $\gamma = \beta$ should not be rejected, provided the market's reaction to nontechnical discount rate changes has not been affected by the Fed's change in discount rate policy. If the market sometimes mis-

¹³Cook and Hahn (1988) and Thornton (1998) have partitioned ΔDR_{NT} into those that were made in part to realign the discount rate and those that were made solely for policy-related reasons and found that the responses were not significantly different.

¹⁴See Thornton (1986, 1998). The exception is the technical adjustment on October 12, 1982, which occurred about the time the Fed was de-emphasizing M1. See Thornton (1986) for details.

perceived the Fed's intentions, estimates of both γ and μ will be significantly different from zero. Because the market's reaction is determined solely by the market's perception, this will occur whether or not information-deficient discount rate changes have been correctly partitioned into technical and nontechnical changes.

III. The Data and Test Results

The data are daily and cover the period January 4, 1954 to December 31, 1993.¹⁵ The interest rate used is the 3-month T-bill rate, TB. The Treasury rate is taken near market close, about 4:00 p.m. E.S.T. Changes in the discount rate are percentage-point changes on the day the discount rate change was first announced. Changes in the discount rate are aligned so that the change in the market rate reflects announcements of discount rate changes.¹⁶ There were 101 discount rate changes, 20 information-deficient discount rate changes and 81 discount rate changes after the change in discount rate policy — 30 technical and 51 nontechnical. This sample includes 7 technical and 11 nontechnical discount rate changes not considered in previous work. Hence, the robustness of the previous findings is investigated.

Since the Fed has not indicated which of the discount rate changes prior to the change in discount rate policy were technical, the partitioning of information-deficient discount rate changes into technical and nontechnical is accomplished by a review of the discussions of the

¹⁵The sample ends in 1993 because of anomalies in the market's reaction to discount rate changes that appear to arise from the Fed's new policy of immediate disclosure (Thornton 1996), which began with the February 1994 meeting of the FOMC.

¹⁶This was done by examining the official press release announcing discount rate changes. All but nineteen of the releases had the precise time of the release. In these nineteen cases, it was assumed that the Fed followed the practice of announcing the discount rate action just after the market closed.

Board of Governors on deciding these discount rate changes. Summaries of these discussions are published in the *Annual Report of the Board of Governors of the Federal Reserve System*. These discussions almost invariably contain some reference to recent economic and financial market developments and to the stance of monetary policy. Consequently, unlike the classification from the statements of intent from the Fed's press releases, there is an element of uncertainty associated with this procedure. Because we are interested in knowing whether the markets respond to discount rate changes that the Fed clearly intended to be technical, information-deficient discount rate changes are classified as technical only when it is absolutely clear that this was the Fed's sole motivation. Using this procedure, exactly half of the 20 information-deficient discount rate changes are classified as technical.¹⁷ The proportion of information-deficient changes classified as technical appears to be at odds with the Fed's characterization that *most* of these changes were technical. It is not surprising that a conservative approach may have understated the number of technical information-deficient changes.

To investigate the hypothesis that the market misconstrued the Fed's intentions prior to 1963, the equation

$$\Delta TB_t = \alpha + \theta(L)\Delta TB_{t-1} + \delta\Delta DR_{T,t} + \beta\Delta DR_{NT,t} + \mu\Delta DR_{IDT,t} + \gamma\Delta DR_{IDNT,t} + \varepsilon_t \quad (3)$$

was estimated. The n^{th} -order polynomial in the lag operator, L , $\theta(L) = \theta_0 + \theta_1L + \theta_2L^2 + \dots +$

¹⁷The changes classified as technical were those approved on 2/4/54, 4/13/54, 8/3/55, 8/25/55, 8/8/57, 3/6/58, 10/23/58, 9/10/59, 6/2/60 and 8/11/60. Those classified as nontechnical were approved on 4/13/55, 11/17/55, 4/12/56, 8/23/56, 11/14/57, 1/21/58, 4/17/58, 8/14/58, 3/5/59 and 5/28/59.

$\theta_n L^n$, is included in this and all subsequent regressions, but is not reported.¹⁸

The results, presented in Table 1, confirm previous findings that the market does not respond to discount rate changes that the Fed announced were solely technical realignments of the discount rate.¹⁹ The estimate of δ is small and not significantly different from zero at the 5 percent significance level. The market response to discount rate changes that the Fed announced are nontechnical, however, is highly significant.

The market also responded significantly to information-deficient discount rate changes that the Fed intended to be mere realignments of the discount rate. While the coefficient is much smaller than that of nontechnical discount rate changes, it is significantly different from zero. The market's response to nontechnical information-deficient discount rate changes is somewhat larger than that of nontechnical discount rate changes; however, the difference is not significant at the 5 percent level.

¹⁸The order of this distributed lag was 10. A distributed lag of the federal funds rate was also included. Equation 3 assumes that the T-bill rate responds to changes in the discount rate but the discount rate does not respond to changes in the T-bill rate. There is no way to completely defend this assumption; however, if the results for nontechnical changes are due to the Fed responding to the market rather than the other way around, this should also be true for technical discount rate changes since, presumably, such changes are more likely made in response to a change in market rates. In addition, Thornton (1998) has shown that discount rate changes of both types appear to be very difficult to predict on the basis of past movements in market rates and other variables, so it seems unlikely that the results are due to a systematic response of the Fed to changes in market rates.

¹⁹The estimates reported in this paper are adjusted for heteroskedasticity using a two-step generalized least squares (GLS) procedure. The equations are initially estimated using ordinary least squares (OLS). The OLS estimated residuals are partitioned into different periods and estimates of the standard errors for each period are made. The data are then transformed with the usual square-root transformation and OLS is reapplied to the transformed data. See Fomby, Hill and Johnson (1984) for additional details.

The fact that the response to information-deficient discount rate changes classified as nontechnical is significantly larger than the response to those classified as technical, suggests that the market correctly distinguished some of the technical discount rate changes. This is not surprising since other policy changes or statements of Fed officials around the time of discount rate changes should have provided the market some information about the Fed's intentions.

Because this classification procedure appears to have understated the number of technical discount rate changes and to investigate the sensitivity of the results to the classification procedure, information-deficient discount rate changes are reclassified. This time discount rate changes are classified as nontechnical only if it is clear that the Fed intended the change to have some policy significance. This approach yielded 15 technical information-deficient discount rate changes.²⁰

Estimates of Equation 3 with this partitioning of information-deficient discount rate changes are presented in Table 2. Once again, the market responded significantly to information-deficient discount rate changes that we classified as technical. The magnitude of the average response is only slightly larger than the estimate presented in Table 1. Hence, the market may have had some reservations about the policy significance of the five discount rate changes that were reclassified. The response to nontechnical information-deficit discount rate changes is much larger than that of nontechnical discount rate changes; however, the sample is very small.

Given the uncertainty associated with either of the above classifications of information-deficient changes and the fact that there are only 20 information-deficient discount rate changes,

²⁰The discount rate changes approved on 4/13/55, 4/12/56, 8/23/56, 4/17/58, and 5/28/59 were reclassified from nontechnical to technical.

it is useful to consider the case where the market was unable to decipher the Fed's intentions.

The assumption that the market is unable to distinguish between technical and nontechnical information-deficient discount rate changes implies that $\Delta DR_{IDT} = \Delta DR_{IDNT}$. With this restriction, Equation 3 is rewritten as:

$$\Delta TB_t = \alpha + \theta(L)\Delta TB_{t-1} + \delta\Delta DR_{T,t} + \beta\Delta DR_{NT,t} + \pi\Delta DR_{ID,t} + \varepsilon_t \quad (4)$$

If the market was unable to determine which of the information-deficient discount rate changes were technical and which were nontechnical and if there was no change in the market's response to discount rate changes following the change in discount rate policy, the average response to information-deficient changes should equal the average response to nontechnical changes, i.e., $\pi = \beta$.

Estimates of Equation 4, presented in Table 3, show that on average the market's reaction to nontechnical and information-deficient discount rate changes are nearly equal and the null hypothesis of equality is not rejected at any reasonable significance level.

The robustness of this result and its temporal stability is further investigated by partitioning ΔDR_{ID} into two groups, A and B, with the first N discount rate changes put in group A; the remainder put in group B. The equation is estimated and the null hypotheses that the coefficients for groups A and B are significantly different from zero and equal are tested. Three discount rate changes are then added to group A and removed from group B and the process is repeated.²¹ This procedure is repeated, each time with more discount rate changes in group A

²¹Qualitatively identical results are obtained by adding one discount rate change to the first sample and deleting it from the second.

and fewer in group B. Finally, information-deficient discount rate changes are partitioned into three groups, A, B, and C.

The results, presented in Table 4, indicate that the average response to information-deficient discount rate changes is remarkably robust, changing little over time. The coefficient estimates are similar in magnitude, always significant and the null hypothesis of equality of the response is never rejected. Hence, not only does the market respond inappropriately when uninformed of the Fed's intentions, but the evidence suggests that the mean response to nontechnical discount rate changes was quite stable and not affected by the change in the Fed's discount rate disclosure policy.²²

The evidence suggests that when the market is informed that discount rate changes are merely technical adjustments, it does not respond. However, when the Fed makes technical adjustments to the discount rate but does not inform the market, the market appears to interpret the discount rate change to have more significance than the Fed intended. Had the Fed been forthcoming about its intentions when it changed the discount rate prior to July 1963, the market would not have responded to most discount rate changes.

Furthermore, the response to discount rate changes prior to July 1963 is nearly identical to the response to nontechnical discount rate changes after July 1963, suggesting that the

²²The result that the mean response is unaffected by the change in discount rate policy is consistent with the results of the market's reaction to the Fed's policy of immediate disclosure. Thornton (1996) finds that the market responds immediately to changes in the Fed's funds rate target under a policy of immediate disclosure and with a lag of about three days under delayed disclosure. However, the magnitude of the total response is the same under immediate and delayed disclosure.

market's response was not affected by this change in discount rate policy.²³

IV. Conclusions

In its landmark Freedom of Information Act case, *Merrill vs. FOMC*, the Fed argued that secrecy was important for the efficacy of monetary policy. Most economists, however, believe that the efficacy of monetary policy is greatest when a central bank clearly states its goal, provided that the market believes that the central bank can and will achieve it. This paper undertakes a limited empirical investigation of the Fed's argument for secrecy by investigating the market's reaction to discount rate changes before and after the Fed began announcing the reason for making discount rate changes in the early 1960s.

Historically the Fed has made two basic types of discount rate changes, those made for policy reasons and those made solely to realign the discount rate with market rates. Prior to July 1963 the Fed merely announced discount rate changes, without informing the market which changes were merely technical adjustments and which had policy significance. Previous research has shown that the market does not react to discount rate changes that the Fed announced were solely technical adjustments.

Discount rate changes made prior to the Fed's change in discount rate policy were classified as "technical" or "nontechnical" based on Federal Reserve records. Based on this classification, the evidence indicates that the market responded significantly to discount rate changes that the Fed had intended to be merely technical realignments of the discount rate. Had

²³This is consistent with the recent finding of Thornton (1996) with respect to the market's reaction to changes in the Fed's federal funds rate target following the FOMC's change in disclosure policy. Specifically, Thornton found that the market's reaction was the same before and after the change in disclosure policy.

the market been properly informed of the Fed's intentions, the evidence suggests that it would not have responded to such discount rate changes. Uninformed of the Fed's intentions, however, the market appears to have inferred some significance, greater than was intended, to these discount rate changes.

The empirical analysis is limited in that only the market's reaction to one of the Fed's policy tools is investigated. Nevertheless, the results support the widely-held belief that monetary policy works best when policymakers are explicit about their objective. In so doing, they vindicate the critics of the Fed's early discount rate policy [Friedman (1960), Smith (1956, 1958), Young (1964)] who argued that by not stating them, the Fed's intentions would be misconstrued.

It is important to remember, however, that market forces will not necessarily reinforce the their objective simply because policymakers make it known. The market must believe that the policymakers' objective is obtainable and the policymakers' commitment to the objective must be credible. Stronger evidence on the importance of transparency and credibility likely will come from the many inflation targeting experiments that are currently under way.

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Table 1: Estimated Response to Discount Rate Changes by Type

Type/[Number]	ΔTB
Const.	0.0074 (0.75)
ΔDR_T [30]	0.0625 (1.54)
ΔDR_{NT} [51]	0.2505* (18.08)
ΔDR_{IDT} [10]	0.1193* (3.05)
ΔDR_{IDNT} [10]	0.3208* (7.87)
Adj R ²	0.0737
Null Hypothesis	F-Statistic
IDT=IDNT	12.7533*
NT=IDNT	2.6697

**Table 1, continued: Estimated Variances
Used in the Two-Step
Estimation**

ΔTB	
Period	Estimate
1/4/53-1/24/58	0.0370
1/25/58-9/15/61	0.0672
9/16/61-5/26/66	0.0203
5/27/66-7/25/73	0.0627
7/26/73-7/3/75	0.1721
7/4/75-9/10/79	0.0757
9/11/79-11/29/82	0.2717
11/30/82-8/6/90	0.0768
8/7/90-12/31/93	0.0369

Absolute value of t-statistic in parentheses.

*Indicates statistical significance at the 5% level.

The equations in this paper are estimated using a two-step procedure to correct for heteroscedasticity. Specifically, each equation, written more compactly as $y = X\beta + \varepsilon$, was estimated using ordinary least squares, OLS. The OLS residuals are partitioned into N groups, $i = 1, 2, \dots, N$. It is assumed that $E(\varepsilon_i \varepsilon_i') = \sigma_i^2 I$ for all i . The equation was then re-estimated using generalized least squares, i.e., $\tilde{\beta} = (X' \tilde{\Omega}^{-1} X)^{-1} X' \tilde{\Omega}^{-1} Y$, where $\varepsilon = (\varepsilon_1, \varepsilon_2, \varepsilon_3, \dots, \varepsilon_N)'$ and $E[\varepsilon \varepsilon'] = \Omega$, a diagonal matrix. For more details see Fomby, Hill and Johnson (1984, pp. 174-76). The estimated variances, presented above for $N=9$, shows how the variance changes over the sample.

Table 2: Estimated Response to Discount Rate Changes by Type

Type/[Number]	ΔTB
Const.	0.0078 (0.79)
ΔDR_T [30]	0.0625 (1.54)
ΔDR_{NT} [51]	0.2505* (18.08)
ΔDR_{IDT} [15]	0.1290* (3.90)
ΔDR_{IDNT} [5]	0.4409* (8.29)
Adj R ²	0.0749
Null Hypothesis	F-Statistic
IDT=IDNT	24.8093*
NT=IDNT	12.0101*

Table 3: Estimated Response to Discount Rate Changes by Type

Type/[Number]	ΔTB
Const.	0.0075 (0.76)
ΔDR_T [30]	0.0624 (1.54)
ΔDR_{NT} [51]	0.2505* (18.08)
ΔDR_{ID} [20]	0.2158* (7.62)
Adj R ²	0.0726
Null Hypothesis	F-Statistic
NT=ID	1.2128

Table 4: Tests For Robustness in Response to Information-Deficient Discount Rate Changes			
Number [A, B]	ΔTB		
	A	B	C
[7, 13]	0.2023* (3.64)	0.2205* (6.71)	--
[10, 10]	0.2443* (6.65)	0.1744* (3.94)	--
[13, 7]	0.2161* (6.47)	0.2150* (4.04)	--
[7, 7, 6]	0.2023* (3.64)	0.2323* (5.64)	0.1999* (3.68)
F-test [7, 13]	0.0791	--	--
F-test [10, 10]	1.4804	--	--
F-test [13, 7]	0.0003	--	--
F-test [7, 7, 6]	0.1519	--	--

Absolute value of t-statistics in parentheses.

*Indicates statistical significance at the 5% level