Market-Based Monetary Policy Transparency Index, Risk and Volatility – The Case of the United States

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April 2004

* I would like to thank Dr. Katherine Graham, dean of the Faculty of Public Affairs and Management at Carleton University, for providing a research grant for this project.

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Abstract

This paper extends the literature by developing an objective market-based index, which is dynamic and continuous and can be used to measure the monetary policy transparency for a country or, simultaneously, a series of countries. It was found that the more transparent the monetary policy is, the less risky and volatile the money market will be. Furthermore, during the tenure of Chairman Greenspan the volatility and risk in the money market fell. The policy regime changes of adjusting the target rate by multiples of 25 or 50 basis points and including a balance-of-risks sentence in FOMC statements also resulted in a reduction in volatility in the money markets.

Keywords: Monetary policy transparency, risk, volatility, money market

JEL Codes: E43; E51; E52; E58

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I. Introduction

Central banks are unequivocally moving towards greater openness or to more transparent monetary policy frameworks by engaging in, among other things, inflation targeting, publishing inflation forecasts and increasing the number of public statements from bank officials. Whether such moves are desirable or not, or to what degree they are desirable, is still open to question. The theoretical studies in favor of and/or against more transparency in central banking, although ample, are not unanimous in their findings, and empirical tests of these arguments are scarce, mostly because transparency in monetary policy is a concept hard to measure.

The existing transparency measures have some limitations. Most of them are not in time-series form and so can be used only for cross-sectional studies. Moreover, they can only be used for a limited number of hypotheses. They are based on the quantity, timeliness, and periodicity of information provided by central banks and finally, they are somehow static. The purpose of this paper is to develop an index, which is dynamic and continuous and can be used to measure monetary policy transparency for a country or, simultaneously, a series of countries, using time-series as well as cross-sectional data.

The existing measures of transparency can be divided into four groups:

(i) Descriptive accounts of transparency: This kind of transparency measure concentrates on strategies that central bankers follow in order to communicate with the public. It mostly includes do's and don'ts of the central bankers' actions, see, e.g., Blinder *et al.* (2001). The main problem with this measure is that no index can be derived/constructed from these do's and don'ts.

(ii) Central bank surveys or self-evaluating transparency indexes: A series of surveys are sent to central banks to investigate the extent to which they communicate their private information to the public, including the degree to which they are following the *Code of Good Practices on Transparency in Monetary and Financial Policies* developed by the International Monetary Fund (IMF), see, e.g., Fry *et al.* (2000) and Sundararajan *et al.* (2003). The limitation with this type of measure is that there is a possibility for researchers to misunderstand the survey questions and/or for central banks to manipulate responses to obtain an appropriate score.

(iii) Official documents and information: Researchers construct indexes of transparency of monetary policy by evaluating the behavior of central bankers (e.g., whether they give speeches regularly or not) and the type and frequency of documents the central bank makes available to the public (such as minutes from meetings, inflation reports, etc.), see, e.g., Eijffinger and Geraats (2002), de Haan and Amtenbrink (2002), and Bini-Smaghi and Gros (2001). One possible weakness with this approach is that the particular items looked at and the weight assigned to them by each set of authors may differ for purely subjective reasons.

Furthermore, these measures quantify the degree of openness of central banks based on the information provided, but do not necessarily reflect the true degree of understanding, by the public, of central banking practices. In sum, the common problem with the above three measures is that they are not in time-series form; instead, they are calculated for cross-sectional studies. Thus, these measures limit the number of hypotheses that may be tested concerning the impact of more transparent monetary policies in the economy.

Finally, (iv) market-based indicators: These indexes are based on what market participants understand from the central banks' actions and signals as well as the implementation of the monetary policy. The existing market-based indicators also have limitations. For example, Howells and Mariscal (2002) provide a measure of monetary policy transparency for a small number of cross-section countries, therefore, limiting the number of hypotheses that may be tested.

The degree to which market participants understand and anticipate monetary policy can also be gauged by using time-series market-based expectations of monetary policy, and more particularly, high frequency measures of monetary policy surprises. In general, the time-series market-based measures of policy surprises in the U.S. include those based on federal funds futures rates, e.g., Poole and Rasche (2000), Kuttner (2001) and Söderström (2001). These measures restrict the analysis to post 1988, the year when this market was established. Furthermore, as it was mentioned by Poole *et al.* (2002), fed funds rate futures could reflect the expected changes in the target rate only if the times of target rate changes were known. Since this information became available only after 1994, these measures further restrict researchers to post 1994.

Other measures are based on actual market rates including Treasury bill rates and Eurodollar deposit rates, e.g., Ellingsen and Söderström (1999) and Cochrane and Piazzesi (2002). These measures mostly concentrate on a change in the single interest rate at the time of a target change. Consequently, these measures are static and, more importantly, they are very narrowly defined since they put too much emphasis on a single piece of information. Interest rates in general, and especially their relationships, reflect the behavior of market participants (arbitrageurs and speculators).

Finally, some policy surprise measures are based on the analysis of the financial press, e.g., Poole *et al.* (2002) and Söderström (2001). These measures can be subjective as the interpretation of the financial press fully depends on the background and experience of the researchers. The overall limitation of these measures arises from the fact that they are usually series of unequal intervals. Therefore, they may restrict the researcher to studies with quarterly or less frequent data or to specific techniques of estimation such as the factor-model approach which allows the researcher to deal systematically with data irregularities [e.g., Stock and Watson (2002)].

Consequently, this study attempts to develop an index, which is dynamic and can be used to measure the monetary policy transparency for a country or, simultaneously, a series of countries. To the best knowledge of the authors, no such index exists in the literature. We will develop the measure for the United States monetary policy for the 1982-2003 period. The choice of country is based on the fact that the United States has a complicated banking system (12 Federal Reserves) with no clear policy objectives, like inflation targeting, interest rate band, etc. Consequently, the index, if successful in detecting the Federal Reserve monetary transparency, will be useful to check the central bank transparency of any country, especially countries like Canada, New Zealand, etc., who have clear monetary policy goals like inflation targeting.

Our main contribution to the literature is the construction of a monetary policy index, which is dynamic and can also be continuous when intraday minute or shorter interval observations are used. Furthermore, we found, using our index, that the more transparent the monetary policy is, the less risky and volatile the money market will be.

Section II provides a description of our data and of the transparency oriented reforms at the Fed. Section III is devoted to the theoretical foundation of the index and its construction. Section IV covers the empirical tests on the power of the index in investigating the hypothesis that higher transparency reduces risk and volatility in the money market. The final section provides a summary and conclusions.

II. Data Description

The daily data on fed funds effective rates and Treasury bill (secondary market) rates for the period 1982 (October 5)-2003 (December 31) are used. The number of observations is 5308 days. The source of these data is the St. Louis Federal Reserve website. We also obtained from the same source the data on the sum of the individual bank excess reserve positions, but data is in monthly observations. To generate a daily series we computed an interpolation of the monthly series while maintaining the last value in each period. An ARIMA(1,1,0) process was used to generate the data with RATS computer software.

The choice of the sample period is based on the availability of data on target fed funds rates. According to Sarno and Thornton (2003, p. 1099), the Fed was explicitly targeting the funds rate from 1974 to October 1979. The Fed switched to a non-borrowed reserves operation procedure in October 1979, and in October 1982 switched to a borrowed reserves operating procedure. However, "Exactly when the Fed switched from a borrowed reserve operating procedure to an explicit funds rate targeting procedure is contentious [...] there seems to be general agreement that the Fed has explicitly targeted the funds rate at least since the late 1980s." In any event, for the purpose of this paper and the construction of our index, available target rates with their respective dates are needed.

To the best knowledge of the authors, a non-interrupted set of data on fed funds target rates is only available from October 1982. For the period 1982-1989 we used a series prepared by the staff of the Board of Governors of the Federal Reserve System. This series is based on staff's unofficial interpretations of FOMC meeting transcripts and other documents publicly available. We obtained this series through the Secretariat's office of the FOMC but it can also be partially found in Thornton and Wheelock (2000).[1] Note that May 7, 1988 corresponds to a Saturday, when markets were closed. Following Rudebusch (1995), we use May 9, 1988 as the day when the target was changed. Furthermore, again following Rudebusch, for the target change of "early January 1989", we assume January 5 as the day when the target was changed.

For the period 1990 onwards, the series reported on the Board of Governors of the Federal Reserve System's website was used (see series under the heading of "intended federal funds rate").[2] The target rate changes are presented in Table 1. Following Poole *et al.* (2002), we call "event days" the days on which the FOMC meets (whether they change the target or not) and the inter-meeting days on which the target rate was changed. The FOMC meeting dates are provided in Table 2.

Tables 1 and 2 about here

The rates reported in Table 1 are on a 360-day basis. Furthermore, in the calculation of our transparency index, to avoid an artificial reduction in the index, we use 360-day fed funds and Treasury bill rates. For all other analyses in this paper, however, rates are expressed on a 365-day basis. For the period under consideration, the Fed has made some transparency-oriented changes. Some of the most representative changes include: (i) October 19, 1989 when the Fed started the practice of adjusting the funds rate target by 25 or 50 basis points,[3] (ii) February 4, 1994 when the Fed began announcing policy decisions after each FOMC meeting, (iii) August 19, 1997 when the FOMC started including a quantitative fed funds target rate in its Directive to the New York Fed Trading Desk and (iv) May 18, 1999 when the Fed extended its explanations regarding policy decisions, and started including in press statements an indication of the FOMC's view regarding prospective developments (or the policy bias). Furthermore, (v) on January 19, 2000, the FOMC issued a press statement explaining that it would include a

[1] Rudebusch (1995) also constructed a federal funds target rate series. His series is available for the periods 1974-1979 and 1984-1992. Although Rudebusch's series has been widely used by researchers, we use the FOMC Secretariat's series because it allows us to study the longest consecutive time period.

[2] Alternatively, the series can be found in the Federal Reserve Bank of New York's website.

[3] According to Poole and Rasche (2003), this practice started in August 1989, however, we will follow Sarno and Thornton's (2003) estimation of October 1989, since it is likely that it took the market at least two months to realize that the FOMC had enacted this practice. Also note that according to Rudebusch (1995), the target change occurred on October 18, 1989, not on the 19. Since we work with the Secretariat series, we will assume that the change started on the 19.

balance-of-risks sentence in its statements, replacing the previous bias statement.[4] The practice was first implemented in the following FOMC meeting, on February 2. Finally, (vi) since March 19, 2002 the Fed has included in FOMC statements the vote on the directive and the names of dissenter members (if any).[5]

We will use our index to determine whether transparency-oriented reforms at the Fed have indeed increased the market's understanding of Fed policies. Finally, we will also test whether monetary policy has been more transparent during Alan Greenspan's tenure (August 11, 1987 to the present).

III. A Money-Market Measure of the Transparency of Fed Policy Making

In a recent paper Sarno and Thornton (2003) have shown the federal funds and 3-month Treasury bill rates are cointegrated. Furthermore, the adjustment toward the long-run equilibrium largely occurs through the movements in the federal funds rate rather than the TB rate. Thornton (2004), moreover, finds that in conducting its monetary policy the Fed reacts to movements of short-term interest rates by following an "interest-rate smoothing" policy. Such a policy implies that all target changes are endogenous responses to economic shocks.

Other studies [see Thornton (2004) on relevant literature] argue that private agents drive the interbank rate to the level desired by the Fed. The action of these agents reflects the Fed's "open mouth operations". Under such operations, the Fed announces its intention and market participants, knowing that the Fed can and will change the fed funds rate to what monetary authorities intend, react in such a way that the rate moves to what the Fed intends. Under open market operations, through purchases or sales of securities, the Fed influences the fed funds rate. In both of these cases, the Fed conducts a "discretionary" monetary policy to influence the fed funds rate. Then the fed funds rate changes affect other money market rates. However, under the "interest-rate smoothing" policy the Fed, by influencing fed funds rate, reacts to movements of short-term interest rates either to moderate the movements or to lead these rates to a specific direction or level that the monetary authorities consider desirable. In this case, short-term money

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[4] Federal Reserve Board, "Modifications to the FOMC's Disclosure Procedures" 19 January 2000.

[5] For a review of these changes, see Poole and Rasche (2003).

market rates, which reflect economic conditions and/or market participants' expectations, influence the fed funds rate. On these issues, see Thornton (2004) who reports all relevant literature and analyses clearly all these possibilities. Using the result of the existing literature we assume that the monetary policy in the United States can be "discretionary" or "interest-rate smoothing", or a combination of these two regimes.

In this section, using the above assumption, we will construct an index of the transparency of monetary policy. Our index is based on the degree to which money market participants anticipate the decisions taken at the regularly scheduled FOMC meetings (whether a target change occurred or not), as well as those (target changes) enacted outside these meetings. We will first introduce the theoretical justification for our index and then we will construct both our formal index and an extended version.

A. A Monetary Policy Index: Theoretical Justification

Suppose full certainty (100% transparency) on monetary policy exists, i.e., the Fed fully conveys its private information on monetary policy decisions to the market. The implementation of the monetary policy can be conducted in one or more of the following ways: remarks of the Chairman of the Federal Reserve as well as other senior management of the Fed, testimony before the House and Senate Banking Committee, the release of the Beige book, the minutes of the Federal Open Market Committee meetings, changes in reserve requirements, changes in the discount rate and open market operations.

Suppose at time t the Fed conducts a "discretionary" monetary policy and tightens the market by, say, an outright sale of Treasury bills in order to increase the target rate from FF_0 to FF_1 at time t+1, the target-change day or the day of the FOMC meeting. There will be a drain in reserves. Banks compete for the interbank funds and the Federal funds rate will go up. This will lead to an increase in the Treasury bill-Federal funds rate differential, Dif_t ($= FF_t - TB_t$). Banks will also sell their Treasury bills or other liquid assets to obtain the required liquidity and so put a further downward pressure on Treasury bill prices. Since we assumed full monetary policy transparency, the market participants, knowing the intention of the Fed, will also sell Treasury bills. These speculative/arbitrage activities will continue until the interbank and the money markets are again in equilibrium at time t+1. At such time, we would expect, when full transparency exists, Dif_{t+1} and Dif_t to almost coincide.

The Fed's action and the subsequent market's reaction will continue until the next target-change day or FOMC meeting when the Fed's desired target rate (FF_1) is officially announced. According to this analysis, one would expect under full monetary policy transparency, deviations of Dif from its average/trend (say, Tdif) be temporary. In fact, using the assumption that FF causes TB, we may consider Dif during the transitory period (between two equilibrium positions) as a measure of the stance of the monetary policy.

If we assume there is a lack of (less than 100%) monetary policy transparency, then deviations of Dif from Tdif last longer and may not be temporary. The reason is that market participants could easily be confused by the action of the Fed and may overreact/underreact in the right or the opposite direction where the authorities wish the market to go. This may make the life of the central bankers more difficult and may result in more activities by the Fed to correct the situation. For example, an outright sale of Treasury bills by the Fed may be considered a smoothing action by the market and lead the participants to purchase Treasury bills in order to sell them at a higher price when the Fed starts buying them back. This will result in widening the deviations of Dif from Tdif. Consequently, any $|D_t|$ — where $D_t = Dif_t - Tdif_{t-1}$ — is an indication of the monetary policy transparency, a small $|D_t|$ means a high transparency and vice versa.

Note that we are assuming the market is not efficient in a strong form, i.e., the market participants do not know the Fed's private information before it is publicized. If the market is efficient in the strong form, market participants will, on average, perceive the target rate change in advance, and if there exists potential for arbitrage/speculative profits arbitrageurs and speculators will trade until potential profits are eliminated. Namely, arbitrage and speculative activities will eliminate any D_t, which is associated with potential arbitrage/speculative profits. If the market is not efficient in a strong form, arbitrageurs and speculators must be given the inside information through Fed's signals/operations.

Let us now assume the Fed is following an "interest-rate smoothing" policy. Starting from full monetary policy transparency, suppose market participants, due to some signals from the Fed and/or some economic shocks which caused movements in the equilibrium interest rate, expect a positive change in the target rate. A higher expected rate in the near future creates potential for arbitrage/speculative profits. Profit maximization leads arbitrageurs/speculators (investors) to operate along the short end of the yield curve by selling their three-month bills and buying very short-term bills or lending overnight. This action leads to an increase in TB and a reduction in D. To moderate the reduction in the overnight rate as well as to confirm its intention, the Fed will put an upward pressure on non-borrowed reserves by selling bills. The Fed's action leads to an upward/downward pressure on FF/TB. Arbitrage and speculative activities as well as the Fed reactions continue until the money market is again in equilibrium. As before, one would expect D, under full monetary policy transparency, to approach zero at equilibrium when potential for arbitrage/speculative profits is eliminated. Clearly, when monetary policy transparency is low, D is high in absolute value.

In sum, so far, based on the empirical results in literature, we have established theoretical justification behind our index. Such an index, contrary to the existing market based indexes in the literature, e.g., Howells and Mariscal (2002), is dynamic and includes expected policy actions.

B. Basic Index

We will construct our index in three steps as follows:

(1) We identify "event days" as the days on which the Federal funds target rate was changed whether at a regularly scheduled FOMC meeting or outside the meetings (Table 1) and also the days on which the FOMC met but did not change the target rate. When the FOMC meetings took place over two days we choose the second day of the meeting as the event day. Our event days can be seen in Table 4, which also shows our index.

Our first event date in the sample is October 5, 1982, the first meeting of the FOMC during our period of study. On this date, the FOMC adopted a target for the Federal funds rate of 10%. Our second event date is October 8, 1982, when the FOMC changed the target (to 9.5%) outside a regularly scheduled meeting. Our last event date is December 9, 2003, the last meeting of the FOMC within our sample period. On this occasion the Fed left the target rate unchanged. In total, we have 227 event days.

(2) For each event day, we calculate $|D_t| = |Dif_t - Tdif_{t-1}|$, where $Dif_t = FF_t - TB_t$ and where $Tdif_{t-1}$ is the average of Dif_t between two event dates. Namely, we calculate daily observations of the absolute value of the deviation of FF minus TB from the trend differential at each event date.[6] To further clarify the calculation of the index, we provide in Table 3 a detailed calculation of $|D_t|$ for three event dates in the sample, i.e., i = October 5, 1982, j and i = October 8, 1982 and j = November 16, 1982. Dif_t is easily constructed by subtracting TB_t from FF_t at each date. $Tdif_{j-1}$ is found as the arithmetic average of Dif_t for, e.g., t = 5-Oct-82, 6-Oct-82, 7-Oct-82, is,

$$Tdif_{j-1} = (2.13 + 1.40 + 2.06)/3 = 1.863333.$$

Finally, $|D_j| = |Dif_j - Tdif_{j-1}| = |1.88 - 1.863333| = 0.016667$.

(3) We consider the maximum/minimum of $|D_t|$, at the event dates in the sample period, to be the least/most transparent over the period, and we calculate the index as follows:

$$T_t = \text{transparency index} = \frac{100}{e^{|D_t|}}. \tag{1}$$

If $|D| = 0\%$, we will have $T = 100\%$, the highest transparency degree and for $|D| = 10\%$ we will have $T = 0.0045\%$ which may be considered zero transparency for the case of the United States. In sum, under the environment when the Treasury bill market is not efficient in a strong form, market participants can completely perceive the target rate, only due to 100% transparency, so that $e^{|D|} = 1$. Table 4 reports the transparency index for our sample period. See also Figure 1.

Figure 1 about here

Tables 3 and 4 about here

For the entire sample, index T averages 83.64%. The maximum value of T is 100 (full transparency or full anticipation) and it occurs on September 26, 1995. The least transparent outcome (T = 23.42%) occurs early on in the sample on December 16, 1987.

[6] Although it would be more intuitive to calculate Tdif as the daily geometric average (as opposed to the arithmetic average), about 10 percent of the time Dif is a negative value and often the number of days between event days is an even number. Consistent approximations of the geometric average are also not possible for all dates in the sample. To make the measure consistent across observations we use simple arithmetic averages. Another potential problem with geometric averages occurs when the differential is zero or close to zero, because in such a case the geometric mean artificially drives the trend to zero.

A fairly low value for T also occurs on September 17, 2001, clearly due to the uncertainty created by the events of September 2001.

As explained in Section II, during our sample period there have been policy regime changes, which, without any doubt, resulted in a higher monetary policy transparency in the United States. These changes occurred on August 11, 1987, October 19, 1989, February 4, 1994, August 19, 1997, May 18, 1999, February 2, 2000 and, March 19, 2002. We will use our index to determine whether the above transparency-oriented changes at the Fed have indeed increased the market's understanding of Fed policies.

Since our basic index, T, has irregular intervals we constructed a quarterly sample out of the observations. Namely, we took the average of our index in each quarter. According to both Dickey-Fuller and Phillips-Perron tests, variable T is stationary.[7] Table 5 reports the means with their standard errors (adjusted for autocorrelation and heteroscedasticity) of the index before and after each policy regime change. All of the means are statistically significant. The above policy regime changes resulted in positive and statistically significant changes in the transparency index. Consequently, according to these results, the index developed in this paper clearly captures the increase in the monetary policy transparency created by the above policy regime changes. Namely, the index developed in this paper fully reflects a transparency index.

Table 5 about here

C. Extension of the Index

Being a variable with unequal intervals, our basic index can be used in studies with quarterly or less frequent data. Alternatively, it restricts the researchers to specific techniques of estimation, such as the factor-model approach which allows researchers to deal systematically with data irregularities [e.g., Stock and Watson (2002)]. To make the measure suitable for all kinds of research, using the above methodology and logic, we extend our index as follows. For the event days, the index is defined exactly as before [Equation (1)]. For all other days, we compute an estimated or forecasted value of D_t,

[7] The absolute value of the augmented Dickey Fuller *t* was estimated to be 6.77 [more than 2.89 (5% critical value)] and the absolute value of the Phillips-Perron non-parametric *t* was estimated to be 7.12 [more than 2.89 (5% critical value)]. Both of these tests were done for a lag length of zero (where, for a global lag of 20 days, the AIC is at its minimum).

called $\hat{D}_t$, where $\hat{D}_t$ = $|Dif_t - Adif_t|$, with Dif_t as defined as before (= $FF_t - TB_t$) and with

$Adif_t = \frac{\sum_{i=1}^{j} Dif_{t-i}}{n}$, where j is the last event day and n is the number of days since the last event day. Given $\hat{D}_t$, we calculate an index for non-event days $\hat{T}_t$,

$$\hat{T}_t = 100 / e^{|\hat{D}_t|}. \quad (2)$$

Note that our index $\hat{T}_t$ is dynamic and also continuous in the sense that we can construct it for intraday-minute or even shorter-interval, instead of daily, observations. To further clarify how the index is constructed on non-event days consider once again the first two event dates in the sample i = October 5, 1982 and j = October 8, 1982, and assume that we want $\hat{T}_t$ for t = October 7, 1982. We first compute $Adif_t = \frac{\sum_{i=1}^{j} Dif_{t-i}}{n}$ = (2.13+1.40)/2 = 1.765. We then compute $\hat{D}_t$ = $|Dif_t - Adif_t|$ = |2.06-1.765| = 0.295, and $\hat{T}_t = 100 / e^{0.295} = 74.453159$. Figure 2 depicts our extended index. Note that for event days the extended index is given by T_t and for non-event days, by $\hat{T}_t$. On average, for the entire sample period, the extended transparency index equals 85.68**.** See Table 3 for the extension of the example for the next event date.

Figure 2 about here

We will again investigate, using our daily observations and extended index, whether the regime changes of August 11, 1987, October 19, 1989, February 4, 1994, August 19, 1997, May 18, 1999, February 2, 2000, and March 19, 2002 have resulted in more transparency (as measured by our extended index). According to both Dickey-Fuller and Phillips-Perron tests, our extended index $\hat{T}$ is stationary.[8] Table 5 also reports the means with their standard errors (adjusted for autocorrelation and heteroscedasticity) of the daily index before and after each policy regime change. As the results reported in the table indicate, all means and their changes are positive and

[8] The absolute value of the augmented Dickey Fuller *t* was estimated to be 41.46 (more than 2.86 [5% critical value)] and the absolute value of the Phillips-Perron non-parametric *t* for the lag length of 4 (where,

statistically significant, confirming the earlier findings that these policy regime changes resulted in a higher monetary policy transparency. Furthermore, the results imply that the daily monetary policy transparency index developed in this paper also fully and clearly captures the increase in the monetary policy transparency created by the above policy regime changes. Namely, the daily index developed in this paper also fully reflects a monetary policy transparency index.

IV. Risk and Volatility in the Money Market: Further Evaluation of the Index

It is commonly believed [e.g., Thornton (1996) and Blinder *et al.* (2001)] that monetary policy transparency leads to a lower uncertainty and risk in the financial markets. If our index, both the basic and the extended, is a true proxy for monetary policy transparency in the United States it should have a negative relationship with the risk observed in the money market in the country. This section is devoted to such an investigation. We will first test if the index has a negative impact on the risk in the money market. We will conduct this test by using the rational expectations model of the term structure. The test is based on the idea that the more the Fed conveys its private information to the market the higher the forecast ability of the market participants will be and, consequently, they will demand a lower risk premium. We then test if our index has any impact on the volatility in the money market in the United States. This test is based on the idea that a higher volatility of the return in the money market is associated with a higher risk in the market and, therefore, if a more transparent monetary policy results in a lower volatility it will help to reduce risk in the money market.

A. Risk in the Money Market and the Index

The pure (rational) expectations model of the term structure (RE), in which the term premia are set identically to zero, implies that at any moment in time, the expected TB, for example, prevailing at the beginning of three months from now (${}_{1+3}TB_t^e$) should be equal to the implied forward three-month Treasury bill rate (FTB_t) in the absence of term premium or any other risk. From the first statement of the theory [e.g., Van Horne (1965)], we know that $FTB_t = [(1 + TB6_t/4)^2/(1 + TB_t/4)] – 1$. Here TB6 is the six-month

for a global lag of 20 days, the AIC is at its minimum) was estimated to be 42.32 [more than 2.86 (5% critical value)].

spot rate and we assume both six- and three-month spot Treasury bill rates are at the annual rate. Specifically, we can write:

$${}_{1+3}TB_t^e = FTB_t. \qquad (3)$$

If this equality is violated, investors and speculators, trade three- and six-month Treasury bills, to capture potential arbitrage profits, until Equation (3) is restored. For example, if ${}_{1+3}TB_t^e > FTB_t$ speculators will sell their six-month bills and buy three-month bills, pushing the price of six-month bills down ($TB6_t$ will go up) and increasing the price of three-month bills up ($TB3_t$ will go down). This speculative activity continues until the potential for arbitrage profits is eliminated, i.e., ${}_{1+3}TB_t^e$ is again equal to FTB_t. Furthermore, by orthogonal decomposition at any given time t we have:

$$TB_t = TB_t^e + V_t, \qquad (4)$$

where V_t is the agents' forecast error in the absence of transaction costs, risk and other premia (including term premium, liquidity premium and reinvestment premium). Substituting (3) in (4) yields:

$$TB_{t+1} = FTB_t + V_{t+1}. \qquad (5)$$

If the market is efficient (expectations are rational), $TB_{t+1} - FTB_t = V_{t+1}$ is stationary [e.g., Campbell and Shiller (1987)] and, in the absence of risk premia and transaction costs, has a zero mean. The error term (V_t) is stationary as both Dickey-Fuller and Phillips-Perron tests reject the null hypothesis that V_t is not stationary. The absolute value of the augmented Dickey Fuller *t* was estimated to be 6.87 and the absolute value of the Phillips-Perron non-parametric *t* for the lag length of 4 was estimated to be 7.20, both *t* statistic results are higher than 2.86 (5% critical value).[9] However, the mean of V_t over our sample period was found to be -0.2956%, at the annual rate, with an autocorrelated-heteroscedastic adjusted *t* statistic of -17.73.[10] The mean of the absolute value of V was found to be 0.4216%, at the annual rate, with an autocorrelated-heteroscedastic adjusted *t* statistic of 31.392. Both of these means are far from being zero, indicating term premium or other risk premia exist, assuming a trivial transaction cost. Although a completely different approach was used, this result (i.e., on average, the RE hypothesis is

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[9] In this paper the lag length in augmented Dicky-Fuller or Phillips-Perron nonparametric tests was obtained according to Akaike's AIC and/or Schwarz's SC criteria, where for a global lag of 20 days the AIC and/or SC are/is at their/its minimum.

valid in the United States money market, and risk premia exist) is consistent, among many others, with the finding of Van Horne (1965), Mankiw and Miron (1986) and Taylor (1992).

We will, consequently, modify Equation (5) to

$$TB_{t+1} = FTB_t + RP_{t+1} + V_{t+1} = FTB_t + W_{t+1}, \tag{6}$$

where RP is risk premia and $W_t = RP_t + V_t$. Note that RP includes term, liquidity, interest exposure and reinvestment risk premia where reinvestment risk premium has a negative effect on RP. If our index is a satisfactory representative of the monetary policy transparency in the United States it should have a negative relationship with W_t in Equation (6), see Thornton (1996), Haldane and Read (2000) and Blinder *et al.* (2001), among others, for arguments and econometric tests on the relationship between transparency and forecast errors of market participants.

We estimate the following equation:

$$\left|W_t\right| = \xi_0 + \xi_1 LT_{t-1} + DUM_{t-1}'\, \varsigma + \epsilon_t, \tag{7}$$

where $\left|W_t\right|$ is the absolute value of the forecast error from Equation (6), LT_t is the logarithm of $\hat{T}_t$, ξ's are constant parameters, ς is a vector of constant parameters and ϵ_t is the white noise disturbance term. Vector DUM is included in the equation in order to capture the impact of monetary policy regime changes as well as other shocks on the risk premia, where, DUM = (M_t, T_t, WED_t, TH_t, $D851231_t$, $D861231_t$, $GREEN_t$, $OCT87_t$, $ASIA_t$, TA_t, TAF_t, $SWED_t$, $REMA_t$, $D940418_t$, $D970819_t$, $D981015_t$, $D99518_t$, $D000202_t$, $D010103_t$, $D010418_t$, $D010917_t$, $D020319_t$, $EDAY_t$, $TARATE_t$).

M_t, T_t, WED_t and TH_t are dummy variables for Mondays, Tuesdays, Wednesdays and Thursdays, respectively. For example, M = 1 for Mondays and zero, otherwise. Dummy variables $D851231_t$ and $D861231_t$ are equal to one on December 30 and 31, 1985 and December 31, 1986, respectively, and are equal to zero, otherwise. These dummy variables are included to capture the high volatility of fed funds rate on those days. Dummy variable $GREEN_t$ =1 since August 11, 1987 when Alan Greenspan was appointed chair of the Fed and is zero, otherwise. $OCT87_t$ and $ASIA_t$ are dummy

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[10] Autocorrelation is due to the overlapping observations. We used, as before, the Newey and West's (1987) robusterror for 5-order moving average to correct the standard error.

variables accounting for the October 87 and Asian crises, respectively. In both events, central banks in the industrial countries flooded the money markets with liquidity to ease the downfall in the stock markets. The easing of the markets took at least until the end of October of the year the crisis took place.

Consequently, we created $OCT87_t = 1$ for October 19 to 30, 1987 and zero, otherwise, and $ASIA_t = 1$ for October 17 to 30, 1997 and zero, otherwise. Dummy variable $TA_t = 1$ since February 4, 1994 and is equal to zero, otherwise. Dummy variable $TAF_t = 1$ since October 19, 1989 and is zero, otherwise. These two dummy variables were created to account for the two policy regime changes, which have happened in the sample period as explained before. Dummy variable $SWED_t$ accounts for settlement days on Wednesdays, i.e., it is equal to one on Wednesdays when it was a settlement day and zero, otherwise. Dummy variable $REMA_t = 1$ since February 2, 1984 when the reserve maintenance period was modified from one week (for most large institutions) to two weeks (for all institutions) and is zero, otherwise.

Dummy variable $D970819_t = 1$ since August 19, 1997, when the FOMC started including a quantitative fed funds target rate in its Directive to the New York Fed Trading Desk, and zero, otherwise. Dummy variable $D99518_t = 1$ since May 18, 1999, when the Fed extended its explanations regarding policy decisions, and started including in press statements an indication of the FOMC's view regarding prospective developments (or the policy bias), and zero, otherwise. Dummy variable $D000202_t = 1$ since February 2, 2000, when the FOMC started to include a balance-of-risks sentence in its statements replacing the previous bias statement, and zero, otherwise. Dummy variable $D020319_t = 1$ since March 19, 2002, when the Fed included in FOMC statements the vote on the directive and the names of dissenter members (if any), and zero, otherwise.

Dummy variables $D940418_t$, $D981015_t$, $D010103_t$, $D010418_t$ and $D010917_t$ are equal to one for April 18, 1994; October 15, 1998; January 3, 2001; April 18, 2001 and September 17, 2001 (when the Fed changed the FF target outside their regular meetings), respectively, and zero otherwise. Dummy variable $EDAY_t$ is equal to one for the days ("event") when the federal funds target rate was changed whether at a regularly scheduled FOMC meeting, or otherwise (reported in Table 1), and also for the days on which the FOMC met, but did not change the target rate. It is equal to zero, otherwise. Dummy variable TARATE is equal to one for the days when the federal funds target rate actually was changed (Table 1) and is equal to zero, otherwise. These days can be among the regularly scheduled FOMC meeting dates or other days. Note that TARATE is a subset of EDAY, as it excludes the days when FOMC met, but did not change the target. Note that we also assume the forecast error may be different in the "event" days and days when the target rate was changed.

Note that variables LT and DUM enter in Equation (7) with one lag length (three months ago) since the implied forward rate was used three months before (at the time of forecast) the actual rate was realized. Our index, if it is a real proxy for monetary transparency in the United States, should have a negative relationship with the risk premia if the estimated ξ_1 is negative and statistically significant. Since our sample is daily observations, LT is our extended index and the lag length is 90 days. Equation (8) is the parsimonious estimated result of Equation (7), where the figures in brackets are standard errors adjusted for autocorrelation and heteroscedasticity.

$$\begin{aligned}
|W_t| = {} & 1.03\ (0.21) - 0.12\ (0.04)\ LT_{t-1} - 0.13\ (0.02)\ TA_{t-1} + 0.15\ (0.07)\ REMA_{t-1} \\
& -0.19\ (0.05)\ GREEN_{t-1} + 0.51\ (0.03)\ D010917_{t-1} + 0.39\ (0.01)\ D010103_{t-1} \\
& + 0.15\ (0.01)\ D940418_{t-1} + 0.57\ (0.15)\ OCT87_{t-1} - 0.52\ (0.25)\ D851231_{t-1}, \\
& -1.56\ (0.38)\ D861231_{t-1}, \qquad (8)
\end{aligned}$$

$\bar{R}^2=0.09$, $\sigma=0.39$, RESET=0.20 (significance level=0.90).

The estimated coefficient of LT is negative and statistically significant implying that as the monetary policy is more transparent the forecast errors and risk premia will fall. This result confirms the views and findings of several authors, including Thornton (1996), Haldane and Read (2000) and Blinder *et al.* (2001). According to the estimated coefficient of dummy variable TA, the Fed policy of changing FF rate at regular FOMC meetings resulted in a lower risk and forecast error in the money market in the United States.

The positive and statistically significant estimated coefficient of REMA implies that modifying the reserve maintenance period from one week (for most large institutions) to two weeks (for all institutions) in February 1984 resulted in a higher forecast error, while the negative and statistically significant coefficient of the dummy variable GREEN means the forecast error in the money market fell during the tenure of Chairman Greenspan in the United States. The estimated coefficient of D010917, as one would expect, is positive and statistically significant, which reflects a higher risk environment associated with September 2001.

Furthermore, as the positive and statistically significant estimated coefficient of D010103 and OCT87 indicates, the unexpected change in the target rate on January 3, 2001 and during the October 87 stock crisis resulted in a higher forecast error. However, according to the estimated coefficient of dummy variable D940418, which is negative, the forecast error (and/or risk premia) fell on April 18, 1994 when the Fed changed the FF target outside the regular meetings. The surprising result is the estimated coefficients of dummy variables D851231 and D861231. Both are negative and statistically significant implying a high volatility of FF on December 31, 1985 and December 30 and 31, 1986 resulted in a lower forecast error on those days.

We also used quarterly averages of the daily observations to create a quarterly sample to test the power of our basic index T. For quarterly observations of T, we also took the average of our index in each quarter. We adjusted Equation (7) for relevant quarterly dummy variables and used the least squared estimation technique to estimate the equation with our quarterly data. In the first round of regression, among dummy variables, only REMA was statistically significant. After dropping dummy variables with statistically insignificant coefficients we found the coefficient of dummy variable REMA to be statistically insignificant. We, consequently, dropped this dummy variable from the regression. The parsimonious estimated Equation (7) with LT being the logarithm of our quarterly index is as follows:

$$\left|W_t\right| = 7.87\ (2.41)\ -1.68\ (0.54)\ LT_{t-1}, \tag{9}$$

$\overline{R}^2$=0.09, σ=0.33, DW=1.69, Godfrey(5)=0.85 (significance level=0.53), White=2.78 (significance level=0.73), ARCH(5)=3.10 (significance level=0.68), RESET=0.10 (significance level=0.95).

According to the Godfrey test result, the error term is not autocorrelated and as White and ARCH test results indicate it is also homoscedastic. According to the RESET test result, there is no misspecification. The negative and statistically significant coefficient of LT clearly confirms the earlier finding in this paper that a higher monetary policy transparency leads to a lower forecast error (a higher efficiency in the money market).

B. Volatility in the Money Market and the Index

To further investigate the strength of our transparency index we will examine the relationship between our index and risk, measured by the volatility, in the money market. It is important to note that theoretically speaking the impact of transparency on volatility is arguable. For example, in a 1976 *Freedom of Information Act* filing, the Fed argued in favor of secrecy motivated by its desire to reduce interest rate variability [see Goodfriend (1986)]. This view is consistent with the literature [see, e.g., Dotsey (1987)] that argues that the cleaner and more frequent the "signal" (or the more transparent monetary policy) is the larger the responsiveness of interest rates to news will be, and thus the greater their volatility is.

Another strand of the literature, however, argues that more transparency tends to reduce market volatility. Tabellini (1987), for example, shows that when market participants face parameter uncertainty (or multiplicative uncertainty) and learn over time, using Bayes' rule, the learning process is the source of additional volatility in asset prices. In this case, more transparency tends to reduce market volatility. Since recent empirical evidence suggests that the 1994 transparency move by the Fed is not associated with higher market volatility [e.g., Rafferty and Tomljanovich (2001) and Thornton (1996)], we will follow Tabellini (1987) and assume a more transparent monetary policy tends to lower volatility.

Volatility Model

According to the existing literature [e.g., Sarno and Thornton (2003) and Thornton (2004)] FF and TB are cointegrated. Hence, we would expect the volatility of the daily movements in FF, say VFF, be directly related to the volatility of the daily movements in TB, say VTB, (i.e., the risk in the money market).[11] Furthermore, Ho and Saunders (1985) rationalize the determination of the fed funds rate in the context of a theoretical micro model. They show that, under the condition of managerial risk aversion, the variance of FF, among other factors, is a positive function of the variance of the rate on short-term securities, say three-month Treasury bill rate, and the variance of the sum

[11] The reverse, of course, is also true.

of the individual bank excess reserve positions. Moreover, the variance of FF is a negative function of the covariance between the short-term rate and the sum of the individual bank excess reserve positions (ER) [see, Ho and Saunders (1985), Equation (22), p. 985]. In an implicit form we may write Ho and Saunders' Equation (22) as:

$$\text{Var(FF)}_t = \text{F(Var(TB)}_t, \text{Var(ER)}_t, \text{Cov(TB and ER)}_t, Z_t, e_t) \qquad (10)$$

where $F_{Var(TB)} > 0$, $F_{Var(ER)} > 0$, $F_{Cov(TB\ and\ ER)} < 0$, $F_Z > 0$ and $F_e > 0$. $F_{Var(TB)}$, $F_{Var(ER)}$, $F_{Cov(TB\ and\ ER)}$, F_Z and F_e are partial derivatives of Var(FF) in terms of Var(TB), Var(ER), Cov(TB and ER), Z, and e, respectively. Z is a measure of risk aversion and e is the slope of reserve adjustment opportunity curve. Note that since Cov(TB and ER) is negative it also affects the variance of FF positively. The more negative this covariance is, the greater the positive effect it has on the variance of the funds rate.

We extend Ho and Saunders' model to develop a model capable to relate the impact of monetary policy transparency on the volatility of the fed funds market. Define $\rho_{TB,\ ER}$ as the correlation coefficient between TB and ER and SD(TB) as well as SD(ER) as standard deviation of TB and ER, respectively. We know that Cov(TB and ER) = $\rho_{TB,\ ER}$ SD(TB) SD(ER). Let us substitute for Cov(TB and ER) in (10) to get:

$$\text{Var(FF)}_t = \text{F(Var(TB)}_t, \text{Var(ER)}_t, \rho_{TB,\ ER}\ \text{SD(TB)}_t\ \text{SD(ER)}_t, Z_t, e_t) \qquad (11)$$

Furthermore, assume the correlation coefficient between TB and ER is constant and Z and e are a function of monetary policy transparency as well as all domestic and foreign shocks. We may assume a linear approximation of Equation (11) as:

$$\text{VFF}_t = \Gamma_0 + \sum_{i=1}^{k} \Gamma_i\ \text{VTB}_{t-i} + \sum_{i=1}^{k} \Phi_i\ \text{VER}_{t-i} + \text{EDUM}_t'\Gamma + \gamma\ \text{LT}_t + \varepsilon_t, \qquad (12)$$

where VER is the volatility of the growth of ER, $\Gamma_0,\ldots,\Gamma_k$, $\Phi_0,\ldots, \Phi_k$ and Γ are constant parameters. The disturbance term ε_t is assumed to be normally, identically and independently distributed. Dummy vector EDUM = (DUM_t, STU_t, $TUE1_t$, HB_t, $HA1_t$, $HB3_t$, $HA3_t$, LDY_t, $LQBA_t$, LQ_t). Dummy variables included in DUM were defined before. To capture the possible volatility in the fed funds rate created by other factors, like window dressing, holidays and other seasonality, following Hamilton (1996), we included dummy variables STU_t, $TUE1_t$, $HB1_t$, $HA1_t$, $HB3_t$, $HA3_t$, LDY_t, $LDBYA_t$, $LQBA_t$ and LQ_t.

These dummy variables are defined as: STU = 1 on Tuesdays before settlement Wednesdays and zero, otherwise. TUE1 = 1 on Tuesdays before settlement Wednesdays if Wednesday was a holiday, and = 0, otherwise. HB1 = 1 for the day before a one-day holiday, and = 0, otherwise. HA1 = 1 for the day after a one-day holiday, and = 0, otherwise. HB3 = 1 for the day before a three-day holiday, and = 0, otherwise. HA3 = 1 for the day after a three-day holiday, and = 0, otherwise. LDY =1 for the last days of the year, and = 0, otherwise. LDBYA = 1 for 2 days before, 1 day before, on, 1 day after, or 2 days after the end of the year, and = 0, otherwise. LQBA = 1 for the day before, on, or after the last day of the first, second and third quarters, and = 0, otherwise. And finally, LQ = 1 for the last day of the first, second, third and fourth quarters, and = 0, otherwise.

Note that in (12) both VTB and VER are predetermined and if γ is negative then the higher the monetary policy transparency (LT) is the lower the volatility in the fed funds market will be. Following, among many, Schwert (1989), Kearney (2000) as well as Kia (2003b), the methodology developed by Davidian and Carroll (1978) was used. Let x be any variable in column vector $x_t = (\Delta TB_t, \Delta FF_t, GER_t)'$, where GER is the growth rate of the excess reserves of depository institutions in the United States, and estimate Equation (13) for ΔTB_t, ΔFF_t and GER_t.[12]

$$x_t = \sum_{i=1}^{20} \alpha_i^x x_{t-i} + EDUM_t'\mu^x + u_{xt}, \qquad u_{xt} \sim niid(0, \Sigma) \tag{13}$$

The parameters α^x's and vector μ^x are assumed to be constant. We assume a lag length of 20 days (reflecting a month) is sufficient for the market participants to learn from the past

[12] For the variable TB, the absolute value of the augmented Dickey Fuller *t* statistic (for a lag length of 5) is 0.0910 and the absolute value of the Phillips-Perron non-parametric *t* statistic (for a lag length of 4) is 0.56884. Both *t* statistics are less than 2.86 (5% critical value), indicating that TB has one unit root. For the variable ΔTB, the absolute value of the augmented Dickey Fuller *t* statistic (for a lag length of 4) is 27.74 and the absolute value of the Phillips-Perron non-parametric *t* statistic (for a lag length of 4) is 62.19. Both *t* statistics are more than 2.86 (5% critical value), indicating that ΔTB is stationary. For the variable FF, the absolute value of the augmented Dickey Fuller *t* statistic (for a lag length of 10) is 0.5484 and the absolute value of the Phillips-Perron non-parametric *t* statistic (for a lag length of 4) is 1.57231. Both *t* statistics again are less than 2.86 (5% critical value), indicating that FF also has a unit root. For the variable ΔFF, the absolute value of the augmented Dickey Fuller *t* statistic (for a lag length of 9) is 25.21 and the absolute value of the Phillips-Perron non-parametric *t* statistic (for a lag length of 4) is 86.86. Both *t* statistics are more than 2.86 (5% critical value), indicating that ΔFF is stationary. For the variable GER, the absolute value of the augmented Dickey Fuller *t* statistic (for a lag length of zero) is 75.18 and the absolute value of the Phillips-Perron non-parametric *t* statistic (for a lag length of 4) is 75.19. Both *t* statistics are more than 2.86 (5% critical value), indicating that GER is stationary. Note that the lag length in all of these tests was chosen according to the minimum of AIC and BIC.

movements in the TB rate. The dummy variables included in vector EDUM capture the shocks on the rate during our sample period. Furthermore, a 20th-order autoregression for the absolute values of errors from Equation (13), including dummy variables in vector EDUM that allow for different daily standard deviations (adjusted for heteroscedasticity and autocorrelation), should be estimated:

$$|\hat{u}_{xt}| = \sigma_t^x = \sum_{i=1}^{20} \delta_i^x \sigma_{t-i}^x + EDUM_t'\eta^x + v_t, \tag{14}$$

where δ_i^x, for i = 1 to 20 and the column vector η^x are constant parameters. The absolute value of the fitted value of u_{xt} (i.e., $|\hat{u}_{xt}|$) is the standard deviation (adjusted heteroscedasticity and autocorrelation) of x_t, for $x_t = \Delta TB_t$, ΔFF_t and GER_t. However, since the expected error is lower than the standard deviation from a normal distribution, following Schwert (1989), all absolute errors are multiplied by the constant 1.2533.

As it was also mentioned by Kia (2003b), the conditional volatility in Equation (14) represents a generalization of the 20-day rolling standard estimator used by Officer (1973), Fama (1976) and Merton (1980). This is due to the fact that the conditional volatility estimated by Equation (14) allows the conditional mean to vary over time in Equation (13), while it also allows different weights to be applied to the lagged absolute unpredicted changes in Treasury bills and fed funds rates as well as the daily growth of the sum of the individual bank excess reserve positions.

Note that here the conditional mean of these rates was also allowed to vary with the shocks represented by dummy variables included in vector EDUM. Furthermore, Engle (1993) reviews the merit of this measure of volatility, among others. This measure of volatility is similar to the autoregressive conditional heteroscedasticity (ARCH) model of Engle (1982), which, in its various forms, has been widely used in the finance literature. Davidian and Carroll (1978) argue that the specification in Equation (14) based on the absolute value of the prediction errors is more robust than those based on the squared residuals in Equation (13).

However, it should be noted that the dependent variables of equations (12) and (14) are generated regressors. Consequently, when the equations are estimated, their *t* statistic should be interpreted with caution. To cope with this problem, following, among many, Kearney (2000) and Kia (2003b), the equation for the conditional volatility [i.e., Equation (12)] is estimated jointly with the equations determining the conditional volatilities of ΔTB, ΔFF and GER using the generalized least squares (GLS) estimation procedure (SUR).[13]

In the GLS system, three equations are generated by Equation (13), three equations are generated by Equation (14) and including Equation (12) a system of seven equations with 5,308 observations (with a final 3,644 usable observations) is estimated. In the GLS estimation, for each equation and the system of equations, we used the Newey and West (1987) robusterror for 5-order moving average to correct for heteroscedasticity and autocorrelation. The GLS estimator incorporates the possibility of cross-equation correlation among the error terms. The final parsimonious GLS estimation result of Equation (12), where standard errors, corrected for autocorrelation and heteroscedasticity, are in brackets, is given in the second column of Table 6.[14]

Table 6 about here

According to the negative and statistically significant estimated coefficient of LT we can conclude again that a higher monetary policy transparency leads to a lower volatility in the money (fed funds) market. Namely, our index fully reflects monetary policy transparency in the United States. None of the coefficients of VTB, except VTB_{t-2}, was statistically significant and so they were dropped in the final estimation. Consequently, the volatility of TB affects VFF only after two days, but it has a wrong sign (negative). One possible explanation for this negative estimated coefficient is that while these rates do move together within a few hours apart it takes about two days for bills to be delivered (there are 24 to 48 hours between transaction and settlement dates). It is possible a high volatility in TB on the transaction date leads to a lower volatility in FF on the settlement date when the associated banker acceptances are matured.

[13] See Kia (2003b), Footnote 4, for a full explanation on why in our case the GLS estimation technique should be used.

[14] The stationarity test results for VTB are as follows: The absolute value of the augmented Dickey Fuller t, for a lag length of 8 = 11.07 and the absolute value of the Phillips-Perron non-parametric *t* test for the lag length 3 = 52.04, both *t* statistics are higher than 2.86 (5% critical value) indicating the conditional volatility VTB is stationary. The stationarity test results for VFF are as follows: The absolute value of the augmented Dickey Fuller *t*, for a lag length of 9 = 15.42 and the absolute value of the Phillips-Perron non-parametric *t*-test for the lag length 10 = 49.49, both *t* statistics are higher than 2.86 (5% critical value) indicating the conditional volatility VFF is stationary. The stationarity test results for VER are as follows: The absolute value of the augmented Dickey Fuller *t* is equal to 70.75 and the absolute value of the

Furthermore, the volatility of fed fund rates is strongly affected by the volatility in the sum of the individual bank excess reserve positions as the coefficients of VER up to twenty business days are statistically significant and mostly positive. Among all dummy variables, only the coefficient of D940418 is found to be statistically significant. The sign of this coefficient is negative indicating that when the Fed changed the fed funds target rate outside its regular meeting on April 18, 1994 it helped in fact to reduce the volatility in the interbank market.

To use the actual rather than the generated data of the excess reserves of the depository institutions in order to investigate the usefulness of our index, we constructed a monthly series from our basic index by averaging the observations in each month. For those few months with no observation available we used the average value of the index for the previous month and the month after. For FF and TB, we also used the average of all observations in the month and used our monthly ER observations. We again estimated the system of seven equations, using a two-month lag length, with all appropriate dummy variables reflecting policy and other shocks as well as monthly dummy variables, with 241 usable observations. The final parsimonious GLS estimation result of Equation (12), with monthly observations is given in the third column of Table 6.

Dummy variables March, May and August are dummy variables equal to 1 for the months of March, May and August, respectively, and zero, otherwise. As we can see again the estimated coefficient of our index is negative and statistically significant, confirming earlier results. However, we found neither the coefficient of VTB nor the coefficient of VER was statistically significant at a conventional level and so both were dropped from the regression. Interestingly, the volatility of fed funds market is lower during the months of March, May and August and it fell since March 19, 2002 when the Fed included in the FOMC statements the vote on the directive and the names of dissenter members (if any). Caution should, however, be exercised with the estimation results with monthly observations. The reason is that in the first round of GLS we simultaneously estimated seven equations with more than 100 coefficients by using only 241 observations. Consequently, the test inferences may be unreliable.

Phillips-Perron non-parametric *t*-test for the lag length 4 = 70.76, both *t* statistics are higher than 2.86 (5% critical value) indicating the conditional volatility VER is stationary.

We further investigate the usefulness of our index in capturing the impact of monetary policy transparency on the volatility of money markets. We will use the empirical results of Sarno and Thornton (2003) and Thornton (2004) and assume the volatility of TB is a function of the volatility of FF and policy regime changes as well as other shocks specified in EDUM. We assume such a relationship has a linear approximation as specified by Equation (15):

$$VTB_t = \Gamma_0 + \sum_{i=1}^{k}\Gamma_i\ VFF_{t-i}\ +\ EDUM_t{}'\Gamma + \gamma\ LT_t + \varepsilon_t \qquad (15)$$

We will estimate, as before, a system of equations (13), (14) and (15) using the GLS estimation technique (SUR). In this exercise two equations are generated by Equation (13), two equations are generated by Equation (14) and including Equation (15) a system of five equations with 5,308 observations (with a final 5,034 usable observations) is estimated. As before, for each equation and the system of equations, we used the Newey and West (1987) robusterror for 5-order moving average to correct for heteroscedasticity and autocorrelation. The final parsimonious GLS estimation result of Equation (15) where standard errors, corrected for autocorrelation and heteroscedasticity, are in brackets, is given in the last column of Table (6).

Among all dummy variables included in EDUM, the coefficients of dummy variables GREEN, TAF, ASIA, D851231, D861231, D940418, D000202, D010103, D010418 and D010917 were found to be statistically significant. As the negative coefficient of dummy variable GREEN indicates during the tenure of Chairman Greenspan the volatility and risk in the money market fell. As it would be expected, the estimated coefficient of TAF is negative, implying that the Fed’s change of policy regime in October 1989 led to a lower volatility in the money market in the United States. This result confirms the earlier finding in this paper.

As it would be expected, the estimated sign of dummy variable ASIA was negative, reflecting the massive intervention of all industrial countries’ central banks in money markets. The estimated coefficient of dummy variables D851231 and D861231 is negative implying that the outliers in the fed funds rate in the last days of 1985 and 1986 resulted in a lower volatility in the Treasury bill rate. The estimated coefficient of

D940418 is negative implying that when the Fed changed FF target outside the regular meetings resulted in a lower volatility in the money market.

According to estimated negative coefficients of dummy variable D000202 when the FOMC started to include a balance-of-risks sentence in its statements replacing the previous bias statement it led to a reduction in the volatility in the money market. According to estimated negative coefficients of dummy variables D010103, D010418 and D010917, a 50 basis point reduction in the target rate on January 3, April 18 and September 17, 2001 reduced the volatility in the money market. Finally, the estimated coefficient of our monetary policy index is negative, indicating that a more transparent monetary policy leads to a lower volatile money market. This result confirms the view of researchers, e.g., Tabellini (1987), who believe a higher degree of transparency tends to lower market volatility.

In sum, we showed in this section the monetary policy transparency indexes developed in this paper can be used successfully to detect the impact of monetary policy transparency on risk and volatility.

V. Summary and Conclusions

The existing measures of monetary policy transparency include indicators based on descriptive accounts, surveys, official documents and information as well as market interest rates. However, these measures have some limitations, such as a lack of an objectively designed index or indexes without time-series properties. In this paper, we developed an objective market-based index, which is dynamic and continuous and can be used to measure monetary policy transparency for a country or, simultaneously, a series of countries, using time-series as well as cross-sectional data.

We developed our index for the United States monetary policy for the period October 1982-December 2003. Furthermore, we found, using our index, that the more transparent the monetary policy in the United States is, the less risky and volatile the money market will be. Moreover, the rational expectations model of the term structure is valid in the United States money market, but risk premia in this market exist.

Using our constructed index, we found a negative relationship between monetary policy transparency and risk and volatility in the economy. Furthermore, risk and uncertainty in money market fell in the United States during the tenure of Chairman

Greenspan. Moreover, the Fed policy of changing fed funds target rate at regular FOMC meetings resulted in a lower risk and forecast error in the money market. We also found that the Fed's change of policy regime in October 1989, when the Fed started the practice of changing the fed funds target rates by multiples of 25 or 50 basis points, led to a lower volatility in the money market. Finally, we conclude that the practice of a more transparent monetary policy leads to more stability and lower risk in the financial markets.

One possible extension of this study is to use the index developed in this paper to investigate if a more transparent monetary policy leads to higher economic growth. Even though the Federal Reserve became officially transparent only recently, it would also be interesting to do the same exercise for the period starting when the Federal Reserve was first established. Finally, it would also be interesting to extend this line of research by comparing the power of different time-series market-based measures of monetary policy transparency, including our index and the popular policy surprise measures based on federal funds futures data.

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Table 1: Federal Funds Target Rate Changes

DATE	TARGET	DATE	TARGET
5-Oct-82	10	19-Dec-89	8.25
8-Oct-82	9.5	13-Jul-90	8
19-Nov-82	9	29-Oct-90	7.75
14-Dec-82	8.5	13-Nov-90	7.5
24-May-83	8.5-8.75	7-Dec-90	7.25
23-Jun-83	9 or slightly higher	18-Dec-90	7
13-Jul-83	9 or somewhat higher (9-9.5)	9-Jan-91	6.75
4-Oct-83	9.25-9.5	1-Feb-91	6.25
27-Mar-84	10-10.5	8-Mar-91	6
17-Jul-84	11.25	30-Apr-91	5.75
2-Oct-84	10.5-10.625	6-Aug-91	5.5
7-Nov-84	9.5	13-Sep-91	5.25
21-Nov-84	9	31-Oct-91	5
18-Dec-84	8-8.5	6-Nov-91	4.75
13-Feb-85	8.25-8.5	6-Dec-91	4.5
21-Feb-85	8.5	20-Dec-91	4
18-Apr-85	8.25	9-Apr-92	3.75
17-May-85	7.75	2-Jul-92	3.25
1-Aug-85	7.75 or a shade higher	4-Sep-92	3
6-Sep-85	8	4-Feb-94	3.25
17-Dec-85	7.75	22-Mar-94	3.5
7-Mar-86	7.25 or a shade higher	18-Apr-94	3.75
18-Apr-86	6.75 or slightly higher	17-May-94	4.25
5-Jun-86	6.875	16-Aug-94	4.75
10-Jul-86	6.375	15-Nov-94	5.5
14-Aug-86	6.25-6.375	1-Feb-95	6
20-Aug-86	5.875	6-Jul-95	5.75
15-Jan-87	6	19-Dec-95	5.5
30-Apr-87	6.5 or somewhat higher	31-Jan-96	5.25
19-May-87	6.75 or somewhat lower	25-Mar-97	5.5
3-Sep-87	6.75-7	29-Sep-98	5.25
4-Sep-87	7.25	15-Oct-98	5
22-Sep-87	7.375	17-Nov-98	4.75
23-Oct-87	7	30-Jun-99	5
28-Oct-87	6.75-6.875	24-Aug-99	5.25
28-Jan-88	6.5-6.75	16-Nov-99	5.5
10-Feb-88	6.5	2-Feb-00	5.75
29-Mar-88	6.75	21-Mar-00	6
7-May-88	7	16-May-00	6.5
25-May-88	7.25	3-Jan-01	6
22-Jun-88	7.5	31-Jan-01	5.5
9-Aug-88	8-8.25	20-Mar-01	5
22-Nov-88	8.375	18-Apr-01	4.5
14-Dec-88	8.625-8.75	15-May-01	4
Early 01/89	8.875-9	27-Jun-01	3.75
14-Feb-89	9-9.125	21-Aug-01	3.5
24-Feb-89	9.75-9.875	17-Sep-01	3
6-Jun-89	9.5-9.625	2-Oct-01	2.5
6-Jul-89	9.25	6-Nov-01	2
27-Jul-89	9	11-Dec-01	1.75
19-Oct-89	8.75	6-Nov-02	1.25
6-Nov-89	8.5	25-Jun-03	1

Source: for 1982-1989 – FOMC Secretariat and for 1990-2003 – Board of Governors of the Federal Reserve System.

Note: When constructing the index we assumed that the target change of 7-May-88 (Saturday) took place on 9-May-88, and we assumed that the target change of “Early 01/89” took place on 5-Jan-89.

Table 2: FOMC Meeting Dates (1982-2003)

1982	**1987**	**1992**	**1997**	**2002**
February 1-2	February 10-11	February 4-5	February 4-5	January 29-30
March 29-30	March 31	March 31	March 25	March 19
May 18	May 19	May 19	May 20	May 7
June 30-July 1	July 7	June 30-July 1	July 1-2	June 25-26
August 24	August 18	August 18	August 19	August 13
October 5	September 22	October 6	September 30	September 24
November 16	November 3	November 17	November 12	November 6
December 20-21	December 15-16	December 22	December 16	December 10
1983	**1988**	**1993**	**1998**	**2003**
February 8-9	February 9-10	February 2-3	February 3-4	January 28-29
March 28-29	March 29	March 23	March 31	March 18
May 24	May 17	May 18	May 19	May 6
July 12-13	June 29-30	July 6-7	June 30-July 1	June 24-25
August 23	August 16	August 17	August 18	August 12
October 4	September 20	September 21	September 29	September 16
November 14-15	November 1	November 16	November 17	October 28
December 19-20	December 13-14	December 21	December 22	December 9
1984	**1989**	**1994**	**1999**	
January 30-31	February 7-8	February 3-4	February 2-3	
March 26-27	March 28	March 22	March 30	
May 21-22	May 16	May 17	May 18	
July 16-17	July 5-6	July 5-6	June 29-30	
August 21	August 22	August 16	August 24	
October 2	October 3	September 27	October 5	
November 7	November 14	November 15	November 16	
December 17-18	December 18-19	December 20	December 21	
1985	**1990**	**1995**	**2000**	
February 12-13	February 6-7	January 31-February 1	February 1-2	
March 26	March 27	March 28	March 21	
May 21	May 15	May 23	May 16	
July 9-10	July 2-3	July 5-6	June 27-28	
August 20	August 21	August 22	August 22	
October 1	October 2	September 26	October 3	
November 4-5	November 13	November 15	November 15	
December 16-17	December 18	December 19	December 19	
1986	**1991**	**1996**	**2001**	
February 11-12	February 5-6	January 30-31	January 30-31	
April 1	March 26	March 26	March 20	
May 20	May 14	May 21	May 15	
July 8-9	July 2-3	July 2-3	June 26-27	
August 19	August 20	August 20	August 21	
September 23	October 1	September 24	October 2	
November 5	November 5	November 13	November 6	
December 15-16	December 17	December 17	December 11	

Source: Board of Governors of the Federal Reserve System

TABLE 3: Basic and Extended Index Methodology*

General Information				Basic Index			Extended Index		
DATE	TB_t	FF_t	Dif_t	$Tdif_t$	$\|D_t\|$	T_t	$Adif_t$**	$\|\hat{D}_t\|$	$\hat{T}_t$
5-Oct-82	**8.14**	**10.27**	**2.13**				NA	NA	NA
6-Oct-82	8.05	9.45	1.40				2.130000	0.730000	48.191
7-Oct-82	7.76	9.82	2.06	**1.863333**			1.765000	0.295000	74.453
8-Oct-82	**7.75**	**9.63**	**1.88**		**0.016667**	**98.347**	**1.863333**	**0.016667**	**98.347**
12-Oct-82	7.38	9.20	1.82				1.880000	0.060000	94.176
13-Oct-82	7.42	9.69	2.27				1.850000	0.420000	65.705
14-Oct-82	7.54	9.57	2.03				1.990000	0.040000	96.079
15-Oct-82	7.56	9.43	1.87				2.000000	0.130000	87.810
18-Oct-82	7.43	9.59	2.16				1.974000	0.186000	83.027
19-Oct-82	7.48	9.42	1.94				2.005000	0.065000	93.707
20-Oct-82	7.56	9.81	2.25				1.995714	0.254286	77.547
21-Oct-82	7.57	9.49	1.92				2.027500	0.107500	89.808
22-Oct-82	7.64	9.42	1.78				2.015556	0.235556	79.013
25-Oct-82	7.87	9.55	1.68				1.992000	0.312000	73.198
26-Oct-82	7.96	9.40	1.44				1.963636	0.523636	59.236
27-Oct-82	8.00	9.41	1.41				1.920000	0.510000	60.050
28-Oct-82	7.91	9.44	1.53				1.880769	0.350769	70.415
29-Oct-82	7.90	9.41	1.51				1.855714	0.345714	70.771
1-Nov-82	7.81	9.43	1.62				1.832667	0.212667	80.843
3-Nov-82	7.79	9.68	1.89				1.819375	0.070625	93.181
4-Nov-82	7.73	9.55	1.82				1.823529	0.003529	99.648
5-Nov-82	7.78	9.40	1.62				1.823333	0.203333	81.601
8-Nov-82	7.92	9.45	1.53				1.812632	0.282632	75.380
9-Nov-82	8.00	9.31	1.31				1.798500	0.488500	61.355
10-Nov-82	8.08	9.64	1.56				1.775238	0.215238	80.635
12-Nov-82	8.28	9.61	1.33				1.765455	0.435455	64.697
15-Nov-82	8.43	9.82	1.39	**1.731667**			1.746522	0.356522	70.011
16-Nov-82	**8.40**	**9.56**	**1.16**		**0.571667**	**56.458**	**1.731667**	**0.571667**	**56.458**

* Event days are in bold.
** Note that on an event day $Adif_t$ equals $Tdif_{t-1}$.

Table 4: Transparency Index

Date	Index	Date	Index	Date	Index	Date	Index
5-Oct-82	na	18-Aug-87	84.254	20-Aug-91	94.082	19-Aug-97	92.648
8-Oct-82	98.347	3-Sep-87	99.667	13-Sep-91	82.745	30-Sep-97	73.794
16-Nov-82	56.458	4-Sep-87	83.527	1-Oct-91	92.774	12-Nov-97	84.279
19-Nov-82	82.696	22-Sep-87	76.965	31-Oct-91	84.166	16-Dec-97	94.136
14-Dec-82	91.507	23-Oct-87	47.994	5-Nov-91	95.441	4-Feb-98	99.125
21-Dec-82	58.042	28-Oct-87	77.105	6-Nov-91	94.176	31-Mar-98	66.750
9-Feb-83	60.342	3-Nov-87	36.788	6-Dec-91	98.857	19-May-98	78.709
29-Mar-83	90.758	16-Dec-87	23.417	17-Dec-91	96.630	1-Jul-98	45.158
24-May-83	70.795	28-Jan-88	92.841	20-Dec-91	93.863	18-Aug-98	98.347
23-Jun-83	88.481	10-Feb-88	42.694	5-Feb-92	98.151	29-Sep-98	81.451
13-Jul-83	88.216	29-Mar-88	94.176	31-Mar-92	93.264	15-Oct-98	83.224
23-Aug-83	86.190	9-May-88	90.840	9-Apr-92	92.973	17-Nov-98	57.538
4-Oct-83	60.758	17-May-88	76.593	19-May-92	88.331	22-Dec-98	89.621
15-Nov-83	94.982	25-May-88	88.692	1-Jul-92	82.944	3-Feb-99	99.005
20-Dec-83	86.791	22-Jun-88	92.166	2-Jul-92	88.692	30-Mar-99	94.948
31-Jan-84	83.527	30-Jun-88	52.905	18-Aug-92	95.421	18-May-99	73.807
27-Mar-84	51.373	9-Aug-88	70.678	4-Sep-92	89.583	30-Jun-99	75.604
22-May-84	86.447	16-Aug-88	88.161	6-Oct-92	91.829	24-Aug-99	83.417
17-Jul-84	93.534	20-Sep-88	96.239	17-Nov-92	79.283	5-Oct-99	89.121
21-Aug-84	83.393	1-Nov-88	97.045	22-Dec-92	95.083	16-Nov-99	95.531
2-Oct-84	79.673	22-Nov-88	77.050	3-Feb-93	55.512	21-Dec-99	77.105
7-Nov-84	62.683	14-Dec-88	87.052	23-Mar-93	89.611	2-Feb-00	95.682
21-Nov-84	92.723	5-Jan-89	88.061	18-May-93	84.953	21-Mar-00	91.893
18-Dec-84	28.682	8-Feb-89	94.546	7-Jul-93	72.274	16-May-00	82.632
13-Feb-85	88.119	14-Feb-89	96.319	17-Aug-93	94.469	28-Jun-00	95.727
21-Feb-85	85.214	24-Feb-89	80.367	21-Sep-93	80.018	22-Aug-00	80.358
26-Mar-85	68.804	28-Mar-89	74.862	16-Nov-93	90.222	3-Oct-00	91.236
18-Apr-85	75.910	16-May-89	72.989	21-Dec-93	99.917	15-Nov-00	95.504
17-May-85	81.523	6-Jun-89	98.230	4-Feb-94	88.150	19-Dec-00	80.707
21-May-85	82.283	6-Jul-89	75.148	22-Mar-94	94.511	3-Jan-01	99.115
10-Jul-85	90.617	27-Jul-89	78.297	18-Apr-94	96.400	31-Jan-01	99.161
1-Aug-85	71.355	22-Aug-89	77.492	17-May-94	74.119	20-Mar-01	98.228
20-Aug-85	75.462	3-Oct-89	92.184	6-Jul-94	53.275	18-Apr-01	88.161
6-Sep-85	72.313	19-Oct-89	89.665	16-Aug-94	79.728	15-May-01	91.057
1-Oct-85	69.680	6-Nov-89	79.189	27-Sep-94	58.962	27-Jun-01	77.958
5-Nov-85	84.754	14-Nov-89	99.667	15-Nov-94	66.546	21-Aug-01	92.360
17-Dec-85	93.975	19-Dec-89	93.084	20-Dec-94	94.098	17-Sep-01	50.441
12-Feb-86	85.013	7-Feb-90	77.668	1-Feb-95	55.334	2-Oct-01	89.828
7-Mar-86	91.165	27-Mar-90	92.256	28-Mar-95	80.867	6-Nov-01	96.039
1-Apr-86	83.841	15-May-90	79.477	23-May-95	86.336	11-Dec-01	97.425
18-Apr-86	83.591	3-Jul-90	90.644	6-Jul-95	86.445	30-Jan-02	96.810
20-May-86	81.576	13-Jul-90	95.805	22-Aug-95	87.385	19-Mar-02	86.620
5-Jun-86	82.696	21-Aug-90	82.146	26-Sep-95	100.000	7-May-02	97.359
9-Jul-86	89.583	2-Oct-90	74.107	15-Nov-95	94.635	26-Jun-02	92.496
10-Jul-86	99.005	29-Oct-90	82.604	19-Dec-95	94.958	13-Aug-02	93.749
14-Aug-86	93.501	13-Nov-90	99.402	31-Jan-96	85.611	24-Sep-02	99.210
19-Aug-86	95.759	7-Dec-90	72.062	26-Mar-96	84.322	6-Nov-02	92.527
20-Aug-86	98.020	18-Dec-90	80.367	21-May-96	90.484	10-Dec-02	97.531
23-Sep-86	86.672	9-Jan-91	38.180	3-Jul-96	97.987	29-Jan-03	97.310
5-Nov-86	56.027	1-Feb-91	45.955	20-Aug-96	85.137	18-Mar-03	97.015
16-Dec-86	84.523	6-Feb-91	72.615	24-Sep-96	88.988	6-May-03	93.048
15-Jan-87	30.422	8-Mar-91	85.458	13-Nov-96	87.013	25-Jun-03	97.656
11-Feb-87	72.172	26-Mar-91	94.727	17-Dec-96	89.778	12-Aug-03	93.920
31-Mar-87	93.437	30-Apr-91	85.535	5-Feb-97	89.529	16-Sep-03	98.964
30-Apr-87	25.875	14-May-91	96.464	25-Mar-97	88.611	28-Oct-03	94.112
19-May-87	68.124	3-Jul-91	87.284	20-May-97	82.611	9-Dec-03	99.466
7-Jul-87	93.324	6-Aug-91	94.793	2-Jul-97	85.699		

Table 5: Policy Regime Changes and Monetary Transparency - Standard Errors Adjusted for Heteroscedasticity and Autocorrelation in Brackets

Period	Quarterly Index	Daily Index
Oct. 1982-Aug. 1987	77.75 (2.79)	80.84 (1.14)
Change in: Aug. 1987-Dec. 2003: Greenspan period*	8.06 (3.07)	6.26 (1.22)
Oct. 1982-Oct. 1989	78.19 (2.20)	81.81 (0.86)
Change in: Oct. 1989-Dec. 2003: 25 and 50 bp period**	8.66 (2.52)	5.78 (0.98)
Oct. 1982-Feb. 1994	81.26 (1.73)	83.14 (0.66)
Change in: Feb. 1994-Dec. 2003: Announcing Target Change period***	5.83 (2.29)	5.43 (0.84)
Oct. 1982-Aug. 1997	82.11 (1.48)	83.79 (0.54)
Change in: Aug. 1997-Dec. 2003: Target & NY period****	6.19 (2.33)	6.28 (0.83)
Oct. 1982-May. 1999	82.24 (1.36)	84.10 (0.50)
Change in: May. 1999-Dec. 2003: Explanation period*****	7.87 (2.44)	7.22 (0.86)
Oct. 1982-Feb. 2000	82.22 (1.29)	84.24 (0.48)
Change in: Feb. 2000-Dec. 2003: Balance of Risk period******	9.45 (2.32)	7.78 (0.89)
Oct. 1982-Mar. 2002	82.81 (1.22)	84.81 (0.46)
Change in: Mar. 2002-Dec. 2003: Vote & Names period*******	12.68 (1.38)	10.22 (0.66)

*Alan Greenspan took office as Chairman of the Fed on August 11, 1987.
** On October 19, 1989 the Fed started the practice of changing the fed funds target rate in multiples of 25 and 50 basis points.
***Beginning on February 4, 1994 the Fed started announcing policy decisions at the conclusion of the FOMC meetings.
****The FOMC started to include a quantitative fed funds rate in its Directive to the NY Fed Trading desk.
***** Since May 18, 1999 the Fed extended its explanations regarding policy decisions, and started to include in press statements an indication of the FOMC's view regarding prospective developments (or the policy bias).
****** On January 19, 2000, the FOMC issued a press statement explaining that they would include a balance-of-risks sentence in their statements, replacing the previous bias statement. The practice was first implemented the following FOMC meeting, on February 2.
******* Since March 19, 2002, the Fed has included in FOMC statements the vote on the directive and the names of dissenter members (if any).

Table 6: GLS Estimation of Volatility and Transparency Index***

Variables*	Daily data - Dep. Var.= VFF Coeff. (Std.Error**)	Monthly data - Dep. Var.= VFF Coeff. (Std.Error**)	Daily data - Dep. Var.= VTB Coeff.(Std.Error**)
Constant	1.71 (0.19)	0.32 (0.02)	0.02 (0.0023)
LT_t	- 0.31 (0.03)	- 0.0003 (0.00001)	- 0.002 (0.001)
VFF_{t-1}	0.13 (0.02)	0.18 (0.07)	-
VFF_{t-5}	-	-	-0.002 (0.0009)
VFF_{t-15}	-	-	-0.002 (0.0003)
VFF_{t-17}	0.32 (0.02)	-	-
VTB_{t-1}	-	-	0.58 (0.03)
VTB_{t-2}	- 0.26 (0.08)	-	0.38 (0.03)
VTB_{t-3}	-	-	0.09 (0.03)
VTB_{t-4}	-	-	- 0.13 (0.02)
VTB_{t-5}	-	-	- 0.32 (0.03)
VTB_{t-6}	-	-	0.09 (0.02)
VTB_{t-7}	-	-	0.18 (0.02)
VER_{t-3}	0.0001 (0.00001)	-	-
VER_{t-9}	0.001 (0.0001)	-	-
VER_{t-10}	0.001 (0.0002)	-	-
VER_{t-11}	0.0003 (0.0001)	-	-
VER_{t-12}	0.001 (0.0001)	-	-
VER_{t-14}	- 0.01 (0.001)	-	-
VER_{t-15}	- 0.01 (0.004)	-	-
VER_{t-17}	0.0001 (0.00001)	-	-
VER_{t-19}	0.001 (0.00004)	-	-
VER_{t-20}	0.0004 (0.0001)	-	-
$GREEN_t$	-	-	-0.002 (0.0004)
TAF_t	-	- 0.14 (0.01)	-0.002 (0.0005)
$OCT87_t$	-	0.03 (0.008)	-
$ASIA_t$	-	-	-0.006 (0.001)
$D851231_t$	-	-	-0.05 (0.0007)
$D861231_t$	-	-	-0.03 (0.003)
$D940418_t$	- 0.05 (0.004)	-	-0.01 (0.0004)
$D000202_t$	-	-	-0.02 (0.0003)
$D010103_t$	-	-	-0.02 (0.0002)
$D010418_t$	-	-	-0.02 (0.0003)
$D010917_t$	-	-	-0.03 (0.0004)
$D020319_t$	-	- 0.06 (0.006)	-
$March_t$	-	- 0.09 (0.01)	-
May_t	-	- 0.08 (0.003)	-
$August_t$	-	-0.11 (0.006)	-
$\overline{R}^2$ and σ	0.30.and 0.14	0.91 and 0.03	0.88 and 0.0007

* Variables VFF_t, VTB_t and VER_t are autoregressive conditional volatility of the first differences of fed funds rate, Treasury bills rate and the sum of the excess reserves of the depository institutions, respectively. Dummy variables are: GREEN=1 since August 11, 1987 and zero, otherwise, TAF_t=l since October 19, 1989 and zero, otherwise, $OCT87_t$=1 for October 19 to 30, 1987 and zero, otherwise, ASIA=1 for October 17 to 30, 1997 and zero, otherwise, $D851231_t$ and $D861231_t$ are equal to 1 on December 30 and 31, 1985 and December 31, 1986, respectively, and to zero, otherwise, D940418=1 on April 18, 1994 and zero, otherwise, D000202=1 on February 2, 2000 and zero, otherwise, D010103=1 on January 3, 2001 and zero, otherwise, D010418=1 on April 18, 2001 and zero, otherwise, D010917=1 on August 17, 2001 and zero, otherwise, and D020319=1 on March 19, 2002 and zero, otherwise. Finally, dummy variables March, May and August are equal to 1 for the months of March, May and April, respectively, and to zero, otherwise.

** The Newey and West (1987) robusterror for 5-order moving average was used to correct for autocorrelation and heteroscedasticity.

*** The estimation method is GLS and σ is the standard error of the regression.

Figure 1: Transparency Index

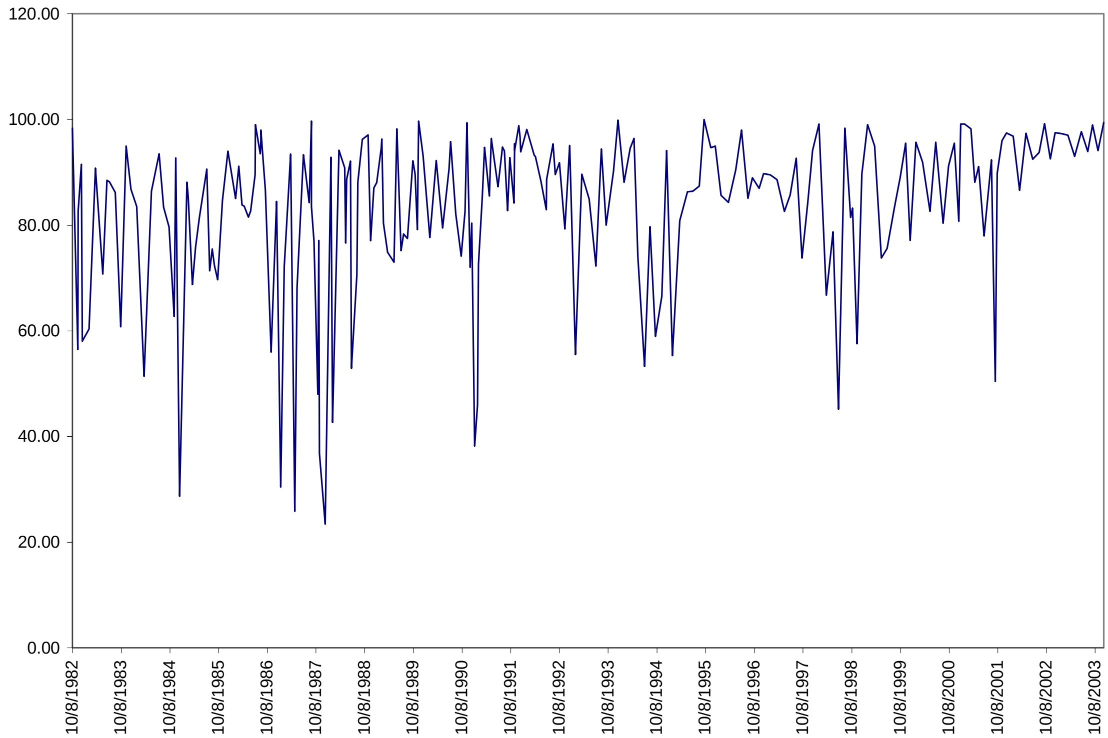

Figure 2: Extended Transparency Index