The Impact of Monetary policy Transparency on Risk and Volatility of Interest Rates: Evidence from the United States

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Abstract

Because of using unsatisfactory measures of the monetary policy transparency the existing literature found mixed empirical results for the relationship between the monetary policy transparency and risk as well as volatility. This paper extends the literature by using a recently developed monetary transparency index [Kia’s (2011) index] which is dynamic and continuous. It was found that the more transparent the monetary policy is the less risky and volatile the money market will be.

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

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1. Introduction

The empirical findings of the impact of monetary policy transparency on the volatility of interest rates and/or forecast error/risk are mixed. 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. Furthermore, Thornton (1996), using Fed Funds futures and Mean Squared Error, finds the consequences of the Fed's policy shift toward immediate disclosure on the federal funds rate in 1994 resulted in a lower forecast error for all interest rates. Blinder (1998) argues, theoretically, that more open public disclosure of central bank policies may enhance the efficiency of markets. Haldane and Read (2000), using dummy variables for the change in the monetary policy transparency, show that a higher monetary policy transparency leads to a lower conditional variance in the yield curve in the United Kingdom and the United States. Their cross-country (Italy, Germany, UK and US) empirical results also confirm their finding.

Blinder, et al. (2001), using descriptive accounts of transparency (do’s and don’ts of the central bankers’ actions), find a higher market transparency leads to a lower forecast error. Geraats (2002) theoretically shows the transparency reduces the variance of private sector forecast errors. Rafferty and Tomljanovich (2002) study whether the Federal Reserve System's 1994 policy shift toward more open disclosure improved or worsened the predictability of financial markets. They find that since 1994, the forecasting error has decreased for interest rates on U.S. bonds of most maturity lengths and that the expectations hypothesis has performed better
at the low end of the yield curve. Reeves and Sawicki (2007), using dummy variables, find evidence that the publication of the Minutes of Monetary Policy Committee meetings and the Inflation Report in UK significantly affect near-term interest rate expectations, an effect particularly visible in intraday data. Neuenkirch (2012), using data of nine major central banks, finds that, in general, monetary policy transparency, by reducing the variation of expectations, reduces expectation bias in money market.

Lasaosa (2005) analyzes the impact of the announcements on market activities and concludes that the increase in transparency facilitates the prediction of monetary policy in the UK once the latest macroeconomic data are known. She investigates the impact of the announcement five, fifteen and sixty minutes after an announcement. Then she compares the result with those days with no announcement at the same times. Swanson (2006) argues that increases in the monetary policy transparency in the US have played a significant impact on the private sector’s forecast improvement. He uses Fed futures and Eurodollar options rate to estimate and compare forecast errors as well as implied volatility, respectively, in different periods. Cruijsen and Demertzis (2007), using Eijffinger and Geraats’ (2006) index, and Rosa and Verga (2007), using dummy variables, find that monetary transparency improves the expectation on inflation as well as short-term interest rate, respectively. Ehrmann and Fratzscher (2007) find communication is a tool to prepare markets for upcoming decisions. Blinder, et al. (2008) conclude that central bank communications lead to improvement in the ability of the market to predict monetary policy. Demiralp, et al. (2012), using dummy variables, find the announcement of monetary statement in Turkey improves the predictability of the next interest rate in Turkey.
Ehrmann and Fratzscher (2009), using both dummy variable and coding approach (i.e.,
the value of \(-1\) for statements indicating an easing inclination, \(1\) for statements indicating a
tightening, and \(0\) otherwise), find that the timing of statements is important. Specifically,
statements in the pre-FOMC (Federal Open Market Committee) purdah resulted in a rise of
market volatility, but statements in the post-FOMC purdah period and outside the purdah led to
significantly lower market volatility. Biefang-Frisancho Mariscal and Howells (2010), using
dummy variables, show that the various forms of Fed communications are highly significant on
the volatility and market’s expectations. Interestingly, Apergis (2014) using intraday data of
6 US asset prices found the impact of the minutes released by the FOMC has significant effects
on the mean of volatility of asset prices only before the 2008 crisis and not after the crisis.
Ehrmann, et al. (2012), using a set of different measures for the central bank transparency, find
monetary transparency reduces, with a decreasing effect, forecast disagreements on inflation,
interest rates and other macroeconomic variables among market participants in twelve advanced
countries. They found that the announcement of a qualified inflation objective and the release of
the central bank’s internal forecasts of inflation and output, in particular, are more effective and
also additive.

However, some studies found monetary policy transparency does not affect the interest
rate volatility, but actually it contributes to more volatility in the financial markets. In fact, 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). Dotsey (1987) 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, and thus the greater their volatility.
Biefang-Frisancho Mariscal and Howells (2007), using dummy variables, update Haldane and Read’s (2000) study on the UK by investigating the changes in anticipation on either side of the two major reforms in UK policy making in 1992 and 1997. They conclude that the Bank of England independence and its associated reforms have not added to the understanding of monetary policy by market participants. Chadha and Nolan (2001) use dummy variables accounting for days on and before the announcement day to investigate the impact of the announcement on the volatility of interest rate over selected periods in the UK. They concluded that transparency did not contribute to the volatility of interest rate.¹

The main problem with the current literature, in general, is that central bank communications are difficult to measure. Furthermore, using dummy variables, as it was also mentioned by Lasaosa (2005) and Kia (2011), can result in a misleading conclusion as some announcements may have already been taken into account by the market participants before the announcement. Furthermore, as Blinder, et al. (2008) argue, there are unobserved factors which affect asset prices. A rise in the volatility as a result of central bank communications may be due to the reaction of financial markets to shocks other than central bank communication. Moreover, the communication of the central bank may be due to a sudden change in economic outlook or some other news which also increase the volatility in asset prices. Therefore, the higher volatility is not due to the central bank communications, but to the shocks which caused the communications.

¹ There are other arguments in favor or against monetary policy transparency in terms of other factors in the economy. For example, Frenkel, et al. (2006) argue that the key reason that European Central Bank’s intervention in the exchange market was ineffective was due to its shortcomings in the information and communication policy. Baghestani (2008) shows that the private forecasts are more informative because they encompass those of the Federal Reserve’s forecast and, consequently, a higher transparency has helped to improve the effectiveness of monetary policy and thus enhanced the economic welfare through a credible commitment to price stability, as it has allowed the public to make better decisions.
Consequently, the dummy variables may not actually reflect the impact of the announcements or the change in the policy. Moreover, as also mentioned, among others, by Blinder, et al. (2008), the coding approach is subjective and there is always a possibility of misclassifications. To investigate clearly the impact of monetary policy transparency on forecast error, risk or volatility we need to have an objective market-based monetary policy transparency index. Such an index should also be dynamic so that it can be used for a long range of time series data. Kia (2011) has developed such an index for the United States which 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. Using Kia’s index, this study investigates the impact of monetary policy transparency on risk (forecast error) and volatility in the money market in the United States. Papadamou and Arvanitis (2014) also use Kia’s (2011) index to investigate the effectiveness of the Federal Reserve’s transparency on the volatility of inflation and output in the United States.

The next section briefly explains Kia’s index and will be followed with a section on the impact of the index on the risk in the money market. Section IV is devoted to the analysis of the impact of monetary policy transparency on the volatility in the money market in the United States. The final section provides some concluding remarks. The description of the data and the definitions of dummy variables are given in the Appendix.

2. **Brief Description of Kia’s (2011) Index**

Kia postulates that when there is no expected change in the structure of the interbank market and/or the credibility of the United States government to pay its debt at equilibrium we will have $D_{it} = F_{Ft} - TB_{it} = \text{risk premium} - \text{maturity risk premium} = TD_{it}$, where $F_{Ft}$ is the Fed Funds rate, $TB$ is the three-month Treasury Bill rate and $TD$ is the trend value or the
equilibrium level of Dif. Under full transparency Dif is equal to Tdif and under opacity he finds Dif as:

\[
O_{dif_t} = FF_{t-1} + \alpha (OER_t - ER_{t-1}) + \alpha \tau_t - TB_{t-1} - \gamma_1 (FF_t - TFF_t)
\]

\[
- \gamma_2 \left[ \frac{\sigma_{T+1}^2}{\sigma_{T+1}^2 + \sigma_{\tau}^2} (\alpha \tau_t) - TFF_{T+1} \right] + \frac{\sigma_{T+1}^2 + \sigma_{\tau}^2}{\sigma_{T+1}^2 + \sigma_{\tau}^2} (\alpha \tau_t) - TFF_{T+1}\],
\]

where Odif is Dif under opacity, OER is the banking system optimal excess reserve, ER is the actual excess reserve, \(\tau\) is the shock to the economy, TFF is the target Fed Funds rate, and \(TFF\) is the mean of the target rate. \(\sigma_{T+1}^2\) is the variance of the target rate at the next FOMC meeting day, \(\sigma_{\tau}^2\) is the variance of \(\tau\), and \(\alpha\) and \(\gamma\)'s are coefficients, see Equation (6) in Kia (2011). Kia found the deviation between Dif under opacity and full transparency (D) to be:

\[
D_t = Odif_t - Tdif_t = + \gamma_2 \left[ \frac{\sigma_{T+1}^2}{\sigma_{T+1}^2 + \sigma_{\tau}^2} (\alpha \tau_t) - TFF_{T+1} \right].
\]

He considered the maximum/minimum of \(|D_t|\), at the event (FOMC meetings) dates in the sample period, to be the least/most transparent monetary policy over the period, and calculated the index (defined basic index) \(T_t = \text{transparency index} = \frac{100}{e^{\|D_t\|}}\). If \(|D| = 0\%, we will have \(T = 100\%. Clearly the higher is \(|D_t|, the lower will be the transparency index. In this formula, Kia calculated Tdif as the average of Dif between two event days. Since event days are in irregular intervals, Kia (2011) takes the quarterly average of the basic index to construct quarterly observations of the index.
He also developed the high frequency data of the index $\hat{T}_t = 100/e^{\hat{D}_t}$, where $\hat{D}_t = |\text{Dif}_t - \text{Adif}_t|$, where Dif$_t$ is defined as before ($= \text{FF}_t - \text{TB}_t$) and Adif$_t = \frac{\sum_{i=1}^{j} \text{Dif}_{i-t}}{n}$. Here j is the last event day and n is the number of days since the last event day. Using $\hat{D}_t$, we can calculate an index for non-event days $\hat{T}_t$. Kia’s index is dynamic and can be used to calculate an index for each minute of the day using the intra-day observations on FF and TB.

3. Risk/Forecast Error in the Money Market and the Monetary Policy Transparency

In this section we will investigate, using Kia’s index, whether a higher monetary policy transparency leads to a lower/higher risk and forecast error in the money market. Consequently, market participants will ask for a lower/higher risk premium as the Fed conveys more its private information to the market. See Data Appendix for the sample period and sources of the data. Note that Kia’s index is market based, i.e., it reflects what market participants perceive from hints, actions or reactions (to exogenous shocks) of the monetary authorities and not what these authorities intend to convey to the market. In other words, the public availability of the data does not suffice to achieve transparency, see Kia (2011). As he stressed, market participants may observe a different norm/direction in the policy during the day or within a month or a period than what the central bank actually follows.

In this study, risk is measured by using the pure (rational) expectations model of the term structure (RE). According to RE the term premia are set identically to zero, which implies that at any moment in time, the expected TB, for example, prevailing at the beginning of three months from now $(1 + 3\text{TB}_t^e)$ 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 $\text{FTB}_t = \left(1 + \frac{\text{TB}_6}{4}\right)^2 / \left(1 + \frac{\text{TB}_4}{4}\right) - 1$. Here TB6 is the six-month spot rate and we assume both six- and three-month spot Treasury bill rates are at the annual rate. Specifically, we can write:

$$1 + 3\text{TB}_t^e = \text{FTB}_t. \quad (1)$$

If this equality is violated, investors and speculators, trade three- and six-month Treasury bills, to capture potential speculative profits, until Equation (1) is restored. For example, if $1 + 3\text{TB}_t^e > \text{FTB}_t$, speculators sell their six-month bills and buy three-month bills, pushing the price of six-month bills down (TB6 will go up) and increasing the price of three-month bills up (TB3 will go down). This speculative activity continues until the potential for speculative profits is eliminated, i.e., $1 + 3\text{TB}_t^e$ is again equal to FTBt. Furthermore, by orthogonal decomposition at any given time t, we have:

$$\text{TB}_t = \text{TB}_t^e + V_t, \quad (2)$$

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 (1) in (2) yields:

$$\text{TB}_{t+1} = \text{FTB}_t + V_{t+1}. \quad (3)$$

If the market is efficient, $\text{TB}_{t+1} - \text{FTB}_t = V_{t+1}$ 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 the Augmented 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 8.40 and the absolute value of the Phillips-Perron non-parametric $t$ was estimated to be 8.55, both $t$ statistics results are higher than 3.43 (1% critical value).\(^2\) However, the mean of

\(^2\) The lag length in Augmented Dickey-Fuller or Phillips-Perron non-parametric tests was obtained according to AIC and SC criteria for a global lag of 20 days.
V_t over our sample period was found to be -0.30%, at the annual rate, with an autocorrelated-heteroscedastic adjusted t statistic of -20.92. The mean of the absolute value of V was found to be 0.40%, at the annual rate, with an autocorrelated-heteroscedastic adjusted t statistic of 32.80. 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 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 (3) to

\[
TB_{t+1} = FTB_t + RP_{t+1} + V_{t+1} = FTB_t + W_{t+1},
\]

(4)

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. To test the impact of monetary policy transparency on the forecast errors and risk in the money market we need to test the relationship between \( W_t \) in Equation (4) and the transparency index. For arguments and econometric tests on the relationship between transparency and forecast errors of market participants, see, e.g., Thornton (1996), Haldane and Read (2000) and Blinder, et al. (2001).

As it would be expected the higher is the volatility of the interest rate, the higher will be the investors’ demand for term, liquidity and interest exposure as well as reinvestment risk premia. For example, a higher volatility would make the forecasting more difficult, see, e.g., Ehrmann, et al. (2012) and the references in it. Consequently, we would expect the volatility of three-month Treasury Bill rate (VTB) to have a positive impact on \( W_t \), while a higher monetary

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3 Autocorrelation is due to the overlapping observations. I used Newey and West’s (1987) robusterror for 5-order moving average to correct the standard error.
policy transparency reduces this risk and forecast error variable. We estimate the following equation:

\[
|W_t| = \xi_0 + \xi_1 \ln LT_{t-1} + \xi_2 VTB_{t-1} + DUM_{t-1} \zeta + \epsilon_t,
\]

where \(|W_t|\) is the absolute value of the forecast error from Equation (4), \(LT_t\) is the logarithm of the monetary transparency index developed by Kia (2011), \(\xi\)'s are constant parameters, \(\zeta\) is a vector of constant parameters and \(\epsilon_t\) is the white noise disturbance term. To construct \(VTB\), following Schwert (1989) and Kia (2003), the methodology developed by Davidian and Carroll (1978) was used. In the next section we will fully explain the construction of this volatility.\(^4\)

Vector \(DUM\) is defined as:

\[
DUM = (M_t, T_t, WED_t, TH_t, D851231_t, D861231_t, Green_t, Bernanke_t, OCT87_t, ASIA_t, TA_t, TAF_t, SWED_t, REMA_t, minutes_t, transcripts_t, state_t, D940418_t, D970819_t, Irr_t, D981015_t, D99518_t, D000202_t, D010103_t, D010917_t, D020319_t, EDAY_t, TARATE_t, USCrisis_t).
\]

For the definition of these dummy variables see the Appendix. \(DUM\) 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 as well as the forecast error.

Note that variables \(LT\), \(VTB\) and \(DUM\) enter in Equation (5) with one lag length (three months earlier) since the implied forward rate was used three months before (at the time of forecast) the actual rate was realized. Since our sample is daily observations, \(LT\) is Kia’s (2011) extended index, which is based on the formula suggested by Kia (2011), was constructed for our sample period. The lag length is 90 days. According to the Augmented Dickey-Fuller and

\(^4\) It should also be mentioned that, as we will demonstrate in the next section, the index also influences the volatility of the three-month TB rate and so there is a possibility of multicollinearity. However, as we can see in Table 2, both variables are highly statistically significant when we estimate Equation (5), and when one of these variables was dropped the other variable remains statistically significant while R-bar squared fell drastically to 0.20. Therefore, we conclude the existence of multicollinearity does not create a serious problem.
Phillips-Perron test results, we can reject the null hypothesis that $|W|$, VTB and LT are not stationary. The absolute value of the Augmented Dickey Fuller $t$ was estimated for $|W|$ to be 9.20, for VTB to be 14.02 and for LT to be 17.04. The absolute value of the Phillips-Perron non-parametric $t$ was estimated for $|W|$ to be 9.22, for VTB to be 63.21 and for LT to be 43.68. All $t$ statistics results are higher than 3.43 (1% critical value).

Table 2 reports the parsimonious estimation result of Equation (5), where the standard errors are adjusted for autocorrelation and heteroscedasticity. In this Table $\sigma$ is the standard error of the estimate, Godfrey is the five-order Godfrey’s (1978) test, White is the White’s (1980) general test for heteroscedasticity and ARCH is the five-order Engle’s (1982) test. L is Hansen’s (1992) stability L test on coefficients and variance of the error term. According to Godfrey’s test result, the error is autocorrelated and both White and ARCH tests results confirm the existence of heteroscedasticity.

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 finding of Thornton (1996), Haldane and Read (2000), Blinder, et al. (2001) and Swanson (2006). The estimated coefficient of the volatility in money market (VTB) as it would be expected is positive and statistically significant. 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

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5 The lag length in Augmented Dickey-Fuller or Phillips-Perron non-parametric tests was obtained according to AIC and SC criteria for a global lag of 20 days.
6 Because of overlapping observations these results would be expected.
variable Green means the forecast error and risk in the money market fell during the tenure of Chairman Greenspan.

Furthermore, as the positive and statistically significant estimated coefficient of D010103 indicates, the unexpected change in the target rate on January 3, 2001 resulted in a higher risk and forecast error. But the negative and statistically significant estimated coefficient of D010418 indicates that the unexpected change in the target rate on April 18, 2001 resulted in a reduction in risk/forecast error. The surprising result is the estimated coefficient of dummy variable D861231 which is negative and statistically significant implying a high volatility of FF on December 30 and 31, 1986 resulted in a lower risk and forecast error on those days. The positive estimated coefficient of D940418 indicates that when the Fed changed the FF target rate outside its regular meetings the risk and forecast error went up. The negative estimated coefficient of the dummy variable minutes indicates that since March 23, 1993, when the Fed began releasing the minutes of the FOMC meetings (with 6-8 week lag) resulted in a reduction of risk and forecast error. Finally, according to the estimated coefficient of USCredit during the US Credit Crisis both risk and forecast error increased.

However, according to Hansen’s stability test result, most coefficients and the variance are not stable. Because of the existence of heteroscedasticity, we would expect the variance not to be stable. Furthermore, in a 30-year sample of daily data (more than 7580 effective observations) one would expect some instability in the estimated coefficients. The main question is if the estimated coefficients of the relevant variables have the same impact (negative or positive), even though with a different magnitude in the different sub-samples of the sample period. To test this question I estimated the model for three 10-year sub-samples, 1982:10-06-1992:10:06, 1992:10:07-2002:10:06 and 2002:10:07-2012:02:30 periods. In all three cases the
estimated sign of coefficients of our two main variables, i.e., the index and the volatility, and relevant dummy variables remain the same, though in different magnitudes.

For example, the estimated coefficient of the index was -0.06, -0.07 and -0.39 in the first, second and last sub-samples, respectively, indicating the monetary transparency had a stronger impact on risk and forecast error in the recent period. The estimated coefficient of the volatility variable was 2.95, 1.39 and 4.73 in the first, second and last sub-samples, respectively. The interesting result was that the R-bar squared was the highest (0.55) in the last sub-sample, indicating the model is stronger in the last sub-sample. The full estimated results are available upon request.

To further investigate the above fact, I used quarterly averages of the daily observations to create a quarterly sample to test the impact of monetary policy transparency on forecast errors/risk. For this test I used Kia’s (2011) basic index T. For quarterly observations of T, following Kia (2011), I also took the average of the basic index in each quarter. Since the quarterly constructed index is highly correlated with the set of variables in DUM, see Kia (2011), most of the estimated coefficients while having the correct sign were statistically insignificant (the estimation result is available upon request). The parsimonious estimation result is reported in Table 3. According to the Augmented Dickey-Fuller and Phillips-Perron test results (not reported, but available upon request) the risk/forecast error variable and the index as well as the volatility variable are stationary.

Table 3 about here

According to the specification tests there is no autocorrelation or heteroscedasticity. Based on Hansen’s stability test result, all of the coefficients, individually or jointly, as well as the variance of the estimate are stable. The estimated coefficient of both LT as well as minutes is
negative and statistically significant. The estimated coefficient of the volatility and USCrisis is also positive and statistically significant. Both of these results confirm the result reported for the daily observations. In sum, we conclude that the more the monetary policy is transparent the less will be forecast errors and risk premia. Clearly, if a higher monetary policy transparency results in lower forecast errors and risk premia in a large country like the United States it is also useful for other countries. In fact, one can conclude that a 100% monetary policy transparency can completely eliminate forecast errors and risk premia, not just in the United States, but also in any country in the world.

4. Volatility in the Money Market and the Monetary Policy Transparency

In this section I will examine the relationship between monetary policy transparency, using Kia’s (2011) index, and risk, measured by the volatility, in the money market. We know that FF and TB are cointegrated and the adjustment toward the long-run equilibrium largely occurs through the movements in the FF rate rather than the TB rate [Sarno and Thornton (2003) and Kia (2010)]. Hence, we would expect the volatility of the daily movements in FF, say VFF, to affect the volatility of the daily movements in TB (i.e., VTB the risk in the money market). Let us assume the volatility of TB is a function of the volatility of FF and policy regime changes as well as other exogenous shocks specified in EDUM defined below. Furthermore, assume such a relationship has a linear approximation as specified by Equation (6):

\[ VTB_t = \Gamma_0 + \gamma LT_t + \sum_{i=1}^{k} \Gamma_i VFF_{t-i} + \sum_{i=1}^{k} \Phi_i VTB_{t-i} + EDUM_t' \Gamma + \varepsilon_t, \]

where \( \Gamma_0, \ldots, \Gamma_k, \Phi_0, \ldots, \Phi_k, \gamma \) and \( \Gamma \) are constant parameters. Dummy vector \( EDUM = (DUM_t, \ STU_t, \ TUE1_t, \ HB1_t, \ HA1_t, \ HB3_t, \ HA3_t, \ LDY_t, \ LDBYA_t, \ LQBA_t, \ LQ_t) \). Dummy variables included in EDUM are defined in Table 1. To capture the possible volatility in the money market
created by other factors, like window dressing, holidays and other seasonality, following Hamilton (1996), beside dummy variables in vector DUM, I included dummy variables STU_t, TUE1_t, HB1_t, HA1_t, HB3_t, HA3_t, LDY_t, LDBYAt, LQBA_t and LQt, see Table 1 in Data Appendix.

Note that in Equation (6) VFF is predetermined and if \( \gamma \) is negative/positive then the higher the monetary policy transparency (LT) is, the lower/higher the volatility of the three-month Treasury bill rate will be. Following, among many, Schwert (1989) and Kia (2003), the methodology developed by Davidian and Carroll (1978) was used. Let \( x \) be any variable in column vector \( x_t = (\Delta TB_t, \Delta FF_t)' \) and estimate Equation (7) for \( \Delta TB_t \) and \( \Delta FF_t \).

\[
x_t = \sum_{i=1}^{20} \alpha_i^x x_{t-i} + u_{xt}, \quad u_{xt} \sim \text{iid}(0, \Sigma).
\]

(7)

The parameters \( \alpha_i^x \)'s and vector \( \mu^x \) are assumed to be constant. I assume a lag length of 20 days (reflecting a month) is sufficient for the market participants to learn from the past movements in the TB rate. Furthermore, a 20th-order autoregression for the absolute values of errors from Equation (7) allow for different daily standard deviations, should be estimated:

\[
|\hat{u}_{xt}| = \sigma_i^x = \sum_{i=1}^{20} \delta_i^x \sigma_{t-i} + v_t,
\]

(8)

where \( \delta_i^x \), for \( i = 1 \) to 20 and the column vector \( \eta^x \) are constant parameters. The absolute value of the fitted value of \( u_{xt} \) (i.e., \( |\hat{u}_{xt}| \)) is the standard deviation (adjusted for heteroscedasticity and autocorrelation due to overlapping observations) of \( x_t \) for \( x_t = \Delta TB_t \) and \( \Delta FF_t \). 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 (2003), the conditional volatility in Equation (8) 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 (8) allows the conditional mean to vary over time in Equation (7), while it also allows 
different weights to be applied to the lagged absolute unpredicted changes in Treasury bills and 
Fed Funds rates.

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 (8) based on the 
absolute value of the prediction errors is more robust than those based on the squared residuals in 
Equation (7).

However, it should be noted that the variables in equations (6) and (8), excluding dummy 
variables, are generated regressors. Consequently, when these equations are estimated, their 
t statistic should be interpreted with caution. To cope with this problem, following, among many, 
Kia (2003), the equation for the conditional volatility [i.e., Equation (6)] is estimated jointly with 
the equations determining the conditional volatilities of ΔTB and ΔFF using the Generalized 
Least Squares (GLS) estimation procedure (SUR).7

In the GLS system, two equations are generated by Equation (7), two equations are 
generated by Equation (8) and including Equation (6) a system of five equations with 7623 
observations (with a final sum of 7613 usable observations) is estimated. In the GLS estimation, 
for each equation and the system of equations, I used Newey and West’s (1987) robusterror for 
5-order moving average to correct for heteroscedasticity and autocorrelation. The GLS estimator

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7 See Kia (2003), Footnote 4, for a full explanation on why in our case the GLS estimation technique should be used.
incorporates the possibility of cross-equation correlation among the error terms. The final parsimonious GLS estimation result of Equation (6) is given in Table 4.  

Table 4 about here

As it would be expected specification test results indicate both the existence of autocorrelation and heteroscedasticity. Based on Hansen’s stability test result, all of the coefficients individually are stable. However, because of heteroscedasticity the variance and joint coefficients and the variance are not stable. The estimated coefficient of our monetary policy index (LT) is negative, indicating that a more transparent monetary policy leads to a lower volatile money market. This result confirms the finding of Tabellini (1987), Haldane and Read (2000), Swanson (2006), Ehrmann and Fratzscher (2009) and Biefang-Frisancho Mariscal and Howells (2010), among many, that a higher degree of transparency tends to lower market volatility. The volatility of FF after 4 days influences negatively the VTB. Among all dummy variables included in EDUM, the coefficients of dummy variables TAF, D851231 and D861231 were found to be statistically significant. As it would be expected, the estimated coefficient of TAF is negative, implying that the policy regime change of announcing policy decisions after each FOMC meeting, since October 1989, led to a lower volatility in the money market in the United States. The estimated sign of dummy variables D851231 and D861231 is negative indicating that, surprisingly, a high volatility of FF on December 31, 1985 and on December 30 and 31, 1986 resulted in a lower volatility in the money market on that day. This result further confirms the estimated sign of VFF.

Table 5 about here

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8 The stationarity test results for VFF are as follows: The absolute value of the Augmented Dickey Fuller t, for a lag length of 19 is 11.90 and the absolute value of the Phillips-Perron non-parametric t-test for the lag length of 4 is 56.17, both t statistics are higher than 3.43 (1% critical value) indicating the conditional volatility VFF is
I also repeated the above exercise with our quarterly data explained above and Kia’s basic index. According to specification test results, reported in Table 5, there is the absence of both autocorrelation and heteroscedasticity. Based on Hansen’s stability test result, all of the coefficients individually or jointly are stable. As we can see except the basic index and the volatility, none of the dummy variables was statistically significant. This could be because of the high collinearity between the index and the dummies representing the policy-regime changes, see Kia (2011). The index has a negative effect on volatility, but the estimated coefficient was statistically significant only at 92% level (the full result is available upon request). This could be due to a lack of observations on the index in each quarter. VFF influences VTB positively after a year. In sum, it was shown in this section that a higher monetary policy transparency leads to a lower volatility in the money market in the United States. To eliminate this volatility this study suggests a 100% monetary policy transparency. Such a policy recommendation is useful not only for a large country like the United States, but also for other countries.

5. Concluding Remarks

The empirical findings on the impact of monetary policy transparency on risk and volatility are mixed. One possible explanation for these findings is the lack of a proper index to measure monetary policy transparency. The literature so far has been using dummy variables constructed according to the central banks’ announcements and actions or coding approach. However, these measures for the monetary policy transparency have some limitations, such as a lack of an objectively designed index or indexes without time-series properties. Furthermore, dummy variables may not really reflect the impact of an announcement or changes in the policy.
That is because market participants may have already incorporated the impact of a policy change before the central bank communication.

This is also possible when shocks which resulted in the central bank communications already affected the economy, say the volatility. Clearly using different measures for monetary policy transparency results in mixed empirical findings. This is especially true when these different measures have different shortcomings. Kia (2011) developed an objective market-based monetary policy transparency index. The index 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. In this paper I used Kia’s (2011) index to investigate the impact of monetary policy transparency on risk and volatility in the United States.

It was found 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. It was also found 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 risk in the money market, while the risk fell during the tenure of Chairman Greenspan.

Furthermore, the unexpected change in the target rate on January 3, 2001 and April 18, 2001 resulted in a higher risk in the United States. However, a high volatility of FF on December 31, 1985 and December 30 and 31, 1986 resulted in a lower risk as well as volatility on those days. It was also found that the policy regime change of releasing the minutes of the FOMC meetings (with 6-8 week lag) since March 23, 1993, resulted in a reduction of risk and forecast error and the policy regime change of announcing policy decisions after each FOMC meeting.

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9 Papadamou and Arvanitis (2014), using also Kia’s (2014) index find that a higher monetary policy transparency leads to a lower volatility of both inflation and output.
since October 1989, led to a lower volatility in the money market in the United States. It was also found that the current US financial crisis led to a higher risk and forecast error. We conclude that the practice of a more transparent monetary policy leads to more stability (lower volatility) and lower risk in the financial markets.

Based on the findings of this paper we recommend a 100% monetary policy transparency in the United States. Clearly if a higher monetary policy transparency results in lower forecast errors, risk premia and volatility, a 100% monetary policy transparency should lead to the elimination of risks associated with forecasting errors and volatility in a large country like the United States. Furthermore, such transparency can be shown to be optimum in all countries in the world. Since Kia’s monetary policy index can be easily constructed for any country, future research should be devoted to a similar study on other countries to further justify the policy recommendation of this paper.
REFERENCES


http://dx.doi.org/10.1080/02692171.2014.945994.


Data Appendix

The daily data on the effective Fed Funds rate and the three-month Treasury bill rate (secondary market) for the period 1982 (October 5) - 2012 (March 1) are used. The choice of the sample period is based on the availability of data for the construction of the transparency index which was developed by Kia (2011). The period covers more than 29 years with 7580 effective daily observations. The source of these data is the St. Louis Federal Reserve website. The effective Fed Funds rate is a weighted average of the rates on Fed Funds reported daily by a group of brokers to the Federal Reserve Bank of New York. Both Fed Funds and three-month Treasury bill rates are expressed as bond equivalent yields on a 365-day basis. The definitions of the dummy variables in DUM and EDUM are given in the following table.

Table 1: Definition of DUM and EDUM*

<table>
<thead>
<tr>
<th>Dummy Variables</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_t$, $T_t$, $WED_t$, and $TH_t$</td>
<td>$M_t$, $T_t$, $WED_t$, and $TH_t$ = 1 for Mondays, Tuesdays, Wednesdays and Thursdays, respectively, and are equal to zero, otherwise.</td>
</tr>
<tr>
<td>$D851231_t$ and $D861231_t$</td>
<td>$D851231_t$ and $D861231_t$ = 1 on December 31, 1985 and December 30 and 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.</td>
</tr>
<tr>
<td>$Green_t$</td>
<td>$Green_t$ = 1 since August 11, 1987 to January 31, 2006 when Alan Greenspan was the chair of the Fed and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>$Bernanke_t$</td>
<td>$Bernanke_t$ = 1 since February 1, 2006 when Chairman Bernanke was appointed chair of the Fed and is zero, otherwise.</td>
</tr>
<tr>
<td>$OCT87_t$ and $ASIA_t$</td>
<td>$OCT87_t$ = 1 for October 19 to 30, 1987 and is equal to zero, otherwise, and $ASIA_t$ = 1 for October 17 to 30, 1997 and is equal to zero, otherwise. These dummy variables account for the October 87 and Asian crises, respectively. In both events, central banks in 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.</td>
</tr>
<tr>
<td>$TA_t$</td>
<td>$TA_t$ = 1 since February 4, 1994 (when Fed started to announce target changes) and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>$TAF_t$</td>
<td>$TAF_t$ = 1 since October 19, 1989 (when the Fed adopted the practice of changing the FF targets by 25 or 50 basis points) and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>$SWED_t$</td>
<td>$SWED_t$ accounts for settlement days on Wednesdays, i.e., it is equal to one on Wednesdays when it is a settlement day and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>$REMA_t$</td>
<td>$REMA_t$ = 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 equal to zero, otherwise.</td>
</tr>
<tr>
<td>$minutes_t$</td>
<td>$minutes_t$ = 1 since March 23, 1993 when the Fed began releasing the minutes of the FOMC meetings (with 6-8 week lag) and is equal to zero, otherwise.</td>
</tr>
</tbody>
</table>
| $transcripts_t$ | $transcripts_t$ = 1 since November 16, 1993 when the Fed began releasing the transcripts of the FOMC meetings (with 5-year lag) and is equal to zero,
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{state}_t)</td>
<td>(\text{state}_t=1) since August 16, 1994 when the Fed began describing the state of the economy and further rationale for the policy action after FOMC decisions, and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{Irr}_t)</td>
<td>(\text{Irr}_t=1), since July 30, 1998 and is equal to zero, otherwise. On March 26, 1998 the Fed moved from contemporaneous reserve requirements back to lagged reserve requirements. This policy went into effect with the reserve maintenance period beginning July 30, 1998. (\text{Irr}) accounts for this policy regime change.</td>
</tr>
<tr>
<td>(\text{D970819}_t)</td>
<td>(\text{D970819}_t=1) since August 19, 1997 when the FOMC started to include a quantitative Fed Funds target rate in its Directive to the New York Fed Trading Desk, and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{D99518}_t)</td>
<td>(\text{D99518}_t=1), since May 18, 1999 when 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), and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{D000202}_t)</td>
<td>(\text{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 is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{D020319}_t)</td>
<td>(\text{D020319}_t=1) since March 19, 2002 when the Fed included in FOMC statements the vote on the directive and the name of dissenter members (if any), and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{D940418}_t, \text{D981015}_t, \text{D010103}_t, \text{D010418}_t, \text{D010917}_t)</td>
<td>(\text{D940418}_t, \text{D981015}_t, \text{D010103}_t, \text{D010418}_t, \text{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 rate outside its regular meetings), respectively, and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{EDAY}_t)</td>
<td>(\text{EDAY}_t=1) for the days (“event”) when the Fed Funds target rate was changed whether at a regularly scheduled FOMC meeting, or otherwise, and also for the days on which the FOMC met, but did not change the target rate. It is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{TARATE}_t)</td>
<td>(\text{TARATE}_t=1) for the days when the Fed funds target rate actually was changed and is equal to zero, otherwise. These days can be among the regularly scheduled FOMC meeting dates or other days. Note that (\text{TARATE}) is a subset of (\text{EDAY}), as it excludes the days when FOMC met, but did not change the target.</td>
</tr>
<tr>
<td>(\text{USCrisis}_t)</td>
<td>(\text{USCrisis}_t=1) for the period September 30, 2007 - September 30, 2008 and is equal to zero, otherwise. The housing bubble started to burst in 2006, and the decline accelerated in 2007 and 2008. Housing prices stopped increasing in 2006, started to decrease in 2007. The decline in prices meant that homeowners could no longer refinance when their mortgage rates were reset, which caused delinquencies and defaults of mortgages to increase sharply, especially among subprime borrowers. “It was in August 2007 when BNP Paribas, a large French bank, froze withdrawals in three investment funds that people began to panic. If a bank with zero obvious exposure to the U.S. mortgage sector could have this measure of difficulty, anyone could be hiding untold losses. This marked the official beginning of the credit crisis.” Harrison (2008)</td>
</tr>
<tr>
<td>(\text{STU}_t)</td>
<td>(\text{STU}_t=1) on Tuesdays before settlement Wednesdays and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{TUE1}_t)</td>
<td>(\text{TUE1}_t=1) on Tuesdays before settlement Wednesdays if Wednesday was a holiday, and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{HB1}_t, \text{HA1}_t, \text{HB3}_t, \text{and HA3}_t)</td>
<td>(\text{HB1}_t=1) for the day before a one-day holiday, and is equal to zero, otherwise. (\text{HA1}_t=1) for the day after a one-day holiday, and is equal to zero, otherwise. (\text{HB3}_t=1) for the day before a three-day holiday, and is equal to zero, otherwise. (\text{HA3}_t=1) for the day after a three-day holiday, and is equal to zero, otherwise.</td>
</tr>
<tr>
<td>(\text{LDY}_t)</td>
<td>(\text{LDY}_t=1) for the last day of the year, and is equal to zero, otherwise. (\text{LDBYA}_t=1) for 2 days before, 1 day before, 1 day after, or 2 days after the end of the year, and is equal to zero, otherwise.</td>
</tr>
</tbody>
</table>

The housing bubble started to burst in 2006, and the decline accelerated in 2007 and 2008. Housing prices stopped increasing in 2006, started to decrease in 2007. The decline in prices meant that homeowners could no longer refinance when their mortgage rates were reset, which caused delinquencies and defaults of mortgages to increase sharply, especially among subprime borrowers. “It was in August 2007 when BNP Paribas, a large French bank, froze withdrawals in three investment funds that people began to panic. If a bank with zero obvious exposure to the U.S. mortgage sector could have this measure of difficulty, anyone could be hiding untold losses. This marked the official beginning of the credit crisis.” Harrison (2008)
\[ \text{LQBA}_t, \text{and LQ}_t \]

<table>
<thead>
<tr>
<th>\text{LQBA}_t</th>
<th>\text{LQ}_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 1 for the day before, on, or after the last day of the first, second and third quarters, and is equal to zero, otherwise.</td>
<td>\text{LQ}_t = 1 for the last day of the first, second, third and fourth quarters, and is equal to zero, otherwise.</td>
</tr>
</tbody>
</table>

* Part of this table is taken from Kia (2010). See also Kia (2011).

\[ \text{DUM} = (M_t, T_t, \text{WED}_t, \text{TH}_t, D851231_t, D861231_t, \text{Green}_t, \text{Bernanke}_t, \text{OCT87}_t, \text{ASIA}_t, \text{TAX}_t, \text{TAF}_t, \text{SWED}_t, \text{REMA}_t, \text{minutes}_t, \text{transcripts}_t, \text{state}_t, D940418_t, D970819_t, \text{Ir}_{t}, D981015_t, D99518_t, D000202_t, D010103_t, D010418_t, D010917_t, D020319_t, \text{EDAY}_t, \text{TARATE}_t, \text{USCrisis}_t). \]

\[ \text{EDUM} = (\text{DUM}_t, \text{STU}_t, \text{TUE1}_t, \text{HB1}_t, \text{HA1}_t, \text{HB3}_t, \text{HA3}_t, \text{LDY}_t, \text{LDBYA}_t, \text{LQBA}_t, \text{LQ}_t). \]
Table 2: Parsimonious Estimation Result of Equation (5) – Daily Observations

Dependent Variable $= |W| = \text{Risk and Forecast Error}$

<table>
<thead>
<tr>
<th>Explanatory Variables*</th>
<th>Coefficients</th>
<th>Standard Error**</th>
<th>Hansen’s Stability $L_i$ Test ($p$-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.64</td>
<td>0.21</td>
<td>0.00</td>
</tr>
<tr>
<td>LT$_{t-1}$</td>
<td>-0.11</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>VTB$_{t-1}$</td>
<td>4.06</td>
<td>0.43</td>
<td>0.00</td>
</tr>
<tr>
<td>REMA$_{t-1}$</td>
<td>0.17</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Green$_{t-1}$</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>D010103$_{t-1}$</td>
<td>0.22</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>D010418$_{t-1}$</td>
<td>-0.11</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>D861231$_{t-1}$</td>
<td>-1.27</td>
<td>0.37</td>
<td>0.10</td>
</tr>
<tr>
<td>D940418$_{t-1}$</td>
<td>0.27</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>minutes$_{t-1}$</td>
<td>-0.19</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>USCrisis$_{t-1}$</td>
<td>0.63</td>
<td>0.12</td>
<td>0.42</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

Specification Tests

- $R^2=0.26$, $\sigma=0.44$
- DW$=0.08$, Godfrey (5) $= 1466$ ($p$-value=0.00),
- White$=1162$ ($p$-value=0.00), ARCH (5)$= 6896$ ($p$-value=0.00)***
- Joint (coeffs + var.)$= 50$ ($p$-value$=0.00$)

* The sample period is 1982:10:06-2012:02:30. LT$_t$ is the logarithm of the monetary transparency index, and VTB is the volatility of the three-month Treasury bill rate. For the definition of the dummy variables, see Table 1.
** The estimation method is OLS where Newey and West’s (1987) robust error for 5-order moving average was used to correct for autocorrelation and heteroscedasticity.
*** $R^2$, $\sigma$ and DW, respectively, denote the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin-Watson statistic. Godfrey is the five-order Godfrey’s (1978) test, White is White’s (1980) general test for heteroscedasticity and ARCH is the five-order Engle’s (1982) test.
Table 3: Parsimonious Estimation Result of Equation (5) – Quarterly Observations
Dependent Variable = |W| = Risk and Forecast Error

<table>
<thead>
<tr>
<th>Explanatory Variables*</th>
<th>Coefficients</th>
<th>Standard Error**</th>
<th>Hansen’s Stability L₁ Test (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>2.60</td>
<td>1.15</td>
<td>0.71</td>
</tr>
<tr>
<td>LTₜ₋₁</td>
<td>-0.60</td>
<td>0.25</td>
<td>0.66</td>
</tr>
<tr>
<td>VTBₜ₋₂</td>
<td>1.43</td>
<td>0.54</td>
<td>0.80</td>
</tr>
<tr>
<td>minutesₜ₋₁</td>
<td>-0.16</td>
<td>0.08</td>
<td>0.57</td>
</tr>
<tr>
<td>USCrisisₜ₋₁</td>
<td>0.27</td>
<td>0.10</td>
<td>0.47</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td>0.19</td>
</tr>
</tbody>
</table>

Specification Tests

$_{R}^2$ = 0.18, $\sigma$ = 0.35
DW = 1.41, Godfrey (5) = 2.17 (p-value = 0.05),
White = 12 (p-value = 0.90), ARCH (5) = 9.27 (p-value = 0.10)***

Joint (coeffs + var.) = 1.62 (p-value = 0.06)

* The sample period is 1983Q1-2011Q4. LT is the logarithm of the monetary transparency index, and VTB is the volatility of the three-month Treasury bill rate. For the definition of the dummy variables, see Table 1.

** The estimation method is OLS.

*** $_{R}^2$, $\sigma$ and DW, respectively, denote the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin-Watson statistic. Godfrey is the five-order Godfrey’s (1978) test, White is White’s (1980) general test for heteroscedasticity and ARCH is the five-order Engle’s (1982) test.
Table 4: Parsimonious Estimation Result of Equation (6) – Daily Observations
Dependent Variable = VTB = Conditional Volatility of Three-month TB Rate

<table>
<thead>
<tr>
<th>Explanatory Variables*</th>
<th>Coefficients</th>
<th>Standard Error**</th>
<th>Hansen’s Stability L_i Test (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.03</td>
<td>0.002</td>
<td>0.71</td>
</tr>
<tr>
<td>LT_t</td>
<td>-0.01</td>
<td>0.001</td>
<td>0.76</td>
</tr>
<tr>
<td>VFF_{t-4}</td>
<td>-0.002</td>
<td>0.001</td>
<td>0.54</td>
</tr>
<tr>
<td>VTB_{t-3}</td>
<td>0.66</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>VTB_{t-2}</td>
<td>0.40</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>VTB_{t-1}</td>
<td>-0.40</td>
<td>0.01</td>
<td>0.15</td>
</tr>
<tr>
<td>VTB_{t-5}</td>
<td>0.20</td>
<td>0.01</td>
<td>0.45</td>
</tr>
<tr>
<td>VTB_{t-8}</td>
<td>-0.06</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>VTB_{t-9}</td>
<td>0.11</td>
<td>0.01</td>
<td>0.92</td>
</tr>
<tr>
<td>VTB_{t-11}</td>
<td>-0.07</td>
<td>0.01</td>
<td>0.73</td>
</tr>
<tr>
<td>VTB_{t-14}</td>
<td>0.17</td>
<td>0.02</td>
<td>0.41</td>
</tr>
<tr>
<td>VTB_{t-15}</td>
<td>-0.11</td>
<td>0.01</td>
<td>0.35</td>
</tr>
<tr>
<td>TAF_t</td>
<td>-0.002</td>
<td>0.0003</td>
<td>0.49</td>
</tr>
<tr>
<td>D851231_t</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.09</td>
</tr>
<tr>
<td>D861231_{t-4}</td>
<td>-0.03</td>
<td>0.009</td>
<td>0.10</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Specification Tests</td>
<td>( \bar{R}^2=0.85, \sigma=0.01 )</td>
<td>( DW=1.94, \text{Godfrey (5)}= 4.46 )( (p\text{-value}=0.00), \text{White}=1677 )( (p\text{-value}=0.00), \text{ARCH (5)}= 1069 )( (p\text{-value}=0.00) )***</td>
<td>Joint (coeffs + var.)= 9.12 ( (p\text{-value}=0.00) )</td>
</tr>
</tbody>
</table>

* The sample period is 1982:10:06-2012:02:30. LT, is the logarithm of the monetary transparency index, and VFF is the volatility of the Fed Funds rate. For the definition of the dummy variables, see Table 1.
** The estimation method is the Generalized Least Squared (SURE) while Newey and West’s (1987) robusterror for 5-order moving average was used to correct for autocorrelation and heteroscedasticity.
*** \( \bar{R}^2, \sigma \) and DW, respectively, denote the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin-Watson statistic. Godfrey is the five-order Godfrey’s (1978) test, White is White’s (1980) general test for heteroscedasticity and ARCH is the five-order Engle’s (1982) test.
### Table 5: Parsimonious Estimation Result of Equation (6) – Quarterly Observations
Dependent Variable = VTB = Conditional Volatility of Three-month TB Rate

<table>
<thead>
<tr>
<th>Explanatory Variables*</th>
<th>Coefficients</th>
<th>Standard Error**</th>
<th>Hansen’s Stability L_i Test (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.59</td>
<td>0.18</td>
<td>0.60</td>
</tr>
<tr>
<td>LT_t</td>
<td>-0.07</td>
<td>0.04</td>
<td>0.57</td>
</tr>
<tr>
<td>VFF_{t-4}</td>
<td>0.19</td>
<td>0.09</td>
<td>0.70</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td>0.46</td>
</tr>
</tbody>
</table>

| Specification Tests    |                                          |                                                |
|------------------------|                                          |                                                |
| $\bar{R}^2$            | =0.4, $\sigma=0.06$                      |                                                |
| DW=1.83, Godfrey (5)   | =1.49 (p-value=0.19), White=6.63 (p-value=0.25), ARCH (5)=6.63 (p-value=0.25)** | Joint (coeffs + var.)= 0.61 (p-value=0.50) |

* The sample period is 1983Q1-2011Q4. LT_t is the logarithm of the monetary transparency index, and VFF is the volatility of the Fed Funds rate. For the definition of the dummy variables, see Table 1.
** The estimation method is the Generalized Least Squared (SURE).
*** $\bar{R}^2$, $\sigma$ and DW, respectively, denote the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin-Watson statistic. Godfrey is the five-order Godfrey’s (1978) test, White is White’s (1980) general test for heteroscedasticity and ARCH is the five-order Engle’s (1982) test.