Developing a Market-Based Monetary Policy Transparency Index:
Evidence from the United States

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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.

1. INTRODUCTION

CENTRAL BANKS ARE MOVING UNEQUIVOCALLY 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 favour of and/or against more transparency in central banking, although ample, are not unanimous in their findings,[2] and empirical tests of these arguments are scarce, mostly because transparency in monetary policy is a concept hard to measure. According to Blinder *et al.* (2008), central bank communication can be an important factor in improving the ability of the market to predict monetary policy and to help monetary authorities achieve their objectives.

The existing transparency measures have some limitations. Most of them are not in time-series form and therefore can only be used for cross-sectional studies and 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 somewhat static. In general, 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 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). With this type of measure there is a possibility of misunderstanding the survey questions and/or manipulating responses by the central banks to obtain an appropriate score.

(iii) Official documents and information, also known as the 'characteristics' approach *à la* Biefang-Frisancho Mariscal and Howells (2007): Researchers construct indexes of the transparency of monetary policy by evaluating the behaviour 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. Chadha and Nolan (2001), de Haan and Amtenbrink (2002), Eijffinger and Geraats (2006) and Cruijsen *et al.* (2010). Possible weaknesses with this approach, as also mentioned by Biefang-Frisancho Mariscal and Howells (2007), are that the particular items looked at and the weight assigned to them by each set of authors may differ for purely subjective reasons and there is no theoretical justification for linking the characteristics to transparency. 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. 'Clearly, the more information that is released the better informed people *should* be. But this is dangerously circular. If we are not careful, transparency itself comes to be defined as "full information (of any sort)" and then inevitably it follows that the more information is released the more transparent a regime is' Biefang-Frisancho Mariscal and Howells (2007, p. 605). 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.[3] Thus, these measures limit the number of hypotheses that may be tested concerning the impact of more transparent monetary policies in the economy.

(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 degree to which market participants understand and anticipate monetary policy can 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 US include those based on federal funds futures rates, e.g. Robertson and Thornton (1997), Kuttner (2001) and Söderström (2001).

The existing market-based indicators also have limitations. They restrict the analysis to post 1988, when the federal funds futures market was established. Furthermore, as mentioned by Poole *et al.* (2002), Fed funds futures rate 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. Finally, as shown by Robertson and Thornton (1997), there is a potential bias for the federal funds futures rate to forecast the future target rate, but this rate may forecast future funds rates and not the Fed action.

Other measures are based on actual market rates including Treasury bill rates and Eurodollar deposit rates, e.g. Cochrane and Piazzesi (2002). These measures concentrate mostly on a change in the single interest rate at the time of a target change. A single rate does not contain full information on monetary policy transparency as, in general, interest rates, and especially their relationships, reflect the behaviour of market participants (arbitrageurs and speculators). Consequently, these measures are static and, more seriously, they are very narrowly defined by putting much emphasis on a single piece of information.

Some policy surprise measures are based on an 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 depends fully on the background and experience of the researchers. The overall limitation of these measures arises from the fact that they are usually a 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).

Finally, dummy variables are used in some studies to evaluate the impact of more transparent policy on volatility in financial markets. The problem with using dummy variables to capture the impact of announcements or policy regime changes is that market participants, especially in highly efficient financial markets like those in the United Kingdom and the United States, may incorporate the change in the policy or announcements in their activities before the actual change. In other words, an official change may have been anticipated or in some cases fully anticipated. Consequently, the dummy variables may not actually reflect the impact of the announcements or the change in the policy. For example, Haldane and Read (2000) and Blinder *et al.* (2001), among others, tested the relationship between transparency and forecast errors of market participants. Chadha and Nolan (2001) used 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.

Haldane and Read (2000), using dummy variables for the change in monetary policy transparency, show that higher monetary policy transparency leads to 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 the above finding. Lasaosa (2005) analyses 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 an announcement five, fifteen and sixty minutes after its announcement. Then she compares the result with those days with no announcement at the same times. As also mentioned by Lasaosa (2005), some announcements may already have been taken into account by market participants before the announcement.

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 two major reforms in UK policy-making, in 1992 and 1997. They conclude that the Bank of England's independence and its associated reforms have not added to the understanding of monetary policy by market participants, confirming Haldane and Read's (2000) findings.

Biefang-Frisancho Mariscal and Howells (2010), using dummy variables, show that the various forms of Fed communication are highly significant to volatility and market expectations. Because of the problems mentioned above in using dummy variables, it would be appropriate to construct a market-based monetary policy index and revisit the above studies. Specifically one may use the index developed in the present paper to revisit the study of both Haldane and Read (2000), at least for the United States, and Biefang-Frisancho Mariscal and Howells (2010). As we shall see below, the constructed index confirms indirectly some findings of Biefang-Frisancho Mariscal and Howells (2010).

It should be noted that the construction of a market-based index depends on the characteristics of the market or markets whose prices are used to establish the index. Consequently, it is extremely important to identify the market(s) carefully before constructing a monetary policy index based on the information generated from the market(s). The purpose of this paper is to develop an index which is dynamic and can be used to measure monetary policy transparency for an individual or, simultaneously, a series of countries. To the best knowledge of the author, no such index exists in the literature. In this study, the measure is developed for United States monetary policy for the 1982-2010 (September) period. The choice of the country is based on the fact that the United States has a complex banking system (12 Federal Reserves) with no clear policy objectives, such as inflation targeting, an interest rate band, etc. Thus the index, if successful in detecting the Federal Reserve monetary transparency, will be useful in checking the central bank transparency

of any country which has a similar monetary system to the United States, especially countries that have clear monetary policy goals such as Canada, New Zealand and the United Kingdom.

This paper makes two major contributions to the literature. First, a monetary policy index is constructed. Such an index is dynamic and can also be continuous when intraday minute or shorter interval observations are used. Second, it is found, using the index, that monetary policy transparency in the United States went up during the period of the Greenspan and Bernanke chairmanships. Furthermore, using the index it is found monetary policy regime changes since 1989 have enhanced monetary policy transparency in the United States.

A description of the data is given in Section 2. Section 3 is devoted to the theoretical foundation of the index. It is followed by a section on the construction of the index, as well as the power of the index in investigating whether the recent policy regime changes have increased monetary policy transparency in the United States. The final section provides a summary and conclusions.

2. DATA DESCRIPTION

The daily data on the effective Fed funds, the Treasury bill (secondary market) and the exchange rates (Japanese Yen per US dollar) for the period 1982 (October 5) to 2010 (September 30) are used. The number of observations is 7304 days. 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 transactions of a group of Fed funds brokers who report their transactions daily to the Federal Reserve Bank of New York.

The choice of the sample period is based on the availability of data on target Fed funds rates. According to Sarno and Thornton (2003), the Fed was explicitly targeting the funds rate from 1974 to October 1979. It switched to a non borrowed reserves operation procedure in October 1979, and in October 1982 switched to a borrowed reserves operating procedure. However, since it is not known when exactly the Fed switched from a borrowed reserve operating procedure to an explicit funds rate targeting procedure, for the purpose of this paper and the construction of the index, available target rates with their respective dates are needed. October 1982 has thus been chosen as the start of the period.

To the best knowledge of the author, a non-interrupted set of data on Fed funds target rates is only available from October 1982. For the period 1982-1989, a series prepared by the Federal Open Market Committee (FOMC) Secretariat is used. This series is based on the staff's interpretations of FOMC transcripts and other documents publicly available.[4] Following Poole *et al.* (2002), (2002), we call 'event days' the days on which the FOMC meets (whether the target was changed or not) and the inter-meeting days on which the target rate was changed. Note that the following business days were con-

sidered event days for those days when the FOMC meetings took place on weekends/holidays. Furthermore, for the target change of 'early January 1989', we assume January 5 as the day when the target was changed. For the period from 1990, the series reported on the Board of Governors of the Federal Reserve System's website is used.[5]

In the calculation of the transparency index, we use 360-day Fed funds and Treasury bill rates to avoid an artificial reduction in the index. For the period under consideration, the Fed has made some transparency oriented changes, for example: (i) On October 19, 1989 the Fed started the practice of adjusting the funds target rate by 25 or 50 basis points,[6] (ii) on March 23, 1993 the Fed began releasing the minutes of the FOMC meetings (with a 6-8 week lag), (iii) on November 16, 1993 the Fed began releasing transcripts of FOMC meetings (with a 5-year lag), (iv) on February 4, 1994 the Fed began announcing policy decisions after each FOMC meeting, (v) on August 16, 1994 the Fed began describing the state of the economy and further rationales for policy actions after FOMC decisions, (vi) on August 19, 1997 the FOMC started including a quantitative Fed funds target rate in its Directive to the New York Fed Trading Desk, and (vii) on May 18, 1999 the Fed extended its explanations regarding policy decisions, and started including in press statements an indication of the FOMC view regarding prospective developments (or the policy bias), (viii) on January 19, 2000 the FOMC issued a press statement explaining that it would include a balance-of-risk sentence in its statements, replacing the previous bias statement.[7] The practice was first implemented at the following FOMC meeting, on February 2. Finally, since March 19, 2002, the Fed has included in the FOMC statements the vote on the directive and the name of dissenter members (if any).[8]

The index developed in this paper will be used to determine whether transparency-oriented reforms at the Fed have indeed increased the market's understanding of Fed policies. Finally, we also test changes in monetary policy transparency during Chairman Alan Greenspan's tenure (August 11, 1987 to January 31, 2006), and Chairman Ben Bernanke's tenure (February 1, 2006 to September 30, 2010).

3. MARKET-BASED MONETARY POLICY INDEX: THEORETICAL JUSTIFICATION

The 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) made outside these meetings. Specifically, by monetary policy transparency, following Sundararajan *et al.* (2003, p. 5), we mean '[...] an environment in which the objectives of the policy; its legal, institutional, and economic framework; policy decisions and their rationale; data and information related to monetary and financial policies; and the accountability of the policymaking body are provided to the public in an understandable, accessible and timely basis.' Under this

definition, there is an absence of asymmetric information between monetary policy makers and other economic agents. The implementation of the monetary policy can be made public in one or more of the following ways: remarks of the Chairman of the Federal Reserve as well as other senior Fed management, testimony before the House and Senate Banking Committee, the release of the Beige book, the minutes of FOMC meetings, changes in reserve requirements, changes in the discount rate and open market operations.

Since the index developed in this paper is market based, it is assumed there is no uncertainty. Specifically, we distinguish between risk and uncertainty in the sense of Knight (1921). It should be noted that there are periods of uncertainty in the sample period, specifically towards the end of the Federal Reserve Chairman Paul Volcker's tenure and the start of Chairman Greenspan's tenure. In that period, because of the change in authority, market participants could not easily understand or interpret Fed signals. Other periods of uncertainty are associated with the October 1987 stock market crisis as well as September 2001 terrorist attacks. Consequently, we do not expect the index developed in this paper to properly reflect a market-based monetary transparency index. Note we do not consider the Fed reaction relevant to the Asian crisis as an uncertain event from agents' point of view, since agents could use the recent historical reaction of the Fed related to the October 1987 crisis to calculate the probability associated with what action the Fed was likely to take.

Furthermore, it is assumed Fed funds and three-month Treasury bill rates are cointegrated. Since the construction of the monetary policy index in this paper is based on data at the short end of the yield curve, we need short-term rates, say Fed funds and three-month Treasury bill rates, to be cointegrated. The existing literature provides empirical evidence for this assumption. For example, Sarno and Thornton (2003) and Kia (2010) have shown the Fed funds rate (FF) and three month Treasury bill rate (TB) to be cointegrated. Moreover, the adjustment toward the long run equilibrium occurs largely through the movements in the FF rather than the TB.[9] Finally, it is assumed market participants are forward looking in the sense of Lucas (1976). Kia (2010) provides empirical evidence in support of this assumption. He shows that agents are forward looking in the money market of the United States in the sense that their behaviour is not policy-invariant and expectations are formed rationally.[10]

Through swept accounts, banks could effectively reduce the required reserves. However, because of uncertainty in check clearing, a manager of a depository institution may hold excess cash reserves above the minimum required level. Furthermore, the depository institution manager may hold some buffer reserves in the form of government securities that can be turned into cash quickly if deposit withdrawals are unusually high, or to prompt the early stages of a bank run. Even though the manager knows with certainty the value of the target or required reserves throughout the reserve maintenance

period, s/he still has a challenge in maintaining sufficient deposits in reserve at the Fed to hit the reserve target without holding too large an excess reserve balance (Saunders and Millon Cournett, 2008). This is because excess reserves, similar to the reserve target, have a negative interest return. Note that the Fed began paying interest on reserves, both required and excess, on October 9, 2008. This rate, currently, is the target rate plus 25 basis points (Thornton, 2009). However, even after October 9, 2008, the return on excess reserves is negative since the risk-adjusted lending rates are typically much more than the Fed target rate plus 25 basis points. Consequently, reserve managers of the banking system keep an optimum excess reserve (OER). Let us define OER as the private or prudential optimum excess reserve ratio used by the banking system.

We may express the daily behaviour of FF at time t ($t \geq T$, where T is the time of the last change of the target rate or the last FOMC meeting), as:

$$FF_t = TFF_T + \alpha(OER_t - ER_t) \, , \qquad (1)$$

where ER is the actual excess reserve ratio, TFF_T is the target Fed funds rate at time T, the previous event day and α (known by the public) is a coefficient which can change as the behaviour of forward-looking market participants changes (see Kia, 2010). As mentioned above, because of uncertainty in check clearing, banks in the United States should keep a positive excess reserve. Specifically, if the manager of a bank perceives that the regulatory-required minimum level of reserves is lower than that needed for expected and unexpected deposit withdrawal exposure, s/he will maintain a liquidity position at the prudently adequate level, but at a lower possible cost. This implies that some excess reserves might be held in highly liquid (noninterest-bearing) cash form, but at least part of any excess reserve position might, depending on the yield spread, be held in buffer assets such as short-term securities or Treasury bills that earn interest but are not quite as liquid as cash. However, at equilibrium the optimum excess reserves are equal to the actual excess reserves (see, e.g. Saunders and Millon Cournett, 2008).

In general, the variable OER is affected mostly by factors like day-of-the-week, seasons, the geographic position as well as the size of the bank, etc., while ER is affected mainly by Fed open market operations; see Equation (2) below. It should be noted that before July 30, 1998, when the two-week reserve computation period was implemented, the day-of-the week effect (e.g. Wednesday effect) was stronger; see Kotomin and Winters (2007).

Equation (1) is consistent with backward and forward-looking Taylor rules (see Bernanke and Boivin, 2003, and the literature therein). This is because the Fed always changes FF by influencing ER in Equation (1). Even the change in FF through a signal effect (or an open-mouth-operation *à la* Thornton, 2004) is conducted by a change in the expression $(OER_t - ER_t)$ in Equation (1). Suppose the Fed gives a signal to the market that the rate will

go up the following day. Since the reserves a bank must hold in the United States are the average of the two-week period (the maintenance period) reserves of the bank, each bank tries to increase its ER on the days when the FF is low, and vice versa. If, because of the Fed's signal, FF is expected to rise the following day, banks will increase their ER on that day when the opportunity cost of reserves (FF) is relatively low; and reduce their ER, by lending it to those banks in need of funds, the following day when FF is relatively high. In this way they can earn some positive return on their excess reserves. This speculative activity leads to a higher FF the day before the change in FF. Consequently, we can see that even the signal effect of the Fed affects the $(OER_t - ER_t)$ of the banking system.

In the spirit of the models of Geraats (2002) and Geraats *et al.* (2006), we assume that at time *t* the monetary policy instrument set by the central bank is:

$$ER_t = ER_{t-1} + \tau_t, \tag{2}$$

where $\tau \sim N(0, \sigma_\tau^2)$, under opacity, is only known by the Fed and not by the public. To avoid incorrect information assume that the public is aware of the information asymmetry. Furthermore, we can assume that τ is an economic shock that the central bank decides to offset, and which is independent of TFF. When there is full transparency both the Fed and the public know τ. Since ER_{t-1} is already known by the public it is a deterministic variable. Substituting (2) in (1) we have:

$$FF_t = FF_{t-1} + \alpha(OER_t - ER_{t-1}) + \alpha\tau_t. \tag{3}$$

Define TFF_{T+1} as the target rate at the next FOMC meeting or event day. In the United States the public has imperfect information about TFF_{T+1} so we may state that the public expectation on the target rate on the next event day/FOMC meeting day can be expressed as $TFF_{T+1} \sim N(\overline{TFF}, \sigma_{T+1}^2)$. The more uncertain is the public about TFF at time $T+1$, the higher is σ_{T+1}^2. To construct an equation which expresses the daily behaviour of TB, let us start with an equilibrium situation, where $OER_t = ER_t$, an outright sell of Treasury bills by the Fed results in a reduction of ER. Banks compete for interbank funds and the Federal funds rate will go up. Furthermore, as FF goes up (the interbank market becomes tight) banks sell their other liquid assets such as Treasury bills and, therefore, exert an upward pressure on TB. This means that an increase in $FF_t - TFF_T$ results in an increase in TB. Furthermore, an increase in $[E(TFF_{T+1}|FF_t) - TFF_T]$ leads to an expected potential speculative loss in keeping Treasury bills, where E is the expectation operator and $E(TFF_{T+1}|FF_t)$ is the expected TFF_{T+1} conditional on FF_t, which is known by the public at time *t*. Speculators will sell their bills to reduce their loss and exert an upward

pressure on TB. Consequently, we may express the daily movements of TB as:

$$TB_t = TB_{t-1} + \gamma_1(FF_t - TFF_T) + \gamma_2[E(TFF_{T+1}|FF_t) - TFF_T], \tag{4}$$

where γ_i for $i = 1$ and 2 are coefficients which can change as the behaviour of forward-looking market participants changes and are known by the public. The expression $(FF_t - TFF_T)$ is known as the unintended Fed funds rate. We add and subtract TFF_{T+1} in the third expression of (4) to get:

$$TB_t = TB_{t-1} + \gamma_1(FF_t - TFF_T) + \gamma_2\{[E(TFF_{T+1}|FF_t) - TFF_{T+1}] + [TFF_{T+1} - TFF_T]\} \tag{5}$$

In Equation (5), given TFF_T at time t, the expression $(FF_t - TFF_T)$ reflects the Fed action to influence the interest rates, and $[E(TFF_{T+1}|I_t) - TFF_{T+1}]$ is the unexpected change in the target rate, while $[TFF_{T+1} - TFF_T]$ is the actual change in the target rate on the next event day. On the next event day, $t=T+1$, if the Fed does not change the target rate we will have $FF_{T+1} = TFF_T$ and if the expected target rate for the following event day is the same as the current target rate, everything else being equal, we would expect $TB_{T+1} = TB_{t-1}$. Equation (5) is also consistent with the literature. For example, Hsing (2007), Demiralp and Jorda (2004) and Cochrane and Piazzesi (2002) have shown that the FF and unintended Fed funds rate affect Treasury bills. Furthermore, expression $[E(TFF_{T+1}|FF_t) - TFF_{T+1}] + [TFF_{T+1} - TFF_T]$ corresponds to Equation (8) of Kuttner (2001), which was also tested on three-month Treasury bills rate.

Since the rate on non collateralised overnight interbank loans (Fed funds) is risky, while loans to the Federal Government (Treasury bills) are risk-free, the difference between FF and TB rates (Dif) is positive. Thus, Dif measures the default risk minus maturity risk premiums. Suppose further that there is no expected significant change in the structure of the US banking industry (i.e. the risk associated with interbank loans is constant) and/or in the credibility of the US government to pay its debt. Under these assumptions, there is no reason to believe that Dif deviates from its equilibrium value (its trend) unless Fed actions, and/or other exogenous shocks, change one or both of these rates in a different proportion. In fact, one can consider Dif as a measure of the stance of monetary policy. For example, Simon (1990) provided evidence that the TB-FF spread has a predictive power for the future changes in FF. Furthermore, Bernanke and Blinder (1992) showed the funds rate or the spread between the funds rate and some other interest rates to be a good indicator of the Federal Reserve's monetary policy stance. Specifically, they provide evidence that short run fluctuations in the Fed funds rate or the spread between the funds rate and some other interest rates are dominated by shifts in the stance of monetary policy. More importantly, they show the Fed funds rate, or its spread from some other interest rates, is not affected by current (within-month in their monthly observations) developments in the economy.

In general, one would expect at equilibrium to have $\text{Dif}_t = \text{FF}_t - \text{TB}_t =$ risk premium - maturity risk premium = Tdif_t, provided 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. Tdif_t is the trend value or the equilibrium level of Dif.[11] Define Dif under opacity as Odif, then using (3) and (5) we will have: $\text{Odif}_t = \text{FF}_{t-1} + \alpha(\text{OER}_t - \text{ER}_{t-1}) + \alpha\tau_t - \text{TB}_{t-1} - \gamma_1(\text{FF}_t - \text{TFF}_T) - \gamma_2\{[E(\text{TFF}_{T+1} \,|\, \text{FF}_t) - \text{TFF}_{T+1}] + [\text{TFF}_{T+1} - \text{TFF}_T]\}$. Since FF and FFT are bivariate normal variables we will have:

$$E(\text{TFF}_{T+1} \,|\, \text{FF}_t) = E(\text{TFF}_{T+1}) + \frac{\text{Cov}(\text{TFF}_{T+1}, \text{FF}_t)}{\text{Var}(\text{FF}_t)} \, [\text{FF}_t - E(\text{FF}_t)]^{12} =$$

$$\overline{\text{TFF}} + \frac{\text{Cov}(\text{TFF}_{T+1}, \text{FF}_t)}{\text{Var}(\text{FF}_t)} \; \alpha\tau_t = \overline{\text{TFF}} + \frac{\sigma_{T+1}^2}{\sigma_{T+1}^2 + \sigma_\tau^2} \; \alpha\tau_t.$$

Consequently, Dif under opacity will be:

$$\text{Odif}_t = \text{FF}_{t-1} + \alpha(\text{OER}_t - \text{ER}_{t-1}) + \alpha\tau_t - \text{TB}_{t-1} - \gamma_1(\text{FF}_t - \text{TFF}_T)$$

$$- \gamma_2\{[\,\overline{\text{TFF}} + \frac{\sigma_{T+1}^2}{\sigma_{T+1}^2 + \sigma_\tau^2} \; \alpha\tau_t - \text{TFF}_{T+1}] + [\text{TFF}_{T+1} - \text{TFF}_T]\}. \tag{6}$$

Suppose full monetary policy transparency exists, i.e. there is no asymmetric information between monetary policy makers and market participants. In this case τ and TFF_{T+1} are known by the public. Hence we will have:

$$\begin{aligned}\text{Dif}_t = \text{Tdif}_t = \text{FF}_{t-1} + \alpha(\text{OER}_t - \text{ER}_{t-1}) + \\ \alpha\tau_t - \text{TB}_{t-1} - \gamma_1(\text{FF}_t - \text{TFF}_T) - \gamma_2[\text{TFF}_{T+1} - \text{TFF}_T].^{13}\end{aligned} \tag{7}$$

The deviation between Dif under opacity and full transparency (D) will be:

$$D_t = \text{Odif}_t - \text{Tdif}_t = \gamma_2 \{[\,\overline{\text{TFF}} + \frac{\sigma_{T+1}^2}{\sigma_{T+1}^2 + \sigma_\tau^2} \; (\alpha\tau_t) - \text{TFF}_{T+1}]\}. \tag{8}$$

According to Equation (8), the higher is τ_t (the higher is the shock to the economy which is not known by the public, but is known by the Fed) the more Dif deviates from its equilibrium value, implying that market participants demand a higher default risk premium. Furthermore, the more uncertain the public is about the future target rate (i.e. the higher is σ_{T+1}^2) the higher will be the deviation between the actual and the equilibrium value of Dif. This deviation will be higher, on average, in a high interest rate environment (high $\overline{\text{TFF}}$).

Figure 1: Monetary Policy Transparency

$$Dif_t = FF_t - TB_t$$
$$D_t = Dif_t - Tdif_t$$
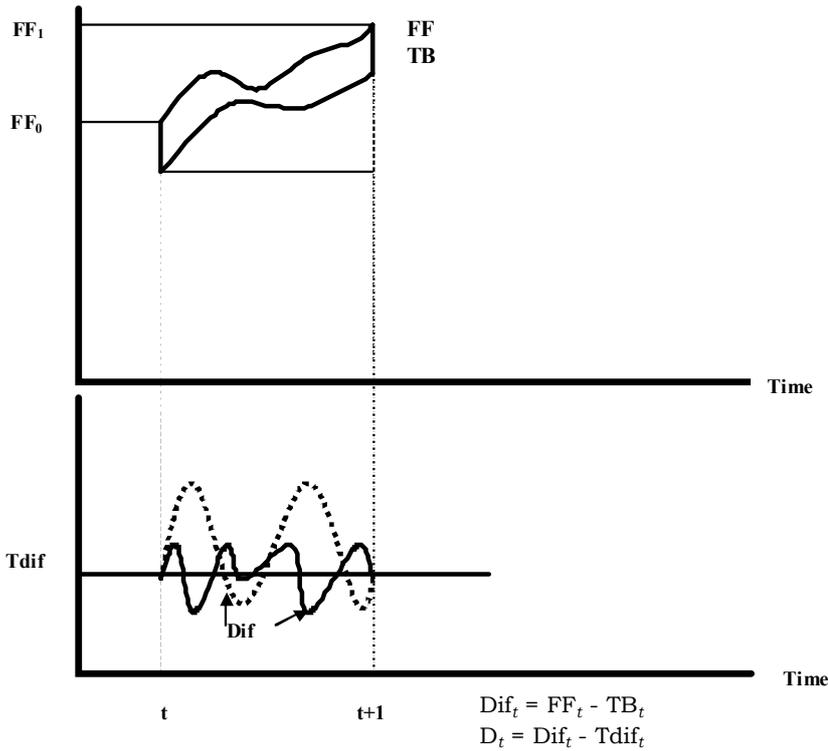
Let us consider Figure 1. The upper panel shows the movements of the FF and TB rates. The lower panel shows the movements of Dif around its trend or equilibrium level. Suppose 100 per cent monetary policy transparency exists, i.e. the Fed conveys fully its private information on monetary policy decisions to the market (i.e. τ is also known by the public). Let us start from equilibrium, i.e. $Dif_t = Tdif_t$, and assume at time t the Fed conducts a 'discretionary' monetary policy. For example, it 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 $t+1$, which is the target-change day or the day of the FOMC meeting.[14] There will be a drain in reserves. Banks compete for interbank funds and the Federal funds rate will go up (Equation (1)). This will lead to an increase in the Federal funds-Treasury bill rates differential, Dif_t. Banks will also sell their Treasury bills or other liquid assets to obtain the required liquidity, thus exerting a further downward pressure on Treasury bill prices, a higher TB through Equation (4). These speculative/arbitrage activities will continue until the interbank and money markets are again in equilibrium. At such a time, we would expect, when full transparency exists, Dif_{t+1} and Tdif to almost coincide.

The Fed's action and the subsequent market reaction will continue until the next target-change day or FOMC meeting, when the Fed's desired target rate (FF_1) is announced officially. According to this analysis one would expect, under full monetary policy transparency, deviations of Dif from its average/trend (or equilibrium) to be temporary. The solid curve in the lower panel of Figure 1 depicts such movements. If we assume there is a lack of monetary policy transparency (less than 100 per cent or vague public knowledge of τ), then deviations of Dif from Tdif last longer and may not be temporary (see the broken curve in the panel). The reason is that the forward-looking market participants (i.e. when expectations are formed rationally) could easily be confused by the action of the Fed and may overreact/underreact in the intended or the opposite direction to the authorities wish the market to go, see Equation (6). This may create difficulty for the central bankers, resulting in more activities by the Fed to correct the situation.

For example, given our assumption that market participants are forward looking and so their behaviours are not policy invariant (γ_1 and γ_2 are not invariant to policy change), an outright sale of Treasury bills by the Fed may be considered an interest rate smoothing action by the market and may lead the participants to purchase Treasury bills in order to sell them at a higher price when the Fed starts buying them back; thus resulting in widening the deviations of Dif from Tdif, and deviations of Dif from Tdif last longer, through changes in γ_1 and γ_2 in Equation (6). Consequently, any $|D_t|$ — where $D_t = \text{Dif}_t - \text{Tdif}_t$ — is an indication of monetary policy transparency: a small $|D_t|$ means a high transparency and vice versa.

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

Let us now assume the Fed is following an 'interest-rate smoothing' policy (see Kia, 2010, Equation (8)). Starting from full monetary policy transparency (i.e. τ is known by the public) and equilibrium, suppose market participants, through signals from the Fed and/or economic shocks which caused movements in the equilibrium interest rate, expect a positive change in the target rate. An expected increase in the target rate (TFF_{T+1}) at the next FOMC meeting leads to an expected potential speculative loss in keeping Treasury bills (Equation (4)). Profit maximisation leads arbitrageurs/speculators 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 tends to

reduce FF and increase TB. To moderate the fall in very short term rates as well as FF, the Fed sells bills to put an upward pressure on FF. Arbitrage and speculative activities as well as the Fed reactions continue until the interbank and money markets are again in equilibrium.

As before one would expect D, under full monetary policy transparency, to approach zero at equilibrium when the potential for arbitrage/speculative profits is eliminated. In this case, the magnitude of D, in absolute value, is small and short-lived as Dif represented by the solid curve shows in Figure 1. Clearly, when monetary policy transparency is low, as the movements of Dif represented by the broken curve indicate, D is high in absolute value and is long-lived. Note that again, even while monetary policy transparency from the central bank point of view may remain constant, the market perception of a monetary policy action may change when such an action is conducted.

Let us consider another case of 100 per cent monetary transparency. Suppose the Fed changes the target rate and hints that this rate will soon be changed (increased) again, say, within the next three months. Let us start from equilibrium, where D=0. To avoid the capital loss resulting from the increase, holders of three-month Treasury bills sell their bills and invest in shorter-term assets or in the overnight market. This leads to an increase in TB and a fall in FF, i.e. Dif falls and $|D_t|$ will increase. To moderate the fall in FF and make its intention clear, the Fed exerts an upward pressure on non borrowed reserves, for example, by an outright sale of Treasury bills. Given the fact that TB is high, instead of selling bills banks compete for interbank funds and exert an extra upward pressure on FF. Market actions and Fed reactions continue until equilibrium is again achieved (D=0). Specifically, there are enough speculative and arbitrage activities by the forward-looking market participants to make deviations of Dif from Tdif short lived along the solid line in the lower panel of Figure 1 so that at the time of the target rate announcement $|D_t|$=0 or is very close to zero (i.e. an indication of 100 per cent or very close to 100 per cent transparency). Thus, when FF and TB are cointegrated and market participants are forward looking (expectations are formed rationally), $|D_t|$ can capture a market-based monetary policy transparency, provided uncertainty does not exist.

In sum, so far, based on conditions (assumptions) the validity of which have been verified in the literature, we have established a theoretical justification behind our index. Such an index is dynamic and includes expected policy actions. As it was mentioned earlier, Dif measures the default risk premium minus maturity risk premium. There is no theoretical reason or empirical evidence, to the best knowledge of the author, to believe these premiums deviate on average from their equilibrium values (trends) when the structure of the interbank market or the credibility of the US government in servicing the outstanding debt, or expected future debt, remains constant. This is especially true at high frequency observations. It is, however, possible that the credibility of a bank or some banks in the interbank market may change. But FF is

the weighted average of the interbank rates, which should not be changed, since one or some banks pay more on their interbank loans while other banks pay less. An overall banking crisis, if it exists in the sample, should, of course, be dummied out.

In general, under a forward-looking assumption, the deviations of Dif from its equilibrium level should be short-lived if there is an absence of asymmetric information between monetary policy makers and other economic agents. This is because such deviations lead to potential arbitrage or speculative profits/losses. Such potential profits/losses result in arbitrage and/or speculative activities until the deviation of Dif from its equilibrium value is eliminated. Thus we can establish the following:

> Proposition: *Because FF and TB are cointegrated and money market participants are forward looking, the life of deviations of Dif from its equilibrium value depends on the degree of monetary policy transparency, provided there is no uncertainty. The deviations are short-lived if monetary policy is highly transparent, and vice versa.*

It should be mentioned that one may argue that Dif may deviate from its trend not only because of speculative and arbitrage activities of market participants based on their expectations (understanding) of future Fed actions, but also based on additional factors, such as the mobility of capital. Let us investigate whether the deviation of Dif from its trend can be a function of the mobility of capital at high frequency data, even for a large country like the United States. Before such a scenario can be investigated, it should be noted that the mobility of capital, as well as any other internal or external shocks aside from the expectations on Fed activities, do influence FF and TB in the same proportion, especially at high frequency observations, provided the structure of the interbank market remains the same. To provide empirical evidence for this argument, we investigate the Granger causality between the change in the log of the US exchange rate (ge) and the gap between Dif and its forty-day (to capture two months) moving average (gap). This test is based on the assumption that the exchange rate (Japanese Yen per US dollar) movements at high frequency data capture the mobility of capital.

The Wald test (adjusted for heteroscedasticity and autocorrelation) result (Chi Squared(1)=1.38 with significance level 0.24) strongly rejects the null hypothesis that 'ge' Granger causes 'gap'. This result is consistent with the finding of Bernanke and Blinder (1992), who provided empirical evidence that the Fed funds rate, or its spread from some other interest rate (including three-month Treasury bill rate), is independent of current developments in the economy. Consequently, we conclude that Dif deviates from its equilibrium level only because of speculative and arbitrage activities of the market participants, based on their expectations (understanding) on future Fed actions.

4. A MONETARY-MARKET MEASURE OF THE TRANSPARENCY OF FED POLICYMAKING

A. Basic Index

The index will be constructed in three steps:

(1) Let us identify 'event days' as the days on which the Federal funds target rate was changed, whether at a scheduled FOMC meeting or outside the meetings; 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, the second day of the meeting was chosen as the event day.

   The first event date in the sample is October 5, 1982, the first meeting of the FOMC during the period of study. On this date, the FOMC adopted a target for the Federal funds rate of 10 per cent. The second event date is October 8, 1982, when the FOMC changed the target (to 9.5 per cent) outside a regularly scheduled meeting. The last event date is September 21, 2010, the last meeting of the FOMC within our sample period. On this occasion, the Fed left the target rate unchanged.

(2) For each event day, we calculate $|Dt| = |Dif_t - Tdif_t|$, where $Tdif_t$ 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.[15] For example, for the event day of October 8, 1982, $Tdif^t$, as the arithmetic average of Dif_t for t = 5-Oct-82, 6-Oct-82, 7-Oct-82, is $Tdif_t$ = (2.13 + 1.40 + 2.06)/3 = 1.863333, while $|D_t| = |Dif_t - Tdif_t| = |1.88 - 1.863333| = 0.016667$.

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

$$T_t = \text{transparency index} = \frac{100}{e^{|D_t|}} \,. \tag{9}$$

If $|D| = 0$ per cent, we will have T = 100 per cent, the highest transparency degree; and for $|D| = 10$ per cent we will have T = 0.0045 per cent, which may be considered zero transparency for the case of the United States. Consequently, our calculated index for the first event day in the sample period (October 8, 1982) is $100/e^{|0.016667|}$ = 98.347. In sum, when the Treasury bill market is not efficient in a strong form, forward-looking market participants can perceive completely the target rate, only for 100 per cent transparency, so that $e^{|D|} = 1$. Since the basic index, T, has irregular intervals, using the average of the index in each quarter, a quarterly sample out of the observations was constructed. However, in order to demonstrate more clearly the movement of the index, Figure 2 depicts the annual average of the index.

Figure 2: Transparency Index

Basic Index
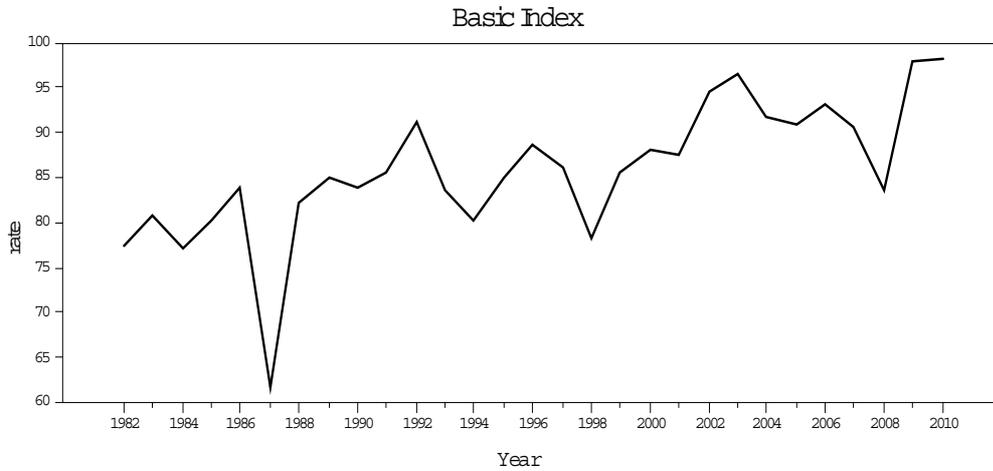
Recall that the index was constructed based on the assumption of no uncertainty in the sense of Knight (1921), thus it is biased during the October 1987 stock market crisis, the high volatility of the Fed funds rate on December 30 and 31 1985, and before the start of Chairman Greenspan's tenure in 1987; as well as during the Russian debt crisis which led to the near-collapse of Long-Term Capital Management in 1998 and caused credit markets to freeze and resulted in the intervention of the Fed. The index might also be biased by the uncertainty created by the September 2001 crisis and the US financial crisis which started in the third quarter of 2007.[16] As Figure 2 shows we can see a drastic fall in the index in these periods.

To provide empirical support, we estimate the index on a constant and dummy variables which reflect those periods of uncertainty. Equation (10) reports the estimation result, where OCT87=1 for the 1987Q4 and zero, otherwise, Dec85=1 for 1985Q4 and zero, otherwise, BGreen=1 for 1987Q1-1987Q3 and zero, otherwise and USCrisis=1 for 2007Q3-2008Q3 and zero, otherwise.[17] The figures in brackets are standard errors adjusted for autocorrelation and heteroscedasticity. As we can see the coefficients of all dummy variables are negative and statistically significant.

Index = 87.60 - 41.28 OCT87 - 17.33 Dec85 - 31.43 BGreen - 16.20 Sep11
SE   (0.95)   (0.95)   (0.95)   (4.68)   (0.95)

-10.75 Russian - 6.58 USCrisis
(1.31)   (2.67)

(10)

$\overline{R}^2$ = 0.33, σ = 8.44

Table 1: Policy Regime Changes and Monetary Transparency
Standard Errors Adjusted for Heteroscedasticity and Autocorrelation in Brackets

Period	Quarterly index	Daily index
Oct. 1982- Aug. 1987	77.74 (2.64)	80.84 (1.14)
Change in the Index:		
Aug. 1987-Jan. 2006: Greenspan period*	8.65 (2.43)	3.62 (1.66)
Oct. 1982-Oct. 1989	78.19 (2.12)	81.81 (0.86)
Change in the Index:		
Oct. 1989-Sept. 2010: 25 and 50 bp period**	10.33 (2.35)	7.24 (0.97)
Oct. 1982-March 1993	80.81 (1.78)	82.64 (0.69)
Change in the Index:		
March 1993- Sept. 2010: Releasing minutes & transcripts and announcing Target Change period***	8.19 (2.10)	7.31 (0.83)
Oct. 1982-Aug. 1997	82.10 (1.46)	83.79 (0.54)
Change in the Index:		
Aug. 1997- Sept. 2010: Target & NY period****	8.09 (1.88)	7.33 (0.76)
Oct. 1982-May 1999	82.24 (1.34)	84.10 (0.50)
Change in the Index:		
May 1999- Sept. 2010: Explanation period*****	9.00 (1.80)	7.69 (0.76)
Oct. 1982-Feb. 2000	82.22 (1.28)	84.24 (0.48)
Change in the Index:		
Feb. 2000- Sept. 2010: Balance of Risk period******	9.68 (1.70)	7.83 (0.76)
Oct. 1982-March 2002	82.80 (1.21)	84.81 (0.46)
Change in the Index:		
March 2002- Sept. 2010: Vote & Names period*******	10.01 (1.65)	7.91 (0.82)
Oct. 1982-Dec. 2005	84.63 (1.17)	86.32 (0.43)
Jan. 2006-Sept. 2010: Bernanke Period	7.71 (2.23)	5.47 (1.24)

*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.
*** On March 23, 1993, the Fed began releasing the minutes of the FOMC meetings and, on November 16, 1993, the Fed began releasing the transcripts of the FOMC meetings. Beginning on February 4, 1994, the Fed started announcing policy decisions at the conclusion of FOMC meetings and, on August 16, 1994, it began describing the state of the economy and further rationale for the policy action after FOMC decisions. Since these policy regime changes took place within a very short period of each other, we investigate the power of the index on these changes together.
****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 view regarding prospective developments (or the policy bias).
****** On January 19, 2000, the FOMC issued a press statement explaining that it would include a balance-of-risks sentence in its 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 name of dissenter members (if any).

It should again be noted that the index developed in this paper is market based. It therefore 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. Specifically, the public availability of data does not suffice to achieve transparency. What is important is how agents interpret or process the data to extract useful information. In other words, a market-based measure of monetary transparency depends on the understanding of the data. Namely, market participants may observe a different norm/direction in the policy during the day or within a month or a period than that which the central bank actually follows. Furthermore, even though monetary authorities believe they have been as transparent as before, the index developed in this paper reflects changes in what market participants understand from policy regime changes. Consequently, a market-based transparency index may fluctuate as policy regime changes or when there are exogenous shocks to the system when agents are forward looking. This can be seen clearly in our index (Figure 2).

As explained in Section 2, during the 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, March 23, 1993, November 16, 1993, February 4, 1994, August 16, 1994, August 19, 1997, May 18, 1999, February 2, 2000 and, March 19, 2002. We use the index developed in this paper to determine whether the above transparency-oriented changes at the Fed have indeed increased the market's understanding of the Fed policy changes.

Table 1 reports the means with their standard errors (adjusted for autocorrelation and heteroscedasticity) of the index before and after each policy regime change. All 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, implying that it reflects fully a transparency index. Note that since policy regime changes in 1993 and 1994 took place (see above) within a very short period of each other, we investigated the power of the index on these changes together (see rows 6 and 7 of Table 1). The result of the individual impact of these policy regime changes (available upon request) also indicates an improvement in the index.

B. Extension of the index

The basic index developed in this paper, being a variable with unequal intervals, 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 the basic index as follows. For event days, the index is defined as before (Equation (9)). For all other days, we compute an estimated or forecast value of D_t, called $\hat{D}_t$, where $\hat{D}_t = |\text{Dif}_t - \text{Adif}_t|$, Dif_t, as before,= $FF_t - TB_t$ and

$\text{Adif}_t = \dfrac{\sum\limits_{i=1}^{j} \text{Dif}_{t-i}}{n}$ 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 $\hat{T}_t$:

$$\hat{T}_t = 100/e^{|\hat{D}_t|} . \qquad (11)$$

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.[18] To clarify further how the index is constructed on non-event days, consider 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 $\text{Adif}_t = \dfrac{\sum\limits_{i=1}^{j} \text{Dif}_{t-i}}{n}$ = (2.13+1.40)/2 = 1.765. We then compute

$\hat{D}_t = |\text{Dif}_t - \text{Adif}_t| = |2.06-1.765|$ = 0.295, and $\hat{T}_t = 100/e^{0.295}$= 74.453159. Figure 3 depicts the annual average of the 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 87.23 per cent (SD=13.42 per cent)[19] while the average of the basic index in the sample period is 84.98 per cent (SD=14.93 per cent).

Figure 3: Extended Transparency Index

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As Figure 3 shows, the extended index is smoother than the basic index as it contains more information. However, these two indices show almost the same movements during the sample period. We can also show that during the periods of uncertainty in our sample the index was downward biased. As before, we estimate the extended index on dummy variables which reflect these periods of uncertainty in the sample period. We find the index fell during these periods. For the sake of brevity the estimated result is not reported, but is available upon request. We again investigate, using our daily observations and extended index, whether the regime changes of August 11, 1987, October 19, 1989, March 23, 1993, November 16, 1993, February 4, 1994, August 16, 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).[20] Table 1 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 indicate, all means and their changes are positive and statistically significant, confirming the earlier findings that these policy regime changes resulted in 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. It should be emphasised again that, as both developed indexes reflect, the view of the market, based on the actions of the central bank, could rapidly change if agents are forward looking. Both indexes are based on two important assumptions: FF and TB are cointegrated and market participants are forward looking, i.e. expectations are formed rationally and the behaviours of participants in the overnight money market in the United States are not policy invariant.

5. SUMMARY AND CONCLUSIONS

The existing measures of monetary policy transparency include indicators based on descriptive accounts, surveys, official documents and information, and market interest rates. However, these measures have limitations, such as a lack of an objectively designed index or indexes without time-series properties. In this paper, we have 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.

Assuming that participants in the money market are forward looking, we developed an index for United States monetary policy for the period October 1982-September 2010. Using the constructed index, it was found that monetary policy transparency in the United States went up during the period of the Greenspan and Bernanke chairmanships. Furthermore, according to the index, the following policy regime changes have increased the monetary

policy transparency in the United States: the practice of increasing/decreasing the Fed funds target rate in multiples of 25 and 50 basis points, releasing the minutes and the transcripts of the FOMC meetings, announcing policy decisions at the conclusion of FOMC meetings, describing the state of the economy and further rationale for the policy action after FOMC decisions, including a quantitative Fed funds rate in its Directive to the NY Fed Trading desk, extending its explanations regarding policy decisions, starting to include in press statements an indication of the FOMC view regarding prospective developments (or the policy bias), issuing a press statement explaining that it would include a balance-of-risks sentence in its statements, replacing the previous bias statement and including in FOMC statements the vote on the directive and the name of dissenter members (if any). This result confirms indirectly findings of some previous studies, especially the recent work of Biefang-Frisancho Mariscal and Howells (2010).

One possible extension of this study is to modify the index for markets where market participants are not forward looking. Moreover, future studies should use the index developed in this paper to investigate if a more transparent monetary policy leads to higher economic growth and lower risk as well as volatility in the United States. Furthermore, 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, one could also 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.

ENDNOTES

2. For example, see Demertzis and Hallett (2007) and Dai and Sidiropoulos (2008).

3. For example, Demertzis and Hallett (2007) used the index constructed by Eijffinger and Geraats (2006) for nine countries, to investigate the impact of transparency, both political and economic, on inflation and output gap. This study is confined to nine cross-sectional observations.

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

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

6. According to Poole and Rasche (2003), this practice started in August 1989; however, I 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 realise that the FOMC had enacted this practice. Also note that according to Rudebusch (1995), the target change occurred on October 18, 1989, not the 19th. Since the Secretariat's series are used we assume the change started on the 19th.

7. Federal Reserve Board, 'Modifications to the FOMC's Disclosure Procedures', January 19, 2000. For better understanding of the changes in disclosures practice and institutional settings at the Fed between 1994 and March 2006, see Biefang-Frisancho Mariscal and Howells (2010).

8. It should also be noted that Chairman Greenspan delivered a speech in October 2001 highlighting FOMC moves towards greater transparency. For a review of these changes, see Poole and Rasche (2003) and Swanson (2006).

9. Note that FF and TB may deviate from each other for a few hours during the course of a day (or over a few days), but market forces and/or intraday (interday) monetary policy can bring them back together by the close of the markets (or by the end of the maintenance period) if these rates are cointegrated.

10. Since the sample period in this paper is longer than the period used in Kia (2010), we re-estimated the cointegration and superexogeniety tests used in Kia's study. Our estimation results (not reported, but available upon request) confirm the cointegration relationship between TB and FF and the fact that market participants are forward looking in the money markets in the US (Kia's, 2010, conclusion).

11. When both Treasury bills and Fed funds markets are in equilibrium, both TB and FF are equilibrium rates and, therefore, their difference (Tdif) will be an equilibrium value.

12. See, e.g. Geraats (2002).

13. One may argue that Treasury bills are not taxed by state and local governments and, therefore, Dif_t also includes a tax premium (FF_t), where   is the tax rate. However, in this case $Tdif_t$ also includes this premium and at equilibrium, when there is no potential for speculative or arbitrage profit, these two premia should be equal so that again $Dif_t = Tdif_t$.

14. Note that a 'discretionary' conduct of policy means that the central bank is free at any time to alter its instrument setting instead of complying with a rule. In an 'interest-rate smoothing' regime the central bank follows a 'rule-based' policy. However, the discretionary conduct of policy also includes interest-rate smoothing, as the central bank is free to react at any time to the movements of the market (see e.g. Kia, 2010).

15. Although it would be more intuitive to calculate Tdif as the daily geometric average (as opposed to the arithmetic average), about 10 per cent of the time Dif is a negative value and often the number of days between event days is an even number. Furthermore, consistent approximations of the geometric average are not possible for all dates in the sample. To make the measure consistent across all observations we use

simple arithmetic averages. Another potential problem with geometric averages occurs when the differential is zero or close to zero, since in such a case the geometric mean drives the trend artificially to zero.

16. It should be noted while after September 11, 2001 market participants knew the Fed would ease policy, a great deal of uncertainty existed over the magnitude of the expansion as well as its impact on the economy. This is also true for the recent US financial crisis, when for at least one year market participants were uncertain as to the impact of the stimulus, Fed quantitative easing and the new government's reaction to the crisis.

17. According to both Dickey Fuller and Phillips Perron tests, our basic index T is stationary. The absolute value of the augmented Dickey Fuller t was estimated to be 7.68 (more than 3.46 (one per cent critical value)) and the absolute value of the Phillips-Perron non parametric t for the lag length of 4 was estimated to be 8.16 (more than 3.489 (one per cent critical value)).

18. It should be mentioned that there are several important characteristics of the Federal funds market (e.g. the last day of the reserve maintenance period, the last day of quarters, years and months, etc.) that lead to predictable movements in the funds rate without any impact on the three-month Treasury bill rate. The daily index, consequently, can be affected, mostly, negatively by these characteristics.

19. Note that there are known days in the sample that FF had a very high volatility while TB remained within its pace. These high-volatile-Fed-fund-rate days include: December 30, 1982 (TB=8.02 per cent, FF=10.75 per cent), December 31, 1985 (when TB=7.05 per cent and FF=13.46 per cent), December 29, 1986 (TB=5.67 per cent, FF=8.38 per cent), December 30, 1986 (TB=5.69 per cent, FF=16.17 per cent), December 31, 1986 (TB=5.67 per cent, FF=16.17 per cent), December 26, 1990 (TB=6.48 per cent, FF=8.86 per cent), January 23, 1991 (TB=6.14 per cent, FF=10.39 per cent) and July 1, 1996 (TB=5.08 per cent, FF=7.80 per cent). On these days the extended index was very low because of uncertainty in the market.

20. According to both Dickey Fuller and Phillips Perron tests, our extended index $\hat{T}$ is stationary. The absolute value of the augmented Dickey Fuller t was estimated to be 9.34 (more than 3.43 (one per cent critical value)) and the absolute value of the Phillips-Perron non parametric t for the lag length of 4 (where, for a global lag of 20 days, the AIC and SC criteria are at their minimum) was estimated to be 44.40 (more than 3.43 (one per cent critical value)).

REFERENCES

Bernanke B S and Blinder A S (1992) 'The Federal Funds and the Channels of Monetary Transmission', *American Economic Review*, 82, 901-921.

Bernanke B S and Boivin J (2003) 'Monetary Policy in a Data-rich Environment', *Journal of Monetary Economics*, 50, 525-546.

Biefang-Frisancho Mariscal I and Howells P (2007) 'Monetary Policy Transparency in the UK: The Impact of Independence and Inflation Targeting', *International Review of Applied Economics,* 21, 603-617.

Biefang-Frisancho Mariscal I and Howells P (2010) 'Central Bank Communication, Transparency and Interest Rate Volatility: Evidence from the US' in Fontana G, McMombie J and Sawyer M (eds) *Macroeconomics, Finance and Money, Essays in Honour of Philip Arestis*, New York: Palgrave Macmillan.

Blinder A, Goodhart C, Hildebrand P, Lipton D and Wyplosz C (2001) *How do central banks talk?*, Geneva: International Center for Monetary and Banking Studies.

Blinder A S, Ehrmann M, Fratzscher M, De Hann J and Jansen D (2008) 'Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence', *Journal of Economic Literature*, 46, 910-945.

Chadha J S and Nolan C (2001) 'Inflation Targeting, Transparency and Interest Rate Volatility: Ditching "Monetary Mystique" in the U.K.', *Journal of Macroeconomics*, 23, 349-366.

Cochrane J H. and Piazzesi M (2002) 'The Fed and Interest Rates: A High Frequency Identification', *American Economic Review Papers and Proceedings,* 92, 90-101.

Cruijsen C A B, Eijffinger S C W and Hoogduin L H (2010) 'Optimal Central Bank Transparency', *Journal of International Money and Finance*, 29, 1482-1507.

Dai M and Sidiropoulos M (2008) 'Central bank's conservatives and transparency', *Research in Economics*, 62, 179-187.

de Haan J and Amtenbrink F (2002) 'A non-transparent European Central Bank? Who is to blame?' Paper given at the conference on Monetary Policy Transparency, Bank of England, May 10.

Demertzis M and Hallett A H (2007) 'Central Bank transparency in theory and practice', *Journal of Macroeconomics*, 29, 760-789.

Demiralp S and Jorda O (2004) 'The response of Term Rates to Fed Announcements', *Journal of Money, Credit, and Banking*, 36, 387-405.

Eijffinger S C W and Geraats P M (2006) 'How transparent are central banks?', *European Journal of Political Economy*, 22, 1-21.

Fry M D, Julius L, Roger M S and Sterne G (2000) 'Key issues in the choice of monetary policy framework', in Mahadeva, L and Sterne, G (eds) *Monetary Policy Frameworks in a Global Context*, London: Routledge.

Geraats P M (2002) 'Central Bank Transparency', *The Economic Journal*, 112, F532-F565.

Geraats P M, Eijiffinger S C W and Cruijisen C A B (2006) 'Does Central Bank Transparency Reduce Interest Rates?' DNB Working Paper, January.

Haldane A. and Read V (2000) 'Monetary policy surprises and the yield curve', Bank of England Working Paper no. 106.

Hsing Y (2007) 'Effects of the Intended and Unintended Federal Funds Rates on the Treasury Yield Curve During the Greenspan Era', *Applied Financial Economics Letters*, 3, 155-159.

Kia A (2010) 'Overnight Monetary Policy in the United States: Active or Interest-Rate Smoothing?', *Journal of Macroeconomics,* 32, 378-391.

Knight F H (1921) *Risk, Uncertainty, and Profit.* Boston: Hart, Schaffner and Marx, Houghton Mifflin Company.

Kotomin V and Winters D B (2007) 'The Impact of the Return to Lagged Reserve Requirements on the Federal Funds Market', *Journal of Economics & Business*, 59, 111-129.

Kuttner K N (2001) 'Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Future Market', *Journal of Monetary Economics*, 3, 523-544.

Lasaosa A (2005) 'Learning the Rules of the New Game? Comparing the Reactions in Financial Markets to Announcements Before and After the Bank of England's Operational Independence', Bank of England Working Paper no. 255.

Lucas Jr R E (1976) 'Econometric Policy Evaluation: A Critique' in Brunner K and Meltzer A H (eds) *The Phillips Curve and Labor Markets*, Amsterdam: North-Holland.

Poole W, Rasche R H and Thornton D L (2002) 'Market Anticipations of Monetary Policy Actions', *Federal Reserve Bank of St. Louis Review*, July-August, 65-94.

Poole W and Rasche R H (2003) 'The Impact of Changes in FOMC Disclosure Practices on the Transparency of Monetary Policy: Are Markets and the FOMC Better "Synched"?', *Federal Reserve Bank of St. Louis Review*, January-February, 1-10.

Robertson J C and Thornton D (1997) 'Using Federal Funds Futures Rates to Predict Federal Reserve Actions', *Federal Reserve Bank of St. Louis Review*, November/December, 45-53.

Rudebusch G D (1995) 'Federal Reserve Interest Rate Targeting, Rational Expectations, and the Term Structure', *Journal of Monetary Economics*, 24, 245-274.

Sarno L and Thornton D (2003) 'The Dynamic Relationship Between the Federal Funds Rate and the Treasury Bill Rate: An Empirical Investigation', *Journal of Banking and Finance*, 27, 1079-1110.

Saunders A and Millon Cournett M (2008) *Financial Institutions Management, A Risk Management Approach,* 6th ed., New York: McGraw-Hill Irwin.

Simon D P (1990) 'Expectations and the Treasury bill-Federal Funds rate Spread over Recent Monetary Policy Regimes', *Journal of Finance*, 45, 467-477.

Söderström U (2001) 'Predicting monetary policy using federal funds futures prices', *Journal of Futures Markets,* 21, 377-391.

Stock J H and Watson M W (2002) 'Macroeconomic Forecasting Using Diffusion Indexes', *Journal of Business & Economic Statistics*, 20, 147-162.

Sundararajan V, Das U S and Yossifov P (2003) 'Cross-Country and Cross-Sector Analysis of Transparency of Monetary and Financial Policies', IMF Working Paper no. WP/03/94.

Swanson E T (2006) 'Have Increases in Federal Reserve Transparency Improved Private Sector Interest Rate Forecasts', *Journal of Money, Credit, and Banking*, 38, 791-819.

Thornton D (2004) 'The Fed and Short-Term Rates: Is it Open Market Operations, Open Mouth Operations or Interest Rate Smoothing?', *Journal of Banking and Finance*, 28, 475-498.

Thornton D (2009) 'Negating the Inflation Potential of the Fed's Lending Programs', *Economic Synopses*, Federal Reserve Bank of St. Louis, Working Paper no. 30.