Does more complex language in FOMC decisions impact financial markets?

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Abstract:

This paper is built around a simple premise that is based on the theoretical models of Harris and Raviv (1993) and Kandel and Pearson (1995). Complex statements are more difficult to interpret and may be construed in different ways by different agents. This creates heterogeneity of beliefs among market participants that manifests in increased market activity. We confirm existing results that show monetary policy surprises have a significant impact on financial markets. Importantly, we demonstrate that linguistic complexity (measured in terms of readability and number of words) of FOMC statements that accompany monetary policy decisions significantly increases the trading volume, and volatility of returns, in stock, bond, and currency markets. We also establish that financial markets are more responsive to monetary policy decisions (and the language of those statements) during recession.

Keywords: Monetary policy decisions, Financial Markets, Federal Reserve, Linguistic complexity, FOMC statements

JEL Codes: G1, G10, G12, G14

"I guess I should warn you, if I turn out to be particularly clear, you've probably misunderstood what I've said."

Alan Greenspan, Chairman of the Federal Reserve, 1987

1. Introduction

Central bankers place great significance on the response of financial markets to monetary policy decisions. They recognise that asset prices are an important conduit of monetary policy that can be used to influence real economic activity. Asset prices affect the cost of capital for firms, as well as their capacity to raise new capital and invest, and this is in addition to the wealth effect on consumption. The financial market response provides policymakers with information as to whether their decisions are anticipated by market participants, and how investors adjust their views in reaction to a given decision. The transcripts of Federal Open Market Committee (FOMC)

meetings reveal that officials are concerned about the impact of policy actions on financial markets and the subsequent effect on consumption and investment.

Over time, central banks have placed a greater importance on the transparency and predictability of monetary policy activities. Communication has played a significant role in the process of conducting monetary policy, particularly with regards achievement of the mandated objectives. Communication is vital for transparency purposes and this helps to foster credibility and improve the predictability of the course of future monetary policy. The FOMC statements that accompany monetary policy decisions are known to significantly impact financial markets. These effects arise not only because the statements provide information about near-term Fed policy but also because the statements convey information about the outlook for the economy. As a result of efforts to increase transparency, and engagement in unconventional monetary policy, the linguistic complexity of FOMC statements has changed over time; the statements have become longer and more difficult to comprehend.

The principal aim of this paper is to examine whether the change in language of monetary policy statements affects the market response to monetary policy decisions. We contend that as the information provided by the FOMC becomes lengthier, and more complex, in nature there is an increased opportunity for investors to interpret this information in different ways. This divergence in opinions regarding public information results in increased market activity that is realised via greater volatility and heightened trading volume. This hypothesis is consistent with the theoretical models of Harris and Raviv (1993), Kim and Verrechia (1994), Kandel and Pearson (1995), and Li (2005) that explain market activity through the lens of agent heterogeneity (this can arise either because agents have different private information or because they interpret public information differently).

Our empirical results show that the complexity of language in the statements that accompany FOMC decisions has a statistically significant impact on the market response to monetary policy news. We confirm existing results that show monetary policy surprises have a significant influence on financial markets. In addition, we find that linguistic complexity (both readability and length of the statement) significantly increases the trading volume, and volatility of returns, in stock, bond, and currency markets, that results from FOMC decisions. We demonstrate that financial markets are more responsive to monetary policy decisions during specific economic states (recession and zero interest rates).

Our study is important for policymakers who are seeking to understand the policy transmission mechanism via the link between monetary policy and asset prices. This is particularly the case for central bankers who draft policy statements and may wish to avoid the creation of additional uncertainty in financial markets. The results are also relevant to agents who issue market statements, and to those who invest in assets in the period around monetary policy decisions. If agents are more capable of assessing, managing, and hedging the risks around decisions then this may contribute to enhancing welfare.

This paper is relevant to two strands of literature. The first is related to monetary policy predictability and the role of transparency. This literature focuses on estimating the surprise element of monetary policy at the time of policy announcements. Essentially, predictability of monetary policy refers to the ability of financial markets to correctly anticipate monetary policy decisions (Poole and Rasche, 2000; Kuttner, 2001). The importance of predictability is recognized as a key ingredient in the successful and effective conduct of monetary policy (King, 2000; Woodford, 2003; Bernanke, 2004; Blinder and Wyplosz, 2004). Generally, central banks do not deliberately attempt to surprise financial markets. King (2000) suggests that news about monetary policy should arise in macroeconomic news and not in the actions of the central bank.

The second strand relates to the increased transparency of central bank announcements (Geraats, 2002; Wynne, 2013). Transparency is seen as safeguarding the democratic legitimacy of independent central banks, and policymakers are aware that it can impact the predictability and effectiveness of monetary policy. Woodford (2005) argues that monetary policy is an inherently complex process that cannot adequately be described by a precise rule that governs central bank behaviour. The presence of information asymmetry, which reduces predictability and increases uncertainty around monetary policy decisions, makes it more difficult for the central bank to achieve its aims (Bernanke, 2004). The outcome is even worse when market participants are now aware of the economic indicators the central bank uses to assess its policy stance (Haldane and Read, 2000). Rosa and Verga (2005) and Ehrmann and Fratzscher (2007) illustrate that transparent communication alone is not sufficient to reduce all uncertainties surrounding monetary policy; timing and complexity must also be considered.

The remainder of this paper proceeds as follows. In section 2 we outline the related literature. In section 3 we describe our data with a particular emphasis on FOMC policy decisions

and the language of accompanying statements. In section 4 we report our empirical results. Section 5 concludes.

2. Relevant Literature

An extensive literature has developed surrounding the impact of macroeconomic announcements on asset prices. The evidence suggests that surprises have a significant effect on prices in the stock (Ederington and Lee, 1993; Flannery and Protopapdakis, 2002), bond (Jones et al., 1998; de Goeij and Marquering, 2006; Smales, 2013), currency (Andersen et al., 2003; Ehrmann and Fratzscher, 2005), and commodity markets (Chatrath et al., 2012; Smales, 2015) that is asymmetric in the sense that bad news has a greater influence than good news.

Monetary policy decisions form an important subset of macro announcements. The efficient market hypothesis dictates that asset prices should respond only to the surprise component of monetary policy decisions. Bomfim (2003) and Bernanke and Kuttner (2005) confirm this is true for the stock market, while Fatum and Scholnick (2008) and Rosa (2011a) find this holds for exchange rates. Kuttner (2001) suggests the presence of this finding in the bond market is consistent with the expectations hypothesis of the term structure. There is broad consensus that monetary policy surprises impact financial markets. Chen et al. (1999) and Bernanke and Kuttner (2005) report a significant impact on stock market returns, volatility and trading volume. The magnitude of the monetary policy response in stocks is greater for stocks in small firms that are more financially constrained (Ehrmann and Fratzscher, 2004; Basistha and Kurov, 2008; Maio, 2014; Tsai, 2014).

Kurov (2010) notes that monetary policy decisions also has an important influence investor sentiment in stock markets, and they also play a significant role in explaining volatility in European (Andersson, 2010) and Asian (Hausman and Wongswan, 2011) stock markets. Thornton (1998) and Kuttner (2001) find that short- and long-term rates respond to changes in the Fed Funds target. Thornton suggests that the lack of significance in the relationship for long-term rates is related to the Fed's credibility as an inflation fighter. An asymmetric effect is also present in the monetary policy response of asset prices. Bomfim (2003) finds that tighter than expected monetary policy tends to have a larger effect on market volatility than does easier policy. Chulia et al. (2010) suggests that this effect is subtle as the occurrence of a surprise matters most in the case of bad news, while magnitude of news is more important for good news.

The identified relationships are shaped by the economic cycle and financial market conditions. McQueen and Roley (1993) find that the stock market responds to news about prices and real activity during periods of strong economic growth. Andersen et al. (2003) notes that good economic news tends to have a negative effect on the stock market during periods of economic expansion. Monetary policy has a larger effect on market returns in bear markets (Chen, 2007; Kurov, 2010) which Jansen and Thai (2010) suggests is a result of the increased importance of obtaining external finance in economic downturns.

Blinder et al. (2008) note that communication can be an important and powerful tool for a central bank since it has the ability to move financial markets and achieve its objectives. Fawley and Neely (2014) note that since the 1970s the Fed has clarified its objectives and modified its procedures to become more transparent. While increased transparency has helped the Fed fulfil its mandate, as unconventional policies have been adopted in the era post-2007, the statements which accompany Fed monetary policy decisions have also been characterized by greater levels of complexity which could generate uncertainty in financial markets if they are too difficult to comprehend (Jansen, 2011; Wynne, 2013; Hernandez-Murrillo and Shell, 2014).

Rosa (2011b) reports that such statements have great explanatory power for market returns since it provides information on the outlook for future policy in addition to the rationale for policy action. One consequence of the statement containing such information is that monetary policy surprises may be disaggregated into a target surprise and a path surprise factor (Gürkaynak et al. ,2005; Smales, 2012). Hausman and Wongswan (2011) find that equity indexes respond to the target surprise, while exchange rates and bond markets respond mainly to the path surprise.

There is theoretical support to explain why financial markets respond to Fed monetary policy decisions and accompanying explanatory statements. Harris and Raviv (1993) and Kandel and Pearson (1995) propose models of trading behaviour that suggest financial markets respond to public information as a result of difference in interpretation. We hypothesise that information that is longer, and more complex in nature, creates more opportunities for such divergence in opinion to occur.

Kandel and Pearson (1995) develop a model of trade around public announcements that incorporates differential interpretations of public announcements and show that the no-trade theorem of Milgrom and Stokey (1982) does not apply when investors have a difference of

opinion regarding public information. This model only requires investors to interpret signals differently in a single period. In contrast, Harris and Raviv (1993) predict that trading can occur only when investors have a different interpretation about public signals in every period. They assume that traders share common prior beliefs and receive common information but differ in the way in which they interpret this information. They observe that absolute price changes and volume are positively related.

Kim and Verrecchia (1994), Bessembinder et al. (1996), and Sarkar and Schwartz (2009) suggest that the release of public information creates a divergence of opinion that result in larger trading volumes and increased market volatility. If investors struggle to comprehend more complex public pronouncements, then the processed information may be less precise. Li (2005) suggests that this may serve to increase the risk premium and market volatility.

3. Data

We investigate the impact of post-meeting Federal Open Market Committee (FOMC) statements on the returns and trading volume of three important future markets; the S&P 500 Index, the 10-year Note, and the U.S. Dollar Index.

3.1 FOMC Meeting Statements and Policy Surprises

The Federal Funds Target Rate (FFTR) is one of the primary monetary policy tools utilized by the US Federal Reserve. The Federal Open Market Committee (FOMC) holds eight regularly scheduled meetings each year (approximately every 6 weeks) in order to review the economic and financial environment and determine the appropriate monetary policy stance. A statement is issued at approximately 2pm on the day each meeting concludes. The statement details the change (if any) in the FFTR together with an explanation as to decision and a brief summary of the Committee's view on current and future economic conditions.

The information provided by the FOMC regarding the outcome of their meetings has changed over time. Prior to February 1994, the market only became aware of FOMC decisions on the FFTR via the actions of the Fed's market operations. Subsequently, the FOMC started announcing decisions regarding the FFTR. In May 1999 the FOMC began issuing fuller statements, even when leaving rates unchanged, which contained an assessment of their bias with respect to future changes in the FFTR. As of March 2002, the FOMC has released information

detailing the Committee vote immediately after each meeting. More recently, the FOMC has expedited the release of meeting minutes and increased the frequency and content of publicly released forecasts. To ensure that the statements that we consider in our empirical analysis are broadly consistent in their level of informativeness we take May 1999 as the start date of our sample. The sample ends with the FOMC statement of 29 July 2015, providing 136 scheduled and non-scheduled meeting announcements.

<Insert Figure 1>

During our sample period, there have been three chairs of the FOMC: Alan Greenspan (11 Aug 1987 – 31 Jan 2006), Ben Bernanke (01 Feb 2006 – 31 Jan 2014), and Janet Yellen (Feb 1 2014 – Present). Figure 1 illustrates how the FFTR has evolved over the sample period. Rates were relatively volatile during the Greenspan era, reaching a peak of 6.50% in May 2000 and a low of 1.00% in June 2003. The FFTR reached the zero-bound in December 2008, during Bernanke's tenure, and remains there throughout the Yellen era contained in our sample.

The FFTR affects asset prices by conveying new information regarding the FOMC's monetary policy stance. The efficient market hypothesis implies that asset prices observable immediately prior to the FOMC decision already incorporate market expectations on the upcoming announcement. Therefore, if there is a significant market reaction to the announcement, the effect must be due to the unexpected component of the announcement. The importance of this news effect is supported in the literature[1]. We follow Kuttner (2001) in computing the target rate surprise using the change in the implied rate of the current-month Fed Funds future on the day of the FOMC decision:

$$TS_t = \frac{D}{D-d}(f_t^0 - f_{t-1}^0) \quad (\mathbf{1})$$

Where TS_t is the target rate surprise at meeting t, f_t^0 is the fed funds rate implied in the settlement price of the current month fed funds contract on the day of the FOMC decision, f_{t-1}^0 is the settlement price on the day prior to the FOMC announcement, d is the day of the current FOMC meeting and D is the number of days in the month. The first term is a scaling factor that adjusts for the number of remaining days in the month affected by the rate change.

[1] For example Kuttner (2001), Bernanke and Kuttner (2005), and Fatum and Scholnick (2008).

Gürkaynak et al. (2005), Andersson (2010), and Smales (2012) show that it is possible to disaggregate the response of asset prices to changes in monetary policy into a second factor. The path surprise (PS_t) factor measures the degree to which market participants revise their expectations of future monetary policy on the basis of the target rate decision and/or accompanying policy statements. We define the path-surprise factor as the innovation in future monetary policy expectations implied by changes in the yield of one-year ahead 3-month Eurodollar futures contracts.

In addition to the target surprise, and path surprise factor, we consider an additional component of the FOMC decision; quantitative measures of the language contained in the accompanying statement. Hernandez-Murillo and Shell (2014) report that increased transparency of FOMC statements has benefitted financial markets but led to longer and more complex statements. Wynne (2013) suggests it is possible that this could unsettle financial markets if the statements are too difficult to understand. Resche (2004) notes that Greenspan maintained a 'fuzzy transparency' in his deliberations that is bewildering. Abe (2011) notes that the cognitive complexity of Greenspan's language changed across the economic cycle. We follow the work of Hernandez-Murillo and Shell (2014) by considering two aspects of linguistic complexity with regards the FOMC statement. We analyse each of the statements in turn using ETS TextEvaluator™[2].

First, we count the average number of words in each statement (*Words*) on the basis that is a statement has more words to consider there is a larger amount of mental processing required and there is also an increased likelihood of confusion (or differences in interpretation) among market participants. So that we have consistency across the regimes of monetary policy communication, we discard the last paragraph of the statement that details the number of members voting for the FOMC action. Second, we use the Flesch-Kincaid Grade Level Index[3] to generate a *readability* measure based on education grade levels. The index combines two measures of text complexity (average word length and average sentence length) to generate a reading level that corresponds to a U.S. grade level, or the number of years of education generally required to understand the text; a fall in the index indicates that the readability has increased (less education is required to understand the text). Since a rise (fall) in the Flesch-Kincaid Grade Level Index

[2] https://texteval-pilot.ets.org/TextEvaluator/
[3] See Flesch (1948) and Kincaid et al. (1975).

indicates a decrease (increase) in readability, we multiply the index by -1 for our analysis. This improves the interpretation of our reported results as an increase (decrease) in the variable is able to be interpreted as an increase (decrease) in readability.

Figure 2 depicts how the level of linguistic complexity in FOMC statements has changed over time. During the Greenspan era the statements were relatively short (163 words) and increased in readability over time (the readability index prior to May 2003 averaged 17.2, and 15.1 from that point until the end of his tenure in January 2006). While Bernanke served as Chair the length of the statements increased in length (to 350 words) and decreased in readability (rising from 13 to a peak of 21). The complexities of the economic environment resulting from the 2007-2009 financial crisis were mirrored in the nature of relatively complex and unorthodox monetary policy adopted by the FOMC. Finally, as the FOMC has moved towards the conclusion of its zero-interest rate policy (*ZIRP*) and quantitative easing, during the tenure of Yellen (from Feb 2014), the number of words has continued to increase (averaging 631 words per statement) and the readability has declined (to an average grade level of 17.9).

<Insert Figure 2>

Descriptive statistics for the FOMC decisions and surprise factors considered in this study are reported in Table 1. Panel A shows that the decision to leave the FFTR un-changed predominates, and such decisions tend to be both longer and more difficult to understand. This is at least partly due to the 53 consecutive meetings of no-change that follow the December 2008 decision to lower the FFTR to the zero-bound, and which involved the use of unconventional monetary policy. On average, interest rate cuts are of a greater magnitude than interest rate increases. Panel B provides the transition matrix for FOMC decisions. There is evidence of autocorrelation to the extent that reductions in the FFTR tend to follow reductions (78.3% of occasions), hikes tend to follow hikes (82.6%), and no-change follows no-change (90%). During the sample period the FOMC has never gone from increasing (decreasing) rates at one meeting to decreasing (increasing rates) at the next meeting. Finally, Panel C shows the surprise factors and associated linguistic complexity. Negative surprises (both target and path) tend to be of a larger magnitude than positive surprises. Linguistic complexity tends to be higher following positive target surprises and negative path surprises.

<Insert Table 1>

3.2 Volatility and Trading Volume in Futures Market

To infer the response of asset markets to FOMC decisions, we examine the volatility of returns and trading activity (volume) in three important asset classes. We use the S&P 500 Index future (SPX) as a proxy for equity markets, the implied yield on the 10-Year Note Future (TY) to proxy for bond markets, and the US dollar index future (DXY) to represent the currency market. We obtain daily settlement prices, and trading volume, from Datastream for each futures contract, for our sample period. The study considers only the most liquid contract, following a standard procedure in rolling from the current contract into the next contract when trading volume (and open interest) becomes greater. Figure 3 depicts the evolution of U.S. asset prices over the sample period. The price levels are standardised to 100 at the start of the sample in May 1999. There appears to be a high degree of correlation between returns in all three assets at the start of the sample (prior to 2006). However, in recent years the S&P 500 Index has continued to rise in price while the yield on 10-year notes has remained low.

<Insert Figure 3>

We use a simple measure for volatility that is computed as the absolute value of daily returns for asset *k*, on day *t*:

$$|R_{k,t}| = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (\mathbf{2})$$

Following Fleming and Piazzesi (2005) and Gürkaynak et al. (2005) we use yields rather than futures prices in generating a time series of daily volatility for the 10-year note. Table 2 provides summary statistics for the series of financial returns. The magnitude, and variation, of returns is greatest for all three asset classes on the day of the FOMC decision. This is true for the whole sample and for both pre-ZIRP and ZIRP periods. As is typical of financial market returns there is a high degree of kurtosis (fat tails). On average stock prices have increased, while 10-year yields and the dollar index have declined, over the sample period. The magnitude of this change has been greater during the ZIRP period that has ensued since December 2008.

<Insert Table 2>

4. Empirical Analysis

4.1 Influence of FOMC decisions on asset market volatility

We investigate the influence of FOMC decisions, and the accompanying statement, on asset markets by specifying an ordinary least squares model. We augment the model of Bernanke and Kuttner (2005), and Gürkaynak et al. (2005), with our variables for linguistic complexity of the statement as follows:

$$|R_t| = \alpha + \beta_1 TS_t + \beta_2 PS_t + \beta_3 Readability_t + \beta_4 \log(Words_t) + \varepsilon_t \quad (\mathbf{3})$$

Where $|R_t|$ is the absolute value of the daily return for the specified futures contract on the day of FOMC decision t, TS_t is the target surprise resulting from FOMC decision t (calculated using equation 1), and PS_t is the path surprise. $Readability_t$ refers to the readability of the statement that accompanies FOMC decision t, and is calculated as -1 × Flesch-Kincaid Grade Level Index. $Words_t$ is the total number of words in the statement, and ε_t are Newey-West errors with the lag optimised by Akaike Information Criteria (AIC).

Table 3 reports the estimated coefficients for the regression specified in equation (3). Panel A shows the results for the whole sample period. Both the target surprise and path surprise have a statistically significant relationship with volatility in all three asset classes. This is consistent with the literature and the intuition that unexpected changes in monetary policy should impact the volatility of asset prices. Importantly, volatility of returns increases as linguistic complexity of FOMC statements increases (readability declines or the number of words increases or both). This is well-defined for both bond and currency markets, and is consistent with intuition that more complex statements create differences in interpretation among market participants and stimulates activity.

<Insert Table 3>

Chappell et al. (1995) and Smales and Aspergis (2016) note that the Chair of the FOMC has a significant influence on the monetary policy decision-making process. We investigate whether this influence extends to the relationship between FOMC decisions and asset markets by disaggregating our sample. Panel B reports the results for the period when Alan Greenspan was

Chair (May 99[4] – Jan 06) and Panel C reports results for Ben Bernanke's tenure (Feb 06 – Jan 14). The sample for Janet Yellen (Feb 14 – July 15) is much shorter and so excluded from analysis. For the Greenspan era the sign of the estimated coefficients is the generally the same (the effect of the target surprise on bond yields is reversed), however, only the effect of the target surprise is statistically significant. During the Bernanke era the sign of the coefficients are also similar to relationships identified for the overall sample.

The most important distinction lies in the estimates for the stock market. During Greenspan's period as Chair the target surprise coefficient is negative and significant, and the path surprise has no significant relationship (consistent with Gürkaynak et al., 2005; Hausman and Wongswan, 2011). However, during Bernanke's tenure the target surprise is positive and statistically significant, while the path surprise is negative and highly significant. We postulate that this change in the response to the target surprise is related to state of the economy during the tenure of the respective tenures. The financial crisis of 2007-2009 occurred during Bernanke's time in office. It is possible that during this period a positive target surprise (higher than expected FFTR) is seen by stock market participants as a 'vote of confidence' in the economy which translates into higher stock prices. During the period, the path surprise takes on greater importance (and is statistically significant) as market participants seek reassurance about the future path of short-term rates. In general, the effect of linguistic complexity increases (at least in terms of the magnitude of the reported coefficients) as we advance from the Greenspan to the Bernanke era. In addition, during the Bernanke era, both measures of linguistic complexity have a statistically significant effect on stock market volatility. The identified changes between the two eras are consistent with the response to public information been state dependent.

4.2 Influence of FOMC decisions on trading activity

We consider trading activity using a similar specification to that used in the prior section:

$$\log(TV_t) = \alpha + \beta_1 TS_t + \beta_2 PS_t + \beta_3 Readability_t + \beta_4 \log(Words_t) + \varepsilon_t \quad (\mathbf{4})$$

Where TV_t is the daily trading volume for the specified futures contract on the day of FOMC decision t, TS_t is the target surprise resulting from FOMC decision t (calculated using equation 1), and PS_t is the path surprise. $Readability_t$ refers to the readability of the statement that accompanies FOMC decision t, and is calculated as -1 × Flesch-Kincaid Grade Level Index.

[4] We note that Greenspan became Chair in August 1987 but our sample period starts only in May 1999.

$Words_t$ is the total number of words in the statement, and ε_t are Newey-West errors with the lag optimised by Akaike Information Criteria (AIC). The results are reports in Table 4, and depicted graphically in Figure 4.

<Insert Table 4>

<Insert Figure 4>

For the overall sample the size of the monetary policy surprise (target and path) does not appear to have a significant impact on trading activity in any of the futures markets considered here. However, both measures of linguistic complexity (readability and the number of words in the statement) have a significant impact on trading volume on the day of the FOMC decision. This is consistent with more complex FOMC statements creating a wider degree of heterogeneity in beliefs among market participants and this induces trading, and aligns with the theoretical models of Harris and Raviv (1993) and Kandel and Pearson (1995). The sign of the estimated relationship for readability is consistent across the tenure of both Chairs, but of a greater magnitude during Greenspan's appointment. Interestingly, the number of words in the FOMC statement has a negative relationship with trading volume during Greenspan's tenure. Perhaps this is a result of a greater number of words helping to explain the intentions of the FOMC and reducing heterogeneity. Consistent with the announcement effect identified by Fleming and Piazzesi (2005), the FOMC decision (both target and path surprises) has a significant impact on trading volume in bond futures during Bernanke's tenure.

4.3 State dependence of market response to FOMC decisions

The literature provides evidence that the response of asset prices to macroeconomic announcements may be dependent on the stage of the business cycle (e.g. McQueen and Roley, 1993; Basistha and Kurov, 2008). We investigate whether this also relates to the response to the linguistic complexity of FOMC decisions by repeating our analysis with consideration of two distinct economic states. First, we consider recessionary periods as determined by the National Bureau of Economic Research (NBER). Our sample includes two such periods, the first includes the meetings from 18th April 2001 to 6th November 2001, and the second includes the meetings from 11th December 2007 to 24th June 2009. Second, we consider the period of ZIRP which runs from December 2008 until the end of our sample. We augment our earlier model specification as follows:

$$|R_t| = \alpha + \beta_1 TS_t + \beta_2 PS_t + \beta_3 Readability_t + \beta_4 \log(Words_t) + \beta_5 State_t + \beta_6 State * TS_t + \beta_7 State * PS_t + \beta_8 State * Readability_t + \beta_9 \text{ State} * \log(Words_t) + \varepsilon_t \quad (\mathbf{5.A})$$

$$TV_t = \alpha + \beta_1 TS_t + \beta_2 PS_t + \beta_3 Readability_t + \beta_4 \log(Words_t) + \beta_5 State_t + \beta_6 State * TS_t + \beta_7 State * PS_t + \beta_8 State * Readability_t + \beta_9 \text{ State} * \log(Words_t) + \varepsilon_t \quad (\mathbf{5.B})$$

Where $|R_t|$ is the absolute value of the daily return and TV_t is the daily trading volume for the specified futures contract on the day of FOMC decision t, TS_t is the target surprise resulting from FOMC decision t (calculated using equation 1), and PS_t is the path surprise. $Readability_t$ refers to the readability of the statement that accompanies FOMC decision t, and is calculated as -1 × Flesch-Kincaid Grade Level Index. $Words_t$ is the total number of words in the statement. $State_t$ is a dummy variable that indicates the stage of the business cycle. In one specification this relates to whether the economy is in recession (1) or not (0). In a second specification this relates to whether monetary policy is at the zero-bound (1) or not (0). ε_t are Newey-West errors with the lag optimised by Akaike Information Criteria (AIC).

<Insert Table 5>

Table 5 reports the estimated regression coefficients for the effect of recession on the identified response. Panel A shows that volatility of returns in all assets increases during recession, and the effect of monetary policy surprises is also greater during periods of recession. This suggests that FOMC decisions have greater relevance during recessionary periods. During recession, the number of words in the FOMC statement is positively related to absolute returns across all markets. The results for Panel B demonstrate that while linguistic complexity has an effect on trading volume in general, there is no additional impact during recession periods.

<Insert Table 6>

The results for the effect of the ZIRP period, reported in Table 6, are qualitatively similar with regards returns (Panel A). The results reported in Panel B are most interesting, with readability having both a general effect on daily trading volume and an additional effect during the period of ZIRP. This suggests that the increase in the complexity of FOMC statements apparent during the period of unconventional monetary policy has resulted in increased trading activity, likely as a result of an increase in the ambiguity among the beliefs of investors.

4.4 Effect of linguistic complexity on conditional mean and variance of returns

Our results in the earlier sections appear to identify an important relationship between the linguistic complexity of FOMC statements and both volatility and trading volume in three important future contracts. We take this one step further by employing an EGARCH(1,1) framework to model the conditional variance of returns in the period around FOMC policy decisions. This framework is well-suited to modelling financial market returns that are leptokurtic and non-normal (Nelson, 1991; Engle and Ng, 1993). We can describe our model with the following expression for the conditional mean and conditional variance of returns:

$$R_t = \beta_c + \beta_1 TS_t + \beta_2 PS_t + \beta_3 Readability_t + \beta_4 \log(Words_t) + \beta_5 State_t + \beta_6 State * TS_t + \beta_7 State * PS_t + \beta_8 State * Readability_t + \beta_9 \text{State} * \log(Words_t) + \beta_{10} R_{t-1} \quad (\mathbf{6.A})$$

$$\log(\sigma_t^2) = \lambda_c + \lambda_1 \frac{|\epsilon_{t-1}|}{\sigma_{t-1}} + \gamma_E \frac{\epsilon_{t-1}}{\sigma_{t-1}} + \lambda_2 \sigma_{t-1}^2 + \lambda_3 TS_t + \lambda_4 PS_t + \lambda_5 Readability_t + \lambda_6 \log(Words_t) + \lambda_7 State_t + \lambda_8 State * TS_t + \lambda_9 State * PS_t + \lambda_{10} State * Readability_t + \lambda_{11} \text{State} * \log(Words_t) \quad (\mathbf{6.B})$$

The quasi-maximum likelihood estimates for the EGARCH model are reported in Table 7. The coefficient estimates for the conditional mean equation (Panel A) are consistent with the results already reported. Of more interest are the reported estimates for the conditional variance equation (Panel B). For all markets, the lagged variance (GARCH) term is positive and highly significant, indicating persistence in the volatility of returns. The positive and significant estimate for λ_1 provides evidence that unexpected shocks to the mean return have a significant impact with regards increasing the level of volatility. Consistent with Engle and Ng (1993), there is significant evidence of an asymmetric effect of negative news shocks resulting in a greater increase on volatility than positive shocks (since γ_E is negative and well defined, positive news shocks will generate less volatility). Monetary policy surprises (target and path) have a significant impact on conditional variance in general (although not for stock markets) and, while recessionary conditions appear to increase the volatility of returns, there is no additional effect from FOMC surprises during recession. Most important in the context of our study are the estimated coefficients for linguistic complexity. The relationship for both readability (negative) and the number of words (positive) is statistically significant. This adds to our evidence that the

complexity of the language in FOMC statements has had a statistically significant impact on the market response to FOMC decisions.

In summary, the empirical results in this section confirm evidence from the empirical literature regarding the significant impact of FOMC monetary policy decisions on asset prices. We extend this to consider the effect on the US dollar index in addition to the stock and bond markets. Both the target and path surprise have a significant impact on market volatility. We also confirm that the state of the economic environment (defined by recession or ZIRP) affects the sign and magnitude of this effect. Our most important contribution is to identify whether the language of the FOMC statement that accompanies FFTR decisions has an impact on the market response to such decisions. We find that both the readability and the number of words in the statement, which we categorize as dimensions of linguistic complexity, have a statistically significant impact on both trading volume and the volatility of returns.

5. Conclusion

FOMC monetary policy communication has evolved over time and has become more transparent. As the Fed has entered an unprecedented era of unconventional monetary policy, involving rates close to zero and quantitative easing, the complexity of the language contained in the statements that accompany FFTR decisions has increased. We provide empirical evidence that the complexity of the language in the FOMC statement has a significant impact on both trading volume and volatility across equity, bond, and currency futures markets. Our results are consistent with the notion that more complex information results in differing interpretations of that information and heterogeneous beliefs that increase market volatility and trading activity. The results are important for central bankers to note when drafting statements that may create unintentional uncertainty in financial markets, and are more generally relevant to other agents who may issue declarations to the market (such as earnings guidance by firms).

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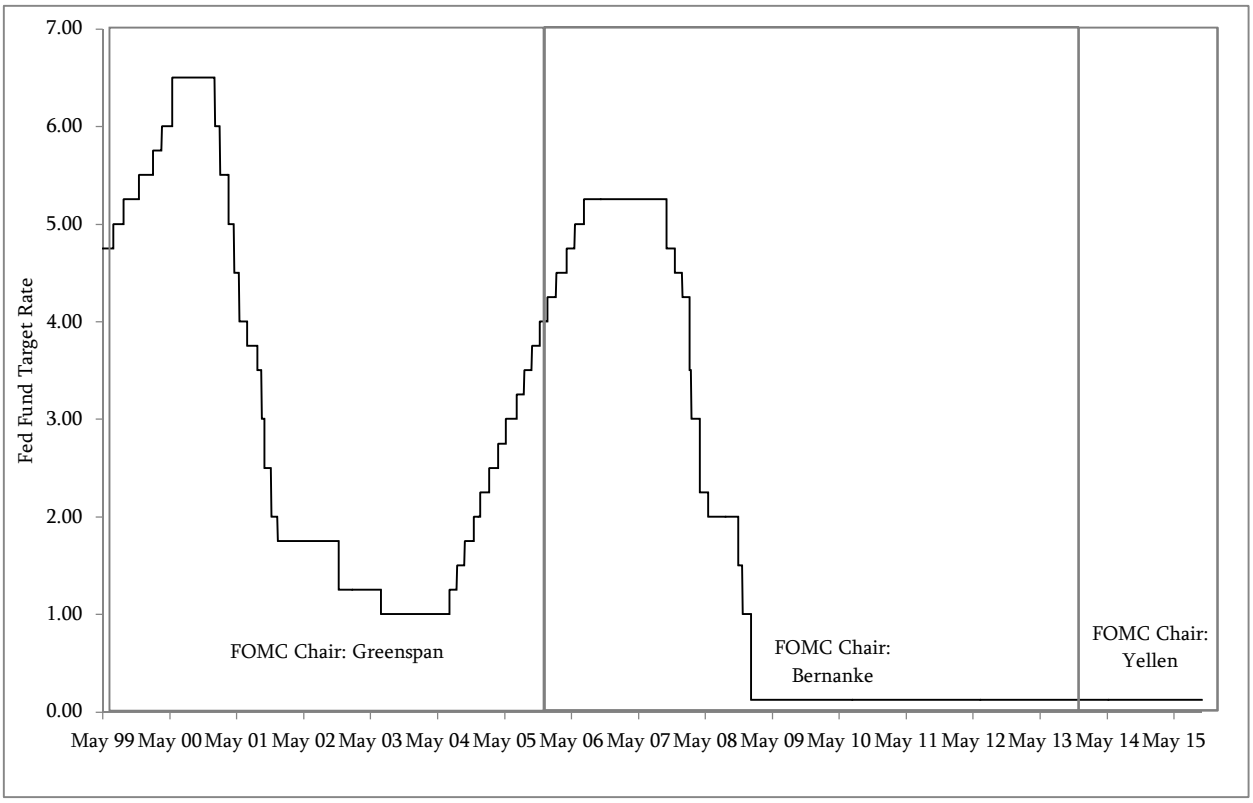


Figure 1. Evolution of Federal Funds Target Rate (FFTR)

This figure illustrates the evolution of the Federal Funds rate (a principal tool of monetary policy) over the sample period May 1999 - July 2015

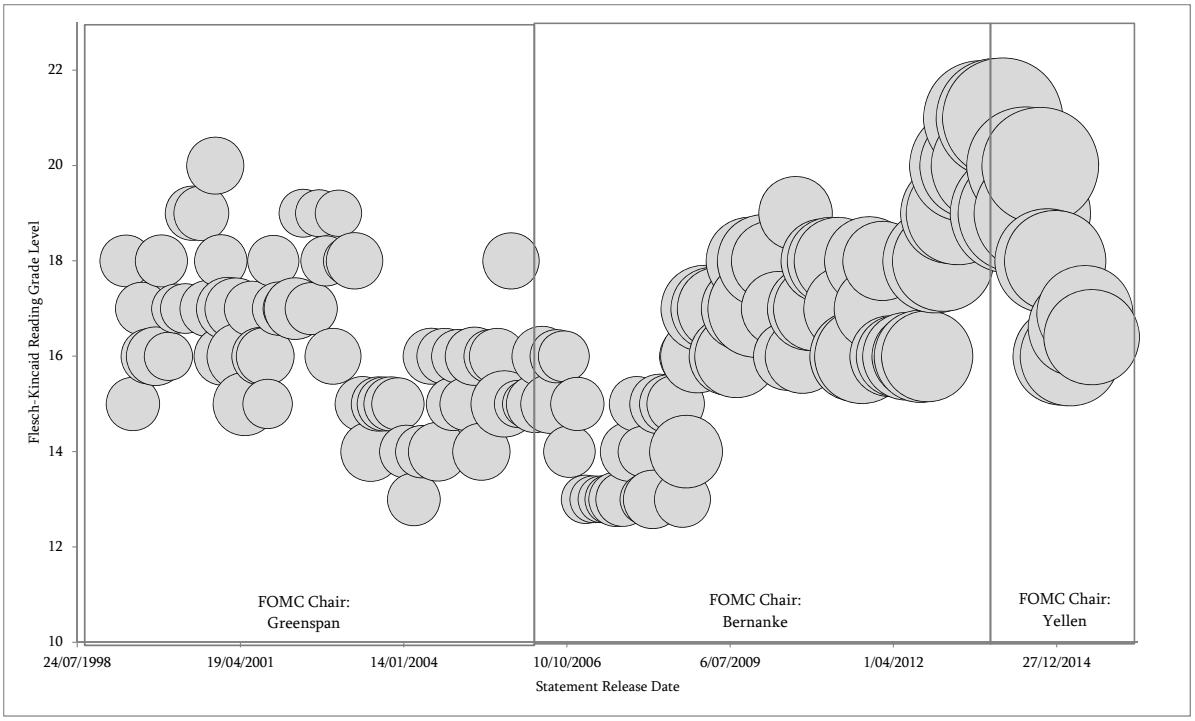


Figure 2. Linguistic complexity of FOMC statements

This figure depicts the trend in the level of readability (measured using the Flesch-Kincaid reading grade level) and the length (total number of words) of FOMC statements accompanying monetary policy decisions. Linguistic complexity is indicated on the y-axis, while the number of words in the statement is indicated by the area of the circle representing the data point.

Figure 3. Evolution of US Asset Prices

This figure illustrates the evolution of the US asset prices over the sample period May 1999 - July 2015. This includes the equity markets (represented by the S&P 500 Index futures), bond markets (yields on 10-year note futures), and currency markets (dollar index futures).

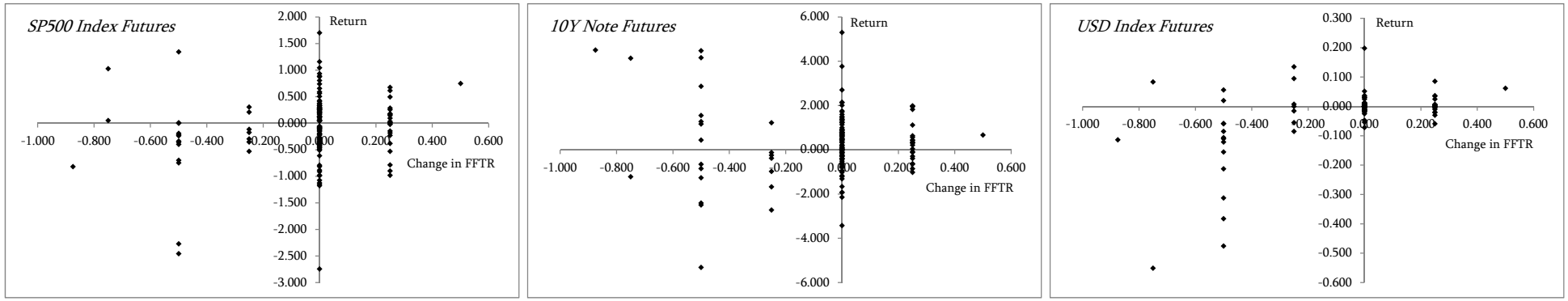
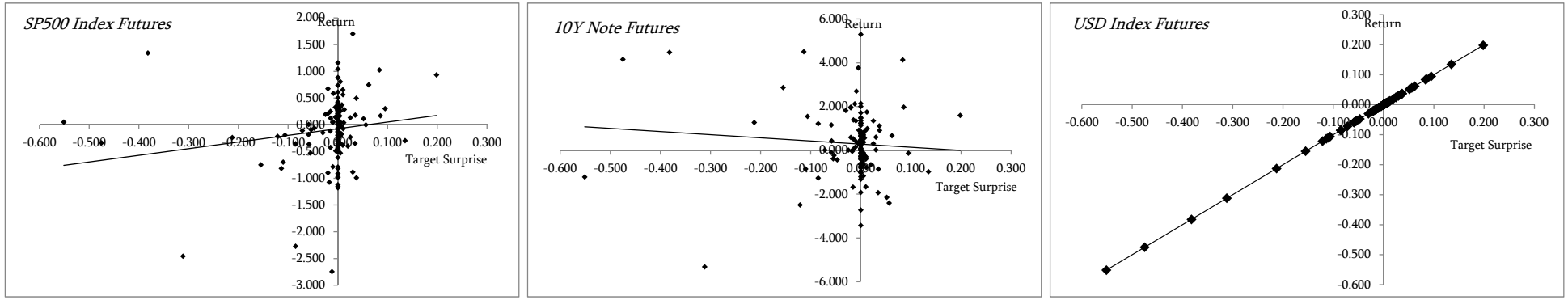
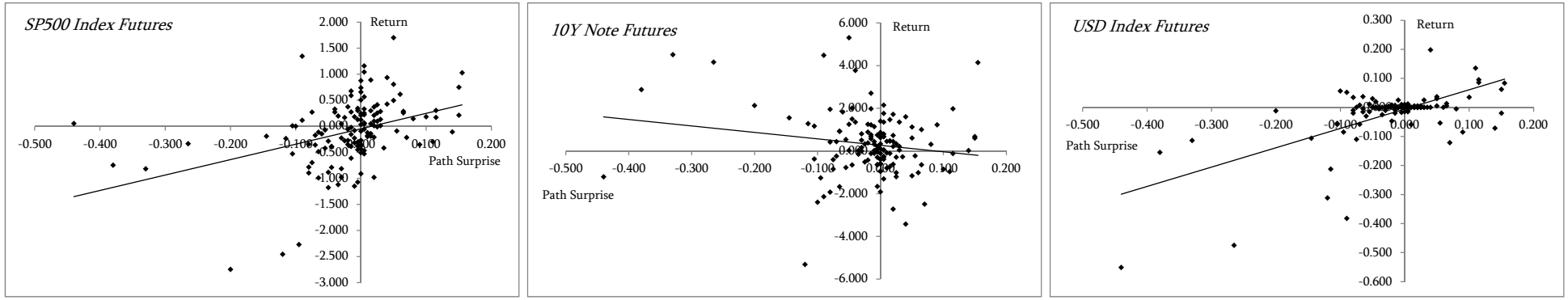


Figure 4. Panel A. Effect of changes in the Fed Funds Target Rate (FFTR) on futures market returns on day of FOMC announcement.



Panel B. Effect of target surprise on futures market returns on day of FOMC announcement.



Panel C. Effect of path surprise on futures market returns on day of FOMC announcement.

Table 1

Summary Statistics - FOMC Decisions, Statements, and Surprise Factors

Panel A: Federal Funds Target Decision

Decisions	N	FFTR Change	Words	Readability
Cut	23	-0.46	190.09	15.35
*No-Change	90	0.00	344.08	16.44
^Hike	23	0.26	166.17	15.69
Total	136	-0.03	295.54	16.50

Panel B: Transition Matrix

	Whole Sample Period	*t*				Pre-ZIRP Period	*t*		
		Cut	No-Change	Hike			Cut	No-Change	Hike
t+1	Cut	78.3%	5.6%	0.0%	*t+1*	Cut	78.3%	13.5%	0.0%
	No-Change	21.7%	90.0%	17.4%		No-Change	21.7%	75.7%	17.4%
	Hike	0.0%	4.4%	82.6%		Hike	0.0%	10.8%	82.6%

Panel C: Surprise Factors

	Target Surprise				Path Surprise			
	N	Average	Words	Readability	N	Average	Words	Readability
Negative	33	-0.101	192.97	15.94	61	-0.070	274.16	16.46
Zero	83	0.000	357.49	16.08	35	0.000	426.33	16.02
Positive	20	0.054	231.55	16.48	40	0.054	232.86	15.78

Notes: This table presents descriptive statistics for the FOMC decisions and accompanying statements regarding changes in the Federal Funds Target Rate (*FFTR*) utilized in this statement. During the sample period May 1999 to July 2015 a total of 136 FOMC meetings (scheduled and unscheduled) resulted in an announcement regarding the FFTR. Panel A shows the number of decisions (*N*) which resulted in a decision to decrease (*cut*), increase (*hike*), or leave the FFTR unchanged (*no-change*). *FFTR Change* is the average change in the FFTR when a decision of that type is made. *Words* is the total number of words in the statement that accompanied a decision of that type. *Readability* is a measure of linguisitic complexity of the accompanying statement, indicated by the Flesch-Kincaid Grade Level Index. Panel B shows the transition matrix of FOMC decisions from meeting t to t+1. For example, when the FOMC decides to cut the FFTR at meeting t the decision at the next meeting is a further reduction on 78.3% of occasions. Panel C shows the size and frequency of target and path surprises, determined following the methodology of Gurkaynak et al. (2005), along with the average size of the respective surprise, and the number of words and linguistic complexity in the statement resulting in that surprise type. The target surprise is significantly smaller (close to zero) in the ZIRP period, while the path surprise is marginally smaller (but significantly different from zero).
*Following the December 2008 meeting the FFTR reached the zero-bound. Subsequent to this there was 53 consecutive meetings of no-change.
^All but one of the decisions to increase the FFTR resulted in a 25b.p. change. The exception is May 2000 when a 50b.p. increase was announced.

Table 2

Summary Statistics - Futures Returns

Panel A: Whole Sample								Partial autocorrealtion at lag:				
	Mean - FOMC	SD	Mean - All	SD	Skewness	Kurtosis	Jarque-Bera	1	2	3	Unit root test statistic	
E-Mini SP 500 Index (ES) Futures	0.340	1.429	0.008	1.262	-0.185	10.96	10867.8	-0.075	-0.052	0.006	-49.4	*
10Y Note (TY) Futures (Yield)	-0.073	2.851	-0.024	1.877	-0.114	7.40	3326.2	-0.001	-0.042	0.007	-64.1	*
Dollar Index (DXY) Futures	-0.121	0.600	-0.002	0.523	-0.026	4.49	381.4	-0.011	0.009	-0.015	-64.7	*

Panel B: Sample disaggregated into pre-ZIRP and ZIRP periods

Pre-ZIRP	Mean - FOMC	SD	Mean - All	SD	*ZIRP*	Mean - FOMC	SD	Mean - All	SD
E-Mini SP 500 Index (ES) Futures	0.278	1.461	-0.018	1.339		0.433	1.387	0.046	1.141
10Y Note (TY) Futures (Yield)	0.077	1.599	-0.031	1.420		-0.301	4.088	-0.014	2.387
Dollar Index (DXY) Futures	-0.093	0.494	-0.009	0.519		-0.164	0.735	0.008	0.529

Notes: This table presents summary data for the futures returns utilized in this study, using daily observations for the period May 1999 - July 2015. The returns of interest are those for the E-Mini SP500 Index futures (*ES*), yield on 10-year Note futures (*TY*), and the US dollar index futures (DXY). Panel A contains statistics for the mean daily return on days when the FOMC decision is announced (*Mean-FOMC*), the mean daily return for all trading days in the sample (*Mean-All*), together with the standard deviation (*SD*), skewness, and kurtosis of the return for all trading days. Unit root tests are conducted using ADF with trend and intercept; * indicates rejection of the null of a unit root. Panel B provides additional information that disaggregates the sample into a *pre-ZIRP* period prior to the Federal Funds Target Rate falling below 0.25% (December 2008) and a period of *ZIRP*.

Table 3
The influence of FOMC decisions on volatility of financial futures

	SP500 Index Futures		10Y Note Futures		USD Index Futures	
Panel A: Whole Sample						
Constant	1.422		-4.721	**	-0.039	
	(0.885)		(1.845)		(0.373)	
Target Surprise	-2.540	**	0.885		1.181	**
	(1.263)		(2.634)		(0.533)	
Path Surprise	-2.554	*	-6.334	**	-2.592	***
	(1.313)		(2.739)		(0.554)	
Readability	-0.077		-0.205	**	-0.030	
	(0.053)		(0.099)		(0.022)	
Log(Words)	0.145		1.776	***	0.169	**
	(0.175)		(0.365)		(0.074)	
No. Observations	136		136		136	
R^2	0.159		0.184		0.180	
F-Stat	6.171		7.367		7.203	
AIC	2.807		4.797		7.203	
Panel B: Greenspan Era						
Constant	-0.286		0.923		0.635	
	(3.840)		(4.204)		(1.476)	
Target Surprise	-5.881	***	-1.228		0.055	
	(1.370)		(1.500)		(0.527)	
Path Surprise	-1.522		-0.982		-0.689	
	(1.736)		(1.901)		(0.667)	
Readability	-0.004		-0.115		-0.040	
	(0.071)		(0.078)		(0.027)	
Log(Words)	0.219		0.361		0.069	
	(0.671)		(0.735)		(0.258)	
No. Observations	58		58		58	
R^2	0.429		0.093		0.066	
F-Stat	9.972		5.133		0.940	
AIC	2.498		2.372		0.586	
Panel C: Bernanke Era						
Constant	0.076		-6.071		0.175	
	(1.474)		(3.884)		(0.685)	
Target Surprise	4.069	*	1.401		2.917	***
	(2.288)		(6.029)		(1.064)	
Path Surprise	-5.807	***	-8.743	*	-4.308	***
	(1.964)		(5.176)		(0.913)	
Readability	-0.299	**	-0.287		0.018	
	(0.119)		(0.314)		(0.055)	
Log(Words)	1.022	**	2.258	*	-0.009	
	(0.482)		(1.272)		(0.224)	
No. Observations	66		66		66	
R^2	0.196		0.120		0.276	
F-Stat	3.715		2.086		5.821	
AIC	2.944		4.882		1.413	

Notes: This table reports the regression estimates of the linear regression model described in Eq. (3) where the dependent variable is the absolute value of the daily *return* on the front contract SP500 Index (*SPX*) future, the 10 Year Note (*TY*) future yield, or USD Index (*DXY*) future. The independent variables include the *target suprise* (identified using the near contract Fed Funds contract at in Eq. (1)), and the *path surprise* (determined using innovations in the 1-year ahead eurodollar interest rate future contract) resulting from FOMC monetary policy decisions, together with variables indicating the *readability* (measured using the Flesch-Kincaid grade level index) and the (natural log) of the total *number of words* in the FOMC statement accompanying decisions. Panel A indicates results for the whole sample period (May 1999 - July 2015), Panel B provides results for the period when Alan Greenspan was FOMC Chair (Start of sample - 31 January 2006), and Panel C provides results for the part of the sample when Ben Bernanke was FOMC Chair (01 February 2006 - 31 January 2014). Newey West standard errors, with the lag length chosen by AIC, are reported in parantheses.
Sample period: May 1999 - July 2015
*,**,*** denotes significance at the 10%, 5%, and 1% level respectively.

Table 4
The influence of FOMC decisions on trading volume of financial futures

	SP500 Index Futures		10Y Note Futures		USD Index Futures	
Panel A: Whole Sample						
Constant	10.053	***	12.799	***	2.711	***
	(0.917)		(2.022)		(1.011)	
Target Surprise	1.147		-4.831	*	-0.681	
	(1.309)		(2.887)		(1.443)	
Path Surprise	-2.026		2.217		0.920	
	(1.361)		(3.002)		(1.501)	
Readability	-0.318	***	-0.180	**	-0.257	***
	(0.054)		(0.089)		(0.060)	
Log(Words)	1.557	***	0.389		2.795	***
	(0.181)		(0.400)		(0.200)	
No. Observations	136		136		136	
R^2	0.375		0.041		0.618	
F-Stat	19.668		1.388		53.044	
AIC	2.879		4.461		3.074	
Panel B: Greenspan Era						
Constant	19.269	***	23.960	**	23.222	***
	(5.110)		(10.116)		(5.517)	
Target Surprise	2.043		-1.429		-4.392	**
	(1.823)		(3.609)		(1.968)	
Path Surprise	-2.561		-4.377		5.741	**
	(2.309)		(4.572)		(2.493)	
Readability	-0.238	**	-0.343	*	-0.326	***
	(0.094)		(0.187)		(0.102)	
Log(Words)	-0.589		-1.307		-2.152	**
	(0.893)		(1.777)		(0.964)	
No. Observations	58		58		58	
R^2	0.126		0.091		0.267	
F-Stat	3.911		2.325		4.821	
AIC	3.067		4.436		3.223	
Panel C: Bernanke Era						
Constant	12.974	***	14.671	***	-0.382	
	(0.793)		(3.168)		(0.955)	
Target Surprise	-4.176	***	-11.806	**	-0.685	
	(1.232)		(4.917)		(1.482)	
Path Surprise	2.473	**	9.120	**	0.041	
	(1.058)		(4.221)		(1.272)	
Readability	-0.138	**	-0.232		-0.031	
	(0.064)		(0.256)		(0.077)	
Log(Words)	0.617	**	1.070		1.792	***
	(0.260)		(1.037)		(0.313)	
No. Observations	66		66		66	
R^2	0.211		0.111		0.660	
F-Stat	4.083		3.906		29.657	
AIC	1.705		2.474		2.076	

Notes: This table reports the regression estimates of the linear regression model described in Eq. (4) where the dependent variable is the natural log of *trading volume* on the front contract SP500 Index (*SPX*) future, 10 Year Note (*TY*) future, or USD Index (*DXY*) future. The independent variables include the *target suprise* (identified using the near contract Fed Funds contract at in Eq. (1)), and the *path surprise* (determined using innovations in the 1-year ahead eurodollar interest rate future contract) resulting from FOMC monetary policy decisions, together with variables indicating the *readability* (computed as -1 x Flesch-Kincaid grade level index) and the (natural log) of the total *number of words* in the FOMC statement accompanying decisions. Panel A indicates results for the whole sample period (May 1999 - July 2015), Panel B provides results for the period when Alan Greenspan was FOMC Chair (Start of sample - 31 January 2006), and Panel C provides results for the part of the sample when Ben Bernanke was FOMC Chair (01 February 2006 - 31 January 2014). Newey West standard errors, with the lag length chosen by AIC, are reported in parantheses.
Sample period: May 1999 - July 2015
*,**,*** denotes significance at the 10%, 5%, and 1% level respectively.

Table 5
The effect of recession on the futures market response to FOMC decisions

	SP500 Index		10Y Note		USD Index		SP500 Index		10Y Note		USD Index	
	Panel A: |Returns|						*Panel B: Volume*					
Constant	1.092		-4.711	***	0.082		9.670	***	13.520	***	2.978	***
	(0.893)		(1.798)		(0.358)		(0.978)		(2.119)		(1.065)	
Target Surprise	-4.387	**	-2.274		-0.599		2.705		-1.785		-2.029	
	(1.865)		(3.754)		(0.748)		(2.042)		(4.426)		(2.224)	
Path Surprise	-2.760	*	-0.183		-1.088	*	-2.596		2.317		1.402	
	(1.563)		(3.146)		(0.626)		(1.711)		(3.709)		(1.864)	
Readability	-0.035		-0.110		-0.029		-0.285	***	-0.156	**	-0.246	***
	(0.054)		(0.109)		(0.022)		(0.060)		(0.068)		(0.065)	
Log(Words)	0.060		1.460	***	0.141	**	1.522	***	0.209		2.819	***
	(0.173)		(0.349)		(0.069)		(0.190)		(0.411)		(0.207)	
Recession	5.862	*	18.648	***	4.002	***	3.329		-2.140		7.604	*
	(3.475)		(6.996)		(1.393)		(3.806)		(8.247)		(4.145)	
Recession*Target Surprise	2.042		9.567	*	4.008	***	-2.728		-4.408		3.702	
	(2.639)		(5.315)		(1.058)		(2.891)		(6.265)		(3.148)	
Recession*Path Surprise	3.066		-14.359	**	-4.062	***	1.864		-3.949		-4.354	
	(2.811)		(5.660)		(1.127)		(3.079)		(6.672)		(3.353)	
Recession*Readability	-0.019		-0.446		-0.036		-0.238		-0.749	*	-0.299	
	(0.171)		(0.345)		(0.069)		(0.187)		(0.406)		(0.204)	
Recession*Log(Words)	1.209	*	4.941	***	0.066	**	0.097		2.333		-0.630	
	(0.667)		(1.343)		(0.267)		(0.731)		(1.583)		(0.796)	
No. Observations	136		136		136		136		136		136	
R^2	0.267		0.349		0.356		0.393		0.100		0.639	
F-Stat	5.112		7.509		7.733		9.056		2.553		24.680	
AIC	2.742		4.142		0.914		2.924		4.471		3.095	

Notes: This table reports the regression estimates of the linear regression model described in Eq.(5.A) and Eq.(5.B) where the dependent variable is the absolute value of daily *return* (Panel A) or natural log of *volume* (Panel B) on the front contract SP500 Index (*SPX*) future, 10 Year Note (*TY*) future, or USD Index (*DXY*) future. Note that the return calculated for the 10 Year Note is based on the implied yield rather than the price change. The independent variables include the *target suprise* (identified using the near contract Fed Funds contract at in Eq. (1)), and the *pa th surprise* (determined using innovations in the 1-year ahead eurodollar interest rate future contract) resulting from FOMC monetary policy decisions, together with variables indicating the *readability* (measured using the Flesch-Kincaid grade level index) and the (natural log) of the total *number of words* in the FOMC statement accompanying decisions. An additional dummy variable is included to signify whether the economy is in *recession* (1) or not (0) as defined by the NBER, and interaction terms are also included. Newey West standard errors, with the lag length chosen by AIC, are reported in parantheses. Sample period: May 1999 - July 2015
*,**,*** denotes significance at the 10%, 5%, and 1% level respectively.

Table 6
The effect of ZIRP on futures market response to FOMC decisions

	SP500 Index		10Y Note		USD Index		SP500 Index		10Y Note Futures		USD Index	
	Panel A: |Returns|						*Panel B: Volume*					
Constant	0.896	***	1.019	***	0.394	***	18.187	***	16.873	**	16.509	***
	(0.019)		(0.025)		(0.007)		(3.352)		(7.748)		(3.360)	
Target Surprise	-3.468	***	-4.216	**	0.329		0.576		-4.233		-2.748	**
	(1.279)		(1.701)		(0.473)		(1.340)		(3.099)		(1.344)	
Path Surprise	-0.371		2.362		-0.933	*	-2.071		0.166		2.546	*
	(1.442)		(1.918)		(0.533)		(1.504)		(3.478)		(1.508)	
Readability	-0.054		-0.193	***	-0.025		-0.389	***	-0.278	**	-0.365	***
	(0.055)		(0.074)		(0.020)		(0.061)		(0.131)		(0.061)	
Log(Words)	0.181		0.595	***	0.070	**	0.161		-0.120		-0.678	
	(0.172)		(0.229)		(0.034)		(0.614)		(1.419)		(0.615)	
ZIRP	0.125	***	0.754	***	-0.005		0.182		4.056		-9.732	**
	(0.029)		(0.040)		(0.011)		(4.433)		(10.247)		(4.444)	
ZIRP*Target Surprise	15.877	***	90.969	***	5.288		4.296		33.740		-3.112	
	(4.124)		(18.787)		(5.225)		(14.481)		(33.474)		(14.517)	
ZIRP*Path Surprise	-5.229		-49.816	***	-7.344	***	4.091		3.308		3.548	
	(4.346)		(5.780)		(1.608)		(4.552)		(10.522)		(4.563)	
ZIRP*Readability	-0.078		-0.094		-0.007		-0.317	**	-0.478	**	-0.322	**
	(0.128)		(0.170)		(0.047)		(0.135)		(0.212)		(0.135)	
ZIRP*Log(Words)	0.214		-0.255		0.017		-0.625		-1.879		1.371	
	(0.375)		(0.498)		(0.139)		(0.878)		(2.029)		(0.880)	
No. Observations	136		136		136		136		136		136	
R^2	0.154		0.119		0.403		0.463		0.093		0.729	
F-Stat	7.097		61.627		9.465		12.05		3.44		37.58	
AIC	2.686		3.257		1.441		2.802		4.477		2.807	

Notes: This table reports the regression estimates of the linear regression model described in Eq.(5.A) and Eq.(5.B) where the dependent variable is the absolute value of daily *return* (Panel A) or natural log of *volume* (Panel B) on the front contract SP500 Index (*SPX*) future, 10 Year Note (*TY*) future, or USD Index (*DXY*) future. Note that the return calculated for the 10 Year Note is based on the implied yield rather than the price change. The independent variables include the *target suprise* (identified using the near contract Fed Funds contract at in Eq. (1)), and the *path surprise* (determined using innovations in the 1-year ahead eurodollar interest rate future contract) resulting from FOMC monetary policy decisions, together with variables indicating the *readability* (measured using the Flesch-Kincaid grade level index) and the (natural log) of the total *number of words* in the FOMC statement accompanying decisions. An additional dummy variable is included to signify whether the Fed Funds target rate has reached the zero-bound (*ZIRP*) (1) or not (0), and interaction terms are also included. Newey West standard errors, with the lag length chosen by AIC, are reported in parantheses. Sample period: May 1999 - July 2015
*,**,*** denotes significance at the 10%, 5%, and 1% level respectively.

Table 7
Estimation of conditional mean and conditional variance using EGARCH(1,1)

	SP500 Index Futures				10Y Note Futures				USD Index Futures			
Panel A: Conditional Mean Equation												
Constant	-0.002		0.006		-0.032	**	-0.033		-0.002		-0.001	
	(0.014)		(0.014)		(0.021)		(0.022)		(0.008)		(0.008)	
Target Surprise	0.968		-7.033	***	-6.855	***	-10.022	***	-1.475	***	-1.773	
	(1.148)		(2.158)		(1.298)		(2.432)		(0.558)		(1.178)	
Path Surprise	-4.247	***	-3.863	**	9.790	***	7.278	***	2.972	***	3.262	***
	(1.505)		(1.889)		(1.655)		(2.278)		(0.741)		(0.833)	
Readability	-0.037		-0.016		-0.113		-0.096		0.012		0.020	
	(0.056)		(0.055)		(0.075)		(0.082)		(0.031)		(0.027)	
Log(Words)	0.140		0.077		0.344		0.292		-0.054		-0.078	
	(0.165)		(0.161)		(0.229)		(0.247)		(0.093)		(0.081)	
Recession			-0.233	***			-0.067				0.029	
			(0.068)				(0.093)				(0.032)	
Recession*Target Surprise			17.109	***			-2.231				1.800	
			(3.939)				(5.431)				(2.319)	
Recession*Path Surprise			-9.254	*			16.536	**			-1.830	
			(5.292)				(7.212)				(3.581)	
Recession*Readability			-0.214				-0.370				0.036	
			(0.244)				(0.347)				(0.170)	
Recession*Log(No. Words)			0.632				1.160				-0.092	
			(0.717)				(1.043)				(0.480)	
Panel B: Conditional Variance Equation												
Constant	-0.087	***	-0.091	***	-0.072	***	-0.065	***	-0.312	***	-1.184	***
	(0.009)		(0.009)		(0.007)		(0.007)		(0.038)		(0.126)	
$\lvert\varepsilon_{t-1}\rvert/\sigma_{t-1}$	0.107	***	0.107	***	0.095	***	0.085	***	0.157	***	0.060	*
	(0.011)		(0.011)		(0.010)		(0.009)		(0.022)		(0.032)	
$\varepsilon_{t-1}/\sigma_{t-1}$	-0.142	***	-0.153	***	-0.348	**	-0.034	***	-0.033	***	-0.045	**
	(0.007)		(0.008)		(0.005)		(0.005)		(0.012)		(0.020)	
$\log(\sigma^2_{t-1})$	0.979	***	0.972	***	0.994	***	0.993	***	0.865	***	0.805	**
	(0.002)		(0.003)		(0.001)		(0.001)		(0.016)		(0.084)	
Target Surprise	0.454		1.804		1.546	***	1.462	**	1.473	*	-3.962	
	(0.507)		(1.127)		(0.466)		(0.736)		(0.760)		(4.877)	
Path Surprise	-0.030		0.504		-2.379	***	-1.805	**	-3.620	***	-0.767	
	(0.652)		(0.936)		(0.461)		(0.708)		(0.879)		(3.967)	
Readability	-0.013	**	-0.013	**	-0.004	**	-0.004	**	-0.002		-0.043	**
	(0.005)		(0.006)		(0.002)		(0.002)		(0.009)		(0.019)	
Log(Words)	-0.021		0.003	***	0.003	***	0.004	**	0.023		0.002	**
	(0.020)		(0.001)		(0.001)		(0.002)		(0.044)		(0.001)	
Recession			0.028	**			0.008	*			0.537	***
			(0.009)				(0.005)				(0.067)	
Recession*Target Surprise			-2.265				0.453				18.947	**
			(1.483)				(1.015)				(7.732)	
Recession*Path Surprise			1.291				-0.581				-20.085	***
			(1.677)				(1.130)				(7.026)	
Recession*Readability			-0.029				-0.061				-0.028	
			(0.023)				(0.046)				(0.090)	
Recession*Log(No. Words)			0.004	***			0.183				0.003	
			(0.001)				(0.132)				(0.616)	
No. Observations	4106		4106		4106		4106		4106		4106	
R^2	0.004		0.011		0.010		0.018		0.011		0.008	
Log-Likelihood	-5774.8		-5750.1		-2023.4		-1978.2		-3034.9		-3054.8	
Durbin Watson	2.150		2.145		2.003		2.002		2.026		2.024	
AIC	2.819		2.812		3.755		3.755		1.485		1.499	

Notes: This table reports the regression estimates of the EGARCH model described in Eq. (6). Panel A reports the conditional mean equation, while Panel B reports the conditional variance equation. The model considers the front contract SP500 Index (*SPX*) future, 10 Year Note (*TY*) future, or USD Index (*DXY*) future. The explanatory variables include the *target suprise* (identified using the near contract Fed Funds contract at in Eq. (1)), and the *path surprise* (determined using innovations in the 1-year ahead eurodollar interest rate future contract) resulting from FOMC monetary policy decisions, together with variables indicating the *readability* (computed as -1 x Flesch-Kincaid grade level index) and the (natural log) of the total *number of words* in the FOMC statement accompanying decisions. An additional dummy variable is included to signify whether the economy is in *recession* (1) or not (0) as defined by the NBER, and interaction terms are also included. Bollerslev-Wooldridge robust standard errors are reported in parantheses. Sample period: May 1999 - July 2015

*,**,*** denotes significance at the 10%, 5%, and 1% level respectively.