Stock Market Reaction to Fed Funds Rate Surprises: State Dependence and the Financial Crisis

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Abstract

This paper examines the impact of Federal Funds rate (FFR) surprises on stock returns in the United States over the period 1989-2009, focusing on the impact of the recent financial crisis. We find that prior to the crisis, stock prices increased as a response to unexpected FFR cuts. State dependence is also identified with stocks exhibiting larger increases when interest rate easing coincided with recessions, bear stock markets, and tightening credit market conditions. However, an important structural shift took place during the financial crisis, which changed the stock market response to FFR shocks, as well as the nature of state dependence. Specifically, during the crisis period stock market participants did not react positively to unexpected FFR cuts. Our results highlight the severity of the recent financial turmoil episode and the ineffectiveness of conventional monetary policy close to the zero lower bound for nominal interest rates.

JEL classification: C32; E44; E52; G01; G14

Keywords: Monetary Policy; Stock Market; State Dependence; Financial Crisis

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"For the bears, low rates are a sign of the desperation of central bankers, and an indication that economic growth will be subdued for some time to come." (The Economist, 18/09/2010)

1. Introduction

The financial crisis that commenced in late 2007 has been global in nature and of an unprecedented magnitude, as compared to previous episodes of financial turmoil. It has led to historically low interest rates in most advanced economies. In the United States (US), the Federal Funds rate (FFR) reached the zero lower bound in December 2008 and subsequently the Fed adopted a non-conventional monetary policy. The relationship between monetary policy and stock market performance has been extensively studied in the previous literature using a variety of empirical approaches, ranging from vector autoregressive models to event studies (see e.g. Cook and Hahn, 1989; Jensen and Johnson, 1995; Thorbecke, 1997; Bernanke and Kuttner, 2005). Previous studies on the US stock market, have widely documented a positive reaction to expansionary monetary policy surprises and state dependence, with the aforementioned reaction being stronger during 'bad times' of negative economic growth and deteriorating financial conditions (see e.g. Basistha and Kurov, 2008; Kurov, 2010).

Nevertheless, these studies focus on the pre-crisis period and therefore an important question is naturally raised regarding the nature of the relationship between monetary policy and stock market performance during the financial crisis. It is not clear, a priori, how stock market participants will react to interest rate cuts when uncertainty in the macro-financial environment is heightened and monetary policy moves closer to the zero lower bound. In fact, since the onset of the credit crunch and up until early 2009, stock market investors have faced falling stock prices

together with sharp cuts in interest rates, indicating that the inverse relationship between interest rates and stock market valuation has weakened.

Since anticipated policy actions should have already been incorporated in to stock market participants' investment decisions, in line with market efficiency arguments, most of the previous studies focus on the reaction of stock returns to the unexpected component of interest rate changes. In agreement with these studies, we adopt an event study approach and use the methodology proposed by Kuttner (2001) to calculate monetary policy shocks using daily data from FFR futures contracts. These contracts provide real-time information about investors' expectations regarding future interest rates. As noted in previous research, endogeneity may impose potential econometric problems since monetary policy can be itself reacting to stock market developments (see Rigobon and Sack, 2003). Nevertheless, the problem of endogeneity in the relationship between monetary policy and stock market performance should be less potent when higher frequency data, such as daily data, are used within an event study framework (see e.g. Bredin et al., 2009; Chen, 2007; Kurov, 2010).

In this paper we investigate the impact of FFR surprises on US stock returns over the period 1989-2009. As far as we are aware this is the first such paper to analyse data from both the recent financial crisis and the pre-crisis periods. Our results can be summarised as follows. First, in line with previous literature, we find that prior to the recent financial crisis, stock prices increased as a response to expansionary monetary policy surprises, with an unexpected 1% cut in the FFR being associated with almost a 4% increase in the S&P 500 index. Second, we find that during the pre-crisis period there was state dependence of similar nature to that identified in previous studies. In particular, stock prices exhibited larger increases when interest rate easing

occurred during 'bad times' of recession, bear stock markets, and tightening credit market conditions, indicating asymmetries in the stock market response to monetary policy.

Third, and most importantly, we show that a structural break took place during the financial crisis period, altering the stock market response to FFR shocks, as well as the nature of state dependence with respect to 'good times' versus 'bad times'. Specifically, we find that during the crisis period, stock market participants did not react positively to expansionary FFR surprises. In fact, some of our estimates indicate that there was a statistically significant *negative* stock market response to the large FFR cuts that took place throughout the financial crisis. The lack of a positive response to expansionary FFR shocks between 2007-2009, a period characterised by sharply deteriorating macro-financial conditions and monetary policy operating close to the zero lower bound, suggests that the type of asymmetric behaviour identified in the previous literature for the pre-crisis period, did not materialise during the recent crisis. Our results highlight the severity of the 2007-2009 crisis, reveal the limits of conventional monetary policy at the zero lower bound and are consistent with the Keynesian liquidity trap theory.

The remainder of the paper is structured as follows: Section 2 describes the dataset. Section 3 presents and discusses the empirical findings. Finally, Section 4 concludes.

2. Data and stylised facts

In this section we analyse the effects of 189 FOMC target rate decisions between June 1989 and December 2009.[1] As Bernanke and Mihov (1998), among others, point out, the FFR

[1] In agreement with most of the previous studies we exclude from our analysis the 17 September 2001 target rate announcement, which took place on the first trading day following the 11 September terrorist attacks (see e.g. Jansen and Tsai, 2010).

has been the key policy instrument in the US and therefore unexpected changes in this rate should provide good estimates of policy shocks. Following Kuttner (2001) and Bernanke and Kuttner (2005) we use data from FFR futures contracts in order to derive the unexpected component of the FFR change. While the FFR is a good proxy of monetary policy stance in relatively 'normal' periods (see e.g. Wright, 2011), the last two years of our sample (2007-2009) are quite exceptional. They are marked by the global financial crisis and the use of unconventional policies by the Fed since late 2008, when the zero lower bound for nominal interest rates was reached and the Fed replaced the FFR with its balance sheet as its primary policy instrument.[2]

As Wright (2011, p.4) argues, "...things are murkier at the zero bound...[and]...there isn't as clean a single measure of the overall stance of unconventional monetary policy". Furthermore, unlike information provided by FFR futures contracts, there are no direct real-time measures of investors' expectations regarding the size of asset purchases. Hence, we use FFR shocks as the principal explanatory term in our empirical analysis, keeping in mind that they can be clearly identified as monetary policy shocks throughout most of the sample period, and will not attempt to measure shocks in unconventional policies.[3]

[2] Quantitative easing (QE) involves altering the Fed's balance sheet composition through significant financial asset purchases in order to support credit markets and to provide economic stimulus. Furthermore, the Fed issued press-release statements signalling that the FFR will be kept at the zero bound for a sustained period of time.

[3] Rosa (2012) identifies the surprise component of asset purchases by the Fed using a methodology based upon interpreting the wording of related articles in the Financial Times. As he points out, though, the estimates of the response of US asset prices to his measure of unconventional policy shocks are surrounded by considerable statistical uncertainty and, overall, are not significantly different from the response to an unanticipated FFR cut.

In line with Basistha and Kurov (2008) and Ehrmann and Fratzscher (2009) among others, we utilise both scheduled (165) and unscheduled (24) FOMC meetings.[4] On the day of the FOMC decision, the FFR shock, Δi_t^u, is measured by the change in the implied rate of the current-month FFR futures contract, as traded on the CBOT market, relative to the day before the FOMC announcement, scaled by a factor related to the number of days in the month affected by the change:

$$\Delta i_t^u = \frac{D}{D-d}\left(f_{m,t} - f_{m,t-1}\right), \quad (1)$$

where Δi_t^u is the unexpected target rate change, $f_{m,t}$ is the current-month implied futures rate (100 minus the futures contract price), and D is the number of days in the month.[5] We measure the expected interest rate change, Δi_t^e, as the actual change in the FFR target rate minus the surprise component:

$$\Delta i_t^e = \Delta i_t - \Delta i_t^u . \quad (2)$$

[TABLE 1 HERE]

Descriptive statistics in Table 1 show that the 189 FOMC meetings in our dataset include 83 changes in the FFR, 31 of which were contractionary ($\Delta i_t > 0$), while 52 were expansionary

[4] Regarding the dating of the FOMC meetings, for the pre-February 1994 period, which was characterised by lack of press releases regarding FOMC decisions and ambiguity about the dates of open market operations, we use dates provided by Kuttner (2003). The FOMC started to explicitly announce rate changes on February 1994 in a move towards greater transparency and the corresponding dates are obtained from the Federal Reserve website at http://www.federalreserve.gov/newsevents/press/monetary/2012monetary.htm

[5] This scaling adjustment is necessary because the futures contract's settlement price is based upon the monthly average FFR. Following Bernanke and Kuttner (2005), unscaled changes in the 1-month futures rate are used to calculate the surprise component when the change takes place during the last three days of the month.

($\Delta i_t < 0$). The average interest rate change was equal to -0.05%, ranging from a minimum of -0.75% to a maximum of 0.75%. As shown in Figure 1, large interest rate surprises typically materialise during periods of monetary expansion and during economic deceleration and decline. Figure 2 plots the BAA-10 year US Treasury bond spread, with the shaded area showing periods where the credit spread exceeds its sample average. These periods of higher credit risk typically overlap with recessionary episodes. A similar pattern emerges from Figure 3 which shows that periods of persistent stock market declines and worsening overall financial conditions tend to materialise during economic contractions. Figure 3 also highlights the severity of the recent financial crisis with the financial conditions index exhibiting an unprecedented decline.

An important stylised fact which emerges from our preliminary analysis is that recessionary/high financial risk periods are associated with large unexpected FFR cuts. This fact will be taken into account in our econometric analysis since stock market participants may exhibit an alternative response to interest rate cuts when there is heightened macro-financial uncertainty and interest rates move closer to the zero lower bound.[6]

[FIGURES 1-3 HERE]

3. Econometric models and results

3.1 Baseline analysis

We begin our empirical investigation by regressing S&P 500 stock returns during FOMC

[6] In the aftermath of the Lehman Brothers collapse in autumn 2008, risk aversion peaked and flight to safety trading saw a significant rebalancing of global investment portfolios, away from declining equities and towards government bonds. This led to a major decline in the US 10 year Treasury bond yield, from 4% in September 2008 to 2% in December 2008.

meeting dates on a constant and unexpected FFR changes [7]:

$$r_t = \alpha + \beta \Delta i_t^u + e_t \,, \tag{3}$$

where stock returns, r_t, are defined as the first difference of the natural log of the S&P 500 index (S_t) on close of the day of the FOMC meeting, relative to the previous trading day: $r_t = 100 * (\ln S_t - \ln S_{t-1})$. (4)

The OLS estimation results with Newey-West robust standard errors are presented in Table 2. The full sample results indicate that the stock market response to the surprise component of FFR changes is statistically insignificant.[8] This finding is in contrast with the results from the previous literature. In fact, as shown in Table 2, utilising sample periods employed in previous research, which do not include the latest episode of financial crisis and recession, we obtain statistically significant estimates of the effect of monetary policy surprises. For example, using the sample period of Bernanke and Kuttner (2005), i.e. June 1989 - December 2002, the estimate of the unexpected interest rate change is -4.22 and statistically

[7] We also experimented with an alternative specification that includes both expected and unexpected FFR changes, in line with Bernanke and Kuttner (2005). We found that the former variable tends to remain statistically insignificant both in the baseline regression and throughout most of the subsequent models we estimated (results available upon request). The finding of statistical insignificance of expected FFR changes can be interpreted as evidence consistent with stock market efficiency (see also Chulia et al., 2010). Following the majority of previous studies (see e.g. Kurov, 2010) we focused on models which include unexpected FFR changes only.

[8] Similar evidence is obtained when FOMC meetings coinciding with employment release dates and unscheduled meetings are removed from the sample. Furthermore, we removed outliers identified by the difference in fits statistic of Welsh and Kuh (1977) and the unexpected FFR change remains statistically insignificant. These results can be seen in Table A2 in the Appendix. Table A1 in the Appendix presents the dates associated with unscheduled meetings, employment information releases and outliers.

significant at the 5% level.[9] Hence, it appears the inclusion of the 2007-2009 financial crisis in the sample leads to statistically insignificant estimates of the FFR shock. This is consistent with previous evidence for the UK by Gregoriou et al. (2009).

[TABLE 2 HERE]

3.2 Structural change during the financial crisis

In this section we formally examine whether the full sample findings in Table 2 can be explained by structural instability in the stock market response to FFR surprises due to the impact of the global financial crisis. We date the start of the financial crisis at September 2007 when the bank run at Northern Rock occurred, doubts regarding the stability of the global financial system emerged, and the the when first FFR cut (-0.5%) since 2003 occurred. Since the onset of the credit crunch on September 2007 and up until March 2009, stock market participants have experienced falling stock prices in tandem with sharp cuts in interest rates, thereby suggesting a weakening of the inverse relationship between interest rates and stock market valuation. Indeed, as shown in Figure 4, while the relationship between FFR surprises and stock returns during the pre-financial crisis period (June 1989 – August 2007) is negative (see Panel A), since September 2007 it ceases to be negative (see Panel B).[10] Hence, it appears that interest rate

[9] Note that our estimates in Table 2 using alternative sample periods are very similar but not always identical to those reported in the previous studies. The differences can be attributed to model specification issues regarding the inclusion (or not) of expected FFR changes. They may also be related to consideration (or not) of unscheduled FOMC meetings, and the meetings that coincide with employment data releases.

[10] A similar picture emerges when the unscheduled meeting of 22 January 2008, which was previously identified as an outlier, is excluded (see Figure A1 in the Appendix). That meeting led to a 0.75% cut in the FFR, the largest single cut since October 1984, which took the market fully by surprise (Δi_t^u = -0.74%). The stock market reaction to the unexpected monetary policy easing was negative with the S&P 500 stock market index declining by 1.1%.

cuts during the financial crisis period were not perceived as good news by stock market investors.[11] In fact, historically low interest rates may be seen as "a sign of the desperation of central bankers" (The Economist, 18/09/2010), and an indication that future profitability will be lower for some time, thereby signalling bad news for equities.

[FIGURES 4-5 HERE]

We proceed by interacting FFR surprises with a slope dummy variable which intends to capture a change in the relationship between stock returns and FFR shocks during the financial crisis:

$$r_t = \alpha + [\beta_1(1 - D_t^{crisis}) + \beta_2 D_t^{crisis}]\Delta i_t^{u} + e_t, \quad (5)$$

where D_t^{crisis} is a dummy variable equal to one during the crisis period, and zero otherwise. In line with the previous discussion, we date the start of the financial crisis at September 2007 and the end of its most intense phase at March 2009, hence the narrow crisis dummy variable is equal to one between September 2007 - March 2009. We also consider a broader definition of the financial crisis period, whereby its end is dated at December 2009.

[TABLE 3 HERE]

Table 3 reports OLS estimates of Equation (5). Accounting for structural change in the impact of FFR surprises, leads to an increase in the adjusted R^2, from 3% in the full sample no-break results of Table 2 to 7% in Table 3 (see Panel A). Importantly, the stock market response to the unexpected FFR changes prior to the crisis period, as indicated by β_1, is negative and statistically significant. During the pre-crisis period, an unexpected 25-basis-point cut in the FFR was associated with almost a 1% increase in the S&P index, a finding consistent with the

[11] The last FFR cut took place in December 2008 (-0.75%) and the zero lower bound was reached (point II in Figure 5). Since then, the FOMC used a target range for the FFR between 0% and 0.25%.

estimates of Bernanke and Kuttner (2005), implying that unexpected interest rate easing was interpreted as a good signal by stock market participants. However, the estimated stock market response to FFR shocks during the crisis period, as indicated by β_2, is no longer negative. The Wald test for equality of coefficients (H_0: $\beta_1=\beta_2$) supports a statistically significant structural shift in the relationship between stock returns and FFR shocks. These findings are robust to the definition of the crisis dummy variable (broad versus narrow).

In order to account for Bernanke and Kuttner's (2005) argument that unexpected interest rate changes on days of employment data announcements may in fact reflect endogenous responses to the release of this information, in Table 3 Panel B we show results for nine FOMC meetings that coincide with employment data releases which are removed from the sample.[12] The evidence in Panel B is similar to that in Panel A, which includes all FOMC meetings, identifying a negative and statistically significant impact of unexpected interest rate tightening on stock returns before the recent financial crisis, followed by an insignificant effect during the crisis period. Furthermore, excluding unscheduled FOMC meetings in Table 3 Panel C, leads to smaller and statistically insignificant estimates of the pre-crisis impact of FFR surprises and major deterioration in the fit of the model. This finding is consistent with previous evidence by Bernanke and Kuttner (2005) and Basistha and Kurov (2008) for the pre-crisis period.

[TABLE 4 HERE]

Table 4 reports MM weighted least squares estimates (Yohai, 1987) of Equation (5). MM estimates are robust in the presence of a large number of outliers (see also Kurov, 2010). The main difference between the OLS and MM results is that in the latter the coefficient of FFR surprises during the crisis period becomes statistically significant thereby implying a more

[12] Furthermore, the stock market itself may be reacting to the employment data releases (see e.g. Boyd et al., 2005).

pronounced change in the nature of the relationship between interest rate changes and stock market performance. The positivity of β_2 estimates indicates that since September 2007 unexpected FFR cuts were perceived as bad news by stock market investors, thereby signifying a radical shift when compared to the pre-crisis positive stock market response to interest rate easing.

The inability of the Fed to boost stock prices by expansionary interest rate cuts since September 2007 highlights the severity of the recent financial turmoil and reveals the limits of conventional interest rate policies close to the zero lower bound. The rebound in the S&P 500, which had declined by 65% since September 2007, and the decline in credit spreads did not occur until March 2009, when the Fed's asset purchases were expanded, marking the end of the financial crisis' most intense phase. Specifically, at the FOMC meeting of 18 March 2009, it was decided that the programme of QE, initiated in late 2008, would be augmented by adding mortgage-backed securities to the Fed's balance sheet.[13] This development can be justified in the light of previous empirical research on the effects of unconventional monetary policies. These studies typically identify a positive impact on economic activity, as well as a negative effect on financial market spreads and/or yields, from such unconventional policies (see e.g. Gambacorta et al., 2012; Gagnon et al., 2011; Wright, 2011). Hence, the stock market rebound at the

[13] As Farmer (2012) argues, movements in mortgage-backed securities prices should be closely correlated with those in stock prices, since both asset classes tend to perform well when the economy recovers. Farmer (2012) points out that the stock price increases that commenced in March 2009, at the beginning of large-scale mortgage-backed securities purchases by the Fed, came to an abrupt stop in April 2010, when the first round of QE ended. Furthermore, the announcement of the second round of QE in August 2010 coincided closely with another major stock market reversal.

announcement of QE can be seen as reflecting expectations of an improved future macro-financial environment.

3.3 State dependence and the financial crisis

Finding that interest rate cuts had no positive impact or even depressed stock prices during the recent financial crisis may seem as a surprising result, when seen in the light of previous studies, while at the same time ignoring the fact that monetary policy was operating close to and, after late 2008, at the zero lower bound. These studies typically identify a stronger stock market rebound when monetary expansion coincides with 'bad times' of negative economic growth, bear stock markets, and tightening credit market conditions (see e.g. Chen, 2007; Basistha and Kurov, 2008; Jansen and Tsai, 2010; Kurov, 2010).[14] Since the 2007-2009 crisis was characterised by a credit crunch, an unprecedented deterioration in overall financial conditions and a major recession one would expect to find a strongly negative FFR shocks coefficient during that period. However, as we saw in Tables 3 and 4, the aforementioned coefficient is either insignificant or positive and significant. This suggests that an important structural shift has taken place in the nature of state dependence which characterises the stock market response to interest rate surprises.

In order to ensure we obtain results consistent with the previous literature for the pre-crisis period, we estimate Equation (6) which interacts FFR surprises with a slope interactive

[14] Note that there are some studies that measure monetary policy surprises using survey data, rather than data on FFR futures as in this paper, and do not identify state dependence with respect to the state of the economy and credit market conditions (see e.g. Andersen et al., 2007).

variable that intends to capture state dependence in the relationship between stock returns and monetary policy shocks with respect to 'good times' versus 'bad times':

$$r_t = \alpha + [\beta_1(1 - D_t^{st}) + \beta_2 D_t^{st}]\Delta i_t^u + e_t, \quad (6)$$

where D_t^{st} is defined as follows: (a) real time recession probability obtained from the dynamic-factor markov-switching model of Chauvet and Piger (2008); (b) dummy variable equal to one when the BAA-10 year Treasury bond spread exceeds its full sample historical average, signifying high credit risk periods, and zero otherwise; (c) dummy variable equal to one when the S&P 500 stock price index is lower than its full sample 3 year moving average, indicating a bear stock market regime, and zero otherwise.[15]

[TABLE 5 HERE]

The MM weighted least squares estimates of Equation (6) in Table 5 show that, in agreement with the previous literature, during the pre-crisis period the impact of monetary policy surprises on stock returns is stronger during recessionary episodes, and periods of sustained stock price declines and worsening credit market conditions.[16] More specifically, the estimated stock market response to interest rate shocks during 'bad times', as indicated by β_2, is statistically significant and more negative as compared to the response during 'good times', as indicated by β_1. For example, excluding FOMC meetings which coincide with employment data releases, the results in Panel B show that prior to recent financial crisis, an unexpected 100-basis-point cut in the FFR was associated with almost a 9% increase in the S&P index during periods of high credit

[15] While there is no commonly accepted definition in the literature, ours is consistent with, what Jansen and Tsai (2010) term as, the 'common understanding' of a bear stock market regime, that is, a period of significant and sustained stock price declines.

[16] Similar results, available upon request, are obtained with OLS estimation.

risk, while the corresponding increase was much smaller, around 2%, during periods of low credit risk. The Wald test for equality of the FFR shocks coefficient across 'good times' and 'bad times' typically rejects the null hypothesis at the 5% level of significance. Thus, the empirical results in Table 5 confirm the findings from previous studies on the pre-crisis period by identifying statistically and economically significant state dependence in the relationship between FFR shocks and stock market performance, in line with the credit channel of monetary policy transmission.

Finally, we estimate Equation (7) which interacts FFR surprises with both the state dependence slope variable (D_t^{st}) and the crisis period dummy variable (D_t^{crisis}) in an effort to separate between the impact of FFR shocks during 'good times' and 'bad times' across the pre-crisis and crisis periods:

$$r_t = \alpha + [\beta_1(1-D_t^{st})(1-D_t^{crisis}) + \beta_2 D_t^{st}(1-D_t^{crisis}) + \beta_3(1-D_t^{st})D_t^{crisis} + \beta_4 D_t^{st} D_t^{crisis}]\Delta i_t^{u} + e_t . \qquad (7)$$

The MM weighted least squares estimates of Equation (7) are shown in Table 6. [17] In line with the results in Table 5 they reveal that prior to the financial crisis the stock market response to FFR surprises during 'bad times' (β_2) dominates its 'good times' counterpart (β_1). The finding of state dependence is confirmed by the Wald test results (H_0: $\beta_1=\beta_2$). The negativity of β_2 estimates reinforces the idea that prior to the crisis period expansionary interest rate shocks were seen as goods news by stock market participants. Nevertheless, an important structural shift occurred during 2007-2009 concerning the impact of FFR shocks during 'bad times'. The Wald test results show that the null hypothesis $\beta_2=\beta_4$ is strongly rejected. The positivity and statistical significance of the β_4 estimates reveal a negative stock market response to unexpected FFR cuts

[17] Similar results, available upon request, are obtained with OLS estimation.

within a sharply deteriorating macro-financial environment.[18] These findings remain consistent across all three panels in Table 6, thereby suggesting that our results are robust to the treatment of unscheduled FOMC meetings and those which coincided with employment data releases.

[TABLE 6 HERE]

The empirical results in Table 6 are very enlightening and novel since not only do they confirm the findings of the pre-crisis literature, by identifying state dependence in the stock market response to FFR shocks, but at the same time reveal that an important structural break occurred in late 2007, affecting the nature of state dependence itself. Our results show that since September 2007 stock market participants did not react positively to expansionary FFR surprises, highlighting the severity of the 2007-2009 financial crisis. The crisis was global in nature and of an order of magnitude significantly larger, as compared to previous episodes of recession and financial instability, led to a major flight to the perceived safety of Treasury bonds, which further depressed stock prices, and rendered conventional monetary policy ineffective.

3.4 Further robustness checks

We further examined the robustness of our findings in a number of ways.[19] First, we experimented with alternative variables to capture state dependence with respect to 'good times' versus 'bad times' and found that the results remain quantitatively and qualitatively similar.

[18] It should be noted that the crisis period is dominated by worsening financial conditions. Hence, the high credit risk and bear market dummy variables are active (equal to one) throughout most of the post September 2007 period. This implies that there are only a few instances where the interpretation of β_3, as the 2007-2009 stock market response to FFR shocks during 'good times', makes sense. Due to the limited number of related observations the standard error of β_3 is quite large.

[19] To save space these results are not reported but are available upon request.

Specifically, in order to proxy the state of the economy we used a dummy variable equal to one when there is a recession according to the NBER, while a dummy variable based upon the BAA-AAA corporate bond spread was employed to measure credit market conditions (see also Basistha and Kurov, 2008). Moreover, we used an alternative proxy for bear market conditions, a dummy variable equal to one if the 3 year S&P 500 return is less than -20%. Finally, we trimmed from our sample period the last year (2009), that contained no interest rate changes since the zero lower bound was reached in December 2008, and obtained almost identical results with the sample period that extends until December 2009.

4. Conclusions

This paper investigates the impact of FFR surprises on US stock returns between 1989-2009. We find that prior to the recent financial crisis, stock prices increased as a response to unexpected FFR cuts. Furthermore, in line with the previous literature, we identify state dependence during the pre-crisis period. Specifically, stock prices exhibited larger increases when interest rate easing coincided with 'bad times' of recession, bear stock markets, and tightening credit market conditions, thereby indicating asymmetries in the stock market reaction to FFR shocks. We also show, however, that an important structural shift took place in September 2007, at the onset of the financial crisis, changing the nature of state dependence. We find that during the crisis period stock market participants did not react positively to unexpected FFR cuts. Our results highlight the severity of the recent financial turmoil episode and the ineffectiveness of conventional monetary policy close to the zero lower bound for nominal interest rates.

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Appendix

Table A1: List of unscheduled meetings, employment releases and outlier dates

Unscheduled	Employment	Outliers
05-Jun-89		
	07-Jul-89	
26-Jul-89		
16-Oct-89		16-Oct-89
06-Nov-89	06-Nov-89	
13-Jul-90		
29-Oct-90		
07-Dec-90	07-Dec-90	
08-Jan-91		
01-Feb-91	01-Feb-91	
08-Mar-91	08-Mar-91	
30-Apr-91		
06-Aug-91	06-Aug-91	
		21-Aug-91
13-Sep-91		
31-Oct-91		
06-Dec-91	06-Dec-91	
20-Dec-91		
09-Apr-92		
	02-Jul-92	02-Jul-92
04-Sep-92	04-Sep-92	
		04-Feb-94
18-Apr-94		
15-Oct-98		15-Oct-98
03-Jan-01		03-Jan-01
		20-Mar-01
18-Apr-01		18-Apr-01
		18-Sep-07
22-Jan-08		22-Jan-08
		18-Mar-08
08-Oct-08		
		16-Dec-08

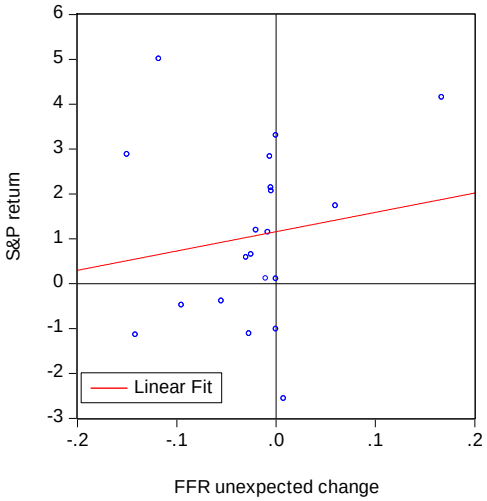
Notes: In Table A1 outliers were identified using the difference in fits (DFITS) statistic.

Table A2: Response of stock returns to unexpected FFR changes, OLS

	Obs	α	β	Adj R^2
Panel A (Excl Empl)	180	0.30***	-2.72	0.05
		(0.10)	(2.31)	
Panel B (Excl Empl & Unsch)	163	0.30***	-1.76	0.00
		(0.11)	(2.12)	
Panel C (Excl Outliers)	177	0.21**	-0.98	0.00
		(0.09)	(0.94)	

Notes: Table A2 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation (3) over FOMC meeting dates: $r_t = \alpha + \beta \Delta i_t^u + e_t$. Δi^u denotes unexpected FFR target rate changes. Sample period is June 1989 - December 2009. Obs indicate the number of relevant FOMC meetings. The 17 September 2001 FOMC meeting is excluded in all Panels. Panel A excludes FOMC meetings on days with employment report releases. Panel B further excludes unscheduled FOMC meetings. Panel C excludes all FOMC meetings associated with outliers identified using the difference in fits (DFITS) statistic. Standard errors in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Figure A1: FFR unexpected change and stock returns during financial crisis and excluding 22/01/2008 FOMC meeting



Notes: Figure A1 scatter plots the FFR unexpected change and S&P 500 daily returns on FOMC meeting dates using data covering the financial crisis period (September 2007 to December 2009) and excluding the FOMC meeting of 22 January 2008. The linear fit is the OLS regression line.

TABLES AND FIGURES

Table 1: Descriptive statistics for FFR changes and unexpected changes

	Obs	Min	Max	Mean	St.Dev
All meetings					
Δi	189	-0.75	0.75	-0.05	0.23
Δi^u	189	-0.74	0.17	-0.03	0.10
Contractionary					
$\Delta i > 0$	31	0.25	0.75	0.30	0.12
Δi^u	31	-0.05	0.14	0.02	0.05
Expansionary					
$\Delta i < 0$	52	-0.75	-0.25	-0.35	0.15
Δi^u	52	-0.74	0.17	-0.11	0.15
No Change					
$\Delta i = 0$	106	0.00	0.00	0.00	0.00
Δi^u	106	-0.20	0.12	-0.01	0.04

Notes: Δi and Δi^u denote FFR target rate changes and unexpected changes, respectively, on FOMC meeting dates over the period June 1989 - December 2009.

Table 2: Response of stock returns to unexpected FFR changes across different sample periods, OLS estimates

Sample Period	Obs	α	β	Adj R^2
Full Sample	189	0.28***	-2.07	0.03
Jun-89 to Dec-09		(0.10)	(1.90)	
Chulia et al. (2010)	80	0.21	-9.56***	0.36
May-97 to Oct-06		(0.14)	(1.47)	
Bernanke and Kuttner (2005)	131	0.12	-4.22**	0.13
Jun-89 to Dec-02		(0.12)	(1.84)	
Kurov (2010)	137	0.15	-3.87**	0.11
Feb-90 to Nov-04		(0.11)	(1.85)	

Notes: Table 2 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation (3) over FOMC meeting dates: $r_t = \alpha + \beta \Delta i_t^u + e_t$. Δi^u denotes unexpected FFR target rate changes. Obs indicate the number of FOMC meetings. The 17 September 2001 FOMC meeting is excluded. Standard errors in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 3: Response of stock returns to unexpected FFR changes controlling for financial crisis, OLS estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
Narrow Crisis	189	0.26**	-3.76**	1.65	[0.02]	0.07
		(0.10)	(1.77)	(1.50)		
Broad Crisis	189	0.26**	-3.74**	1.61	[0.02]	0.07
		(0.10)	(1.77)	(1.51)		
Panel B (Excl Empl)						
Narrow Crisis	180	0.28***	-5.33***	1.68	[0.00]	0.11
		(0.10)	(1.78)	(1.49)		
Broad Crisis	180	0.28***	-5.31***	1.65	[0.00]	0.11
		(0.10)	(1.78)	(1.51)		
Panel C (Excl Empl & Unsch)						
Narrow Crisis	163	0.30***	-1.78	-1.63	[0.99]	0.00
		(0.11)	(1.51)	(11.35)		
Broad Crisis	163	0.30***	-1.74	-1.89	[0.99]	0.00
		(0.11)	(1.51)	(11.35)		

Notes: Table 3 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation (5) over FOMC meeting dates: $r_t = \alpha + [\beta_1(1 - D_t^{crisis}) + \beta_2 D_t^{crisis}]\Delta i_t^u + e_t$. Δi^u denotes unexpected FFR target rate changes. D_t^{crisis} is a dummy variable which is equal to 1 during the crisis period (Narrow crisis: September 2007 - March 2009; Broad crisis: September 2007 - December 2009), and 0 otherwise. Sample period is June 1989 - December 2009. Obs indicates the number of relevant FOMC meetings. Panel A includes all FOMC meetings with the exception of the 17 September 2001 meeting. Panel B excludes FOMC meetings on days with employment report releases. Panel C further excludes unscheduled FOMC meetings. Standard errors in parentheses. *P*-values from the Wald test for equality of coefficients (*F*-statistic) in square brackets. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 4: Response of stock returns to unexpected FFR changes controlling for financial crisis, Robust MM estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
Narrow Crisis	188	0.19***	-1.81**	2.09*	[0.00]	0.03
		(0.07)	(0.83)	(1.10)		
Broad Crisis	188	0.20***	-1.77**	2.05*	[0.01]	0.03
		(0.07)	(0.83)	(1.09)		
Panel B (Excl Empl)						
Narrow Crisis	179	0.19***	-3.91***	2.09*	[0.00]	0.10
		(0.07)	(0.93)	(1.08)		
Broad Crisis	179	0.19***	-3.64***	2.05*	[0.00]	0.09
		(0.07)	(0.92)	(1.05)		
Panel C (Excl Empl & Unsch)						
Narrow Crisis	161	0.26***	-1.80	18.49***	[0.00]	0.13
		(0.06)	(1.19)	(3.83)		
Broad Crisis	161	0.26***	-1.72	17.34***	[0.00]	0.11
		(0.07)	(1.21)	(3.90)		

Notes: Table 4 reports Robust MM weighted least squares estimates (Yohai, 1987) of Equation (6) over FOMC meeting dates: $r_t = \alpha + [\beta_1(1 - D_t^{crisis}) + \beta_2 D_t^{crisis}]\Delta i_t^u + e_t$. Δi^u denotes unexpected FFR target rate changes. D_t^{crisis} is a dummy variable which is equal to 1 during the crisis period (Narrow crisis: September 2007 - March 2009; Broad crisis: September 2007 - December 2009), and 0 otherwise. Sample period is June 1989 - December 2009. Obs indicates the number of relevant FOMC meetings. Panel A includes all FOMC meetings with the exception of the 17 September 2001 meeting. Panel B excludes FOMC meetings on days with employment report releases. Panel C further excludes unscheduled FOMC meetings. Standard errors in parentheses. *P*-values from the Wald test for equality of coefficients (*F*-statistic) in square brackets. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 5: Response of stock returns to unexpected FFR changes controlling for state-dependence, pre-financial crisis, Robust MM estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
(a) Prob. Recession	166	0.17**	-1.90**	0.94	[0.35]	0.01
		(0.06)	(0.92)	(2.66)		
(b) BAA-10Yr TB Spread	168	0.17**	-1.23	-6.90***	[0.00]	0.17
		(0.07)	(0.97)	(1.16)		
(c) S&P Bear Market	167	0.17***	-0.82	-8.05***	[0.00]	0.16
		(0.06)	(0.82)	(1.48)		
Panel B (Excl Empl)						
(a) Prob. Recession	159	0.15**	-2.75***	-11.81***	[0.00]	0.18
		(0.07)	(1.05)	(2.75)		
(b) BAA-10Yr TB Spread	159	0.18***	-1.97*	-8.57***	[0.00]	0.27
		(0.07)	(1.10)	(1.13)		
(c) S&P Bear Market	158	0.17***	-2.10**	-8.01***	[0.00]	0.17
		(0.06)	(0.99)	(1.43)		
Panel C (Excl Empl & Unsch)						
(a) Prob. Recession	144	0.20***	-0.79	-11.31**	[0.06]	0.03
		(0.06)	(1.24)	(5.06)		
(b) BAA-10Yr TB Spread	144	0.21***	0.41	-5.59***	[0.00]	0.05
		(0.06)	(1.35)	(1.82)		
(c) S&P Bear Market	144	0.21***	-0.50	-6.82***	[0.02]	0.04
		(0.06)	(1.25)	(2.46)		

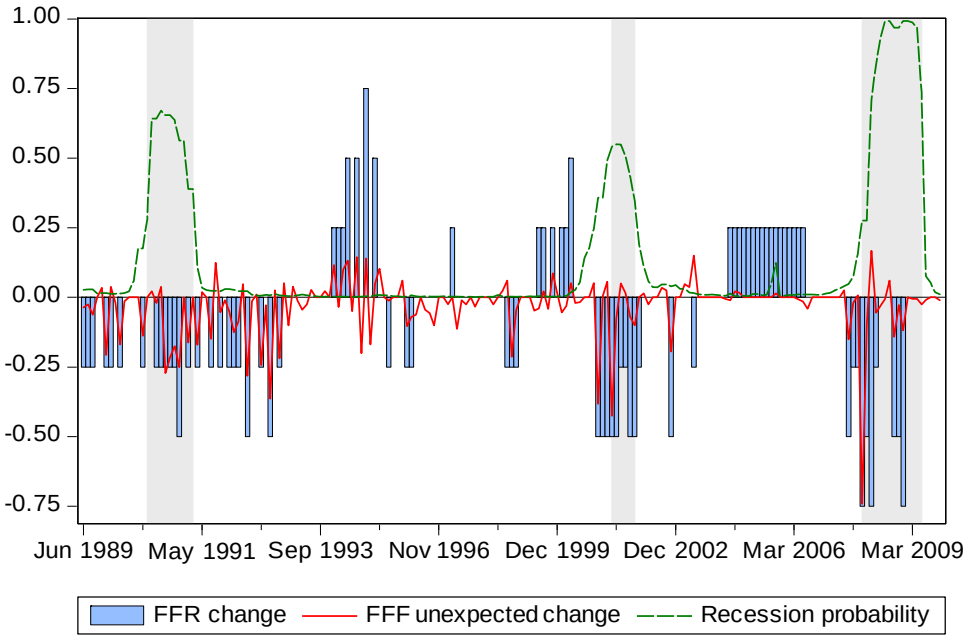
Notes: Table 5 reports Robust MM weighted least squares estimates (Yohai, 1987) of Equation (6) over FOMC meeting dates: $r_t = \alpha + [\beta_1(1 - D_t^{st}) + \beta_2 D_t^{st}]\Delta i_t^u + e_t$. Δi^u denotes unexpected FFR target rate changes. D_t^{st} is defined as follows: (a) real time recession probability obtained from the dynamic-factor markov-switching model of Chauvet and Piger (2008); (b) dummy variable equal to one when the BAA-10 year Treasury bond spread exceeds its full sample historical average, and zero otherwise; (c) dummy variable equal to one when the S&P 500 stock price index is lower than its full sample 3 year moving average, and zero otherwise. Sample period is June 1989 - August 2007. Obs indicates the number of relevant FOMC meetings. Panel A includes all FOMC meetings with the exception of the 17 September 2001 meeting. Panel B excludes FOMC meetings on days with employment report releases. Panel C further excludes unscheduled FOMC meetings. Standard errors in parentheses. *P*-values from the Wald test for equality of coefficients (*F*-statistic) in square brackets. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 6: Response of stock returns to unexpected FFR changes controlling for financial crisis and state-dependence, Robust MM estimates

	Obs	α	β_1	β_2	β_3	β_4	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$	Adj R^2
Panel A (All Meetings)											
(a) Prob. Recession	185	0.21***	-1.82*	0.93	-11.19***	34.58***	[0.39]	[0.00]	[0.00]	[0.00]	0.16
		(0.07)	(0.97)	(2.83)	(2.76)	(6.05)					
(b) BAA-10Yr TB Spread	188	0.20***	-1.16	-7.06***	-18.44***	2.50**	[0.00]	[0.00]	[0.00]	[0.00]	0.20
		(0.07)	(1.03)	(1.20)	(5.74)	(1.25)					
(c) S&P Bear Market	186	0.20***	-0.75	-8.08***	5.91	2.25**	[0.00]	[0.62]	[0.36]	[0.00]	0.13
		(0.07)	(0.87)	(1.56)	(7.27)	(1.13)					
Panel B (Excl Empl)											
(a) Prob. Recession	178	0.20***	-2.62**	-11.92***	-11.27***	34.74***	[0.00]	[0.00]	[0.00]	[0.00]	0.27
		(0.07)	(1.09)	(2.85)	(2.71)	(5.93)					
(b) BAA-10Yr TB Spread	179	0.20***	-1.90	-8.77***	-18.41***	2.42**	[0.00]	[0.00]	[0.00]	[0.00]	0.28
		(0.07)	(1.18)	(1.19)	(5.51)	(1.18)					
(c) S&P Bear Market	177	0.20***	-2.07**	-8.06***	5.97	2.21**	[0.00]	[0.60]	[0.27]	[0.00]	0.15
		(0.07)	(1.05)	(1.54)	(7.14)	(1.11)					
Panel C (Excl Empl & Unsch)											
(a) Prob. Recession	161	0.24***	-0.64	-12.08**	-0.78	28.55***	[0.05]	[0.08]	[0.99]	[0.00]	0.16
		(0.06)	(1.31)	(5.46)	(11.45)	(6.84)					
(b) BAA-10Yr TB Spread	162	0.26***	0.62	-5.80***	-17.97***	19.06***	[0.01]	[0.00]	[0.00]	[0.00]	0.21
		(0.06)	(1.45)	(1.97)	(5.18)	(3.82)					
(c) S&P Bear Market	161	0.24***	-0.38	-7.02***	6.64	23.12***	[0.02]	[0.04]	[0.31]	[0.00]	0.19
		(0.06)	(1.29)	(2.53)	(6.71)	(4.10)					

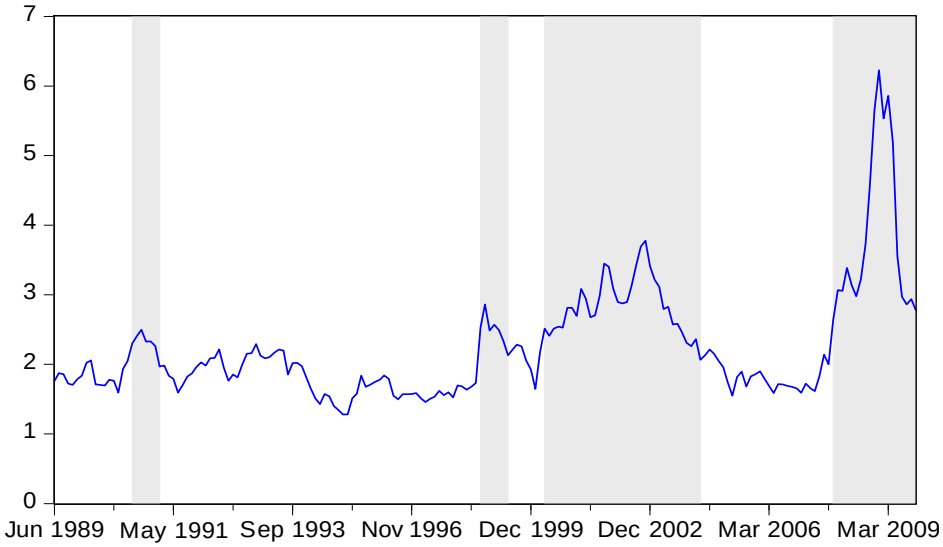
Notes: Table 6 reports Robust MM weighted least squares estimates (Yohai, 1987) of Equation (7) over FOMC meeting dates: $r_t = \alpha + [\beta_1(1 - D_t^{st})(1 - D_t^{crisis}) + \beta_2 D_t^{st}(1 - D_t^{crisis}) + \beta_3(1 - D_t^{st}) D_t^{crisis} + \beta_4 D_t^{st} D_t^{crisis}]\Delta i_t^{u} + e_t$. Δi^{u} denotes unexpected FFR target rate changes. D_t^{st} is defined as follows: (a) real time recession probability obtained from the dynamic-factor markov-switching model of Chauvet and Piger (2008); (b) dummy variable equal to one when the BAA-10 year Treasury bond spread exceeds its full sample historical average, and zero otherwise; (c) dummy variable equal to one when the S&P 500 stock price index is lower than its full sample 3 year moving average, and zero otherwise. D_t^{crisis} is a dummy variable which is equal to 1 during the crisis period (September 2007 - March 2009), and 0 otherwise. Sample period is June 1989 - December 2009. Obs indicates the number of relevant FOMC meetings. Panel A includes all FOMC meetings with the exception of the 17 September 2001 meeting. Panel B further excludes FOMC announcements on days with employment report releases. Panel C further excludes unscheduled FOMC meetings. Standard errors in parentheses. *P*-values from the Wald test for equality of coefficients (*F*-statistic) in square brackets. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Figure 1: FFR change and probability of recession



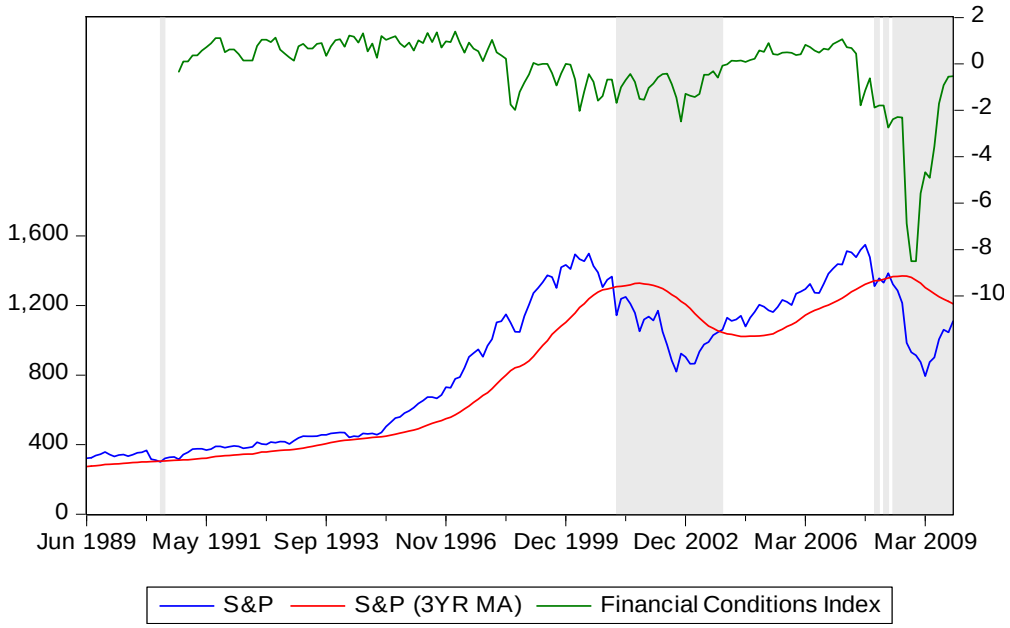
Notes: Figure 1 shows the FFR change and FFR unexpected change on FOMC meeting dates over the period June 1989 to December 2009. The shaded area is associated with NBER recession dates. The dotted line indicates the real time recession probability obtained from the dynamic-factor markov-switching model of Chauvet and Piger (2008). The recession probability data is available at: http://pages.uoregon.edu/jpiger/us_recession_probs.htm.

Figure 2: BAA-10 year Treasury bond spread



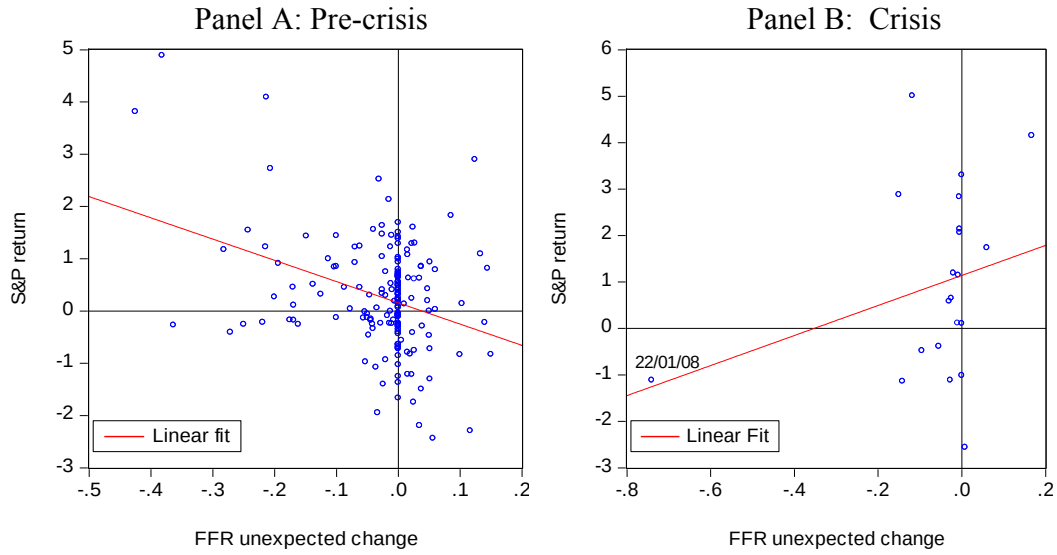
Notes: Figure 2 shows the spread between the Moody's classified BAA corporate bond yield and the 10 year Treasury bond yield on FOMC meeting dates over the period June 1989 to December 2009. The shaded area is associated with FOMC meetings when the BAA-10 year Treasury bond spread exceeded its full sample historical average, indicating tightening credit market conditions.

Figure 3: S&P 500 stock price index and financial conditions index



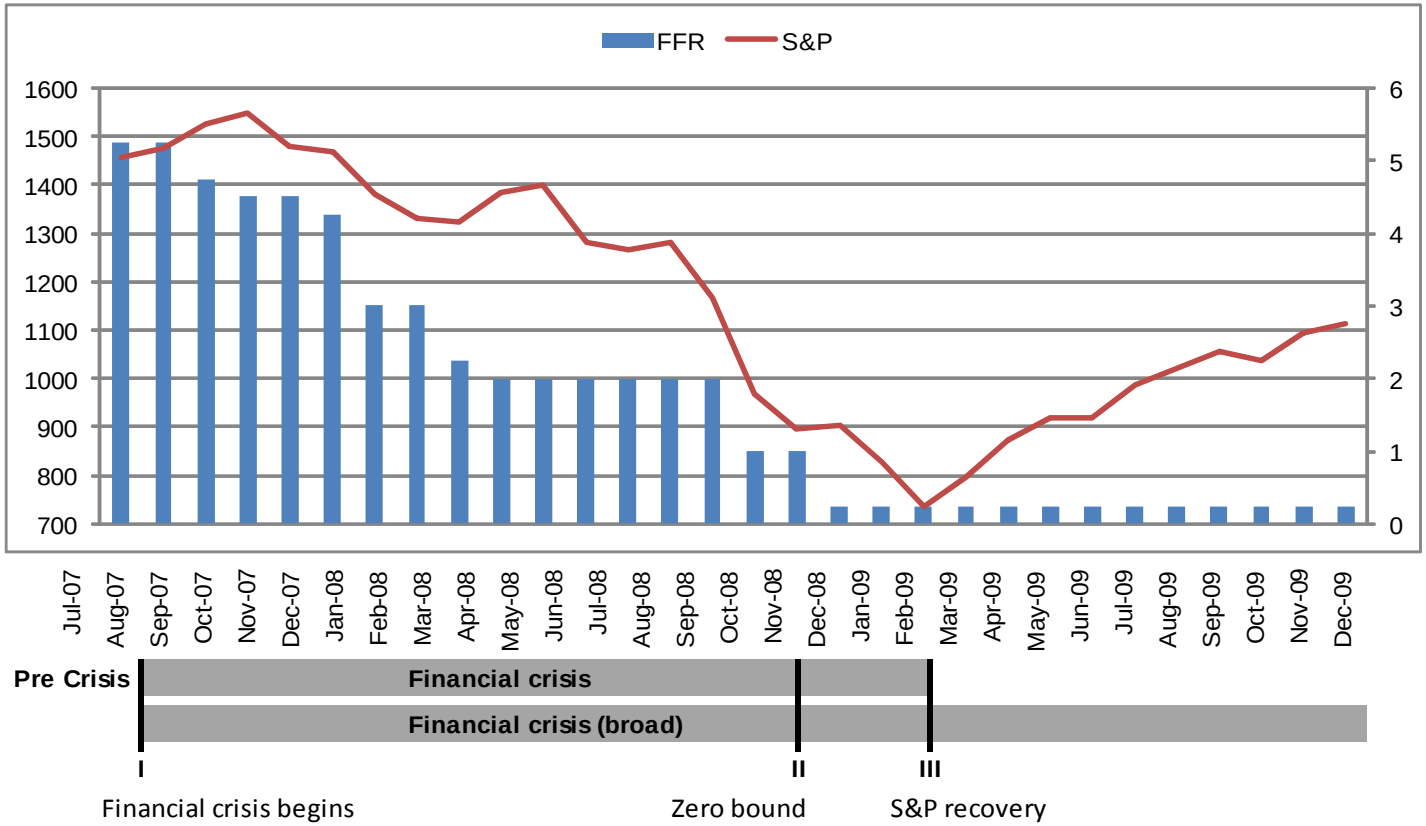
Notes: Figure 3 shows the S&P 500 stock price index and its 3 year moving average (measured on left vertical axis) and the Bloomberg financial conditions index (measured on right vertical axis) on FOMC meeting dates over the period June 1989 to December 2009. A rise in the FCI is indicative of improving financial conditions. The shaded area is associated with FOMC meetings when the S&P 500 index was below its full sample 3 year moving average indicating bear market conditions.

Figure 4: FFR unexpected change and stock returns



Notes: Figure 4 scatter plots the FFR unexpected change and S&P 500 daily returns on FOMC meeting dates. Panel A uses data covering the pre-financial crisis period (June 1989 to August 2007). Panel B uses data covering the financial crisis period (September 2007 to December 2009). The linear fit is the OLS regression line.

Figure 5: FFR and S&P 500 stock price index during financial crisis



Notes: Figure 5 shows the S&P 500 stock price index (measured on left vertical axis) and the FFR (measured on the right vertical axis) over the period July 2007 to December 2009. Point I marks the start of the financial crisis at September 2007. Point II corresponds to December 2008 when the last FFR cut (-0.75%) took place (16 December 2008) and the zero lower bound was reached. Point III marks the end of the financial crisis' most intense phase at March 2009.