Asset Prices and Federal Funds Rate Shocks:
The 2007-2009 Financial Crisis

Mr Aman Saggu., B.S., M.S.,

A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

The Adam Smith Business School

The University of Glasgow

February 2014

104,345 Words

Thesis Abstract

This empirically motivated doctoral thesis investigates the impact of Federal Funds rate (FFR) surprises on asset prices between Jun-89 to Dec-12, with a focus on the effect of the 2007-2009 financial crisis on this relationship. This is an important question to evaluate because the Fed initially responded to the crisis by using conventional monetary policy (i.e. target FFR cuts) to influence financial, monetary and economic conditions in the broader macroeconomy. This was also the primary policy tool of the Fed throughout the majority of the crisis period (Sep-07 to Dec-08) and non-conventional monetary policy measures were only used when the target FFR approached the zero-lower bound. In Chapter 1 we outline the thesis and in Chapter 2 we review empirical studies related to this thesis.

Chapter 3 is the first empirical chapter of this thesis in which we investigate the impact of FFR surprises on US stock returns. We demonstrate that a structural shift occurred during the recent crisis which significantly altered the US stock market response to FFR shocks. In particular, stock returns were shown to be associated with non-positive or negative responses to unexpected FFR cuts during the crisis. The lack of a positive stock response to FFR shocks during the crisis implies that unexpected FFR cuts ceased to be seen as good news by stock market investors, and were rather interpreted as signals from the Fed of worsening macro-financial conditions.

We extend our empirical analysis to the US Treasury market and gold market in Chapter 4. Our estimates show that very short-term maturity (3-Month), longer-term (5-Year, 10-Year and 30-Year) maturity Treasury yields and gold returns were associated with significantly larger magnitude declines in response to unexpected FFR cuts during the crisis. The stronger response of these securities to FFR shocks during the crisis implies that unexpected FFR cuts signalled worsening future economic prospects and triggered a rebalancing of investment portfolios away from falling equities and towards these safe-haven assets. These cuts prompted significantly higher demand for highly liquid securities such as 3-Month T-Bills and gold. The stronger response of longer-term Treasuries implies that investors anticipated a prolonged downturn and increased demand for longer-term, lower-risk, safe-haven assets.

Finally in Chapter 5 we consider the international context, investigating the transmission of FFR shocks to equity indices across 43 advanced and emerging market countries. We find substantial cross country heterogeneity in the responses of foreign equity index returns to FFR shocks outside the crisis, with positive stock responses to FFR shocks where significant. However, we find even greater heterogeneity in the responses of foreign equity indices to FFR shocks during the crisis, with an unexpected 1% FFR cut being associated with significant 2.53%-7.50% decline across the equity indices of 12 countries, and 2.79%-14.04% increases across the equity indices of 19 countries. Our estimates show that cross country heterogeneity in equity market responses to FFR shocks during the crisis period can only partly be explained in terms of real bilateral integration with the US economy, and find that external borrowing from the rest of the world is also an important determinant. Overall, our estimates in this thesis 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.

Table of Contents

Chapter 1: Outline

Chapter 3: The Stock Market Reaction to Federal Funds Rate Surprises: State-dependence and the Financial Crisis (Empirical Analysis)

Chapter 4: The US Treasury & Gold Market Reaction to Federal Funds Rate Surprises: Flight to Quality and the Financial Crisis (Empirical Analysis)

Chapter 6: Thesis Conclusion

List of Tables

Chapter 3

Chapter 3 ***Appendix***

Chapter 4

List of Figures

Chapter 3

Chapter 4

Chapter 5

Acknowledgments

I would like to thank my supervisors; Professor Ronald MacDonald and Professor Alexandros Kontonikas for their helpful and insightful comments throughout my time at the Adam Smith Business School. A very special thanks in particular to Professor Alexandros Kontonikas for all the very detailed feedback, guidance and assistance with the thesis and associated working and published papers. In addition, I would like to thank my family (Mr Dev Saggu, Mrs Kate Saggu and Ms Jasmeen Saggu) for their love, encouragement and support over the years. I am also very grateful to Mr Daniel John Ruddy for his support and understanding over the years, and for helping me to maintain some sanity whilst researching and writing this thesis. I would also like to thank the Adam Smith Business School for providing me with a significant quantity of teaching and marking responsibility, and the School of Psychology for allowing me to take part in a large number of paid experiments; without which I would not have been able to fund this PhD. Thanks also to the internal examiner Dr Serafeim Tsoukas and the external examiner Professor Stuart Hyde for the detailed feedback on my thesis. Lastly, I would like to thank an anonymous referee for the Journal of Banking and Finance for the extensive feedback on the paper which was derived from Chapters 3 and 4 of this thesis.

Author’s Declaration

I declare that except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature ________________________________

Printed Name ________________________________

Introduction

The 2007-2009 crisis was global in nature and of an unprecedented magnitude compared to previous episodes of financial and economic unrest. The Chairman of the Federal Reserve, Ben Bernanke, characterised the period as being "*the worst financial crisis since the 1930s*" (Bernanke, 2009). For the majority of the financial crisis, from Sep-07 to Dec-08, the Fed employed conventional monetary policy via target Federal Funds rate (FFR) changes to combat declining financial and economic conditions. However, the limits of conventional monetary policy were realised on the 16th Dec 08 when the Federal Open Market Committee (FOMC) cut the target FFR by 75 basis points, effectively pushing it towards the zero-lower bound. This meant that there was liquidity trap which ultimately restricted the ability of the Fed to boost financial markets and stimulate economic growth using the conventional tools of monetary policy. In fact, Ben Bernanke repeatedly conceded that "*monetary policy can be a powerful tool, but it is not a panacea for the problems currently faced by the U.S. economy*" (Bernanke, 2011).

As the target FFR approached the zero-lower bound in late 2008, the Fed began employing more non-conventional measures of monetary policy to influence financial markets and the broader macroeconomy. These measures included increasing and more explicit use of forward guidance through FOMC statements and large-scale asset purchase (LSAP) programmes. There is a growing empirical literature examining the impact of non-conventional monetary policy on the prices of financial assets in the US, however there is a comparative dearth of studies investigating the impact of conventional monetary policy on domestic and international financial markets during the 2007-2009 crisis period. This is an important question to evaluate because the Fed initially responded to the crisis by using conventional monetary policy (i.e. target FFR cuts) to influence financial, monetary and economic conditions in the broader macroeconomy. This was also the primary policy tool of the Fed throughout the majority of the crisis period (Sep-07 to Dec-08). Non-conventional monetary policy was only utilised as a last resort measure when the limits of conventional monetary policy were realised in late 2008.

The Federal Reserve was originally mandated by the United States Congress in 1977 to independently administer monetary policy and tasked to achieve a set of broad macroeconomic policy objectives such as; higher employment, sustainable economic growth and stable prices (Federal Reserve Bank of Chicago, 2013)[1]. The Fed primarily administered monetary policy through open market operations, hence the extent to which it could influence these variables were at most indirect. The most direct and immediate effects of conventional monetary policy were observed in changes of financial asset prices, with lagged effects on the broader macroeconomy (Bernanke and Kuttner, 2005). Financial markets therefore serve as the main conduit through which monetary policy operates and ultimately influences these macroeconomic objectives. This thesis investigates the impact of conventional monetary policy shocks on financial markets.

Prior to 2007, studies widely demonstrated that expansionary (contractionary) monetary policy shocks were associated with; positive (negative) stock returns both domestically in the US and internationally in foreign equity markets and negative (positive) responses in US Treasury yield changes (see Kuttner, 2001; Bernanke and Kuttner, 2005; Ehrmann and Fratzscher, 2006). However, the impact of conventional monetary policy shocks on asset prices during the 2007-2009 crisis period is less clear cut. Whilst Krugman (2008) argued that "*the usual tools of economic policy — above all, the Federal Reserve's ability to pump up the economy by cutting interest rates — have lost all traction*", Mishkin (2009) argues that "*that this view is just plain wrong*" and explicitly states that "*the fallacy that monetary policy is ineffective during financial crises is dangerous*." Hence, this empirically motivated thesis investigates the impact of conventional monetary policy shocks on asset prices over the Jun-89 to Dec-12 sample period with a particular emphasis on the 2007-2009 crisis period. In this respect we are interested in three main financial markets; the US stock market (see Chapter 3), the US Treasury market (see Chapter 4) and international stock markets (see Chapter 5).

In Chapter 3 we investigate the impact of FFR surprises on US stock returns over the Jun-89 to Dec-12 sample, and provide a comprehensive analysis of the impact of the 2007-2009 crisis on this relationship. In line with previous literature, we find that outside the crisis period, US stock returns increased (decreased) in response to unexpected FFR cuts (increases) with a hypothetical unexpected 1% FFR cut being associated with an almost 4% increase in the S&P500 index. We find that outside the crisis period, there was state-dependence of similar nature to that identified in previous studies. In particular, US stock prices exhibited

[1] Section 2A of the Federal Reserve Act details the monetary policy objectives of the Federal Reserve as follows, *"The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates"* (Federal Reserve Website, 2013)

significantly larger magnitude increases when unexpected FFR cuts occurred during ‘bad times’ of recession, bear stock markets and tightening credit market conditions, indicating asymmetries in the US stock market response to conventional monetary policy shocks.

Importantly, this chapter contributes to the existing empirical literature by demonstrating that a structural break occurred during the 2007-2009 crisis which significantly altered the US 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, stock market participants *did not respond positively* to expansionary FFR surprises during the crisis. In fact, many of our estimates indicate that there was a statistically *significant negative stock market response* to unexpected FFR cuts during the crisis. The lack of a positive stock response to FFR shocks between 2007-2009, a period characterised by sharply deteriorating macro-financial conditions and conventional 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. This implies that throughout the crisis period, unexpected FFR cuts ceased to be seen as good news by stock market investors and were interpreted as signals from the Fed of worsening financial and economic conditions. These cuts were seen as “*a sign of the desperation of central bankers*” (Coggan, 2010) and an indication that future profitability would be lower for some time, thereby signalling bad news for equities. 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.

In Chapter 4 we extend our empirical investigation to the US Treasury market, analysing the impact of FFR shocks on US Treasury yield changes over the Jun-89 to Dec-12 sample, with an emphasis on the effect of the 2007-2009 crisis on this relationship. As the US Treasury market has been shown to be more forward looking than the US stock market, we also control for non-conventional monetary policy measures such as forward guidance through FOMC statements and LSAP programmes, both of which were designed by the Fed to influence US Treasury yields during the crisis when the target FFR approached the zero lower bound. In line with previous studies, we find that 3-Month to 10-Year maturity Treasuries are associated with statistically significant responses to FFR shocks, and their yields are shown to decline (increase) in response to unexpected FFR cuts (increases).

This chapter contributes to the existing empirical literature by highlighting that there was an important shift in the relationship between US Treasuries and FFR shocks during the crisis. In particular, we find that US Treasuries across the term structure from 3-Months to

30-Years are associated with statistically significant responses to FFR shocks. We also demonstrate that very short-term maturity (3-Month) and much longer-term maturity (5-Year and 10-Year) Treasuries are associated with significantly larger magnitude responses to FFR shocks during the crisis, while the 30-Year Treasury responds significantly to FFR shocks only during the crisis. This *significantly stronger response* of highly liquid 3-Month Treasury bill and longer-term maturity Treasury yields to expansionary FFR shocks during the 2007-2009 crisis implies that these securities were characterised by *flight to quality trading*.

As unexpected FFR cuts during the crisis signalled worsening macro-financial conditions, they prompted investors to sell higher risk financial assets such as equities (see Chapter 3) and significantly increased demand for safe-haven securities. This explains the stronger reaction of the 3-Month T-Bill to unexpected FFR cuts during the crisis, as it is one of the most highly liquid securities in the world and widely perceived to be a safe-haven asset. The stronger reaction of longer-term (5-Year, 10-Year and 30-Year) maturity Treasuries to FFR shocks during the crisis implies that investors anticipated a prolonged downturn and increased their demand for longer-term, lower-yielding, lower-risk safe-haven assets. To demonstrate that unexpected FFR cuts indeed prompted flight to quality trading during the crisis, we extend our investigation to an alternative security which is widely perceived to be a safe-haven asset, a store of value and hedge against inflation; gold. In line with flight to quality trading arguments, we find that gold returns are associated with statistically significant (insignificant) positive responses to unexpected FFR cuts during (outside) the crisis period. Overall, we find that *flight to safety trading taking place throughout the crisis was reinforced at FOMC meeting dates*, with the price of both safe-haven assets (US Treasuries and gold) significantly increasing in response to expansionary FFR shocks.

Finally in Chapter 5 we investigate the international transmission of Federal Funds rate surprises to foreign equity index returns over the Jun-89 to Dec-12 sample, with a focus on the impact of the 2007-2009 global financial crisis. We consider an extensive sample of foreign equity indices across 43 advanced and emerging market economies. Consistent with previous studies, we find substantial cross country heterogeneity in foreign equity index returns to FFR shocks outside the crisis. Our estimates show that foreign equity indices are associated with positive (negative) responses to unexpected FFR cuts (increases) in countries where the relationship is shown to be statistically significant. There are substantial differences in the responses of equity indices to FFR shocks across advanced and emerging market countries.

However, this chapter contributes to the existing literature by demonstrating that the relationship between foreign equity index returns and FFR shocks was characterised by a statistically significant structural shift attributable to the 2007-2009 crisis across 26 countries. Our findings indicate that during the crisis there is even greater cross country heterogeneity in foreign equity index responses to hypothetical 1% expansionary FFR shocks, with equity indices declining 2.53% to 7.50% across 12 countries, and equity indices increasing 2.79% to 14.43% across 19 other countries. We find that this heterogeneity cannot be explained by any single factor, however can be partly explained by a combination of several factors. During the crisis, factors such as the degree of real bilateral integration with the US economy can only explain some of the heterogeneity in equity market responses to FFR shocks across countries with higher real integration, and cannot significantly explain the responses of equity markets in countries with a lower degree of real integration. In terms of financial linkages through the banking sector, we yield some evidence that unexpected FFR cuts during the crisis were associated with negative (positive) equity market response in countries with higher (lower) external borrowing from the rest of the world. Our findings indicate that FOMC monetary policy should be considered a global risk factor outside the crisis period, however during the 2007-2009 crisis it has a less predictable and significantly greater heterogeneous impact on international equity markets.

The remainder of this thesis is structured as follows. In Chapter 2 we review empirical studies related to this thesis. In Chapter 3 we investigate the US stock market response to FFR shocks over the Jun-89 to Dec-12 sample with a focus on the 2007-2009 crisis. In Chapter 4 we investigate the US Treasury market response to FFR shocks over the Jun-89 to Dec-12 sample with an emphasis on the 2007-2009 crisis. In Chapter 5 we investigate the responses of foreign equity indices to FFR shocks with a focus on the 2007-2009 global financial crisis. We would like to point out that whilst there is significant overlap for researching different parts of this thesis, Chapter 5 was mostly researched in my first year of PhD from 2009 to 2010. Chapter 3 was largely researched in my second year of PhD from 2010 to 2011 and most of Chapter 4 was researched in my third year of PhD from 2012 to 2013. All the empirical estimates in this thesis were subsequently updated to the Jun-89 to Dec-12 sample period in my write-up year of PhD. Many of the estimates presented in Chapters 3 and 4 have been published in the Journal of Banking and Finance (see Kontonikas, MacDonald and Saggu, 2013). Another two working papers derived from Chapter 4 and Chapter 5 will be available online in early 2014.

References

Bernanke, B. S., & Kuttner, K. N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Bernanke, B.S. 2009. Financial Reform to Address Systemic Risk: Speech at the Council on Foreign Relations, Washington D.C. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/speech/bernanke20090310a.htm. [Accessed on 22nd Aug 13].

Bernanke, B.S. 2011. Economic Outlook and Recent Monetary Policy Actions Before the Joint Economic Committee, U.S. Congress, Washington, D.C. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/testimony/bernanke20111004a.htm. [Accessed on 22nd Aug 13].

Coggan, P. 2010. Another paradox of thrift. *The Economist Website*. Available from: http://www.economist.com/node/17043652/print. [Accessed on 22nd Aug 13].

Ehrmann, M., & Fratzscher, M. 2006. Global financial transmission of monetary policy shocks. *European Central Bank*. Working Paper No. 1710.

Federal Reserve Bank of Chicago. 2013. The Federal Reserve’s Dual Mandate. *Federal Reserve Bank of Chicago Website*. Available from: http://www.chicagofed.org/webpages/publications/speeches/our_dual_mandate_background.cfm. [Accessed on 22nd Aug 13].

Kontonikas, A., MacDonald, R., & Saggu, A. (2013). Stock market reaction to fed funds rate surprises: state dependence and the financial crisis. *Journal of Banking and Finance* 37(11), 4025-4037

Krugman, P. 2008. Depression Economics Returns. *The New York Times Website*. Available from: http://www.nytimes.com/2008/11/14/opinion/14krugman.html. [Accessed on 22nd Aug 13].

Kuttner, K. N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Mishkin, F. S. 2009. Is Monetary Policy Effective during Financial Crises?. *The American Economic Review* 99(2), 573-577.

Chapter 2: A Review of Empirical Studies Relating to the Reaction of Asset Prices (US Stocks, International Stocks and US Treasuries) to Monetary Policy Shocks

2.1 Introduction

The relationship between asset prices and monetary policy has been extensively researched studies since the early 1960s. Given the sheer volume and scope of material, it is important to outline how we decided which studies to include in our analysis. In Chapter 3 of this thesis we investigate the impact of Federal Funds rate (FFR) surprises on US stock returns, following the study by Bernanke and Kuttner (2005). In Chapter 4 of this thesis we investigate the impact of FFR shocks on US Treasury yield changes, following the study by Kuttner (2001) and in Chapter 5 of this thesis we investigate the impact of FFR shocks on international equity index returns, following the study by Wongswan (2009). We subsequently use the Google Scholar citation index to construct a catalogue of all papers which cited these studies, and upon reading through the abstracts of these studies, we discard those studies which do not explicitly investigate the impact of monetary policy shocks on US stock returns, US Treasury yields, and foreign equity index returns[2]. For the review of older studies related to this thesis, we construct a catalogue of papers most cited by these three studies. This recursive approach to selecting relevant older studies allows for a fuller discussion to ensue, and allows for the most important studies to be included. We also follow a very detailed survey of older empirical studies by Sellin (2001).

In this review of related empirical literature, we begin by evaluating early empirical studies which investigated the extent to which future stock returns could be predicted using money supply as a measure of monetary policy (see Section 2.2). Following Sellin (2001), we subsequently distinguish between two branches of empirical research concerning stock market performance and monetary policy; studies which utilised event-study frameworks (Section 2.3) and studies which investigated monetary policy and the predictability of stock returns (Section 2.4). We furthermore evaluate studies which utilised alternative non-standard measures of monetary policy to examine the impact on the stock market (Section 2.5). In

[2] In 2009 when I began my PhD, there were; 277 studies citing Bernanke and Kuttner (2005), 371 studies citing Kuttner (2001), and 31 studies citing Wongswan (2009). This literature review was updated in 2012 during my write-up year, and there were an additional 412 studies citing Bernanke and Kuttner (2005), an additional 331 studies citing Kuttner (2001) and an additional 58 studies citing Wongswan (2009).

Section 2.6 we undertake a more detailed survey of empirical studies which investigated stock market responses to conventional monetary policy shocks, unexpected FFR changes, which are measured by gauging expectations from CBOT futures contracts following the empirical methodology outlined by Kuttner (2001) and Bernanke and Kuttner (2005).

In Section 2.7, we review more recent studies which examined the impact of monetary policy shocks on stock returns over samples which covered the 2007-2009 crisis in its entirety or in part. This includes studies which investigated stock responses to conventional and non-conventional monetary policy. In Section 2.8 we extend this analysis to the international context, reviewing studies which investigated the foreign stock response to monetary policy shocks from the US. Then, we extend our survey to studies concerning the US Treasury market, and review studies investigating the US Treasury response to monetary policy prior to the 2007-2009 crisis (Section 2.9) and during the crisis (Section 2.10). Finally, we very briefly review the theoretical channels of monetary policy transmission in Section 2.11.

2.2 US Stocks & Monetary Policy (Early Studies)

2.2.1 US Stocks & Monetary Policy (Early Studies from the 1960s and 1970s)

An early attempt to analyse the relationship between monetary policy and stock market performance was undertaken by Sprinkel (1964). This pioneering investigation compared turning points in the S&P 425 Industrial Index with turning points in the six-month moving average of the growth rate in the narrow M1 money supply. On the basis of the turning points, Sprinkel (1964) formulated an investment rule which postulated that bear (bull) markets could be predicted fifteen (two) months following peaks (troughs) in monetary growth. Although the investment rule had been formulated using graphical analyses and was inherently "*statistically deficient*" (Vasudevan, 2003 pp100); it nevertheless provided early evidence for a potential relationship between stock returns and monetary policy, measured in terms of the money supply.

This early study by Sprinkel (1964) sought to analyse the relationship between monetary policy and stock market performance using graphical analyses however it was also investigated using formal empirical analyses in later studies. Homa and Jaffee (1971) for example, argued that the investment rule of Sprinkel (1964) worked less favourably beyond their sample period. They used regression analysis to investigate the relationship between the

S&P 500 Index and the money supply, using quarterly data over the 1954:4-1969:4 sample period. Their estimates demonstrated that both the level and growth rate of money supply yielded significant positive effects on stock prices and explained a significant amount of its variation.

Keran (1971) and Hamburger and Kochin (1972)[3] obtained similar evidence to Homa and Jaffee (1971) with alternative model specifications. In particular, they used out of sample forecasting experiments to demonstrate that past money supply data could be used to predict future stock prices. They furthermore observed that the money supply significantly led stock prices by up to two quarters. The finding of early studies (see Homa and Jaffee, 1971; Keran, 1971; Hamburger and Kochin, 1972) that stock prices could be predicted using past money supply data was fundamentally inconsistent with Fama's (1970) efficient markets hypothesis which implied that stock prices reflected all available information. The fact that studies had successfully predicted stock prices using past money supply data contradicted this hypothesis because it implied excess returns could be generated using a trading strategy which observed movements in money supply (Wiedmann, 2011).

Later empirical studies were generally more sceptical of previous findings that stock prices could be predicted using past money supply data, and they set out to tentatively re-examine these potential relationships. In particular, Pesando (1974) re-examined the models of Homa and Jaffee (1971), Keran (1971) and Hamburger and Kochin (1972). He argued that their models were inherently deficient because they exhibited structural instability over various sample periods, and argued that they only sought to explain stock price behaviour, disregarding portfolio theory which compared expected risks and returns associated with holding financial assets. This raised concerns regarding the analytical framework employed in previous these studies. Whilst these previous studies observed significant relationships between stock *prices* and money supply, Cooper (1974) and Rozeff (1974)[4] demonstrated that past money supply changes did not contain predictive information for stock returns; evidence. This evidence was more consistent with the efficient markets hypothesis. A later study by Rogalski and Vinso (1977) examined the granger-causal relationships between four

---

[3] Keran (1971) examined the 1956:1 to 1970:2 sample period, and considered the impact of money supply on the S&P 500 Index. Hamburger and Kochin (1972) examined the 1956:1 to 1970:2, 1953:1 to 1960:4 and 1961:1 to 1970:4 sample periods, and considered the impact of money supply on the Statistics Canada Investors Index (SCII).

[4] Rozeff (1974) examined the Aug-16 to Dec-72 sample period, and considered the impact of money supply on the S&P 500 Index and the FIS Index. Cooper (1974) examined the Jan-47 to Dec-70 sample period, and considered the impact of money supply on the S&P 500 Index and the FIS Index.

US stock market indices[5] and money supply, using monthly data over the Jan-63 to Dec-74 sample. They found that causality ran from stocks to money supply as opposed to money supply to stocks.

It thus apparent that both graphical and empirical evidence concerning the relationship between the stock market and monetary policy, measured in terms of the money supply, yielded mixed and inconclusive evidence for a potential relationship. This may have been due to the fact that these studies assumed money supply changes were exogenously determined by the Fed. Thus money supply changes may have been endogenously determined. This prompted the use of event-study analyses which sought to mitigate such concerns.

2.3 US Stocks & Monetary Policy (Early Event-Studies)

2.3.1 US Stocks & Monetary Policy (Measured in terms of the discount rate)

Early empirical studies concerning the relationship between stock prices and monetary policy yielded inconclusive evidence for a potential relationship (see Section 2.2). These studies primarily measured monetary policy in terms of the narrow M1 money supply, using aggregate data, in weekly, monthly or quarterly form. These lower frequency measures of money supply were not purely exogenous and could equally have reflected changes in money demand. Thus, the failure to identify a purely exogenous measure of monetary policy cast doubt upon previous empirical findings concerning the relationship between stock market performance and monetary policy in previous studies. It furthermore helped to explain the inconclusive estimates concerning the relationship in earlier studies.

These issues prompted the use of an event-study methodology which examined the stock market effects of monetary policy immediately following announcements or open market operations. Its use proliferated due to the difficulty in isolating purely exogenous measures of monetary policy. It assumed that a higher-frequency measure of monetary policy around announcements or open market operations would be less 'noisy' and less likely to reflect changes in money demand, than lower-frequency measures. The methodology did not however fully consider the potentially endogenous relationship between stocks and monetary policy as a whole. One should however note that the critique concerning money supply measures being influenced by changes in money demand was equally applicable to studies

[5] S&P500, DJIA, NYSE and Fisher Link Relative Index (FIS)

which measured monetary policy in terms of the discount rate which was determined in open markets and could have been influenced by changes in demand.

One of the earliest analyses to consider the relationship between stock returns and monetary policy using an event-study methodology was undertaken by Waud (1970). The study measured monetary policy in terms of Fed discount rate changes. It argued that Fed discount rate changes influenced market expectations of future economic conditions, and thereby affected market expectations of firms' future cash flows. As stocks represented claims on firms' future cash flows, this implied a relationship between stock market performance and monetary policy. Waud (1970) analysed movements in the S&P 500 Index in an event-window around discount rate changes. US stock returns were on average shown to be positive (negative) following discount rate decreases (increases) over the 1953 to 1967 sample period[6]. Thus, event-study investigation provided initial evidence that monetary expansions (contractions) on average were associated with positive (lower or negative) stock returns and interpreted as good (bad) news by investors.

A later study by Santomero (1983) observed that the Fed's policy concerning discount rate changes was generally 'passive' and responded to changes in open market rates with a lag. This implied that investigations concerning the relationship between stock returns and discount rate changes, such as that undertaken by Waud (1970), should also have considered the Fed's motivation and intention for each discount rate change. In response to Santomero's (1983) critique, Smirlock and Yawitz (1985) used published explanations of Fed discount rate changes[7] to distinguish between regular discount rate changes which the Fed used to ensure consistency with market rates (technical changes) and exogenous unexpected discount rate changes (non-technical rates) which the Fed used to influence market rates. They effectively exploited the manner in which the Fed administered monetary policy as a natural proxy to distinguish between endogenous (technical) and exogenous (non-technical) components of discount rate changes. In particular, they estimated the following model (Equation 2.1) over two sample periods; from 1975 to 1979, and from 1979 to 1982.

$$r_t = \alpha + \beta_1\left(\Delta R_t * D_t^T\right) + \beta_2\left(\Delta R_t * D_t^{NT}\right) + \varepsilon_t, \qquad (2.1)$$

where (r_t) denoted the stock return, (ΔR_t) was the percentage discount rate change on the day of announcement, $\left(D_t^T\right)$ was a dummy variable equal to one, when the discount rate is

[6] Similar evidence was obtained by Baker and Meyer (1980) who demonstrated that discount rates influenced Treasury bill rates over the 1953 to 1978 sample period.

[7] The classifications of technical and non-technical changes were based upon the language of published explanations regarding the Fed's actions.

defined as technical and zero otherwise, and $\left(D_t^N\right)$ a dummy variable equal to one, when the discount rate is defined as non-technical.

Smirlock and Yawitz (1985) identified significant (insignificant) stock responses to non-technical (technical) changes for the 1979 to 1982 sample period[8]. Their estimates were consistent with the efficient markets hypothesis which implied that stocks responded only to unanticipated components of discount rate changes, which in this case were non-technical changes. Interestingly, they observed insignificant stock responses to both technical and non-technical discount rate changes over the 1975 to 1979 sample period. An explanation concerning the insignificance of estimates over this sample was offered by Roley and Troll (1984). They contested that prior to 1979, the effects of discount rate changes on market rates may have been mitigated by equivalent changes in non-borrowed reserves by the Fed. This implied that further investigations concerning the impact of monetary policy on asset prices should also have considered the manner in which the Fed administered monetary policy throughout the sample period.

The failure to observe significant stock responses to both technical and non-technical discount rate changes prior to 1979 (see Smirlock and Yawitz, 1985) implied that a structural shift in the Fed's administration of monetary policy may have occurred. A study by Gilbert (1985) identified 3 Fed monetary policy operating procedure regimes between 1970 and the late 1980s. In the first regime *(between 1970 and 8th Oct 79)*, the Fed administered monetary policy by targeting market interest rates such as the FFR, combined with changes in levels of non-borrowed reserves. In the second regime *(between 8th Oct 79 and Oct-82)*, the Fed switched to targeting monetary aggregates such as non-borrowed reserves and the FFR. In the third regime *(Oct-82 to late 1980s[9])*, the Fed primarily targeted borrowed reserves and the FFR.

The date when the Fed switched from targeting borrowed reserves to targeting the FFR is still "*contentious*" and unclear, however an academic consensus emerged suggesting that it occurred in the late 1980s (Sarno and Thornton, 2003). For completeness, we also mention two further regimes. In the fourth regime *(late 1980s to late 2008)* the Fed primarily

[8] It is important to note that Smirlock and Yawitz (1985) considered a small sample period of eight years from 1975 to 1982 which may have imposed sample-bias upon estimation. Lombra and Torto (1977) further argued that the discount rate was above the Treasury bill rate for most of the sample period and that open market operations followed the 'money market strategy' discussed by Guttentag (1966).

[9] Gilbert (1985) considered monetary operating procedures between 1970 and 1982; hence the end of the third monetary regime was not known then combine his dates for monetary policy operating procedures with dates provided by Sarno and Thornton (2003). As the Fed began targeting the FFR exclusively from Sep-87, we also include this date here.

targeted the FFR. In the fifth regime *(late 2008 to present)*, during the recent financial crisis, the Fed considered more unorthodox forms of monetary policy such as Large Scale Asset Purchase Programmes (LSAPs), more commonly known as Quantitative Easing (QE), and increasing use of forward guidance concerning future monetary stance.

Thus, in line with the critique of Roley and Troll (1984), the extent to which discount rate changes influenced stock returns may have been contingent upon the manner in which the Fed administered monetary policy throughout the period. As a response, Jensen and Johnson (1993) explicitly investigated stock responses to technical and non-technical discount rate changes over sub-sample periods which corresponded with monetary policy regimes identified by Gilbert (1985). They furthermore disaggregated their investigation to consider discount rate cuts and discount rate increases in separate samples, as well as considering the impact on pre-announcement, announcement and post-announcement stock returns [10] .Over three sample periods from 1962 to 1990, Jensen and Johnson (1993) demonstrated significant US stock responses to both technical and non-technical discount rate changes, with more pronounced responses to non-technical changes. In contrast to previous studies (see Roley and Troll, 1984; Smirlock and Yawitz, 1985; Pearce and Roley, 1985), they yielded similar results across all three monetary policy regimes considered. They attributed the peculiarity of these results to the separate treatment of discount rate cuts and increases in separate sample periods. Furthermore, their results indicated that technical discount rate changes were generally anticipated in pre-announcement responses, consistent with the efficient markets hypothesis.

As Jensen and Johnson (1993) observed significant stock responses to discount rate changes over sub-sample periods corresponding with monetary policy regimes; they extended their analysis to consider long-horizon responses of stock returns to discount rate changes. In particular, Jensen and Johnson (1995) partitioned their sample in to periods of monetary contraction (discount rate cuts) and monetary contraction (discount rate increases). Over the 1953 to 1991 sample period, they demonstrated that long-horizon stock returns were larger and less volatile following discount rate cuts, compared to those following discount rate increases. This implied that monetary conditions may have influenced required returns demanded by investors; consistent with Fama and French's (1989) argument that predictable

[10] More specifically, they considered the response of cumulative mean adjusted returns (CMAR) however we simply state returns for concision. The CMAR is calculated for the pre-announcement affect (for five days preceding the announcement period), the announcement period (for two days, day zero and one of the announcement), and the post-announcement period (for five days following the announcement period)

stock return variation was indicative of rational variation in required returns (see Section 2.4.1 for further discussion).

2.3.2 US Stocks & Monetary Policy (Measured in terms of the money supply)

So far, we have exclusively discussed empirical event-studies which measured monetary policy in terms of the discount rate. However, akin to the studies discussed in Section 2.3.1), the event-study methodology was also used to investigate the relationship between stock returns and monetary policy, measured in terms of the money supply. We now review such studies. Pearce and Roley (1983) measured monetary policy in terms of money supply announcements, and used an event-study methodology to consider the responses of stock returns to money supply changes. The study was guided by the premise that when money supply increased faster than expected, market participants revised their expectations of future inflation, and this resulted in lower stock price valuations. They tested the theoretical proposition by investigating US stock return (r_t) responses to money supply changes, both expected (ΔM_t^e) and actual (ΔM_t^a). Weekly survey data[11] concerning market participants' expectations of changes in the narrow M1 money supply was used and the unanticipated component of the money supply change was defined as the difference between the actual and expected change. They estimated the following model (Equation 2.2)[12] over three sample periods corresponding with monetary policy regimes identified by Gilbert (1985):

$$r_t = \alpha + \beta\left(\Delta M_t^a - \Delta M_t^e\right) + \sum_i d_i D_{it} + \varepsilon_t, \qquad (2.2)$$

Their estimates demonstrated that unexpected money supply increases exhibited negative effects on US stock prices in all three sub-sample periods. More specifically, responses were negative and significant for the Sep-77 to Oct-79 and Feb-80 to Jan-82 sample periods[13]; however negative and insignificant for the Oct-79 to Jan-80 period. Overall, they found that an unexpected 1% increase in the money supply was associated with an average -0.35% weekly decline in the Dow Jones Industrial Average Index.

[11] The Money Markets Services survey for the M1 (previously M1B) money supply was utilised by Pearce and Roley (1985)

[12] They also included dummy variables (D_{it}) to control for discount rate changes which occurred after the stock market closed and may have affected the estimation.

[13] The statistical insignificance for the Oct-79 to Jan-80 sample period may be attributed to the small sample bias of only fourteen observations.

The study by Pearce and Roley (1983) had been guided by the premise that money supply changes affected stock returns through changes in inflation expectations. To examine the response of stock returns to expected and unexpected $\left(\Delta M_t^u\right)$ money supply changes, Cornell (1983) used survey data to gauge expectations of money supply changes akin to Pearce and Roley (1983). The study subsequently tested the following model (Equation 2.3) over two sample periods from Jan-78 to Oct-79 and from Oct-79 to Dec-81.

$$\Delta SP_t = \alpha + \beta_1 \Delta M_t^e + \beta_2 \Delta M_t^u + \varepsilon_t , \qquad (2.3)$$

In both sample periods, Cornell (1983) observed statistically insignificant responses of the S&P500 index to expected money supply changes, consistent with the efficient markets hypothesis. The response of unexpected money supply changes was negative and significant only for the latter sample period. Qualitative conclusions drawn from these estimates concerning significant (insignificant) stock responses to unexpected (expected) changes in monetary policy were similar to those obtained in studies which used discount rates as their measure of monetary policy. Studies which distinguished between expected (technical) and unexpected (non-technical) discount rate changes also yielded evidence that stocks responded only to unexpected changes (see Smirlock and Yawitz, 1985; Jensen and Johnson, 1993; Jensen and Johnson, 1995).

2.3.3 US Stocks & Monetary Policy (Measured in terms of the discount rate and money supply)

Having evaluated empirical event-studies which examined the relationship between stock market performance and monetary policy measured in terms of the discount rate, or measured in terms of the discount rate; we extend our analysis to briefly consider several later empirical event-studies which jointly investigated the impact of both discount rate changes and money supply changes on stocks. Pearce and Roley (1985) investigated the impact of monetary policy announcements, measured in terms of both discount rate changes and money supply changes on US stock prices. They decomposed M1 money supply announcements in to expected and unexpected components using survey data akin to Pearce and Roley (1983) however assumed discount rate changes were purely exogenous and unexpected because market expectations concerning discount rate changes were unavailable[14]. They demonstrated that US stocks yielded negative and significant responses to unexpected

[14] Despite previous evidence that discount rate changes were not always exogenous, they applied this simplifying assumption due to lack of survey data estimates regarding discount rate changes.

money supply increases in the Sep-77 to Oct-79 and Oct-79 to Oct-82 sample periods; however discount rate cuts exhibited significant positive effects only in the latter sample period. These results were consistent with the critique by Roley and Troll (1984) that prior to 1979; effects of discount rate changes on market rates may have been mitigated by equivalent changes in non-borrowed reserves by the Fed.

Previous event-studies (see Pearce and Roley, 1985; Jensen and Johnson, 1993; Jensen and Johnson, 1995) examined stock responses to monetary policy changes over separate sub-samples which corresponded to monetary policy regimes identified by Gilbert (1985). In contrast to these studies, Hafer (1986) used dummy variables to distinguish between three monetary policy regimes from Sep-77 to Dec-84 without separating the samples and thereby mitigating potential omitted observation bias upon estimates. Hafer (1986) examined the response of five US stock market indices[15] to expected $\left(\Delta M_t^e\right)$ and unexpected $\left(\Delta M_t^u\right)$ money supply changes, discount rate changes $\left(\Delta R_t\right)$, and discount rate surcharge changes $\left(\Delta DRS_t\right)$ by the Fed. The following model (Equation 2.4) was tested, with dummy variables for the first three variables to differentiate between monetary regimes from Sep-77 to Oct-79, Oct-79 to Oct-82 and Oct-82 to Dec-84; however these have been omitted from the equation for concision:

$$\Delta SP_t = \alpha + \beta_1 \Delta M_t^e + \beta_2 \Delta M_t^u + \beta_3 \Delta R_t + \beta_4 \Delta DRS_t + \varepsilon_t , \qquad (2.4)$$

In line with the efficient markets hypothesis, Hafer (1986) demonstrated that expected money supply changes exhibited insignificant effects on all five stock price indices. Interestingly, the effects of unexpected money supply changes were not significantly different across the three monetary policy regimes. Furthermore, asymmetric responses were observed whereby positive (negative) money supply changes exhibited significant (insignificant) positive (negative) effects on stock price indices. Discount rate changes were furthermore demonstrated to exhibit statistically significant effects only in the Oct-79 to Oct-82 sample period.

A subsequent study by McQueen and Roley (1993) examined the S&P 500 Index response to unexpected changes in macroeconomic announcements[16]. Over the Sep-77 to May-88 sample period; they observed significant stock market responses to unexpected

[15] S&P 500, S&P 400, S&P 500 Total Return Index, S&P 500 Utilities Index, S&P 500 Financials Index

[16] Similar to previous studies, expectations of the macroeconomic announcements were disaggregated in to expected and unexpected components using survey data. The Money Markets Survey was used to gauge expectations of money supply announcements and the discount rate was assumed to be unexpected due to the absence of survey data concerning expectations of future changes

money supply changes and insignificant responses to discount rate changes, in line with Pearce and Roley (1985). Guided by earlier studies (see Fama and French, 1989; Schwert, 1990) which suggested that business conditions helped to explain stock return variation, McQueen and Roley (1993) conditioned the unexpected macroeconomic announcements to the state of the economy. They demonstrated that the stock market response to money supply increases was negative and significant only during high and medium states of the economy[17]. In contrast, the stock response to discount rate changes was insignificant across all economic states; high, medium and low.

There are several empirical conclusions which can be drawn from early event-studies which examined stock responses to monetary policy changes. Firstly, in line with the efficient markets hypothesis of Fama (1970), stocks did not respond to expected changes in monetary policy. Specifically, stocks did not yield significant responses to endogenous technical discount rate changes which were used to bring discount rates in line with market rates and were generally expected by market participants. They also did not yield significant responses to expected changes in money supply (see Smirlock and Yawitz, 1985; Cornell, 1983). Secondly, stocks only yielded significant announcement effects in response to unexpected changes in monetary policy. Thus stock returns responded to exogenous non-technical discount rate changes by the Fed which were designed to influence market rates and were generally unexpected by financial markets. They also responded to unexpected changes in money supply, which could be measured using expectations from survey data (see Pearce and Roley, 1983; Cornell, 1983; Smirlock and Yawitz, 1985; McQueen and Roley, 1993; Pearce and Roley, 1985; Hafer, 1986; Jensen and Johnson, 1993). Thirdly, the extent to which stocks could be affected by monetary announcements was contingent upon the monetary policy operating procedure at the time, and whether the Fed was actively using the monetary policy instrument in question to administer monetary policy (see Pearce and Roley, 1983; Cornell, 1983; Pearce and Roley, 1985). Lastly, stock returns responded to asymmetrically to monetary conditions, with stronger responses to monetary expansion compared to monetary contraction (Hafer, 1986; Jensen and Johnson, 1993; Jensen and Johnson, 1995).

[17] This was achieved using data concerning industrial production

2.4 US Stock Return Predictability & Monetary Policy

So far, we have mainly discussed the relationship between stock market performance and monetary policy through an evaluation of event-study analyses. These studies employed various empirical specifications ranging from graphical analyses to regression models. In comparison the empirical literature concerning monetary policy and the predictability of stock returns was largely motivated by antecedent studies which employed regression analyses and vector-autoregression (VAR) models to examine the extent to which various measures could be used to forecast stock returns. We continue our survey of related studies in the literature by briefly evaluating seminal studies which used regression analyses to examine the predictability of stock returns with respect to business conditions and monetary conditions (Section 2.4.1) as well as studies which employed VAR analyses and VAR related analyses to investigate the relationship (Section 2.4.2)[18].We evaluate the VAR methodology for defining monetary policy shocks, and the critique directed at such an approach in Section 2.4.3.

2.4.1 US Stocks & Monetary Policy (Measured using non-VAR models)

The event-study literature concerning the relationship between stock market performance and monetary policy yielded significant evidence for a potential relationship between the two factors (see Sections 2.2 to 2.3). These studies demonstrated that monetary policy, measured in terms of Fed discount rate changes and/or changes in money supply, signalled monetary developments and thereby influenced stock returns. The empirical literature concerning monetary policy and the predictability of stock returns yielded comparative conclusions. In particular, Jensen, Mercer and Johnson (1996) demonstrated that both business conditions and monetary conditions affected required returns demanded by investors, and suggested that the predictable variation in stock returns reflected risk premia associated with macroeconomic influences.

Jensen, Mercer and Johnson (1996) and Patelis (1997) both utilised regression methodologies to examine whether monetary policy could be used to explain some of the variation in excess US stock returns. The empirical framework of these studies was largely

[18] Although Fama and French (1989) did not explicitly consider the role of monetary conditions in predicting stock returns, we also evaluate this study to provide a historical perspective concerning the evolution of this literature. We do not discuss the studies by Campbell (1991) and Campbell and Shiller (1988) because they yielded qualitatively similar empirical conclusions to Fama and French (1989) and did not explicitly consider the role of monetary conditions in predicting stock returns.

motivated by a previous study by Fama and French (1989). Whilst Fama and French (1989) did not explicitly evaluate the role monetary policy in the predictability of stock returns, they nonetheless demonstrated that business conditions were significant predictors of excess US stock returns and affected required returns demanded by investors. The methodology, approach and empirical conclusions of this seminal study significantly influenced subsequent studies in the field concerning monetary policy and stock return predictability (see Jensen, Mercer and Johnson, 1996; Patelis, 1997). For this reason, we review the study by Fama and French (1989) prior to discussing these later studies.

Fama and French (1989) used long-horizon regression analyses to examine the extent to which proxies of business conditions could help explain variation in excess US stock returns. They investigated the predictability of excess stock returns by regressing them at increasing time horizons on a vector of business conditions indicators (x_t) ; such as the dividend yield, default spread and term spread. They defined excess US stock holding period returns $(e_{t+k,t+1})$ as the difference between continuously compounded returns on a US stock portfolio minus the continuously compounded return on the one-month US Treasury bill. More specifically, the following model (Equation 2.5) was tested at increasing time horizons of one-month, one-quarter, and one to four years[19].

$$e_{t+k,t+1} = \alpha_k + \beta_k x_t + \varepsilon_{t+k,t+1}, \qquad (2.5)$$

Fama and French (1989) demonstrated that the predictability of excess stock returns increased with longer time horizons considered. All three indicators of business conditions were furthermore shown to be significant predictors of stock returns. They argued that the predictable variation in stock returns was rational, and reflected short-term business cycles and long-term business conditions. As their evidence implied that stock returns could be predicted to some extent, this naturally contradicted the efficient markets hypothesis. To resolve this contradiction, they interpreted predictability as being indicative of a time varying risk premium, which was influenced by real economic activity and expectations of firms' future returns. In this manner, they concluded that business conditions affected required returns demanded by investors, and thereby influenced stock returns.

From previous studies, it was apparent that business conditions (see Fama and French, 1989) and monetary conditions (see Jensen and Johnson, 1995) may have helped to explain

[19] We quote Patelis' (1997) interpretation of Fama and French's (1989) model for algebraic clarity. Fama and French (1989) calculated excess returns for holding periods beyond one-month through cumulating monthly holding period returns.

stock return variation, in separate studies. In response to these studies, Jensen, Mercer and Johnson (1996) investigated the impact of both business conditions and monetary conditions on US stock returns. To measure monetary conditions, they defined a broad measure using a dummy variable, which was equal to one (zero) when the discount rate was previously an increase (decrease). Using a similar empirical methodology to Fama and French (1989), they investigated the responses of excess stock returns to proxies of business conditions, however also included the broad measure of monetary conditions defined in terms of the directional discount rate dummy. Jensen, Mercer and Johnson (1996) demonstrated that business conditions, measured in terms of the dividend yield and default premium were significant predictors of excess US stock returns only during periods of monetary expansion. Furthermore, in contrast to Fama and French (1989), the term spread[20] was a statistically insignificant predictor of excess stock returns. These estimates were interpreted as being indicative of predictable variation in stock returns which was not only rational, but also related to business conditions and monetary conditions.

Jensen, Mercer and Johnson (1996) demonstrated that monetary conditions influenced stock return predictability however their measure of monetary conditions, a directional dummy variable, was considerably narrow. A subsequent study by Patelis (1997) extended upon this analysis by investigating the role of monetary policy, measured by a set of monetary variables, in stock return predictability. Patelis (1997), akin to Fama and French (1989), used long-horizon regressions to investigate the predictability of excess US stock returns using monetary variables[21] and financial variables[22] as predictors. Over the 1962-1994 sample, it was shown that a higher FFR, indicative of monetary tightening predicted lower expected returns initially in the short run, and higher expected returns thereafter. This was shown by the FFR coefficient which declined at increasing time horizons (monthly, quarterly, annual, bi-annual). The predictability of stock returns also increased as the time-horizon increased; consistent with the hypothesis that monetary conditions influenced the predictability of stock returns.

---

[20] The term spread did however affect bond returns, this is consistent with evidence from previous research which indicates that the term spread is a good explanatory variable for bond returns compared to stock returns (see Fama and French, 1989).

[21] The monetary variables were; the FFR, the spread between FFR and 10-Year US Treasury Note, the spread between 6-Month Commercial Paper and 6-Month T-Bill, the Logged change in Non-Borrowed Reserves, the proportion of growth in Non-Borrowed Reserves orthogonal to growth in Total Reserves

[22] The financial variables were; the Divided Yield, the spread between 10-Year Treasury Bond and 1-Month Treasury Bill, the 1-Month Real Interest Rate

2.4.2 US Stocks & Monetary Policy (Measured using VAR models)

The studies in Section 2.4.1 investigated the role of monetary policy in the predictability of stock returns using single equation models. These models assumed explanatory terms such as monetary policy were inherently exogenous and uni-directionally influenced stock returns. As we discussed in Section 2.3.1, lower-frequency measures of monetary policy were less likely to reflect exogenous changes in monetary policy by the Fed, and more likely to reflect a broad spectrum of factors such as macroeconomic announcements and changes in demand (see Sellin, 2001). Due to the difficulty in isolating purely exogenous measures of monetary policy, and in order to mitigate concerns of potential bi-directional causality between stocks and monetary policy, a number of studies followed the example of Sims (1980), utilising VAR methodologies to examine the role of monetary policy in the predictability of stock returns (see Bernanke and Blinder, 1992; Patelis, 1997; Thorbecke, 1997). The VAR methodology had several advantages in that it treated all variables in the systems considered as endogenous, hence it was not necessary to explicitly specify which measures were exogenous. It furthermore enabled for richer lag structures to be considered. Sellin (2001) further argued that forecasts from VARs outperformed traditional structural models.

To alleviate concerns regarding the simultaneity causality problem and to isolate a measure of monetary policy which was exogenous to the state of the economy, the aforementioned studies measured monetary policy in terms of orthogonalised innovations from VAR models. This was achieved by defining a VAR model with $(n \times 1)$ vector of endogenous variables (y_t), which were assumed to be covariance-stationary (Equation 2.6)[23]. The model was then inverted and expressed in terms of its moving average representation (Equation 2.7); and the residuals were assumed to be identically and independently distributed with a positive definite covariance matrix (Ω). The orthogonalised innovations could subsequently be obtained using a Cholesky factorisation to isolate the lower triangular matrix (P) such that $(\Omega = PP')$, allowing Equation 2.7 to be expressed as Equation 2.8[24] using the lower triangular matrix. Equation 2.8 therefore represented endogenous variables as functions of orthogonalised residuals (υ_{t-i}). Although we have discussed several advantages

[23] where $E(\varepsilon_t \varepsilon'_t) = \Omega$

[24] where $\Gamma_i = C_i P$, $\upsilon_t = P^{-1}\varepsilon_t$, and $E[\upsilon_t \upsilon'_t] = I$

of the VAR methodology, it is important not to overstate the benefits. We evaluate the limitations and disadvantages of this approach at the end of this section.

$$y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + \varepsilon_t , \tag{2.6}$$

$$y_t = \varepsilon_t + C_1 \varepsilon_{t-1} + C_2 \varepsilon_{t-2} + C_3 \varepsilon_{t-3} + \ldots , \tag{2.7}$$

$$\begin{aligned} y_t &= PP^{-1}\varepsilon_t + C_1 PP^{-1}\varepsilon_{t-1} + C_2 PP^{-1}\varepsilon_{t-2} + \ldots \\ &= \Gamma_0 \upsilon_t + \Gamma_1 \upsilon_{t-1} + \Gamma_2 \upsilon_{t-2} + \ldots \end{aligned} , \tag{2.8}$$

The VAR methodology was used by Thorbecke (1997) to investigate the relationship between stock returns and monetary policy in the US. The study estimated a recursive VAR(6)[25] [26] with seven macroeconomic variables and a constant; to examine the impulse responses of contemporaneous stock returns from portfolios to a one-standard deviation shock in the FFR. Recursive VARs are known to be highly sensitive to the ordering specification. Thorbecke (1997) used the following Cholesky ordering: the growth rate of industrial production, rate of inflation, log of a commodity price index, the FFR, log of non-borrowed reserves, log of total reserves and stock returns for a portfolio. The 1967-1990 sample period was used and the study measured monetary policy shocks in terms of orthogonalised innovations in the FFR[27]. Thorbecke (1997) found that a one-standard deviation positive innovation in the FFR (tightening shock) was associated with an average -0.80% monthly decline in stock returns across 22 US industry portfolios[28]. Furthermore, amongst portfolios formed on size, smaller capitalisation stocks (-0.94%) yielded a stronger response as compared to larger capitalisation stocks (-0.57%). This is consistent with Gertler and Gilchrist's (1994) hypothesis that monetary policy affected firms' ability to access

---

[25] A recursive VAR involves estimating a reduced form VAR and computing the Cholesky factorization of the reduced form VAR covariance matrix (see Lütkepohl, 1993 Chapter 2). The residual in each equation is defined to be uncorrelated with the residual from preceding equations. This is achieved by adding contemporaneous values from preceding equation as explanatory variables in subsequent equations.

[26] We would also like to point out that Sims (1980) contested that FFR innovations were correlated with inflation when placed first in Cholesky ordering. Following this critique, Christiano, Eichenbaum and Evans (1994) later demonstrated that sensible estimates were yielded upon inclusion of a commodity price index in the VAR. In particular, they showed that positive FFR innovations were associated with decreased price levels. The identification strategy of Christiano, Eichenbaum and Evans (1994) was subsequently utilised by Thorbecke (1997).

[27] As the Fed had primarily administered monetary policy by targeting non-borrowed reserves between 1979 and 1982, Thorbecke (1997) repeated the analysis using a VAR(2) with two lags, and measured monetary policy in terms of orthogonalised innovations in non-borrowed reserves by placing it ahead of the FFR in recursive ordering. The study demonstrated that an initial one-standard deviation positive innovation in non-borrowed reserves yielded an average 1.79% monthly increase across 22 US industry portfolios

[28] A heterogeneous, yet negative response was observed across the industry portfolios

credit[29]. It was also demonstrated that across the portfolios, 3.94% (15.85%) of the 24-month forecast error variance of stock returns was explained by innovations in the FFR (non-borrowed reserves).

In contrast to Thorbecke (1997), who examined the relationship between monetary policy and contemporaneous stock returns, a subsequent study by Patelis (1997) investigated the relationship between monetary policy and future expected returns. The study adapted the methodology of Campbell (see Campbell and Shiller, 1988; Campbell, 1991; Campbell and Ammer, 1993) by deconstructing excess stock returns in to future expectations of excess returns, real interest rates and dividend growth. The VAR estimates of Patelis (1997) indicated that over the Mar-62 to Nov-94 sample, higher FFR growth (indicative of monetary tightening) was associated with lower short-horizon excess stock returns. Furthermore, the variance-decompositions presented evidence that 82.26% of the variation in unexpected stock returns could be explained by financial variables such as the expected excess return, real interest rate and dividend yield. However, only 3.14% of the variation could be explained by monetary policy variables such as; the FFR change and the proportion of non-borrowed reserve growth orthogonal to total reserves (also known as STRONGIN).

Lastrapes (1998) used VARs to estimate the response of equity prices to money supply shocks in eight industrialised economies. The money supply shocks were identified through the imposition of infinite-horizon[30] restrictions on systems considered. This included long-run monetary neutrality and restrictions so that permanent money supply changes yielded no effect on real variables at infinite-horizons. Over the Jan-59 to May-94 sample period, and restricting our discussion to the US, positive innovations in the money supply yielded significant positive effects on real equity prices. Furthermore, the variance-decompositions demonstrated that over 50% of the US stock returns forecast error-variance was explained by monetary policy.

A more recent study by Becher, Jensen and Mercer (2008) evaluated the efficacy of four alternative monetary indicators in predicting stock returns. For each of four monetary indicators (FFR, FFR premium, commercial paper premium and term premium) a monthly five-variable VAR with 12 lags was estimated. The study progressed in a stepwise manner, beginning with two-variable VARs and increasingly adding additional variables until five-variable VARs were estimated. The five variables considered were; a monetary stance dummy (see Jensen, Mercer and Johnson, 1996), one of the four monetary indicators, an

[29] See also Kontonikas, and Kostakis, 2013 and Maio and Tavares, 2007 for more recent evidence
[30] see Blanchard and Quah (1989) and Shapiro and Watson (1988)

interactive term multiplying the first two variables, the default spread and the real equity return. Cholesky variance-decompositions were used to measure the 24-month ahead forecast error variance of stock returns attributable to predictive variables. Over the Jan-65 to Dec-06 sample period, lagged stock returns explained more of the forecast error variance than the other four variables combined. Together, the monetary stance indicator and interactive variables explained more variance than the default spread. Overall, the study demonstrated that expected stock return variation was explained by both business and monetary conditions.

It is important to note that since the late 1980s and early 1990s, the FFR was increasingly used by studies as the main indicator of monetary policy. The use of the FFR was primarily guided by inference from a seminal study by Bernanke and Blinder (1992) which indicated that it was a good indicator of monetary stance. The late 1980s was also a period characterised by a significant shift in the operating procedure of Fed, as they began administering monetary policy by primarily targeting the FFR (see Sarno and Thornton, 2003). Bernanke and Blinder (1992) demonstrated that the FFR was a good measure of monetary policy and that innovations in the FFR were effective in forecasting real economic activity. They used a VAR to measure monetary policy, and through variance-decompositions and granger-causality tests demonstrated its efficacy in forecasting future movements in macroeconomic variables over the Jul-59 to Dec-89 sample period. The FFR was furthermore argued to be a good indicator of monetary policy because it was sensitive to changes in the supply of bank reserves. Following this seminal study, there was a significant shift in many empirical studies considering monetary policy in terms of the FFR.

Bjørnland and Leitemo (2009) used a structural VAR analysis, identifying the model using short-run and long-run restrictions on multipliers of shocks, in line with previous empirical studies (see Christiano, Eichenbaum and Evans, 1994). Over the Jan-83 to Dec-02 sample period, their estimates demonstrated that a 1% FFR shock was associated with a 9% decrease in real stock prices. Furthermore, a 1% stock price shock was associated with a 0.04% increase in the FFR. This implied an endogenous, simultaneous, interdependent relationship as the stock market responded to monetary policy, however monetary policy, via the Fed, also responded to the stock market.

As the relationship between stock market performance and monetary policy may have been characterised by structural change, Laopodis (2006) considered the relationship over sample periods which corresponded with chairmanship of the Fed. Specifically, Arthur Burns (1970 to 1978), Paul Volcker (1979 to 1987) and Alan Greenspan (1988 to 2002). Laopodis (2006) used a range of bivariate and multivariate VAR, VECM and cointegrational analyses to examine the relationship, however overall the results were mixed and inconclusive. The estimates implied that it was *not* possible to conclude there was a consistent, dynamic relationship between real stock returns and monetary policy which varied significantly across the sub-sample periods.

In a study related to Bjørnland and Leitemo (2009), Crowder (2006) initially used a two-variable structural VAR to investigate the bivariate relationship between S&P500 returns and the effective FFR. It was shown that positive FFR innovations yielded lower S&P500 returns, however conversely and in contrast to Bjørnland and Leitemo (2009), exogenous innovations in the S&P500 failed to yield immediate effects on the effective FFR. The model was extended to also include a commodity price index, to control for the effects of inflation on monetary policy. This was motivated by the fact that the Fed had sought to combat inflation and stabilise price levels over much of the sample period from Feb-70 to Jun-03. The empirical conclusions from the three-variable system were much akin to those in the bivariate analysis and robust to the inclusion of the commodity price index. Interestingly, the results were sensitive to the identification strategy employed. Estimates from the Cholesky variance-decompositions and associated impulse response functions were rendered "*plausible*" through long-run restrictions; however when the identification strategy of Blanchard-Quah (1989) was applied, positive FFR innovations were associated with unrealistically high returns in the S&P500, for both bivariate and trivariate systems.

To investigate the relationship between monetary policy and the stock market, a hybrid model was considered by Bordo, Duecker and Wheelock (2007). They used a latent variable VAR(6) model (also known as Qual-VAR) as well as a dynamic factor model; with starting values gauged from defined rules concerning categorisation if periods of financial boom and bust[31]. It was argued that this approach mitigated subjective judgement concerning identification of market conditions. Over the Aug-52 to Dec-05 sample period; their estimates indicated that money stock growth failed to exhibit significant effects on the US financial market. However, long-term interest rate shocks exhibited significant and persistent negative effects on real stock prices, as well as negative effects on stock market conditions which were significant for the first three-months. After controlling for shocks to long-term interest rates, it was shown that short-term interest rate shocks exerted insignificant, yet negative effects on

[31] Financial booms: periods 36 months or longer from peak to trough with annual increase in real S&P500 of 10% or more, or periods 24 months or longer with annual increase in real S&P500 of 20% or more. Financial busts: periods 12 months or longer from peak to trough with annual decrease in real S&P500 of 20% or more.

real stock prices and positive effects on market conditions. Lastly; short-term interest rate shocks exhibited negative effects on both real stock prices and stock market conditions alike.

Finally, D'Agostino, Sala and Surico (2004) observed that the relationship between the S&P500 and the FFR was characterised by state-dependence. They find that between 1983-2003, An unexpected 1% FFR cut during periods of lower (higher) volatility, yielded a significant (insignificant) increase in the S&P500 Index of 3.34% (8.04%). The estimates were obtained using a four-variable structural VAR, with a threshold variable measuring asset price volatility governing the shift in monetary regime.

2.4.3 US Stocks & Monetary Policy (Critique of VAR & VAR related monetary policy measures)

In Section 2.4.2, we reviewed studies which utilised VAR related frameworks to investigate the relationship between monetary policy and stock market performance, as well as the role of monetary policy in stock return predictability. The VAR methodology was popularised following critique that single equation models failed to acknowledge the potential endogenous relationship between the two variables. In particular, it sought to mitigate concerns regarding an endogenous relationship between the stock market and monetary policy through the modelling of endogenous systems. Despite the popularity of this empirical approach, Rudebusch (1996, 1998) offered a sharp critique of studies which modelled monetary policy using VAR related frameworks.

Rudebusch (1996, 1998) questioned the empirical validity of VARs in the measurement of monetary policy. The argument suggested that monetary shocks, defined in terms of orthogonalised innovations in the FFR or other monetary instruments, were "*structurally fragile*" and "*severely deficient*" however the study made it clear that the critique did not imply that the methodology was "*so deeply flawed as to be useless*". The study indicated that VAR measures of monetary shocks were at odds with the Fed's descriptions of monetary policy actions. The study furthermore demonstrated that unexpected monetary policy shocks, (measured outside the VAR) using expectations from forward looking futures contracts tracking the FFR, were highly dissimilar to monetary policy shocks from recursively identified VARs. Overall, it concluded that monetary VARS "*appear[ed] implausible and mis-specified in many respects*". Bredin, Hyde, Nitzsche and O'Reilly (2009) summarised Rudebusch's (1996, 1998) critique as implying that VAR based measures of monetary shocks were largely "*artificial and meaningless*."

Although the VAR methodology was increasingly used to identify monetary policy shocks, many of these studies failed to acknowledge the critique directed at earlier studies concerning monetary policy and stock market performance (see Section 2.3.1). In earlier studies from the 1970s, 1980s and later VAR studies, lower-frequency aggregate measures of monetary policy were generally employed, and critique suggested that such measures were less likely to reflect exogenous changes in monetary policy by the Fed, and more likely to reflect a broad spectrum of macroeconomic factors. Given that the majority of VAR related studies we evaluated used weekly, monthly or quarterly data in their analyses, they were all subject to such critique. Interestingly, whilst VAR related studies sought to mitigate concerns regarding the endogenous relationship between the stock market and monetary policy, they largely ignored the fact that lower-frequency aggregate measures of monetary policy were in themselves endogenous as they may have been influenced by a plethora of other factors.

Finally, although the VAR methodology had several benefits beyond the single-equation framework, Ehrmann and Fratzscher (2004) argued that it was '*important to consider the correct identification of monetary policy*'. These concerns were prevalent in the study by Crowder (2006), which demonstrated that the structural VAR model was highly sensitive to the identification strategy employed. It is important to note that VAR models are inherently backward looking in their estimation.

2.5 US Stocks & Monetary Policy (Alternative Measures)

2.5.1 US Stocks & Monetary Policy (Measured using heteroscedasticity based techniques)

Following the critique of Rudebusch (1996, 1998), later studies sought to develop alternative measures of monetary policy shocks. In particular, Rigobón and Sack (2002, 2004) developed a new estimator which was based upon the conditional heteroscedasticity present in higher frequency data. They considered a bivariate simultaneous equation model (Equations 2.9 and 2.10); where (Δs_t) was the change in asset price, (Δi_t) was the change in the short-term interest rate and (z_t) represented a vector of common variables (information shocks). The monetary policy shocks (ε_t) entered the monetary policy reaction function, and the stock market response was measured through the simultaneous model specification. Although the model was under-identified, to partially identify the model, they assumed monetary policy shocks occurred on FOMC event days.

$$\Delta i_t = \beta \Delta s_t + \gamma z_t + \varepsilon_t , \tag{2.9}$$

$$\Delta s_t = \alpha \Delta i_t + z_t + \eta_t , \tag{2.10}$$

Over the Jan-94 to Nov-01 sample period, Rigobón and Sack (2002, 2004) used a paired sample of 78 FOMC policy dates and non-policy dates, to examine the impact of monetary policy shocks on the S&P500, WIL500, Nasdaq and DJIA indices. The nearest expiring eurodollar futures contract was used as the measure of the short-term interest rates. Contemporaneous coefficients were estimated using the instrumental variables (IV) approach and the generalised method of moments (GMM). Interestingly, the stock market response to unexpected monetary policy shocks were shown to be consistent across all four US stock market indices and across the IV and GMM estimation methods, however slightly more pronounced coefficients were estimated for the Nasdaq Index (which is generally considered to exhibit higher volatility compared to the S&P500). An unexpected 1% increase in the short-term interest rate yielded a -6.81%(-7.19%) decrease in the S&P500 using IV and GMM. The estimated coefficients were also very similar to those yielded using event-study analyses.

In a related study, Craine and Martin (2003) demonstrated that Rigobón and Sack's (2002, 2004) simultaneous equation model in reduced form was "*observationally equivalent*" to a factor model with four systematic market-wide non-diversifiable risks. They extended upon the analysis of Rigobón and Sack (2002, 2004) by estimating a general factor model which examined stock return responses to various sources of systematic risks such as monetary policy shocks. Akin to Rigobón and Sack (2002, 2004), the model was identified through the restriction that monetary policy shocks occurred only on event-days. In contrast to Rigobón and Sack (2002, 2004) who considered a paired-sample with around 10% of available data (144 event-days), Craine and Martin (2003) used all the available data (more than 3000 daily observations) by setting monetary policy shocks to zero on non event-days. Over the Oct-88 to Dec-01 sample period, they compared estimates from the factor model to those using the model of Rigobón and Sack (2002, 2004). It was shown across various model specifications and alternative samples that the equity return response to monetary policy shocks was more negative and significant using the factor model specified in the paper.

The identification through the heteroscedasticity approach to measuring monetary policy shocks was not widely adopted in empirical studies evaluating the relationship between stock market performance and monetary policy shocks. As we shall see in Sections

2.6 onwards, this may be attributable to the development of alternative measures of monetary policy which were popularised in the mid 2000s.

2.5.2 US Stocks & Monetary Policy (Measured using non-standard indicators)

The measurement of monetary policy and monetary conditions has yielded a vast and voluminous literature. Many of the seminal and related studies evaluated in this thesis primarily measure monetary policy using the FFR, money supply and the discount rate. Despite the widespread use of these monetary measures, in this section we briefly evaluate alternative and less widely used measures of monetary policy and monetary conditions. These measures include; narrative expositions, monetary indices, dummy variable indicators, alternative money-market measures, and survey-based measures. In a highly influential book 'A Monetary History of the United States,' Friedman and Schwartz (1963) collated an extensive archive of historical documents including Fed statements, to undertake an ex-post analysis of Fed monetary policy in the US. The narrative exposition argued that exogenous changes in monetary policy, measured in terms of the growth rate in money supply, were followed by real changes in macroeconomic variables. As later studies (see Fama and French, 1989) demonstrated that business conditions and the macroeconomic environment influenced investor behaviour, this narrative discussion indirectly implied that stock returns were influenced by monetary policy.

In a later study, Boschen and Mills (1995) sought to translate the narrative discussion in Fed statements in to a numerical index concerning Fed monetary stance[32]. They constructed a narrative-based monetary policy index, classifying Fed statements in to five categories; strong emphasis on cutting inflation (-2), emphasis on cutting inflation (-1), neutral (0), emphasis on promoting real growth (1) and strong emphasis on promoting real growth (2). Thorbecke (1997) estimated the response of US industry stock returns to the Boschen and Mills (1995) narrative-based indicator of monetary policy[33] over the Jan-67 to Dec-90 sample period. They demonstrated that a one-unit increase in the index registered an average 0.83% monthly increase across the twenty-two industry portfolios. Narrative-based indicators of monetary policy were less widely used than money market indicators, because the interpretation of Fed statements imposed a subjective bias upon the construction of such

[32] The narrative-based monetary policy indices were largely used to examine the responses of monetary aggregates in lieu of the stock market (see Hakes, 1990; Romer and Romer, 1994)
[33] Other control variables were also used.

indices (Romer and Romer, 1994). It was further argued that whilst FOMC statements were a record of policy intent, they may not have been indicative of actual policy action by the Fed.

An alternative simpler measure of monetary stance was utilised by Conover, Jensen and Johnson (1999). They defined a dummy variable equal to one (zero) when monetary policy was restrictive (expansive) based on discount rate changes. Using this measure they demonstrated that compared to periods of monetary expansion, periods of monetary contraction were associated with lower stock returns[34]. Qualitatively similar conclusions were yielded by Ioannidis and Kontonikas (2008), who utilised the 3-month T-Bill rate as a measure of monetary policy. It is however important to note that these two studies employed non-standard measures of monetary policy because they investigated the impact of monetary policy on stock returns over various countries, and these measures ensured that comparable measures of monetary policy were used across the different countries.

To examine the stock market response to monetary policy, Ehrmann and Fratzscher (2004) used survey-data concerning market participants' expectations of target FFR changes to measure the unexpected component of target FFR change[35]. As the survey poll was undertaken on the Friday prior to each FOMC meeting, this limited their scope of their analysis to scheduled FOMC meetings. They nonetheless estimated the impact of survey-based FFR shocks on individual stocks in the S&P500 index. Over the Feb-94 to Jan-03 sample period, on FOMC event-dates, a 1% FFR shock was associated with a 5.5% decline across the 500 stocks. They documented firm-level heterogeneity in the impact of survey based FFR shocks. Specifically, capital intensive and cyclical industries were shown to exhibit stronger responses compared to other industries, consistent with the credit channel of monetary policy transmission.

2.6 US Stocks & Monetary Policy (FFR Futures Implied Measures)

2.6.1 US Stocks & Monetary Policy (Measured using FFR futures)

It is important to note that although Rudebusch (1996, 1998) offered a sharp critique of VAR based monetary policy shock measures, the argument was highly constructive and offered a potential alternative measure. The proposed measure was defined as the difference between the actual realised target FFR and the expected FFR gauged from the one-month

[34] The primary focus of this study was the international dimension of monetary policy transmission; however we restrict our discussion here to the US.
[35] A Reuters poll was undertaken on the Friday prior to each FOMC meeting concerning the target FFR.

ahead 30-Day FFR futures contract (FFR futures) which tracked the underlying instrument of the effective FFR. The study demonstrated that this market-based measure of unexpected FFR changes exhibited low correlation with monetary policy shock measures derived using VAR related methods. Given that the two measures were inconsistent with one another, the study advocated the use of market-based measures in lieu of the VAR based measure due the overwhelming empirical advantages.

The market-based measure of unexpected FFR changes was efficient in that it represented a natural proxy for the market's expectation of future FFR changes and associated forecast errors. It could furthermore be defined using higher-frequency daily data or ultra-high frequency intra-day data, which was more likely to be exogenous and less likely to endogenously reflect other macroeconomic factors or news compared to lower-frequency monthly aggregate measures used in many VAR related studies. Furthermore, Krueger and Kuttner (1996) demonstrated that FFR futures provided efficient and unbiased forecasts of the target FFR. They observed that there was a very small risk premium in FFR futures, and that they were good at forecasting potential future target FFR changes by the Fed. They concluded that "*traders, investors, or economists interested in predicting near-term Fed actions would be hard pressed to improve on the Fed funds futures rate*."

Whilst the benefits of market-based unexpected FFR measures are apparent, this measure proposed by Rudebusch (1996, 1998) which gauged market expectations of target FFR changes using FFR futures was not immune to critique. In particular, Kuttner (2001) identified two technical complications concerning FFR futures which had yet to be addressed before they could be used. Firstly, FFR futures were based upon the effective realised FFR and not the target FFR. Secondly, the settlement price for FFR futures was based upon the monthly average effective FFR and not the corresponding daily effective FFR. Rudebusch (1996, 1998) had also acknowledged the limitations of the approach, urging caution that prior to 1994 the market-based unexpected FFR measure may have been subject to simultaneity bias, because on several occasions, target FFR changes coincided with employment report releases by the Bureau of Labor Statistics. Later studies (see Chernenko, Schwartz, and Wright, 2004; Piazessi and Swanson, 2008) had also yielded evidence that market-based unexpected FFR measures may have been contaminated by risk-premia present in futures markets. They observed that one-month ahead FFR futures contracts exhibited three basis point risk premia, and that risk premia increased with further ahead contracts.

It is also important to consider the limitations of the market-based measure of unexpected FFR changes, as the advent of FFR futures in October 1988 constrained sample estimation to this date. Furthermore, whilst the Fed targeted the effective FFR through open market operations, it did not entirely control the market, hence negligible discrepancies between the target and effective FFR may have been present in the constructed measure. Despite these several disadvantages, Rudebusch (1996, 1998) characterised the market-based measure as being "*relatively unclouded by time-varying term premia or non-federal-funds-market idiosyncratic movements*."

In a subsequent study, Kuttner (2001) refined and popularised the methodology of Rudebusch (1996, 1998) through the use of an event-study analysis and by addressing many of the technical considerations and potential issues discussed above. The set of event-dates considered were those when the Fed changed the target FFR[36]. On each event-date, Kuttner (2001) measured the unexpected FFR shock $\left(\Delta i_t^u\right)$ as the change in the implied rate on the current-month FFR futures contract $\left(ff_{m,d}^0\right)$, as traded on the CBOT, relative to the day before the change $\left(ff_{m,d-1}^0\right)$. The study assumed risk premia were time invariant around FOMC event-date intervals $[d, d-1]$ as higher-frequency daily data was used. To counteract the fact that the settlement price for the FFR future contract was based upon the average effective FFR over the month, Kuttner (2001) developed a scaling adjustment for the unexpected FFR measure related to the number of days in the month affected by the change[37]. This definition of the unexpected FFR shock is defined in Equation 2.11, with the expected component of FFR change defined in Equation 2.12. The expected interest rate change was calculated as the actual target FFR change minus the computed unexpected FFR change.

$$\Delta i_t^u = \frac{D}{D-d}\left(ff_{m,d} - ff_{m,d-1}\right), \tag{2.11}$$

$$\Delta i_t^e = \Delta i_t - \Delta i_t^e, \tag{2.12}$$

Where $\left(ff_{m,d}^0\right)$ was the implied rate (100 minus the futures contract price) from the current-month FFR futures contract on the month (m) of the FOMC decision, on the day (d) of the FOMC decision and (D) represented the number of days within the month (m). This event-study market-based measure of unexpected FFR changes thus addressed the two technical complications concerning FFR futures contracts as well as concerns regarding risk-

[36] They also considered a set of event-dates which included; dates of target FFR change and dates of scheduled FOMC meetings without FFR changes.

[37] To minimise end of month distortions, unscaled changes were used when target rate changes occurred in the last three days of the calendar month, and the last day of the previous month's FFR contract was used when target rate changes occurred on the first day of the month.

premia in further ahead FFR futures contracts. Kuttner's (2001) pioneering methodology for defining unexpected FFR changes subsequently became one of the most popular measures of defining monetary policy shocks in the empirical literature.

Bernanke and Kuttner (2005) extended the analysis of Kuttner (2001) to investigate the response of daily stock returns (r_t) to expected (Δi_t^e) and unexpected (Δi_t^u) FFR changes, on FOMC event dates. The set of event-dates included scheduled FOMC meetings and unscheduled FOMC meetings with target FFR changes. Prior to 1994, event-dates were defined as dates of open market operations by the Federal Reserve Bank of New York Trading Desk and subsequent media announcements (see Kuttner, 2003).

$$r_t = \alpha + \beta_1 \Delta i_t + \varepsilon_t, \tag{2.13}$$

$$r_t = \alpha + \beta_1 \Delta i_t^e + \beta_2 \Delta i_t^u + \varepsilon_t, \tag{2.14}$$

Between Jun-89 and Dec-02, CRSP Value Weighted US Equity Index (US-CRSP-Val) returns yielded statistically insignificant responses to raw target FFR changes (Δi_t) (see Equation 2.13). Upon disaggregating the target FFR in to its constituent components concerning expected and unexpected FFR changes, an unexpected 1% target FFR increase yielded a *significant* one-day decline of -4.38% in the US-CRSP-Val index (see Equation 2.14). In comparison, the US-CRSP-Val Index yielded a smaller, statistically insignificant response to raw target FFR changes over the period. Only 0.7% of one-day variation in equity returns was attributable to news concerning target FFR changes, compared to 17.1% when considering its disaggregated expected and unexpected components. Upon exclusion of seven outlier observations from the estimation, the US-CRSP-Val Index response to the unexpected FFR shock declined to -2.55%. Interestingly, the impact of the expected FFR coefficient was statistically insignificant, consistent with the efficient markets hypothesis. This implied that the expected component of monetary policy was already priced in to the market, and thereby responded only to unexpected FFR changes. Zebedee, Bentzen, Hansen and Lunde (2008) similarly observed statistically insignificant responses of stock returns to the expected component of monetary policy; in particular they demonstrated that stocks responded significantly only to new information contained within the unexpected component of monetary policy.

Bernanke and Kuttner (2005) furthermore used interactive dummy variables to control for structural change in the unexpected FFR coefficient for the post-1994 period and for event-dates which coincided with employment release reports by the Bureau of Labor Statistics. These robustness checks were undertaken following concerns by Rudebusch (1996,

1998) that market-based unexpected FFR measures may have been influenced by the fact that the Fed began issuing statements following target FFR changes in 1994 and concerns regarding endogenous responses to employment reports. The US-CRSP-Val response was more muted for the pre-1994 period (-2.55%). However, more pronounced for the post-1994 period (-8.13%). On days when employment release reports coincided with unexpected FFR changes, the net market response was close to zero for the pre-1994 period, hence employment reports were interpreted as positive news by markets. Both interaction terms were statistically significant in the estimation. Upon exclusion of outlier observations, the post-1994 interaction term ceased to remain significant; however empirical conclusions concerning the employment report remained robust to the model specification. Interactive dummies were also used to control for positive surprises and positive rate changes in separate estimates, however significant asymmetries were not observed.

The analysis of Bernanke and Kuttner (2005) primarily focused upon a broad equity index (US-CRSP-Val) however they extended their investigation to also examine the responses of Fama-French industry portfolio returns to expected and unexpected FFR changes, using monthly data. An unexpected 1% FFR increase yielded a negative response across all ten industry portfolios, however insignificant responses were observed for Energy and Utilities. The strongest significant negative responses were yielded for Telecoms (-16.10%), High Tech (-14.73%) and Durables (-12.45%). The event-study analysis of Bernanke and Kuttner (2005) assumed unilateral causality from FFR changes to equity returns. They explicitly acknowledged that there were "*no clear examples of instances in which a drop in equity prices led the FOMC to cut rates*." In lieu of aggregate weekly, monthly or quarterly measures which were generally employed in VAR related studies, they utilised daily event-study data to mitigate concerns of endogeneity. They furthermore accounted for potential endogenous responses to employment report releases on event-dates using interactive dummy variables. This was predicated by the fact that between Jun-89 and Jul-92, on ten occasions the event-dates considered coincided with employment release reports.

Following the seminal studies of Kuttner (2001), Kuttner (2003) and Bernanke and Kuttner (2005), later empirical studies concerning the relationship between US monetary policy and US stock returns branched in several dimensions. In particular, Gürkaynak, Sack and Swanson (2002, 2005, 2007) developed these measures further to capture longer-term expectations of monetary policy. This prompted a branch of studies which investigated the impact of such measures on asset prices (see Section 2.6.2). Another branch of studies investigated potential state-dependence in the relationship between monetary policy and stock returns, considering whether business cycle conditions, bull-bear market conditions and credit market conditions influenced the relationship (see Section 2.6.3). A related branch of studies explored potential asymmetries in market responses to monetary policy shocks, with regards to positive versus negative surprises (see Section 2.6.4). Guided by Bonfim's (2003) argument that stock returns measures using ultra-high frequency intra-day data could increase precision of estimates, several of the studies in the following sections utilised such higher frequency measures in their studies. Furthermore, whilst the majority of these studies utilised regression related frameworks for examining these relationships, GARCH models as well as Markov-Switching models were also used to estimate the relationship.

2.6.2 US Stocks & Monetary Policy (Measured using timing and level shocks, or target and path factors)

Following the studies by Krueger and Kuttner (1996) and Rudebusch (1998), a multitude of alternative market-based measures were proposed to derive monetary policy shocks. These measures included; the current-month FFR futures (see Kuttner, 2001), the one-month ahead FFR futures (see Bonfim, 2003), the one-month eurodollar deposit rates (see Cochrane and Piazessi, 2002), the three-month eurodollar futures (see Rigobón and Sack, 2002) and three-month Treasury bill rates (see Ellingsen and Soderstrom, 2004). The proliferation of various competing measures motivated Gürkaynak, Sack and Swanson (2002, 2007) to evaluate the empirical efficacy of alternative market-based monetary policy shock measures in predicting the future trajectory of monetary policy. They demonstrated that measures such as the term federal funds loans, FFR futures, eurodollar deposits, commercial paper, eurodollar futures and Treasury bills all yielded forecasts of the FFR which were superior to that of a Bayesian VAR and AR(1) process[38]. Interestingly, they demonstrated that the methodology of Kuttner (2001), using FFR futures, dominated all other measures in predicting the FFR at one-month to six-month horizons however very similar results were yielded across the measures at longer-horizons. Although FFR futures were shown to exhibit superior forecasting power and lower risk-premia compared to the alternative instruments, these instruments were nonetheless shown to be very close substitutes.

[38] The Bayesian VAR forecast was from the 2007 published paper, whilst the AR(1) forecast was from the 2002 working paper version

Gürkaynak, Sack and Swanson (2002, 2007) observed that Kuttner's (2001) measure of unexpected FFR changes, using FFR futures "*provided the best measures of unexpected changes to the immediate policy setting*" however argued the measure may have been influenced by the timing of target FFR changes. Market participants may have anticipated target FFR changes in the foreseeable future however may have been uncertain whether the Fed would have changed the target FFR in the current FOMC meeting or the subsequent meeting. Consequently, they deconstructed unexpected FFR changes in to two components concerning the 'timing' surprise and the 'level' surprise. The timing surprise measured the component of unexpected FFR change which did not affect expectations beyond that of the "*immediate policy setting*" whilst the level surprise measured the component of unexpected FFR change which captured the "*general level of policy expectations*" or "*changes to the expected near-term policy path rather to the immediate policy.*" The level surprise was computed as follows (see Equation 2.15):

$$level_t^u = \frac{D^1}{D^1 - d^1}\left[\left(ff_{m,d}^1 - ff_{m,d-1}^1\right) - \frac{d^1}{D^1}\left[\frac{D^0}{D^0 - d^0}\left(ff_{m,d}^0 - ff_{m,d-1}^0\right)\right]\right], \quad (2.15)$$

Where $\left(D^1\right)$ was the number of days in the month of the next meeting, $\left(f_{m,d}^1\right)$ the one-month ahead FFR futures contract on day $\left(d^1\right)$ of month the next FOMC meeting, and $\left(f_{m,d-1}^1\right)$ the same measure the previous day. The timing surprise $\left(timing_t^u\right)$ was subsequently calculated as the residual from the regression of the total surprise $\left(\Delta i_t^u\right)$ on the level surprise $\left(level_t^u\right)$. Although the study derived 'timing' surprise and 'level' surprise measures of FFR changes, it did not explicitly examine the impact of such measures on asset prices. A later study by Kurov (2010) utilised such measures to examine the stock return response to such measures.

In a related study, Gürkaynak, Sack and Swanson (2005) sought to deconstruct unexpected FFR changes in to two components concerning the 'target factor' and 'path factor.' The target factor corresponded to "*surprise changes in the current federal funds rate target*" whilst the path factor[39] corresponded to "*changes in futures rates out to horizons of one year that [were] independent of changes in the current funds rate target*[40]." The were motivated by the fact that on 28th January 2004, the target FFR was not changed however

[39] Ehrmann and Fratzscher (2006) also argued that as FOMC decisions concerning the target FFR became increasingly predictable and transparent over time, hence markets responded significantly to 'path surprises.'

[40] The path factor could also be expressed as "*all aspects of FOMC announcements that move futures rates for the upcoming year without changing the current federal funds rate*" (Gürkaynak, Sack and Swanson, 2005)

financial markets responded significantly to a revision in monetary policy stance. The FOMC announced that "*the committee believes it can be patient in removing its policy accommodation*," replacing their earlier stance that "*policy accommodation can be maintained for a considerable period.*" This led market participants to revise their expectations concerning the future trajectory of monetary policy, and whilst the unexpected FFR change would have been a zero-change, it failed to capture the significant shift in monetary policy which occurred.

Gürkaynak, Sack and Swanson (2005) estimated the target and path factors using principal components analysis. In particular they used five variables, the unexpected FFR change (see Equation 2.11), the level surprise (see Equation 2.15), the change in the Eurodollar futures contract with an average of 1.5, 2.5 and 3.5 months to expiration, on FOMC event-dates. The variables were normalised to have zero mean and unit variance, decomposed in to principal components, and linearly transformed such that one factor drove the unexpected FFR change (the target factor), whilst the other factor was orthogonal to the unexpected FFR change (the path factor) and drove longer-term expectations over the next year. The two factors were subsequently re-scaled such that the target factor moved the unexpected FFR change one-for-one, and so that both factors had the same magnitude effect on the one-year ahead Eurodollar futures rate. This methodology ultimately yielded the target factor and path factor, and the latter factor was shown to be closely associated with changes in FOMC statements.

Prior to evaluating asset price responses to target and path factors, Gürkaynak, Sack and Swanson (2005) evaluated the impact of unexpected FFR changes on S&P500 returns using narrow thirty-minute, one-hour and one-day windows around FOMC announcements[41] (see Equation 2.16). The expected component of target FFR change was excluded from estimation because market-efficiency implied that the anticipated component of FFR change was already priced in to the market. Interestingly, the study demonstrated that intra-day and daily measures of unexpected FFR changes were very similar and differed between one to two basis points in many cases, with five anomalous exceptions which corresponded with pre-1994 observations where employment release reports were released several hours following FOMC announcements concerning target FFR changes. Over the Jan-90 to Dec-04 sample period, a hypothetical unexpected target FFR increase of 1% was associated with a

[41] Ultra high-frequency intra-day measures were used to reduce the likelihood of data being affected by 'noise' concerning other market news.

significant -4.03% (-3.96%) decrease in S&P500 returns using thirty-minute (one-day) announcement windows[42].

$$r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t, \qquad (2.16)$$

Furthermore, upon estimating the impact of the target and path factor on S&P500 returns over the same sample period (see Equation 2.17), the target factor yielded a significant -4.28% response; consistent with the unexpected FFR change. Interestingly, the path factor was associated with a statistically *insignificant* -0.96% response in S&P500 returns. These results were counter-intuitive given that anecdotal evidence implied a potential relationship between financial markets and FOMC statements and changes in the future trajectory of monetary policy. One should however note that highly significant responses to the path factor were observed in the US Treasury market.

$$r_t = \alpha + \beta_1 TF + \beta_2 PF + \varepsilon_t, \qquad (2.17)$$

2.6.3 US Stocks & Monetary Policy (State dependence)

As we have seen, the unexpected FFR change measure of Kuttner (2001) was adapted by Gürkaynak, Sack and Swanson (2005) to also consider the role of timing and level surprises, or target and path factors. Given that stock returns were shown to yield statistically insignificant responses to path factors, many studies investigating the relationship between monetary policy and stock market performance utilised Kuttner's (2001) measure of unexpected FFR changes in lieu of alternative measures. In this sub-section we evaluate studies which studied potential state-dependence in the relationship between monetary policy and stock returns. Basistha and Kurov (2008) utilised an equivalent dataset to Bernanke and Kuttner (2005) however extended their analysis in several dimensions, to investigate potential state-dependence in the relationship between S&P500 returns and unexpected FFR changes[43]. The study considered event-dates over the Jan-90 to Dec-04 sample period, however excluded eight event-dates which coincided with employment release reports. The study further excluded expected FFR changes from the analysis akin to by Gürkaynak, Sack and Swanson (2005).

Using OLS regressions, they observed significant S&P500 return responses to unexpected FFR changes (-5.51%), however upon further excluding unscheduled FOMC

[42] A similar result was obtained for the one hour announcement window.

[43] The study was motivated by an earlier study which observed state-dependence (see McQueen and Roley, 1993).

meetings from their analysis, the response ceased to remain statistically significant. These conclusions were robust to the Feb-94 to Dec-04 sub-sample period and to robust MM-weighted least squares estimates of the models. Thus the finding of a significant relationship between stock returns and unexpected FFR changes was contingent upon the inclusion of unscheduled FOMC meetings. To examine whether the relationship was further contingent upon business cycle conditions, Basistha and Kurov (2008) conditioned the unexpected FFR change on three recession indicators $\left(I^{rec}\right)$: the National Bureau of Economic Research (NBER) recession dummy, a dummy variable based upon the Chicago Fed National Activity Index (CFNAI) and the Experimental Coincident Recession Index (XRIC). By interacting these recession indicators with the unexpected FFR change coefficient (see Equation 2.18), they found a stronger stock market response to unexpected FFR changes during recessionary periods across all three measures. For example, an unexpected 1% FFR increase registered a statistically significant (insignificant) one-day decline of -6.52% (-2.73%) in S&P500 returns during recessions (non-recessions), using the CFNAI indicator. The study demonstrated that there was a significant difference in the stock market response to FFR shocks during recessions and expansions.

$$r_t = \alpha + \beta_1 I^{rec} \Delta i_t^u + \beta_2 \left(1 - I^{rec}\right) \Delta i_t^u + \varepsilon_t , \tag{2.18}$$

Basistha and Kurov (2008) also conditioned unexpected FFR changes on two credit conditions indicators: the percentage of loan officers reporting tightening credit standards, and the spread between higher yielding bonds and AAA rated bond yields, both normalised by sample mean and standard deviation. The stock response to FFR shocks was shown to double in magnitude when either credit conditions variable increased by one standard deviation. This implies that stocks are associated with larger magnitude responses to monetary policy shocks during periods of tightening credit market conditions. The finding was also shown to be in contrast to previous studies which did not find significant evidence of state-dependence in the relationship between stock returns and monetary policy attributable to credit market conditions (see Warner and Georges, 2001; Andersen, Bollerslev, Diebold and Vega, 2007)[44]. It was argued that this was due to the fact that these studies measured monetary policy shocks using money-market survey indicators in lieu of market-based indicators (i.e. FFR futures), due to the smaller sample periods considered in previous

[44] The study also observed heterogeneity in the responses of US industry sectors to unexpected FFR changes over the sample. Cyclical and capital intensive industries were shown to respond more strongly to monetary news.

studies. The finding of state-dependence attributable to credit market conditions was interpreted as evidence for the credit channel of monetary transmission.

In a subsequent study, Kurov (2010) estimated S&P500 return responses to unexpected FFR changes[45], during bull market and bear market regimes; using a bull-market probability indicator $\left(I^{bull}\right)$. The indicator was generated by Chen (2007) using a Markov-switching model. Akin to Basistha and Kurov (2008), the study excluded eight-event dates corresponding to employment release reports and further excluded expected FFR changes from the analysis (see Equation 2.19). Their estimates demonstrated that over the Jan-90 to Nov-04 sample period, a hypothetical unexpected 1% increase in the target FFR was shown to be associated with a highly significant -11.85% S&P500 response during bear-markets compared with an *insignificant* -0.68% response during bull-markets. Similar results were obtained using robust MM-weighted least squares estimates.

$$r_t = \alpha + \gamma_1 I^{bull} \Delta i_t^u + \gamma_2 \left(1 - I^{bull}\right) \Delta i_t^u + \varepsilon_t, \qquad (2.19)$$

Having observed state-dependence in the relationship between monetary policy and stock returns, with respect to bull-market and bear market-regimes; Kurov (2010) subsequently estimated S&P500 return responses to level and timing surprises (see Gürkaynak, Sack and Swanson, 2002, 2007) conditioned upon these regimes (see Equation 2.20). A more amplified significant negative response to timing surprises was yielded during bear-markets (-9.69%) compared to that during bull-markets (-2.89%). Interestingly, the stock response to level surprises in bear-markets was *positive*, significant, and larger in magnitude than the timing surprise. The estimates were rationalised as being indicative of market participants over-reacting to timing surprises during bear-markets.

$$r_t = \begin{matrix} \alpha + \gamma_1 I^{bull} timing + i_t^u + \gamma_2 \left(1 - I^{bull}\right) timing_t^u + \\ \gamma_3 I^{bull} level + i_t^u + \gamma_4 \left(1 - I^{bull}\right) level_t^u + \varepsilon_t \end{matrix}, \qquad (2.20)$$

The majority of studies that we have reviewed so far used regression related methodologies for evaluating state-dependence in the stock market response to monetary policy shocks. In contrast to these studies, Davig and Gerlach (2006) estimated the impact of FFR shocks on stock returns using Markov-switching models. Instead of exogenously defining state-dependent regimes as in previous studies, the Markov-switching framework allowed the relationship between stock returns and target FFR shocks to endogenously differ between state-dependent regimes in the sample. Using a high-frequency (30 minute interval)

[45] It is important to note that for these estimates Kurov (2010) used Gürkaynak, Sack and Swanson's (2002, 2007) measure of level FFR surprises, in lieu of the measure developed by Kuttner (2001).

event-study methodology, and deriving target FFR shocks in line with Kuttner (2001), the study by Davig and Gerlach (2006) evaluated the following model (see Equation 2.21).

$$r_t = \alpha + \beta_1(S_t)\Delta i_t^u + \varepsilon_t \qquad \text{where } \varepsilon_t \sim N\left(0, \sigma(S_t)^2\right), \tag{2.21}$$

The unobserved state variable (S_t) was governed by a two-state Markov chain and the variance of the residual was allowed to endogenously vary between the two states: a low volatility regime (Feb-94 to Nov-94, Sep-98 to Sep-02) and high volatility regime (Nov-94 to Sep-98). In the low-volatility regime, a 1% FFR shock was associated with a significant -1.91% decline in the S&P500 index. However an *insignificant* response was obtained during the high-volatility regime. The statistical insignificance was interpreted as being indicative of a more unpredictable and volatile stock return response to FFR shocks. As these estimates only considered scheduled FOMC meetings, the analysis was repeated using a dataset which also included unscheduled meetings. Interestingly all the unscheduled meetings occurred in the high-volatility regime, and including these observations, the statistically insignificant estimates previously obtained became highly significant, with a 1% FFR shock yielding a -1.62% (-6.88%) response in the low-volatility (high-volatility) regime.

In a related study, Chen (2007) used the Markov-switching model framework to evaluate potential state-dependence in the S&P500 response to monetary policy during bull and bear market regimes. The study investigated various measures of monetary policy, including discount rate changes, FFR changes and orthogonalised innovations from VAR models. Over the Jan-65 to Nov-04 sample period, a monetary tightening across any of the measures was shown to yield more pronounced negative stock responses during bear market regimes compared to bull market regimes. It is however important to note that whilst responses in bull-markets were generally statistically significant, the more pronounced responses in bear-markets were largely statistically insignificant. As the aggregate measures considered were subject to critique concerning potential endogeneity and measurement error associated with aggregate monthly data, an event-study methodology was also considered. Akin to Ehrmann and Fratzscher (2004) they measured FFR shocks by gauging expectations from survey data, and extending the linear specification of their model to a Markov-switching framework. Their estimates were consistent with state-dependence in the relationship between monetary policy and stock returns, characterised by bull-market and bear-market regimes, with stronger stock responses to the latter regime.

2.6.4 US Stocks & Monetary Policy (Asymmetries & volatility)

Having evaluated studies concerning state-dependence in the relationship between stock returns and market-based measures of monetary policy shocks, it is apparent that the relationship was characterised by asymmetric responses to recessions versus non-recessions, bear-markets versus bull-markets and tighter versus looser credit market conditions. In this sub-section we review studies which investigated potential asymmetries in stock responses to negative and positive FFR shocks, FFR changes and reversals of policy; as well as studies which evaluated stock volatility responses to FFR changes.

Chulia, Martens and Van Dijk (2010) estimated the responses of S&P100 returns for individual stock to expected and unexpected FFR changes as well as a reversal dummy variable $\left(D^{rev}\right)$ set equal to one on event-dates associated with FOMC reversals in monetary policy (see Equation 2.22)[46]. The analysis was subsequently repeated using S&P100 volatilities, and correlations between individual S&P100 stocks as the dependent variable. By aggregating estimates across stocks, a hypothetical 1% FFR shock was shown to yield a stronger significant response (-7.17%) using daily returns compared to that using five-minute intra-day returns (-3.96%). This may have been indicative of initial under-reaction by financial markets which normalised over the course of the day. In line with previous studies, and consistent with market efficiency, the expected FFR coefficient was statistically insignificant for all the models considered. Interestingly, the stock response to the reversal dummy was highly significant using five-minute returns (-18.08%), but insignificant with daily returns. Furthermore stock volatilities and stock correlations only responded significantly to the surprise component of FFR changes, with a hypothetical 1% positive FFR shock being associated with a 4.83% increase in stock volatility.

$$r_t = \alpha + \beta_1 \Delta i_t^u + \beta_2 \Delta i_t^e + \beta_3 D^{rev} + \varepsilon_t , \qquad (2.22)$$

To investigate whether stock returns, volatilities and correlations responded asymmetrically to negative and positive FFR shocks, the study estimated Equation 2.23 and made a distinction between the "*mere presence of the change*" $\left(\alpha_1, \alpha_2\right)$ and "*the magnitude of surprise*"$\left(\beta_1, \beta_2\right)$. For each of these dependent variables, they demonstrated that for negative FFR shocks, the magnitude of the shock $\left(\beta_1\right)$was more important than its occurrence$\left(\alpha_1\right)$. Conversely, for positive FFR surprises, the mere occurrence of the shock$\left(\alpha_2\right)$was more

[46] Chulia, Martens and Dijk (2010) estimated all their models using individual stocks from the S&P100 Index however aggregated the estimates from each equation to yield the 'market' response. The impact of FFR shocks on the stock correlations were shown to be non-linear due to the Fisher transformation

important than its actual magnitude (β_2). The asymmetries in market responses to positive and negative unexpected FFR changes were observed in both five-minute and daily stock returns, stock volatilities and stock correlations. These results were indicative of market participants reacting more strongly to negative market news (positive FFR shocks) compared to positive market news (negative FFR shocks).

$$r_t = \left(\alpha_1 + \beta_1 \Delta i_t^u\right) D^{\Delta i_t^u < 0} + \left(\alpha_2 + \beta_2 \Delta i_t^u\right) D^{\Delta i_t^u > 0} + \beta_3 D^{rev} + \varepsilon_t, \quad (2.23)$$

In a related study, Andersson (2010) developed an intra-day measure of stock market volatility and analysed its response to target and path factors[47]. The volatility indicator measured the ratio of volatility in the S&P500 index thirty minutes prior to the FOMC announcement and five-minutes before on FOMC event-dates, relative to the measure on non-FOMC event-dates on equivalent days and times of announcement. The target and path factors were constructed using the framework of Gürkaynak, Sack and Swanson (2005) however expectations were gauged using survey-based measures. Upon estimating the volatility indicator response to absolute target and path factors (see Equation 2.24), Andersson (2010) observed on average a significant 'upsurge' in stock market volatility following absolute path surprises, however an insignificant response to the absolute target surprises. These estimates were intriguing given that Gürkaynak, Sack and Swanson (2005) demonstrated that stock returns responded significantly to the target factor in lieu of the path factor. These results were shown not to be contingent upon whether the target FFR was changed or not.

$$\Delta Volratio_{t-30,t} = \alpha + \beta_1 Abs(TF) + \beta_2 Abs(PF) + \varepsilon_t, \quad (2.24)$$

In another related study, Wang, Yang and Wu (2006) evaluated the responses of stock returns, volatilities, trading volumes and bid-ask spreads of two exchange traded funds (ETF); the S&P500 SPY fund and the S&P400 MDY fund, to monetary policy shocks. They considered the responses of these measures to both unexpected FFR changes (one-factor models), and to target and path factors (two-factor models). In the one-factor (two-factor) models, all the aforementioned measures yielded significant responses to unexpected FFR changes (the target factor). The impact of the path factor on the volatilities of the two ETFs was shown to be significant, evidence consistent with Anderson (2010); however the path

[47] The study by Andersson (2010) considered the impact of European Central Bank monetary policy decisions on German bond markets and Euro area stock markets as well as the impact of Fed monetary policy decisions on US bond and stock markets, however we restrict our discussion to that concerning the impact of Fed decisions on US stock volatility.

factor yielded mixed evidence for an impact on stock returns, consistent with evidence from Gürkaynak, Sack and Swanson (2005)[48].

To investigate potential asymmetries in stock responses to monetary announcements, Wang, Yang and Wu (2006) used dummy variables to distinguish between the effects of positive and negative FFR shocks (see Equation 2.25), akin to Chulia, Martens and Dijk (2010). The study also considered potential asymmetries in the target factor and path factor (see Equation 2.26). In the one-factor model, negative (positive) FFR shocks yielded significant (insignificant) effects on returns from the two ETFs, evidence consistent with , Martens and Dijk (2010). However in the two-factor model, only negative surprises in the target factor yielded significant effects on the two ETFs. Both positive and negative surprises in the path factor yielded insignificant responses, in line with Gürkaynak, Sack and Swanson (2005).

$$r_t = \left(\alpha_1 + \beta_1 \Delta i_t^u\right) D^{\Delta i_t^u < 0} + \left(\alpha_2 + \beta_2 \Delta i_t^u\right) D^{\Delta i_t^u > 0} + \varepsilon_t, \quad (2.25)$$

$$r_t = \left(\beta_1 \Delta TF\right) D^{TF<0} + \left(\beta_2 TF\right) D^{TF>0} + \left(\beta_3 \Delta PF\right) D^{PF<0} + \left(\beta_4 PF\right) D^{PF>0} + \varepsilon_t, \quad (2.26)$$

Wang, Yang and Wu (2006) also investigated potential asymmetries in the direction of target FFR changes using dummy variables for target FFR increases and decreases (see Equation 2.27). In the one-factor (two-factor) models, the ETFs yielded significant responses to unexpected FFR changes (the target factor) only during monetary expansion. Interestingly, ETF response to the path factor was significant, at the 10% level, only during periods of monetary contraction. This implied that market participants responded more to path surprises than target rate surprises during periods of monetary contraction.

$$r_t = \left(\beta_1 \Delta TF\right) D^{\Delta i<0} + \left(\beta_2 TF\right) D^{\Delta i>0} + \left(\beta_3 \Delta PF\right) D^{\Delta i<0} + \left(\beta_4 PF\right) D^{\Delta i>0} + \varepsilon_t, \quad (2.27)$$

In a more recent study, Farka (2009) investigated potential asymmetries in S&P500 futures responses to timing and path surprises during easing and tightening cycles. Equation 2.28 was estimated for one-minute, two-minute, three-minute, four-minute, five-minute, ten-minute and twenty-minute windows around FOMC announcements. Stock returns were shown to yield larger negative responses to path surprises during easing cycles compared to tightening cycles. Interestingly, stocks responded positively to timing surprises during easing

[48] The impact of path surprises on the S&P500 SPY Fund was marginally significant (10% significance) and of a low magnitude (-0.79%). Furthermore the S&P400 MDY Fund response to path surprises was statistically insignificant.

cycles however negatively during tightening cycles[49]. Furthermore, as the announcement window was widened from one-minute to twenty-minutes, the magnitude of responses monotonically increased for path surprises, as well as for timing surprises during easing cycles. They also demonstrated using a GARCH model that stock return volatility was abnormally low prior to the FOMC announcement, increased dramatically during the announcement, declined however remained elevated several hours following the announcement and decreased considerably the following day.

$$r_t^{futures} = (\beta_1 Timing)D^{\Delta i>0} + (\beta_2 Timing)D^{\Delta i<0} + (\beta_3 PF)D^{\Delta i>0} + (\beta_4 PF)D^{\Delta i<0} + \varepsilon_t, \qquad (2.28)$$

2.7 US Stocks & Monetary Policy (The 2007-2009 Crisis)

2.7.1 US Stocks & Monetary Policy (Background & dating)

"*The world is suffering through the worst financial crisis since the 1930s, a crisis that has precipitated a sharp downturn in the global economy*" (Bernanke, 2009)

We have reviewed empirical studies which examined the impact of monetary policy shocks on stock returns prior to the 2007-2009 crisis. In this sub-section, we evaluate more recent studies in the field which examined the relationship between monetary policy and stock market performance over the crisis period in its entirety or in part. Prior to reviewing such studies, it is important to refine what is understood to be the crisis period, as this measure would refine our sample of studies. To avoid unintentionally excluding potential studies in our analysis which examined the relationship between stock returns and monetary policy over part of the crisis, we define a very broad measure of the crisis from *Aug-07 to Jun-09*. We thus evaluate studies which examined the relationship between monetary policy and stock market performance over the entirety of the Aug-07 to Jun-09 sample period, or over part of this sample period.

It is important to note that there is contention over the precise dating of the 2007-2009 crisis period, and this primarily stems from the disparity between the actual initial realisation of a crisis in financial markets and the lagged response of the broader macroeconomy. In this context, we begin by distinguishing between the *financial crisis* period and the resulting *economic crisis* period. The NBER Business Cycle Dating Committee conveniently defined the economic recession associated with the 2007-2009 crisis as spanning the Dec-07 to Jun-

[49] As the announcement window increased from one-minute gradually to twenty-minutes, the magnitude of response to path surprises during easing and tightening cycles increased, as did the response to timing surprises during tightening cycles; however the response to timing surprises during easing cycles declined.

09 sample period. Thus many macroeconomic studies have utilised these dates as their measure of the *economic crisis* period. Although these dates were widely recognised as the benchmark specification of the *economic crisis* in the US, the end-point in Jun-09 was only officially recognised by the NBER in Jun-10 (NBER, 2010). Prior to this announcement, empirical studies concerning the *economic crisis* generally utilised the last available observation date as their estimate of the end-point of the crisis. This naturally introduced discrepancies amongst earlier measures of the *economic crisis* period.

To demonstrate the complexity in isolating a precise start date for the associated *financial crisis* period, we provide a brief exposition of events which foreshadowed the 2007-2009 crisis. On 9th Aug 07, the investment bank BNP Paribas was one of the first banks to publicly acknowledge the "*complete evaporation of liquidity in certain market segments of the US securitization market*" (BNP Paribas, 2007). As their funds managers were unable to value holdings, they subsequently closed two funds which were heavily exposed to sub-prime mortgages. In response to these events, credit market conditions deteriorated and on the same day, the European Central Bank (ECB) sought to reassure financial markets by pumping €95billion in to the banking sector to improve liquidity. As these measures proved inadequate, they further pumped an additional €109billion over the following days in an effort to ease market conditions (BBC News, 2007).

On the 10th Aug 07, the Fed responded to these events by issuing a statement to reassure financial markets, "*depository institutions may experience unusual funding needs because of dislocations in money and credit markets. As always, the discount window is available as a source of funding*" (Fed Reserve, 2007a). Unfortunately, the positive market sentiment following ECB and Fed intervention was shown to be short-lived, as financial conditions worsened following the downgrade of Countrywide Financial Corporation's credit rating (the largest mortgage lender in the US) on 16th Aug 07 (SEC, 2007)[50]. The Fed responded once again, on 17th Aug 07, with more concrete measures to ease market conditions, decreasing the primary credit rate 50 basis point to 5.75% (Fed Reserve, 2007b).

By September 2007, the financial crisis had spread internationally and the LIBOR rate had increased to a phenomenal 6.7975%, above the Bank of England's (BOE) base rate which was set at 5.75%. This was the highest LIBOR rate since Dec-98 and indicative of severely tightening credit market conditions. September 2007 was further characterised by the first bank-run in the United Kingdom for 150 years, following leaked reports (14th Sep 07)

[50] Countrywide Financial Corporation's credit rating wad downgraded to BBB+ by Fitch Ratings

that that the British Bank Northern Rock required emergency funding from the BOE (HM Treasury, 2007). As liquidity dried up and market conditions worsened, the Fed intervened once again on 18th Sep 07. They decreased the target FFR by 50 basis points to 4.75%, the first target FFR cut since Jun-03. The primary credit rate was furthermore decreased by 50 basis points to 5.25% (Fed Reserve, 2007c).

Given the complexity of events leading up to the crisis, one may subjectively define when the *financial crisis* began, contingent upon the weighting awarded to events which transpired throughout the period. Whilst the *economic crisis* spanned the Dec-07 to Jun-09 sample period, the *financial crisis* may have been realised in financial markets significantly earlier in Aug-07/Sep-07. This is consistent with lags in the transmission mechanism of financial market changes in to the broader macroeconomy. Dating the start of the financial crisis to the summer of 2007 was furthermore consistent with market indicators such as the TED Spread, VIX Index, and Interbank-Lending Rates which soared during the period. We would also like to point out that whilst the NBER officially defined Dec-07 as the start of the economic crisis when there was a "*peak in employment*", they noted that "*economic activity measured by production was close to flat from roughly September 2007*" (NBER, 2010). As the 2007-2009 crisis period can be disaggregated in to its constituent components of the *financial crisis* and resulting *economic crisis*, the overall 'crisis' covered a sample period beginning as early as Aug-07 and ending as late as Jun-09. We therefore evaluate studies in this section which investigated the relationship between stock returns and monetary policy over a sample period which covered the Aug-07 to Jun-09 sample period in its entirety, or only in part.

2.7.2 US Stocks & Monetary Policy (Overview of pre-crisis studies)

Prior to the 2007-2009 crisis period, studies concerning the impact of monetary policy on stock market performance primarily utilised three alternative interrelated measures for defining *conventional* monetary policy shocks. The first employed the event-study methodology of Kuttner (2001) and Bernanke and Kuttner (2005), disaggregating target FFR changes in to expected and unexpected FFR changes, gauging expectations from CBOT futures contracts tracking the underlying instrument of the effective FFR. The pre-crisis studies using these measures demonstrated that in line with market efficiency, stock returns were shown to yield statistically insignificant (significant) responses to expected (unexpected) FFR changes.

The second approach followed the event-study methodology of Gürkaynak, Sack and Swanson (2005), disaggregating monetary policy changes in to two components concerning a target factor and path factor concerning the future trajectory of monetary policy. The pre-crisis studies using these measures demonstrated that stock returns were associated with significant (insignificant) responses to the target (path) factor (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). The third methodology followed the framework of Rigobón and Sack (2002, 2004) and Craine and Martin (2003), exploiting the conditional heteroscedasticity in high-frequency data to measure monetary policy shocks. These models were identified through the restriction that shocks occurred on FOMC announcement dates.

Following the 2007-2009 crisis period, a growing empirical literature emerged, investigating the impact of non-conventional monetary policy by the Fed on asset prices. As Cenesizoglu, Larocque and Normandin (2012) point out, there was a comparative dearth of studies investigating the impact of *conventional* monetary policy measures by the Fed on asset prices during the crisis. We found this to be rather unusual, because conventional target FFR changes were used as the primary tool of the Fed for the majority of the crisis period (Sep-07 to Dec-08). Non-conventional forms of monetary policy were largely employed after the target FFR approached the zero-lower bound on Dec-08. Thus unusually, the majority of empirical studies concerning monetary policy and stock market performance during the crisis focused on non-conventional monetary policy with a cursory analysis of the impact of conventional monetary policy.

In this sub-section, we review studies which examined the stock return response to monetary policy throughout the 2007-2009 crisis period, or over a sample period which covered part of the crisis. Several studies we evaluate in this section measured conventional monetary policy using the methodology of Kuttner (2001) and Bernanke and Kuttner (2005), or through the framework of Gürkaynak, Sack and Swanson (2005). The former methodology was applied by Gorodnichenko and Weber (2013) and Demiralp and Yilmaz (2012), whilst the latter methodology was utilised by Kurov (2012) and Eijffinger, Mahieu and Raes (2012). We further evaluate studies which extended such analysis to also examine stock return responses to non-conventional monetary policy. In particular, increasing use of forward guidance by the FOMC through statements (see Farka and Fleissig, 2012; Rosa, 2011; Rosa, 2012) and LSAP purchases by the Fed (see Rosa, 2012). Lastly, we evaluate a study which defined monetary policy shocks using a methodology akin to Rigobón and Sack (2002, 2004), over a period where the target FFR was at the zero-lower bound (see Wright, 2012).

We would like to point out that the majority of the studies evaluated in this section did not exist at the time of writing and researching the majority of this thesis. To the best of our knowledge, in 2010 only two studies were available (see Demiralp and Yilmaz 2009, 2010; Farka and Fleissig 2010). By 2011 several new papers had emerged (Eijffinger, Mahieu and Raes 2011; Kurov 2011; Rosa 2011; Wright 2011). A slightly larger empirical literature was established by 2013 (see Rosa 2012; Gorodnichenko and Weber, 2013).

2.7.3 US Stocks & Monetary Policy (Conventional and non-conventional monetary policy)

When the target FFR approached the zero-lower bound in late 2008, the Fed began to rely more heavily on non-conventional forms of monetary policy to influence financial markets and the broader macroeconomy. These measures primarily included "*forward guidance and large-scale asset purchases*" (Williams, 2012). The term '*forward guidance*' typically refers to the increasing and more explicit use of FOMC statements to influence market-rates and expectations concerning the future trajectory of monetary policy during the crisis period. The term '*large-scale asset purchases*' refers to what is commonly known as quantitative easing, a series of programmes which were designed to influence market rates, as well as monetary financial and economic conditions through purchases of longer-term maturity securities such as housing-agency debt, mortgage-backed securities, and US Treasuries. Due to the qualitative nature of FOMC statements, it is difficult to precisely quantify its information content. Several studies have simply extended the approach employed by pre-crisis studies, by measuring the information content of FOMC statements using the path factor whilst others have measured its content using subjectively defined statement indicators. Although *forward guidance* was primarily used to influence US Treasury yields, several studies also considered the impact of such statements on stock returns over the crisis period. We review each of these studies in turn, beginning with a very recent study which solely investigated the impact of conventional monetary policy shocks on US stock returns.

In a very recent study, Gorodnichenko and Weber (2013) estimated the impact of unexpected FFR changes on S&P500 returns over the Feb-94 to Dec-09 sample period. They measured stock return responses using 30-minute and 60-minute windows; however the impact of monetary policy shocks was shown to be statistically *insignificant* in both cases. Interestingly the standard errors were lower using the wider 60-minute window. By restricting the sample to a pre-crisis period, negative and statistically significant responses were recovered, consistent with studies covering pre-crisis sample periods. Similar conclusions were yielded by Kontonikas, MacDonald and Saggu (2013), a paper derived from Chapter 3 and 4 of this thesis.

Gorodnichenko and Weber (2013) subsequently estimated the impact of *squared* FFR shocks on *squared* stock returns, over the whole sample, however the stock return responses were once again shown to be statistically *insignificant* when considering scheduled meetings only, or unscheduled meetings only[51]. Upon further interacting FFR shocks with a measure of the frequency of price adjustment $\left(\lambda_i\right)$ (see Equation 2.29), squared FFR shocks were shown to yield positive effects on squared stock returns, with a hypothetical 0.25% shock yielding a squared stock return of 8.03% for firms with the stickiest price[52]. Interestingly, the interaction term demonstrated that the impact upon firms with the most flexible prices was up to threefold lower than that of firms with most sticky prices.

$$\left(r_t\right)^2 = \alpha + \beta_1\left(\Delta i_t^u\right)^2 + \beta_2\left(\Delta i_t^u\right)^2 \lambda_i + \beta_3\lambda_i + \varepsilon_t, \qquad (2.29)$$

As we have seen, Gorodnichenko and Weber (2013) examined stock return responses to a single measure of monetary policy shocks over a period covering the 2007-2009 crisis. In contrast to this single measure, Demiralp and Yilmaz (2012) constructed a series of target FFR surprises, from one-month to six-months in the future, in an effort capture longer-term expectations of monetary policy. Current month monetary policy shocks were constructed using the methodology of Kuttner (2001), see Equation 2.11, however further j month-ahead FFR shocks were constructed as follows by scaling the previous monetary surprise using further month-ahead futures contracts, as in Equation 2.30[53].

$$\Delta i_{t,j}^u = \frac{D^{j-1}}{D^{j-1} - d^{j-1}}\left[\left(f_{m,d}^{j-1} - f_{m,d-1}^{j-1}\right) - \frac{d^{j-1}}{D^{j-1}}\left[\frac{D^{j-2}}{D^{j-2} - d^{j-2}}\left(f_{m,d}^{j-2} - f_{m,d-1}^{j-2}\right)\right]\right], \qquad (2.30)$$

Demiralp and Yilmaz (2012) estimated S&P500 return responses to each of the one-month to six-month monetary surprises over the May-89 to Jun-08 sample period. The one-month, two-month and three-month target FFR shocks were shown to yield statistically

[51] A significant response was only recovered in very precise circumstances when both scheduled and unscheduled meetings, as well as squared stock returns and shocks were considered

[52] Other control variables were also used, however these are omitted for a more concise discussion.

[53] Special caveats should also be noted, specifically FFR surprises were calculated as $\left(f_{m,d}^{j+1} - f_{m,d-1}^{j+1}\right)$ for the last five days of the month, and as $\left(f_{m,d}^{j+1} - f_{m,d-1}^{j+2}\right)$ for the first day of the month. See the paper for more detailed discussion concerning calculation of unscheduled FOMC meeting surprises. This methodology was essentially an extension of 'level surprise' developed by Gürkaynak, Sack and Swanson (2005).

insignificant effects on S&P500 returns in each case[54]. After excluding outlier observations, the one-month (two-month) target monetary policy shocks yielded *significant* -2.04% (-2.94%)[55] effects on stock returns; however longer-term monetary policy shocks exhibited statistically *insignificant* effects. As the study had demonstrated that US Treasuries at various maturities responded significantly to one-month to six-month shocks, this implied that the equity market may not have been as forward looking as the US Treasury market.

To investigate the impact of monetary policy in the foreseeable future on asset prices, Demiralp and Yilmaz (2012) constructed an alternative measure of path revision in monetary policy by averaging the one-month to three-month monetary surprises. However, S&P500 returns were shown to be associated with statistically *insignificant* responses to the path revision measure. After excluding outlier observations, the stock response to path revision became significant (-5.24%) and outweighed the impact of the current-month target FFR shock. This was in contrast to pre-crisis studies which observed highly *significant* negative stock market responses to target rate shocks and insignificant responses to path surprises (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). One should however note that this measure of path surprises differed from Gürkaynak, Sack and Swanson's (2005) path factor.

In a related study, Kurov (2012) estimated the impact of the target factor and path factor on S&P500 returns over a period which included part of the 2007-2009 crisis; from Jan-94 to Sep-08. Consistent with pre-crisis studies, stock returns responded significantly (-6.01%) to the target factor and statistically *insignificantly* to the path factor. Similar results were obtained using robust MM-Estimator regressions. To investigate whether the relationship was characterised by state-dependence, the model was further conditioned upon state of the economy using an NBER recession dummy variable (see Equation 2.31).

$$r_t = \beta_1 TF\left(D^{NBER}\right) + \beta_2 TF\left(1 - D^{NBER}\right) + \beta_3 PF\left(D^{NBER}\right) + \beta_4 PF\left(1 - D^{NBER}\right) + \varepsilon_t, \qquad (2.31)$$

Consistent with pre-crisis studies, state-dependence was further observed in the target factor, with a hypothetical 1% shock yielding a significant -7.25% (-4.54%) decrease in stock returns during recession (expansion). After conditioning the model to the state of economy, the stock return response to the path factor was negative and significant during expansion

[54] These estimates were presented in the external online appendix and the Demiralp and Yilmaz (2010) working paper. S&P500 return responses to four-month, five-month and six-month monetary policy shocks, not excluding outliers, were not shown in any of these studies; hence we cannot comment on such estimates.

[55] These estimates were consistent with Bernanke and Kuttner (2005) who yielded a significant -2.55% US-CRSP-Val response to a hypothetical 1% FFR shock over the Jun-89 to Dec-04 sample period after excluding outlier observations.

however *positive* and *significant* during recession. A 0.25% positive surprise in the path factor yielded a 2.73% (-0.75%) increase (decrease) in stock returns during recession (expansion)[56]. The positive stock response to the path factor during recession implied that market participants may have been more interested in the Fed's assessment of the economy in the future than its monetary stance[57].

Whilst Kurov (2012) considered a sample period which covered part of the 2007-2009 crisis period, a very similar study by Eijffinger, Mahieu and Raes (2012) examined the impact of both the target and path factor on S&P500 stock returns over a sample period which covered the entirety of the crisis period; from Feb-94 to Dec-09. The study also differed in that it defined the path factor as the one-year ahead Eurodollar interest rate futures contract orthogonal to the target FFR shock[58]. Consistent with with Kurov (2012), the study by Eijffinger, Mahieu and Raes (2012) estimated Equation 2.31 and observed state-dependence in the stock return response to the path factor; with a *negative (positive)* and *significant* response during recession (expansion)[59].

Whilst the estimates concerning the path factor were consistent across these two studies, this was not the case for estimates of the target factor. Kurov (2012) estimated a significant *negative* stock return response to the target factor during both recession and expansion, with a more amplified negative response during the former. Eijffinger, Mahieu and Raes (2012) similarly estimated *negative* and *significant* stock responses to the target factor during expansion. However the stock return response to the target factor during recessions was *positive* and *significant* across individual S&P500 stocks. This was robust to a shorter sample period (Jun-03 to Dec-09). The coefficient became statistically insignificant when considering S&P500 index returns. It furthermore became *negative* and *significant* (in line with Kurov, 2012) upon the exclusion of outlier observations. To examine whether the aforementioned state-dependence in target and path factors persisted across industry sectors, Eijffinger, Mahieu and Raes (2012) estimated Equation 2.31 for each of thirty-three industrial sector returns. For each industry that yielded a negative and significant response to the target factor during expansion, a stronger negative response was observed during recession.

---

[56] Similar results were obtained using the filtered recession probability of Chauvet and Piger (2008).

[57] Similar empirical conclusions were yielded using a GARCH model.

[58] More specifically, the path factor was the residual from a regression of one-year ahead Eurodollar interest rate futures on the target FFR shock.

[59] These estimates were robust to the inclusion or exclusion of outliers, to the response of individual S&P500 stock returns or the S&P500 index returns, and to the Jun-03 to Dec-09 sub-sample period.

Furthermore, the path factor during recession was shown to be positive and significant in all but two industries.

Whilst these studies measured the information content of FOMC statements using the path factor, several studies used statement indicators by interpreting media reports around dates of FOMC action and statements to "*assess the importance of the information content of FOMC statements as perceived by the consensus view at the time of release*" (Farka and Fleissig, 2012). Farka and Fleissig (2009, 2012)[60] were amongst the first to examine the impact of both target FFR shocks and FOMC statements on stock returns over a sample period which covered part of the crisis. They interpreted news reports[61] following FOMC statements to determine whether they conveyed important information to financial markets and constructed an FOMC statement indicator variable $\left(I_t^{statement}\right)$. This indicator was set equal to one when it revealed new information concerning monetary policy or the economic outlook to financial markets[62]; and zero when it revealed information expressed in previous statements. The study began by estimating the impact of target FFR shocks on 20-minute intra-day S&P500 returns over the May-99 to Dec-07 sample period. Consistent with previous studies, a hypothetical unexpected 1% FFR shock yielded a -5.17% decrease in the S&P500 index. Upon augmenting the model to include an FOMC statement indicator (see Equation 2.32); stocks responded significantly (-4.84%) to the statement indicator and outweighed the impact of unexpected FFR changes (-1.40%). This implied that over the period, when FOMC statements conveyed important information to financial markets, they dominated the impact of the target FFR shock[63] by a factor of 3.5.

In a related study, Rosa (2011) constructed an FOMC statement indicator $\left(IS_t\right)$, which measured whether the tone of each FOMC statement was more hawkish (-1), dovish (1) or neutral (0). The surprise component of the statement indicator was generated using a

[60] We refer here to the 2009 and 2012 version of the paper to highlight that the original working paper was available in 2009.

[61] From Reuters, Bloomberg and the Wall Street Journal.

[62] Farka and Fleissig (2009, 2012) define their statement indicator as being equal to one when "the statements reveal: (a) important information about the near-term path of monetary policy; (b) a change in the Fed's assessment of the economic outlook; or (c) changes in the wording of key phrases (such as 'policy bias' or 'balance-of-risk') compared with a preceding release. In contrast, the indicator assumes a value of zero when a statement is an (almost) exact replica of a previous one."

[63] The study also used a GARCH model to examine the impact of target FFR shocks and FOMC statements on the volatility of stock returns. Consistent with previous studies, they demonstrated a 'tent' shaped impact whereby volatility was abnormally low prior to FOMC announcements, increased dramatically during the announcement, declining however remaining high several hours following the announcement and returning to pre-announcement levels the following day.

forecasting regression which considered macroeconomic variables and other indicators to predict future announcements. Over the May-97 to Jun-10 sample period, S&P500 index returns yielded significant responses to unexpected FFR changes (-6.11%) and significant responses to the statement indicator (-0.78%). Similar estimates were yielded for the DJIA and Nasdaq 100 indices.

$$r_t = \alpha + \beta_1 \Delta i_t^u + \beta_1 I_t^{statement} + \varepsilon_t, \qquad (2.32)$$

During the 2007-2009 crisis period, the FOMC also utilised other non-conventional forms of monetary policy such as LSAP purchases. In another study, Rosa (2012) constructed a surprise indicator of Fed LSAP purchases $(LSAP_t)$ which measured whether LSAP announcements were more restrictive than expected (-1), more expansionary than expected (1), or largely anticipated by market participants (0). The indicator was constructed through the interpretation of media reports concerning such LSAP purchases around announcement windows. Rosa (2012) estimated S&P500 return responses to FFR shocks (see Kuttner, 2001), statement surprises (see Rosa, 2011) and LSAP surprises, on scheduled FOMC meetings over the May-99 to Jun-11 sample period (see Equation 2.33).

$$r_t = \alpha + \beta_1 \Delta i_t^u + \beta_2 IS_t^{statement} + \beta_3 LSAP_t + \varepsilon_t, \qquad (2.33)$$

A hypothetical 1% target FFR increase was shown to be associated with a -5.39% decrease in the S&P500 index. Furthermore, stocks responded significantly (-0.58%) to the unexpected component of FOMC statements which conveyed information concerning the future trajectory of monetary policy. Lastly, an unanticipated dovish LSAP announcement was shown to be associated with a *significant* 0.92% increase in the S&P500 index. Thus, the estimates were indicative of conventional and non-conventional monetary policy shocks exhibiting significant effects on stock returns during the crisis period.

It is important to recognise that the FOMC statement indicators used in these studies were based upon the subjective interpretation of FOMC statements and media news reports surrounding announcements. Farka and Fleissig (2012) explicitly outlined the limitations of such an approach to defining indicators, arguing that "*words tend to be subjectively interpreted by different agents*." They acknowledged that the interpretation of news reports surrounding announcements in lieu of the FOMC statements themselves ensured that market participants incorporated conveyed information. However they conceded that "*the classification of statements involves some measure of subjectivity since it is based on our own judgment of the reading of the newswire reports*." In this manner, the indicators considered in these studies should be considered tentatively.

In lieu of subjective interpretation of non-conventional monetary policy measures when the target FFR approached the zero-lower bound, Wright (2012) adopted an alternative empirical framework, defining monetary policy shocks using an identified VAR. The methodology was similar to the 'identification through heteroscedasticity' approach evaluated in Section 2.5.1. By regressing S&P500 futures returns on the constructed monetary policy shock measure, a one-standard deviation positive monetary policy shock was shown to be associated with a significant 0.55% increase in stock returns. It is important to recognise the limitations of Wright's (2012) approach as the study considered only 21 observations over the Nov-08 to Dec-10 sample, a period characterised by major market uncertainty and risk aversion by investors.[64].

2.7.4 US Stocks & Monetary Policy (Overview)

Prior to the 2007-2009 crisis period, a plethora of empirical studies documented highly significant stock return responses to monetary policy shocks, however stocks were generally shown to yield statistically insignificant responses to measures concerning the future trajectory of monetary policy. Having evaluated studies which investigated the relationship between stock returns and monetary policy over the crisis period (in its entirety or in part), it is apparent that the 2007-2009 crisis period may have changed the nature of this relationship. Several studies observed that the relationship between stock response to conventional monetary policy shocks ceased to remain statistically significant upon inclusion of the crisis period sample. Another branch of studies observed that stocks responded to non-conventional measures of monetary policy over this period. Interestingly, these studies did not explicitly consider a potential structural change in the relationship between stock returns and monetary policy shocks over the crisis period.

[64] We would like to point out that the 21 observations considered over the Nov-08 to Dec-10 sample period considered included an observation where the target FFR was changed, observations where LSAP purchases occurred, and observations where previous studies identified FOMC statements which conveyed information concerning the future trajectory of monetary policy.

2.8 US Stocks & Monetary Policy (The International Transmission)

As we have seen, there is a vast and extensive empirical literature concerned with the relationship between US stock returns and US monetary policy. This relationship has been well documented as we have pointed out in this review of related studies. However, there are comparatively fewer studies concerned with the foreign stock response to US monetary policy shocks. In this sub-section, we review more recent studies which investigate the international transmission of US monetary policy to foreign stock markets. It is beyond the scope of this thesis to review studies concerned with the bilateral relationship between the US and each individual country in the world, hence we refine our analysis to studies which investigate the impact of US monetary policy on more than one foreign stock market. This section of the literature review is motivated by Chapter 5, in which we investigate the impact of FFR shocks on international equity markets over a sample period which covers the 2007-2009 crisis period.

Studies which estimated the impact of US monetary policy on international equity markets widely measured US monetary policy using a variety of different approaches. These methodologies naturally reflected Fed monetary policy operating procedure (see Section 2.3.1) and econometric advancements in the field. In Section 2.8.1, we briefly review earlier studies which estimated foreign stock responses to US monetary policy over the 1970s and 1980s (see Bailey, 1990)[65]. This study measured US monetary policy in terms of the money supply because the Fed primarily targeted the growth rate of money supply over that period. We also review studies whose sample period extended in to the 1990s and measured US monetary policy using the Fed discount rate (see Johnson and Jensen, 1993) or using dummy variables as proxies for US monetary conditions (see Conover, Jensen and Johnson, 1999).

In the late 1980s, the Fed began targeting the FFR and in Section 2.8.2 we review studies which examined the relationship between international stock markets and US monetary policy, measured using the target FFR. In particular, we review seminal studies which measured US monetary policy using the unexpected FFR change measure of Kuttner (2001) and Gürkaynak, Sack and Swanson (2005)'s target and path factor (see Ammer, Vega and Wongswan, 2010; Ehrmann and Fratzscher, 2009; Hausman and Wongswan, 2011; Wongswan, 2009). Finally in Section 2.8.3 we review several more recent studies whose

[65] Husted and Kitchen (1985) were amongst the first to investigate the impact of US monetary policy, measured in terms of the money supply on foreign interest rate differentials, while Mudd (1979) was amongst the first to investigate the impact of Fed discount rate changes on foreign exchange rates.

sample periods extended in to the 2007-2009 crisis period (see Laeven and Tong, 2012; Rosa, 2011). At the time of writing Chapter 5, the studies mentioned in Section 2.8.3 did not exist.

2.8.1 International Stocks & Monetary Policy (Early studies)

Bailey (1990) was amongst the earliest studies to establish a link between US monetary policy and foreign stock markets. The study investigated the impact of US money supply shocks on nine pacific rim stock markets, gauging money supply expectations using Money Market Services survey data. An unexpected 1% growth in the US money supply was shown to be associated with statistically insignificant responses across all nine stock markets over the Oct-77 to Sep-79 and Oct-79 to Sep-82 samples, however statistically significant stock market declines across five foreign countries over the Oct-82 to Sep-85 sample. In each case, the magnitude of response was shown to be larger than that of the US stock market. The study argued that this heterogeneity could be explained in terms of capital controls and exchange rate regimes. Countries with freer capital markets (Singapore, Hong, Kong, Malaysia) and floating currencies (Australia) responded significantly, whilst countries with higher capital controls (Philippines and Thailand) and pegged or heavily regulated currencies (Philippines, Taiwan, Thailand) yielded statistically insignificant responses. Interestingly, the heterogeneity was not shown to be related to the degree of exports to the US, as countries with a lower (higher) degree of exports to the US were shown to be associated with significant (insignificant) responses, such as in Australia (Korea and Taiwan).

In a related study, Johnson and Jensen (1993) analysed foreign stock market responses to discount rate changes by the Fed over the Oct-79 to Dec-91 sample. This was motivated by the fact that the Fed targeted monetary aggregates over that period (see Section 2.3.1). Consistent with previous studies (see Smirlock and Yawitz, 1985); the study distinguished between technical and non-technical discount rate changes by the Fed. They found that seven (three) out of fifteen foreign stock markets were associated with statistically significant responses to non-technical (technical) discount rate changes. This was consistent with the fact that technical changes were intended to align discount rates with market rates, whilst non-technical rates were more informative and more unexpected, intended to influence market rates. Furthermore, in countries where the response was significant, discount rate decreases (increases) were shown to be associated with positive (negative) stock market responses, consistent with evidence from the US stock market.

Conover, Jensen and Johnson (1999) in a subsequent study analysed foreign stock return response to the local and US monetary environment across sixteen industrialised countries. For each country (i), they defined a dummy variable $\left(D^{local}\right)$ equal to one when the local monetary authority pursued restrictive monetary policy and equal to zero if expansive. They also defined a dummy variable $\left(D^{con}\right)$ equal to one when the FOMC in the US pursued restrictive monetary policy and zero if expansive. Using monthly data, they regressed foreign stock returns r_t for each country (i) on these proxies for the local and US monetary environment (Equation 2.39). They found that over the Jan-56 to Dec-95 sample, foreign stock returns were associated with statistically significant responses to both the local and US monetary environment in six countries. This implied that restrictive monetary conditions locally in each country or in the US were associated with lower stock returns in those countries. It also demonstrated that the US monetary environment (i.e. monetary policy) was an important factor in explaining foreign stock market returns across some countries.

$$r_t = \alpha + \beta_1 D_t^{con} + \beta_2 D_t^{local} + \varepsilon_t, \tag{2.39}$$

2.8.2 International Stocks & Monetary Policy (Pre-crisis studies)

As Conover Jensen and Johnson (1999) used lower-frequency monthly data, Ehrmann and Fratzscher (2004) argued that the variables used were "*unlikely to be exogenous*" and may have reflected other factors. This critique prompted researchers to use higher-frequency intra-day or daily data to isolate monetary policy shocks. More recently, studies have primarily employed two alternative empirical approaches to defining conventional US monetary policy shocks. The first is the approach of Kuttner (2001) which gauges expectations from CBOT futures contracts tracking the effective FFR, to define a measure of unexpected FFR changes. The second is the approach of Gürkaynak, Sack and Swanson (2005) which measures US monetary policy in terms of a target factor shown to be associated with the unexpected FFR change measure of Kuttner (2001) and a path factor shown to be associated with FOMC statements. Both of these measures of US conventional monetary policy shocks could be estimated at a daily or intra-day frequency and were therefore more likely to be exogenous.

Ehrmann and Fratzscher (2006, 2009) estimated foreign stock return responses to Gürkaynak, Sack and Swanson (2005)'s target factor (TF) controlling for day of the week effects (Z) (Equation 2.40). Overall, they found that a hypothetical unexpected 1% FFR cut (increase) was associated with a statistically significant 2-3% decline (increase) in foreign equity returns across 49 countries over the Feb-94 to Dec-04 sample. However, at an individual country by country level, they found that stock markets in less than half of thes countries (22 out of 49) were associated with statistically significant responses to FFR shocks. In each case where the relationship was shown to be significant, the estimated coefficient was negative which implied that unexpected FFR cuts (increases) by the FOMC in the US were associated with positive (negative) stock market returns in those countries. Nevertheless, they found that there was substantial cross-country heterogeneity in stock market responses to FFR shocks, ranging from an unexpected 1% FFR cut being associated with a stock market decline of 1.1% in Chile to a 5.7% decline in Hong Kong.

Furthermore, this cross country heterogeneity did not appear to be characterised by differences attributable to whether they were advanced or emerging market economies. This was shown by the fact that stock markets in advanced and emerging market economies responded significantly (UK and South Africa) or insignificantly (Germany and Peru) to FFR shocks. It was however shown that countries with more closed financial markets (i.e. China and Malaysia) did not respond significantly to FFR shocks from the US. Ehrmann and Fratzscher (2009) used a broad set of macroeconomic and financial variables to explain the substantial cross-country heterogeneity in stock market responses to FFR shocks from the US across the 49 countries. They ranked countries in to three categories (lower, medium and higher) based upon these variables, and estimated Equation 2.41 for each of these potential determinants.

$$r_t = \alpha + \beta_1 TF + \beta_2 Z + \varepsilon_t , \tag{2.40}$$

$$r_{it} = \alpha + \beta_1 (TF) X_{it}^{low} + \beta_2 (TF) X_{it}^{med} + \beta_3 (TF) X_{it}^{high} + \varepsilon_t , \tag{2.41}$$

Where X_{it}^{low} was equal to one when the determinant X for country i at time t was ranked in the lowest third of countries, and similarly for X_{it}^{med} and X_{it}^{med}. They found that countries with a higher degree of GDP correlation with the US yielded larger magnitude responses to FFR shocks than countries with a lower degree of GDP correlation. A significant difference in the stock market responses of countries with higher versus lower exchange rate volatility was also documented. Interestingly, the study contributed to the existing empirical literature by demonstrating that the degree of global integration with the world economy, and not the degree of bilateral integration with the US economy was a significant factor in explaining this heterogeneity. Equity markets in counties with a higher degree of trade with the world yielded significantly greater responses to FFR shocks compared to those with a lower degree of trade with the world. In line with these estimates, they found that financial linkages between each country and the world were more important in explaining cross country heterogeneity in stock market responses to FFR shocks than financial linkages directly with the US.

In a closely related study, Wongswan (2009) estimated the impact of both target and path surprises on foreign stock returns over the Sep-98 to Nov-04 sample, controlling for a set of factors (Z)[66]. The target surprise (TS) was similar to the unexpected FFR change measure of Kuttner (2001) however was constructed using intra-day data (30 minute windows) around announcements[67]. The path surprise (PS) was measured as the residual from a regression of four-quarter ahead Eurodollar futures rate $\Delta EDQ4$ on the target factor over FOMC meeting dates (Equation 2.42)[68]. The study found that foreign stock returns (5-minute window) were associated with statistically significant positive responses to target surprise cuts across most (14 of 15) of the countries considered (Equation 2.4.3). Interestingly, the impact of the path surprise was statistically insignificant across most countries[69]. This evidence was consistent with that concerning the US stock market which was shown to yield statistically insignificant responses to the path factor (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). Wongswan (2009) repeated the estimates excluding event-dates associated with unscheduled FOMC meetings and found that the fit of the model deteriorated in each case, which implied that these event-dates contained an important source of information concerning unexpected FFR changes for market participants. The study also found that financial linkages were more important than real economic integration in explaining cross country heterogeneity in stock market response to the target surprise.

$$\Delta EDQ4_t = \alpha + \beta_1 \Delta i_u + \varepsilon_t \,, \tag{2.42}$$

$$r_{it} = \alpha + \beta_1 TS + \beta_2 PS + \beta_3 Z + \varepsilon_t \,, \tag{2.43}$$

As the sample period of Wongswan (2009) covered only 53 observations over a short time-span with a sample of only 15 countries, in a subsequent study, Hausman and Wongswan (2006, 2011) extended the sample to span the Feb-94 to Mar-05 period and estimated Equation 2.43 for each of 49 advanced and emerging market economies. The foreign stock response to the target surprise was shown to be statistically significant across 27 out of 49 countries, while the path surprise was significant only for several countries in Far

[66] The control was the net of FOMC effect in S&P500 futures returns.

[67] The use of intra-day data constrained the sample period of study.

[68] The path factors reflected "*news that market participants have learned from the FOMC's statement about the expected future path of policy over and above what they have learned about the level of the target rate*" (Wongswan, 2009).

[69] With the exception of Hong Kong, Korea and Taiwan, where the response was significant only at the 10% level.

East Asia. They argued that equity indices responded "*mainly to the target surprise*" whilst other assets (exchange rates, short-term and long-term Treasury yields) also responded significantly to the path surprise. Using a panel specification, the study interacted the target surprise with a series of potential determinants in an attempt to explain the cross country heterogeneity in stock responses to the target surprise. In contrast to Ehrmann and Fratzscher (2009), they found that real economic integration with the US economy was an important determinant in the international transmission of FFR shocks. They also found that financial linkages through the banking sector were an important factor in explaining the cross-country heterogeneity in response to FFR shocks.

In a another related study, Ammer, Vega and Wongswan (2010) argued that previous studies did not account for non-synchronous trading as Asian and European equity markets typically responded to FFR shocks the following day when their equity markets opened. To account for this, they constructed a dataset of foreign assets on the CRSP and Compustat databases which traded contemporaneously with US stocks. Instead of an individual country by country analysis, the study investigated the aggregate foreign stock response to target surprises. Over the Feb-94 to Dec-06 sample, they found that foreign firms were more sensitive to target surprises if they were in more cyclically sensitive industries, had a higher degree of sales outside their home country and if the country in which they were based in countries with exchange rates pegged to the US dollar.

2.8.3 International Stocks & Monetary Policy (Crisis studies)

After much of this thesis was written, several studies also investigated the impact of conventional monetary policy shocks on foreign stock returns over sample periods which covered some of the 2007-2009 crisis period. As Taylor (2010) points out, in Sep-10, US and foreign stock returns in UK, Germany, France, Brazil and Japan were higher on the Friday after the Lehman Brothers bankruptcy than the Friday before, however they collapsed more than 30% in Oct-10, a month characterised by a 50 basis point FFR cut. Whilst Taylor (2010) concedes this did not imply causality, it would be interesting to examine the foreign stock market response to conventional US monetary policy shocks during the crisis.

Rosa (2011) estimated the foreign stock market response to conventional monetary policy shocks over a sample which extended several months in to the crisis period (Feb-99 to Dec-07). The study employed two alternative empirical approaches to measuring monetary policy shocks. The first was the approach of Kuttner (2001) evaluated in Section 2.6.1 whilst the second was the approach of Rigobon and Sack (2004) evaluated in Section 2.5.1. Using the former approach, the study documented statistically significant foreign stock responses to FFR shocks in less than half (23 out of 50) of the countries. In each case where the relationship was shown to be statistically significant, unexpected FFR cuts (increases) were associated with positive (negative) foreign stock responses. Very similar coefficient estimates were yielded for the 50 countries using the heteroscedasticity based estimator of Rigobon and Sack (2004) which indicated that the estimates were robust towards either model specification. In line with previous studies, there was substantial cross-country heterogeneity in foreign stock responses to FFR shocks, with a hypothetical unexpected 1% FFR cut (increase) being associated with a statistically significant 1.69% (21.58%) increase in foreign stock returns in Luxembourg (Turkey). The study argued that the OLS estimator approach "*outperform[ed] in an expected squared error sense*" however the heteroscedasticity-based approach yielded "*more accurate readings*", nevertheless "*on the whole the event-study methodology should be preferred*" to studying the foreign stock response to FFR shocks.

In another study, Laeven and Tong (2012) estimated the impact of unexpected FFR changes measured using the approach of Kuttner (2001) on foreign stock returns across 44 countries using a panel model specification. Over the Jul-90 to Dec-08 sample, a hypothetical unexpected 1% FFR cut (increase) was shown to be associated with a 4% increase (decrease) in foreign stock market returns across the 44 countries (Equation 2.44). The study continued by controlling for a measure of an industry's financial dependence on external finance (FD) using the financial dependence index of Rajan and Zingales (1998). By interacting the financial dependence variable with unexpected FFR changes, they find that the impact of FFR shocks is significantly higher for foreign industry sectors which rely more on external financing. A hypothetical unexpected 5 basis point decrease in the FFR was associated with a stock response which is 6 basis points higher for firms with financial dependence at the 75th percentile relative to firms with financial dependence at the 25th percentile. This implied that foreign stocks are associated with stronger responses to FFR shocks with a higher dependence of external financing.

$$r_{it} = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t , \qquad (2.44)$$

2.8.4 International Stocks & Monetary Policy (Overview)

Overall, one can conclude that pre-crisis studies widely documented statistically significant foreign stock responses to conventional monetary policy shocks. However the relationship was shown to be characterised by substantial cross-country heterogeneity. The stock market response to FFR shocks was shown to be statistically significant in some advanced and emerging market economies whilst statistically insignificant in others. Where significant, an unexpected FFR cut (increase) was shown to be associated with a positive (negative) foreign stock return in those countries. These studies had considerably greater difficulty in explaining this cross-country heterogeneity in response, as stock markets in some advanced and emerging market economies yielded significantly larger magnitude responses to FFR shocks than the US stock market, whilst many other advanced and emerging market economies yielded statistically insignificant responses. Nevertheless, there was some evidence of this heterogeneity being explained in terms of real economic integration with the US or world economy depending on the study, and some evidence of it being explained in terms of financial linkages in terms of lending through the banking sector, and in terms of exchange rate regime. However the very few studies whose sample periods extended in to the 2007-2009 sample period yielded similar responses. Nevertheless, it would be interesting to explicitly investigate the impact of the 2007-2009 crisis on the relationship.

2.9 US Treasuries & Monetary Policy

2.9.1 US Treasuries & Monetary Policy (Outline)

In Sections 2.1 to 2.8 we reviewed empirical studies concerning the relationship between stock returns and monetary policy shocks. We continue our review of the literature by extending the survey of studies to the US Treasury market. More specifically, we evaluate studies which investigated the US Treasury bill (T-Bill) and Treasury bond (T-Bond) yield responses to monetary policy shocks.

It is important to note that the evolving econometric methodology for investigating US Treasury market responses to monetary policy shocks is very similar to that concerning the stock market response. Many of the empirical studies we have thus so far evaluated also considered the impact of such measures on the US Treasury market. We therefore continue by briefly evaluating earlier empirical studies concerning the relationship between US Treasury yields and conventional monetary policy in Section 2.9.2. This is followed by a more detailed discussion of the empirical results yielded by Kuttner (2001) concerning the impact of unexpected FFR shocks on US Treasury yields in Section 2.9.3. In Section 2.10.1, we evaluate more recent studies which studied the impact of conventional monetary policy on US Treasuries over sample periods which covered the 2007-2009 crisis period in its entirety or in part, and subsequently evaluate studies which examined the impact of both conventional and non-conventional monetary policy on US T-Bill and T-Bond yields.

2.9.2 US Treasuries & Monetary Policy (Early studies)

The FOMC has traditionally sought to achieve macroeconomic objectives through monetary policy by influencing financial markets, particularly money market interest rates such as US Treasury yields. We begin by evaluating earlier studies concerning the relationship between US Treasury yields and conventional monetary policy through standard econometric frameworks such as single-equation models and VARs. Cook and Hahn (1989) were amongst the first to estimate the impact of target FFR changes on US Treasury yields. They regressed one day changes in US Treasury yields (y_t) on target FFR changes (Δi_t), on dates of FFR change through an event-study analysis over the Sep-79 to Sep-89 sample period (see Equation 2.34). The study demonstrated that target FFR changes yielded larger one day movements in shorter term maturity treasuries compared to longer term maturity treasuries. Importantly, the (β_1) coefficient was positive for all Treasuries which implied that target FFR cuts (increases) were associated with decreases (increases) in US Treasury yields.

$$y_t = \alpha + \beta_1 \Delta i_t + \varepsilon_t, \tag{2.34}$$

In a related study, Roley and Sellon (1995) estimated the impact of effective FFR changes on the 30-Year T-Bond yield, on days of target FFR changes over the Oct-87 to Jul-95 sample period. In contrast to Cook and Hahn (1989), the response was found to be statistically insignificant on days of target FFR changes, however significant on days prior to days of target FFR changes. This implied that a component of target FFR changes may have been anticipated by market participants and incorporated in to yield changes on days prior to actual changes by the FOMC. Similarly, Jensen and Jonhson (1995) demonstrated that in the fifteen days prior to a discount rate increase, there was a -5.27% (-3.24%) cumulative decline in returns on the 3-Month T-Bill (10-Year T-Bond Index). They furthermore yielded estimates which indicated that both shorter-term and longer-term maturity Treasuries responded significantly to discount rate changes on announcement days. The lack of a significant post-announcement response was also indicative of the US Treasury market being highly efficient in incorporating new information concerning monetary policy.

As we discussed in Section 2.6.1, conventional monetary policy shocks measured using the approach of Kuttner (2001) with FFR futures have significant advantages above VAR based measures. Nevertheless, studies which sought to evaluate the US Treasury response to monetary policy shocks using the measure of Kuttner (2001) were constrained to the post Oct-88 sample period, as this is when FFR futures first began trading in the open market. Due to this complication, longer-run analyses typically employed alternative measures of monetary policy shocks which were not constrained in this manner. Thus, despite Rudebusch's (1996, 1998) critique of monetary policy shocks derived from VAR models, several studies continued to measure FFR shocks in terms of orthogonalised innovations.

Edelberg and Marshall (1996) for example evaluated the relationship between US Treasuries and monetary policy using a VAR methodology. They defined monetary policy shocks in terms of orthogonalised innovations (see Section 2.4.2) from a seven-variable[70] VAR. The impulse responses demonstrated that monetary policy shocks exhibited larger statistically significant effects on shorter term US T-Bills, a smaller effect on T-Bonds with

[70] Edelberg and Marshall (1996) used a seven-variable VAR with the following variables: log of non agricultural employment, log of price level, change in an index of sensitive materials prices, FFR, log of non borrowed reserves, log of total reserves and yield on zero-coupon bonds of varying maturity.

maturity between 3 and 15 years, and a statistically insignificant effect on T-Bonds with maturity beyond 15 years[71].

Berument and Froyen (2006) also estimated the impact of monetary policy shocks, measured in terms of innovations in the FFR from a five-variable VAR[72], on 1-Year and 10-Year US Treasuries, over the Jan-75 to Oct-02 sample period as well as the Jan-75 to Sep-79 and Oct-87 to Oct-02 sub-sample periods. Consistent with previous studies, the impulse response functions showed that the 1-Year Treasury exhibited a larger magnitude response to FFR shocks compared to the 10-Year Treasury across all three sample periods. Interestingly, the impulse response functions highlighted that both Treasuries exhibited larger magnitude responses during the Jan-75 to Sep-79 period compared to the Jan-87 to Oct-82 sample periods. These estimates directly contradicted the evidence from the study by Thorbecke and Zhang (2008) which identified the opposite result using single equation models over comparable sample periods[73]. Nonetheless, in line with Edelberg and Marshall (1996), the study by Berument and Froyen (2006) found that longer-term interest rates did not respond significantly to monetary policy shocks.

Due to the conflicting empirical evidence between estimates obtained using single equation and VAR models, a subsequent study by Berument and Froyen (2008) surveyed empirical studies concerning the relationship between US Treasuries and FFR shocks using both approaches. Using a VAR approach, they demonstrated that FFR innovations exhibited small and statistically insignificant effects on longer-term US Treasuries (10-Year Treasury) over the Chairmanship of Alan Greenspan, from 1987 to 2005, with even smaller effects over the 1971 to 2005 sample period. In contrast, using the single-equation framework, they demonstrated that longer-term US Treasuries (10-Year Treasury) responded significantly to FFR shocks estimated using the approach of; Kuttner (2001), or by estimating reaction functions at intervals bracketing FOMC meetings. A negligible difference between the two approaches was observed for the pre-1979 sample period.

Berument and Froyen (2008) argued that differences may have been attributable to the fact that VAR models suffered from an identification problem which was largely mitigated

[71] As Kuttner (2001) points out, studies concerning the relationship between monetary policy and US Treasury yields demonstrated a significantly weaker relationship throughout the 1990s sample periods compared to that of Cook and Hahn (1989).

[72] Berument and Froyen (2006) used a five-variable VAR with the following variables: FFR, log of long-term interest rate, log of unemployment claims, log of economic activity and log of commodity prices and money

[73] Thorbecke and Zhang (2008) observed stronger responses of US Treasury yields to FFR changes from Jun-89 to Jun-06 compared to the Sep-74 to Sep-79 period.

by single equation models which used daily data, and reiterated Rudebusch's (1996, 1998) concerns regarding monetary policy shocks measured using VAR models[74].

2.9.3 US Treasuries & Monetary Policy (Measured using FFR futures)

Kuttner (2001) replicated the analysis of Cook and Hahn (1989) for the Jun-89 to Feb-00 sample period. The estimates were indicative of a uniformly weaker response of US Treasuries across the maturity spectrum to target FFR changes. A 1% target FFR cut was associated with a 26.8 (10.4) basis point decrease in the 3-Month T-Bill (5-Year T-Bond) yield and with statistically insignificant responses for 10-Year and 30-Year Treasuries. The study argued the increasing transparency of FOMC monetary actions may have induced a significant shift in Treasury market response over the extended sample period. This argument was furthermore consistent with previous studies which had documented pre-announcement effects in the US Treasury market, with significant changes in yields prior to official dates of target FFR changes by the FOMC; implying that market participants may have partly or entirely anticipated potential target FFR changes, and such information was incorporated in to Treasury prices and associated yields prior to actual announcements of changes.

Kuttner (2001) extended upon the methodology of Cook and Hahn (1989) by disaggregating target FFR changes in to expected and unexpected components, gauging expectations from futures contracts tracking the effective FFR[75]. The study also addressed the sample selection biases of previous studies which only considered event-dates with target FFR changes, whilst Kuttner (2001) also considered all scheduled FOMC event-dates with potential target FFR changes. In lieu of raw target FFR changes, Kuttner (2001) estimated the impact of both expected and unexpected FFR changes on US Treasury yields across the maturity spectrum. The impact of expected FFR changes was shown to be statistically insignificant across *most* of the US Treasuries, consistent with the efficient markets hypothesis. In contrast, the impact of unexpected FFR changes on US Treasuries was greater in magnitude compared to target FFR changes. An unexpected 1% FFR cut was associated with a 79.1 (22.0) basis point decrease in the 3-Month T-Bill (10-Year T-Bond) yield, with a statistically insignificant response for the 30-Year T-Bond. The impact of unexpected FFR shocks on US Treasuries was shown to monotonically decline in magnitude and statistical

[74] On another note, it would have been interesting if Berument and Froyen (2006) study had also evaluated whether very long term Treasuries such as 30-Year Treasuries responded significantly across the two alternative empirical models.
[75] As we discussed this approach in considerable detail in Section 2.6, we do not repeat the discussion here.

significance as the term to maturity increased. The impact of lagged target FFR changes on US Treasury yields on event-dates was furthermore shown to be statistically insignificant.

Whilst Kuttner (2001) evaluated US Treasury market responses to unexpected FFR changes using a daily announcement window around FOMC announcements, Gürkaynak, Sack and Swanson (2005) compared estimates using both an hourly window and a daily window around FOMC announcements. They demonstrated that an unexpected 1% FFR cut was associated with a statistically significant 58.3 (66.9) basis point decrease in the 3-Month T-Bill yield, 47.5 (42.9) decrease in the 2-Year T-Bond yield and 26.7 (31.8) decrease in the 5-Year Bond yield using hourly (daily) announcement windows. Interestingly, the response of the 10-Year T-Bond was shown to be statistically insignificant in both cases. These estimates indicated that the magnitude of response overall increased substantially using daily data as market participants and investors had more time to re-evaluate their positions and portfolio holdings over the course of the day and respond accordingly to the new information conveyed by the FOMC via target FFR changes.

Gürkaynak, Sack and Swanson (2005) subsequently used a principal components analysis with Eurodollar futures of varying dates to expiration in order to deconstruct unexpected FFR changes in to two components concerning the target factor and path factor. They demonstrated that the target factor was closely associated with unexpected FFR changes whilst path factor was associated with FOMC statements. Although the S&P500 was shown to be associated with a statistically insignificant response to the path factor, US Treasuries were shown to respond significantly to both the target and path factor. In fact, an unexpected 1% FFR increase was shown to be associated with a significant 48.2 (12.8) basis point increase in the 2-Year (10-Year) Treasury yield, whilst 1% innovation in the path factor was shown be associated with a significant 41.1 (28.3) basis point increase respectively. This implies that the impact of FOMC statements outweighed the impact of FFR shocks for longer-term maturity Treasuries. It is however important to consider that the study only assessed the impact upon 2-Year, 5-Year and 10-Year T-Bond, omitting analyses of T-Bill yields and longer term T-Bonds.

2.9.4 US Treasuries & Monetary Policy (Structural instability)

In a later study, Thornton (2009) replicated the analysis of Kuttner (2001); estimating the impact of expected and unexpected FFR changes on 3-Month to 20-Year US Treasuries over the Jun-89 to Feb-00 and Feb-00 to Jun-07 sample periods. The impact of expected FFR changes on US Treasuries was shown to be statistically insignificant for all Treasuries across both sample periods; in line with market efficiency arguments. In the former sample period, the impact of FFR shocks was statistically significant across all Treasuries, and the magnitude of response declined monotonically as the term to maturity increased. An unexpected 1% FFR cut induced a 79.2, 43.0 and 29.0 basis point decline in the 3-Month, 5-Year and 10-Year Treasuries respectively. In contrast, the impact was statistically significant only for the 3-Month to 1-Year Treasuries for later Feb-00 to Jun-07 sample period. These estimates implied that there was significant structural change in the relationship between US Treasuries and monetary policy shocks. Thornton (2009) argued that these estimates may have been yielded because Kuttner's (2001) measure of FFR shocks may have been influenced by other 'ambient news' throughout the trading day. In response, Thornton (2009) augmented the econometric model of Kuttner (2001) to account for a potential joint-response bias, whereby US Treasury yields and market-based measures of monetary policy shocks may have responded simultaneously to all news rather than just to FFR shocks (see Equation 2.35). .

$$\Delta r_t = \alpha + \beta_1 D_t^{PE} + \beta_2 \Delta i_t^u + \beta_3 \Delta i_t^u D_t^{PE} + \varepsilon_t \ , \qquad (2.35)$$

Where $\left(D_t^{PE}\right)$ was a dummy variable equal to one on days with monetary policy changes and zero otherwise. Upon estimating this model over the Jun-89 to Feb-00 sample period, the $\left(\beta_2\right)$ coefficient was shown to be statistically significant across all Treasuries, larger in magnitude for shorter term compared to longer term Treasuries. However the $\left(\beta_3\right)$ coefficient was shown to be statistically insignificant for the 3-Year to 20-Year Treasuries, which implied that FFR shocks exhibited no effect beyond that of ambient news. Interestingly, upon estimating a similar model for the Feb-00 to Jun-07 sample period, the relationship was shown to be characterised by structural instability as, the $\left(\beta_2\right)$ coefficient was significant only for the 3-Month to 1-Year Treasuries, and the $\left(\beta_3\right)$ coefficient was shown to be statistically insignificant for the 3-Month and 6-Month Treasuries; implying a reversal in the relationship.

In line with Thornton (2009), a study by Thorbecke and Zhang (2008) also demonstrated that the relationship between US Treasuries and monetary policy shocks was characterised by structural instability. They estimated the impact of monetary policy shocks on US Treasuries over the Sep-74 to Sep-79 and Jun-89 to Jun-06 sample periods. For the latter sample period, monetary policy shocks were measured in line with Kuttner (2001)[76]. For the former period, FFR shocks were measured as the difference between the actual FFR change and that predicted by a forecasting model[77]. The impact of FFR shocks on 3-Month to 5-Year Treasuries was shown to be statistically significant in both sample periods, with a larger magnitude response for the Jun-89 to Jun-06 period. Interestingly, in both sample periods the magnitude of response declined as the term to maturity increased, consistent with previous studies. It is thus apparent that the magnitude of US Treasury response to FFR shock may have changed over time.

2.9.5 US Treasuries & Monetary Policy (Measured using alternative approaches)

As the Fed began formally announcing target FFR changes from Feb-94, Hamilton (2008) argued that days of monetary policy action by the Fed prior to this date may not have been explicitly known. In response, the study employed a signal extraction approach to identifying potential dates of target FFR changes for defining monetary policy shocks. Interestingly, this approach yielded empirical conclusions akin to Thornton (2009); as the responses of shorter-term Treasuries were larger in magnitude compared to those of longer-term Treasuries, however the impact did not monotonically decline as the term to maturity was increased. An alternative empirical approach to measuring monetary policy shocks was also developed by Rigobon and Sack (2002, 2004) as we discussed in Section 2.5.1. They measured FFR shocks by exploiting the conditional heteroscedasticity present in higher-frequency data. Their estimates indicated that US Treasuries across the maturity spectrum responded significantly to shocks defined using this approach. Furthermore the impact was more pronounced for shorter-term Treasuries compared to longer-term Treasuries. In a study related to Rigobon and Sack (2002, 2004) (see Section 2.5.1), Craine and Martin (2003) estimated the impact using a general factor model and concluded that "*The yield curve response to a monetary surprise displays the classical textbook pattern—short maturity yields rise and long maturity yields do nothing*."

[76] The construction of Kuttner's (2001) measure of unexpected FFR changes was restricted to the post 1989 sample period due to the advent of FFR futures.

[77] Thorbecke and Zhang (2008) regressed FFR changes on a constant and monthly changes in the unemployment rate, inflation rate, three-month Treasury bill rate, log of trade-weighted nominal exchange rate and log of gold price two months prior to the FFR change

2.9.6 US Treasuries & Monetary Policy (Overview)

Prior to the 2007-2009 crisis period, studies which investigated the US Treasury response to conventional monetary policy shocks primarily employed two alternative empirical approaches to analysing the relationship; these include single-equation models and VAR models. Furthermore, empirical conclusions concerning the relationships were markedly different to that concerning the stock market. We discuss each of the empirical conclusions concerning the pre-crisis studies in turn. Firstly, pre-crisis which estimated US Treasury responses to expected and unexpected FFR changes demonstrated that consistent with market efficiency, Treasuries across the maturity spectrum exhibited statistically insignificant responses to expected FFR changes, with only occasional anomalous cases of statistical significance (see Kuttner, 2001).

Secondly, pre-crisis studies measuring monetary policy shocks using the approach of Kuttner (2001), using the target factor of Gürkaynak, Sack and Swanson (2005), the difference between target FFR changes and estimates from a prediction equation or using VAR based models widely demonstrated that the impact of unexpected FFR changes on US Treasuries declined in magnitude and statistical significance as the term to maturity increased (see Gürkaynak, Sack and Swanson, 2005; Kuttner, 2001; Thorbecke and Zhang, 2008; Thornton, 2009). Thirdly, in many cases very long-term maturity Treasuries were shown to exhibit statistically insignificant responses to monetary policy shocks (see Berument and Froyen, 2006; Gürkaynak, Sack and Swanson, 2005; Kuttner, 2001; Thornton, 2009). Lastly, whilst stocks were shown to exhibit statistically insignificant responses to the path factor, which was shown to be associated with FOMC statements, shorter-term US Treasuries were shown to exhibit statistically significant responses to the path factor (see Gürkaynak, Sack and Swanson, 2005).

2.10 US Treasuries & Monetary Policy (The 2007-2009 Crisis)

2.10.1 US Treasuries & Monetary Policy (Outline)

In this sub-section we review more recent studies which investigated the impact of conventional and non-conventional monetary policy measures on US Treasury yield changes over sample periods which spanned the 2007-2009 crisis period in its entirety or in part. For a more detailed discussion of the crisis period, we refer the reader to Section 2.7 and for an in depth discussion of non-conventional monetary policy measures during the crisis, we refer the reader to Chapter 4 of this thesis, particularly Sections 4.3.4 and 4.3.5. We continue by reviewing studies which investigated the impact of conventional monetary policy shocks on US Treasuries using both single-equation and VAR models (see Beechey and Wright, 2009; Cenesizoglu, Larocque and Normandin, 2012; Demiralp and Yilmaz, 2012; Farka and DaSilva, 2011) in Section 7.10.2. Then in the following sections we review studies which investigated the impact of conventional and non-conventional monetary policy on US Treasuries. In particular, we review studies which considered the impact of FFR shocks and forward guidance by the FOMC in Section 7.10.3 (see Farka and Fleissig, 2012; Kurov, 2012; Lucca and Trebbi, 2009), and studies which also considered the impact of LSAP programmes in Section 7.10.4 (see Rosa, 2012; Szczerbowicz, 2011; Wright, 2011).

It is important to point out, that many of these studies were evaluated during the write-up year of this PhD thesis, and at the time of researching this Chapter in 2011 only five working papers were available concerning the impact of conventional monetary policy shocks on US Treasury yields over sample periods which extended in to the 2007-2009 crisis period (see Beechey and Wright, 2009; Demiralp and Yilmaz, 2009; Farka and DaSilva, 2009; Lucca and Trebbi, 2009; Szczerbowicz, 2011). As many of these studies were evaluated in detail with regards to the stock market response in Section 2.7, we discuss only the results with regards to the US Treasury market response here where relevant.

2.10.2 US Treasuries & Monetary Policy (Conventional monetary policy)

We begin by reviewing studies which evaluated the impact of conventional monetary policy on US Treasuries over sample periods which covered the 2007-2009 crisis period in part of in its entirety. Amongst the first[78] of such studies, Farka and DaSilva (2011) investigated the responses of US Treasury futures to FFR shocks, defined using the approach

[78] We refer in particular to the Farka and DaSilva (2009) working paper as the earlier study.

of Kuttner (2001), using both daily and intra-day announcement windows, over the Feb-94 to Dec-07 sample period. Consistent with studies concerning the pre-crisis period, it was shown that US Treasuries across the maturity spectrum from 3-Month to 10-Years responded significantly to current-month FFR shocks, and the magnitude of response declined as the term to maturity increased. Furthermore, very similar estimates were yielded using both daily and intra-day announcement windows[79]. Interestingly, upon excluding event-dates associated with unscheduled FOMC meetings, the model fit was shown to deteriorate, a similar dynamic was observed in the stock market response to FFR shocks (see Basistha and Kurov, 2008).

As the sample period of Farka and DaSilva (2011) covered a very small proportion of the 2007-2009 crisis period, their estimates may have been indicative of a largely pre-crisis response of US Treasuries. In contrast, Beechey and Wright (2009) investigated the impact of macroeconomic news announcements on 5-Year and 10-Year US Treasuries over the Feb-04 to Jun-08 sample period. They were amongst the first to employ intra-day data for the US Treasury yields in their analysis. In contrast to previous studies, both Treasuries exhibited statistically *insignificant* responses to FFR shocks, measured using the approach of Kuttner (2001). However, equivalent maturity TIPS Treasuries (Treasury Inflation Protected Security) were shown to exhibit significant responses to FFR shocks. This implied that US Treasuries responded to changes in real interest rates rather than nominal interest rates. They rationalised the findings as follows; unexpected monetary tightening led to upwards revisions in expectations of the future path of monetary policy and a downward revision in expectations of inflation.

The studies by Farka and DaSilva (2011) and Beechey and Wright (2009) only considered current-month FFR shocks, however a subsequent study by Demiralp and Yilmaz (2012) estimated the impact of not only current-month FFR shocks but also up to six-month monetary policy shocks (see Section 2.7.3) on US Treasuries over the May-89 to Jun-08 sample period. They demonstrated that the current-month FFR shock exhibited a statistically *significant* impact upon 3-Month to 10-Year Treasuries; however consistent with pre-crisis studies, the impact on the 30-Year Treasury was shown to be statistically *insignificant*. The magnitudes of responses observed were consistent with that yielded by Kuttner (2001). Upon estimating the impact of two-month to six-month monetary policy shocks on US Treasuries, it was shown that as the surprise horizon was increased, US Treasuries across the maturity

[79] There was a 98% correlation between daily and intra-day measures of FFR shocks.

spectrum[80] exhibited larger magnitude responses to the associated FFR shocks. This implied that unexpected FFR shocks beyond the current-month were interpreted by market participants as being indicative of further changes in monetary policy by the FOMC in the near future. Demiralp and Yilmaz (2012) furthered their investigation by constructing a measure of path revision which reflected monetary policy in the foreseeable future, as inferred from FFR futures contracts. Interestingly, they found that US Treasuries across the maturity spectrum from 3-Month to 30-Years responded *significantly* to the measure of path revision; and in each case the impact was larger in magnitude than the current-month FFR shock.

In contrast to these studies, Cenesizoglu, Larocque and Normandin (2012) evaluated the relationship over a sample period which stretched beyond the 2007-2009 crisis period, from Nov-82 to Sep-10[81]. In particular, the study investigated the relationship between the term structure of interest rates, as inferred from 1-Month to 5-Year US Treasuries, and conventional monetary policy shocks using a structural VAR model in lieu of the traditional single-equation framework[82].The impulse response functions demonstrated that over the Nov-82 to Dec-07 sample period, an unexpected monetary expansion led to a negative effect in the level of the yield curve, thereby decreasing yields across the maturity spectrum. In comparison, over the Nov-82 to Sep-10 sample period, whilst the yields responded negatively to unexpected monetary expansion, the magnitude of response was significantly weaker in magnitude to extent that it no longer remained economically significant. These results implied that the 2007-2009 crisis period reduced the effectiveness of conventional monetary policy in influencing the term structure of interest rates, and the study argued that this could have been attributable to the fact that the period was characterised by a substantial changes in excess returns and real rates of returns.

2.10.3 US Treasuries & Monetary Policy (Non-conventional monetary policy: increasing use of forward guidance)

As we have already discussed in great depth throughout this Chapter (2), the limits of conventional monetary policy were realised on 16th Dec 08, when the target FFR approached

[80] With the exception of the 3-Month Treasury.

[81] These two sub-sample periods were selected because estimation of pre-crisis and crisis period samples may have exhibited small sample bias on the latter sample.

[82] Their identification strategy was based upon the conditional heteroscedasticity of structural innovations, which allowed the study to use an unrestricted SVAR model, thereby mitigating concerns regarding inconsistencies in the selection of monetary policy indicators as with traditional identification strategies.

the zero-lower bound, following a 75 basis point cut. In response to the impotence of monetary policy at this level, the Fed employed more non-conventional forms of monetary policy such as more explicit use of *forward guidance* and *large-scale asset purchases* to influence financial markets, as well as financial, monetary and economic conditions in the broader macroeconomy. Williams (2012) argued that "*these tools have been effective in pushing down ... Treasury yields*." In this sub-section and the next sub-section we evaluate studies which investigated the impact of not only conventional, but also non-conventional monetary policy on US Treasuries over sample periods which extended in to or beyond the 2007-2009 crisis period.

Farka and Fleissig (2012) estimated the impact of FFR shocks on US Treasuries over the May-99 to Dec-07 sample period. In line with pre-crisis studies, significant responses were observed for 3-Month to 10-Year Treasuries, declining in magnitude as the term to maturity increased. In an attempt to measure *forward guidance* by the Fed, they constructed an indicator variable for FOMC statement by assessing their information content (see Section 2.7.4). By augmenting the model to account for the FOMC statement indicator (see Equation 2.32), the 3-Month and 2-Year Treasuries exhibited comparatively smaller magnitude responses to FFR shocks, whilst the impact upon 5-Year and 10-Year Treasuries was shown to be statistically *insignificant*. In contrast, the US Treasury response to FOMC statements was shown to be significant across the maturity spectrum, and for 2-Year to 10-Year Treasuries outweighed the impact of FFR shocks.

In contrast to Farka and Fleissig (2012), who utilised a subjective interpretation of FOMC statements (see Section 2.7.4 for a critique); Gürkaynak, Sack and Swanson (2005) constructed the target factor and path factor which were shown to be associated with FFR shocks and FOMC statements respectively (see Section 2.6.2). Kurov (2012) investigated the impact of the target factor (Z_1) and path factor (Z_2) measures on US Treasuries over the Jan-94 to Sep-08 sample period. The study employed a TGARCH model, akin to Smales (2012), and interacted the variables with a recession probability indicator to evaluate the differences in US Treasury responses during periods of recession and expansion respectively. The conditional mean equation (Equation 2.36) and conditional variance equations (Equations 2.37 and 2.38) are defined below.

$$R_t = \begin{matrix} \beta_0 + \beta_1 RP_t + \beta_2 I_t^{FOMC} RP_t + \beta_3 I_t^{FOMC}(1 - RP_t) + \\ \gamma_1 Z_{1t} RP_t + \gamma_2 Z_{1t}(1 - RP_t) + \gamma_3 Z_{2t} RP_t + \gamma_4 Z_{2t}(1 - RP_t) + u_t \end{matrix}, \tag{2.36}$$

$$u_t = h_t \varepsilon_t, where\ \varepsilon_t \sim i.i.d.N(0,1), \tag{2.37}$$

$$h_t^2 = \begin{matrix} \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-1}^2 \Gamma_{t-1} + \alpha_3 h_{t-1}^2 + \\ \delta_1 |Z_{1t}| RP_t + \delta_2 |Z_{1t}| (1 - RP_t) + \delta_3 |Z_{2t}| RP_t + \delta_4 |Z_{2t}| (1 - RP_t) + \\ \sum_{i=1}^{4} \phi_i DW_{it} + \phi_{h1} PRE_t + \phi_{h2} PRE_t \end{matrix}, \quad (2.38)$$

Where (RP_1) was the filtered recession probability of Chauvet and Piger (2008), (I_t^{FOMC}) an indicator variable equal to one on scheduled FOMC meetings, and dummy variables equal to one on weekdays (DW_{it}), days preceding holidays (PRE_t) and days following holidays $(POST_t)$. In lieu of an event-study analysis, they considered daily returns over the sample period. Their estimates indicated that average bond returns were higher (lower) at scheduled FOMC meetings during periods of economic expansion (recession). Furthermore, the path factor shocks positively affected the volatility of Treasury returns during recessionary episodes, however lowered volatility during periods of economic expansion. The study demonstrated that Treasury returns were not characterised by significant state dependence with regards to recessionary versus expansionary periods for both the target factor and the path factor. Interestingly, whilst the 1-Year Treasury responded significantly to both factors during periods of recession and expansion, the 10-Year Treasury exhibited significant (insignificant) responses to the target factor during recession (expansion) and to the path factor during expansion (recession).

In a related study, Lucca and Trebbi (2009) constructed indicator variables which scored the information content of FOMC statements using linguistic algorithms to search result from Google and Factiva databases. These variables compared the number of hawkish-dovish search results before and after FOMC announcements, measuring the unexpected content of FOMC statements as the difference between the scores. This automated and computationally intensive approach partially mitigated concerns regarding subjective interpretation of news reports, or indirect measurement through the path factor. The study estimated the impact of Kuttner's (2001) based FFR shocks and the FOMC statement indicator variables constructed using Google and Factiva searches over the May-99 to Dec-08 sample. They demonstrated that whilst shorter-term US Treasuries responded significantly to FFR shocks, longer-term Treasuries responded more significantly to the statement indicator. These estimates were consistent with empirical evidence by Farka and Fleissig (2012).

2.10.4 US Treasuries & Monetary Policy (Non-conventional monetary policy: large-scale asset purchase programmes)

Rosa (2012) estimated the impact of unexpected FFR changes, the unexpected component of FOMC statements, and unexpected LSAP measures by the FOMC on US Treasuries over the May-99 to Jun-11 sample period (see Section 2.7.4). Upon estimating Equation 2.33, US Treasuries across the maturity spectrum from 3-Months to 10-Years were shown to exhibit statistically significant responses to FFR shocks. Although shorter-term maturity Treasuries yielded larger responses compared to longer-term maturity Treasuries, the magnitude of response did not monotonically decline as the term to maturity increased. It was also shown that US Treasuries of maturity beyond 3-Months responded significantly to the unexpected component of FOMC statements which conveyed information concerning the future trajectory of monetary policy. In each case, where significant, the magnitude of response to FOMC statements was less than a quarter of that regarding the FFR shock. For example, the 6-Month and 5-Year Treasury yields declined 55.5 (35.2) basis points in response to an unexpected 1% FFR cut however declined 2.4 (5.7) basis points in response to a dovish FOMC statement. The estimates concerning LSAP announcements were rather inconclusive, as a dovish LSAP announcement was associated with a *significant* 9 basis point decline in the 6-Month Treasury yield, a *significant* 85 basis point increase in the 5-Year Treasury yield and statistically *insignificant* responses for the 3-Month, 2-Year and 10-Year Treasuries. By expressing these measures in terms of their cumulative impact and in terms of FFR changes, they yielded 0 and 197 basis point responses in the 3-Month and 10-Year Treasuries respectively.

In a more focused study, Szczerbowicz (2011) evaluated the impact of conventional and unconventional monetary policy by the Fed on the 10-Year Treasury. The study defined conventional monetary policy using the approach of Kuttner (2001); however unconventional monetary policy measures were disaggregated in to five distinct categories concerning; interest rate commitments, long-term Treasury bond purchases, agency debt and mortgage-backed security purchases, provision of liquidity facilities and Fed rescue operations. Over the Jan-99 to Jul-10 sample period, an unexpected 1% FFR cut was associated a 22 basis point decline in the 10-Year Treasury yield. Interestingly, purchases of agency debt and long-term Treasury bond purchases lowered the 10-Year Treasury yield by 17 and 22 basis points respectively. However, the other three measures of unconventional monetary policy yielded statistically insignificant responses. The estimates yielded were robust to the inclusion and exclusion of Quantitative Easing II, and illustrated an off-setting effect of inflation, whereby Quantitative Easing I lowered long-term rates without affecting inflation whilst QE2 increased inflation expectations without affecting long-term interest rates.

Lastly, as we discussed in Section 2.7.4, Wright (2011) measured monetary policy shocks using an identified VAR methodology akin to the 'identification through heteroscedasticity' approach we evaluated in Section 2.5.1. The sample period explicitly considered FOMC event-dates characterised by the zero-lower bound, and thereby monetary policy shocks by construction measured non-conventional measures by the Fed[83]. Over the Nov-08 to Dec-10 sample period, a one-standard deviation monetary policy shock was associated with a -0.06% and -0.12% decline in 2-Year and 10-Year Treasury yields respectively. These estimates were consistent with evidence concerning LSAP measures by Szczerbowizcz (2011).

2.10.5 US Treasuries & Monetary Policy (Overview)

Thus we can make several stylised observations from studies which investigated the impact of conventional and non-conventional monetary policy on US Treasury yields over a sample which covers the 2007-2009 crisis in its entirety or in part. Firstly, whilst pre-crisis studies yielded conflicting and contrasting empirical evidence concerning the 10-Year Treasury response to conventional monetary policy shocks (see Berument and Froyen, 2008), studies whose sample periods extended significantly in to or beyond the 2007-2009 crisis period widely documented statistically significant responses of the 10-Year Treasury (see Farka and DaSilva, 2011; Farka and Fleissig, 2012; Demiralp and Yilmaz, 2012; Rosa, 2012; Bauer and Neely, 2012). It is thus apparent that the impact of conventional monetary policy shocks throughout the 2007-2009 crisis period may have been markedly different from that prior to the crisis period.

Secondly, whilst shorter-term maturity Treasuries were shown to yield smaller magnitude and/or statistically insignificant responses to various measures of *forward guidance*, longer-term Treasuries exhibit stronger responses (see Demiralp and Yilmaz, 2012; Farka and Fleissig, 2012; Rosa, 2012; Kurov, 2012). Thirdly, longer-term maturity Treasuries were shown to yield stronger responses to *large-scale asset purchase programmes* by the Fed

[83] The effects of non-conventional monetary policy were observed by assuming monetary policy shocks are heteroscedastic and have abnormally high variance on FOMC meeting days.

compared to shorter-term maturity Treasuries (see Rosa, 2012; Szczerbowizcz, 2011; Wright, 2011).

2.11 The Monetary Policy Transmission Mechanism Channels (Theory)

Although this is an empirically motivated thesis, some believe it is important to consider the theoretical channels through which monetary policy is transmitted to financial markets and the broader economy. In this sub-section we briefly review the traditional channels of monetary policy transmission outlined by Mishkin (1996, 2001, 2007a, 2007b) amongst others. These include the interest rate channel, the exchange rate channel, Tobin's q theory, the wealth effects channel, the bank lending channel, the balance sheet channel, the cash flow channel and the unanticipated price level channel[84].

2.11.1 Traditional Interest Rate Channels

The interest rate channel of monetary policy transmission has early roots in traditional Keynesian economics and continues to play an important role in modern economic policy, demonstrated by the fact that the Fed continues to administer monetary policy primarily by targeting the FFR. From a Keynesian ISLM perspective, ceteris paribus if the Fed buy (sells) through open market operations then banks have more (less) reserves which they can lend out at lower (higher) interest rates. The monetary expansion (contraction) lowers (increases) real interest rates and the cost of capital, thereby inducing higher (lower) investment by businesses and consumer households[85]. This ultimately translates in to higher (lower) aggregate demand and output in the economy.

As Mishkin (1996) points out, the transmission operates through real interest rates. If prices are assumed to be sticky (i.e. aggregate price levels adjust slowly over time), then a monetary expansion would be expected to lower not only nominal short-term interest rates, but also real short-term interest rates. Longer-term interest rates would also be expected to decline, as the expectations hypothesis of the term structure implied that long-term interest rates represent an average of longer-term rates.

---

[84] These are not the only channels of transmission; however they are cited as the main channels. The channels are also not independent of one another but in many cases inter-related. By convention, they are usually discussed in turn.

[85] Keynes originally thought this channel operated solely through changes in investment decisions by firms; however more recently it has been shown that this channel also operates through changes in longer-term investment decisions by households, such as purchases of durable goods.

However, this is a rather idealised scenario and in reality short-term interest rates may not move by precisely the same amount of an official target FFR change. Furthermore, as George, King, Clementi, Budd, Buiter, Goodhart, Julius, Plenderleith and Vickers (1999) point out, whilst short-term interest rates move in the same direction of official FFR changes, the direction in which longer-term rates move is more ambiguous. This is because longer-term rates are influenced by an average of current and expected future short-term rates, implying that longer-term rates also depend on expectations of the future path of interest rates. For example, a monetary contraction could create an expectation of lower future interest rates, hence longer-term rates may decline in response to a monetary contraction. Nevertheless, it has been argued that the interest rate channel of monetary policy transmission remains effective during a liquidity trap when nominal interest rates approach the zero-lower bound, during a deflationary period. This is because a commitment by monetary authorities of future monetary expansion can cause price level and inflation expectations to increase, thereby lowering real interest rates. There is considerable academic debate regarding the strength of the interest rate channel of monetary policy transmission. Whilst Taylor (1995) argues that this transmission channel is strong, Bernanke and Gertler (1995) contested the efficacy of this monetary policy transmission channel.

2.11.2 Exchange Rate Channels

In an increasingly integrated global financial economy and with more countries adopting flexible exchange rate regimes, monetary policy can be transmitted through the exchange rate channel. As the exchange rate is the price of one currency in terms of another foreign currency, this implies that its value depends upon both domestic and foreign monetary conditions. Traditional theory suggests that ceteris paribus, if the Fed buys (sells) through open market operations, then banks have more (less) reserves which they can lend out at lower (higher) interest rates. The monetary expansion (contraction) lowers (increases) real interest rates, and this makes assets denominated in the domestic currency more (less) attractive to international investors compared to assets denominated in foreign currencies. As the value of domestic deposits decline (increase), the resulting outflow (inflow) of international investment from the domestic currency translates in to a depreciation (appreciation) of the exchange rate. The depreciation (appreciation) makes domestic goods more competitive and cheaper than foreign goods, causing net exports to increase (decrease). This ultimately results in higher (lower) aggregate demand and output in the economy.

In reality, the impact of a monetary expansion of contraction on the exchange rate is ambiguous. This is because the exchange also depends upon domestic and foreign interest rate and inflation expectations, which both in turn may be influenced by monetary policy decisions. Obstfeld and Rogoff (1995) argued that the exchange rate channel of monetary policy transmission was important, and Eichenbaum and Evans (1995) yielded significant evidence for this channel in the US.

2.11.3 Tobin's q Theory & Wealth Effects Channels

As much of this thesis investigates the stock return response to monetary policy, it is important to analyse the channels through this transmission may operate. Tobin's q theory (Tobin and Brainard, 1968) defines q as the market value of a firms divided by the replacement cost of capital. When Tobin's q is higher than one, the market value of firms is higher than the replacement cost of capital. This implies that the stock is overvalued and if firms issue new stock at the higher price to replace the capital. When Tobin's q is lower than one, the market value of firms is lower than the replacement cost of capital. This implies that the stock is undervalued and if firms can purchase other firms at a lower price to replace the capital. Tobin's q theory suggests that ceteris paribus, if the Fed buys (sells) through open market operations, then banks have more (less) reserves which they can lend out at lower (higher) interest rates. The monetary expansion (contraction) lowers (increases) interest rates, which encourages (discourages) borrowing by consumers and businesses. One place individuals can invest their money is in the stock market, thereby increasing (decreasing) demand and prices of stocks. The increase in stock prices results in a higher (lower) Tobin's q value, which encourages (discourages) investment by firms as the cost of replacing capital is lower (higher) than the market value of the firm. Ehrmann and Fratzscher (2004) yield significant evidence of firms with high Tobin's q being associated with significantly larger magnitude responses to monetary policy shocks.

Another channel through which stocks can be influenced by monetary policy is through the wealth effects channel. This theory assumes consumers smooth out their investment over their lifetime which implies that consumption is contingent upon the total lifetime of consumer's resources and not their current level of income. Following on from Tobin's q theory discussed above; if a monetary expansion (contraction) leads to a decrease (increase) in stock prices, then the value of a consumer's wealth also increases (decreases). If this results in an increase in actual wealth, or a perceived increase in wealth, then it will result in an increase in consumption. Modigliani (1971) was a major proponent of this channel, and later studies yielded significant evidence for this channel (see Case, Quigley and Shiller, 2005). Whilst Tobin's q theory and the wealth effects channel theory predict that stock returns increase (decrease) in response to monetary policy, these models can equally apply to equity in housing and land which are large components of consumer's wealth.

2.11.4 Credit Channels (Balance Sheet and Bank Lending Channels)

The credit channel proposes two main channels of monetary policy transmission which arise in response to information asymmetries in the credit markets. These include the balance sheet channel and the bank lending channel. The bank lending channel is important because bank loans are the main source of financing for many consumers and businesses in the economy. Banks overcome information asymmetries in the credit market by screening the credit worthiness of consumers and businesses. If the Fed buys (sells) through open market operations, ceteris paribus, then banks have more (less) reserves and bank deposits which they can lend out at lower (higher) interest rates. The monetary expansion (contraction) increases (decreases) the supply of loanable funds available and this leads to an increase (decrease) in investment. This implies that a monetary contraction reduces the supply of intermediated credit by banks, and firms more dependent on this source of financing may face more onerous credit terms, a significant decline in credit and incur greater search costs for securing credit from other financial intermediaries. Thus consumers and firms more dependent on this source of financing are likely to yield larger magnitude responses to monetary policy shocks (see Bernanke and Gertler, 1995).

It has been argued that the bank lending channel of monetary policy transmission has weakened over time. In the mid-1980s, reserve requirements for certificates of deposit (CDs) were removed by authorities, and this made it significantly easier for banks to bridge the shortfall in funds by issuing CDs at market interest rates without having to back them with reserve requirements (see Mishkin, 2007a). Nevertheless, banks remain exposed to an external financing premium reflected in the cost of raising uninsured funds.

The balance sheet channel is more complex and there are several ways in which monetary policy can influence the balance sheets of businesses. It suggests that the external financing premium is inversely related to the net worth of the borrowers reported on balance sheets. Businesses with a higher (lower) net worth are more likely to use self-financing to fund investment, and more (less) likely to have collateral against which funds may be borrowed. As higher net worth businesses are more likely to be fully collateralised than lower net worth businesses, this results in adverse selection because there is lower (higher) risk in lending to higher (lower) net worth businesses (see Mishkin, 2007a). This implies that a decrease (increase) in a firm's net worth is associated in a decline (increase) in lending and investment. More specifically, if the Fed buys (sells) through open market operations, the monetary expansion (contraction) leads to an increase (decrease) in stock prices through Tobin's q theory and the wealth effects channel. This results in lower (higher) adverse selection and moral hazard, thereby inducing an increase (decrease) in overall lending and investment (see Mishkin, 1996).

Secondly, the balance sheet channel also operates by influencing cash flows. If the Fed buy (sells) through open market operations, ceteris paribus, then banks have more (less) reserves which they can lend out at lower (higher) interest rates. The monetary expansion (contraction) lowers (increases) nominal interest rates and this causes an improvement (worsening) in the balance sheets of firms because it increases (decreases) their cash flows. The improvement (worsening) in the balance sheet of businesses stems from the fact that it increases (decreases) their liquidity and the ability of lenders to understand the ability of businesses in repaying loans. It has also been argued that monetary expansion can lower interest rates; stimulate investment and higher aggregate demand and output through the credit rationing phenomenon (see Mishkin, 2007b). Credit rationing is when borrowers are not granted loans even with higher interest rates because those willing to pay the higher rates are more likely to be those with riskier investment projects. This implies that higher (lower) interest rates are likely to increase (decrease) the degree of adverse selection in this regard. Therefore a monetary expansion is likely to result in a lower proportion of borrowers with higher-risk investment strategies (see Mishkin, 2001).

Thirdly, the balance sheet channel also operates by influencing the general price level in the economy. When firms repay their borrowing, the terms of repayment are typically tied to nominal interest rates. If a monetary expansion results in an unexpected price level increase, it increases the net worth of businesses, and decreases adverse selection and moral hazard problems. This ultimately leads to higher investment, aggregate demand and output (see Mishkin, 2007a). Although the channels of monetary policy transmission discussed above are theoretical channels, there is varying evidence for the empirical efficacy of these channels, and this evidence appears to change over time as some channels become more significant than others. It is however important to remember that these are *theoretical* channels and they should be treated as such. To evaluate the impact of monetary policy on financial markets and the economy, it is important to empirically investigate the relationship.

2.11.5 Asset Pricing Channels

Traditional asset pricing theory values financial assets as the present value of expected future cash flows. Providing that international financial markets have sophisticated financial infrastructures and assets are highly traded, we infer that traded assets are highly efficient in reflecting contemporaneous and future expectations of cash flows. In a rational expectations framework, assets of an equivalent risk class are priced to offer the same expected return. Thus unexpected monetary action should immediately be reflected in asset prices upon announcement. The discounted cash flow model is widely employed as a basis for valuation of financial assets and provides insights into the potential effects of monetary policy action on equity prices. A stock price $[S_t]$ is defined as the present value of expected future dividends $[DIV_{t+k}]$ and the expected future stock price $[S_{t+k}]$; both contingent upon available information at time $[t]$ and discounted by the opportunity cost, such as the return from a risk-free asset $[R]$; over the holding period horizon $[k]$ (Equation 2.39).

$$S_t = E_t\left[\sum_{i=1}^{k}\frac{DIV_{t+i}}{(1+R)^i}\right] + E_t\left[\frac{S_{t+k}}{(1+R)^k}\right], \qquad (2.39)$$

If an investor holds a stock for perpetuity, the theoretical holding horizon approaches infinity and the terminal value approaches zero. The stock price is determined purely by a perpetual flow of future expected dividends per share as in Equation 2.40. This assumes the company issuing stock remains solvent and stock is not retired from acquisition.

$$S_t = E_t\left[\sum_{i=1}^{\infty}\frac{DIV_{t+i}}{(1+R)^i}\right], \qquad (2.40)$$

To ensure computational clarity, the discounted cash flow model imposes two further unrealistic assumptions; it firstly assumes that discount rates are constant and secondly assumes expected stock returns follow a martingale process while remaining constant over the holding horizon. In reality, discount rates and expected stock returns are time-varying and the stock valuation model follows a non-linear specification. Campbell, Lo and MacKinlay (1997) propose a log-linear approximation of the classic model, which enables stock price valuation under any non-linear specification of expected returns and discount rates. By imposing the terminal condition $[\lim_{i\to\infty} E_t(\lambda^i p_{t+i}) = 0]$, the possibility of a permanent rational stock price bubble is eliminated, yielding the log-linear stock price approximation defined in Equation 2.41[86].

$$s_t = \frac{k}{1-\lambda} + (1-\lambda)\left[\sum_{i=0}^{\infty} \lambda^i E_t\left(div_{t+1+i}\right)\right] - \left[\sum_{i=0}^{\infty} \lambda^i E_t\left(r_{t+1+i}\right)\right] \qquad (2.41)$$

The discounted cash flow model of asset pricing in its classical or log-linear form has direct and indirect implications for the effect of monetary policy on stock price valuations. The direct effect operates through capitalisation rates of expected cash flows[87], assuming investors value financial assets in terms of a rational expectations discounting framework; exogenous decreases (increases) in interest rates through expansionary (contractionary) monetary policy yield lower (higher) stock price valuations. The indirect effect operates through signalling by the monetary authorities: changes in monetary stance are interpreted by investors as revisions in expectations of economic and financial conditions. A decrease in interest rates may be indicative of an economic slowdown which in turn affects expectations of future cash flows from assets. Thus investor expectations regarding future returns from stocks in terms of returns from capital gains and dividend yields may be indirectly impacted by changes in monetary stance, independent of the discounting factor. Investor interpretation of monetary stance remains a pivotal issue in behavioural finance.

Monetary policy can therefore exhibit a dual effect on stock prices through both discount rates and revisions in expectations. A simultaneous decrease (increase) in interest rates combined with expectations of improved (worsened) economic conditions results in higher (lower) stock price valuations through the discounting factor and expectations of higher dividends and capital gains, ceteris paribus. Alternatively, a combination of higher (lower) interest rates and improved (worsened) produces an ambiguous effect on stock prices, conditional upon the strength of each effect and ability to outweigh one another. Expectations can therefore disproportionately outweigh the asset pricing implications of changes in monetary policy.

---

[86] The lowercase letters denote logged variables and the parameters $[k]$ and $[\lambda]$ are defined by the identities $k \equiv -\ln(\lambda) - (1-\lambda)\ln\left(\frac{1}{\lambda - 1}\right)$ and $\lambda \equiv 1/1 + e(div - p)$

[87] Cash flows from stocks are defined as returns from capital gains and returns from dividends over the holding horizon

2.12 References

Ammer, J., Vega, C., & Wongswan, J. 2010. International transmission of US monetary policy shocks: evidence from stock prices. *Journal of Money, Credit and Banking* 42(1), 179-198.

Andersson, M. 2010. Using intraday data to gauge financial market responses to Federal Reserve and ECB monetary policy decisions. *International Journal of Central Banking* 6(2), 117-146.

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Vega, C. 2007. Real-time price discovery in global stock, bond and foreign exchange markets. *Journal of International Economics* 73(2), 251-277.

Bailey, W. 1990. US money supply announcements and Pacific Rim stock markets: Evidence and implications. *Journal of International Money and Finance* 9(3), 344-356.

Baker, H. K., & Meyer, J. M. 1980. Impact of discount rate changes on treasury bills. *Journal of Economics and Business* 33(3), 43-48.

Basistha, A., & Kurov, A. 2008. Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 32(12), 2606-2616.

Bauer, M.D., and Neely, C.J. 2012. International channels of the Fed's unconventional monetary policy. *Federal Reserve Bank of St. Louis*. Working Paper 2012-028A.

BBC News Website. 2007. ECB moves to help the banking sector. *BBC News Website*. Available from: http://news.bbc.co.uk/1/hi/business/6938425.stm. [Accessed on 18th Aug 13].

Becher, D.A., Jensen, G.R., & Mercer, J.M. 2008. Monetary policy indicators as predictors of stock returns. *Journal of Financial Research* 31(4), 357-379.

Beechey, M.J., and Wright, J.H. 2009. The high-frequency impact of news on long-term yields and forward rates: is it real? *Journal of Monetary Economics* 56(4), 535-544

Bernanke, B. S., & Gertler, M. 1995. Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives* 9(4), 27-48.

Bernanke, B.S. 2009. Financial reform to address systemic risk. *Federal Reserve Webiste*. Available from: http://www.federalreserve.gov/newsevents/speech/bernanke20090310a.htm. [Accessed on 18th Aug 13].

Bernanke, B.S., & Blinder, A.S. 1992. The Federal funds rate and the channels of monetary transmission. *The American Economic Review* 82(4), 901-921.

Bernanke, B.S., & Kuttner, K.N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Berument, H., and Froyen, R.T. 2006. Monetary policy and long-term US interest rates. *Journal of Macroeconomics* 28(4), 737-751

Berument, H., and Froyen, R.T. 2008. Monetary policy and U.S. long-term interest rates: how close are the linkages? *Journal of Economics and Business* 61(1), 34-50

Bjørnland, H.C., & Leitemo, K. 2009. Identifying the interdependence between US monetary policy and the stock market. *Journal of Monetary Economics* 56(2), 275-282.

Blanchard, O.J., & Quah, D. 1989. The dynamic effects of aggregate demand and supply disturbances. *The American Economic Review* 79(4), 655-673.

BNP Paribas Website. 2007. BNP Paribas Investment Partners temporaly suspends the calculation of the net asset value of the following funds: Parvest Dynamic ABS, BNP Paribas ABS EURIBOR and BNP Paribas ABS EONIA. *BNP Paribas Website*. Available from: http://www.bnpparibas.com/en/news/press-release/bnp-paribas-investment-partners-temporaly-suspends-calculation-net-asset-value-fo. [Accessed on 18th Aug 13].

Bomfim, A.N. 2003. Pre-announcement effects, news effects, and volatility: Monetary policy and the stock market. *Journal of Banking & Finance* 27(1), 133-151.

Bordo, M.D., Dueker, M.J., and Wheelock, D.C. 2007. Monetary policy and stock market booms and busts in the 20th century. *Federal Reserve Bank of St. Louis*. Working Paper 2007-020.

Boschen, J.F., & Mills, L.O. 1995. The relation between narrative and money market indicators of monetary policy. *Economic Inquiry* 33(1), 24-44.

Bredin, D., Hyde, S., Nitzsche, D., & O'Reilly, G. 2009. European monetary policy surprises: the aggregate and sectoral stock market response. *International Journal of Finance & Economics* 14(2), 156-171.

Campbell, J.Y. 1991. A Variance Decomposition for Stock Returns. *The Economic Journal* 101(405), 157-179.

Campbell, J.Y, Lo, A.W., and MacKinlay, A.C. 1997. *The Econometrics of Financial Markets*. Princeton University Press. Chapter 7: Present-Value Relations.

Campbell, J.Y., & Ammer, J. 1993. What moves the stock and bond markets? a variance decomposition for long-term asset returns. *The Journal of Finance* 48(1), 3-37.

Campbell, J.Y., & Shiller, R.J. 1988. Stock prices, earnings, and expected dividends. The *Journal of Finance* 43(3), 661-676.

Case, K.E., Quigley, J.M., & Shiller, R.J. 2005. Comparing Wealth Effects: The Stock Market versus the Housing Market. *The B.E Journal of Macroeconomics* 5(1), 1-34.

Cenesizoglu, T., Montréal, H.E.C., Larocque, D., & Normandin, M. 2012. Conventional Monetary Policy and the Term Structure of Interest Rates during the Financial Crisis. *HEC Montreal Finance Department*. Working Paper.

Chauvet, M., Piger, J. 2008. A comparison of the real-time performance of business cycle dating methods. *Journal of Business and Economic Statistics* 26(1), 42-49.

Chen, S.S. 2007. Does monetary policy have asymmetric effects on stock returns?. Journal *of Money, Credit and Banking* 39(2-3), 667-688.

Chernenko, S., Schwarz, K., & Wright, J. 2004. The information content of forward and futures prices: Market expectations and the price of risk. *FRB International Finance*. Discussion Paper 808.

Christiano, L.J., Eichenbaum, M., & Evans, C. 1994. The effects of monetary policy shocks: Some evidence from the flow of funds. *National Bureau of Economic Research*. Working Paper w4699.

Chuliá, H., Martens, M., & Dijk, D.V. 2010. Asymmetric effects of Federal Funds target rate changes on S&P100 stock returns, volatilities and correlations. *Journal of Banking & Finance* 34(4), 834-839.

Cochrane, J.H., & Piazzesi, M. 2002. The Fed and interest rates: a high-frequency identification. *The American Economic Review* 92(2), 90-95.

Conover, C.M., Jensen, G.R., & Johnson, R.R. 1999. Monetary environments and international stock returns. *Journal of Banking & Finance* 23(9), 1357-1381.

Cook, T., and Hahn, T. 1989. The effect of changes in the Federal Funds rate target on market interest rates in the 1970s. *Journal of Monetary Economics* 24, 331-351

Cooper, R.V. 1974. Efficient capital markets and the quantity theory of money. *Journal of Finance* 29(3), 887-908.

Cornell, B. 1983. The money supply announcements puzzle: Review and interpretation. *American Economic Review* 73(4), 644-57.

Craine, R., & Martin, V. 2003. Monetary policy shocks and security market responses. *University of California Berkeley Economics*. Working Paper.

Crowder, W.J. 2006. The interaction of monetary policy and stock returns. *Journal of Financial Research* 29(4), 523-535.

D'Agostino, A., Sala, L., & Surico, P. 2004. The Fed and the Stock Market. *Universite' Libre de Bruxelles, European Central Bank, Bocconi University, Bank of England & University of Bari*. Working Paper.

Davig, T., & Gerlach, J.R. 2006. State-dependent stock market reactions to monetary policy. *International Journal of Central Banking* 2(4), 65-83

Demiralp, S., & Yilmaz, K. 2009. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *TÜSİAD-Koç University Economic Research Forum*. Working Paper.

Demiralp, S., & Yilmaz, K. 2010. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *TÜSİAD-Koç University Economic Research Forum*. Working Paper.

Demiralp, S., & Yilmaz, K. 2012. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *Journal of Macroeconomics* 34(2), 404-418.

Edelberg, W., and Marshall, D. 1996. Monetary policy shocks and long-term interest rates. *Economic Perspectives* Mar, 2-17

Ehrmann, M., & Fratzscher, M. 2004. Taking stock: Monetary policy transmission to equity markets. *Journal of Money, Credit, and Banking* 36(4), 719-737.

Ehrmann, M., & Fratzscher, M. 2006. Global financial transmission of monetary policy shocks. *European Central Bank*. Working Paper No. 1710.

Ehrmann, M., & Fratzscher, M. 2009. Global Financial Transmission of Monetary Policy Shocks. *Oxford Bulletin of Economics and Statistics* 71(6), 739-759.

Eichenbaum, M., & Evans, C. L. 1995. Some empirical evidence on the effects of shocks to monetary policy on exchange rates. *The Quarterly Journal of Economics* 110(4), 975-1009.

Eijffinger, S., Mahieu, R., & Raes, L. 2012. Can the Fed talk the hind legs off the stock market?. *European Banking Center*. Discussion Paper 2012-006.

Eijffinger, S.C., Mahieu, R.J., & Raes, L. 2011. Can the Fed talk the hind legs off the stock market? *CEPR*. Discussion Papers 8450.

Ellingsen, T. & Söderström, U. 2004. Why are long rates sensitive to monetary policy? *Society for Computational Economics*. Working Paper 31.

Fama, E.F. 1970. Efficient capital markets: A review of theory and empirical work. *The Journal of Finance* 25(2), 383-417.

Fama, E.F., & French, K.R. 1989. Business conditions and expected returns on stocks and bonds. *Journal of Financial Economics* 25(1), 23-49.

Farka, M. 2009. The effect of monetary policy shocks on stock prices accounting for endogeneity and omitted variable biases. *Review of Financial Economics* 18(1), 47-55.

Farka, M., & DaSilva, A. 2009. The Fed and the Term Structure: Addressing Simultaneity within a Structural VAR Approach. *California State University Department of Economics*. Working Paper.

Farka, M., & Fleissig, A.R. 2009. The effect of FOMC statements on asset prices. *California State University Department of Economics*. Working Paper.

Farka, M., & Fleissig, A.R. 2010. The effect of FOMC statements on asset prices. *California State University Department of Economics*. Working Paper.

Farka, M., & Fleissig, A.R. 2012. The effect of FOMC statements on asset prices. *International Review of Applied Economics* 26(3), 387-416.

Farka, M., and DaSilva, A. 2011. The Fed and the term structure: addressing simultaneity within a structural VAR model. *Journal of Empirical Finance* 18(5), 935-952

Federal Reserve. 2007a. Press release statement on 17th Aug 07. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/press/monetary/20070817a.htm. [Accessed on 18th Aug 13].

Federal Reserve. 2007b. Press release statement on 18th Sep 07. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/press/monetary/20070918a.htm. [Accessed on 18th Aug 13].

Federal Reserve. 2007c. Press release statement on 8th Oct 07. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/press/monetary/20070810a.htm. [Accessed on 18th Aug 13].

Friedman, M., & Schwartz., A.J. 1963. *A Monetary History of the United States, 1867-1960*. Princeton University Press

George, E., King, M., Clementi, D., Budd, A., Buiter, W., Goodhart, C., Julius, D., Plenderleith, I., and Vickers, J. 1999. The transmission mechanism of monetary policy. *Bank of England*, 1-12.

Gertler, M., & Gilchrist, S. 1994. Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics* 109(2), 309-340.

Gilbert, R. A. 1985. Operating procedures for conducting monetary policy. *Federal Reserve Bank of St. Louis Review* 67(2), 13-21.

Gorodnichenko, Y., & Weber, M. 2013. Are Sticky Prices Costly? Evidence from the stock market. *National Bureau of Economic Research*. Working Paper w18860.

Gürkaynak, R. S., Sack, B., & Swanson, E. 2002. Market-based measures of monetary policy expectations. *Board of Governors of the Federal Reserve System*. Working Paper 2002-40.

Gürkaynak, R.S., Sack, B., & Swanson, E.T. 2005. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking* 1(1), 55-93

Gürkaynak, R.S., Sack, B.P., & Swanson, E.T. 2007. Market-based measures of monetary policy expectations. *Journal of Business & Economic Statistics* 25(2), 201-212.

Guttentag, J. M. 1966. The strategy of open market operations. *The Quarterly Journal of Economics* 80(1), 1-30.

Hafer, R. 1986. The response of stock prices to changes in weekly money and the discount rate. *Federal Reserve Bank of St. Louis Review* Mar, 5-14.

Hakes, D. R. 1990. The objectives and priorities of monetary policy under different Federal Reserve chairmen. *Journal of Money, Credit and Banking* 22(3), 327-337.

Hamburger, M.J., & Kochin, L.A. 1972. Money and stock prices: The channels of influence. *The Journal of Finance* 27(2), 231-49.

Hamilton, J.D. 2008. Assessing monetary policy effects using daily Federal Funds futures contracts. *Federal Reserve Bank of St. Louis Review* 90(4), 377-393

Hausman, J., & Wongswan, J. 2006. Global asset prices and FOMC announcements. *FRB International Finance*. Discussion Paper 886.

Hausman, J., & Wongswan, J. 2011. Global asset prices and FOMC announcements. *Journal of International Money and Finance* 30(3), 547-571.

HM Treasury Website. 2007. Liquidity support facility for Northern Rock plc. The *HM Treasury Website*. Available from: http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/press_94_07.htm. [Accessed on 18th Aug 13].

Homa, K.E., & Jaffee, D.M. 1971. The supply of money and common stock prices. *The Journal of Finance* 26(5), 1045-1066.

Husted, S., & Kitchen, J. 1985. Some evidence on the international transmission of US money supply announcement effects. *Journal of Money, Credit and Banking* 17(4), 456-66.

Ioannidis, C., & Kontonikas, A. 2008. The impact of monetary policy on stock prices. *Journal of Policy Modeling* 30(1), 33-53.

Jensen, G.R., & Johnson, R.R. 1993. An examination of stock price reactions to discount rate changes under alternative monetary policy regimes. *Quarterly Journal of Business and Economics* 32(2), 26-51.

Jensen, G.R., & Johnson, R.R. 1995. Discount rate changes and security returns in the US, 1962–1991. *Journal of Banking & Finance* 19(1), 79-95.

Jensen, G.R., Mercer, J.M., & Johnson, R.R. 1996. Business conditions, monetary policy, and expected security returns. *Journal of Financial Economics* 40(2), 213-237.

Johnson, R. R., & Jensen, G. R. 1993. The reaction of foreign stock markets to US discount rate changes. *International Review of Economics & Finance* 2(2), 181-193.

Keran, M. W. 1971. Expectations, money, and the stock market. *Federal Reserve Bank of St. Louis Review* Jan, 16-31.

Kontonikas, A., & Kostakis, A. 2013. On Monetary Policy and Stock Market Anomalies. *Journal of Business Finance and Accounting* (forthcoming)

Kontonikas, A., MacDonald, R., & Saggu, A. (2013). Stock market reaction to fed funds rate surprises: state dependence and the financial crisis. *Journal of Banking and Finance* 37(11), 4025-4037

Krueger, J.T., & Kuttner, K.N. 1996. The Fed Funds futures rate as a predictor of Federal Reserve policy. *Journal of Futures Markets* 16(8), 865-879.

Kurov, A. 2010. Investor sentiment and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 34(1), 139-149.

Kurov, A. 2011. What determines the stock market's reaction to monetary policy statements?. *West Virginia University College of Business and Economics*. Working Paper.

Kurov, A. 2012. What determines the stock market's reaction to monetary policy statements?. *Review of Financial Economics* 21, 175-187.

Kuttner, K.N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Kuttner, K.N. 2003. Dating changes in the Federal Funds rate, 1989-92. *Oberlin College*. Working Paper.

Laeven, L., & Tong, H. 2012. US monetary shocks and global stock prices. *Journal of Financial Intermediation* 21(3), 530-547.

Laopodis, N.T. 2006. Dynamic interactions among the stock market, federal funds rate, inflation, and economic activity. *Financial Review* 41(4), 513-545.

Lastrapes, W.D. 1998. International evidence on equity prices, interest rates and money. *Journal of International Money and Finance* 17(3), 377-406.

Lombra, R. E., & Torto, R. G. 1977. Discount rate changes and announcement effects. *The Quarterly Journal of Economics* 91(1), 171-176.

Lucca, D.O., and Trebbi, F. 2009. Measuring central bank communication: an automated approach with application to FOMC statements. *National Bureau of Economic Research*. Working Paper 15367.

Lütkepohl, H. 1993. *Introduction to Multiple Time Series Analysis. Springer-Verlag*. Chapter 2: Stable Vector Autoregressive Processes.

Maio, P., Tavares, J., 2007. Monetary policy and the cross-section of equity returns: Small versus Large and Value versus Growth. *Bilkent University Faculty of Business Administration*. Working Paper.

McQueen, G., & Roley, V. V. 1993. Stock prices, news, and business conditions. *Review of Financial Studies* 6(3), 683-707.

Mishkin, F. 1996. The Channels of Monetary Transmission: Lessons for Monetary Policy. *National Bureau of Economic Research*. Working Paper w5464.

Mishkin, F. S. 2001. The transmission mechanism and the role of asset prices in monetary policy. *National Bureau of Economic Research*. Working Paper w8617.

Mishkin, F.S. 2007a. *The Economics of Money, Banking, and Financial Markets: 8th Edition*. Pearson Addison Wesly, Chapter 23.

Mishkin, F.S. 2007b. *Monetary Policy Strategy*. The MIT Press, Chapter 3.

Modigliani, F. 1971. Consumer spending and monetary policy: the linkages. *Federal Reserve Bank of Boston Conference Series* (5), 9-84.

Mudd, D. R. 1979. Did discount rate changes affect the foreign exchange value of the dollar during 1978?. *Federal Reserve Bank of St. Louis Review* 61(4), 20-26.

NBER (The National Bureau of Economic Research). 2010. Determination of the December 2007 peak in economic activity. *The National Bureau of Economic Research Website*. Available from: http://www.nber.org/cycles/dec2008.pdf. [Accessed on 18th Aug 13].

Obstfeld, M., & Rogoff, K. S. 1995. The Mirage of Fixed Exchange Rates. *Journal of Economic Perspectives* 9(4), 73-96.

Patelis, A.D. 1997. Stock return predictability and the role of monetary policy. *The Journal of Finance* 52(5), 1951-1972.

Pearce, D.K., & Roley, V.V. 1983. The reaction of stock prices to unanticipated changes in money: A note. *The Journal of Finance* 38(4), 1323-1333.

Pearce, D.K., & Roley, V.V. 1985. Stock prices and economic news. *The Journal of Business* 58(1), 49-67.

Pesando, J.E. 1974. The supply of money and common stock prices: Further observations on the econometric evidence. *The Journal of Finance* 29(3), 909-21.

Piazzesi, M., & Swanson, E.T. 2008. Futures prices as risk-adjusted forecasts of monetary policy. *Journal of Monetary Economics* 55(4), 677-691.

Rajan, R. G., & Zingales, L. 1998. Financial Dependence and Growth. *American Economic Review* 88(3), 559-586.

Rigobón, R., & Sack, B. 2002. The impact of monetary policy on asset prices. *National Bureau of Economic Research*. Working Paper 8794.

Rigobón, R., & Sack, B. 2004. The impact of monetary policy on asset prices. *Journal of Monetary Economics* 51(8), 1553-1575.

Rogalski, R.J., & Vinso, J. D. 1977. Stock returns, money supply and the direction of causality. *The Journal of Finance* 32(4), 1017-30.

Roley, V. V., & Sellon, G. H. 1995. Monetary policy actions and long-term interest rates. *Federal Reserve Bank of Kansas City Economic Quarterly* 80(4), 77-89.

Roley, V.V., & Troll, R. 1984. The impact of discount rate changes on market interest rates. *Federal Reserve Bank of Kansas City Economic Review* 69(1), 27-39.

Romer, C.D., & Romer, D.H. 1994. Monetary policy matters. *Journal of Monetary Economics* 34(1), 75-88.

Rosa, C. 2011. The Validity of the Event-study Approach: Evidence from the Impact of the Fed's Monetary Policy on US and Foreign Asset Prices. *Economica* 78(311), 429-439.

Rosa, C. 2011. Words that shake traders: The stock market's reaction to central bank communication in real time. *Journal of Empirical Finance* 18(5), 915-934.

Rosa, C. 2012. How 'unconventional' are large-scale asset purchases? The impact of monetary policy on asset prices. *FRB of New York Staff Report*. Working Paper 560.

Rozeff, M.S. 1974. Money and stock prices: Market efficiency and the lag in effect of monetary policy. *Journal of Financial Economics* 1(3), 245-302.

Rudebusch, G.D. 1996. Do measures of monetary policy in a VAR make sense?. *Federal Reserve Bank of San Francisco*. Working Paper 96-05.

Rudebusch, G.D. 1998. Do Measures of Monetary Policy in a VAR Make Sense?. *International Economic Review* 39(4), 907-31.

Santomero, A.M. 1983. Controlling monetary aggregates: The discount window. *The Journal of Finance* 38(3), 827-843.

Sarno, L., & Thornton, D.L. 2003. The dynamic relationship between the federal funds rate and the Treasury bill rate: An empirical investigation. *Journal of Banking & Finance* 27(6), 1079-1110.

Schwert, G.W. 1990. Stock returns and real activity: a century of evidence. *The Journal of Finance* 45(4), 1237-1257.

SEC (The Securities and Exchange Commission). 2007. Countrywide supplements funding liquidity position. *The Securities and Exchange Commission Website*. Available from: http://www.sec.gov/Archives/edgar/data/25191/000095014807000204/v33101exv99w3.htm. [Accessed on 18th Aug 13].

Sellin, P. 2001. Monetary policy and the stock market: theory and empirical evidence. *Journal of Economic Surveys* 15(4), 491-541.

Shapiro, M., & Watson, M. 1988. Sources of business cycles fluctuations. *NBER Macroeconomics Annual 1988* (3), 111-156.

Sims, C. A. 1980. Macroeconomics and reality. *Econometrica: Journal of the Econometric Society* 48(1), 1-48.

Smales, L.A. 2012. RBA monetary policy communication: the response of Australian interest rate futures to changes in RBA monetary policy. *Pacific-Basin Journal* 20(5), 793-808

Smirlock, M.J., & Yawitz, J.B. 1985. Asset returns, discount rate changes, and market efficiency. *The Journal of Finance* 40(4), 1141-58.

Sprinkel, B. 1964. *Money and Stock Prices*. Homewood, Illinois: Richard D. Erwin.

Szczerbowicz, U. 2011. Are unconventional monetary policies effective? *Dipartimento di Economia e Finanza LUISS Guido Carli*. Working Paper 1107.

Taylor, J. B. 1995. The monetary transmission mechanism: an empirical framework. *The Journal of Economic Perspectives* 9(4), 11-26.

Taylor, J. B. 2010. Getting back on track: macroeconomic policy lessons from the financial crisis. *Federal Reserve Bank of St. Louis Review* 92(3), 165-176.

Thorbecke, W. 1997. On stock market returns and monetary policy. *The Journal of Finance* 52(2), 635-654.

Thorbecke, W., and Zhang, H. 2008. Monetary policy surprises and interest rates: choosing between the inflation-revelation and excess sensitivity hypothesis. *Research Institute of Economy, Trade and Industry (REITI)*. Discussion Paper 08016.

Thornton, D. L. 2009. The identification of the response of interest rates to monetary policy actions using market-based measures of monetary policy shocks. *Federal Reserve Bank of St. Louis*. Working Paper.

Thornton, D.L. 2012. The identification of the response of interest rates to monetary policy actions using market-based measures of monetary shocks. Federal *Reserve Bank of St.Louis*. Working Paper 2009-037B.

Tobin, J. & Brainard, W. C, J. 1968. Pitfalls in financial model building. *The American Economic Review* 58(2), 99-122.

Vasudevan, A. 2003. *Money and Banking: Select Research Papers by Economists of RBI*. Academic Foundation.

Wang, T., Yang, J., & Wu, J. 2006. Central bank communications and equity ETFs. *Journal of Futures Markets* 26(10), 959-995.

Warner, E. J., & Georges, C. 2001. The credit channel of monetary policy transmission: evidence from stock returns. *Economic Inquiry* 39(1), 74-85.

Waud, R. N. 1970. Public interpretation of Federal Reserve discount rate changes: evidence on the"announcement effect". *Econometrica* 38(2), 231-250.

Wiedmann, M. 2011. *Money, stock prices and central banks: a cointegrated var analysis*. Physica-Verlag: A Springer Company.

Williams, J. C. 2012. The Federal Reserve's Unconventional Policies. *FRBSF Economic Letter* 34, 1-9

Wongswan, J. 2009. The response of global equity indexes to US monetary policy announcements. *Journal of International Money and Finance* 28(2), 344-365.

Wright, J. H. 2011. What does monetary policy do to long-term interest rates at the zero lower bound?. *National Bureau of Economic Research*. Working Paper w17154.

Wright, J. H. 2012. What does monetary policy do to long-term interest rates at the zero lower bound?. *The Economic Journal* 122(564), F447-F466.

Zebedee, A. A., Bentzen, E., Hansen, P. R., & Lunde, A. 2008. The Greenspan years: an analysis of the magnitude and speed of the equity market response to FOMC announcements. *Financial Markets and Portfolio Management* 22(1), 3-20.

Chapter 3: The Stock Market Reaction to Federal Funds Rate Surprises: State-dependence and the Financial Crisis (Empirical Analysis)

3.1 Abstract

This chapter investigates the impact of Federal Funds rate (FFR) surprises on US stock returns over the Jun-89 to Dec-12 sample period, with a particular emphasis on the 2007-2009 crisis. In line with previous studies we find that outside the crisis stock returns increased in response to unexpected FFR cuts. The relationship was furthermore shown to be characterised by state-dependence as stock returns as stock returns yielded more amplified responses to conventional monetary policy shocks during periods of recession, bear-market conditions and tightening credit market conditions. However we demonstrate that a significant shift occurred during the 2007-2009 crisis period which changed the nature of stock returns' response to FFR shocks. We demonstrate that outside the crisis period, stock returns did not respond positively to unexpected FFR cuts and we yield some evidence which suggests stock returns actually responded negatively to these cuts. Throughout the crisis period, these cuts were interpreted by market participants as signals of worsening future economic conditions. Our results highlight the severity of the recent financial crisis and the ineffectiveness of conventional monetary policy close to the zero-lower bound.

3.2 Introduction

"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." (Buttonwood, 2010)

The 2007-2009 crisis was global in nature and of an unprecedented magnitude compared to previous episodes of financial and economic turmoil. The chair of the Federal Reserve, Ben Bernanke, characterised the period as being "*the worst financial crisis since the 1930s*" (Bernanke, 2009). For much of the crisis period (Sep-07 to Dec-08), the Fed employed conventional monetary policy measures such as target FFR changes to combat declining financial and economic conditions. As the target FFR approached the zero-lower bound in Dec-08, the Fed subsequently adopted more non-conventional measures of monetary policy such as increasing and more explicit use of forward guidance through FOMC statements and large-scale asset purchase (LSAP) programmes to influence financial, monetary and economic conditions. However, as Cenesizoglu, Larocque and Normandin

(2012) point out, whilst there is a growing empirical literature concerning the efficacy of non-conventional forms of monetary policy during the crisis period, there is a comparative dearth of studies concerning the impact of conventional monetary policy on financial markets and the broader macroeconomy. This is intriguing given that the Fed's initial response during the crisis was to employ conventional monetary policy measures (ie. target FFR changes) to combat declining financial and economic conditions, and this monetary tool was the primary policy instrument of the Fed for the majority of the financial crisis (Sep-07 to Dec-08). Motivated by this fact, in this chapter we investigate the relationship between US stock returns and FFR shocks over the Jun-89 to Dec-12 sample period, with a particular emphasis on the effect of the 2007-2009 crisis on this relationship.

In Chapter 2 we evaluated empirical studies related to this empirical chapter which investigated the relationship between stock market performance and monetary policy measures. The evolution of this empirical literature was shown to naturally reflect econometric advancements in the field and the development of alternative monetary policy indicators, and this in itself also reflected shifts in Fed operating procedures[88]. For example, when the Fed began administering monetary policy by primarily targeting the FFR in the late 1980s, this subsequently became the primary measure of conventional monetary policy in the US. Prior to the 2007-2009 crisis period, studies which investigated the relationship between stock returns and conventional monetary policy primarily employed three alternative interrelated measures for defining conventional monetary policy shocks. The first methodology employed the event-study technique of Kuttner (2001) and Bernanke and Kuttner (2005), disaggregating target FFR changes in to expected and unexpected components by gauging expectations from CBOT futures contracts tracking the underlying instrument of the effective FFR. Pre-crisis studies which measured conventional monetary policy shocks in this manner widely documented statistically significant (insignificant) stock return responses to unexpected (expected) FFR changes. They furthermore demonstrated that unexpected FFR cuts (increases) were associated with positive (negative) stock returns, and found that the relationship between US stock returns and FFR shocks was characterised by

[88] Before 1979, the Fed targeted the FFR by changing the supply of reserves to achieve defined FFR target ranges. They furthermore targeted market interest rates to influence the FFR. From 1979 to 1982, they stopped targeting the FFR and targeted levels of non-borrowed reserves to achieve target objectives for levels of money stock. From 1982 to the late 1980s, they targeted borrowed reserves (from the Fed) to a desired level. From the late 1980s to 2008, they targeted the FFR. From 2008 to present, they utilised non-conventional monetary policy measures such as forward guidance through statements and LSAP purchases. In this manner, studies which evaluated the impact of monetary policy on asset prices naturally reflected the changing operating procedure of Fed and the monetary measures they targeted over those periods respectively.

state-dependence, with a significantly larger magnitude response during periods of deteriorating financial and economic conditions (see Basistha and Kurov, 2008; Kurov, 2010; and Section 2.6).

A second approach to defining monetary policy shocks was developed by Gürkaynak, Sack and Swanson (2005). They disaggregated conventional monetary policy changes in to two components concerning a target factor and path factor. The target factor was shown to be closely associated to the unexpected FFR change measure of Kuttner (2001) whilst the path factor was shown to reflect information concerning the future trajectory of monetary policy as conveyed in FOMC statements[89]. Pre-crisis studies which measured conventional monetary policy using this approach widely documented statistically significant (insignificant) stock return responses to the target (path) factor (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). A third, less widely used methodology for measuring monetary policy shocks was developed by Rigobón and Sack (2002, 2004) and Craine and Martin (2003). These studies exploited the conditional heteroscedasticity present in higher-frequency data to define monetary policy shocks.

Nevertheless, the vast majority of these studies focused upon the pre-crisis period, and therefore an important question is raised concerning the nature of this relationship during the crisis period. It is not clear, a priori, how stock market participants may have reacted to target FFR cuts when the uncertainty in the macro-financial environment was heightened and monetary policy moved closer towards the zero-lower bound. In fact, since the onset of the crisis in late 2007, and up until early 2009, stock market participants faced falling stock prices together with sharp interest rate cuts. This implied that the classical inverse relationship between stock market performance and interest rates, as predicted by traditional asset pricing theory, may have weakened or perhaps collapsed. When this empirical chapter was originally researched and written in 2009-2010, there were only two empirical studies which investigated the relationship between US stock returns and FFR shocks over a sample period which extended several months in to the crisis (see Demiralp and Yilmaz 2009; Farka and Fleissig 2010). Although, there was a significant proliferation of studies investigating the impact of non-conventional monetary policy on financial asset prices and the broader macro-economy, there were significantly fewer studies concerning the relationship between US stock returns and conventional monetary policy shocks over the crisis period.

[89] It was furthermore shown to be associated with FOMC statements

More recently, several studies have investigated the relationship between US stock returns and FFR shocks over a sample which covers the crisis (in its entirety or in part) however the empirical conclusions from these studies are mixed and inconclusive (see Section 2.7). For example, several studies have documented statistically insignificant stock return responses to FFR shocks over the crisis period (see Gorodnichenko and Weber, 2013; Demiralp and Yilmaz, 2012) and only managed to recover statistically significant relationships using alternative model specifications[90]. Other studies have demonstrated that stock returns respond to non-conventional monetary policy measures such as increasing use of forward guidance by the FOMC and LSAP programmes (see Farka and Fleissig, 2012; Rosa, 2012; Wright, 2012). Interestingly, not one of the aforementioned studies explicitly evaluated a potential structural shift in the relationship between stock returns and *conventional* monetary policy shocks characterised by the 2007-2009 crisis period.

In this chapter we investigate the impact of FFR surprises on US stock returns over the Jun-89 to Dec-12 sample, and provide a comprehensive analysis of the global financial crisis' impact on this relationship. Our results can be summarised as follows. First, in line with previous studies, we find that outside the crisis period, stock returns increased (declined) in response to expansionary (contractionary) FFR shocks, with an unexpected 1% cut in the FFR being associated with almost a 4% increase in the S&P 500 index. We further demonstrate that the relationship between US stock returns and FFR shocks outside the crisis period was characterised by state-dependence as stock returns exhibited larger magnitude increases when unexpected FFR cuts occurred during 'bad times' of recession, bear stock markets, and tightening credit market conditions, indicating asymmetries in the stock market response to monetary policy.

Secondly, and most importantly this chapter contributes to the existing empirical literature concerning stock market performance and conventional monetary policy shocks, by providing a comprehensive analysis of the impact of FFR shocks on US stock returns over the 2007-2009 crisis period. In particular, we show that a structural break occurred during the financial crisis period which significantly altered the US stock market response to FFR

[90] In the working paper version of Demiralp and Yilmaz's (2009) study, they demonstrated that US stock returns were associated with statistically insignificant responses to FFR shocks. Only after excluding a large number of outlier observations did they recover a significant relationship. This relationship was furthermore shown to only be marginally statistically significant at the 10% level. Gorodnichenko and Yilmaz (2013) also demonstrated that US stock returns were associated with statistically insignificant responses to FFR shocks. They only managed to recover a statistically significant relationship by examining the impact of squares FFR shocks on US stock returns.

shocks, as well as the nature of state dependence with respect to 'good times' versus 'bad times'. More specifically, we find that throughout the 2007-2009 crisis, stock market participants did not respond positively to expansionary FFR shocks. In fact, some of our estimates indicate that there was a statistically significant negative stock market response to unexpected FFR cuts during the financial crisis. The lack of a positive stock return response to expansionary FFR shocks during the crisis, 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.

Finally, using data from industry portfolios, we show that patterns observed in the aggregate US stock market response to FFR surprises are also present across the majority of industrial sectors. Specifically, the relationship between industry sector returns and FFR shocks exhibits structural change during the financial crisis, as well as state dependence with respect to 'good times' versus 'bad times'. However, this relationship is shown to be characterised by significant cross sectoral heterogeneity, consistent with evidence in previous studies.

This chapter is structured as follows: in Section 3.3 we describe the dataset and sample period, in Section 3.4 we evaluate the econometric models and results, and finally in Section 3.5 we conclude the chapter.

3.3 Data and sample period

3.3.1 Measuring conventional monetary policy shocks

As Bernanke and Mihov (1998) point out, the FFR has been the key policy instrument of the Fed since the late 1980s, and therefore unexpected changes in this rate should yield good estimates of conventional monetary policy shocks. In this chapter we define conventional monetary policy shocks using the event-study technique of Kuttner (2001) and Bernanke and Kuttner (2005). This technique uses implied rates from Chicago Board of Trade 30-Day Federal Funds Futures contracts (CBOT futures) to derive expectations of target FFR changes by the FOMC. This market based measure of unexpected FFR changes is efficient in that it represents a natural proxy for the market's expectations of future FFR changes and associated forecast errors. The measure has also been shown to yield efficient and unbiased forecasts of the target FFR (see Krueger and Kuttner, 1996).

Furthermore, upon evaluating the empirical efficacy of alternative market based measures in predicting the FFR, Gürkaynak, Sack and Swanson (2002, 2007) demonstrated that FFR futures, hence Kuttner's (2001) measure dominated all other measures in predicting the FFR at one-month to six-month horizons. It was shown to yield superior forecasting power and lower risk premia relative to alternative market-based measures. All of which helps to mitigate concerns that FFR futures contracts track the underlying instrument of the effective FFR and not the target FFR. Further advantages include the fact that Kuttner's (2001) measure could be defined using higher-frequency daily data which is more likely to be exogenous and less likely to reflect other macroeconomic factors of news compared to lower frequency aggregate, weekly, monthly or quarterly data[91]. Lastly, as interest-rate futures represent the largest derivatives market in the world, this implies that the FFR futures contract is highly traded and an efficient market proxy for expectations in target FFR changes (Bank of International Settlements Website, 2013). Nevertheless, Wright (2012) argues that whilst the target FFR is a good measure of conventional monetary policy during normal times, things are "*murkier at the zero-bound*" and "*there is not as clean a single measure of the overall stance of unconventional monetary policy*." Unlike FFR futures contracts, there are no direct real time measures of market expectations of non-conventional monetary policy measures such as increasing use of forward guidance and the size of LSAP purchases. We therefore use FFR shocks as the principal explanatory term in our empirical analysis in lieu of measuring unconventional monetary policy shocks[92].

In this chapter, we consider a set of event-dates which include all scheduled FOMC meetings[93] and all unscheduled FOMC meetings with target FFR changes over the Jun-89 to Dec-12 sample period. The unexpected FFR change Δi_t^u is defined as the change in the

[91] Lower-frequency aggregate weekly, monthly and quarterly data is traditionally used in VAR models where monetary policy shocks are calculated as orthogonalised innovations in a monetary instrument, in identified systems.

[92] Rosa (2012) measures the unexpected component of LSAP purchases by constructing an indicator based upon subjective interpretations of reports from the media. However, as the study argues, this measure of unconventional monetary policy shocks is surrounded by considerable statistical uncertainty.

[93] 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/2013monetary.htm

implied rate on the current-month FFR futures contract $ff^{0}_{m,d}$ relative to the rate the day before the change $ff^{0}_{m,d-1}$. There is however a complication in deriving FFR shocks using this approach because the settlement price for CBOT futures contracts are based upon the arithmetic average of the daily effective FFR of the delivery month, including non-trading days were the previous day's price is carried over. To counteract this complication, we use Kuttner's (2001) scaling adjustment $[D / D-d]$ which is related to the number of days in the month affected by the change. However, this introduces end of month distortions, hence we use unscaled changes when target FFR changes occur in the last three days of the calendar month, and we use the last day of the previous month's FFR futures contract when the target FFR change occurs on the first day of the calendar month. This highly attenuated technique of calculating unexpected FFR changes is summarised in Equation 3.1. The expected component of target FFR changes is subsequently computed as the actual target FFR change minus the unexpected component (see Equation 3.2).

$$\Delta i^{u}_{t} = \begin{cases} \dfrac{D^{0}}{D^{0}-d^{0}}\left(ff^{0}_{m,d} - ff^{0}_{m,d-1}\right) & where...\ \left[\left(D^{0}-d^{0}\right)>2\right]\ and\ \left[d^{0}>1\right] \\ \left(ff^{1}_{m+1,d} - ff^{1}_{m+1,d-1}\right) & where...\ \left[\left(D^{0}-d^{0}\right)\leq 2\right]\ and\ \left[d^{0}>1\right], \\ \dfrac{D^{0}}{D^{0}-d^{0}}\left(ff^{0}_{m,d} - ff^{1}_{m,d}\right) & where...\ \left[\left(D^{0}-d^{0}\right)\leq 2\right]\ and\ \left[d^{0}=1\right] \end{cases} \qquad (3.1)$$

$$\Delta i^{e}_{t} = \Delta i_{t} - \Delta i^{e}_{t}, \qquad (3.2)$$

Where $ff^{0}_{m,d}$ is the implied rate (100 minus the future contract price) from the current-month FFR futures contract on month m^{0} and day d^{0} of the FOMC event-date, and D^{0} represents the number of days in the month of the FOMC event-date.

Thus so far we have only discussed the advantages of Kuttner (2001) and Bernanke and Kuttner's (2005) market-based measure of unexpected FFR changes however it is important to also acknowledge the limitations of this approach to defining conventional monetary policy shocks. Firstly, the FOMC officially began announcing target FFR changes from Feb-94, and target FFR changes prior to this date were primarily inferred from dates of open market operations by the Federal Reserve Bank of New York and subsequent media announcements. We therefore use event-dates defined by Kuttner (2003) for the Jun-89 to Feb-94 sample period. This study more precisely identifies when target FFR changes occurred using unpublished Fed manuscripts and news reports[94]. Due to the difficulty in

[94] As Bernanke and Kuttner (2005) point out, there are seven minor deviations in the timing of decisions listed in the Kuttner (2003) study. We account for such discrepancies in this study.

precisely identifying when target FFR changes occurred prior to Jun-89, our sample is ultimately constrained to this date. Without this constraint, our sample would still have been constrained to after Oct-88, as this is when CBOT FFR futures first began trading in the open market. Further limitations of this approach were also pointed out by Rudebusch (1996, 1998) who argued that the market-based measure of unexpected FFR changes may have been subject to simultaneity bias. This is because on several occasions, target FFR changes occurred on the same day as employment release reports by the Bureau of Labor Statistics, and this could have contaminated the measure. We address this concern throughout the chapter by further excluding these observations from our estimation to ensure the results are robust to such critique.

Other studies have also argued that FFR futures contracts may have been contaminated by risk-premia present in futures markets (see Chernenko, Schwartz, and Wright, 2004; Piazessi and Swanson, 2008). They demonstrated that one-month ahead FFR futures contracts exhibited three basis point risk-premia, which increased with further ahead FFR futures contracts. Whilst we acknowledge this may be the case, and FFR futures may in fact have been contaminated by time-varying risk-premia, one would be hard pressed to find a more efficient measure of expectations in target FFR changes. Several studies have sought to mitigate these concerns by using survey-data; however this measure is infrequently quoted[95] and not available at a daily frequency. Furthermore, relative to alternative market-based measures and monetary instruments, Krueger and Kuttner (1996) demonstrated that FFR futures were not as contaminated by risk-premia relative to these alternative measures. Similarly, Gürkaynak, Sack and Swanson (2002, 2007) demonstrated that FFR futures dominated all other measures in predicting FFR changes. However, one should also acknowledge that although the Fed targeted the effective FFR through open market operations, it did not entirely control the market; hence negligible discrepancies may have been present in the measure. As CBOT FFR futures track the underlying instrument of the effective FFR and not the target FFR, one must assume that the two measures are approximately equivalent to construct this measure of FFR shocks.

As we have discussed, a competing measure of conventional monetary policy shocks was constructed by Gürkaynak, Sack and Swanson (2005). They derived conventional monetary policy using the target factor, which reflected Kuttner's (2001) measure of unexpected FFR changes, and a path factor which was shown to be associated with FOMC

[95] Surveys were taken on the Friday prior to each scheduled FOMC meeting.

statements. Prior to the crisis, empirical studies widely documented statistically insignificant US stock return responses to the path factor (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). There were also mixed conclusions concerning the impact of the path factor on US stock returns over sample periods which covered part (see Kurov, 2012) or all of the crisis period (see Eijffinger, Mahieu and Raes, 2012). Given that US stock returns are widely shown to respond significantly only to unexpected FFR changes, we focus on this component of FFR shocks.

Several previous studies have also argued that the relationship between US stock returns and FFR shocks may be endogenous, as monetary policy could itself be responding to stock market developments (see Rigobon and Sack, 2003). In this chapter we use an event-study framework with higher-frequency daily data to help mitigate such concerns. Older studies used VAR frameworks to examine the potentially endogenous relationship between stock returns and monetary policy through the modelling of endogenous systems. However, the VAR approach to defining conventional monetary policy shocks has been widely critiqued by previous studies (see Rudebusch, 1998; Bredin, Hyde, Nitzsche and O'Reilly 2009)[96]. We evaluate critique of such an approach in detail in Section 2.4.3.

Lastly, several recent studies have utilised ultra-high frequency intra-day data to measure stock market responses to monetary policy shocks; evaluating responses using intervals ranging from 1-minute to 1-hour (see Farka, 2009; Gürkaynak, Sack and Swanson, 2005). This approach may mitigate concerns regarding endogenous responses to other news during the interval considered however it introduces other potential problems. Firstly, the acquisition of tick-by-tick data from private sources makes it difficult for others to replicate research[97]. Secondly, although tick-by-tick data was available from Bloomberg, the data was only available from 1997 which would have significantly constrained the sample period of this study. Thirdly, according to the Stothard (2012), automated algorithmic trading by firms accounted for 36% of all US trading volume from 2007-2011. Much of the ultra-high frequency trading data reflects automated algorithmic trading of stocks which follow defined mathematical rules, and are less likely to reflect actual investors' expectations and valuations of stocks. As Farka (2009) demonstrated (see Section 2.6.4), the magnitude of stock response to conventional monetary policy shocks increased in magnitude as the interval was increased

[96] The VAR approach to defining conventional monetary policy shocks was characterised by Bredin, Hyde, Nitzsche and O'Reilly (2009) as being rather "artificial and meaningless." Rudebusch (1998) also suggested that these measures were "structurally fragile" and "severely deficient" however made it clear that the critique did not imply that the methodology was "so deeply flawed as to be useless".

[97] Gürkaynak, Sack and Swanson (2005) acquired data from Genesis Financial Technologies

from one-minute to twenty-minutes. A similar dynamic was observed by demonstrated by Gürkaynak, Sack and Swanson (2005), as the interval was increased from 30-minutes to 1-hour. This implies that it takes time for investors to react to new information, and higher-frequency measures are more likely to reflect the evaluation of automated trading systems. Furthermore, Gürkaynak, Sack and Swanson (2005) argued that the "*average absolute difference between the daily and intra-day surprise measures is only about 2 bp and the difference is 0 bp on many days*"[98] which demonstrates that there are very minor differences in estimates using higher-frequency or daily data.

3.3.2 Descriptive statistics

The descriptive statistics in Table 3.1 show that there were 213 target FFR decisions by the Fed over the Jun-89 to Dec-12 sample period. As FOMC meetings are scheduled eight times a year, this corresponds to 189 scheduled FOMC meetings and 24 unscheduled FOMC meetings with target FFR changes. The average target FFR change is shown to range symmetrically, although non-normally from 75 basis point cut (min) to a 75 basis point increase (max), with an average target FFR change of -0.04%. There were a total of 31 decisions to increase the target FFR ($\Delta i_t > 0$) and 52 decisions to decrease the target FFR ($\Delta i_t < 0$). The FOMC decided to maintain the current target FFR on 130 occasions and such non-changes represent monetary inaction by the Fed in over half of the event-dates considered (61%). Interestingly, the unexpected component of FFR change ranges from -0.74% to +0.17% which implies that over the sample period, there were more unexpected FFR cuts than unexpected FFR increases. The null hypothesis of normal distribution is rejected across all the measures; this is a common feature of financial data.

3.3.3 Preliminary graphical analysis

In Figure 3.1 we graph target FFR changes and plot unexpected FFR changes. The shaded are corresponds to periods associated with NBER recession dates. This closely corresponds to the dotted line which is the real time recession probability from the dynamic-factor Markov-switching model of Chauvet and Piger (2008). We find that large unexpected FFR cuts typically materialise during periods of monetary expansion and periods during periods of economic deceleration and decline. In contrast, non-crisis periods are typically

---

[98] They also identified several anomalous exceptions to this.

associated with target FFR increases which are largely anticipated by market participants. In Figure 3.2 we plot the BAA-10Year US Treasury bond spread on FOMC event-dates. The shaded area corresponds to when the credit spread exceeds its historical average[99]. By comparing Figure 3.2 with Figure 3.1, periods of tighter credit market conditions typically overlap with recessionary episodes.

A similar pattern emerges in Figure 3.3 where we plot the S&P500 Index on FOMC event-dates alongside its 3-Year moving average. The highlighted periods are associated with bear-market conditions[100], when the S&P500 Index falls below its 3-Month moving average. By comparing Figure 3.3 with Figure 3.1, it is clear that periods of persistent stock market declines (bear-markets) typically coincide with recessionary episodes, as defined by the NBER. On the right-axis of Figure 3.3 we plot the Bloomberg financial conditions index on FOMC event-dates. This highlights the severity of the 2007-2009 crisis period as the financial conditions index is characterised by an unprecedented decline.

Overall several important stylised facts emerge from this preliminary analysis. Firstly, recessionary episodes, bear-markets and tightening credit market conditions are typically associated with large unexpected FFR cuts. This fact will be taken in to account in the econometric analysis as stocks may yield an alternative response to FFR cuts when there is heightened macro-financial uncertainty and when the target FFR approaches the zero-lower bound.

3.4 Econometric models and results

3.4.1 Preliminary estimates

We begin our econometric analysis by regressing S&P500 stock returns on unexpected FFR changes, on FOMC event-dates over the Jun-89 to Dec-12 sample period (see Equation 3.3). In line with previous studies, we exclude the 17th Sep 01 observation from all analyses and focus on the unexpected component of target FFR change (see Basistha and Kurov, 2008; Davig and Gerlach, 2006; Eijffinger, Mahieu and Raes, 2012; Ehrmann and

[99] The historical average is computed using all the daily observations from Jun-89 to Dec-12, as an average only on FOMC event-days would have imposed a selective bias.

[100] Although there is no commonly accepted definition of bear-market conditions in the empirical literature, we define it in line with Jansen and Tsai (2010) who characterise the periods as being associated with significant and sustained stock price declines.

Fratzscher, 2004; Farka and Fleissig, 2012; Gorodnichenko and Weber, 2013; Kurov, 2010)[101].

$$r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t \,, \qquad (3.3)$$

$$r_t = 100 * (\ln S_t - \ln S_{t-1}), \qquad (3.4)$$

Where stock returns r_t is defined as the first difference of the natural log of the S&P500 index S_t on the close of the FOMC meeting relative to that the previous trading day (Equation 3.4). The OLS estimates of Equation 3.3 with Newey-West robust standard errors are reported in Table 3.2. The full sample estimates indicate that the US stock return response to unexpected FFR changes is statistically *insignificant*[102]. This finding is in contrast with results from previous empirical studies which widely documented statistically significant responses[103].

To understand why we find a statistically insignificant result, in Table 3.2 we re-estimate Equation 3.3 utilising sample periods employed in previous studies which do not include the recent 2007-2009 financial crisis and recession. Interestingly across all nine studies, we find that the stock return response to FFR shocks is statistically *significant*[104]. For example, utilising the sample period of Bernanke and Kuttner (2005), from Jun-89 to Dec-02, the β_2 coefficient is negative and statistically significant. This implies that a hypothetical

[101] The 17th Sep 01 was excluded from analyses by these studies because this target FFR decision was taken on the first day of trading following the 11th Sep 01 attacks, and markets may have responded to the unorthodox nature of the target FFR change, the backlog of trading activity as well as the attacks themselves. Market efficiency arguments imply that the anticipated component of conventional monetary policy action may already have been priced in to stocks and incorporated in to market participants' investment decisions, in line with these studies, we focus upon the unexpected component of target FFR changes. We also experiment with alternative model specifications which include both expected and unexpected FFR changes, in line with Bernanke and Kuttner (2005), however find that the expected component tended to remain statistically insignificant in the baseline regression and many of the subsequent models estimated throughout this chapter. The finding of statistical insignificance was interpreted as being indicative of stock market efficiency (Chulia, Martens and Dijk, 2010).

[102] Similar evidence is obtained when FOMC meetings coinciding with employment release dates and unscheduled meetings are removed from the sample. Furthermore, we remove 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 A3.1 in the Appendix. Table A3.2 in the Appendix presents the dates associated with unscheduled meetings, employment information releases and outliers.

[103] With the exception of Gorodnichenko and Weber (2013) which was available online following our paper version of this chapter (see Kontonikas, MacDonald and Saggu, 2013).

[104] It is important to note that the estimates in Table 3.2 and Table 3.3 using alternative sample periods are very similar, but not always identical to those reported in those studies. The differences can be attributed to the wide spectrum of model specifications considered by these studies. These include the inclusion (or not) of expected FFR changes, the inclusion (or not) of unscheduled FOMC meetings, the inclusion (or not) of event-dates which coincided with employment reports, and the use of daily (or intraday) data.

unexpected 1% FFR cut is associated with a 4.22% increase in US stock returns. Hence it appears that the inclusion of the 2007-2009 financial crisis in our sample period renders the relationship between US stock returns and FFR shocks statistically insignificant. This evidence is consistent with empirical evidence concerning the UK stock market response to monetary policy shocks by the Bank of England (see Gregoriou, Kontonikas, MacDonald and Montagnoli, 2009).

Over the course of writing this PhD thesis (2009 to 2013), several studies emerged which evaluated the US stock return response to FFR shocks over a sample period which covered the 2007-2009 in part or in its entirety. In Table 3.3 we re-estimate Equation 3.3 using the sample periods considered in these very recent studies. We find that the stock return response to unexpected FFR changes is statistically *insignificant* in each case. This demonstrates that the relationship between US stock returns and FFR shocks may have changed during the recent financial crisis.

3.4.2 Dating the 2007-2009 crisis (Exogenous)

In the previous section we demonstrated that the US stock return response to FFR shocks was statistically *significant* over sample periods which did not extend beyond the 2007 period however extending the sample beyond 2007 rendered the relationship statistically *insignificant*. As the major part of the 2007-2012 sample period was characterised by the recent financial crisis, this implies that the relationship between US stock returns and FFR shocks may have been affected by the crisis. In this section we formally examine whether the statistically *insignificant* US stock return response to FFR shocks over the Jun-89 to Dec-12 sample period can be explained in terms of structural change attributable to the impact of the recent financial crisis.

It is important to note that there is some contention over the precise dating of the 2007-2009 crisis period, and this contention primarily stems from the disparity between the actual realisation of a crisis in financial markets and the lagged response of the broader macroeconomy. In Section 2.7.1 we carefully outlined the distinction between the *financial crisis* and the *economic crisis* which followed it[105]. The NBER defined the *economic crisis* associated with the 2007-2009 crisis as spanning the Dec-07 to Jun-09 sample period and in this chapter we define the *financial crisis* as spanning the Sep-07 to Mar-09 sample. Dating the start of the *financial crisis* to September 2007 is motivated by several defining factors.

[105] In lieu of repeating this discussion, we briefly evaluate the conclusions.

Firstly it corresponds to the first target FFR cut (50 basis points cut) by the FOMC since Jun-03. As the Fed has access to private databases and sources of information concerning the wider macroeconomy beyond the casual investor, this target FFR decision implicitly represents an acknowledgement by the Fed of deteriorating financial conditions, and thereby conveys important information concerning the future financial and economic outlook to market participants.

September 2007 also characterised by the first bank run in the United Kingdom for 150 years at the British Bank Northern Rock. It was also marked by the highest LIBOR rate (6.7975%) since Dec-98, indicative of severely tightening credit market conditions and declining confidence in the banking sector due to counterparty risk. We date the end of the financial crisis period in Mar-09, when the most intense phase of the crisis in financial markets came to an end and the stock market began to recover. This month marks the lowest level of the S&P500 Index over the entire crisis period, after which the US stock market significantly recovered until the end of our sample in Dec-12. In Figure 3.3 we graph the S&P500 Index and the target FFR level. This shows that stock market participants faced falling stock prices in tandem with sharp target FFR cuts over the Sep-07 to Mar-09 period.

The dating of the *financial crisis* to the Sep-07 to Mar-09 sample is also shown to be consistent with market indicators such as the TED spread which soared throughout the crisis period[106]. In Figure 3.5 we plot the TED spread on FOMC event-dates over the Jun-89 to Dec-12 sample period. The shaded area corresponds to periods where the TED spread exceeds its historical average by a factor of two; indicative of severe interbank pressures. It also precisely spans the Sep-07 to Mar-09 period, consistent with our definition of the financial crisis[107]. Our dating of the financial crisis to this period is also consistent with previous studies (see Cornett, McNutt, Strahan and Tehranian, 2011; Kacperczyk and Schnabl, 2010).

3.4.3 Dating the 2007-2009 crisis (Endogenous)

Having exogenously defined the *financial crisis* using a subjective interpretation of events which transpired during the crisis period, we continue by formally evaluating whether there is potentially significant structural change in the relationship between US stock returns

[106] The TED spread measures the difference between the 3-month LIBOR and the 3-month Treasury bill rate.
[107] The historical average is computed using all the daily observations from Jun-89 to Dec-12, as an average only on FOMC event-days would have imposed a selective bias.

and unexpected FFR changes. In particular, we use the Quandt-Andrews unknown breakpoint test (Andrews, 1993), the endogenously determined structural breakpoint tests of Bai and Perron (1998), and rolling regressions. Firstly, we begin by testing for parameter stability in Equation 3.3 using the Quandt-Andrews test for structural breaks which performs a Chow breakpoint test[108] at every observation between two dates π_1 and π_2 (see Table 3.4). The test statistics (max LR F-stat, Exp LR F-Stat, Average LR F-Stat)[109] all indicate that the null hypothesis of no structural breaks is rejected at the 1% level. The estimated breakpoint identified on 22nd Jan 08, is determined by the largest of the F-stats[110].

Secondly, we follow the methodology of Bai and Perron (1998) to endogenously identify structural breakpoints in Equation 3.3. In Table 3.5 we report test statistics for the Sequentially Determined $L+1$ versus L Test for Structural Breaks (Panel A), the Global L Breaks versus None Test for Structural Breaks (Panel B), and the Global Information Criteria Test for Structural Breaks (Panel C). In Panel A, we reject the null hypothesis of 0 and 1 breakpoints in favour of the alternative 1 and 2 breakpoints using the F-Stat and Scaled F-Stat criteria. This corresponds to the 15th Oct 98 and 22nd Jan 08 break-dates using the Sequential F-Stat Criteria[111]. In Panel B, the sequential procedure identifies five break-dates by testing from 1 to 5 potential breakpoints until the null is no longer rejected[112] however the $UD_{\max}$ and $WD_{\max}$ statistics select three break-dates. These correspond to the 15th Oct 98, 6th Nov 02, and 16th Dec 08 break-dates using the maximised unweighted and weighted statistics. In Panel C, the Global Information Criteria and Schwartz Criterion select 2 break-dates. These

---

[108] The Chow test divides a sample, and estimates two regressions then calculates whether there is a statistically different change between the two.

[109] The Max LR F-Stat is the largest F-stat from amongst the Chow breakpoint tests $MaxF = \max_{\pi_1 \le \pi \le \pi_2} \left(F(\pi)\right)$. The Exp LR F-Stat is $ExpF = \ln\left(\frac{1}{k}\sum_{\pi=\pi_1}^{\pi_2} \exp\left(0.5\left(F(\pi)\right)\right)\right)$. The Average LR F-Stat is the average of the F-Stats, $AveF = \frac{1}{k}\sum_{\pi=\pi_1}^{\pi_2} F(\pi)$ (see Andrews, 1993).

[110] The same breakpoint is identified using 5%, 10% and 15% trimming percentages and the null hypothesis of no breakpoints is rejected in each case.

[111] For all three Bai-Perron tests, we use a trimming percentage of 15% however the results were robust to the use of 10% and 5% trimming percentages. Results for the Sequentially Determined $L+1$ versus L Test for Structural Breaks were also to robust to using the sequential procedure and repartition procedure. We also allow the error distributions to differ across breaks, thereby allowing for error heterogeneity in the Sequentially Determined $L+1$ versus L Test and the Global Information Criteria Test for structural breaks. These results were however also robust to not allowing error distributions to differ across breaks.

[112] The identified breakpoints are: 18th Nov 92, 13th Nov 96, 22nd Aug 00, 16th Mar 04, 16th Dec 08.

correspond to the 15th Oct 98 and 22nd Jan 08 break-dates. Across all three Bai and Perron (1998) tests, we find that the 22nd Jan 08 event-date is a major break-date. This is also consistent with the Quandt-Andrews test for structural breaks.

Finally in Figure 3.6 we show the unexpected FFR change coefficient from a rolling regression of Equation 3.3 which is estimated using OLS with Newey-West robust standard errors on FOMC event-dates over the Jun-89 to Dec-12 sample period. We also plot the 95% confidence intervals. In Panel A we use a 60 observation rolling window and in Panel B we use an 80 observation rolling window. Both graphs are very similar and identify an abrupt shift in the relationship between US stock returns and FFR shocks on the 22nd Jan 08.

We previously defined the *financial crisis* associated with the 2007-2009 crisis period as spanning the Sep-07 to Mar-09 sample period. This dating scheme was supported by narrative evidence concerning the events which transpired during the period, and furthermore found it to be consistent with the Ted spread, a gauge of interbank pressures. In a similar vein, the structural breaks tests located a highly significant structural break in stock return response to unexpected FFR changes, on the 22nd Jan 08. This evidence indicates that there was an abrupt shift in the stock market reaction to conventional monetary policy. This may help to explain why the stock return response to unexpected FFR changes was rendered statistically *insignificant* upon inclusion of the crisis period. It also implies that the 2007-2009 crisis period was characterised by a very different market response to such shocks than that observed prior to the crisis period.

3.4.4 Structural change during the 2007-2009 crisis

Having identified a highly significant structural break in the relationship between stock returns and FFR shocks, characterised by the 2007-2009 crisis period, we augment our model to account for such structural change during the period. In particular we interact FFR shocks with a crisis dummy variable D_t^{crisis} equal to one during the crisis and zero otherwise (see Equation 3.5).

$$r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t, \tag{3.5}$$

In Section 3.4.1, we defined the *financial crisis* as spanning the Sep-07 to Mar-09 sample period, hence we set the crisis dummy variable equal to one throughout this period and zero otherwise. Given that this measure of the financial crisis was exogenously defined using a subjective interpretation of events which transpired during the 2007-2009 crisis period, we refer to this measure as the *exogenous crisis* period. To ensure our estimates are not sensitive to the definition of the crisis period considered, for robustness, we also consider an alternative definition of the crisis as spanning the Jan-08 to Mar-09 period. This empirically motivated measure of the crisis period is guided by evidence from endogenously determined tests for structural breaks; hence we refer to this measure as the *endogenous crisis* period (see Section 3.4.2). In Table 3.6, we report OLS estimates of Equation (3.5) with heteroscedasticity and autocorrelation consistent standard errors, over the Jun-89 to Dec-12 sample period. In Panel A we present an estimate using the *exogenous* crisis and *endogenous* crisis definitions; and considering all FOMC event-dates excluding the 17th Sep 01 observation. In Panel B, we repeat the estimation by further excluding event-dates associated with employment report releases by the Bureau of Labor Statistics. In Panel C, we once again repeat the estimation by further excluding event-dates associated with unscheduled FOMC meetings.

Prior to evaluating the estimates, we briefly outline the manner in which results are interpreted. When the crisis dummy variable D_t^{crisis} is set equal to one during the Sep-07 to Mar-09 period, in line with the *exogenous crisis* definition; the β_2 coefficient measures the stock response to unexpected FFR changes during this measure of the crisis period. However the β_1 coefficient measures the stock response *outside the crisis* period; from Jun-89 to Aug-07 and from Apr-08 to Dec-12. We cannot refer to this period as reflecting the pre-crisis period, because it also reflects part of the post-crisis period in the sample. Similarly, the β_2 coefficient measures the stock response during the Jan-08 to Mar-09 period when using the *endogenous crisis* definition, while the β_1 coefficient measures the response *outside the crisis* period from Jun-89 to Dec-07 and Apr-08 to Dec-12.

Upon accounting for structural change attributable to the crisis period, the adjusted R^2 statistic increases from 2% in Table 3.2 (without the structural break) to 6-7% in Table 3.6 Panel A (with the structural break). Importantly, whilst we previously documented a statistically *insignificant* stock return response to unexpected FFR changes over the Jun-89 to Dec-12 sample period in Table 3.3 (without the structural break); upon inclusion of the structural break in Table 3.6 Panel A, we now document a negative and highly *significant* response *outside the crisis* period. In particular, the β_1 coefficient indicates that an hypothetical unexpected 1% target FFR cut is associated with a roughly 4% increase in the S&P500 index[113]. This estimate is robust to both the endogenous and exogenous definitions

[113] Sep-07 to Mar-09: $-3.73 * -0.25\% = 0.93\%$, Jan-08 to Mar-09: $-3.98 * -0.25\% = 1.00\%$.

of the crisis period, and is furthermore consistent with previous studies which evaluated stock responses to FFR shocks over sample periods which did not extend in to or beyond the 2007-2009 crisis period (see Bernanke and Kuttner, 2005). It also implies that unexpected interest rate easing *outside the crisis* period is interpreted as a good signal by stock market participants. However, we contribute to the existing literature by demonstrating that the stock response to FFR shocks ceases to be negative during the crisis period, as shown by the β_2 coefficient. Interestingly, it is positive and *insignificant* (*significant*) when using the *exogenous* (*endogenous*) definition of the crisis period. The Wald tests also reject the null hypothesis of equality of coefficients $\beta_1 = \beta_2$, thereby supporting the hypothesis that there is a significant shift in the relationship between stock returns and FFR shocks due to the 2007-2009 crisis period. We undertake two robustness checks for these estimates.

Firstly we exclude event-dates associated with employment release reports by the Bureau of Labor Statistics. This is motivated by the fact that on eight occasions between 1989 and 1992, target FFR decisions occurred several hours following the release of these reports. To mitigate Rudebusch's (1996, 1998) concerns that this may have imposed simultaneity bias upon estimation, in Panel B we re-estimate Equation 3.5 excluding these event-dates from our model. The evidence in Table 3.6 Panel B is very similar to that in Panel A which includes all FOMC meeting, identifying a negative and statistically *significant* impact of unexpected FFR shocks on stock returns *outside the crisis*. This is followed by either an *insignificant* or positive and *significant* response during the crisis, contingent upon the definition of the crisis dummy. Similarly, the Wald tests fail to reject the null hypothesis of equality of coefficients, implying that there is a statistically significant change during the crisis and *outside the crisis* period.

Secondly, we evaluate whether the model specification behaves in a similar manner to that observed in previous studies. Basistha and Kurov (2008) had previously demonstrated that the stock response to unexpected FFR changes declined from statistical significance to statistical insignificance upon excluding observations associated with unscheduled FOMC event-dates. This implied that unscheduled FOMC event-dates contained important information concerning unexpected FFR changes for market participants. Given that unscheduled FOMC event-dates by their very nature largely unanticipated, they are more likely to contain important information concerning unexpected FFR changes than scheduled FOMC event-dates. In Table 3.6 Panel C, we re-estimate Equation 3.5 excluding event-dates associated with employment release dates and unscheduled FOMC target FFR changes.

Consistent with this evidence, the stock response to unexpected FFR changes declines in to statistical insignificance *outside the crisis* period and the Wald tests fail to reject the null of equality of equality of coefficients during the crisis and outside the crisis period. This implies that unscheduled FOMC meetings with target FFR changes contain an important source of information concerning unexpected FFR changes for market participants both during the crisis and *outside the crisis*.

3.4.5 Robust MM-estimator weighted least squares

Traditional ordinary least squares estimation, which we have thus so far used in this chapter, can be highly sensitive to the presence of potential outliers in a dataset. This can lead to unreliable coefficient estimates which may not accurately characterise the relationship between stock returns and FFR shocks. As Edgeworth (1887) argues, in the presence of outliers, the most objectionable feature of classical OLS estimation is the calculation of squared residuals which attributes disproportionately high importance to outlier observations with larger residuals. This bias towards outlier observations can lead to distortions in the generation of coefficient estimates due to the potential influence of vertical outliers and bad leverage point outliers in a dataset. In this chapter, we employ recent technical innovations in econometric analysis to model the relationship between stock returns and FFR shocks in the presence of potential outlier observations. More specifically we use the robust MM-Estimator weighted least squares methodology of Yohai (1987). This approach has been shown to be highly robust towards outlier observations, demonstrated to have a high-breakdown point and exhibit high Gaussian efficiency compared to OLS estimation (Verardi and Croux, 2010). The MM-Estimator procedure combines S-Estimation and M-Estimation and is therefore addresses outliers in both the dependent and independent variables. It is computed using iteratively re-weighted least squares estimation.

Given that previous studies demonstrated the relationship between stock returns and unexpected FFR changes was characterised by outlier observations (see Bernanke and Kuttner, 2005; Chulia, Martens and Dijk, 2010), it is unsurprising that we also identified outlier observations in Equation 3.3 using the DFITS diagnostic test for detecting outliers (see Table A3.1 and Table A3.2). In Table 3.7 we report robust MM-Estimator weighted least squares estimates of Equation 3.5 using the methodology of Yohai (1987)[114]. The main

[114] The MM-Estimates procedure begins by computing S-Estimation and uses the scale estimates as the initial starting point for the M-Estimation. Throughout this chapter, we use a tuning value of 2.937 in the S-Estimator

difference between the OLS and MM-Estimator results is that in the latter, the β_2 coefficient, which measures the stock return response to unexpected FFR changes during the crisis period, is statistically *significant*, regardless of the *exogenous* and *endogenous* dating of the 2007-2009 crisis period. The positivity of this coefficient is contrary to that observed in previous studies, and indicates that during the crisis period, unexpected FFR cuts were perceived as bad news by stock market investors. This signifies a radical shift in the perception of market participants to unexpected FFR cuts during the crisis compared to that *outside the crisis* period. In particular, an unexpected -0.50% FFR cut during the crisis period is associated with a roughly 1.05% decrease in the S&P500 index. Furthermore, the β_2 coefficient, which measures the stock response to FFR shocks *outside the crisis* period, is more muted in magnitude compared to that using OLS. An unexpected 0.50% FFR shock is associated with a roughly 0.88% increase in the S&P500 index. The magnitude of this response is consistent with Bernanke and Kuttner (2005) who also measured a more muted coefficient upon accounting for outlier observations[115]. Interestingly, the stock response to FFR shocks both during the crisis and outside the crisis are of a very similar magnitude, however the direction of response has changed.

In line with the previous table, we undertake robustness checks by excluding event-dates associated with employment release reports. The estimates in Table 3.7 Panel B are very similar to those when considering all event-dates; hence the estimates are robust towards the argument that estimates may be influenced by employment reports. The Wald tests for equality of coefficients $\beta_1 = \beta_2$ are also rejected in all panels at the 1% level. This implies that there is a highly significant structural change in the relationship between stock returns and conventional monetary policy during the 2007-2009 crisis period. Lastly, the estimates in Panel C are consistent with the argument that upon excluding unscheduled FOMC meetings from estimation, the model deteriorates significantly (see Basistha and Kurov, 2008 and Bernanke and Kuttner, 2005). Our estimates are highly robust towards these various model specifications. These estimates demonstrate the inability of the Fed to boost stock prices using conventional monetary policy via target FFR cuts during the 2007-2009 crisis period. It highlights the severity of the recent financial turmoil and reveals the limits of conventional

for a breakdown of 0.25, a tuning of 3.44 in the M-Estimator for relative efficiency of 0.85, and a Bisquare weighting function.

[115] Bernanke and Kuttner (2005) measured a coefficient of -2.55 upon accounting for outlier observations, however their study differed in that they excluded outlier observations in lieu of using MM-estimator regressions.

monetary policy close to the zero-lower bound.

3.4.6 State-dependence and the financial crisis

The estimates in the previous section indicate that unexpected FFR cuts had a negative effect on stock returns during the 2007-2009 crisis period. This may appear to be a surprising result when seen in the context of previous studies which widely documented positive stock responses to unexpected FFR cuts and when reconciling with classical asset pricing theory which purports positive stock responses to interest rate cuts. However it is important to recognise that the 2007-2009 crisis period was of an unprecedented magnitude compared to previous episodes of financial and economic turmoil, and conventional monetary policy was operating close to the zero-lower bound. Bernanke himself commented that "*the world is suffering through the worst financial crisis since the 1930s, a crisis that has precipitated a sharp downturn in the global economy*" (Bernanke, 2009).

As we previously discussed, studies whose sample periods did not extend in to or beyond the 2007-2009 crisis period widely documented a state dependent response of stock returns to unexpected FFR changes (see Basistha and Kurov, 2008; Kurov, 2010; Davig and Gerlach, 2006; Chen, 2007). These studies typically identified a stronger stock market rebound when unexpected FFR cuts coincided with *bad times*, such as periods of negative economic growth, bear stock markets and periods of tightening credit market conditions compared to periods of *good times*, such as positive economic growth, bull stock markets and periods of looser credit market conditions. Given that the 2007-2009 crisis period was also characterised by a significant decline in credit, a deterioration of credit market conditions and a major recession, in light of these studies one would have expected a strongly positive stock return response to unexpected FFR cuts during the crisis. However, as we saw in Tables 3.9 and 9, the stock return response to FFR shocks was statistically insignificant or positive and statistically significant, in contrast to that one would have expected in light of previous empirical evidence. This implies that an important structural shift has taken place in the nature of state-dependence which characterises the stock market response to conventional monetary policy shocks.

In this sub-section, we investigate whether the 2007-2009 crisis period was characterised by state-dependence akin to that observed in the pre-crisis period. However prior to evaluating such a hypothesis, we constrain the sample period to the Jun-89 to Aug-07 sample period to ensure we obtain estimates consistent with previous studies concerning the pre-crisis period, then subsequently augment the estimation and extend the sample period to the end of Dec-12 to evaluate whether the nature of state dependence changed during the crisis period.

More specifically, we estimate Equation 3.6 which includes a slope interactive variable D_t^{state} which intends to capture state-dependence[116] in the relationship between stock returns and unexpected FFR changes with respect to *good times* versus *bad times* as defined above.

$$r_t = \alpha + \left[\beta_1\left(1 - D_t^{state}\right) + \beta_2\left(D_t^{state}\right)\right]\Delta i_t^u + \varepsilon_t, \qquad (3.6)$$

Where D_t^{state} is defined as follows: (a) the real time recession probability indicator of Chauvet and Piger (2008) which is estimated using a dynamic factor Markov-switching model, (b) a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, (c) a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. These measures capture state dependence with regards to (a) recessionary and non-recessionary periods, (b) tightening credit market conditions and higher credit risk versus looser credit market conditions and lower credit risk, (c) bear-market conditions versus bull-market conditions[117].

We present MM-Estimator weighted least squares of Equation 3.6 over the Jun-89 to Aug-07 sample period in Table 3.8. In line with studies which evaluated stock return

[116] In this chapter we define state-dependent regimes exogenously using pre-defined variables. We differentiate between two-states in each case; (a) bear and bull market states, (b) recessionary and non-recessionary states, (c) tightening and loosing credit market conditions states. The two exogenously defined states in each case are referred to as ‘state-dependence’ throughout the chapter. Previous studies in this field have typically defined state-dependent regimes using this approach (see Basistha and Kurov, 2008; Kurov, 2010). It is important to recognise that this significantly differs from Heckman (1981) and Wooldridge’s (2005) definition of ‘true structural state dependence’ which refers to a condition whereby an individual’s state observed in a previous period increases the likelihood of being in that state in a another period. This type of true structural state dependence may also be time invariant and unobservable, in which case it is defined as spurious as the persistence is not contingent upon a previous period. An alternative approach to exogenously defining state-dependent regimes would be to employ a Markov-switching model which allows the relationship to endogenously differ between several regimes in a sample. The unobserved state variable would thereby be governed by a two-state Markov chain, allowing the variance to endogenously differ between two regimes. This empirical approach was employed by Davig and Gerlach (2006) and has empirical advantages in that the state variable is not exogenously defined, however the identified regimes can often be difficult to interpret and rationalise (see Section 2.6.3). By exogenously defining the state-dependent regimes, as in this chapter, there is greater clarity in the interpretation of empirical results.

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

responses to FFR shocks over sample periods which did not extend in to or beyond the 2007-2009 crisis period, across all three panels, the impact of unexpected FFR changes is more amplified during periods of (a) recession, (b) tightening credit market conditions and (c) bear-market conditions. More specifically the stock market response to FFR shocks during *bad times*, as shown by the β_2 coefficient, is statistically significant and larger in magnitude compared to that during periods of *good times*, as shown by the β_1 coefficient. It is however important to note that the estimate of (a) probability of recession in Table 3.8 Panel A in this relationship is shown to be affected by event-dates which coincided with employment release reports, and upon excluding such event-dates in Panel B, estimates consistent with previous studies were obtained. Due to this concern, we focus upon estimates in Panel B.

Upon excluding event-dates associated with employment releases, the estimates in Table 3.8 Panel B indicate that an unexpected -0.50% FFR cut during is associated with a 7.12%[118] increase in the S&P500 index when the probability of recession is one while the corresponding increase was much smaller, a 1.47%[119] response when the probability of recession is zero. Similarly, a -0.50% FFR shock induces a stock return response of 4.00%[120] during bear-market regimes compared to a more muted 1.05%[121] response during bull-market regimes. Furthermore, the Wald test for equality of coefficients across *good times* versus *bad times* $\beta_1 = \beta_2$ is rejected at a 1% level in the panel. Thus, we can confirm that our estimates concerning the state-dependent relationship between stock returns and FFR shocks are consistent with pre-crisis studies, and in line with the credit channel of monetary policy transmission.

To investigate whether the 2007-2009 crisis period was characterised by state-dependence akin to that observed in the pre-crisis period, we estimate Equation 3.7 which interacts unexpected FFR changes with both the state-dependence variable D_t^{state} and the crisis dummy variable D_t^{crisis}.

$$r_t = \alpha + \begin{bmatrix} \beta_1\left(1 - D_t^{crisis}\right)\left(1 - D_t^{state}\right) + \beta_2\left(1 - D_t^{crisis}\right)D_t^{state} \\ + \beta_3 D_t^{crisis}\left(1 - D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state} \end{bmatrix} \Delta i_t^u + \varepsilon_t, \quad (3.7)$$

The MM-weighted least squares estimates of Equation 3.7 over the Jun-89 to Dec-12 sample period are presented in Table 3.9. In line with estimates in Table 3.8, *outside the*

---

118 $-14.03 * -0.50\% = 7.12\%$

119 $-2.93 * -0.50\% = 1.47\%$

120 $-8.01 * -0.50\% = 4.01\%$

121 $-2.10 * -0.50\% = 1.05\%$

crisis period, the stock response to FFR shocks during *bad times* β_2 dominates its *good times* β_1 counterpart. The magnitude and significances of these two coefficients are very similar to those observed for pre-crisis estimates in Table 3.8; akin to which the (a) probability of recession estimate in Panel A is shown to be affected by event-dates with employment release reports. In Table 3.9 Panel B, the finding of state-dependence outside the crisis period for *good times* versus *bad times* is confirmed by Wald tests $\beta_1 = \beta_2$ which reject the null hypothesis of equality at the 1% level. The stock response to FFR shocks is shown to be significant and more amplified in magnitude during bad times, as shown by the β_2 coefficient, compared to that during bad times, as shown by the β_1 coefficient. These estimates are consistent with pre-crisis studies concerning the state-dependent relationship between stock returns and FFR shocks. It also reinforces the idea that unexpected FFR shocks were seen as good news by stock market participants during periods of periods of (a) recession, (b) tightening credit market conditions and (c) bear-market conditions.

Nonetheless, an important structural shift in the relationship between stock returns and FFR shocks occurred during the 2007-2009 crisis period. Interestingly, the β_4 coefficient which measures the stock response to unexpected FFR cuts during *bad times* in the 2007-2009 crisis period is positive and significant in all three panels. An unexpected -0.50% FFR cut during this period was associated with an -11.33%[122] decrease in the S&P500 index when the probability of recession was equal to one, compared to a 7.27%[123] increase during *bad times outside the crisis* period as shown by the β_2 coefficient. Similarly during *bad times*, an unexpected -0.50% FFR cut was associated with a -1.21%[124] decrease in the S&P500 index during the crisis period, compared to a 4.72%[125] increase *outside the crisis* period.

The positivity and statistical significance of the β_4 coefficient is consistent with empirical evidence in Tables 3.6 and 3.7 where we estimated the stock return response to unexpected FFR changes during the crisis and *outside the crisis* period without considering potential a state-dependent relationship. It also reveals that during *bad times* throughout the 2007-2009 crisis period, unexpected FFR cuts were associated with negative stock market responses due the sharply deteriorating macro-financial environment. These estimates are

[122] $22.65 * -0.50\% = -11.33\%$
[123] $-14.53 * -0.50\% = 7.27\%$
[124] $2.41 * -0.50\% = -1.21\%$
[125] $-9.44 * -0.50\% = 4.72\%$

consistent across the three panels, and robust towards the exclusion of event-dates associated with employment reports, and interestingly also robust towards the exclusion of unscheduled FOMC event-dates[126]. Furthermore, the Wald test for equality of coefficients during *bad times*, *outside the crisis* and during the crisis $\beta_2 = \beta_4$ is rejected at the 1% level for all estimates in all three panels.

3.4.7 Evidence from industrial sectors

The empirical analysis thus so far has focused primarily on the relationship between conventional monetary policy shocks and broad stock market index returns, the S&P500 index. We continue our analysis by disaggregating the broad stock market index in to ten industry sectors to investigate their responses to conventional monetary policy shocks. We begin by estimating Equation 3.6 repeatedly using returns from Fama-French industry portfolios as the independent variable in each case, using MM-Estimator weighted least squares estimates. We focus upon these industry sectors to retain comparability with estimates by Bernanke and Kuttner (2005).

The estimates in Table 3.10 Panel A demonstrate that there is significant heterogeneity in the responses of different industry sector returns to FFR shocks both outside the crisis and throughout the crisis period. As Ehrmann and Fratzscher (2004) point out, the impact of conventional monetary policy on industry sectors is likely to be highly heterogeneous due to a combination of factors. Firstly, FFR shocks influence exchange rates and thereby tradable goods industries which are open to trade are more likely to be affected. Secondly, industries which produce goods and services with highly cyclical demand or interest rate sensitive demand are more likely to have revisions in their future expected cash flows due to target FFR changes. This implies that industries are likely to differ significantly in their responses to unexpected FFR changes, as demonstrated in Table 3.10 Panel A.

Nevertheless, with the exception of shops, the remaining nine industries exhibit statistically significant responses to unexpected FFR changes either outside the crisis, during the crisis or during both periods. Notably, across both periods, telecommunications and

[126] 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. Furthermore, the standard error of β_3 is relatively large and this may be due to the limited number of related observations.

healthcare are significantly affected. We find that outside the crisis period, telecommunications and durables (energy) industries were most (least) affected. This is consistent with previous studies (see Bernanke and Kuttner, 2005; Ehrmann and Fratzscher, 2004; Basistha and Kurov, 2008) which demonstrated that the response of cyclical industries such as telecommunications and technology have a higher interest rate sensitivity to FFR shocks compared to less cyclical industries such as utilities and energy.

In line with estimates concerning the broad stock market, the S&P500 index, the coefficient outside the crisis period is negative where statistically significant, shown by the β_1 coefficient, whilst positive where statistically significant during the crisis period, shown by the β_2 coefficient. The Wald tests for equality of coefficient outside the crisis and during the crisis is rejected at the 10% level for all but the shops industry sector $\beta_1 = \beta_2$. This once again implies a highly significant structural change in the relationship between industry returns and FFR shocks over the 2007-2009 crisis period. Furthermore, upon excluding event-dates associated with employment release reports, the estimates remain very similar where statistically significant (see Table 3.10 Panel B).

It is thus apparent that the industrial sector response to FFR shocks was significantly affected by the 2007-2009 crisis period, akin to that observed for the broad stock market index, the S&P500 index. Stock returns responded positively to unexpected FFR cuts *outside the crisis period*, and negatively throughout the crisis period; albeit in a heterogeneous manner akin to that observed across industrial sectors in pre-crisis studies. We finally conclude this chapter by investigating whether the relationship between industrial sector returns and unexpected FFR changes is characterised by state-dependence outside the crisis and during the crisis period akin to that observed for the broad stock market.

We present MM-weighted least squares estimates of Equation 3.7 using industrial sector returns as the dependent variable in Tables 3.11 and 3.12. The state-dependence variables are measured in line with Tables 3.9; however due to the size of the expanded tables, we consider tightening versus loosening credit market conditions in Table 3.11 and bear-market versus bull-market conditions in Table 3.12. Overall, the estimates are consistent with those concerning the broad stock market index in Table 3.9. The estimates in Table 3.11 demonstrate that the industrial sector response to FFR shocks is characterised by state-dependence both *outside the crisis*, and *during the crisis* period. In particular, *outside the crisis* period, the impact is more negative and significant during periods of tighter credit market conditions β_2 compared to periods of looser credit market conditions β_1. More specifically, the response is statistically *insignificant* across all ten industry sectors during periods of looser credit market conditions. However during periods of tightening credit market conditions the response is negative and *significant* for all but the energy sector. Nevertheless, the response during tightening credit market conditions is characterised by heterogeneity across industrial sectors. The most affected industries include durables, high-tech and telecoms industries whilst the least affected include energy and utilities industries. This is consistent with evidence from pre-crisis studies which demonstrated that cyclical industries exhibited higher interest rate sensitivity to FFR shocks compared to less cyclical industries. The Wald test for equality of coefficients $\beta_1 = \beta_2$ is rejected at the 10% level for all but the energy and utilities sectors, implying that outside the crisis period, the relationship between industrial sector returns is characterised by state-dependence.

In agreement with estimates throughout this chapter, we find that industrial sectors responded negatively to unexpected FFR cuts throughout the 2007-2009 crisis period. The β_4 coefficient measures the response during periods of tightening credit market conditions throughout the crisis period, and is *positive* and statistically significant in seven industrial sectors. Interestingly, the energy sector and durables sectors yielded the largest magnitude responses. Furthermore, the Wald test for equality of coefficients $\beta_2 = \beta_4$ is rejected at the 1% level for all industrial sectors, indicating that there was a statistically significantly different response of industrial sector returns to FFR shocks during periods of tightening credit market conditions *outside the crisis* and *during the crisis* period. We tests the robustness of estimates in Table 3.14 by re-estimating the models with event-dates associated with employment release reports excluded from estimation. These estimates are presented in Appendix A3.3 and demonstrate that the model is robust towards this specification as very similar estimates are yielded. Whilst previous studies have shown that the relationship between stock returns and FFR shocks significantly deteriorates upon excluding event-dates associated with unscheduled FOMC meetings, in Appendix A3.4 we find that the relationship persists for several industrial sectors which illustrates the strength and robustness of findings documented in this chapter.

Interestingly, the estimates in Table 3.12 which measure state-dependence in terms of the bear-market versus bull-market periods are very similar to those in Table 3.11 which measure state-dependence in terms of looser and tighter credit market conditions. For example, outside the crisis period, the impact of FFR shocks on industry sectors in bull-markets is statistically *insignificant* for all but the others industry sector. Furthermore outside the crisis period, during bear-markets, the response is negative and *significant* for all but the energy sector. Akin to estimates in Table 3.12, the most (least) responsive industries include durables, high-tech and telecoms (energy). We also find that during bear-markets throughout the 2007-2009 crisis period, seven industrial sectors exhibited statistically *significant* negative responses to unexpected FFR cuts, as shown by the positive and *significant* β_4 coefficient. The Wald tests for equality of coefficients $\beta_2 = \beta_4$ is also rejected at the 5% level across all industry sectors, indicating that there is a significant difference in industry sector response to unexpected FFR changes during bear-markets *outside the crisis* and *during the crisis* period. These estimates are also robust to the exclusion of event-dates associated with employment release reports (see Appendix A3.5), however the model deteriorates upon excluding event-dates associated with unscheduled FOMC meetings (see Appendix A3.6).

3.4.8 Further robustness checks

We have undertaken a significant number of robustness checks for all the empirical models evaluated in this chapter. Nevertheless, to investigate the sensitivity of our estimates, we consider several additional robustness checks in this sub-section. Firstly, in Tables 3.11 and 3.12 we defined the D_t^{crisis} variable using the *exogenous crisis* and *exogenous crisis* definitions; however in subsequent tables we only considered the *exogenous crisis* definition. This decision was taken to ensure a concise discussion without a multitude of robustness checks compounding and stifling the discussion. To reassure the reader that the estimates obtained are robust to the *endogenous crisis* definition, in Appendix A3.6 we replicate Table 3.12 using this measure. The estimates are shown to be very similar across both tables. It is however important to note that by setting a dummy variable D_t^{state} equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, it becomes very similar to the *exogenous crisis* indicator D_t^{crisis}; hence we cannot estimate Equation 3.7 with regards to credit market conditions due to collinearity. Nevertheless, the remaining estimates are very similar to those in Table 3.12.

Secondly, it is important to note that whilst the 2007-2009 crisis period is dominated by worsening financial and economic conditions, the dummy variables for credit market conditions and bear-market conditions in Tables 3.9, 3.11 and 3.12 are active (equal to one) throughout the majority of the crisis period. This implies that there are only a few event-dates where the β_3 coefficient in Equation 3.7 can be adequately interpreted. Furthermore, compared to the other coefficients, the standard error of the β_3 coefficient is relatively large and this may be attributable to the limited number of related event-dates. To mitigate concerns that positivity of the β_4 was induced due to the construction of the state-dependent variables considered, we estimate an alternative model specification without considering state-dependent during the 2007-2009 crisis period in Table A3.8 with estimates of Equation 3.8.

$$r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right)\left(1 - D_t^{state}\right) + \beta_2\left(1 - D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\right]\Delta i_t^u + \varepsilon_t \qquad (3.8)$$

The estimates in Table A3.7 demonstrate that outside the crisis period, the stock response to unexpected FFR changes during bad times β_2 dominates its good times β_1 counterpart. In the latter the response is negative and statistically significant in all three panels indicative of highly robust estimate. Furthermore the β_3 coefficient which measures the stock return response to FFR shocks during the crisis period is positive and statistically significant in all three panels, supporting the empirical conclusions throughout this chapter.

Thirdly, Jansen and Tsai (2010) point out that there is no commonly accepted empirical methodology for defining bear market and bull market regimes. Nevertheless, there is a commonly accepted understanding of these regimes, whereby bear (bull) markets typically refer to periods of "substantial and sustained" declines (increases) in stock prices. Our definition of bear and bull markets in this chapter is consistent with this definition. It is important to note that an alternative empirical approaches to defining bear and bull markets was proposed by Chen (2007). A bear (bull) market was defined when a k-period moving average of stock returns fell below (exceeded) zero. A more formal procedure for characterising periods in to bear and bull market regimes was proposed by Pagan and Sossounov (2003) and this has become the dominant empirical approach employed in the literature. This more sophisticated algorithm identifies major turning points in stock prices and defines bear (bull) markets as periods between peaks (troughs) and troughs (peaks). This approach has been agued by Jansen and Tsai (2003) as more closely resembling the 'common understanding' of bear and bull market regimes.

Throughout this chapter we defined a state-dependent dummy variable for bear-market conditions as being equal to one when the S&P500 stock price index was lower than its full sample 3-year moving average and zero otherwise. To address concerns that this may not have been an adequate measure of bear-market regimes, we also use an alternative proxy for bear-market conditions based upon the Pagan and Sossounov (2003) dating algorithm. In

Tables A3.9 and A3.10 we re-estimate the models presented in Tables 3.8 and 3.9 using this alternative measure of bear and bull market regimes. We find that empirical conclusions drawn in this chapter are highly robust towards this alternative proxy and reinforce the main conclusions of our analysis, i.e. a stronger pre-crisis reaction to FFR shocks during 'bad times' (bear market) and a structural break during the financial crisis, with stocks responding negatively to unexpected FFR cuts during the crisis.

Finally, when this chapter was first written, all the estimates were for the Jun-89 to Dec-09 sample period. The estimates were updated to the Jun-89 to Dec-12 sample period in the write-up year of this thesis. Surprisingly, almost identical estimates throughout the chapter were yielded for both sample periods.

3.5 Conclusion

This chapter investigates the impact of unexpected FFR changes by the FOMC on US stock returns over the Jun-89 to Dec-12 sample period. Previous studies widely documented that stocks yielded positive and statistically *significant* responses to unexpected FFR cuts over sample periods which did not extend in to or beyond the 2007-2009 crisis period. In contrast, we demonstrate that upon extending the sample to the Jun-89 to Dec-12 period, the relationship declines to statistical *insignificance*. We demonstrate that the finding of a statistically insignificant relationship between stock returns and unexpected FFR changes is attributable to the 2007-2009 crisis period. In particular, we undertake a comprehensive series of tests to show that the relationship is characterised by a significant structural change during the crisis period. Consistent with previous studies we find that stock responded positively to unexpected FFR cuts *outside the crisis* period. However in contrast to previous studies we find that stocks exhibited negative and statistically *significant* responses to FFR cuts throughout the 2007-2009 crisis period, as cuts were interpreted as signals of worsening future economic conditions and perceived as bad news by investors and stock market participants. This signifies a radical shift in the perception of market participants to unexpected FFR cuts *during the crisis* compared to that *outside the crisis* period.

In line with previous studies, we document a state-dependent response of stock returns to unexpected FFR changes; with more amplified responses during periods of recession, tightening credit market conditions and bear-markets *outside the crisis* period. As the 2007-2009 crisis period was characterised by a significant decline in credit, a deterioration of credit market conditions and a major recession, one would expect a strongly positive stock return response to unexpected FFR cuts during the crisis period. However, contrary to that which one may expect, stock did not respond positively to FFR cuts throughout the crisis period. These estimates demonstrate the inability of the Fed to boost stock prices using conventional monetary policy via target FFR cuts during the 2007-2009 crisis period. It highlights the severity of the recent financial turmoil and reveals the limits of conventional monetary policy close to the zero-lower bound.

3.6 References

Andrews, D.W. 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica* 62(6), 821-856.

Bai, J. 1997. Estimating multiple breaks one at a time. *Econometric Theory* 13(03), 315-352.

Bai, J., & Perron, P. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica* 66(1), 47-78.

Bank of International Settlements Website. 2013. BIS Quarterly Review December 2012: Table 19: Amounts outstanding of over-the-counter (OTC) derivatives. Available from: *The Bank of International Settlements Website*. http://www.bis.org/statistics/otcder/dt1920a.csv. [Accessed on 10th Dec 13].

Basistha, A., & Kurov, A. 2008. Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 32(12), 2606-2616.

Bernanke, B. S., & Mihov, I. 1998. Measuring monetary policy. *The Quarterly Journal of Economics* 113(3), 869-902.

Bernanke, B.S. 2009. Financial Reform to Address Systemic Risk: Speech at the Council on Foreign Relations, Washington D.C. Available from: *The Federal Reserve Website*. http://www.federalreserve.gov/newsevents/speech/bernanke20090310a.htm. [Accessed on 22nd Aug 13].

Bernanke, B.S., & Kuttner, K.N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Bredin, D., Hyde, S., Nitzsche, D., & O'Reilly, G. 2009. European monetary policy surprises: the aggregate and sectoral stock market response. *International Journal of Finance & Economics*, 14(2), 156-171.

Buttonwood. 2010. Another paradox of thrift, Why low interest rates could also encourage saving. *The Economist*. 18 September 2010.

Cenesizoglu, T., Montréal, H.E.C., Larocque, D., & Normandin, M. 2012. Conventional Monetary Policy and the Term Structure of Interest Rates during the Financial Crisis. *HEC Montreal Finance Department*. Working Paper.

Chauvet, M., & Piger, J. 2008. A comparison of the real-time performance of business cycle dating methods. *Journal of Business and Economic Statistics* 26(1), 42-49.

Chen, S. 2007. Does monetary policy have asymmetric effects on stock returns? Journal of Money, Credit and Banking 39(2-3), 667-688.

Chernenko, S., Schwarz, K., & Wright, J. 2004. The information content of forward and futures prices: Market expectations and the price of risk. *FRB International Finance*. Discussion Paper 808.

Chuliá, H., Martens, & M., Dijk, D. 2010. Asymmetric effects of Federal Funds target rate changes on S&P100 stock returns, volatilities and correlations. *Journal of Banking and Finance* 34(4), 834-839.

Cornett, M.M, McNutt, J.J, Strahan, P.E., & Tehranian, H. 2011. Liquidity risk management and credit supply in the financial crisis. *Journal of Financial Economics* 101(2), 297-312.

Craine, R., & Martin, V. 2003. Monetary policy shocks and security market responses. *University of California Berkeley Economics*. Working Paper.

Davig, T., & Gerlach, J.R. 2006. State-dependent stock market reactions to monetary policy. *International Journal of Central Banking* 2(4), 65-83

Demiralp, S., & Yilmaz, K. 2009. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *TÜSİAD-Koç University Economic Research Forum*. Working Paper.

Demiralp, S., & Yilmaz, K. 2012. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *Journal of Macroeconomics* 34(2), 404-418.

Edgeworth, F. Y. 1887. On observations relating to several quantities. *Hermathena* 6(13), 279-285.

Ehrmann, M., & Fratzscher, M. 2004. Taking stock: monetary policy transmission to equity markets. *Journal of Money Credit and Banking* 36(4), 719-737.

Eijffinger, S., Mahieu, R., & Raes, L. 2012. Can the Fed talk the hind legs off the stock market?. *European Banking Center*. Discussion Paper 2012-006.

Farka, M. 2009. The effect of monetary policy shocks on stock prices accounting for endogeneity and omitted variable biases. *Review of Financial Economics* 18(1), 47-55.

Farka, M., & Fleissig, A. R. 2012. The effect of FOMC statements on asset prices. *International Review of Applied Economics* 26(3), 387-416.

Farka, M., & Fleissig, A.R. 2010. The effect of FOMC statements on asset prices. *California State University Department of Economics*. Working Paper.

Gorodnichenko, Y., & Weber, M. 2013. Are Sticky Prices Costly? Evidence from the stock market. *National Bureau of Economic Research*. Working Paper w18860.

Gregoriou, A., Kontonikas, A., MacDonald, R., & Montagnoli, A. 2009. Monetary policy shocks and stock returns: evidence from the British market. *Financial Market and Portfolio Management* 23(4), 401-410.

Gürkaynak, R. S., Sack, B., & Swanson, E. 2002. Market-based measures of monetary policy expectations. *Board of Governors of the Federal Reserve System*. Working Paper 2002-40.

Gürkaynak, R.S., Sack, B., & Swanson, E.T. 2005. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking* 1(1), 55-93

Gürkaynak, R.S., Sack, B.P., & Swanson, E.T. 2007. Market-based measures of monetary policy expectations. *Journal of Business & Economic Statistics* 25(2), 201-212.

Hansen, B.E. 1997. Approximate Asymptotic P Values for Structural-Change Tests. *Journal of Business and Economic Statistics* 15(1), 60-67

Heckman, J. J. 1981. Heterogeneity and state dependence. In *Studies in Labor Markets*. University of Chicago Press. Chapter 3.

Jansen, D.W., & Tsai, C. 2010. Monetary policy and stock returns: Financing constraints and asymmetries in bull and bear markets. *Journal of Empirical Finance* 17(5), 981-990.

Kacperczyk, M., & Schnabl, P. 2010. When safe proved risky: Commercial paper during the financial crisis of 2007-2009. *Journal of Economic Perspectives* 24(1), 29-50.

Kontonikas, A., MacDonald, R., & Saggu, A. (2013). Stock market reaction to fed funds rate surprises: state dependence and the financial crisis. *Journal of Banking and Finance* 37(11), 4025-4037

Krueger, J.T., & Kuttner, K.N. (1996). The fed funds futures rate as a predictor of Federal Reserve policy. *Journal of Futures Markets* 16(8), 865-879.

Kurov, A. 2010. Investor sentiment and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 34(1), 139-149.

Kurov, A. 2012. What determines the stock market's reaction to monetary policy statements?. *Review of Financial Economics* 21, 175-187.

Kuttner, K.N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Kuttner, K.N. 2003. Dating changes in the Federal Funds rate, 1989-92. *Oberlin College*. Working Paper.

Pagan, A. R., & Sossounov, K. A. 2003. A simple framework for analysing bull and bear markets. *Journal of Applied Econometrics* 18(1), 23-46.

Piazzesi, M., & Swanson, E.T. 2008. Futures prices as risk-adjusted forecasts of monetary policy. *Journal of Monetary Economics* 55(4), 677-691.

Rigobon, R., & Sack, B. P. 2002. The Impact of Monetary Policy on Asset Prices. *National Bureau of Economic Research*. Working Paper 8794.

Rigobón, R., & Sack, B. 2004. The impact of monetary policy on asset prices. *Journal of Monetary Economics* 51(8), 1553-1575.

Rigobon, R., & Sack, B. 2003. Measuring the reaction of monetary policy to the stock market. *The Quarterly Journal of Economics* 118(2), 639-669.

Rosa, C. 2012. How 'unconventional' are large-scale asset purchases? The impact of monetary policy on asset prices. *FRB of New York Staff Report*. Working Paper 560.

Rudebusch, G.D. 1996. Do measures of monetary policy in a VAR make sense?. *Federal Reserve Bank of San Francisco*. Working Paper 96-05.

Rudebusch, G.D. 1998. Do Measures of Monetary Policy in a VAR Make Sense?. *International Economic Review* 39(4), 907-31.

Stothard, M. 2012. Morgan Stanley fined over coding error. Available from: *The Financial Times Website*. http://www.ft.com/cms/s/0/231c4304-9f3d-11e1-a455-00144feabdc0.html#axzz2n72qbnIW. [Accessed on 10th Dec 13].

Verardi, V., & Croux. C. 2010. Sire applied robust regression workshop. *The University of Strathclyde*. Course Notes from Three-Day Workshop.

Wang, T., Yang, J., & Wu, J. 2006. Central bank communications and equity ETFs. *Journal of Futures Markets* 26(10), 959-995.

Welsh, R., & Kuh, E. 1977. Linear Regression Diagnostics. *Massachusetts Institute of Technology Technical Report*, 369-395.

Wooldridge, J. M. 2005. Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *Journal of Applied Econometrics* 20(1), 39-54.

Wright, J.H. 2012. What does monetary policy do to long-term interest rates at the zero lower bound? *Economic Journal* 122(564), F447-F466.

Yohai, V.J. 1987. High breakdown-point and high efficiency robust estimates for regression. *The Annals of Statistics* 15(2), 642-656.

CHAPTER 3 – TABLES AND FIGURES

Table 3.1: Descriptive statistics for target and unexpected FFR changes

Sample Period	Obs	Min	Max	Mean	St.Dev	Jarque-Bera
All meetings						
Δi	213	-0.75	0.75	-0.04	0.22	34.54***
Δi^u	213	-0.74	0.17	-0.03	0.10	2405.22***
Contractionary						
$\Delta i > 0$	31	0.25	0.75	0.30	0.12	65.49***
Δi^u	31	-0.05	0.14	0.02	0.05	6.27**
Expansionary						
$\Delta i < 0$	52	-0.75	-0.25	-0.35	0.15	12.56***
Δi^u	52	-0.74	0.17	-0.11	0.15	52.85***
No Change						
$\Delta i = 0$	130	0.00	0.00	0.00	0.00	-
Δi^u	130	-0.20	0.12	0.00	0.04	503.08***

Notes: Table 3.1 reports descriptive statistics for target Δi_t and unexpected Δi_t^u FFR changes on FOMC event-dates over the Jun-89 to Dec-12 sample period.

Table 3.2: Response of US stock returns to unexpected FFR changes (sample periods of pre-crisis studies), OLS estimates

Sample Period	Obs	α	β	Adj R^2
Full Sample	213	0.29***	-2.06	0.02
Jun-89 to Dec-12		(0.09)	(1.88)	
Chulia et al. (2010)	80	0.21	-9.56***	0.36
May-97 to Oct-06		(0.14)	(1.47)	
Andersson (2010)	59	0.13	-9.19*	0.39
May-99 to May-06		(0.16)	(1.65)	
Wang, Yang and Wu (2006)	81	0.23	-8.83*	0.33
May-95 to Dec-04		(0.14)	(1.62)	
Davig and Gerlach (2006)	74	0.17	-7.51*	0.29
Feb-94 to Sep-02		(0.14)	(2.26)	
Farka (2009)	100	0.21***	-7.10*	0.26
Feb-94 to Dec-05		(0.11)	(2.14)	
Bernanke and Kuttner (2005)	131	0.12	-4.22**	0.13
Jun-89 to Dec-02		(0.12)	(1.84)	
Gürkaynak et al (2005)				
Basistha & Kurov (2008)	138	0.15	-3.87**	0.11
Kurov (2010)				
Feb-90 to Dec-04		(0.11)	(1.85)	

Notes: Table 3.2 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 3.3 on FOMC event-dates: $r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. The sample period corresponds with that used in each study listed. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded in all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.3: Response of US stock returns to unexpected FFR changes (sample periods of crisis studies), OLS estimates

Sample Period	Obs	α	β	Adj R^2
Full Sample	213	0.29***	-2.06	0.02
Jun-89 to Dec-12		(0.09)	(1.88)	
Demiralp and Yilmaz (2012)	177	0.28*	-1.87	0.02
May-89 to Nov-09		(0.11)	(1.92)	
Rosa (2012)	91	0.41*	-2.39	0.02
May-99 to Jan-10		(0.15)	(3.40)	
Rosa (2012)	102	0.36**	-2.47	0.02
May-99 to Jun-11		(0.14)	(3.50)	
Kurov (2012)	123	0.31*	-2.63	0.04
Feb-94 to Sep-08		(0.11)	(2.92)	
Gorodnichenko and Weber (2013) *Eijffinger, Mahieu and Raes (2012)*	134	0.36*	-2.72	0.04
Feb-94 to Dec-09		(0.12)	(2.90)	

Notes: Table 3.3 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 3.3 on FOMC event-dates: $r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. The sample period corresponds with that used in each study listed. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded in all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.4: Quandt-Andrews structural breakpoint tests

	Value	P-Value
Max LR F-Stat	10.08***	0.00
Exp LR F-Stat	2.77***	0.01
Average LR F-Stat	3.61***	0.01
Break Date	22nd Jan 08	-

Table 3.4 reports test statistics for the Quandt-Andrews test for structural breaks (Max F-Stat, Exp F-Stat, Ave F-Stat). The test considers the null hypothesis of no structural breaks versus the alternative of unknown structural breaks (Andrews, 1993). We use a trimming percentage of 15% and the probabilities were calculated using the methodology of Hansen (1997). The tests were performed on Equation 3.3 which was estimated using OLS with heteroscedasticity and autocorrelation consistent standard errors, on FOMC event-dates. The 17th Sep 01 event-date is excluded in the estimate prior to testing for structural breaks. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.5: Bai-Perron structural breakpoint tests

Panel A (Sequential L+1 Breaks vs. L)

Break No.	*F-Stat*	*Scaled F-Stat*	*Crit Val*
0 vs. 1 *	7.51	15.02*	11.47
1 vs. 2 *	17.58	35.17*	12.95
2 vs. 3	2.02	4.03	14.03
3 vs. 4	2.00	3.99	14.85
4 vs. 5	0.00	0.00	15.29

Panel B (Global L Breaks vs. None)

Break No.	*F-Stat*	*Scaled F-Stat*	*Weighted F-Stat*	*Crit Val*
1 *	7.51	15.02	15.02	11.47
2 *	17.34	34.68	40.80	9.75
3 *	38.19	76.37	104.79	8.36
4 *	30.39	60.78	96.97	7.19
5 *	22.69	45.38	88.98	5.85
Number of Breaks Selected	*UD Max Stat*	*UD Max Crit*	*WD Max Stat*	*WD Max Crit*
3	76.37	11.70	104.79	12.81

Panel C (Global Information Criteria)

Break No.	*No. of Coefs*	*Sum Sqr Res*	*Log-L*	*Schwarz Crit*
0	2	312.41	-343.02	0.43
1	5	284.93	-333.22	0.42
2	8	256.16	-321.89	0.39
3	11	242.76	-316.16	0.41
4	14	239.66	-314.79	0.47
5	17	240.51	-315.17	0.55

	Selection Criteria	*No. Breaks*	*Break Date 1*	*Break Date 2*	*Break Date 3*
Panel A (Sequential L+1 Breaks vs. L)	Seq F-Stat	2	15 Oct 98	22 Jan 08	
Panel B (Global L Breaks vs. None)	UD & WD Max	3	15 Oct 98	06 Nov 02	16 Dec 08
Panel C (Global Information Criteria)	Schwarz Criterion	2	15 Oct 98	22 Jan 08	

Table 3.5 reports the Bai-Perron test statistics for three tests: the Sequentially Determined $L+1$ versus L Test for Structural Breaks (F-Stat and Scaled F-Stat) in Panel A, the Global L Breaks versus None Test for Structural Breaks (F-Stat, Scaled F-Stat, $UD_{\max}$ Stat and $WD_{\max}$ Stat) in Panel B, and the Global Information Criteria Test for Structural Breaks (Sum of Squared Residuals, Log-Likelihood Ratio) in Panel C. We also report the Bai-Perron critical values and the Schwartz Information Criterion Statistic for selecting structural breakpoints (see Bai, 1997; Bai and Perron, 1998). We use a trimming percentage of 15% and allow for up to 5 breakpoints. In Panel B and C we allow error distributions to differ across breaks. The final three lines report the breakpoint dates selected by estimation in each Panel. The tests were performed on Equation 3.3 which was estimated using OLS with heteroscedasticity and autocorrelation consistent standard errors, on FOMC event-dates. The 17th Sep 01 event-date is excluded in the estimate prior to testing for structural breaks. ** indicates statistical significance at the 5% level.

Table 3.6: Response of US stock returns to unexpected FFR changes, controlling for the 2007-2009 crisis, OLS estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
Crisis (Sep-07 to Mar-09)	213	0.27***	-3.73**	1.66	[0.02]	0.06
		(0.09)	(1.75)	(1.49)		
Crisis (Jan-08 to Mar-09)	213	0.26***	-3.98**	2.40**	[0.00]	0.07
		(0.09)	(1.73)	(1.14)		
Panel B (Excl Empl)						
Crisis (Sep-07 to Mar-09)	204	0.28***	-5.31***	1.69	[0.00]	0.09
		(0.09)	(1.76)	(1.48)		
Crisis (Jan-08 to Mar-09)	204	0.28***	-5.60***	2.43**	[0.00]	0.11
		(0.09)	(1.72)	(1.14)		
Panel C (Excl Empl & Unsch)						
Crisis (Sep-07 to Mar-09)	187	0.30***	-1.77	-1.62	[0.99]	0.00
		(0.09)	(1.50)	(11.33)		
Crisis (Jan-08 to Mar-09)	187	0.30***	-2.55	4.96	[0.58]	0.01
		(0.10)	(1.66)	(13.45)		

Notes: Table 3.6 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 3.5 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the crisis period and zero otherwise. The two alternative crisis periods definitions considered are: Sep-07 to Mar-09 (*exogenous crisis*) and Jan-08 to Mar-09 (*endogenous crisis*). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.7: Response of US stock returns to unexpected FFR changes, controlling for the 2007-2009 crisis, robust MM-estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
Crisis (Sep-07 to Mar-09)	210	0.20***	-1.76**	2.10*	[0.00]	0.03
		(0.06)	(0.82)	(1.09)		
Crisis (Jan-08 to Mar-09)	211	0.20***	-2.03**	2.45**	[0.00]	0.04
		(0.06)	(0.82)	(1.20)		
Panel B (Excl Empl)						
Crisis (Sep-07 to Mar-09)	202	0.19***	-3.76***	2.10*	[0.00]	0.09
		(0.06)	(0.92)	(1.07)		
Crisis (Jan-08 to Mar-09)	202	0.19***	-4.42***	2.40**	[0.00]	0.11
		(0.06)	(0.91)	(1.18)		
Panel C (Excl Empl & Unsch)						
Crisis (Sep-07 to Mar-09)	184	0.25***	-1.76	18.50***	[0.00]	0.11
		(0.06)	(1.18)	(3.81)		
Crisis (Jan-08 to Mar-09)	185	0.25***	-2.21*	19.25***	[0.00]	0.13
		(0.06)	(1.18)	(3.83)		

Table 3.7 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.5 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the crisis period and zero otherwise. The two alternative crisis periods definitions considered are: Sep-07 to Mar-09 (*exogenous crisis*) and Jan-08 to Mar-09 (*endogenous crisis*). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.8: Response of US stock returns to unexpected FFR changes, controlling for state-dependence (pre-crisis sample), 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**	-1.93**	1.79	[0.28]	0.02
		(0.06)	(0.90)	(3.09)		
(b) BAA-10Yr TB Spread	168	0.17***	-1.02	-8.50***	[0.00]	0.25
		(0.07)	(0.93)	(1.14)		
(c) S&P Bear Market	167	0.17***	-0.81	-8.05***	[0.00]	0.15
		(0.06)	(0.82)	(1.47)		
Panel B (Excl Empl)						
(a) Prob. Recession	159	0.15**	-2.93***	-14.23***	[0.00]	0.19
		(0.07)	(1.03)	(3.42)		
(b) BAA-10Yr TB Spread	159	0.18***	-1.65	-9.37***	[0.00]	0.30
		(0.06)	(1.07)	(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***	-1.00	-11.88**	[0.09]	0.02
		(0.06)	(1.23)	(5.96)		
(b) BAA-10Yr TB Spread	144	0.21***	0.39	-5.79***	[0.01]	0.05
		(0.06)	(1.33)	(1.85)		
(c) S&P Bear Market	144	0.21***	-0.50	-6.82***	[0.02]	0.04
		(0.06)	(1.25)	(2.45)		

Table 3.8 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.6 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{state}\right) + \beta_2\left(D_t^{state}\right)\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{state} is defined as follows: (a) the real time recession probability indicator of Chauvet and Piger (2008) which is estimated using a dynamic factor Markov-switching model, (b) a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, (c) a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Aug-07. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.9: Response of US stock returns to unexpected FFR changes, controlling for the 2007-2009 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	209	0.23***	-1.76*	1.78	-4.87**	23.71***	[0.34]	[0.00]	[0.20]	[0.00]	0.08
		(0.06)	(0.95)	(3.31)	(2.24)	(5.97)					
(b) BAA-10Yr TB Spread	211	0.20***	-0.95	-8.29***	-18.42***	2.42**	[0.00]	[0.00]	[0.00]	[0.00]	0.23
		(0.06)	(0.97)	(1.18)	(5.53)	(1.19)					
(c) S&P Bear Market	209	0.20***	-0.70	-8.08***	5.98	2.24**	[0.00]	[0.61]	[0.36]	[0.00]	0.12
		(0.06)	(0.85)	(1.55)	(7.19)	(1.12)					
Panel B (Excl Empl)											
(a) Prob. Recession	201	0.22***	-2.76**	-14.53***	-4.57**	22.65***	[0.00]	[0.00]	[0.47]	[0.00]	0.20
		(0.06)	(1.08)	(3.60)	(2.23)	(5.93)					
(b) BAA-10Yr TB Spread	202	0.20***	-1.58	-9.44***	-18.39***	2.41**	[0.00]	[0.00]	[0.00]	[0.00]	0.27
		(0.06)	(1.12)	(1.19)	(5.42)	(1.16)					
(c) S&P Bear Market	200	0.20***	-2.00*	-8.06***	6.03	2.21**	[0.00]	[0.59]	[0.26]	[0.00]	0.14
		(0.06)	(1.04)	(1.52)	(7.08)	(1.10)					
Panel C (Excl Empl & Unsch)											
(a) Prob. Recession	183	0.24***	-0.79	-12.93**	3.14	30.84***	[0.08]	[0.11]	[0.70]	[0.00]	0.13
		(0.06)	(1.29)	(6.51)	(10.20)	(8.79)					
(b) BAA-10Yr TB Spread	185	0.25***	0.57	-5.84***	-18.03***	19.11***	[0.01]	[0.00]	[0.00]	[0.00]	0.19
		(0.06)	(1.42)	(1.98)	(5.12)	(3.78)					
(c) S&P Bear Market	184	0.24***	-0.30	-7.09***	6.62	23.11***	[0.02]	[0.04]	[0.31]	[0.00]	0.17
		(0.06)	(1.29)	(2.54)	(6.73)	(4.11)					

Table 3.9 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1 \left(1 - D_t^{crisis}\right)\left(1 - D_t^{state}\right) + \beta_2 \left(1 - D_t^{crisis}\right) D_t^{state} + \beta_3 D_t^{crisis}\left(1 - D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as follows: (a) the real time recession probability indicator of Chauvet and Piger (2008) which is estimated using a dynamic factor Markov-switching model, (b) a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, (c) a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.10: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis, robust MM-estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
Nondurables	209	0.12***	-1.32***	0.39	[0.05]	0.02
		(0.04)	(0.51)	(0.72)		
Durables	209	0.14**	-1.61**	0.52	[0.09]	0.01
		(0.06)	(0.78)	(1.04)		
Manufacturing	206	0.17***	-0.64	1.90**	[0.02]	0.02
		(0.05)	(0.59)	(0.88)		
Energy	210	0.19***	0.84	4.11***	[0.03]	0.04
		(0.07)	(0.83)	(1.30)		
Hi-tech	209	0.24***	-0.72	3.41***	[0.01]	0.03
		(0.07)	(0.94)	(1.19)		
Telecoms	207	0.11	-1.85**	2.13*	[0.01]	0.03
		(0.07)	(0.87)	(1.18)		
Shops	209	0.16***	-0.39	-0.57	[0.87]	-0.01
		(0.05)	(0.68)	(0.91)		
Health care	211	0.14**	-2.54***	3.75***	[0.00]	0.09
		(0.06)	(0.80)	(1.08)		
Utilities	207	0.18***	-0.53	3.96***	[0.00]	0.17
		(0.04)	(0.45)	(0.62)		
Other	204	0.17***	-1.51***	0.21	[0.04]	0.04
		(0.04)	(0.48)	(0.67)		
Panel B (Excl Empl)						
Nondurables	202	0.12***	-1.52**	0.39	[0.04]	0.02
		(0.04)	(0.59)	(0.72)		
Durables	201	0.14**	-3.01***	0.54	[0.01]	0.04
		(0.06)	(0.91)	(1.07)		
Manufacturing	198	0.18***	-1.01	1.97**	[0.01]	0.02
		(0.05)	(0.72)	(0.91)		
Energy	201	0.20***	1.47	4.12***	[0.10]	0.05
		(0.07)	(0.97)	(1.33)		
Hi-tech	200	0.24***	-1.05	3.43***	[0.01]	0.03
		(0.07)	(1.15)	(1.20)		
Telecoms	198	0.12	-3.10***	2.15*	[0.00]	0.05
		(0.07)	(1.05)	(1.22)		
Shops	200	0.16***	-0.81	-0.56	[0.84]	0.00
		(0.05)	(0.80)	(0.92)		
Health care	202	0.15**	-3.23***	3.76***	[0.00]	0.10
		(0.07)	(0.94)	(1.10)		
Utilities	198	0.18***	-0.65	3.97***	[0.00]	0.17
		(0.04)	(0.54)	(0.63)		
Other	195	0.17***	-1.48**	0.22	[0.05]	0.02
		(0.04)	(0.57)	(0.68)		

Table 3.10 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.5 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates

associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.11: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (credit market conditions), robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Nondurables	210	0.12***	-0.69	-2.41***	-13.26***	0.55	[0.08]	[0.00]	[0.00]	[0.01]	0.09
		(0.04)	(0.62)	(0.78)	(3.61)	(0.72)					
Durables	208	0.15**	-0.33	-7.26***	-16.17***	12.25***	[0.00]	[0.00]	[0.00]	[0.00]	0.25
		(0.06)	(0.89)	(1.05)	(5.08)	(3.04)					
Manufacturing	206	0.17***	0.53	-2.73***	-19.85***	1.94**	[0.00]	[0.00]	[0.00]	[0.00]	0.13
		(0.05)	(0.71)	(0.90)	(4.34)	(0.88)					
Energy	208	0.19***	0.37	1.61	-16.07**	17.41***	[0.43]	[0.00]	[0.02]	[0.00]	0.12
		(0.07)	(1.02)	(1.20)	(6.66)	(3.52)					
Hi-tech	210	0.23***	0.63	-5.07***	-12.84**	3.88***	[0.00]	[0.01]	[0.03]	[0.00]	0.08
		(0.07)	(1.07)	(1.72)	(6.10)	(1.29)					
Telecoms	207	0.09	-0.46	-6.59***	-16.53***	2.43**	[0.00]	[0.00]	[0.01]	[0.00]	0.14
		(0.07)	(1.00)	(1.32)	(5.90)	(1.15)					
Shops	210	0.17***	1.14	-4.18***	-21.24***	-0.49	[0.00]	[0.00]	[0.00]	[0.01]	0.16
		(0.05)	(0.79)	(1.01)	(4.45)	(0.90)					
Health care	211	0.15**	0.07	-6.53***	-7.84	4.14***	[0.00]	[0.03]	[0.16]	[0.00]	0.19
		(0.06)	(0.97)	(1.06)	(5.50)	(1.10)					
Utilities	207	0.18***	-0.50	-1.66*	-14.78***	4.00***	[0.25]	[0.00]	[0.00]	[0.00]	0.22
		(0.04)	(0.54)	(0.86)	(3.71)	(0.63)					
Other	206	0.17***	-0.73	-2.97***	-18.18***	0.23	[0.02]	[0.00]	[0.00]	[0.00]	0.18
		(0.04)	(0.59)	(0.73)	(3.29)	(0.66)					

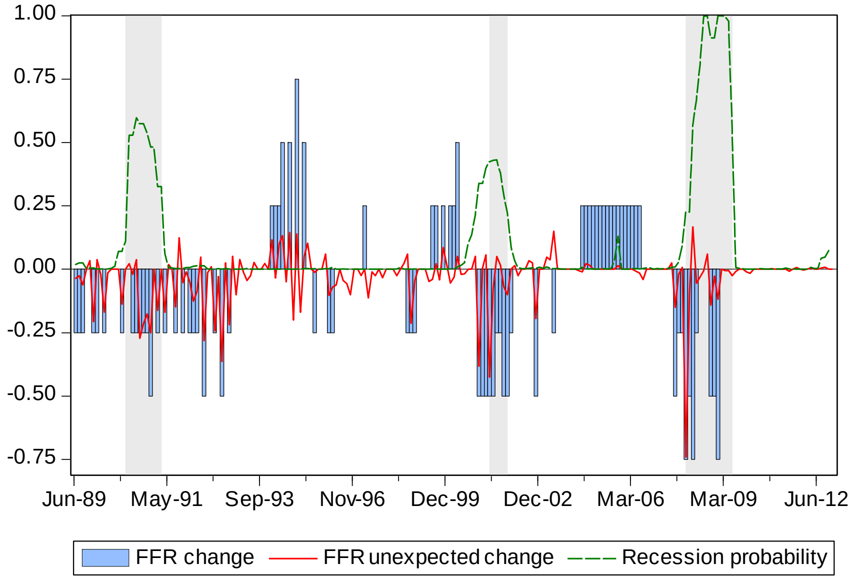
Table 3.11 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 3.12: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (bear-markets versus bull markets), robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Nondurables	210	0.12***	-0.90	-2.52**	-11.12***	0.44	[0.17]	[0.00]	[0.00]	[0.02]	0.07
		(0.04)	(0.57)	(1.05)	(3.35)	(0.72)					
Durables	208	0.13**	-0.68	-7.74***	-10.15**	14.18***	[0.00]	[0.00]	[0.05]	[0.00]	0.18
		(0.06)	(0.80)	(1.48)	(4.70)	(3.36)					
Manufacturing	205	0.18***	0.12	-3.56***	4.85	1.78**	[0.01]	[0.58]	[0.39]	[0.00]	0.05
		(0.05)	(0.63)	(1.21)	(5.52)	(0.85)					
Energy	208	0.17**	0.86	0.24	-9.23*	19.73***	[0.77]	[0.00]	[0.07]	[0.00]	0.10
		(0.07)	(0.91)	(1.92)	(5.51)	(4.00)					
Hi-tech	209	0.21***	-0.33	-13.02***	-8.16	16.11***	[0.00]	[0.00]	[0.14]	[0.00]	0.24
		(0.07)	(0.96)	(1.84)	(5.16)	(3.98)					
Telecoms	207	0.10	-1.20	-8.89***	-8.79	2.29*	[0.00]	[0.06]	[0.19]	[0.00]	0.12
		(0.07)	(0.92)	(1.77)	(5.77)	(1.20)					
Shops	208	0.17***	0.65	-4.92***	0.50	-0.53	[0.00]	[0.87]	[0.98]	[0.01]	0.06
		(0.05)	(0.71)	(1.28)	(6.00)	(0.90)					
Health care	211	0.14**	-1.16	-6.06***	-4.40	4.21***	[0.01]	[0.07]	[0.49]	[0.00]	0.11
		(0.06)	(0.88)	(1.58)	(4.57)	(1.17)					
Utilities	207	0.17***	-0.42	-4.95***	-11.98***	4.00***	[0.01]	[0.00]	[0.00]	[0.00]	0.22
		(0.04)	(0.49)	(1.64)	(3.05)	(0.66)					
Other	203	0.17***	-0.93*	-3.11***	2.26	0.16	[0.04]	[0.64]	[0.47]	[0.00]	0.05
		(0.04)	(0.53)	(0.94)	(4.40)	(0.66)					0.07

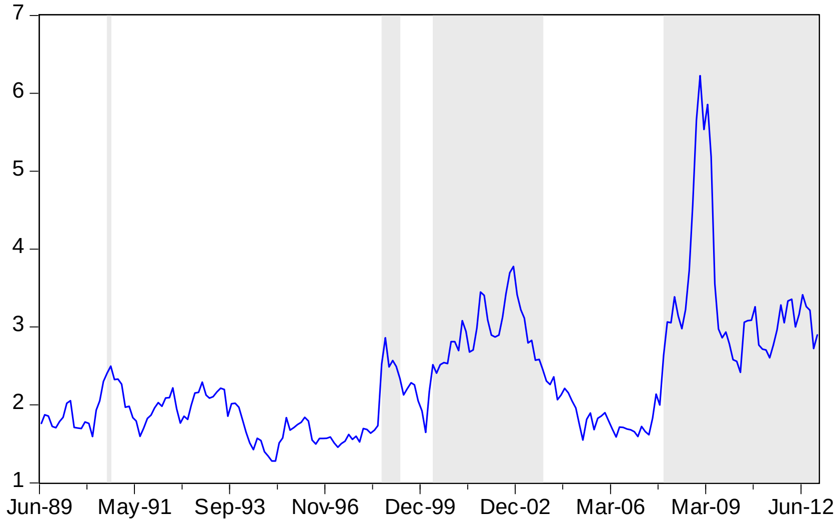
Table 3.12 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Figure 3.1: Target FFR changes, unexpected FFR changes and the probability of recession



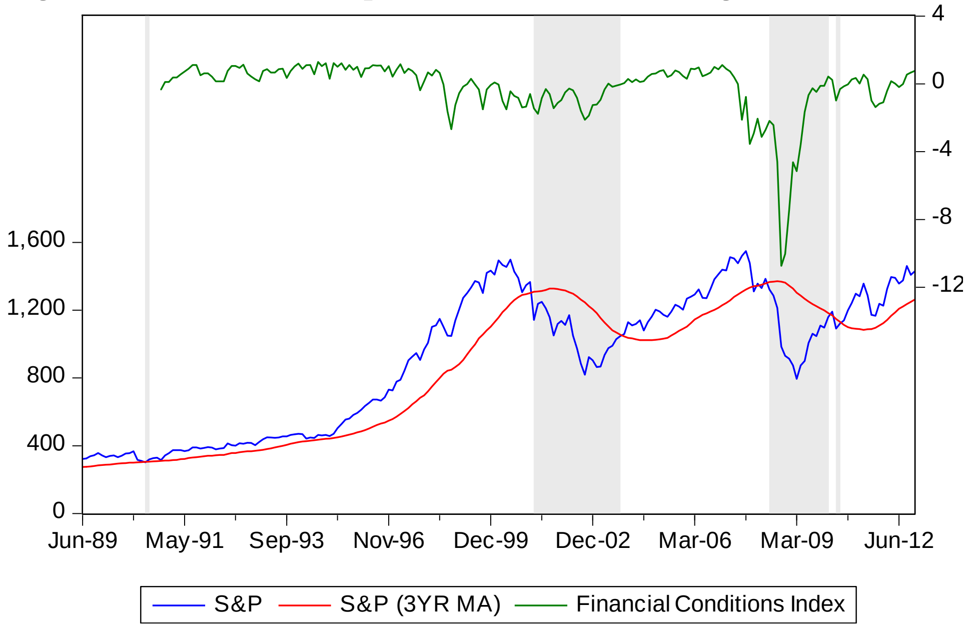
Notes: Figure 3.1 shows the target FFR change and unexpected FFR change on FOMC event-dates over the Jun-89 to Dec-12 sample period. The shaded area corresponds with NBER recession dates on FOMC event-dates. The dotted line indicates the real time recession probability of Chauvet and Piger (2008) which was constructed using a dynamic-factor Markov-switching model.

Figure 3.2: BAA-10 year Treasury bond spread



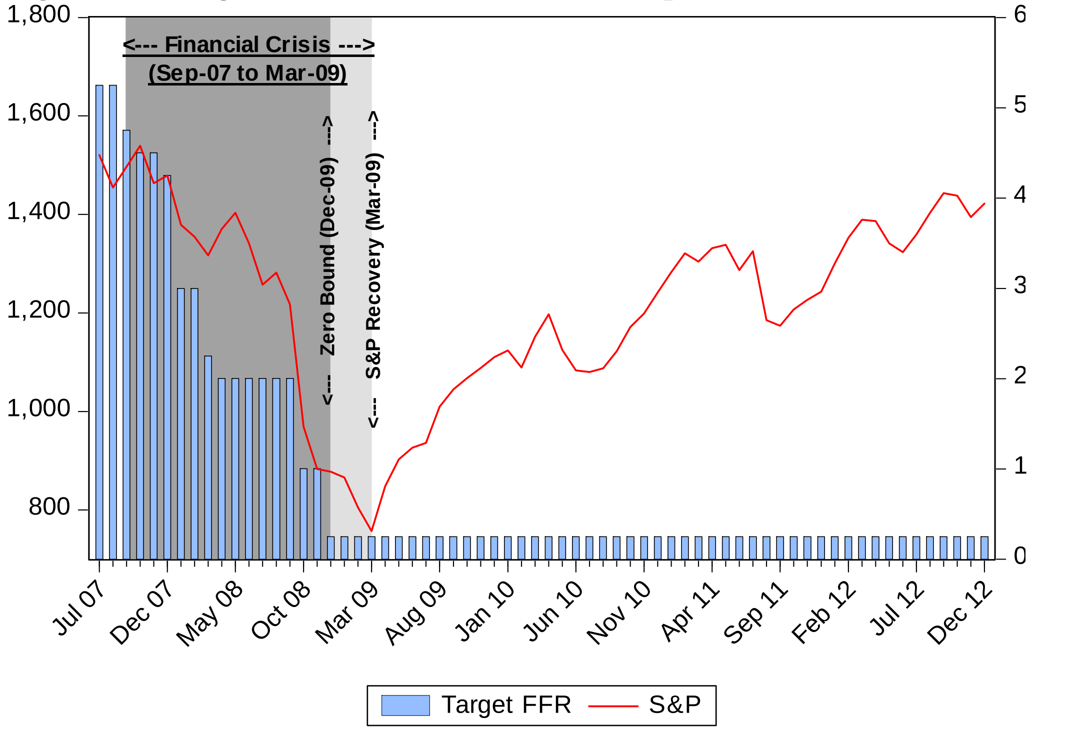
Notes: Figure 3.2 shows the spread between the Moody's classified BAA generic corporate bond yield and the 10-year US Treasury bond yield on FOMC event-dates over the Jun-89 to Dec-12 sample period. The shaded area corresponds with FOMC event-dates when the BAA –10 year Treasury bond spread exceeds its full sample historical average, indicating tight credit market conditions. The historical average is for all daily observations over the Jun-89 to Dec-12 sample period instead of just FOMC event-dates.

Figure 3.3: S&P500 stock price index and Bloomberg financial conditions index



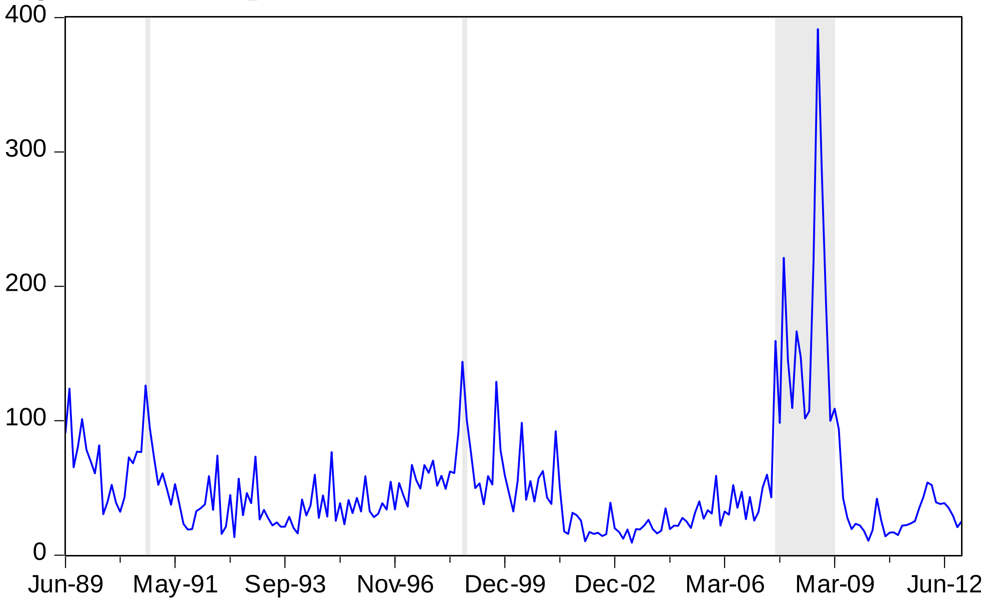
Notes: Figure 3.3 shows the S&P500 index and its 3-year moving average (measured on the left vertical axis), and the Bloomberg financial conditions index (measured on the right vertical axis) on FOMC event-dates over the Jun-89 to Dec-12 sample period. The shaded area corresponds with FOMC event-dates when the S&P500 Index moves below its 3-year moving average. The 3-year moving average was calculated for all daily observations over the Jun-89 to Dec-12 sample period instead of just FOMC event-dates.

Figure 3.4: Target FFR level and S&P500 stock price index (Jul-07 to Dec-12)



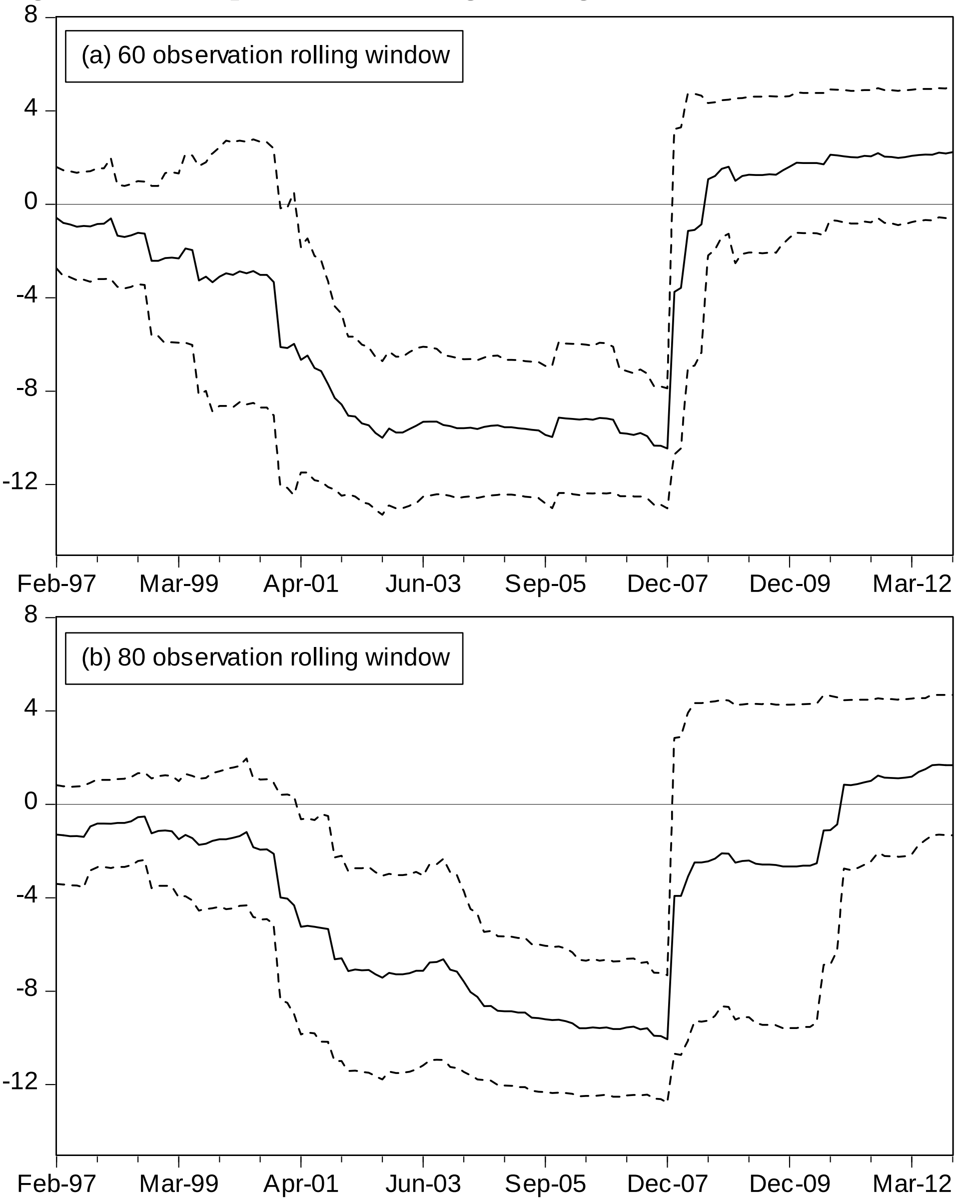
Notes: Figure 3.4 shows the S&P500 index (measured on the left vertical axis), and the target FFR (measured on the right vertical axis) over the Jul-07 to Dec-12 sample period; using monthly data. The shaded area corresponds with the Sep-07 to Mar-09 *financial crisis* period. We also use markers to indicate: when the target FFR approached the zero-lower bound following a -0.75% cut in Dec-08, and when the S&P500 index began to recover, and when the S&P500 reached its lowest point and began to recover in Mar-09.

Figure 3.5: TED spread



Notes: Figure 3.5 shows the Ted Spread which measures the difference between the 3-month LIBOR and the 3-month Treasury bill rate on FOMC event-dates over the Jun-89 to Dec-12 sample period. The shaded area corresponds with FOMC event-dates when the Ted spread exceeds its full sample historical average by a factor of two, indicating severe interbank pressures. The historical average is for all daily observations over the Jun-89 to Dec-12 sample period instead of just FOMC event-dates.

Figure 3.6: Unexpected FFR change rolling coefficient



Notes: Figure 3.6 shows the unexpected FFR change coefficient from a rolling regression estimate of Equation (3.3) on FOMC event-dates: $r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. The sample period is from Jun-89 to Dec-12. We exclude the 17th Sep 01 event-date from estimation. The dotted lines denote the rolling 95% confidence intervals for the unexpected FFR change coefficient. Panel A uses 60 observation rolling windows and Panel B uses 80 observation rolling windows.

CHAPTER 3 – APPENDIX

Table A3.1: Response of US stock returns to unexpected FFR changes, OLS estimates

	Obs	α	β	Adj R^2
Panel A (All Meetings)	213	0.29***	-2.06	0.02
Jun-89 to Dec-12		(0.09)	(1.88)	
Panel B (Excl Empl)	204	0.30***	-2.71	0.03
Jun-89 to Dec-12		(0.09)	(2.29)	
Panel C (Excl Empl & Unsch)	187	0.30***	-1.75	0.00
Jun-89 to Dec-12		(0.09)	(2.11)	
Panel D (Excl Outliers)	198	0.22***	-1.18	0.00
Jun-89 to Dec-12		(0.08)	(0.95)	

Notes: Table A3.1 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 3.3 on FOMC event-dates: $r_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, C and D). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. Panel D excludes FOMC event-dates associated with high influence statistics identified using the Difference in Fits Statistic of Welsh and Kuh (1977). Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.2: List of unscheduled FOMC meetings with target FFR changes, FOMC meetings with employment release reports and DFITS outlier event-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	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
		09-Aug-11
		21-Sep-11

Notes: Table A3.2 reports; FOMC event-dates associated with employment reports by the Bureau of Labor Statistics, FOMC event-dates associated with unscheduled FOMC event-dates, and FOMC event-dates associated with high influence statistics in Equation (3.3) identified using the Difference in Fits Statistic of Welsh and Kuh (1977).

Table A3.3: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (credit market conditions), robust MM-estimates, excluding employment

	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
Nondurables	202	0.12***	-0.65	-2.80***	-13.23***	0.57	[0.07]	[0.00]	[0.00]	[0.00]	0.09
		(0.04)	(0.75)	(0.90)	(3.64)	(0.73)					
Durables	199	0.15***	-0.55	-8.51***	-16.13***	12.22***	[0.00]	[0.00]	[0.00]	[0.00]	0.29
		(0.06)	(1.05)	(1.12)	(5.09)	(3.05)					
Manufacturing	199	0.19***	0.53	-3.75***	-19.77***	2.08**	[0.00]	[0.00]	[0.00]	[0.00]	0.14
		(0.05)	(0.87)	(1.08)	(4.46)	(0.95)					
Energy	200	0.20***	1.31	1.65	-15.99**	17.43***	[0.85]	[0.00]	[0.00]	[0.00]	0.12
		(0.07)	(1.24)	(1.42)	(6.82)	(3.66)					
Hi-tech	201	0.22***	0.26	-12.10***	-12.87**	3.87***	[0.00]	[0.01]	[0.04]	[0.00]	0.24
		(0.07)	(1.28)	(1.66)	(6.17)	(1.30)					
Telecoms	198	0.10	-1.07	-8.23***	-16.46***	2.47**	[0.00]	[0.00]	[0.01]	[0.00]	0.16
		(0.07)	(1.21)	(1.51)	(6.00)	(1.17)					
Shops	201	0.17***	1.21	-5.35***	-21.23***	-0.47	[0.00]	[0.00]	[0.00]	[0.00]	0.17
		(0.05)	(0.94)	(1.14)	(4.50)	(0.91)					
Health care	202	0.15**	0.19	-7.24***	-7.82	4.15***	[0.00]	[0.03]	[0.16]	[0.00]	0.20
		(0.06)	(1.17)	(1.20)	(5.55)	(1.11)					
Utilities	197	0.18***	-0.33	-3.12***	-14.76***	4.01***	[0.03]	[0.00]	[0.00]	[0.00]	0.23
		(0.04)	(0.65)	(1.12)	(3.76)	(0.65)					
Other	197	0.17***	-0.48	-3.16***	-18.14***	0.23	[0.02]	[0.00]	[0.00]	[0.00]	0.17
		(0.04)	(0.70)	(0.85)	(3.30)	(0.66)					

Table A3.3 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date and FOMC event-dates associated with employment report releases are excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.4: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (credit market conditions), robust MM-estimates, excluding employment and unscheduled

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Nondurables	185	0.15***	-0.67	-2.60*	-13.03***	12.48***	[0.24]	[0.00]	[0.00]	[0.00]	0.17
		(0.04)	(0.95)	(1.35)	(3.45)	(2.65)					
Durables	182	0.18***	-1.47	-5.46**	-15.95***	10.17***	[0.12]	[0.00]	[0.01]	[0.00]	0.10
		(0.06)	(1.37)	(2.17)	(5.00)	(3.82)					
Manufacturing	181	0.21***	0.23	-2.58	-19.57***	14.23***	[0.17]	[0.00]	[0.00]	[0.00]	0.19
		(0.05)	(1.11)	(1.72)	(4.27)	(3.04)					
Energy	184	0.20***	0.67	-1.59	-15.99**	17.75***	[0.45]	[0.00]	[0.02]	[0.00]	0.09
		(0.07)	(1.68)	(2.47)	(6.86)	(4.47)					
Hi-tech	183	0.26***	-0.50	-4.49*	-12.61**	-1.23	[0.19]	[0.21]	[0.05]	[0.65]	0.02
		(0.07)	(1.63)	(2.56)	(5.92)	(6.79)					
Telecoms	182	0.13*	-1.20	-4.20	-16.30***	-1.44	[0.33]	[0.12]	[0.01]	[0.72]	0.04
		(0.07)	(1.59)	(2.59)	(5.92)	(7.37)					
Shops	183	0.18***	0.85	-3.17*	-21.11***	1.29	[0.66]	[0.00]	[0.00]	[0.42]	0.11
		(0.05)	(1.21)	(1.79)	(4.38)	(5.20)					
Health care	185	0.17***	-0.43	-3.82*	-7.67	6.38	[0.19]	[0.04]	[0.20]	[0.02]	0.02
		(0.06)	(1.47)	(2.14)	(5.40)	(3.94)					
Utilities	184	0.18***	-0.10	-3.51**	-14.72***	8.87***	[0.04]	[0.00]	[0.00]	[0.00]	0.14
		(0.04)	(0.93)	(1.37)	(3.90)	(2.57)					
Other	179	0.18***	-0.10	-2.50*	-18.06***	3.43	[0.14]	[0.00]	[0.00]	[0.16]	0.15
		(0.04)	(0.90)	(1.31)	(3.27)	(3.99)					

Table A3.4 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date and FOMC event-dates associated with employment report releases and unscheduled FOMC meetings are excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.5: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (bear-markets versus bull markets), robust MM-estimates, excluding employment

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Nondurables	201	0.12***	-0.97	-2.52**	-11.02***	0.44	[0.22]	[0.00]	[0.00]	[0.02]	0.07
		(0.04)	(0.70)	(1.05)	(3.38)	(0.73)					
Durables	199	0.14**	-0.99	-7.74***	-10.11	14.14***	[0.00]	[0.00]	[0.06]	[0.00]	0.18
		(0.06)	(1.01)	(1.51)	(4.76)	(3.41)					
Manufacturing	196	0.19***	0.16	-3.59***	4.82	1.86**	[0.01]	[0.61]	[0.42]	[0.00]	0.05
		(0.05)	(0.82)	(1.26)	(5.74)	(0.89)					
Energy	200	0.18**	1.80	0.23	-8.98	19.73***	[0.48]	[0.00]	[0.06]	[0.00]	0.11
		(0.07)	(1.11)	(1.96)	(5.63)	(4.11)					
Hi-tech	200	0.22***	-0.36	-12.99***	-8.11	16.11***	[0.00]	[0.00]	[0.15]	[0.00]	0.24
		(0.07)	(1.20)	(1.87)	(5.22)	(4.03)					
Telecoms	198	0.11	-1.74	-8.87***	-8.54	2.31*	[0.00]	[0.07]	[0.25]	[0.00]	0.13
		(0.07)	(1.15)	(1.79)	(5.84)	(1.21)					
Shops	199	0.17***	0.86	-4.92***	0.49	-0.53	[0.00]	[0.87]	[0.95]	[0.01]	0.06
		(0.05)	(0.88)	(1.29)	(6.01)	(0.90)					
Health care	202	0.14**	-0.77	-6.06***	-4.40	4.21***	[0.01]	[0.07]	[0.44]	[0.00]	0.11
		(0.06)	(1.11)	(1.61)	(4.63)	(1.18)					
Utilities	199	0.17***	-0.38	-4.99***	-11.56***	4.02***	[0.01]	[0.00]	[0.00]	[0.00]	0.21
		(0.04)	(0.61)	(1.69)	(3.16)	(0.68)					
Other	195	0.18***	-0.53	-3.11***	2.32	0.17	[0.03]	[0.64]	[0.53]	[0.01]	0.04
		(0.04)	(0.67)	(0.95)	(4.48)	(0.67)					

Table A3.5 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right)\left(1 - D_t^{state}\right) + \beta_2\left(1 - D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1 - D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date and FOMC event-dates associated with employment report releases are excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.6: Response of US industry sector returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence (bear-markets versus bull markets), robust MM-estimates, excluding employment and unscheduled

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Nondurables	183	0.13***	-0.59	-3.94**	-11.61***	3.38	[0.07]	[0.06]	[0.00]	[0.32]	0.08
		(0.04)	(0.86)	(1.66)	(3.17)	(7.11)					
Durables	182	0.16***	-1.11	-6.95***	-9.87**	-6.98	[0.04]	[0.81]	[0.08]	[0.99]	0.05
		(0.06)	(1.30)	(2.58)	(4.75)	(11.30)					
Manufacturing	180	0.20***	0.28	-5.61***	5.22	17.56***	[0.01]	[0.05]	[0.36]	[0.00]	0.16
		(0.05)	(0.99)	(2.09)	(5.32)	(3.26)					
Energy	184	0.17**	0.86	-4.28	-9.15	21.73***	[0.14]	[0.00]	[0.08]	[0.00]	0.09
		(0.07)	(1.54)	(3.14)	(5.58)	(5.24)					
Hi-tech	185	0.26***	-0.43	-9.16***	-7.72	-30.77***	[0.01]	[0.01]	[0.17]	[0.00]	0.13
		(0.07)	(1.51)	(3.20)	(5.08)	(6.84)					
Telecoms	182	0.15**	-1.30	-9.37***	10.41	-41.62***	[0.03]	[0.00]	[0.15]	[0.00]	0.21
		(0.07)	(1.48)	(3.39)	(7.92)	(6.48)					
Shops	182	0.19***	0.72	-4.89**	0.81	1.57	[0.02]	[0.95]	[0.99]	[0.53]	0.01
		(0.05)	(1.09)	(2.18)	(5.83)	(10.13)					
Health care	185	0.17***	-0.48	-5.71**	-4.17	-33.03***	[0.08]	[0.00]	[0.42]	[0.00]	0.15
		(0.06)	(1.34)	(2.66)	(4.41)	(6.01)					
Utilities	184	0.17***	-0.33	-5.10***	-11.18	2.43	[0.02]	[0.08]	[0.00]	[0.30]	0.08
		(0.04)	(0.86)	(1.75)	(3.25)	(7.10)					
Other	178	0.17***	-0.21	-3.57**	2.23	-40.36***	[0.06]	[0.00]	[0.58]	[0.00]	0.38
		(0.04)	(0.81)	(1.59)	(4.33)	(3.87)					

Table A3.6 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote stock returns for ten industry portfolios and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date and FOMC event-dates associated with employment report releases and unscheduled FOMC meetings are excluded from estimation. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.7: Response of US stock returns to unexpected FFR changes, controlling for the 2007-2009 crisis (Endogenous: Jan-08 to Mar-09) and state-dependence, robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	β_1=β_2	β_3=β_4	β_1=β_3	β_2=β_4	Adj R^2
Panel A (All Meetings)											
(a) Prob. Recession	210	0.22***	-2.28**	1.37	-2.39	17.33***	[0.33]	[0.01]	[0.96]	[0.02]	0.07
		(0.06)	(0.98)	(3.38)	(2.34)	(5.70)					
(b) BAA-10Yr TB Spread											
(c) S&P Bear Market	210	0.21***	-0.95	-8.08***	8.12	2.27**	[0.00]	[0.44]	[0.22]	[0.00]	0.12
		(0.06)	(0.86)	(1.57)	(7.41)	(1.14)					
Panel B (Excl Empl)											
(a) Prob. Recession	201	0.21***	-3.24***	-14.09***	-2.15	16.17***	[0.01]	[0.01]	[0.66]	[0.00]	0.19
		(0.06)	(1.08)	(3.59)	(2.24)	(5.58)					
(b) BAA-10Yr TB Spread											
(c) S&P Bear Market	201	0.21***	-2.34**	-8.05***	8.09	2.20**	[0.00]	[0.42]	[0.15]	[0.00]	0.15
		(0.06)	(1.03)	(1.52)	(7.16)	(1.10)					
Panel C (Excl Empl & Unsch)											
(a) Prob. Recession	184	0.25***	-1.30	-12.72*	7.47	28.25***	[0.10]	[0.26]	[0.42]	[0.00]	0.13
		(0.06)	(1.30)	(6.64)	(10.84)	(9.07)					
(b) BAA-10Yr TB Spread											
(c) S&P Bear Market	185	0.24***	-0.75	-7.08***	8.50	23.09***	[0.03]	[0.07]	[0.19]	[0.00]	0.17
		(0.06)	(1.29)	(2.56)	(6.86)	(4.13)					

Table A3.7 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right) + \beta_2\left(1-D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1-D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Jan-08 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as follows: (a) the real time recession probability indicator of Chauvet and Piger (2008) which is estimated using a dynamic factor Markov-switching model, (b) a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, (c) a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.8: Response of US stock returns to unexpected FFR changes, controlling for 2007-2009 crisis period, and state dependence (only outside the crisis), robust MM-estimates

	Obs	α	β_1	β_2	β_3	$\beta_1=\beta_2$	$\beta_2=\beta_3$	$(\beta_1+\beta_2)=\beta_3$	Adj R^2
Panel A (All Meetings)									
(a) Prob. Recession	209	0.20***	-1.86*	1.64	2.11*	[0.34]	[0.89]	[0.49]	0.02
		(0.06)	(0.95)	(3.31)	(1.08)				
(b) BAA-10Yr TB Spread	211	0.21***	-0.93	-8.27***	2.12*	[0.00]	[0.00]	[0.00]	0.19
		(0.06)	(0.98)	(1.19)	(1.10)				
(c) S&P Bear Market	210	0.20***	-0.69	-8.08***	2.12**	[0.00]	[0.00]	[0.00]	0.12
		(0.06)	(0.85)	(1.54)	(1.06)				
Panel B (Excl Empl)									
(a) Prob. Recession	201	0.19***	-2.87***	-14.59***	2.09*	[0.01]	[0.00]	[0.00]	0.16
		(0.06)	(1.08)	(3.59)	(1.08)				
(b) BAA-10Yr TB Spread	202	0.21***	-1.56	-9.42***	2.12*	[0.00]	[0.00]	[0.00]	0.24
		(0.06)	(1.13)	(1.20)	(1.08)				
(c) S&P Bear Market	201	0.20***	-2.00*	-8.07***	2.12**	[0.00]	[0.00]	[0.00]	0.14
		(0.06)	(1.04)	(1.53)	(1.05)				
Panel C (Excl Empl & Unsch)									
(a) Prob. Recession	183	0.25***	-0.75	-12.84*	18.48***	[0.08]	[0.00]	[0.00]	0.12
		(0.06)	(1.29)	(6.51)	(3.83)				
(b) BAA-10Yr TB Spread	184	0.26***	0.59	-5.84***	18.50***	[0.01]	[0.00]	[0.00]	0.14
		(0.06)	(1.43)	(2.00)	(3.79)				
(c) S&P Bear Market	184	0.26***	-0.23	-7.12***	18.50***	[0.02]	[0.00]	[0.00]	0.13
		(0.06)	(1.32)	(2.60)	(3.80)				

Table A3.8 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.8 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1-D_t^{crisis}\right)\left(1-D_t^{state}\right)+\beta_2\left(1-D_t^{crisis}\right)D_t^{state}+\beta_3 D_t^{crisis}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 crisis period and zero otherwise. D_t^{state} is defined as follows: (a) the real time recession probability indicator of Chauvet and Piger (2008) which is estimated using a dynamic factor Markov-switching model, (b) a dummy variable equal to one when the BAA – 10-year Treasury bond spread exceeds its full sample historical average, (c) a dummy variable equal to one when the S&P500 stock price index is lower than its full sample 3-year moving average and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively

Table A3.9: Response of US stock returns to unexpected FFR changes, controlling for state-dependence using the Pagan and Sossounov (2003) bear dummy (pre-crisis sample), robust MM-estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
(a) Pagan & Sossounov (2003)	168	0.16**	-0.86	-10.32***	[0.00]	0.28
		(0.06)	(0.82)	(1.25)		
Panel B (Excl Empl)						
(a) Pagan & Sossounov (2003)	158	0.17***	-2.34**	-5.37***	[0.17]	0.06
		(0.06)	(1.02)	(1.97)		
Panel C (Excl Empl & Unsch)						
(a) Pagan & Sossounov (2003)	143	0.18***	-1.10	-18.78***	[0.00]	0.17
		(0.06)	(1.17)	(3.42)		

Table A3.9 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.6 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{state}\right) + \beta_2\left(D_t^{state}\right)\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{state} is a dummy variable equal to one during bear markets using Pagan and Sossounov's (2003) dating algorithm and zero otherwise. The sample period is from Jun-89 to Aug-07. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A3.10: Response of US stock returns to unexpected FFR changes, controlling for the 2007-2009 crisis and state-dependence using the Pagan and Sossounov (2003) bear dummy 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) Pagan & Sossounov (2003)	211	0.19***	-0.78	-10.21***	-18.78***	2.42**	[0.00]	[0.00]	[0.00]	[0.00]	0.26
		(0.06)	(0.85)	(1.31)	(5.54)	(1.16)					
Panel B (Excl Empl)											
(a) Pagan & Sossounov (2003)	202	0.21***	-2.41**	-5.47***	2.08**	39.34***	[0.19]	[0.00]	[0.00]	[0.00]	0.20
		(0.06)	(1.05)	(2.08)	(1.05)	(6.82)					
Panel C (Excl Empl & Unsch)											
(a) Pagan & Sossounov (2003)	184	0.23***	-0.91	-18.75***	-18.49***	19.34***	[0.00]	[0.00]	[0.00]	[0.00]	0.26
		(0.06)	(1.22)	(3.61)	(5.20)	(3.72)					

Table A3.10 reports robust MM-Estimator weighted least squares estimates Yohai (1987) of Equation 3.7 on FOMC event-dates: $r_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right)\left(1 - D_t^{state}\right) + \beta_2\left(1 - D_t^{crisis}\right)D_t^{state} + \beta_3 D_t^{crisis}\left(1 - D_t^{state}\right) + \beta_4 D_t^{crisis} D_t^{state}\right]\Delta i_t^u + \varepsilon_t$, where r_t and Δi_t^u denote S&P500 stock returns and unexpected FFR changes respectively. D_t^{state} is a dummy variable equal to one during bear markets using Pagan and Sossounov's (2003) dating algorithm and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A, B, and C). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Panel C excludes FOMC event-dates associated with employment report releases and unscheduled FOMC meetings. P-Values from the Wald test for equality of coefficients (F-Statistic) are in square brackets. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Chapter 4: The US Treasury & Gold Market Reaction to Federal Funds Rate Surprises: Flight to Quality and the Financial Crisis (Empirical Analysis)

4.1 Abstract

This chapter investigates the impact of Federal Funds rate (FFR) surprises on US Treasury yield changes and spot gold returns from 1989 to 2012, with an emphasis on the effect of the 2007-2009 crisis. We demonstrate that outside the crisis period, 3-Month to 10-Year Treasury yields were associated with significant negative responses to unexpected FFR cuts. However there was an important shift in the relationship between US Treasuries and FFR shocks during the crisis. Our estimates show that US Treasury yields across the maturity spectrum from 3-Months to 30-Years responded significantly to FFR shocks, declining in response to unexpected FFR cuts. Furthermore, very short-term maturity (3-Month) and longer-term maturity (5-Year and 10-Year) Treasuries yielded significantly larger magnitude responses to FFR shocks during the crisis, while the 30-Year Treasury responded significantly to FFR shocks only during the crisis. This stronger reaction of the highly liquid 3-Month T-Bill and longer-term Treasury yields during the crisis period is indicative of flight to quality trading, as investors interpreted unexpected FFR cuts as FOMC signals of deteriorating financial and economic conditions, such cuts prompted higher demand for these safe-haven assets. To highlight this point, we demonstrate that gold, an alternative safe-haven asset, experienced significant gains following unexpected FFR cuts during the crisis. Our estimates are not significantly influenced by LSAP announcements, however longer-term maturity Treasuries are shown to respond significantly to these purchases.

4.2 Introduction

"*The flight to quality bid from all this subprime turmoil is likely to be ongoing and so push [US] Treasury yields even lower*" (Finch, 2007).

On 11th Dec 07, three months since the onset of the 2007-2009 crisis period, Bloomberg News headlined "*Treasuries rise most in three years as Fed rate cuts disappoint*" (Finestone and Hernandez, 2007) and Reuters News headlined "*Investors dump stocks after Fed's modest rate cut*" (Cooke, 2007). These headlines and the corresponding US Treasury and stock market reactions were prompted primarily by a 25 basis point target FFR cut by the

FOMC that afternoon. Following this cut, a fund manager in the US advocated that "*the flight-to-quality, flight-to-liquidity trade is going to continue*" (Finestone and Hernandez, 2007). From these headlines, we can infer that this FFR cut during the crisis triggered a rebalancing of investment portfolios away from falling equities and towards safe-haven assets such as US Treasuries. This market behaviour is consistent with flight to quality trading, where investors sell higher risk assets and purchase safe-haven securities such as US Treasuries and gold. In Chapter 3 we demonstrated that there was a non-positive stock response to unexpected FFR cuts during the crisis, as such cuts were interpreted as Fed signals of deteriorating financial and economic conditions. Having already documented the stock market response to FFR shocks during the crisis, we extend the analysis towards the US Treasury market in this Chapter (4).

As we explained in Section 2.9 and Section 2.10 of this Thesis, there is a growing empirical literature which evaluates the impact of non-conventional monetary policy measures on US Treasury yields over the crisis period, however there is a comparative dearth of studies investigating the impact of conventional monetary policy[127]. This is an important question because the FOMC initially responded to the crisis by using conventional monetary policy, i.e. target FFR cuts, to influence financial markets and the broader macroeconomy, and this tool was used as the primary tool of the FOMC throughout much of the crisis period. Non-conventional monetary policy was only employed because conventional monetary policy became increasingly ineffective as it approached the zero-lower bound towards the end of the crisis period.

Previous studies which evaluated the relationship between US Treasuries and conventional monetary policy prior to the 2007-2009 crisis period employed a range of empirical approaches to measuring *conventional* monetary policy shocks; from single-equation models, to VAR models and non-traditional techniques. There is significant overlap with the field of studies which analysed the relationship between US stock returns and conventional monetary policy shocks. Studies which employed single-equation models to investigate the relationship between US Treasuries and conventional monetary policy shocks widely utilised the event-study approach of Kuttner (2001) to disaggregate target FFR changes in to expected and unexpected components, gauging expectations from FFR futures contracts tracking the underlying instrument of the effective FFR. The single-equation framework of Gürkaynak, Sack and Swanson (2005) was also widely employed; whereby

[127] A similar conclusion was yielded by Cenesizoglu, Larocque and Normandin (2012)

conventional monetary policy shocks were decomposed in to the target and path factor, shown to be associated with unexpected FFR changes and FOMC statements concerning the future trajectory of monetary policy.

As the advent of FFR futures contracts in Oct-88 constrained the sample periods of these studies to a period following this date, many employed alternative empirical approaches to measuring conventional monetary policy shocks. These included the VAR approach, which measured FFR shocks in terms of orthogonalised innovations in the monetary instrument targeted by the Fed, or using non-traditional approaches such as that employed by Thorbecke and Zhang (2008) which measured FFR shocks as the differences between target FFR changes and estimates from a prediction equation using a range of macroeconomic variables. Rudebusch (1998) demonstrated that VAR measures of monetary shocks were at odds with the Fed's descriptions of monetary policy actions, and the prediction equation approach assumed that regressions of macroeconomic variables on target FFR changes were an adequate representation of expectations of changes in conventional monetary policy (see Section 2.4.3). However, as Berument and Froyen (2006) alluded to, although these measures were not as efficient as market-based measures of FFR shocks, they were the only main alternative for very long-run analyses of the relationship between US Treasuries and monetary policy shocks.

Overall, it is important to note that regardless of the empirical approach employed for defining conventional monetary policy shocks, these pre-crisis studies widely demonstrated that the US Treasury market response to conventional monetary policy shocks was larger for shorter-term maturity Treasuries, and smaller for longer-term maturity Treasuries, with the impact declining monotonically in magnitude and statistical significance as the term to maturity increased (see Gürkaynak, Sack and Swanson, 2005; Kuttner, 2001; Thorbecke and Zhang, 2008; Thornton, 2009). In fact, very long-term maturity Treasuries were widely shown to yield statistically *insignificant* responses to conventional monetary policy shocks (see Berument and Froyen, 2006; Gürkaynak, Sack and Swanson, 2005; Kuttner, 2001; Thornton, 2009). Furthermore, longer-term maturity Treasuries were shown to yield statistically *significant* responses to the path factor which was shown to be associated with FOMC statements (see Gürkaynak, Sack and Swanson, 2005)[128]. Nevertheless, different studies yielded contrasting evidence for a significant or insignificant reaction of 10-Year Treasuries to conventional monetary policy shocks. Berument and Froyen (2008)

[128] This is in contrast to stock returns which were shown to yield statistically insignificant responses to the path factor

comprehensively surveyed these studies and demonstrated that the estimates yielded were contingent upon the measurement of monetary policy, and the sample periods considered.

In contrast to the pre-crisis studies, we find that more recent studies which investigate the impact of FFR shocks on US Treasuries over sample periods which extend in to or beyond the 2007-2009 crisis period uniformly document statistically significant responses for the 10-Year Treasury (see Farka and DaSilva, 2011; Farka and Fleissig, 2012; Demiralp and Yilmaz, 2012; Rosa, 2012; Bauer and Neely, 2012) [129] [130]. These studies also widely demonstrate that longer-term maturity Treasury yields declined in response to LSAP purchases by the FOMC (see Rosa, 2012; Szczerbowizcz, 2011; Wright, 2011). Nevertheless, the focus of these studies is primarily on the impact of non-conventional monetary policy on US Treasuries. For a more detailed discussion of these studies, we refer the reader to Section 2.10[131].

In this chapter, we empirically investigate the impact of Federal Funds rate (FFR) surprises on US Treasury yield changes and spot gold returns over the Jun-89 to Dec-12 sample period, with an emphasis on the effect of the 2007-2009 crisis on this relationship. We also control for non-conventional monetary policy such as more explicit use of forward guidance by the FOMC and large-scale asset purchase (LSAP) programmes. Our results can be summarised as follows. Firstly, in line with Kuttner (2001), we find that US Treasury yields are associated with larger magnitude responses to unexpected FFR changes compared to raw target FFR changes. However the relationship between US Treasuries and unexpected FFR changes is shown to be characterised by a large number of outlier observations. We account for these outliers using the robust MM-Estimator weighted least squares approach of Yohai (1987) which has been shown to be highly robust towards large numbers of outliers (see Verardi and Croux, 2010). Using this approach, we find that 3-Month to 30-Year Treasuries respond significantly to unexpected FFR changes from 1989 to 2012. These

[129] In Chapter 2, we review empirical studies which investigated the relationship between US Treasuries and conventional monetary policy shocks over sample periods which extended in to or beyond the 2007-2009 crisis period.

[130] The Fed began utilising more non-conventional forms of monetary policy such as forward guidance through FOMC statements concerning the future trajectory of monetary policy and the economy, and through LSAP purchases. One may therefore argue that the statistical significance of the 10-Year Treasury may have been attributable to these measures, however a study by Rosa (2012) constructed measures of both factor and demonstrated that the response of US Treasuries to FFR shocks persisted regardless.

[131] For a more detailed discussion of these studies we refer the reader to Section 2.10. We would like to point out that at the time of writing this empirical chapter, there were only five such working papers available (see Beechey and Wright, 2009; Demiralp and Yilmaz, 2009; Farka and DaSilva, 2009; Lucca and Trebbi, 2009; Szczerbowicz, 2011); however we evaluate empirical conclusions from studies dated up to 2012.

estimates are shown to be consistent with estimates yielded by Demiralp and Yilmaz (2012) in a recent study.

Secondly, we demonstrate that our initial estimates are biased as they do not account for structural change in the relationship during the 2007-2009 crisis period, and do not control for non-conventional monetary policy measures employed by the FOMC when the target FFR approached the zero-lower bound. Our estimates show that 3-Month to 10-Year Treasuries respond significantly to FFR shocks outside the crisis period. However 3-Month to 30-Year Treasury yields respond significantly to FFR shocks during the crisis period, declining in response to unexpected FFR cuts. We contribute to the existing literature by highlighting that there was an important shift in the relationship between US Treasuries and FFR shocks during the crisis period. In particular, we find that very short-term maturity (3-Month) and longer-term maturity (5-Year and 10-Year) Treasuries are associated with significantly larger magnitude responses to FFR shocks during the crisis, and the 30-Year Treasury responds to FFR shocks only during the crisis.

This stronger reaction of the highly liquid 3-Month T-Bill and longer-term maturity Treasury yields to FFR shocks during the crisis is indicative of flight to quality trading, and consistent with our hypothesis that unexpected FFR cuts during the crisis were interpreted as signals from the Fed of declining financial and economic conditions, 'bad news' for the economy, thereby prompting higher demand for safe-haven assets[132]. This explains the stronger reaction of the 3-Month T-Bill to FFR shocks during the crisis, as it is one of the most highly liquid financial securities in the world and widely perceived to be a safe-haven asset. The stronger reaction of longer-term maturity (5-Year to 30-Year) Treasuries to FFR shocks during the crisis implies that market participants anticipated a prolonged economic downturn, and invested in these longer-term, lower-yielding, lower-risk assets.

In line with previous studies (see Farka and Fleissig, 2012; Gürkaynak, Sack and Swanson, 2005), we find that the impact of FOMC statements dominates the impact of FFR shocks for 2-Year to 30-Year Treasuries. Intermediate-term (2-Year and 5-Year) Treasuries exhibit the largest magnitude responses to FOMC statements compared to shorter-term (3-Month and 6-Month) and longer-term (10-Year and 30-Year) Treasuries. We also find that longer-term maturity Treasuries respond significantly to LSAP programmes.

[132] It is also consistent with estimates in Chapter 3 which demonstrated that US stocks did not respond positively to unexpected FFR cuts during the crisis, and implies that investors reallocated capital away from equities to safe-haven assets.

Thirdly, we extend our investigation to the gold market, as this commodity is widely perceived to be a safe-haven asset during times of uncertainty, a hedge against inflation and a store of value. We find that outside the crisis, gold returns do not respond significantly to FFR shocks. However, an unexpected 25 basis point FFR cut during the crisis is associated with a roughly 3% increase in gold returns. Interestingly, gold returns are also shown to increase by roughly 1% following LSAP announcements by the FOMC. These estimates are consistent with flight to quality trading during the crisis, following unexpected FFR cuts.

This chapter is structured as follows: in Section 4.3 we describe the dataset and sample period, in Section 4.4 we evaluate the econometric models and results, and finally in Section 4.5 we conclude the chapter.

4.3 Data and sample period

4.3.1 Measuring conventional monetary policy shocks

In this section we describe the dataset used in the empirical analysis. We measure conventional monetary policy shocks using the event-study approach of Bernanke and Kuttner (2005), decomposing target FFR changes in to expected and unexpected components by gauging expectations from implied rates of CBOT futures contracts tracking the underlying instrument of the effective FFR. Our dataset includes a set of event-dates with 189 scheduled FOMC meetings and 24 unscheduled FOMC meetings with target FFR changes over the Jun-89 to Dec-12 sample period. We refer the reader to Section 3.5.1 and Section 3.5.2 for a more detailed discussion concerning the measurement of these conventional monetary policy shocks, and for an analysis of the related descriptive statistics.

4.3.2 Asset price data

To evaluate the impact of conventional monetary policy shocks on US Treasuries across the maturity spectrum, we consider quotes for yields to maturity y_t on the most recently issued on the run US Treasuries on FOMC meeting dates relative to those the previous day y_{t-1} (Equation 4.1). In our analysis we include the 3-Month and 6-Month maturity Treasury bills; and the 2-Year, 5-Year, 10-Year and 30-Year maturity Treasury bonds.

$$\Delta y_t = y_t - y_{t-1}, \tag{4.1}$$

The US Treasury discontinued auction of the 12-Month maturity Treasury for the Feb-01 to Mar-08 period, the 3-Year maturity Treasury for the May-07 to Nov-08 period, and the 7-Year maturity Treasury for the Jul-93 to Feb-09 period[133]. We do not investigate the impact of FFR shocks on these three Treasuries because they ceased trading on the open market for a significant proportion of the 2007-2009 crisis period. Although several previous studies have extrapolated the yields on these Treasuries using related securities, we exclude these Treasuries from our study, as the artificial construction of these yields may impose bias upon our estimation. To evaluate the impact of conventional monetary policy shocks on spot gold returns, we define gold returns g_t^{ret} as the first difference of the natural log of the spot gold price g_t^p on the close of each FOMC meeting, relative to the previous trading day g_{t-1}^p (Equation 4.2).

$$g_t^{ret} = 100 * \left(\ln g_t^p - \ln g_{t-1}^p \right), \qquad (4.2)$$

4.3.3 Non-conventional monetary policy

The primary focus of this chapter is to investigate the impact of *conventional* monetary policy shocks on US Treasuries over the 2007-2009 crisis period, however it is important to recognise that the FOMC also employed *non-conventional* monetary policy measures over this period. The limits of conventional monetary policy were realised on the 16th Dec 08 when the FOMC cut the target FFR by 75 basis points, effectively pushing it towards the zero-lower bound. In response to the impotence of conventional monetary policy at this level, the Fed employed more non-conventional forms of monetary policy such as increasing and more explicit use of *forward guidance* and *large-scale asset purchases* to influence financial, monetary and economic conditions in the broader macroeconomy. Thus to investigate the overall influence of conventional monetary policy shocks on US Treasury yield changes over the crisis period, one must control for the potential effects of alternative non-conventional monetary policy measures.

4.3.4 Controlling for non-conventional monetary policy: forward guidance

The term '*forward guidance*' traditionally refers to FOMC statements concerning the future trajectory of monetary policy and the future economic outlook. These statements have

[133] Hence there is a gap in the data for the 12-Month (3-Year) Treasury for the Aug-01 to Jun-08 (Nov-07 to Nov-08) period.

significantly evolved over time; hence it is important to understand the history of this measure to understand how it came to be a non-conventional form of monetary policy in its own right. Prior to Feb-94, target FFR changes by the FOMC were primarily inferred by market participants through open market operations of the Federal Reserve Bank of New York Trading Desk as well as subsequent news reports in the financial media and press (see Kuttner, 2003). After Feb-94, the FOMC began issuing press-release statements, explicitly outlining the target FFR change undertaken in each meeting. These statements provided financial markets with a clear indication of the target FFR level, allowed for greater transparency of central bank action, and increased communication with financial markets and the broader public. They adopted a procedure whereby statements were released at around 2:15pm Eastern Time Zone[134] following target FFR changes, hence market participants widely followed these early FOMC statements.

From May-99, the FOMC began issuing statements following all monetary policy meetings, regardless of whether the target FFR changed. The character of these statements also changed, as they not only conveyed the rationale behind decisions, but also commented on the likely future path of monetary policy; known as the 'policy tilt' (Rasche and Thornton, 2002). These statements were widely interpreted by market participants as being firm commitments on future monetary policy, and this created confusion when actual target FFR changes and non-changes occurred at FOMC meetings (see Farka and Fleissig, 2012). The future monetary policy comments were subsequently replaced by comments concerning Fed macroeconomic objectives concerning output and inflation; known as the 'balance of risk assessment' (see Rasche and Thornton, 2002). These comments indirectly indicated the future trajectory of monetary policy without explicitly referring to potential future monetary policy changes by the FOMC. By Aug-03, the statements had become increasingly characterised by 'forward looking language' which more directly conveyed information concerning the likely future trajectory of monetary policy (see Carlstrom and Fuerst, 2005).

It is thus apparent that FOMC statements had evolved over time to encompass several important features; they explicitly outlined the rationale behind monetary policy decisions, they contained language which evaluated economic risks and the economic outlook, and often included an evaluation of the likely future trajectory of monetary policy. The information contained within these statements collectively became known as *forward guidance*. By 2008, when the target FFR approached the zero-lower bound, the FOMC

[134] In practice the FOMC issued statements within several minutes of this target, however many unscheduled target FFR changes occurred outside this time period.

increasingly used forward guidance through statements to influence market-rates and expectations concerning the future trajectory of monetary policy.

For example, surveys of professional forecasters in Aug-11 indicated that private sector economists expected the target FFR to be increased within the next year (Williams, 2012). As the target FFR was at the zero-lower bound, the FOMC issued the following statement following a scheduled meeting on 9th Aug 11: "*The Committee currently anticipates that economic conditions--including low rates of resource utilization and a subdued outlook for inflation over the medium run--are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013*" (Federal Reserve Website, 2011). This statement explicitly stated the intention of the FOMC to maintain the target FFR at the zero-lower bound until mid-2013. It led to revisions in expectations of economists and market expectations, resulting in a significant decline in US Treasury yields, between 10-20 basis point (see Williams, 2012). Thus, the FOMC effectively used forward guidance through an FOMC statement to influence financial markets and thus the broader macroeconomy.

To measure forward guidance by the FOMC, studies have employed a range of empirical approaches. Farka and Fleissig (2012) interpreted news reports from Reuters, Bloomberg and the Wall Street Journal following FOMC statements to "*assess the importance of the information content of FOMC statements as perceived by the consensus view at the time of release.*" They subsequently constructed a dummy variable equal to one when the consensus view from news reports indicated that the statement revealed new information concerning monetary policy or the economic outlook, or equal to zero when it revealed information expressed in previous statements[135]. In a related study, Rosa (2012) also interpreted news reports following FOMC statements however constructed an indicator variable which measured whether the tone of each statement was more hawkish, dovish or neutral compared to previous statements. This yielded an alternative indicator of forward guidance by the FOMC. It is important to note that Farka and Fleissig (2012) and Rosa (2012) employed a subjective interpretation of news reports following each FOMC statement (see Section 2.7.3 for a more detailed discussion). These studies explicitly acknowledged the limitations of this approach to measuring forward guidance by the FOMC and characterised it

[135] Farka and Fleissig (2012) define their statement indicator as being equal to one when "the statements reveal: (a) important information about the near-term path of monetary policy; (b) a change in the Fed's assessment of the economic outlook; or (c) changes in the wording of key phrases (such as 'policy bias' or 'balance-of-risk') compared with a preceding release. In contrast, the indicator assumes a value of zero when a statement is an (almost) exact replica of a previous one."

as involving a "*measure of subjectivity since it is based on our own judgment of the reading of the newswire reports*" (Farka and Fleissig, 2012).

An alternative approach [136] to measuring forward guidance was developed by Gürkaynak, Sack and Swanson (2005). In lieu of subjectively interpreting news reports following FOMC meetings, they used a principal components analysis to construct target and path factor measures (see Section 2.6.2). They demonstrated that the target factor reflected conventional monetary policy shocks, unexpected FFR changes, akin to the measure of Kuttner (2001). The path factor was structurally interpreted as reflecting the future path of monetary policy, and was shown to be closely associated with the impact of FOMC statements[137]. More recently, Wongswan (2009) adapted the approach of Gürkaynak, Sack and Swanson (2005) to measuring forward guidance by the FOMC. In this chapter, we define the path factor using this approach. Wongswan (2009) amongst others[138], defined the path factor as the component of the change in the implied rate of the four quarter ahead Eurodollar futures contract $\Delta EDQ4$ on FOMC meeting dates, orthogonal to Kuttner's (2001) measure of unexpected FFR changes Δi_u (Equation 4.3).

$$\Delta EDQ4_t = \alpha + \beta_1 \Delta i_u + \varepsilon_t \,, \tag{4.3}$$

The path factor is thus estimated as the residual from a regression of Equation 4.3. This measure of forward guidance reflects all news which moves implied Eurodollar futures rates for the upcoming year on FOMC meeting dates without affecting conventional monetary policy shocks. In particular, it corresponds to "*news that market participants have learned from the FOMC's statement about the expected future path of policy over and above what they have learned about the level of the target rate*" (Wongswan, 2009). More recent

[136] A range of empirical approaches have been employed by studies to measure non-conventional monetary policy. Gertler and Karadi (2011) defined non-conventional monetary policy in terms of the amount of direct lending by the Fed to private markets. However, Gambacorta, Hofman and Peersman (2012) argued that the total amount of central bank assets were a more appropriate measure for non-conventional monetary policy. Although the Fed's balance sheet was widely used as a measure of non-conventional monetary policy, Wright (2012) concedes that there is difficulty in distinguishing between anticipated and unanticipated components of forward guidance and LSAP announcements by the FOMC. In contrast to these studies, Hanson and Stein (2012) measured non-conventional monetary policy using one-day changes in 2-Year Treasury yields and a similar approach is employed by Gilchrist, López-Salido and Zakrajšek (2013). Given that the Fed aimed to influence longer-term Treasury yields, one could also measure non-conventional monetary policy in terms of the total reduction in the 10-Year Treasury yield over the year.

[137] As Gürkaynak, Sack and Swanson (2005) made their dataset available online in a data appendix, the majority of studies directly used their dataset which spanned the Feb-90 to Dec-04 sample period. To the best of our knowledge, Kurov (2012) was the only study to replicate the principal components analysis approach to measuring the target and path factors.

[138] See Hausman and Wongswan (2011) and Eijffinger, Mahieu and Raes (2012)

studies which have employed this approach to measuring the path factor have argued that it is more intuitive to interpret and econometrically more concise in its construction.

4.3.5 Controlling for non-conventional monetary policy: large-scale asset purchase programmes (QE1, QE2, Operation Twist and QE3)

As conventional monetary policy approached the zero-lower bound in 2008, the Fed not only increasingly used forward guidance through FOMC statements, but also began a series of *large-scale asset purchase* programmes to stimulate the economy. This non-conventional monetary policy tool was designed to influence market rates, as well as monetary, financial and economic conditions. The Fed conducted these LSAP programmes by purchasing longer-term maturity securities such as housing-agency debt, mortgage-backed securities, and US Treasuries directly from the open market in an effort to reduce supply, increase prices and thereby lower market inferred rates and yields. The investors which sold their securities to the Fed would then invest their money elsewhere, thereby stimulating investor demand for alternative securities. Furthermore, the lower market inferred rates were also intended to lower mortgage-rates and borrowing rates of households, thereby boosting economic activity (see Williams, 2012).

On the 25th Nov 08, the Fed announced QE1, a plan to purchase $500billion in agency mortgage backed securities (AMBS) and $100billion in agency-debt, and on 15th Dec 08, this was officially implemented. The FOMC announced their plan to extend QE1 by purchasing a further $750billion in AMBS, $100billion in agency-debt and $300billion in longer-term maturity Treasuries on 18th Mar 09. At a meeting in Jackson Hole on 27th Aug 10, Bernanke indicated that a programme of QE2 may be implemented and on 3rd Nov 10 the FOMC announced their plan to purchase $600billion in longer-term maturity Treasuries. On 21st Sep 11, the FOMC announced 'Operation Twist,' an intention to purchase $400billion in longer-term maturity Treasuries, financed by selling shorter-term maturity Treasuries. They announced their intention to extend this programme by $267billion on 20th Jun 12. Finally, on the 13th Sep 12, the FOMC announced a programme of QE3, a plan to purchase $40billion a month in AMBS. They extended this programme by purchasing $40billion in AMBS and $45billion in longer-term maturity Treasuries on 12th Dec 12. To control for the impact of LSAP announcements on our estimates, we construct a dummy variable D_t^{LSAP} equal to one when announcements relating to QE1, QE2, Operation Twist and QE3 purchases coincide with FOMC event-dates in our dataset. These dates are outlined in detail in Table 4.1.

4.3.6 Descriptive statistics

We report descriptive statistics for US Treasury yield changes and spot gold returns on FOMC event-dates in Table 4.2. The average yield change is negative across all Treasuries, and declines monotonically in magnitude as the term to maturity is increased, from -2.13 basis points with the 3-Month Treasury to -0.55 basis points with the 30-Year Treasury. The range of yield changes is also non-symmetric, with the largest yield declines (min) being of greater magnitude than the largest yield increases (max). For gold returns, the average changes on FOMC event-dates is 0.17% and ranges from a minimum of -2.73% to 3.45%.

4.3.7 Preliminary graphical analysis

In Figure 4.1, we plot US Treasury yields and the target FFR using daily data over the Jun-89 to Dec-12 sample period. The shaded area corresponds to periods associated with NBER recession dates. We find that US Treasury yields across the maturity typically decline during recessionary periods. There is a significant degree of co-movement between US Treasuries of varying maturity, and the shorter-term maturity 3-Month and 6-Month Treasury bill yields (shown in blue and red respectively) very closely follow the target FFR. At first glance, one may therefore expect that if there is an unexpected change in the target FFR, then shorter-term maturity Treasuries would also respond, with a less pronounced effect on Treasuries of longer-term maturity.

4.4 Econometric models and results

4.4.1 Preliminary estimates

Throughout this section we empirically investigate the relationship between US Treasury yield changes and FFR shocks over the Jun-89 to Dec-12 sample, with a particular emphasis on the impact of the 2007-2009 crisis period. In the spirit of earlier research by Cook and Hahn (1989), we begin by estimating the impact of raw target FFR changes Δi_t on US Treasury yield changes over FOMC event-dates (Equation 4.4). Consistent with previous studies, we utilise all scheduled FOMC meetings (189) and unscheduled FOMC meetings with target FFR changes (24). Our sample covers the Jun-89 to Dec-12 period and excludes the 17th Sep 01 observation from all estimates.

$$\Delta y_t = \alpha + \beta_1 \Delta i_t + \varepsilon_t \tag{4.4}$$

We present OLS estimates of Equation 4.4 with Newey-West robust standard errors in Table 4.3. The full sample estimates in Panel A show that 3-Month to 5-Year Treasury yields are associated with statistically *significant* negative (positive) responses to target FFR cuts (increases). However longer-term maturity 10-Year and 30-Year Treasuries are associated with statistically *insignificant* responses to target FFR changes. The magnitude of response as shown by the β_1 coefficient is shown to monotonically decline in magnitude and statistical significance as the term to maturity is increased. The magnitude of each coefficient is very similar that documented by Kuttner (2001) for the Jun-89 to Feb-00 sample period.

In Table 4.3 Panel B, we re-estimate Equation 4.4 with Newey-West robust standard errors however we exclude event-dates associated with employment release reports. This is motivated by the fact that on eight occasions between 1989 and 1992, target FFR decisions occurred several hours following employment release reports by the Bureau of Labor Statistics. Rudebusch (1998) argued that target FFR decisions on these dates may in fact have reflected endogenous responses by the FOMC to these reports. To determine the sensitivity of our estimates to these observations, we exclude these event-dates from estimation in Panel B of each table in this chapter. In Table 4.3 Panel B we find that our estimates are indeed sensitive to this model specification. We now find that 3-Month to 2-Year Treasury yields associated with statistically *significant* negative (positive) responses to target FFR changes, whilst 5-Year to 30-Year Treasuries are associated with statistically *insignificant* responses.

Having evaluated the impact of raw target FFR changes on US Treasury yields over FOMC event-dates, we continue to decompose this broad measure of conventional monetary policy in to its constituent components concerning expected and unexpected FFR changes using the technique of Kuttner (2001). We subsequently estimate the impact of unexpected FFR changes Δi_t^u on US Treasury yield changes (Equation 4.5). In line with previous studies we focus on the unanticipated component of FFR changes (see Farka and DaSilva, 2011; Farka and Fleissig, 2012; Rosa, 2012; Szczerbowicz, 2011; Thorbecke and Zhang, 2008; Thornton, 2009)[139].

$$\Delta y_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t , \tag{4.5}$$

In Table 4.4 we report OLS estimates of Equation 4.4 with Newey-West robust standard errors. The β_1 coefficient now measures the US Treasury yield response to

[139] This is motivated by the premise that asset prices respond to the unanticipated component of FFR changes, as the anticipated component would already be factored in to asset prices in efficient markets.

unexpected FFR changes for each Treasury. We find that 3-Month to 10-Year Treasuries are associated with statistically *significant* responses to FFR shocks however the 30-Year Treasury is associated with a statistically *insignificant* response. In particular, a hypothetical unexpected 1% FFR cut is associated with a 58.64 (19.72) basis point decline in the yield of the 3-Month (10-Year) Treasury. This evidence is consistent with Kuttner (2001) who similarly demonstrates that 3-Month to 10-Year Treasuries respond significantly to FFR shocks whilst the 30-Year Treasury does not[140]. We also find that these empirical conclusions are not qualitatively changed in Panel B when excluding event-dates associated with employment release reports. Overall we find that unexpected FFR changes explain significantly more variation in US Treasury yield changes compared to raw target FFR changes. Furthermore, across all US Treasuries, the magnitude of response to unexpected FFR changes is shown to be greater in magnitude than the response to raw target FFR changes by more than a factor of two.

At first glance, the estimates presented in Table 4.4 appear to be well specified as they are consistent with estimates by Kuttner (2001) and robust to excluding event-dates associated with employment release reports. Nevertheless, previous studies have demonstrated that the relationship between asset prices and FFR shocks is characterised by influential outlier observations (see Bernanke and Kuttner, 2005; Basistha and Kurov, 2008), and we similarly demonstrated in Chapter 3 that the relationship between US stock returns and FFR shocks was characterised by outlier observations. In Table 4.5 we list large outlier observations in estimates of Equation 4.4 using the Difference in Fits statistic of Welsh and Kuh (1977). As we expected, the relationship between US Treasuries and FFR shocks is characterised by a large number of outlier observations. For example, the relationship between the 3-Month (2-Year) Treasury and FFR shocks is characterised by 11 (18) large outliers.

In light of these concerns, to account for potential outliers in the relationship between US Treasuries and FFR shocks, we use the robust MM-Estimator weighted least squares methodology of Yohai (1987). This approach has been shown to be highly robust towards vertical outliers and leverage point outliers, as well as clusters of outliers. It has also been shown to be exhibit a high-breakdown point with higher Gaussian efficiency compared to classical OLS models (see Verardi and Croux, 2010). Thus in Table 4.6 we report robust MM-Estimator weighted least squares estimates of Equation 4.4 over the Jun-89 to Dec-12

[140] See Table 5 in Kuttner (2001).

sample period. Interestingly we now find that US Treasuries across the term structure from 3-Months to 30-Years are associated with statistically *significant* responses to FFR shocks. In contrast to previous studies, the US Treasury response to FFR shocks β_1, is shown be highly significant at the 1% level for each Treasury across the maturity spectrum. Furthermore, the magnitude and statistical significance of the β_1 coefficient is shown to monotonically decline in magnitude as the term to maturity is increased. We find that a hypothetical unexpected 1% FFR cut is associated with a 73.48 (14.96) basis point decline in the 3-Month (30-Year) Treasury yield.

Upon accounting for outlier observations using robust MM-Estimator weighted least squares, we now find that unexpected FFR changes explain 76% (7%) of the one-day variation in 3-Month (30-Year) Treasury yield changes on FOMC event-dates, however only explained 44% (2%) of the variation when using OLS estimation in Table 4.4. This is a significant improvement in the overall fit of each estimated model. Furthermore, the estimates presented in Panel A are highly robust to the exclusion of event-dates associated with employment release reports as shown in Panel B, as we continue to find that 3-Month to 30-Year Treasuries respond significantly to FFR shocks at the 1% level in each case. The coefficient estimates in Panel A and Panel B are also shown to differ by only 1 to 5 basis points in each case which demonstrates the robustness of the estimates presented.

4.4.2 Flight to quality during the 2007-2009 financial crisis

Previous studies which evaluated the relationship between US Treasuries and conventional monetary shocks prior to the 2007-2009 crisis period widely yielded conflicting evidence for a statistically *significant* or *insignificant* response for the 10-Year Treasury (see Berument and Froyen, 2008). In contrast, more recent studies which estimated the relationship over a sample period which extended in to or beyond the crisis period widely documented a statistically *significant* response for the 10-Year Treasury to conventional monetary policy shocks (see Bauer and Neely, 2012; Demiralp and Yilmaz, 2012; Farka and DaSilva, 2011; Rosa, 2012; Szczerbowicz, 2011). Furthermore, whilst Kuttner (2001) found that the relationship between the 30-Year Treasury and FFR shocks was statistically *insignificant* for the Jun-89 to Feb-00 period, a more recent study by Demiralp and Yilmaz (2012) yielded stronger evidence for a *significant* relationship between the 30-Year Treasury and FFR shocks over the Jun-89 to Nov-09 period[141]. Thus, whilst pre-crisis studies widely demonstrated that the relationship between longer-term maturity Treasuries and FFR shocks was statistically *insignificant*, studies which considered sample periods which extended in to or beyond the 2007-2009 crisis documented *significant* relationships. However these previous studies did not differentiate between the US Treasury response to FFR shocks during and outside the crisis period.

In light of this evidence, we continue our analysis by investigating whether the relationship between US Treasuries and FFR shocks was markedly different during the 2007-2009 crisis period. We show in Figure 4.2 the unexpected FFR change coefficient from rolling regressions of Equation 4.4 which is estimated using robust MM-Estimator weighted least squares on FOMC event-dates, for each of the US Treasuries. The graphs use a 60 observation rolling window and we also plot the 95% confidence intervals and highlight the crisis period[142]. It is immediately apparent that there is markedly larger magnitude US Treasury response to FFR shocks during the crisis period for most Treasuries. In fact, we find a markedly larger magnitude response to FFR shocks for 3-Month, 2-Year, 5-Year, 10-Year and 30-Year Treasuries during the crisis period however we see a less clear cut shift for the 6-Month Treasury. For example, the graph shows that the 3-Month Treasury yield declines around 60 basis points in response to a hypothetical unexpected 1% FFR cut, however during the crisis period it declined around 70 basis points. The magnitude of the coefficient is also in line with pre-crisis and crisis studies (see Kuttner, 2001; Rosa, 2012).

These preliminary estimates are indicative of flight to quality trading during the 2007-2009 crisis period. Flight to quality is when investors move capital away from riskier financial assets towards safe-haven securities such as US Treasuries and gold, typically during periods of significant financial and economic uncertainty. Flight to quality would therefore imply a stronger US Treasury yield response to FFR shocks as investors flee riskier assets and increase their demand for these safe-haven assets[143]. The graphs in Figure 4.2 indeed demonstrate that US Treasuries exhibit a larger magnitude response to FFR shocks during the crisis period compared to outside the crisis (non-crisis) period. Nevertheless, this does not imply there is a statistically significant difference in US Treasury response to FFR

[141] Demiralp and Yilmaz (2012) found that the 30-Year Treasury did not respond significantly to current month FFR shocks however responded significantly at the 10% level to one-month ahead FFR shocks using OLS estimation with Newey-West robust standard errors.

[142] We highlight the crisis period for Sep-07 to Mar-09, and this definition will be outlined in more detail later.

[143] For example when financial markets in the US opened following the 11th Sep 01 attacks, gold prices jumped from $215 an ounce to $287 an ounce as investors sold riskier assets in favour of safe-haven securities.

shocks during the crisis compared to that outside the crisis period, for which we need to estimate another model.

Having gained some preliminary insights in to the relationship between US Treasuries and FFR shocks during the crisis period, we continue to evaluate whether the relationship between US Treasuries and conventional monetary policy shocks was markedly different during the 2007-2009 crisis period compared to that outside the crisis (non-crisis) period. More specifically, we interact unexpected FFR changes with a crisis dummy variable $\left(D_t^{crisis}\right)$ set equal to one during the crisis period and zero otherwise (Equation 4.6). This allows us to compare the response of US Treasuries to FFR shocks during the crisis period β_2 and outside the crisis period β_1.

$$\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t, \qquad (4.6)$$

Before we estimate the model outlined in Equation 4.6, it is important to define how we date the *financial crisis* period. In Chapter 3 we dated the financial crisis to the Sep-07 to Mar-09 sample period, motivated by several monetary, financial and economic events which transpired during the crisis. The dating of the financial crisis to September 2007 is primarily motivated by the fact that it was the characterised by the first target FFR cut by the FOMC since Jun-03. The -0.50% target FFR cut was also less 'gradualist' than previous target FFR changes, and this uncharacteristically large cut in response to the crisis implicitly represented an acknowledgement by the Fed that financial and economic conditions were significantly deteriorating. This is further reflected by comments made by Alan Greenspan in September 2007 that there was "*froth*" in the US housing sector, which he revealed to the Financial Times as being a euphemism for a bubble. He also added that housing market declines would be in "*double digits*" and indicated that the crisis would be "*larger than most people expect[ed]*" (Guha, 2007). In terms of market interest rates, the LIBOR rate reached 6.7975% in Sep-07, the highest rate since Dec-98, indicative of significant interbank stress. We date the end of the financial crisis to Mar-09, when the S&P500 Index reached its lowest level throughout the crisis period and began its recovery. The dating of the crisis period to the Sep-07 to Mar-09 sample period is also consistent with market indicators as we find that the TED spread exceeded its historical average over the Jun-89 to Dec-12 sample period by a factor of two over this period[144]. As a robustness check we also consider an alternative definition for the economic crisis associated with the financial crisis using dates from the NBER.

[144] It is important to reiterate that this chapter seeks to evaluate whether there was a stronger US Treasury reaction to FFR shocks during the crisis period, in line with flight to quality trading arguments. In Chapter 3 we

In Table 4.7 Panel A we estimate Equation 4.6 using robust MM-Estimator weighted least squares over the Jun-89 to Dec-12 sample. The β_2 coefficient measures the US Treasury yield response to FFR shocks *during the crisis* period, from Sep-07 to Mar-09, and the β_1 coefficient measures the response *outside the crisis* (non-crisis). Interestingly, we find that a hypothetical unexpected 1% FFR cut is associated with a statistically significant 67.30 basis point decline in the 3-Month Treasury yield outside the crisis period β_1, and a 78.04 basis point decline during the crisis period β_2. We reject the Wald test for equality of coefficients $\beta_1 = \beta_2$ for the 3-Month Treasury at the 5% significance level. This implies that there is significant difference in response of the 3-Month Treasury to FFR shocks during the crisis compared to outside the crisis period. To test the robustness of our estimates, we exclude event-dates associated with employment release reports in Table 4.6 Panel B. We find that the β_1 coefficient is indeed sensitive to this model specification, however upon excluding these event-dates; we find there is a significantly greater response of the 3-Month Treasury to FFR shocks during the crisis period[145]. In fact we reject the null hypothesis for equality of coefficients $\beta_1 = \beta_2$ at the 1% significance level.

Flight to quality during the crisis would imply a stronger US Treasury response to FFR shocks, as investors sell higher risk assets and increase their demand for safe-haven securities. We indeed find a stronger response of the 3-Month Treasury to FFR shocks during the crisis period and this is consistent with flight to quality trading. This is shown in Table 4.7 Panel B as we find that a hypothetical unexpected 1% FFR cut is associated with a 78.22 (64.03) basis point decline in the 3-Month T-Bill yield during (outside) the crisis. This demonstrates that there is a significant 14 basis point difference in response attributable to the crisis period. Our estimates imply that unexpected FFR cuts during the crisis were interpreted by market participants as being signals from the Fed of significantly deteriorating financial and economic conditions, thereby reinforcing flight to quality trading which was taking place, and prompting a sell of higher risk assets and higher demand for safe-haven securities such as 3-Month Treasury Bills. Previous studies have shown that lower risk and highly liquid financial assets typically benefit from flight to quality trading (see McCauley and McGuire,

---

demonstrated that unexpected FFR cuts were associated with non-positive or negative stock responses. To investigate the remaining channel of flight to quality phenomenon, we retain this dating of the crisis period for comparability with the previous chapter.

[145] The β_1 coefficient is more sensitive to event-dates associated with employment release reports because these event-dates occurred between 1989 and 1992.

2009) and given that 3-Month Treasury Bills are amongst the most highly liquid financial securities in the world, and widely perceived to be safe-haven securities (see Amihud, Mendelson and Pederse, 2012), it is unsurprising that we find this security as being characterised by flight to quality trading in response to unexpected FFR cuts during the crisis period.

Nevertheless, although we find that there is a highly significant structural shift in the relationship between 3-Month Treasury bills and FFR shocks characterised by the 2007-2009 crisis period, in Table 4.7 Panel B we do not yield significant evidence for flight to quality trading across any other maturity US Treasuries. Furthermore, we unexpectedly find that US Treasuries across the term structure, from 3-Months to 30-Years respond significantly to FFR shocks both outside and during the crisis period. This evidence is inconsistent with previous studies which have demonstrated that very long-term maturity Treasuries do not respond significantly to FFR shocks over pre-crisis sample periods (see Gürkaynak, Sack and Swanson, 2005; Kuttner, 2001). To explain this dilemma, we point out that the US Treasury market is significantly more forward looking than the US stock market. Previous studies have shown that the US stock market does not respond significantly to the path factor, which is associated with FOMC statements, however longer-term maturity Treasuries do respond significantly to this measure (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006).

As we explained in Section 4.3.4, the FOMC increasingly used *forward guidance* through FOMC statements to influence financial, monetary and economic conditions when the target FFR approached the zero-lower bound. These statements typically occurred following FOMC meetings and outlined the rationale behind target FFR decisions, outlined economic risks and the economic outlook, and often included an indication of the likely future trajectory of monetary policy. As target FFR decisions and FOMC statements occurred concurrently, our estimates in Table 4.7 may have been biased as they did not account for the impact of increasing use of forward guidance by the FOMC during the crisis. This has greater implications for longer-term maturity Treasuries which have been shown to be more forward looking and more likely to respond to these measures. Thus in the next section, we control for this measure to determine the robustness of our findings and to correct this omitted variable bias.

4.4.3 Controlling for non-conventional monetary policy: forward guidance

In the previous section we demonstrated that 3-Month Treasury bills were characterised by flight to quality trading during the 2007-2009 crisis period as they yielded significantly larger magnitude responses to FFR shocks. However, we did not find significant evidence of flight to quality trading in other US Treasury securities. This may be explained by the fact that we did not control for the impact of *non-conventional* monetary policy by the Fed during the crisis[146]. As the target FFR approached the zero-lower bound in late 2008, the FOMC increasingly used *forward guidance* through statements and *large-scale asset purchase* programmes to influence financial monetary and economic conditions. These non-conventional monetary policy measures were primarily intended to influence longer-term maturity Treasury yields, and given that we did not control for these measures, this may explain why we did not observe flight to quality trading in Treasuries of maturity beyond 3-Months[147]. Thus we continue our investigation in a stepwise manner, by augmenting the previous model to control for forward guidance by the Fed through FOMC statements using the path factor $(Path_t)$ of Wongswan (2009), which is shown to be associated with FOMC statements (see Section 4.3.4).

In Table 4.8 we estimate Equation 4.7 using robust MM-Estimator weighted least squares over the Jun-89 to Dec-12 sample[148]. The β_1 coefficient measures the US Treasury response to FFR shocks outside the crisis period, whilst the β_2 coefficient measures the response throughout the 2007-2009 crisis period. The β_3 measures the US Treasury response to news from FOMC statements concerning the future trajectory of monetary policy and the economic outlook beyond that which they were aware of concerning the current level of the target FFR.

---

[146] A study by Farka and Fleissig (2012) demonstrated that over the May-99 to Dec-07 sample period, 3-Month to 10-Year Treasuries yielded highly significant responses to FFR shocks however upon controlling for FOMC statements.

[147] The Fed has described non-conventional monetary policy in terms of more explicit use of forward guidance as follows: "*The target for the federal funds rate, is already effectively as low as it can go ... [and] through "forward guidance," the Federal Open Market Committee provides an indication to households, businesses, and investors about the stance of monetary policy expected to prevail in the future ... [and] forward guidance language can put downward pressure on longer-term interest rates and thereby lower the cost of credit for households and businesses, and also help improve broader financial conditions*" (Federal Reserve Website, 2013a).

[148] In Appendix A4.1 we also consider the impact of the path factor on US Treasuries outside the crisis and during the crisis period. The primary focus of this investigation is on the impact of conventional monetary policy shocks, and we only include non-conventional monetary policy as a control variable, hence we do not discuss the results here but relegate them to the robustness checks section.

$$\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \varepsilon_t, \qquad (4.7)$$

In Table 4.8 Panel A, we find that outside the crisis period, 3-Month to 10-Year maturity Treasuries are associated with statistically *significant* responses to FFR shocks β_1, however the 30-Year Treasury is associated with a statistically *insignificant* response. The magnitude and statistical significance of the relationship between US Treasuries and FFR shocks is generally shown to decline in magnitude and statistical significance as the term to maturity is increased. These estimates are consistent with previous studies concerning the pre-crisis period which find that longer-term maturity Treasuries such as the 30-Year Treasury do not respond significantly to FFR shocks. In contrast, we find that US Treasuries across the term structure from 3-Months to 30-Years are associated with statistically *significant* responses to FFR shocks during the 2007-2009 crisis period β_2. As the 30-Year Treasury is associated with statistically significant responses to FFR shocks *only during* the crisis period, this stronger response is consistent with flight to quality trading. It implies that unexpected FFR cuts during the crisis increased investor demand for safe-haven securities such as very long-term maturity Treasuries.

Upon excluding event-dates associated with employment release reports in Table 4.8 Panel B, we find that these overall empirical conclusions remain relatively similar[149]. In Panel B we continue to find that 3-Month to 10-Year Treasuries respond significantly to FFR shocks outside the crisis period, whilst the 30-Year Treasury does not. Furthermore, we continue to find that 3-Month to 30-Year Treasuries respond significantly to FFR shocks during the crisis period. Our estimates demonstrate that a hypothetical unexpected 1% FFR cut is associated with a 78.23 (69.52) basis point decline in the 3-Month Treasury yield during (outside) the crisis period. We also reject the Wald test for equality of coefficients $\beta_1 = \beta_2$ at the 5% significance level for the 3-Month Treasury which demonstrates that there is a significantly larger magnitude response to FFR shocks during the crisis period. This is consistent with estimates in the previous section (see Table 4.7), and demonstrates that 3-Month Treasuries were characterised by flight to quality trading during the crisis, in response to unexpected FFR cuts.

Interestingly, after controlling for the impact of forward guidance by the FOMC on our estimates, we now find that longer-term maturity 5-Year and 10-Year Treasuries are characterised by significantly larger magnitude responses to FFR shocks during the crisis

[149] Consistent with empirical evidence in previous tables, we find that our estimates are sensitive to event-dates associated with employment release reports (see Panel B).

period β_2. Our estimates show that a hypothetical unexpected 1% FFR cut is associated with a 47.05 (26.60) basis point decline in the 5-Year Treasury yield, and a 28.04 (11.75) basis point decline in the 10-Year Treasury yield during β_2 (outside β_1) the crisis period. In both cases, we reject the Wald test for equality of coefficients $\beta_1 = \beta_2$, at the 5% significance level for the 5-Year Treasury and at the 1% significance level for the 10-Year Treasury. This demonstrates that there is a significantly larger magnitude response of 5-Year and 10-Year Treasuries to FFR shocks during the crisis period β_2, with an almost two-fold increase in the magnitude of response for both Treasuries. This stronger response to FFR shocks during the crisis period is consistent with flight to quality trading during the crisis period as investors sold higher risk financial assets and increased their demand for safe-haven securities such as longer-term maturity Treasuries.

In line with previous studies we find that the β_3 coefficient is positive for US Treasuries across the maturity spectrum. This implies that FOMC statements which indicate a downward (upward) revision in the future path of monetary policy have a negative (positive) effect on US Treasury yields. The impact is shown to be tent-shaped, with a smaller magnitude impact on shorter-term (3-Month and 6-Month) and longer-term (10-Year and 30-Year) maturity Treasuries, with the largest responses for intermediate-term (2-Year and 5-Year) maturity Treasuries. In the case of 2-Year to 30-Year Treasuries, the magnitude of response is greater than that of conventional FFR shocks. Overall, we find that longer-term maturity Treasuries exhibit larger magnitude responses to FOMC statements. These estimates are robust towards excluding event-dates associated with employment release reports (see Panel B).

Due to the complexity of these results, in Figure 4.3 we plot the β_1, β_2 and β_3 coefficients shown in Table 4.8 Panel B for each of the six Treasuries. This allows us to compare the US Treasury response to a hypothetical 1% FFR shock outside the crisis and during the crisis period, and also compare it against the impact of the path factor. Overall, these results indicate an important shift in the relationship between US Treasuries and FFR shocks characterised by the 2007-2009 crisis period. Firstly, we find that there is a significantly larger magnitude response of the 3-Month Treasury to FFR shocks during the crisis period. This is shown to be consistent with flight to quality trading during the crisis period as the 3-Month Treasury is one of the most liquid financial assets in the world. Secondly, we find that longer-term maturity 5-Year, 10-Year and 30-Year Treasuries yield larger magnitude responses to FFR shocks during the crisis period. In the case of the 5-Year and 10-Year Treasuries, the magnitude of response is shown to be greater during the crisis by almost a factor of two. To complement this, the 30-Year Treasury is shown to respond significantly to FFR shocks only during the crisis period. This strengthening of the longer end of the maturity spectrum implies that investors increased their demand for longer-term maturity Treasuries during the crisis in response to unexpected FFR cuts. These empirical results demonstrate that unexpected FFR cuts during the crisis period were interpreted by market participants as signals from the Fed of deteriorating financial and economic conditions, and thereby prompted investors to rebalance their portfolios by selling higher risk asset such as equities (see Chapter 3) and increasing their demand for highly liquid financial assets such as the 3-Month Treasury, and safe-haven assets such as longer-term maturity (5-Year, 10-Year and 30-Year) Treasuries.

4.4.4 Controlling for non-conventional monetary policy: LSAP programmes

In the previous section we demonstrated that the 3-Month Treasury was associated with a significantly larger magnitude response to FFR shocks during the 2007-2009 crisis period. Interestingly, upon controlling for increasing use of forward guidance by the FOMC, we yielded similar empirical conclusions for longer-term (5-Year, 10-Year and 30-Year) maturity Treasuries. As we discussed in Section 4.3.5, the crisis period was characterised by several *large-scale asset purchase* programmes such as QE1, QE2, Operation Twist and QE3, and many of these programmes were announced on FOMC event-dates. One may therefore argue that our estimates in the previous section were influenced by these announcements. To control for the effects of LSAP announcements on our estimates, we use a dummy variable equal to one when these announcements coincide with event-dates in our dataset as detailed in Table 4.1. We subsequently augment the previous model to control for this measure of non-conventional monetary policy (Equation 4.8).

$$\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP} + \varepsilon_t, \quad (4.8)$$

We present robust MM-Estimator weighted least squares estimates of Equation 4.8 on FOMC event-dates in Table 4.9. Upon controlling for LSAP announcements, we find that our estimates are highly robust towards this model specification. More specifically, the β_1, β_2 and β_3 coefficients in Table 4.9 Panel A and Panel B differ from those in Table 4.8 Panel A and Panel B by less than 2.5 basis points in each case. This is a strong indication that our estimates are not significantly influenced by LSAP announcements by the Fed over the sample. In Figure 4.4 we plot the β_1, β_2 and β_3 coefficients shown in Table 4.9 Panel B for each of the six Treasuries to demonstrate the similarities with the estimates yielded in the previous model (see Table 4.8). In Table 4.9 Panel B, we once again find that 3-Month to 10-Year Treasuries are associated with statistically significant responses to FFR shocks outside the crisis period however 3-Month to 30-Year Treasuries respond significantly to FFR shocks during the crisis. We find that shorter-term (3-Month) and longer-term (5-Year, 10-Year and 30-Year) Treasuries yield larger magnitude responses to FFR shocks during the crisis. In the case of the 3-Month, 5-Year and 10-Year Treasuries, this is shown by the fact that we reject the Wald test for equality of coefficients $\beta_1 = \beta_2$ at the 5% significance level, while the 30-Year Treasury responds significantly to FFR shocks only during the crisis period.

Our estimates concerning the impact of LSAP programme announcements on US Treasuries are quite revealing. In particular we find that 10-Year and 30-Year Treasuries are associated with statistically *significant* responses to LSAP programme announcements during the crisis. The 10-Year and 30-Year Treasuries are associated with roughly 17 and 18 basis point yield decreases on FOMC event-dates associated with LSAP announcements. The magnitude of this coefficient is in line with previous studies (see Hamilton and Wu, 2012; Krishnamurthy and Vissing-Jorgensen, 2011; Swanson, 2011). This evidence is also consistent with the fact that the QE1, QE2, Operation Twist and QE3 programmes by the Fed were primarily geared towards lowering long-term borrowing costs for business and households, and the fact that Treasury purchases in each of these programmes primarily included significant purchases of longer-term maturity Treasuries. As the Fed points out "*the overall effect of the Fed's LSAPs is to put downward pressure on yields of a wide range of longer-term securities, support mortgage markets, and promote a stronger economic recovery*" (Federal Reserve Website, 2013b) and our estimate demonstrate that longer-term maturity Treasury yields declined in response to these announcements. Overall, we find that our estimates are not sensitive to large-scale asset purchase announcements.

4.4.5 Flight to quality in the gold market

Having evaluated the relationship between US Treasuries and FFR shocks during the 2007-2009 crisis period in considerable depth, we have found significant evidence of flight to quality trading in response to FFR shocks during the crisis period, particularly for shorter-term (3-Month) and longer-term (5-Year, 10-Year, 30-Year) maturity Treasuries. As a robustness check, we extend our analysis towards gold, an alternative safe-haven security.

This is motivated by several factors. Firstly on the 18th Sep 07, at the onset of the financial crisis, CNBC News reported "*U.S. Gold ... Hit 28-year High After Fed Cut*" (CNBC News, 2007). This implies that the 50 basis point target FFR cut prompted investors to significantly increase their demand for this safe-haven security. Secondly, Baur and Lucey (2009) demonstrated that gold was a good safe-haven asset for most developed countries throughout the recent financial crisis. Thirdly, throughout this chapter we argue that unexpected FFR cuts during the crisis prompted flight to quality trading in the US Treasury market. If this argument is to hold, then it should also hold for alternative safe-haven securities such as gold. In this manner, it serves an robustness check for our argument. In Table 4.10 we re-estimate the empirical models used in this chapter using spot gold returns (g_t) as the dependent variable in each case. In particular, we estimate Equations 4.9 to 4.13 using robust MM-Estimator weighted least squares.

$$g_t = \alpha + \beta \Delta i_t + \varepsilon_t , \tag{4.9}$$

$$g_t = \alpha + \beta \Delta i_t^u + \varepsilon_t , \tag{4.10}$$

$$g_t = \alpha + \left[\beta_1 \left(1 - D_t^{crisis} \right) + \beta_2 \left(D_t^{crisis} \right) \right] \Delta i_t^u + \varepsilon_t , \tag{4.11}$$

$$g_t = \alpha + \left[\beta_1 \left(1 - D_t^{crisis} \right) + \beta_2 \left(D_t^{crisis} \right) \right] \Delta i_t^u + \beta_3 Path_t + \varepsilon_t , \tag{4.12}$$

$$g_t = \alpha + \left[\beta_1 \left(1 - D_t^{crisis} \right) + \beta_2 \left(D_t^{crisis} \right) \right] \Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP} + \varepsilon_t , \tag{4.13}$$

The estimates for Equation 4.9 show that gold returns are associated with statistically *insignificant* responses to target FFR cuts β_1 over the sample. However by disaggregating target FFR cuts in to expected and unexpected components using the technique of Kuttner (2001), we estimate Equation 4.10 and find that gold returns are associated with statistically *significant* positive (negative) responses to unexpected FFR cuts (increases) β_1. Interestingly, when we extend this analysis to investigate if the relationship between gold returns and FFR shocks is influenced by the 2007-2009 crisis period, by estimating Equation 4.11 we find that gold returns are associated with statistically *significant* positive (negative) responses to unexpected FFR cuts (increases) during the crisis β_2, and statistically *insignificant* responses to FFR shocks outside the crisis period β_1. The Wald test for equality of coefficients $\beta_1 = \beta_2$ is also rejected at the 1% level which demonstrates that there is a highly significant structural shift in the relationship between gold returns and FFR shocks characterised by the crisis period. In particular, a hypothetical unexpected -0.50% FFR cut is associated with a statistically *significant* gold return of 6.33% during the crisis β_2 and a statistically *insignificant* response outside the crisis β_1.

When we estimate Equation 4.12, we yield very similar β_1 and β_2 coefficients to those previously observed (in Equation 4.11), which demonstrates that our estimates are highly robust towards this model specification. The impact of forward guidance through FOMC statements β_3 is shown to be statistically insignificant which implies that upward or downward revisions in the future trajectory of monetary policy have no effect on spot gold returns, which is a sensible conclusion. Finally, we estimate Equation 4.13 and once again yield very similar β_1 and β_2 coefficients to those previously observed (in Equation 4.11 and Equation 4.12). However, we find that spot gold returns have statistically significant positive responses to LSAP announcements β_4. An LSAP announcement is shown to be associated with a 1.02% increase in gold returns. Across Equations 4.11 to 4.13, we find that there is a highly significant structural shift in the relationship between gold returns and FFR shocks characterised by the financial crisis. In each case gold returns do not respond significantly to FFR shocks outside the crisis period, however are associated with highly significant responses to FFR shocks during the crisis. Furthermore, we reject the Wald test for equality of coefficients $\beta_1 = \beta_2$ at the 1% level in each case. These models are all shown to be highly robust towards excluding event-dates associated with employment release reports and change by less than half a basis point in each case in Panel B. This significantly stronger response of gold returns to FFR shocks during the crisis period is consistent with flight to quality trading in response to unexpected FFR cuts during the 2007-2009 crisis period.

The estimates in Table 4.10 concerning the gold market complement our findings concerning the US Treasury market, as we demonstrate that unexpected FFR cuts during the 2007-2009 crisis period were associated with higher returns in the gold market and lower yields in the US Treasury market. In both cases, this implies that unexpected FFR cuts during the crisis prompted significantly higher demand for safe-haven securities such as gold and shorter-term (3-Month) maturity Treasuries, however risk aversion was so significant that it also prompted significantly higher demand for longer-term (5-Year, 10-Year and 30-Year) maturity Treasuries. The stronger response of these safe-haven securities to FFR shocks during the crisis period is consistent with flight to quality trading in response to unexpected FFR cuts during the crisis, as investors rebalance their portfolios during times of economic and financial distress by selling higher risk securities such as equities (see Chapter 3) in favour of lower-risk securities and safe-haven assets (see Chordia, Sarkar and Subrahmanyam, 2005; Goyenko and Ukhov, 2009).

4.4.6 Further robustness checks

Throughout this chapter we have undertaken a number of robustness checks for each of the estimated models however we undertake several further robustness checks in this sub-section to determine the sensitivity of our estimates. Firstly, the primary focus of this investigation was to investigate the relationship between US Treasuries and *conventional monetary policy* shocks over the crisis period. As the latter part of the crisis was characterised by non-conventional monetary policy measures, it was important to control for these alternative measures to adequately model the relationship between US Treasuries and FFR shocks. In Table 4.9 we estimated the impact of FFR shocks on US Treasuries both outside and during the crisis period, and controlled for forward guidance through FOMC statements using the path factor of Wongswan (2009), as well as LSAP announcements. As the path factor was used purely as a control variable, we did not consider potential structural change in the US Treasury response to the path factor during the crisis and outside the crisis. To reassure the reader that this did not significantly influence our estimates, we consider this here as a robustness check.

$$\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \left[\beta_3\left(1 - D_t^{crisis}\right) + \beta_4\left(D_t^{crisis}\right)\right]Path_t + \beta_5 D_t^{LSAP} + \varepsilon_t, \quad (4.14)$$

In Table A4.1 we present robust MM-Estimator weighted least squares estimates of Equation 4.14 on FOMC event-dates. In both Panels A and B, we find outside the crisis period that an FOMC statement which indicates a downward (upward) revision in the future trajectory of monetary policy is associated with a statistically significant decline (increase) in US Treasuries across the term structure from 3-Months to 30-Years outside the crisis period, however a statistically significant decline (increase) in longer-term 2-Year to 30-Year Treasuries during the crisis period. This evidence is rather revealing in that it demonstrates how only longer-term maturity Treasuries responded significantly to FOMC statements concerning the future trajectory of monetary policy during the crisis period. For the 10-Year Treasury in particular, the magnitude of response during the crisis is more than twice that observed outside the crisis period.

These results are very interesting; however they do not change the empirical conclusions yielded throughout this chapter, as they are highly consistent with estimates presented in Table 4.8 and 4.9. In Table A4.1 Panel A we find that outside the crisis period, 3-Month to 10-Year maturity Treasuries respond significantly to FFR shocks however during the crisis 3-Month to 30-Year Treasuries are associated with significant responses to FFR shocks. In Panel B, we reject the Wald test for equality of coefficients $\beta_1 = \beta_2$ for the short-term (3-Month) and longer-term maturity (5-Year and 10-Year) Treasuries, while the 30-Year Treasury is shown to respond significantly to FFR shocks only during the crisis period. We also continue to find that 10-Year and 30-Year Treasuries are associated with significant responses to LSAP announcements.

Secondly, to demonstrate that our estimates for the gold market are not influenced by this model specification, we estimate Equation 4.15 in Table A4.2 using robust MM-Estimator weighted least squares. In line with the estimates in Table 4.10, we find that gold returns are associated with statistically significant (insignificant) responses to FFR shocks during (outside) the crisis period. We find that FOMC states indicating a downward (upward) revision in the future trajectory of monetary policy does not have a significant effect on gold respects, which is sensible. Nevertheless, we continue to find that spot gold returns increase in response to LSAP announcements.

$$g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \left[\beta_3\left(1 - D_t^{crisis}\right) + \beta_4\left(D_t^{crisis}\right)\right]Path_t + \beta_5 D_t^{LSAP} + \varepsilon_t, \quad (4.15)$$

Thirdly, we defined the financial crisis as spanning the Sep-07 to Mar-09 period, motivated by events which transpired during the period. As an additional robustness check, to demonstrate that our estimates are not sensitive to the dating of the crisis, we use the NBER definition of the economic crisis. In Table A4.3 we estimate Equation 4.8 using robust MM-Estimator weighted least squares however we define the $\left(D_t^{crisis}\right)$ variable as being equal to one for the Dec-07 to Jun-09 sample period. We continue to find that 3-Month to 10-Year Treasuries respond significantly to FFR shocks outside the crisis period while US Treasuries across the term structure from 3-Months to 30-Years are associated with significant negative responses to unexpected FFR cuts during the crisis. Our estimates also show that FOMC statements indicating a downward (upward) revision in the future trajectory of monetary policy is associated with a significant decline in yields across the maturity spectrum from 3-Months to 30-Years. Interestingly, although we continue to find that the 3-Month, 5-Year and 10-Year Treasuries are associated with significantly larger magnitude responses to FFR shocks during the crisis, each of the Wald tests $\beta_1 = \beta_2$ is rejected at the 1% level. We also yield some evidence that the 2-Year Treasury is associated with a significantly larger magnitude response to FFR shocks during the crisis.

Lastly, to demonstrate that our estimates for gold returns were not significantly influenced by the dating of the crisis period, in Table A4.4 we estimate Equation 4.8 using robust MM-Estimator weighted least squares however we define the $\left(D_t^{crisis}\right)$ variable as being equal to one for the Dec-07 to Jun-09 sample period. We find that the estimates are highly consistent with those yielded in Table 4.10. In particular, we continue to find that gold returns respond significantly to FFR shocks only during the crisis period. A hypothetical unexpected 0.50% FFR cut is associated with a 6.48% increase in gold returns during the crisis period. The estimates also indicate that gold returns do not respond significantly to FOMC statements concerning the future trajectory of monetary policy however do respond positively to LSAP announcements. Finally, when this chapter was first written, all the estimates were for the Jun-89 to Dec-10 sample period. The estimates were updated to the Jun-89 to Dec-12 sample period in the write-up year of this thesis. Comparable empirical estimates were yielded in both cases.

4.5 Conclusion

Overall our findings indicate that conventional monetary policy shocks constituted an important source of variation in US Treasury yield changes and gold returns on FOMC event-dates over the Jun-89 to Dec-12 period. We demonstrate that highly liquid financial assets such as gold, short-term (3-Month) and longer-term (5-Year, 10-Year and 30-Year) maturity Treasuries were characterised by flight to quality trading in response to unexpected FFR cuts during the 2007-2009 crisis period. This is demonstrated by the fact that we find a significantly larger magnitude response to FFR shocks during the crisis period. We show that unexpected FFR cuts during the crisis period were perceived by market participants as being signals from the Fed that financial and economic conditions were rapidly deteriorating, and thereby prompted investors to sell higher risk securities such as equities (see Chapter 3) and increase their demand for safe-haven securities such as gold, and US Treasuries. We also control non-conventional monetary policy measures such as increasing use of forward guidance through FOMC statements and LSAP announcements on FOMC event-dates.

4.6 References

Amihud, Y., Mendelson, H., Pedersen, L. 2012. *Market liquidity: Asset pricing, risk, and crises*. Cambridge University Press.

Basistha, A., and Kurov, A. 2008. Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 32(12), 2606-2616.

Bauer, M.D., and Neely, C.J. 2012. International channels of the Fed's unconventional monetary policy. *Federal Reserve Bank of St. Louis*. Working Paper 2012-028A.

Baur, D. G., and Lucey, B. M. 2009. Flights and contagion – An empirical analysis of stock-bond correlations. *Journal of Financial Stability* 5(4), 339-352.

Beechey, M.J., and Wright, J.H. 2009. The high-frequency impact of news on long-term yields and forward rates: is it real? *Journal of Monetary Economics* 56(4), 535-544

Bernanke, B.S., & Kuttner, K.N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Berument, H., and Froyen, R.T. 2006. Monetary policy and long-term US interest rates. *Journal of Macroeconomics* 28(4), 737-751

Berument, H., and Froyen, R.T. 2008. Monetary policy and U.S. long-term interest rates: how close are the linkages? *Journal of Economics and Business* 61(1), 34-50

Bredin, D., Hyde, S., Nitzsche, D., & O'Reilly, G. 2009. European monetary policy surprises: the aggregate and sectoral stock market response. *International Journal of Finance & Economics* 14(2), 156-171.

Carlstrom, C. T., & Fuerst, T. S. 2005. Considerable Period of Time: The Case of Signaling Future Policy. *Federal Reserve Bank of Cleveland* (Nov), 1-4

Cenesizoglu, T., Montréal, H.E.C., Larocque, D., & Normandin, M. 2012. Conventional Monetary Policy and the Term Structure of Interest Rates during the Financial Crisis. *HEC Montreal Finance Department*. Working Paper.

Chordia, T., Sarkar, A., Subrahmanyam, A. 2005. An empirical analysis of stock and bond market liquidity. *Review of Financial Studies*, 18(1), 85-129.

CNBC News. 2007. Fed Surprises Investors With Steep Rate Cuts. *CNBC News Website*. Available from: http://www.cnbc.com/id/20828550. [Accessed on 22nd Aug 13].

Cook, T., and Hahn, T. 1989. The effect of changes in the Federal Funds rate target on market interest rates in the 1970s. *Journal of Monetary Economics* 24, 331-351

Cooke, K. 2007. Investors dump stocks after Fed's modest rate cut. *Reuters Website*. Available from: http://uk.reuters.com/article/2007/12/11/markets-stocks-idUKN1155872820071211. [Accessed on 22nd Aug 13]

Demiralp, S., & Yilmaz, K. 2009. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *TÜSİAD-Koç University Economic Research Forum*. Working Paper.

Demiralp, S., & Yilmaz, K. 2012. Asymmetric response to monetary policy surprises at the long-end of the yield curve. *Journal of Macroeconomics* 34(2), 404-418.

Eijffinger, S., Mahieu, R., & Raes, L. 2012. Can the Fed talk the hind legs off the stock market?. *European Banking Center*. Discussion Paper 2012-006.

Farka, M., & DaSilva, A. 2009. The Fed and the Term Structure: Addressing Simultaneity within a Structural VAR Approach. *California State University Department of Economics*. Working Paper.

Farka, M., & Fleissig, A. R. 2012. The effect of FOMC statements on asset prices. *International Review of Applied Economics*, 26(3), 387-416.

Farka, M., and DaSilva, A. 2011. The Fed and the term structure: addressing simultaneity within a structural VAR model. *Journal of Empirical Finance* 18(5), 935-952

Federal Reserve Website. 2011. Fed Press Release on 9th August 2011. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/press/monetary/20110809a.htm. [Accessed on 11th Dec 13]

Federal Reserve Website. 2013a. How does forward guidance about the Federal Reserve's target for the federal funds rate support the economic recovery? *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/faqs/money_19277.htm. [Accessed on 11th Dec 13]

Federal Reserve Website. 2013b. What are the Federal Reserve's large-scale asset purchases? *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/faqs/what-are-the-federal-reserves-large-scale-asset-purchases.htm. [Accessed on 11th Dec 13]

Finch, G. 2007. Treasuries Set for Biggest Weekly Gain since 2005 on Subprime. *Bloomberg Website*. Available from: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=ao0hppVZO6xU. [Accessed on 22nd Aug 13].

Finestone, D., and Hernandez, S. 2007. Treasuries Rise Most in Three Years as Fed Rate Cuts Disappoint. *Bloomberg Website*. Available from: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aIKewvuk5OdE. [Accessed on 22nd Aug 13].

Gambacorta, L., Hofmann, B., & Peersman, G. 2012. The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis. *Bank for International Settlements*. Working Paper 384.

Gertler, M., & Karadi, P. 2011. A model of unconventional monetary policy. *Journal of Monetary Economics* 58(1), 17-34.

Gilchrist, S., López-Salido, D., & Zakrajšek, E. 2013. Monetary Policy and Real Borrowing Costs at the ZLB. *Boston University*. Working Paper.

Goyenko, R., Ukhov, A. 2009. Stock and bond market liquidity: A long-run empirical analysis. *Journal of Financial and Quantitative Analysis*, 44(1), 189-212.

Guha, K. 2007. Greenspan alert on US house prices. *The Financial Time Website*. Available from: http://www.ft.com/cms/s/0/31207860-647f-11dc-90ea-0000779fd2ac.html#axzz2cj4VeBb9. [Accessed on 22nd Aug 13].

Gürkaynak, R.S., Sack, B., & Swanson, E.T. 2005. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking* 1(1), 55-93

Hamilton, J. D., & Wu, J. C. 2012. The effectiveness of alternative monetary policy tools in a zero lower bound environment. *Journal of Money, Credit and Banking*, 44(1), 3-46.

Hanson, S. G., and J. C. Stein. 2012. Monetary Policy and Long-Term Real Rates. *Federal Reserve Board*. Discussion Series Paper 2012-46.

Hausman, J., and Wongswan, J. 2011. Global asset prices and FOMC announcements. *Journal of International Money and Finance* 30(3), 547-571.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The effects of quantitative easing on interest rates: channels and implications for policy. *National Bureau of Economic Research*. Working Paper w17555.

Kurov, A. 2012. What determines the stock market's reaction to monetary policy statements?. *Review of Financial Economics* 21, 175-187.

Kuttner, K.N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Kuttner, K.N. 2003. Dating changes in the Federal Funds rate, 1989-92. *Oberlin College*. Working Paper.

Lucca, D.O., and Trebbi, F. 2009. Measuring central bank communication: an automated approach with application to FOMC statements. *National Bureau of Economic Research*. Working Paper 15367.

McCauley, R., McGuire, P. 2009. Dollar appreciation in 2008: safe haven, carry trades, dollar shortage and overhedging. *BIS Quarterly Review*. Working Paper.

Rasche, R. H., & Thornton, D. L. 2002. The FOMC's Balance-of-Risks Statement and Market Expectations of Policy Actions. *Federal Reserve Bank of St. Louis Review* (Sep), 37-50.

Rosa, C. 2012. How 'unconventional' are large-scale asset purchases? The impact of monetary policy on asset prices. *FRB of New York Staff Report*. Working Paper 560.

Rudebusch, G.D. 1998. Do Measures of Monetary Policy in a VAR Make Sense?. *International Economic Review* 39(4), 907-31.

Swanson, Eric. 2011. Let's Twist Again: A High-Frequency Event-Study Analysis of Operation Twist and Its Implications for QE2. *Federal Reserve Bank of San Francisco*. Working Paper.

Szczerbowicz, U. 2011. Are unconventional monetary policies effective? *Dipartimento di Economia e Finanza LUISS Guido Carli*. Working Paper 1107.

Thorbecke, W., and Zhang, H. 2008. Monetary policy surprises and interest rates: choosing between the inflation-revelation and excess sensitivity hypothesis. *Research Institute of Economy, Trade and Industry (REITI)*. Discussion Paper 08016.

Thornton, D. L. 2009. The identification of the response of interest rates to monetary policy actions using market-based measures of monetary policy shocks. *Federal Reserve Bank of St. Louis*. Working Paper.

Verardi, V., & Croux. C. 2010. Sire applied robust regression workshop. *The University of Strathclyde*. Course Notes from Three-Day Workshop.

Wang, T., Yang, J., and Wu, J. 2006. Central bank communications and equity ETFs. *Journal of Futures Markets* 26(10), 959-995.

Welsh, R., & Kuh, E. 1977. Linear Regression Diagnostics. *Massachusetts Institute of Technology Technical Report*, 369-395.

Williams, J. C. 2012. The Federal Reserve's Unconventional Policies. *FRBSF Economic Letter* 34, 1-9

Wongswan, J. 2009. The response of global equity indexes to US monetary policy announcements. *Journal of International Money and Finance* 28(2), 344-365.

Wright, J. H. 2011. What does monetary policy do to long-term interest rates at the zero lower bound?. *National Bureau of Economic Research*. Working Paper w17154.

Yohai, V.J. 1987. High breakdown-point and high efficiency robust estimates for regression. *The Annals of Statistics* 15(2), 642-656.

CHAPTER 4 – TABLES AND FIGURES

Table 4.1: Dates of LSAP announcements

Date	FOMC Meeting	LSAP Programme	Details
25-Nov-08	No	Quantitative Easing I	The FOMC announces their plan to purchase $600billion in MBS and Agency Debt
15-Dec-08	Yes	Quantitative Easing I	The FOMC implements QE1, a plan to purchase $500billion in AMBS and $100billion in Agency Debt
18-Mar-09	Yes	Quantitative Easing I	The FOMC announces their plan to extend QE1 by purchasing a further $750billion in AMBS, $100billion in Agency Debt and $300billion in longer-term maturity Treasuries
27-Aug-10	No	Quantitative Easing II	At a meeting in Jackson Hole, Bernanke indicates that a programme of QE2 may be implemented
03-Nov-10	Yes	Quantitative Easing II	The FOMC announces their plan to purchase $600billion in longer-term maturity Treasuries
21-Sep-11	Yes	Operation Twist	The FOMC announces ‘Operation Twist,’ a plan to purchase $400billion in longer-term maturity Treasuries, financed by selling shorter-term maturity Treasuries
20-Jun-12	Yes	Operation Twist	The FOMC announce their plan to extend Operation Twist by $267billion
13-Sep-12	Yes	Quantitative Easing III	The FOMC announce a programme of QE3, a plan to purchase $40billion a month in AMBS
12-Dec-12	Yes	Quantitative Easing III	The FOMC announce their plan to extend QE3 by purchasing $40billion in AMBS and $45billion in longer-term maturity Treasuries

Notes: Table 4.1 reports lists LSAP announcement dates, reports whether the announcement occurred on an on an FOMC meeting, details the common term for the LSAP measure and outlines the details of each LSAP announcement.

Table 4.2: Descriptive statistics for gold returns and US Treasury yield changes

Sample Period	Obs	Min	Max	Mean	St.Dev
Gold (Spot)	213	-2.73	3.45	0.17	0.97
3-Month T-Bill	213	-57.61	37.60	-2.13	8.56
6-Month T-Bill	213	-47.95	26.10	-2.45	8.26
2-Year T-Bond	213	-35.14	28.60	-1.44	8.94
5-Year T-Bond	213	-40.62	25.24	-1.23	9.09
10-Year T-Bond	213	-47.36	24.30	-0.94	8.16
30-Year T-Bond	213	-29.29	17.97	-0.55	6.47

Notes: Table 4.2 reports descriptive statistics for spot gold and Treasury yield changes over the Jun-89 to Dec-12 sample period.

Table 4.3: Response of US Treasuries to target FFR changes, OLS estimates

	Obs	α	β_1	Adj R^2
Panel A (All Meetings)				
3-Month T-Bill	213	-1.18***	22.31***	0.33
		(0.42)	(3.51)	
6-Month T-Bill	213	-1.65***	19.02***	0.26
		(0.38)	(3.48)	
2-Year T-Bond	213	-0.91**	12.49***	0.09
		(0.41)	(3.46)	
5-Year T-Bond	213	-0.94**	6.87**	0.02
		(0.42)	(3.28)	
10-Year T-Bond	213	-0.81*	3.20	0.00
		(0.42)	(2.80)	
30-Year T-Bond	213	-0.51	0.93	0.00
		(0.39)	(2.40)	
Panel B (Excl Empl)				
3-Month T-Bill	204	-1.10***	22.14***	0.33
		(0.42)	(3.72)	
6-Month T-Bill	204	-1.53***	18.43***	0.25
		(0.37)	(3.60)	
2-Year T-Bond	204	-0.63	9.95***	0.06
		(0.40)	(3.26)	
5-Year T-Bond	204	-0.74*	5.00	0.01
		(0.42)	(3.24)	
10-Year T-Bond	204	-0.66	1.76	0.00
		(0.42)	(2.84)	
30-Year T-Bond	204	-0.36	-0.50	0.00
		(0.38)	(2.42)	

Notes: Table 4.3 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 4.4 on FOMC event-dates: $\Delta y_t = \alpha + \beta_1 \Delta i_t + \varepsilon_t$, where Δy_t and Δi_t denote US Treasury yield changes and target FFR changes respectively. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17^{th} Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.4: Response of US Treasuries to unexpected FFR changes, OLS estimates

	Obs	α	β_1	Adj R^2
Panel A (All Meetings)				
3-Month T-Bill	213	-0.54	58.64***	0.44
		(0.42)	(7.98)	
6-Month T-Bill	213	-0.88***	58.25***	0.46
		(0.32)	(6.67)	
2-Year T-Bond	213	-0.12	48.50***	0.27
		(0.39)	(8.34)	
5-Year T-Bond	213	-0.34	32.68***	0.12
		(0.44)	(9.74)	
10-Year T-Bond	213	-0.41	19.72**	0.05
		(0.44)	(8.55)	
30-Year T-Bond	213	-0.29	9.65	0.02
		(0.40)	(6.30)	
Panel B (Excl Empl)				
3-Month T-Bill	204	-0.47	62.79***	0.46
		(0.43)	(7.88)	
6-Month T-Bill	204	-0.82**	60.88***	0.48
		(0.32)	(6.58)	
2-Year T-Bond	204	-0.01	44.00***	0.21
		(0.39)	(9.07)	
5-Year T-Bond	204	-0.30	28.55**	0.08
		(0.44)	(11.14)	
10-Year T-Bond	204	-0.38	16.01*	0.03
		(0.45)	(9.64)	
30-Year T-Bond	204	-0.24	5.13	0.00
		(0.40)	(6.39)	

Notes: Table 4.4 reports OLS estimates with heteroscedasticity and autocorrelation consistent standard errors of Equation 4.5 on FOMC event-dates: $\Delta y_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.5: List of DFITs outlier event-dates

3-Month	6-Month	2-Year	5-Year	10-Year	30-Year
16-Oct-89	16-Oct-89	16-Oct-89	16-Oct-89	16-Oct-89	16-Oct-89
				07-Dec-90	07-Dec-90
01-Feb-91	01-Feb-91	01-Feb-91			01-Feb-91
					08-Mar-91
21-Aug-91					
20-Dec-91	20-Dec-91	20-Dec-91			
		09-Apr-92			
02-Jul-92	02-Jul-92	02-Jul-92	02-Jul-92	02-Jul-92	02-Jul-92
04-Sep-92	04-Sep-92	04-Sep-92	04-Sep-92		
	18-Apr-94	18-Apr-94	18-Apr-94	18-Apr-94	18-Apr-94
	17-May-94	17-May-94	17-May-94	17-May-94	17-May-94
16-Aug-94		16-Aug-94	16-Aug-94	16-Aug-94	16-Aug-94
	27-Sep-94				
		06-Jul-95			
	15-Oct-98	15-Oct-98	15-Oct-98	15-Oct-98	
		03-Jan-01	03-Jan-01	03-Jan-01	03-Jan-01
18-Apr-01					
		06-Nov-02	06-Nov-02		
		25-Jun-03	25-Jun-03	25-Jun-03	25-Jun-03
	18-Sep-07				
		11-Dec-07	11-Dec-07		
22-Jan-08	22-Jan-08		22-Jan-08	22-Jan-08	
18-Mar-08	18-Mar-08	18-Mar-08	18-Mar-08	18-Mar-08	
16-Sep-08					
		08-Oct-08	08-Oct-08	08-Oct-08	
				16-Dec-08	16-Dec-08
					28-Jan-09
		18-Mar-09	18-Mar-09	18-Mar-09	18-Mar-09
					21-Sep-11

Notes: Table 4.5 reports FOMC event-dates associated with high influence statistics in Equation 4.5 identified using the Difference in Fits Statistic of Welsh and Kuh (1977).

Table 4.6: Response of US Treasuries to unexpected FFR changes, robust MM-estimates

	Obs	α	β_1	Adj R^2
Panel A (All Meetings)				
3-Month T-Bill	210	-0.14	73.48***	0.76
		(0.26)	(2.82)	
6-Month T-Bill	211	-0.63**	66.78***	0.71
		(0.27)	(2.92)	
2-Year T-Bond	210	0.20	62.93***	0.51
		(0.38)	(4.28)	
5-Year T-Bond	210	-0.04	45.41***	0.31
		(0.44)	(4.62)	
10-Year T-Bond	211	-0.01	29.30***	0.18
		(0.41)	(4.23)	
30-Year T-Bond	212	0.11	14.96***	0.07
		(0.36)	(3.70)	
Panel B (Excl Empl)				
3-Month T-Bill	202	-0.07	72.30***	0.74
		(0.26)	(2.99)	
6-Month T-Bill	203	-0.53**	64.98***	0.72
		(0.26)	(2.87)	
2-Year T-Bond	202	0.24	57.13***	0.43
		(0.39)	(4.60)	
5-Year T-Bond	202	-0.03	42.23***	0.25
		(0.46)	(5.14)	
10-Year T-Bond	202	0.01	25.99***	0.13
		(0.41)	(4.63)	
30-Year T-Bond	203	0.17	10.29***	0.03
		(0.36)	(3.93)	

Notes: Table 4.6 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.5 on FOMC event-dates: $\Delta y_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.7: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis, robust MM-estimates

	Obs	α	β_1	β_2	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)						
3-Month T-Bill	210	-0.16	67.30***	78.04***	[0.04]	0.77
		(0.25)	(3.45)	(4.30)		
6-Month T-Bill	211	-0.60**	71.38***	62.52***	[0.14]	0.72
		(0.28)	(3.72)	(4.74)		
2-Year T-Bond	210	0.22	66.67***	51.90***	[0.08]	0.53
		(0.38)	(4.90)	(6.98)		
5-Year T-Bond	210	-0.04	45.85***	44.64***	[0.90]	0.30
		(0.45)	(5.75)	(8.03)		
10-Year T-Bond	211	0.00	30.58***	26.88***	[0.67]	0.18
		(0.42)	(5.28)	(7.10)		
30-Year T-Bond	212	0.16	18.63***	11.12*	[0.31]	0.08
		(0.36)	(4.51)	(5.98)		
Panel B (Excl Empl)						
3-Month T-Bill	201	-0.06	64.03***	78.22***	[0.01]	0.76
		(0.25)	(3.65)	(4.16)		
6-Month T-Bill	203	-0.55**	68.05***	62.55***	[0.36]	0.70
		(0.27)	(3.94)	(4.61)		
2-Year T-Bond	201	0.29	62.57***	52.09***	[0.25]	0.45
		(0.38)	(5.81)	(7.01)		
5-Year T-Bond	202	-0.05	40.08***	44.60***	[0.67]	0.23
		(0.46)	(6.84)	(8.11)		
10-Year T-Bond	202	0.00	25.12***	26.79***	[0.86]	0.12
		(0.42)	(6.13)	(7.03)		
30-Year T-Bond	203	0.15	9.41*	11.18*	[0.82]	0.02
		(0.36)	(5.15)	(6.03)		

Notes: Table 4.7 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.6 on FOMC event-dates: $\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.8: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis and forward guidance, robust MM-estimates

	Obs	α	β_1	β_2	β_3	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)							
3-Month T-Bill	209	-0.27	69.52***	78.23***	9.45***	[0.12]	0.77
		(0.26)	(3.51)	(4.41)	(2.24)		
6-Month T-Bill	211	-0.65***	70.27***	66.21***	22.65***	[0.44]	0.79
		(0.24)	(3.27)	(4.11)	(2.31)		
2-Year T-Bond	202	0.89***	44.39***	51.19***	68.79***	[0.11]	0.88
		(0.20)	(2.51)	(3.43)	(2.30)		
5-Year T-Bond	203	0.70***	25.71***	47.01***	76.17***	[0.00]	0.82
		(0.25)	(3.12)	(4.14)	(2.89)		
10-Year T-Bond	206	0.49*	13.02***	27.97***	59.90***	[0.02]	0.65
		(0.29)	(3.70)	(5.11)	(3.32)		
30-Year T-Bond	210	0.16	5.58	11.09**	34.36***	[0.38]	0.41
		(0.29)	(3.59)	(5.14)	(2.95)		
Panel B (Excl Empl)							
3-Month T-Bill	201	-0.19	67.10***	78.35***	8.54***	[0.04]	0.76
		(0.25)	(3.78)	(4.26)	(2.21)		
6-Month T-Bill	203	-0.63***	67.96***	65.97***	21.16***	[0.71]	0.77
		(0.23)	(3.57)	(4.03)	(2.30)		
2-Year T-Bond	193	0.96***	45.06***	51.30***	69.56***	[0.16]	0.88
		(0.20)	(2.88)	(3.38)	(2.33)		
5-Year T-Bond	195	0.69***	26.60***	47.05***	77.14***	[0.00]	0.82
		(0.25)	(3.64)	(4.08)	(2.94)		
10-Year T-Bond	197	0.50*	11.75***	28.04***	60.30***	[0.02]	0.64
		(0.29)	(4.34)	(5.09)	(3.40)		
30-Year T-Bond	201	0.17	0.95	11.08**	32.90***	[0.12]	0.38
		(0.29)	(4.05)	(5.13)	(3.00)		

Notes: Table 4.8 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.7 on FOMC event-dates: $\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.9: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis, forward guidance and LSAP announcements, robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)								
3-Month T-Bill	209	-0.29	69.44***	78.28***	9.48***	0.41	[0.11]	0.77
		(0.26)	(3.52)	(4.40)	(2.24)	(1.36)		
6-Month T-Bill	211	-0.65***	70.30***	66.38***	22.73***	-0.28	[0.46]	0.79
		(0.24)	(3.29)	(4.18)	(2.32)	(1.33)		
2-Year T-Bond	203	0.85***	44.23***	51.16***	68.76***	0.84	[0.11]	0.88
		(0.21)	(2.56)	(3.50)	(2.35)	(1.14)		
5-Year T-Bond	204	0.74***	25.93***	46.90***	76.24***	-1.74	[0.00]	0.83
		(0.25)	(3.10)	(4.08)	(2.86)	(1.52)		
10-Year T-Bond	206	0.51*	13.10***	26.84***	59.97***	-16.97***	[0.04]	0.69
		(0.30)	(3.73)	(5.44)	(3.20)	(2.17)		
30-Year T-Bond	208	0.17	4.52	10.42**	36.96***	-17.54***	[0.34]	0.58
		(0.28)	(3.47)	(5.19)	(2.76)	(1.92)		
Panel B (Excl Empl)								
3-Month T-Bill	201	-0.20	67.05***	78.41***	8.59***	0.28	[0.04]	0.76
		(0.26)	(3.79)	(4.27)	(2.22)	(1.32)		
6-Month T-Bill	203	-0.63***	67.96***	66.21***	21.37***	-0.35	[0.75]	0.77
		(0.24)	(3.57)	(4.07)	(2.31)	(1.30)		
2-Year T-Bond	193	0.93***	44.88***	51.36***	69.82***	0.84	[0.15]	0.87
		(0.21)	(2.90)	(3.39)	(2.37)	(1.10)		
5-Year T-Bond	194	0.73***	26.90***	46.95***	77.26***	-1.73	[0.00]	0.82
		(0.25)	(3.63)	(4.04)	(2.93)	(1.51)		
10-Year T-Bond	197	0.50	11.57***	27.68***	59.38***	-16.69***	[0.02]	0.63
		(0.30)	(4.42)	(5.26)	(3.45)	(2.14)		
30-Year T-Bond	200	0.18	0.43	10.35**	35.21***	-17.67***	[0.13]	0.56
		(0.29)	(3.96)	(5.23)	(2.83)	(1.95)		

Notes: Table 4.9 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.8 on FOMC event-dates: $\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP} + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. D_t^{LSAP} is a dummy variable equal to one on FOMC event-dates associated with large-scale asset purchase announcements and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 4.10: Flight to quality in the gold market, robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)								
(i) Equation 4.9	213	0.09*	-0.30	-	-	-	-	0.00
		(0.05)	(0.22)					
(ii) Equation 4.10	213	0.07	-1.53***	-	-	-	-	0.03
		(0.05)	(0.54)					
(iii) Equation 4.11	211	0.06	-0.65	-12.65***	-	-	[0.00]	0.15
		(0.05)	(0.55)	(2.07)				
(iv) Equation 4.12	212	0.06	-0.66	-12.55***	-0.14	-	[0.00]	0.14
		(0.05)	(0.56)	(2.10)	(0.41)			
(v) Equation 4.13	212	0.06	-0.68	-11.19***	-0.23	1.02***		0.18
		(0.05)	(0.56)	(2.11)	(0.40)	(0.30)		
Panel B (Excl Empl)								
(i) Equation 4.9	204	0.09*	-0.27	-	-	-	-	0.00
		(0.05)	(0.24)					
(ii) Equation 4.10	204	0.07	-1.42**	-	-	-	-	0.02
		(0.05)	(0.62)					
(iii) Equation 4.11	202	0.06	-0.34	-12.65***	-	-	[0.00]	0.15
		(0.05)	(0.64)	(2.09)				
(iv) Equation 4.12	203	0.06	-0.35	-12.61***	-0.05	-	[0.00]	0.14
		(0.05)	(0.64)	(2.11)	(0.42)			
(v) Equation 4.13	203	0.06	-0.38	-11.29***	-0.15	0.99***		0.17
		(0.05)	(0.65)	(2.14)	(0.42)	(0.30)		

Notes: Table 4.10 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equations 4.9 to 4.13 on FOMC event dates:

$$g_t = \alpha + \beta_1 \Delta i_t + \varepsilon_t \text{ (4.9)},$$

$$g_t = \alpha + \beta_1 \Delta i_t^u + \varepsilon_t \text{ (4.10)},$$

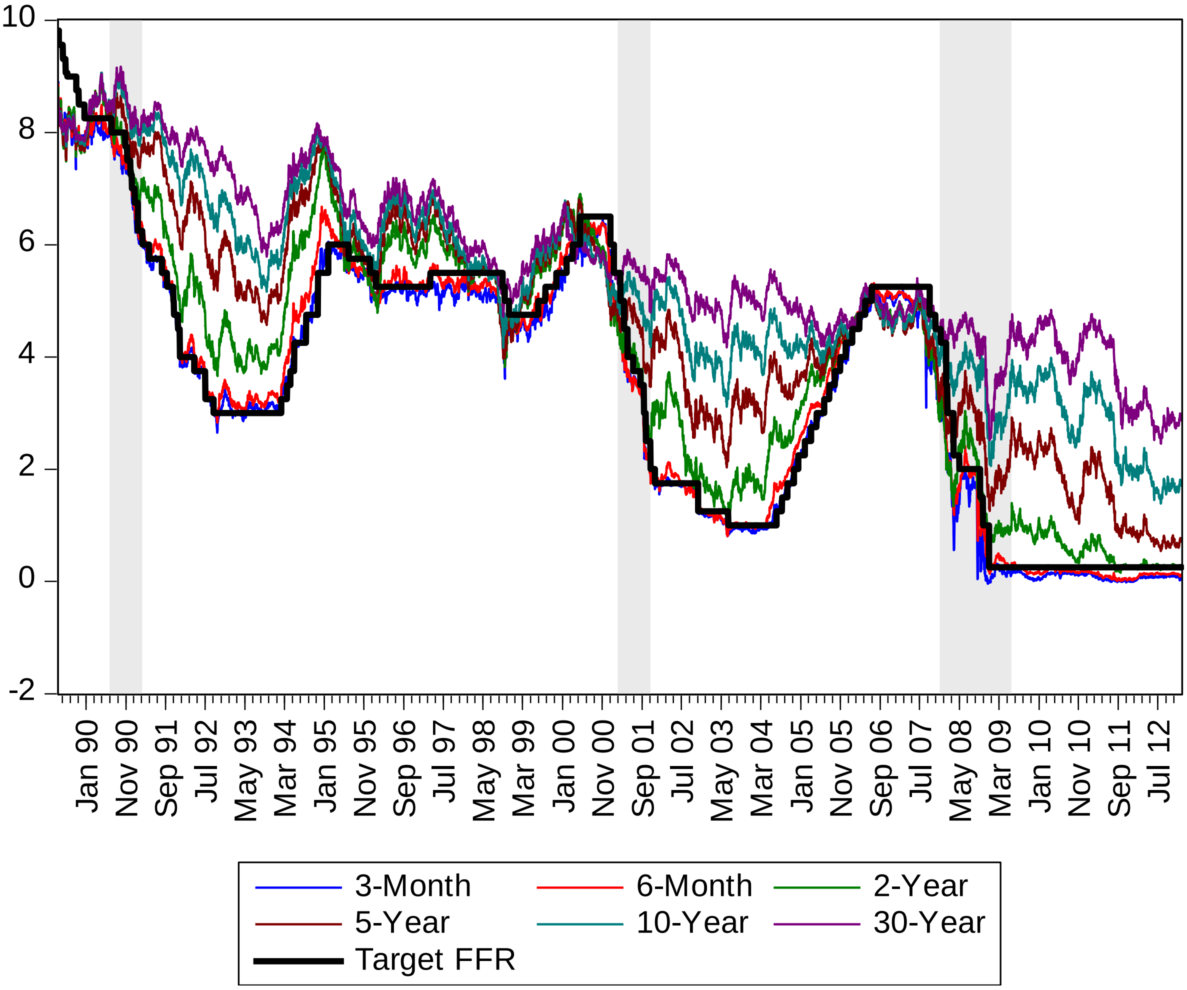
$$g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t \text{ (4.11)},$$

$$g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \varepsilon_t \text{ (4.12)},$$

$$g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP} + \varepsilon_t \text{ (4.13)},$$

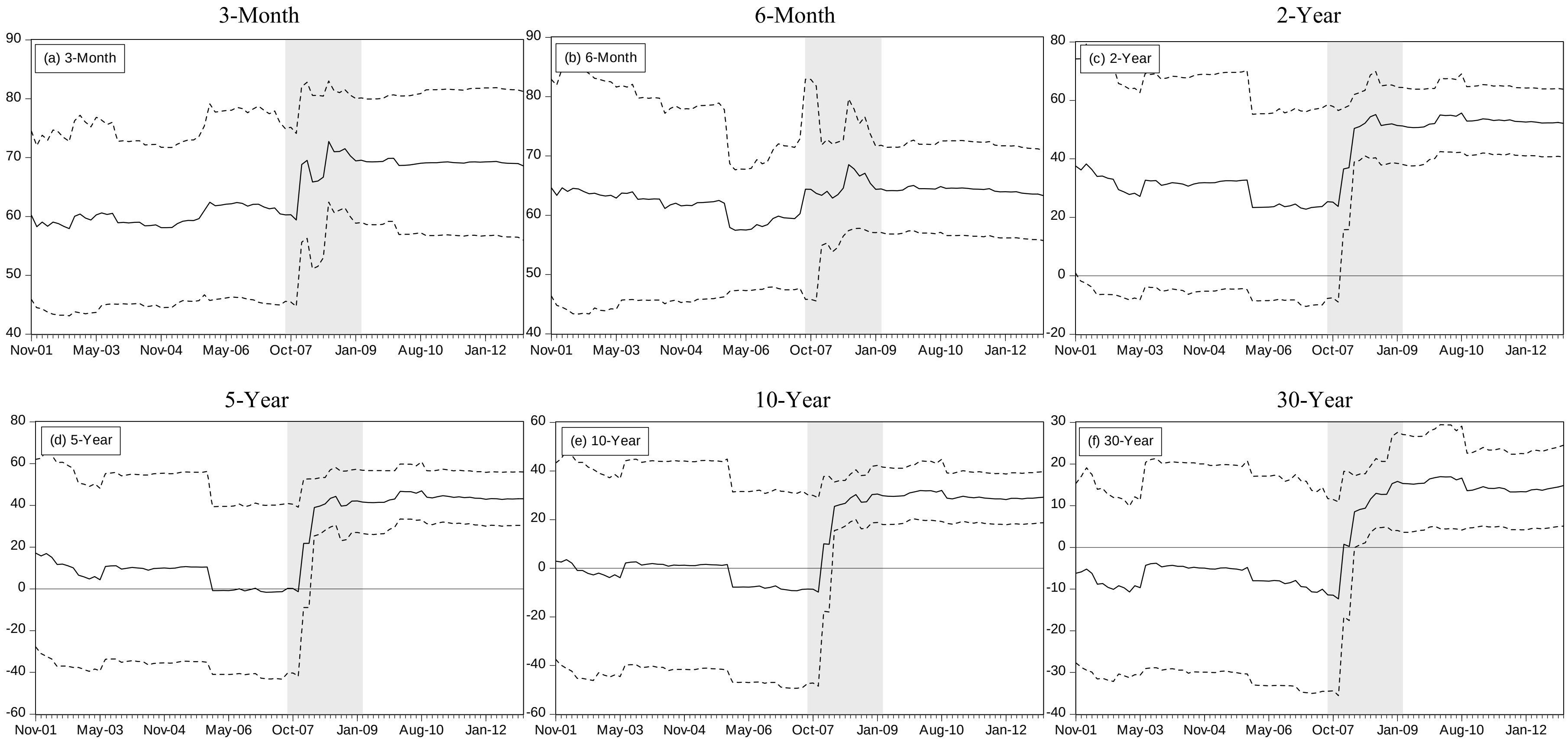
where g_t denotes the spot gold return. Δi_t and Δi_t^u denote target and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. D_t^{LSAP} is a dummy variable equal to one on FOMC event-dates associated with large-scale asset purchase announcements and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Figure 4.1: US Treasury yield level and target FFR level



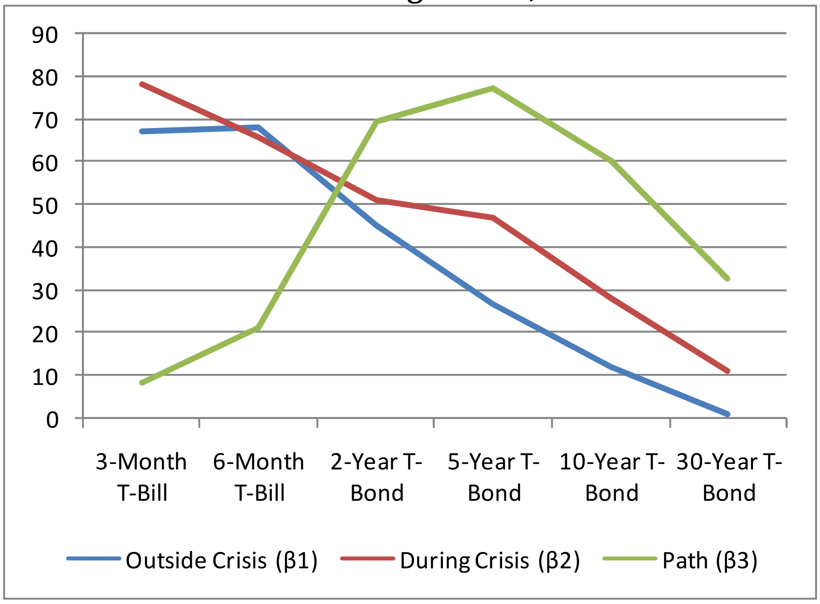
Notes: Figure 4.1 shows the yields on 3-Month, 6-Month, 2-Year, 5-Year, 10-Year and 30-Year on the run Treasuries and the target FFR over the Jun-89 to Dec-12 sample period. The shaded area corresponds to NBER recession dates.

Figure 4.2: Unexpected FFR change rolling coefficient



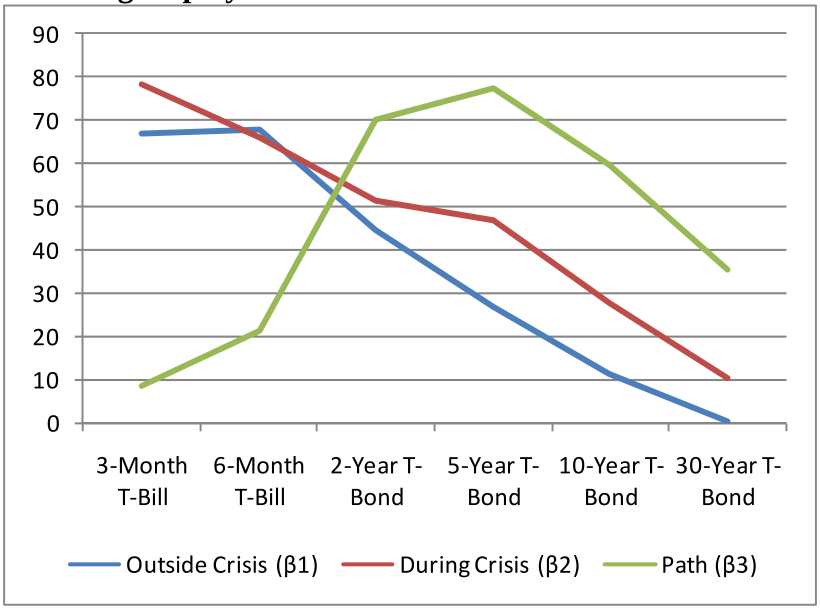
Notes: Figure 4.2 shows the unexpected FFR change coefficient from rolling robust MM-Estimator weighted least squares estimates of Equation (36) on FOMC event-dates: $y_t = \alpha + \beta \Delta i_t^u + \varepsilon_t$, where y_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. The sample period is from Jun-89 to Dec-12. We exclude the 17th Sep 01 event-date from estimation. The dotted lines denote the rolling 95% confidence intervals for the unexpected FFR change coefficient. We use a rolling window of 60 observations. In Panel A we use the 3-Month Treasury as the dependent variable, in Panel B we use the 6-Month Treasury as the dependent variable, in Panel C we use the 2-Year Treasury as the dependent variable, in Panel D we use the 5-Year Treasury as the dependent variable, in Panel E we use the 10-Year Treasury as the dependent variable, in Panel F we use the 30-Year Treasury as the dependent variable.

Figure 4.3: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis and forward guidance, robust MM-estimates, excluding employment



Notes: Figure 4.3 shows the coefficient estimates from Table 4.8 Panel B. The blue line corresponds to the β_1 coefficient which measures the response of US Treasuries to unexpected FFR changes outside the crisis. The red line corresponds to the β_2 coefficient which measures the response of US Treasuries to unexpected FFR changes during the 2007-2009 crisis period.

Figure 4.4: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis, forward guidance and LSAP announcements, robust MM-estimates, excluding employment



Notes: Figure 4.4 shows the coefficient estimates from Table 4.9 Panel B. The blue line corresponds to the β_1 coefficient which measures the response of US Treasuries to unexpected FFR changes outside the crisis. The red line corresponds to the β_2 coefficient which measures the response of US Treasuries to unexpected FFR changes during the 2007-2009 crisis period.

CHAPTER 4 – APPENDIX

Table A4.1: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis, forward guidance and LSAP announcements, robust MM-estimates, structural change in the path factor

	Obs	α	β1	β2	β3	β4	β5	β1 = β2	Adj R^2
Panel A (All Meetings)									
3-Month T-Bill	210	-0.29	69.65***	77.64***	10.51***	-4.75	-0.28	[0.16]	0.77
		(0.26)	(3.52)	(4.44)	(2.35)	(9.36)	(1.47)		
6-Month T-Bill	211	-0.63**	69.98***	64.78***	23.82***	12.46	-0.80	[0.32]	0.79
		(0.24)	(3.30)	(4.11)	(2.48)	(7.64)	(1.40)		
2-Year T-Bond	203	0.86***	44.22***	51.37***	68.94***	70.24***	0.94	[0.10]	0.88
		(0.21)	(2.56)	(3.50)	(2.51)	(6.78)	(1.23)		
5-Year T-Bond	204	0.60**	25.42***	46.77***	75.33***	119.15***	-0.77	[0.00]	0.85
		(0.25)	(3.16)	(4.23)	(3.01)	(8.44)	(1.54)		
10-Year T-Bond	206	0.43	12.68***	31.33***	60.53***	125.06***	-3.80**	[0.00]	0.74
		(0.29)	(3.63)	(5.09)	(3.40)	(10.00)	(1.92)		
30-Year T-Bond	208	0.25	4.11	10.59**	39.04***	28.10***	-18.89***	[0.29]	0.59
		(0.28)	(3.44)	(5.04)	(3.01)	(8.11)	(2.15)		
Panel B (Excl Empl)									
3-Month T-Bill	200	-0.18	66.95***	77.86***	9.48***	-5.95	-0.44	[0.04]	0.77
		(0.25)	(3.73)	(4.17)	(2.28)	(9.03)	(1.38)		
6-Month T-Bill	203	-0.56**	66.56***	64.93***	23.23***	12.12	-0.95	[0.75]	0.78
		(0.23)	(3.50)	(3.89)	(2.44)	(7.36)	(1.32)		
2-Year T-Bond	194	0.94***	44.87***	51.54***	70.01***	71.02***	0.92	[0.13]	0.87
		(0.21)	(2.89)	(3.38)	(2.53)	(6.59)	(1.19)		
5-Year T-Bond	194	0.58**	26.64***	47.03***	76.72***	119.31***	-0.75	[0.00]	0.85
		(0.25)	(3.63)	(4.05)	(3.02)	(8.21)	(1.49)		
10-Year T-Bond	197	0.42	11.42***	31.31***	60.64***	124.95***	-3.80**	[0.00]	0.74
		(0.30)	(4.28)	(5.12)	(3.51)	(10.04)	(1.92)		
30-Year T-Bond	199	0.24	0.23	10.54**	36.98***	28.51***	-18.70***	[0.11]	0.57
		(0.29)	(3.92)	(5.11)	(3.09)	(8.21)	(2.18)		

Notes: Table A4.1 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.14 on FOMC event-dates: $\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \left[\beta_3\left(1 - D_t^{crisis}\right) + \beta_4\left(D_t^{crisis}\right)\right]Path_t + \beta_5 D_t^{LSAP} + \varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A4.2: Flight to quality in the gold market, robust MM-estimates, structural change in the path factor

	Obs	α	β_1	β_2	β_3	β_4	β_5	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)									
(i) Equation 4.14	211	0.05	-0.71	-13.68***	-0.22	2.86	0.55*	[0.00]	0.15
		(0.05)	(0.56)	(2.36)	(0.42)	(1.82)	(0.31)		
Panel B (Excl Empl)									
(i) Equation 4.14	202	0.05	-0.41	-13.69***	-0.14	2.86	0.54*	[0.00]	0.15
		(0.05)	(0.65)	(2.38)	(0.44)	(1.84)	(0.32)		

Notes: Table A4.2 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.15 on FOMC event-dates: $g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \left[\beta_3\left(1 - D_t^{crisis}\right) + \beta_4\left(D_t^{crisis}\right)\right]Path_t + \beta_5 D_t^{LSAP} + \varepsilon_t$, where g_t and Δi_t^u denotes the spot gold return and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A4.3: Response of US Treasuries to unexpected FFR changes, controlling for the 2007-2009 crisis (NBER Crisis: Dec-08 to Jun-09), forward guidance and LSAP announcements, robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)								
3-Month T-Bill	208	-0.23	69.05***	118.28***	9.97***	-0.18	[0.01]	0.68
		(0.26)	(3.45)	(18.36)	(2.23)	(1.40)		
6-Month T-Bill	211	-0.64***	72.13***	65.59***	22.57***	-0.32	[0.20]	0.80
		(0.24)	(3.26)	(4.05)	(2.30)	(1.31)		
2-Year T-Bond	202	0.86***	43.56***	52.34***	69.36***	0.89	[0.04]	0.89
		(0.21)	(2.49)	(3.38)	(2.31)	(1.11)		
5-Year T-Bond	205	0.74***	24.90***	48.20***	76.17***	-1.70	[0.00]	0.82
		(0.25)	(3.09)	(4.41)	(2.87)	(1.53)		
10-Year T-Bond	206	0.51*	12.04***	28.65***	60.36***	-16.90***	[0.01]	0.70
		(0.29)	(3.69)	(5.05)	(3.18)	(2.16)		
30-Year T-Bond	208	0.17	3.63	11.88**	37.06***	-17.48***	[0.17]	0.58
		(0.28)	(3.46)	(4.90)	(2.75)	(1.92)		
Panel B (Excl Empl)								
3-Month T-Bill	200	-0.11	66.18***	121.68***	8.85***	-0.45	[0.00]	0.66
		(0.25)	(3.60)	(17.38)	(2.14)	(1.31)		
6-Month T-Bill	203	-0.62***	69.96***	65.47***	21.07***	-0.38	[0.40]	0.78
		(0.24)	(3.55)	(3.97)	(2.28)	(1.28)		
2-Year T-Bond	192	0.93***	44.15***	52.51***	70.40***	0.88	[0.05]	0.88
		(0.20)	(2.80)	(3.27)	(2.32)	(1.07)		
5-Year T-Bond	196	0.74***	25.07***	48.16***	76.84***	-1.70	[0.00]	0.82
		(0.25)	(3.62)	(4.37)	(2.94)	(1.52)		
10-Year T-Bond	197	0.51*	10.20**	29.20***	60.50***	-16.05***	[0.00]	0.65
		(0.29)	(4.28)	(4.94)	(3.38)	(2.12)		
30-Year T-Bond	200	0.18	-0.64	11.94**	35.09***	-17.60***	[0.05]	0.56
		(0.29)	(3.94)	(4.95)	(2.83)	(1.96)		

Notes: Table A4.3 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.8 on FOMC event-dates: $\Delta y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP}\varepsilon_t$, where Δy_t and Δi_t^u denote US Treasury yield changes and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Dec-07 to Jun-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. D_t^{LSAP} is a dummy variable equal to one on FOMC event-dates associated with large-scale asset purchase announcements and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A4.4: Flight to quality in the gold market (NBER Crisis: Dec-08 to Jun-09), robust MM-estimates

	Obs	α	β_1	β_2	β_3	β_4	$\beta_1 = \beta_2$	Adj R^2
Panel A (All Meetings)								
(i) Equation 4.8	212	0.06	-0.73	-12.95***	-0.26	0.85***	[0.00]	0.18
		(0.05)	(0.55)	(2.32)	(0.40)	(0.30)		
Panel B (Excl Empl)								
(i) Equation 4.8	203	0.06	-0.48	-13.04***	-0.19	0.82***	[0.00]	0.17
		(0.05)	(0.64)	(2.36)	(0.42)	(0.30)		

Notes: Table A4.4 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation 4.8 on FOMC event-dates: $g_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \beta_3 Path_t + \beta_4 D_t^{LSAP} + \varepsilon_t$, where g_t and Δi_t^u denotes the spot gold return and unexpected FFR changes respectively. D_t^{crisis} is a dummy variable equal to one during the Dec-07 to Jun-09 sample period and zero otherwise. The path factor $Path_t$ is the component of change in the four quarter ahead Eurodollar interest rate future orthogonal to unexpected FFR changes. D_t^{LSAP} is a dummy variable equal to one on FOMC event-dates associated with large-scale asset purchase announcements and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all Panels (A and B). Panel A includes all FOMC event-dates. Panel B excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Chapter 5: The International Stock Market Reaction to Federal Funds Rate Surprises: Transmission during the Financial Crisis (Empirical Analysis)

5.1 Abstract

This chapter investigates the transmission of Federal Funds rate surprises to 43 international equity index returns over the Jun-89 to Dec-12 sample, with a focus on the effect of the 2007-2009 global financial crisis. In line with previous studies, we find that outside the crisis period, there is significant cross country heterogeneity in the responses of foreign equity indices to FFR shocks, increasing on average 2.80% in response to an unexpected 1% FFR cut. However, we find that during the crisis period, there is even greater heterogeneity in the responses of foreign equity indices to FFR shocks, with an unexpected 1% FFR cut being associated with significant 2.53%-7.50% *decline* across the equity indices of 12 countries, and 2.79%-14.04% *increases* across the equity indices of 19 countries. We find that cross country heterogeneity in equity market responses to FFR shocks during the crisis period can only partly be explained in terms of real bilateral integration with the US economy, and find that external borrowing from the rest of the world is also an important determinant.

5.2 Introduction

"*World stock markets were mixed today after the U.S. Federal Reserve slashed its key interest rate to historic lows and as worries lingered about the world's largest economy*" (Watt, 2008)

On the 29th Oct 08, amidst the turmoil of the financial crisis, the FOMC sought to ease credit market conditions and stock market fears by cutting the target FFR by 50 basis points, after their scheduled FOMC meeting. Following the meeting, Reuters reported "*S&P500 slip after Fed cuts rates*" (Cooke, 2008) and later in the day, the Wall Street Journal reported "*U.S. stocks end mostly lower after Fed cuts rates*" (Gibson, 2008). However, when European equity markets opened the following day, the British press reported "*FTSE 100 rises after US cuts rates*" (Moore, 2008). This demonstrates that during the crisis period, target FFR cuts by the FOMC were interpreted differently both domestically and internationally. Furthermore, at the onset of the financial crisis, on 19th Sep 07, Reuters reported "*FTSE rises 2.8% on Fed rate cut*" (Lau, 2007) following a scheduled FOMC meeting, however several months later on 11th Dec 07, they reported "*FTSE falls after Fed rate cut*" (Taylor, 2007). This demonstrates that the market participants in the UK may initially have seen target FFR cuts in the US as good news, however amidst the financial crisis, such cuts were interpreted as bad news, signals by the Fed of worsening financial and economic conditions.

As we demonstrated in Chapter 2, there is an extensive empirical literature which examines the relationship between conventional FOMC monetary policy shocks and asset prices in the US. However, there are comparatively fewer studies which analyse the transmission of FFR shocks from the US to international equity markets. To the best of our knowledge, this is the first study to explicitly investigate the impact of the 2007-2009 crisis on this relationship. It is important to evaluate this relationship for a variety of reasons. Firstly, from an asset pricing perspective, if FFR shocks from the US influence foreign asset prices, then FOMC monetary policy should be considered to be a global risk factor, and this has important implications for pricing assets both domestically and internationally. Secondly, from a policy maker's standpoint, if FOMC monetary policy has global asset pricing implications, then it could be used to insulate the US economy from foreign economic and financial crises[150]. Thirdly, from an investor's perspective, if both domestic and international asset prices respond to FOMC monetary policy, there are limited opportunities for portfolio diversification against this global risk factor.

Previous studies which estimated the impact of FFR shocks on international equity markets prior to the 2007-2009 crisis period employed several empirical approaches to defining monetary policy shocks. The literature largely echoed that concerning the domestic US stock market, and emerged as a natural extension to the studies by Kuttner (2001) and Bernanke and Kuttner (2005). More recent studies in this field have principally measured conventional monetary policy shocks in terms of expected and unexpected FFR changes, decomposing raw target FFR changes in to these components using the approach of Kuttner (2001). This market-based measure of unexpected FFR changes has been shown to be efficient as it represents a natural proxy for the market's expectations of future FFR changes and associated forecast errors. It can also be defined using higher-frequency daily or intra-day data which is more likely to be exogenous and less likely to endogenously reflect other macroeconomic factors and news, compared to lower-frequency aggregate measures used in

[150] For example, as Wongswan (2009) points out, the FOMC cut the target FFR three times in late 1998 to protect the US economy from the lasting effects of the 1997 Asian Financial Crisis

many VAR related studies[151]. Furthermore, this measure has been shown to yield efficient and unbiased forecasts of the target FFR with a very small risk premium compared to alternative market instruments[152].

Recent studies[153] which measured conventional monetary policy shocks using the approach of Kuttner (2001) have demonstrated that unexpected FFR changes yield statistically significant responses in equity markets both domestically in the US and internationally in foreign equity markets (see Ehrmann and Fratzsher, 2009; Hausman and Wongswan, 2011). Furthermore, it has been shown that equity markets in both advanced and emerging market economies respond significantly to FFR shocks. However, there is an important caveat, as the impact across equity markets in different countries has been shown to be characterised by significant heterogeneity, with some yielding greater magnitude responses to FFR shocks than the US stock market, and other yielding lower magnitude or statistically insignificant responses. Nevertheless, in each country where the response is shown to be statistically significant, the estimated coefficient is negative, which implies that unexpected FFR cuts (increases) are associated with positive (negative) returns in the equity market of that country.

In an earlier study, Gürkaynak, Sack and Swanson (2005) demonstrated that US Treasuries responded significantly to the 'path factor' measure which was shown to be associated with FOMC statements, however they found that US stock returns did not respond significantly to the measure. This finding was subsequently confirmed in another study by Wang, Yang and Wu (2006) which implied that equity markets were not as forward looking as US Treasury markets. In a more recent study, Wongswan (2009) developed a related 'path factor' measure and demonstrated that foreign equity indices did not respond significantly to this proxy of FOMC statements across a sample of 15 countries. This shows that both

[151] Studies which measure FFR shocks using VAR approaches typically employ lower-frequency weekly, monthly, quarterly or annual data which is more likely to reflect a range of factors, and less likely to reflect a clean exogenous measure of FFR shocks. These studies also require a subjective interpretation of which variables to include in their model which can influence the outcome of estimates. For earlier studies which use this approach, see Thorbecke (1997) and Patelis (1997), for more recent studies see Bonfim (2003) and Rigobon and Sack (2004).

[152] Gürkaynak, Sack and Swanson (2002, 2007) demonstrated that alternative monetary instruments such as the term federal funds loans, FFR futures, eurodollar deposits, commercial paper, eurodollar futures and Treasury bills all yielded forecasts of the FFR which were superior to that of a Bayesian VAR and AR(1) process. However the methodology of Kuttner (2001) which used FFR futures dominated all other measures in predicting the FFR at one-month to six-month horizons.

[153] For earlier studies which evaluate the relationship between international equity returns and conventional monetary policy shocks from the US, see Mudd (1979), Husted and Kitchen (1985), Johnson and Jensen (1993), Conover, Jensen and Johnson (1999), Ehrmann and Fratzscher (2005), Anderssen (2003).

domestic and international equity markets are not as forward looking as other asset classes (see also Hausman and Wongswan, 2011).

Having found that foreign equity indices yielded highly heterogeneous responses to FFR shocks, and statistically insignificant responses to the path factor, these studies sought to investigate potential determinants for this relationship. In particular, Ehrmann and Fratzscher (2009) analysed whether the heterogeneity in international equity market responses to FFR shocks could be explained in terms of real and financial integration with the US economy. They were motivated by the hypothesis that equity markets in countries with higher bilateral integration with the US economy in terms of trade and financial linkages would yield larger magnitude responses to FFR shocks. Interestingly, they concluded that the degree of global integration with the world economy, and not the degree of bilateral integration with the US economy was a significant factor in explaining this heterogeneity[154]. Equity markets in counties with a higher degree of trade with the world yielded significantly greater responses to FFR shocks compared to those with a lower degree of trade with the world. They also found that equity markets in countries with higher business cycle correlation with the US yielded larger magnitude responses to FFR shocks.

In contrast to Ehrmann and Fratzscher (2006), a related study by Hausman and Wongswan (2006) found that real and financial integration with the US economy was more important than integration with the rest of the world in explaining cross country heterogeneity in the responses of international equity indices to FFR shocks[155]. A later study by Ammer, Vega and Wongswan (2010) argued that these two previous studies did not account for non-synchronous trading as Asian and European equity markets typically responded to FFR shocks the following day when their equity markets opened. To account for this concern, they constructed a dataset of foreign assets which responded contemporaneously to FOMC announcements concerning the target FFR. They found that equities in countries with higher levels of external financing were more sensitive to FFR shocks, consistent with the credit channel. Furthermore, foreign equity markets where stocks were largely held by US investors were shown to yield larger magnitude responses to FFR shocks, consistent with the portfolio balance effect.

[154] It was shown that equity markets in countries with a higher degree of bilateral trade with the world did not yield significantly greater responses to FFR shocks than those in countries with a lower degree of trade.

[155] This notable difference was pointed out in an earlier working paper by Hausman and Wongswan (2006) which was referring to the working paper by Ehrmann and Fratzscher (2006) which was later published as Ehrmann and Fratzscher (2009).

In this chapter, we investigate the transmission of Federal Funds rate surprises to international equity indices, over the Jun-89 to Dec-12 sample, with a particular emphasis on the impact of the 2007-2009 crisis on this relationship. Our sample of foreign equity indices covers 43 advanced and emerging market economies[156]. We contribute to the existing empirical literature concerning this relationship in several important dimensions. Firstly, we demonstrate that a significant structural shift occurred during the crisis period which changed the nature of the relationship between foreign equity markets and FFR shocks across 26 countries. We find that outside the crisis period there is significant cross country heterogeneity in the responses of foreign equity indices to FFR shocks, increasing (decreasing) on average 2.80% in response to hypothetical unexpected 1% FFR cut (increase). In line with previous studies, we find that countries in which the equity market responds significantly to FFR shocks outside the crisis period, the coefficient estimate is negative, which implies that unexpected FFR cuts (increases) are associated with significant positive (negative) returns in the equity markets of those countries. However, our findings indicate that during the crisis period, there is even greater heterogeneity in the responses of foreign equity indices to FFR shocks, as the estimated coefficient is negative for some countries whilst positive for others. Our results indicate that a hypothetical unexpected 1% FFR cuts during the crisis is associated with significant 2.53%-7.50% *declines* in the equity indices of 12 countries, and significant 2.79%-14.04% *increases* in the equity indices of 19 countries.

Secondly, this chapter attempts to understand why there is significant heterogeneity in the responses of foreign equity indices to FFR shocks during the crisis period. In particular, we seek to offer some explanations for why equity returns in some countries were positive and others were negative, following unexpected FFR cuts during the crisis. We find that this heterogeneity cannot be entirely explained by any single factor, but rather a combination of various factors. In particular, during the crisis period, factors such as the degree of bilateral integration with the US economy, and the degree of real integration with the world economy, can only significantly explain the responses of equity markets in countries with a higher degree of real integration with the US or world economy, and cannot significantly explain the responses of equity markets in countries with a lower degree of real integration[157]. In terms of financial linkages through the banking sector, we yield some evidence that during the crisis

[156] The selection of countries was solely guided by availability of data.

[157] Previous studies have shown that real bilateral integration with the US economy (see Hausman and Wongswan, 2011), or real integration with the world economy (see Ehrmann and Fratzscher, 2009) are important determinants in explaining heterogeneity in equity market responses to FFR shocks outside the crisis period.

period, unexpected FFR cuts (increases) were associated with negative (positive) equity market returns in countries with higher external borrowing from the rest of the world[158].

This chapter is structured as follows: in Section 5.3 we describe the dataset and sample period, in Section 5.4 we evaluate the econometric models and results, and finally in Section 5.5 we conclude the chapter.

5.3 Data and sample period

5.3.1 Measuring conventional monetary policy shocks

In this section, we describe the dataset used in the empirical analysis. To measure conventional monetary policy shocks we use the event-study approach of Bernanke and Kuttner (2005), disaggregating target FFR changes in to expected and unexpected components by gauging expectations from implied rates of CBOT futures contracts which track the underlying instrument of the effective FFR. Our dataset includes a set of event-dates of 189 scheduled FOMC meetings and 24 unscheduled FOMC meetings with target FFR changes, over the Jun-89 to Dec-12 sample period. We refer the reader to Section 3.5.1 and Section 3.5.2 for a more detailed exposition concerning the measurement of conventional monetary policy shocks and for an analysis of the related descriptive statistics.

5.3.2 Asset price data and timing discrepancies

To investigate the relationship between international indices and unexpected FFR changes, we construct a dataset consisting of 43 equity index returns for a sample of 43 emerging market and advanced economies using data from Datastream. For each of these countries, we consider the benchmark equity index for several important reasons. Firstly, they are closely followed by market participants and are widely quoted in academic studies and the financial press. Secondly, each benchmark equity index is representative of aggregate equity market index performance in that country and these measures are widely used by market participants, academic researchers and policy markers as national benchmarks against which the performance of alternative financial assets can be compared (see Christopherson, Cariño and Ferson, 2009; Taylor, 2010). In the context of investment analysis, the benchmark equity indices represent a diversified portfolio of stocks which respond to non-diversifiable

[158] The negative response of equity markets in countries with higher degree of borrowing from the rest of the world is shown to be significant only at the 10% significance level.

systemic risks such as FFR shocks. Thirdly, the benchmark equity indices typically represent the highest market capitalisation companies in a country, and thereby are more likely to be efficient in incorporating new information as they are more likely to consist of highly traded and liquid securities watched by market participants[159].

In Table 5.1 we list the main benchmark equity index associated with each country in our dataset. These indices are defined as benchmarks by Datastream however there is significant overlap with indices quoted by Bloomberg and the Financial Times Newspaper[160] as being indicative of benchmark equity market performance in each respective country. The selection of 43 countries is restricted only by data availability for all the variables and measures used in this chapter[161]. For each country (i) we calculate the stock market return $\left(r_{it}^{\text{int}}\right)$ as the first difference of the natural log of the equity index $\left(S_t^{index}\right)$ on the close of the FOMC meeting relative to that the previous day (see Equation 5.1).

$$r_{it}^{\text{int}} = 100 * \left(\ln S_t^{index} - \ln S_{t-1}^{index}\right), \qquad (5.1)$$

Prior to discussing more technical nuances in the calculation of foreign equity index returns around FOMC announcements, it is important to outline how financial markets typically became aware of target FFR changes and non-changes over the sample period. From Feb-94, the FOMC began releasing press-release statements which outlined the current level of the target FFR and any changes of non-changes to the rate. The statement often contained further information concerning the rationale behind target FFR changes and non-changes, an evaluation of economic risks and an indication of the future trajectory of monetary policy[162] (see Section 4.5.3). These statements were typically issues at around 2:15pm Eastern Standard Time (EST) following scheduled FOMC meetings and unscheduled FOMC meetings with target FFR changes. Prior to Feb-94, market participants inferred target FFR

---

[159] Ehrmann and Fratzscher (2009) estimated the impact of FFR shocks on equally weighted foreign equity indices however they found that their estimates were "*similar to whether or not value-weighted or unweighted return indices are used*."

[160] We refer here to the UK edition of the Financial Times newspaper.

[161] There was no data available for one or more of the real integration, macroeconomic or financial variables used later in this study for Argentina, Chile, Colombia, Israel, Romania and Taiwan. This meant these countries could not be ranked in the later analysis and for this reason these countries were omitted from the dataset. For Cyprus and Slovenia, the benchmark equity indices cover less than one third of the sample period, hence these two countries are also omitted from the analysis to avoid significant sub-sample bias on estimation.

[162] Previous studies have shown that the US stock market only responds to target FFR shocks and not to other information contained within these statements (see Gürkaynak, Sack and Swanson, 2005; Wang, Yang and Wu, 2006). It has also been demonstrated the foreign equity indices only respond significantly to the unexpected component of target FFR changes and not to FOMC statements (see Wongswan, 2009; Hausman and Wongswan, 2011).

changes through open market operations by the Federal Reserve Ban of New York Trading Desk and subsequent news reports in the financial press (see Kuttner, 2003). These operations typically occurred at around 11:30am EST. On seven occasions prior to Feb-94 and on eleven occasions following this date, announcements or observed open market operations significantly deviated from the above detailed timing schedule. We list these nineteen deviations in Table 5.2.

We raise this important point because the timing of FOMC announcements concerning the target FFR can have significant implications for the calculation of equity index returns in foreign equity markets. At 2:15pm EST when most announcements occurred, the equity markets in Brazil, Canada, Mexico and USA were typically open and therefore the markets responded to contemporaneously in real time to this news. However, equity markets in Asia-Pacific, Europe, Africa and the Middle East were closed and reacted to this news when markets opened the next trading day, hence we calculate equity market returns for these countries using the day following each FOMC announcement, relative to the day prior. In Figure 5.1 we standardise the trading hours for each of the 43 counties to EST to demonstrate that when the majority of announcements occurred at 2:15pm EST, few equity markets were open internationally. Throughout this chapter, we have made relevant adjustments to the calculation of equity index returns on FOMC event-days to account for the trading hours of each country, changes in summer time, and changes in actual trading hours over time as they were adjusted by exchanges. The details of trading hours are from Bloomberg and Market Clocks (2013).

It is also important to note that CBOT futures trade in the open market from 8.20am to 3.00pm EST. Thus the FOMC announcements on 18th Dec 90 and 15th Oct 98 detailed in Table 5.2 occurred after this time. For this reason we use the following day's futures prices to calculate unexpected FFR changes for these dates. In line with previous studies (see Bernanke and Kuttner, 2005; Kurov, 2010), we omit the 17th Sep 01 event-date from the analysis. This is due to the fact that the FOMC, Bank of England and European Central Bank co-ordinated monetary action on this date following the first day of trading in the US following the 11th Sep 01 attacks.

5.3.3 Proxies for real economic integration with the US economy, financial linkages and macroeconomic factors

Following the initial empirical analysis in this chapter, we investigate whether heterogeneity in the responses of international equity indices to FFR shocks during the 2007-2009 crisis period can be explained in terms of real integration with the US economy or in terms of other financial and macroeconomic factors. To measure the degree of each country's real economic integration with the US economy, we use three proxies. Firstly, we use the ratio of each country's trade with the US, that it is its exports plus imports, relative to its GDP. This is motivated by the fact that previous studies have shown it is a significant factor in explaining cross country heterogeneity in the response of equity returns to FFR shocks (see Ehrmann and Fratzscher, 2009; Wongswan, 2009). Secondly, we measure real integration with the US as the ratio of US imports from each country relative to its GDP. This is motivated by the fact that US demand for foreign goods may influence the relationship. Thirdly, we use the ratio of US exports to each country relative to its GDP. The trade data is from the International Trade Administration US Department of Commerce and GDP data is from the World Bank Development Indicators Database.

To consider the role of financial and macroeconomic linkages in the transmission mechanism, we consider several other factors which may explain heterogeneity in international equity index responses to FFR shocks. Firstly, to consider the role of financial linkages through the banking sector, we use the ratio of each country's external lending from the world relative to its GDP[163]. The data is from the Bank of International Settlements International Banking Statistics. Secondly, to consider the role of business cycle correlation in the relationship, we use the correlation of GDP growth rates in the US with each country. The data is from the WDI database. Thirdly we consider the role of time zone differences in the relationship. As Figure 5.1 shows, equity markets in some countries were open when the majority of FOMC announcements concerning the target FFR occurred, however Asian-Pacific, European, African and Middle Eastern equity markets responded the next day. A study by Gürkaynak, Sack and Swanson (2005) demonstrated that the US stock market response to FFR shocks increased in magnitude as the announcement window was increased from intra-day to a daily frequency. In this manner, as Asian and European markets

[163] As Wongswan (2009) points out, an extensive empirical literature has sought to measure the degree of financial integration of different countries however there is no academic consensus as to which variables are most appropriate for measuring these factors.

responded the following day, they may have responded differently to FFR shocks as they had more time to incorporate the new information. To account for this factor, we define a dummy variable equal to one for each country (i) if it was open or closed at the time of FOMC announcements using information from Bloomberg and Market Clocks (2013).

5.3.4 Descriptive statistics

In Table 5.3 we report descriptive statistics for international equity index returns in the 43 emerging market and advanced economies, on FOMC event-dates, over the Jun-89 to Dec-12 sample period. These returns are all adjusted for whether the equity market responded to FFR shocks contemporaneously in real time or the next day, and accordingly adjusted for timing discrepancies in the traditional FOMC announcement schedule as detailed in Section 5.3.2 and Table 5.2. Overall, the summary statistics demonstrate that there is significant heterogeneity in international equity index returns on FOMC event-dates. The average change on FOMC event-dates is shown to be positive for 39 countries and negative for 4 countries. We find that New Zealand, Brazil, Mexico, Australia, Philippines and Canada have the highest correlations of returns with US stock returns on FOMC event-dates, while Singapore, Pakistan, Russia and Poland have the lowest correlations.

5.4 Econometric models and results

5.4.1 Preliminary estimates

In this section, we empirically investigate the transmission of Federal Funds rate surprises to international equity indices, over the Jun-89 to Dec-12 sample, with a particular emphasis on the impact of the 2007-2009 crisis on this relationship. We subsequently extend the analysis to investigate potential factors which explain the strength of transmission and magnitude of equity market response across countries to FFR shocks both outside and during the crisis period. As we demonstrated in Chapter 3, the relationship between US stock returns and FFR shocks was characterised by outlier observations which influenced estimation. This finding was consistent with previous studies which also found that the relationship was characterised by outliers (see Basistha and Kurov, 2008; Bernanke and Kuttner, 2005). As we extend our investigation towards international equity markets, analysing the extent to which they respond to unexpected FFR changes by the FOMC, these relationships are highly likely to also be characterised by outlier observations akin to that observed for the domestic US stock market in Chapter 3. To account for potential outliers in the international transmission of FFR shocks, we use the robust MM-Estimator weighted least squares methodology of Yohai (1987) throughout this chapter. This approach has been shown to be highly robust towards vertical outliers and leverage point outliers, as well as clusters of outliers. It has also been shown to be exhibit a high-breakdown point with higher Gaussian efficiency compared to classical OLS models (see Verardi and Croux, 2010).

Our analysis begins in a stepwise manner, beginning with a simpler model specification and gradually augmenting and adapting the model to suit the characteristic of the dataset. We begin the econometric investigation by investigating the relationships individually, country by country to explore the depth the dataset. In particular, we estimate the impact of raw target FFR changes (Δi_t) on each foreign equity index (r_t^{int}) on FOMC event-dates over the Jun-89 to Dec-12 sample period (see Equation 5.2). In line with previous studies, we use both scheduled (189) FOMC meeting and unscheduled FOMC meetings (24) with target FFR changes, and further exclude the 17th Sep 01 observation from all estimates.

$$r_t^{\text{int}} = \alpha + \beta \Delta i_t + \varepsilon_t, \tag{5.2}$$

The robust MM-Estimator weighted least squares estimates of Equation 5.2 are reported in Table 5.4, and each model is repeatedly estimated using equity index returns for each of the 43 countries in our sample. We specifically begin the investigation using this very simple model specification to demonstrate the inefficacy of this models in capturing the relationship between international equity index returns and conventional US monetary policy shocks. We find that equity market returns in Hong Kong are associated with significant positive (negative) responses to target FFR cuts (increases) over the sample period. Although this is in line with previous studies, unusually across 9 countries we find that the equity market response to target FFR cuts (increases) is negative (positive) and statistically significant. The estimates for these 9 countries not only contradict classical asset pricing theory but also contradict empirical conclusions yielded in previous studies concerning the pre-crisis sample period. One may argue that this unusual finding was rendered due to the fact that our sample period covers the 2007-2009 crisis period in its entirety, however our estimates in the next Table (5.5) demonstrate that these models are severely mis-specified because they consider a rather broad measure of conventional FOMC monetary policy.

Having yielded rather unusual estimates in Table 5.4, we continue our investigation by decomposing the broad measure of conventional monetary policy, i.e. raw target FFR changes, in to its constituent components concerning expected and unexpected FFR changes using the technique of Kuttner (2001) and Bernanke and Kuttner (2005). In Table 5.5 we estimate the impact of unexpected FFR changes $\left(\Delta i_t^u\right)$on each foreign equity index$\left(r_t^{\text{int}}\right)$ on FOMC event-dates over the Jun-89 to Dec-12 sample period (see Equation 5.3). Our focus is primarily on the unanticipated component of FFR change, and this is motivated by the assumption that asset prices in efficient markets have already factored in and incorporated information concerning the anticipated component of target FFR change[164].

$$r_t^{\text{int}} = \alpha + \beta \Delta i_t^u + \varepsilon_t , \quad (5.3)$$

Table 5.5 reports robust MM-Estimator weighted least squares estimates of Equation 5.3 which is estimated repeatedly using equity index returns for each of the 43 countries in our sample. We now find that unexpected FFR cuts (increases) are associated with statistically significant positive (negative) returns in equity markets across 18 emerging market and advanced economies. Our estimates demonstrate that there is significant cross country heterogeneity in international equity market responses to FFR shocks. The largest magnitude responses are observed in South Africa, Russia, Singapore, Brazil and Hong Kong. The equity market returns in these countries are shown to increase (decline) 5-7% in response to a hypothetical 1% FFR cut (increase).

Furthermore, there is significant variation in the reactions of equity markets in both emerging market and advanced economies. Across the advanced economies, we find that equity markets in Singapore, Hong Kong and Italy exhibit significant larger magnitude responses to FFR shocks compared to Japan, Canada and the UK by a factor of two. Across emerging market economies, we find that equity markets in South Africa and Brazil exhibit larger magnitude responses to FFR shocks than many other advanced economies. This implies that heterogeneity in equity market responses to FFR shocks cannot be entirely explained by differences attributable to classification of advanced or emerging market economies. We also find that equity markets in more closed capital markets such as China, and Sri Lanka yield statistically insignificant responses to FFR shocks, however equity markets in more open capital markets such as Denmark, France, and Germany also yield statistically insignificant responses.

Overall, we find significant cross country heterogeneity in international equity index responses to FFR shocks from the US, ranging from statistically insignificant responses across 25 countries, to statistically significant responses in the remaining 18 countries. Our

[164] Consistent with previous studies (see Ammer, Vega, and Wongswan, 2010; Ehrmann and Fratzscher, 2009 Wongswan, 2009), we focus upon the unexpected component of target FFR changes.

estimates are highly consistent with those yielded by Ehrmann and Fratzscher (2009) for the Feb-94 to Dec-04 sample period. They similarly documented statistically significant equity market responses to FFR shocks in less than half of the countries surveyed[165]. In line with their study, we also find significant cross country heterogeneity in equity market responses to FFR shocks, with stronger responses for equity markets in Hong Kong, South Africa and Brazil.

To evaluate the robustness of the estimates in Table 5.5 we re-estimate the models excluding event-dates associated with employment release reports. This robustness check is motivated by the fact that on eight occasions between 1989 and 1992, decisions by the FOMC concerning target FFR changes occurred several hours following employment release reports by the Bureau of Labor Statistics. Rudebusch (1996, 1998) in particular argued that these decisions may in fact have reflected endogenous responses by the FOMC to these employment release reports. In Chapter 3 and Chapter 4, we further excluded event-dates associated with employment release reports from estimation to determine the sensitivity of our estimates to this critique. Due to the size of tables concerning the international transmission of FFR shocks to international equity markets, robustness checks for estimates excluding event-dates associated with employment release reports are relegated to the Appendix. In Table A5.1 we report estimates akin to those in Table 5.5 excluding event-dates associated with employment release reports.

We find that equity markets across the 18 countries which were shown to yield statistically significant responses to FFR shocks in Table 5.5 continue to exhibit statistically significant responses to FFR shocks in Table A5.1. This demonstrates that the estimates are highly robust towards this model specification. In each case where the response is statistically significant in Table 5.5, the coefficient estimate remains negative and statistically significant in Table A5.1[166]. However in Table A5.1 we also find that equity markets in Turkey and the Netherlands exhibit statistically significant responses to FFR shocks. Hence in these two cases, the estimates are shown to be sensitive to this model specification.

[165] Ehrmann and Fratzscher (2009) found that equity markets in 22 out of 49 countries yielded statistically significant responses to FFR shocks.

[166] In Table 5.5 we find that equity markets across 18 countries yield statistically significant responses to FFR shocks. Upon comparing the coefficient estimates for these countries with those in Table A5.1, we find that they are exactly the same for 7 countries. For the remaining 13 countries, they are shown to differ by less than 3 basis points in each case.

5.4.2 Structural change during the 2007-2009 financial crisis

In Chapter 3 we demonstrated that the relationship between US stock returns and FFR shocks was characterised by a highly significant structural shift attributable to the 2007-2009 financial crisis. More specifically, we found that US stock returns were not characterised by positive responses to unexpected FFR cuts during the crisis period, and in some cases they were shown to respond negatively. This implied that unexpected FFR cuts during the crisis period ceased to be good news for stock market investors, and rather were interpreted by market participants as signals from the FOMC of worsening financial and economic conditions. We now extend our empirical investigation towards the international context. In particular, we seek to investigate whether international equity returns were characterised by a significantly different response to FFR shocks during the crisis period compared to that outside the crisis. Thus we interact unexpected FFR changes with a dummy variable $\left(D_t^{crisis}\right)$equal to one during the crisis period and zero otherwise; which allows us to separate the effects of equity return responses to FFR shocks outside the crisis period β_1 and during the crisis period β_2.

$$r_t^{\text{int}} = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t, \tag{5.4}$$

Prior to estimating the model outlined in Equation 5.4, it is important to define how we date the *financial crisis* period. In Chapter 3 and in Chapter 4, we dated the financial crisis to the Sep-07 to Mar-09 sample period (see Section 2.7.1). This dating was motivated by monetary, financial and economic events which transpired both domestically and internationally during the crisis period. Dating the start of the financial crisis to the September 2007 month is motivated by a number of factors. Firstly, it corresponds to the first target FFR cut (-0.50%) by the FOMC since Jun-03 and thereby implicitly represents an acknowledgement by the Fed of declining financial and economic conditions. This is further reflected in the magnitude of the cut which was less 'gradualist' than previous target FFR changes and is clearly reflected in their accompanying statement which modestly stated that "*developments in financial markets since the Committee's last regular meeting have increased the uncertainty surrounding the economic outlook*."

September 2007 was also characterised by the first bank-run in the United Kingdom for 150 years following leaked reports that the Chancellor of the Exchequer had authorised liquidity support from the Bank of England (BOE) for the British Bank Northern Rock. This demonstrates that the financial crisis which originated in the US had spread internationally to the United Kingdom by this time. We also highlight that in Sep-07; the LIBOR rate reached 6.7975%, the highest rate since Dec-98, and this was significantly higher than the BOE base rate which was set at 5.75%. The financial crisis had also been recognised by central banks internationally and this is demonstrated by the fact that the BOE had initially declined to pump liquidity in to financial markets however in Sep-07, however as the crisis escalated, they changed their monetary stance and announced the auction of £10billion[167].

In Chapter 3 and Chapter 4 we dated the end of the financial crisis in Mar-09 when the S&P500 index reached its lowest level throughout the crisis period and began its recovery and this date was also consistent with the TED spread which was shown to be higher than historical average by a factor of two for the Sep-07 to Mar-09 sample period. As the financial crisis originated in the US and spread internationally through financial markets, and given that this chapter seeks to evaluate the impact of FFR shocks from the US to foreign equity markets, the dating of the financial crisis to the Sep-07 to Mar-09 sample period is equally applicable in the international context in this chapter. Thus we can adequately retain the Sep-07 to Mar-09 dating of the global financial crisis in this chapter and accordingly define the dummy variable $\left(D_t^{crisis}\right)$.

We also formally test for parameter stability in the relationship between international equity indices and FFR shocks using the Quandt-Andrews test for structural breaks. In Table 5.6 we present the results for these tests which are applied to robust MM-Estimator weighted least squares estimates of Equation 5.3 for each of the 43 countries in our sample. We find there is significant cross country heterogeneity in structural breakpoints identified using this test for different countries[168]. As our estimates in Table 5.5 and estimates by previous studies demonstrate that international equity market responses to FFR shocks vary significantly in magnitude and statistical significance across different countries, this observation is similarly conveyed in the distribution of statistically significant and statistically insignificant structural breakpoints identified in Table 5.6 for different countries. Nevertheless, we find that the majority of break-dates identified in Table 5.6 cluster around the 2007-2009 crisis period. As a robustness check, we repeat the Quandt-Andrews tests for estimates of Equation 5.3 which

[167] We primarily discuss events in the United Kingdom for clarity of expression as financial markets worldwide were characterised by financial, monetary and macroeconomic events which were of significant note, and discussion of all these events across 43 countries is beyond the scope of this chapter. We do not seek to identify all the possible events which occurred internationally during the crisis period, but rather seek to evaluate whether international equity markets responded differently to FFR shocks on FOMC event-dates during the crisis period.

[168] This is not surprising given that our estimates in Table 5.5 indicated that equity markets across 18 (25) countries yielded statistically significant (insignificant) responses to FFR shocks.

exclude event-date associated with employment release reports and come to a very similar conclusion.

It is important to note that there is no general academic consensus regarding the precise dating of the global financial crisis period. To ensure our estimates in the following section are not sensitive to the dating of the financial crisis period, we also consider an alternative definition as a robustness check. The NBER dated the *economic crisis* associated with the financial crisis as spanning the Dec-08 to Jun-09 sample period. This dating lags behind the dating of the financial crisis due to lags in the transmission of financial market changes to the broader macroeconomy[169]. As this definition of the economic crisis is widely used in academic studies, we use this alternative dating of the general crisis period in the appendix as a robustness check[170].

In Table 5.7 we report robust MM-Estimator weighted least squares estimates of Equation 5.4 which is estimated repeatedly using equity index returns for each of the 43 countries in our sample. In each case the crisis dummy variable $\left(D_t^{crisis}\right)$ is defined as being equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. For each country, the β_2 coefficient measures the response of equity index returns in that country to FFR shocks during the 2007-2009 crisis period, while the β_1 coefficient measures the response outside the crisis.

Our estimates indicate that outside the crisis period β_1, foreign equity index returns are associated with statistically significant responses to FFR shocks across 15 advanced and emerging market countries[171]. In each case where the response is shown to be statistically significant outside the crisis period, the β_1 coefficient is negative which indicates that outside the crisis period, unexpected FFR cuts (increases) are associated with statistically significant

---

[169] One may argue that economies across different countries responded to the financial crisis at different times, as the OECD dated the economic crisis in Japan to the Feb-08 to Mar-09 sample period. However it is important to recognise that these definitions of the crisis typically refer to the economic crisis and differ by country due to lags in the transmission mechanism from financial markets to the broader macroeconomy. The focus of this chapter is on the impact of the 2007-2009 financial crisis on the relationship between international equity returns and FFR shocks, and not the impact of the economic crisis. In the context of the modern, highly integrated, globalised financial market, crises can quickly spread through capital markets and have lagged effects on the economy of each economy; hence we retain the Sep-07 to Mar-09 dating of the financial crisis for this chapter.

[170] We find that our estimates in the following section are not significantly changed using this alternative definition of the crisis period.

[171] In line with previous studies concerning the pre-crisis period see (Ehrmann and Fratzscher, 2009), equity markets across less than half of the countries surveyed yield statistically significant responses to FFR shocks outside the crisis period.

positive (negative) stock returns across these countries. The largest magnitude responses are observed in New Zealand, Brazil, Singapore, Hong Kong, Italy and South Africa, with a hypothetical unexpected 1% FFR cuts (increases) outside the crisis period being associated with 4-5% increases (declines) in equity returns in each case.

Overall, we find significant cross country heterogeneity in equity market responses to FFR shocks outside the crisis period[172]. In Figure 5.2, we demonstrate this cross country heterogeneity in international equity return responses to FFR shocks graphically using a world map. The areas highlighted in green correspond to equity markets across countries which are shown to exhibit statistically significant positive (negative) responses to FFR cuts (increases) outside the crisis period[173]. We find that equity markets across both emerging markets (e.g. Phillipines and South Africa) and advanced economies (e.g. Canada and UK) respond significantly to FFR shocks outside the crisis period. In line with previous studies concerning the pre-crisis period see (Ehrmann and Fratzscher, 2009), equity markets across less than half of the countries surveyed yield statistically significant responses to FFR shocks outside the crisis period[174]. Interestingly our estimates indicate that during the 2007-2009 crisis period β_2 , foreign equity index returns are associated with statistically significant responses to FFR shocks across 31 advanced and emerging market countries. This is more than twice the number of countries in which equity markets responded significantly to FFR shocks outside the crisis period. However, we find that the β_2 coefficient is *negative and significant* for 19 countries, *positive and significant* for 12 countries and statistically *insignificant* for 12 countries.

Across the 19 countries where the β_2 coefficient shown to be negative and statistically significant, this implies that unexpected FFR cuts during the crisis period are associated with *positive* stock returns in the benchmark equity indices of these countries. In each case, the magnitude of equity market response ranges from a 2.79% stock return increase in the Philippines to a 14.40% stock return increase in South Africa. In contrast, across the 12 countries where the β_2 coefficient shown to be positive and statistically significant, this implies that unexpected FFR cuts during the crisis period are associated with

[172] This is consistent with the evidence yielded in Table 5 without the structural break.

[173] We also include the response of the US stock market response to FFR shocks in the figures. The estimates correspond to those presented in Chapter 3.

[174] In line with previous studies (see Ehrmann and Fratzscher, 2009; Hausman and Wongswan, 2011), equity markets across countries with more closed financial markets yield statistically insignificant responses to FFR shocks (e.g. China and Sri Lanka).

negative stock returns in the benchmark equity indices of these countries. In each case, the magnitude of equity market response ranges from a 2.53% stock return decline in Switzerland to a 7.50% stock return decline in Peru. This shows that regardless of the sign of the β_2 coefficient, a hypothetical unexpected 1% FFR cut during the crisis is associated with comparatively larger magnitude above 2.50% stock return increase or decrease in the equity market of that country. The adjusted r-squared statistics also show that up to 34% of one-day variation in equity index returns can be explained in terms of FFR shocks from the US.

Overall, our estimates demonstrate that there is considerably greater cross country heterogeneity in equity market responses to FFR shocks during the crisis period compared to that outside the crisis. The standard deviation of the β_2 coefficient across the 43 countries in Table 5.7 is more than three times greater than that of the β_1 coefficient[175]. Whilst outside the crisis period the β_1 coefficient is negative where statistically significant, during the crisis period, the β_2 coefficient is either positive or negative where statistically significant. In Figure 5.3 we demonstrate the significant cross country heterogeneity in international equity market responses to FFR shocks during the crisis graphically using a world map. The areas highlighted in green (red) correspond to equity markets across countries in which stock returns responded positively (negatively) to unexpected FFR cuts during the crisis, i.e. a negative (positive) and statistically significant β_2 coefficient. It is immediately apparent that heterogeneity in international equity market response to FFR shocks during the crisis period cannot be entirely explained in terms of regional or geographical location[176]. Nor does the heterogeneity appear to be characterised by differences attributable to different responses across advanced and emerging market economies, in which equity markets are shown to be associated with positive (e.g. Canada and Indonesia) or negative (e.g. France and Peru) stock returns in response to unexpected FFR cuts during the crisis[177]. For a more complete picture of the international equity market response to FFR shocks during the crisis, we also highlight countries associated with statistically insignificant responses in Figure 5.4.

The estimates in Table 5.7 demonstrate that the relationship between international equity index returns and conventional monetary policy shocks from the FOMC is

[175] The standard deviation of the β_1 coefficient across the 43 countries is 1.71, and the standard deviation of the β_2 coefficient across the 43 countries is 3.55.

[176] For example, we find that equity markets in South America and Europe are associated with statistically significant positive (e.g. Brazil and Peru) or negative stock returns (e.g. France and UK).

[177]

characterised by a structural shift attributable to the 2007-2009 crisis period. The Wald tests for equality of coefficients $\beta_1 = \beta_2$ also support this empirical conclusion, as we reject the null hypothesis of equality across 26 countries which are indicative of a highly statistically significant structural change across the majority of countries. This may be attributable to the fact that in equity markets across 19 countries, the response to FFR shocks outside the crisis period is statistically insignificant, however significant during the crisis period. Interestingly, equity markets in more closed capital markets such as those in India, Indonesia, and Sri Lanka also respond significantly to FFR shocks during the crisis period. As a robustness check for Table 5.7, we re-estimate the models excluding event-dates associated with employment release reports in Table A5.2. In every case where the β_2 coefficient is significant in Table 5.7, it remains significant in Table A5.2. However, in Table A5.2, the β_2 ceases to remain significant for Netherlands and Philippines and becomes significant for Poland and Turkey. With these minor exceptions, the estimates presented in Table 5.7 are shown to be highly robust towards this model specification.

As a further robustness check for Table 5.7, we re-estimate the models defining the crisis dummy variable $\left(D_t^{crisis}\right)$as being equal to one over the Dec-08 to Jun-09 sample period and zero otherwise in line with the NBER definition of the economic crisis. We find that the β_1 coefficient becomes significant for Netherlands, Portugal, Russia and Turkey. In the case of the β_2 coefficient it ceases to remain significant for Australia, Luxembourg, Finland, India, Philippines and Portugal however becomes significant for China, Italy and Russia. As we would expect, our models are more sensitive to this model specification as it defines an entirely different interpretation of the economic crisis which followed the financial crisis.

5.4.3 Fixed-effects panel estimation with robust MM-Estimator weighted least squares

Thus so far, we have investigated the relationship between international equity index returns and FFR shocks over the crisis period using an individual country by country analysis, to demonstrate the significant cross country heterogeneity in equity market responses to FFR shocks, and to explore the depth of the dataset[178]. To evaluate the average responses of international equity indices to FFR shocks over the crisis period, we used fixed-effects panel estimation with robust MM-Estimator weighted least squares. We use the newly developed

[178] This approach was also employed by Ehrmann and Fratzscher (2009), however they demonstrated that equivalent results could be obtained using fixed-effects panel techniques.

code of Verardi and Croux (2009) to estimate these models. This approach not only allows us to account for cross-country heterogeneity across coefficients, but also increase estimation efficiency through the estimation of fewer coefficients whilst simultaneously accounting for outliers in estimation.

In Table 5.8 Panel A, we estimate the response of international equity returns across all 43 countries to target FFR changes on FOMC event-dates, over the Jun-89 to Dec-12 sample period; using fixed-effects panel estimation with robust MM-Estimator weighted least squares (Equation 5.5). We find that on average, equity returns across countries are associated statistically insignificant responses to target FFR changes. This is consistent with empirical evidence presented in Table 5.4 with the individual country by country analysis. Upon disaggregating target FFR changes in to expected and unexpected FFR components, we find a hypothetical unexpected 1% FFR cut (increase) is associated with an average 1.50% increase (decrease) in stock returns across international equity markets (Equation 5.6).

$$r_{it}^{\text{int}} = \alpha + \beta \Delta i_{it} + \varepsilon_{it} \qquad (5.5)$$

$$r_{it}^{\text{int}} = \alpha + \beta \Delta i_{it}^{u} + \varepsilon_{it} \qquad (5.6)$$

We also estimate the impact of FFR shocks on international equity markets outside and during the 2007-2009 crisis period, akin to that in Table 5.7, however using fixed-effects panel estimation with robust MM-Estimator weighted least squares (Equation 5.7). The estimates in Table 5.8 Panel A demonstrate that outside the crisis period, a hypothetical unexpected 1% FFR cut (increase) is associated with an average 2.04% increase in stock returns across equity markets in the 43 countries. However the response to FFR shocks during the crisis period β_2 is shown to be statistically insignificant across countries. Guided by empirical evidence from the country by country analysis in Table 5.7, it is immediately apparent that the statistical insignificance of the β_2 coefficient is induced by the fact that equity markets in some countries were associated with positive stock returns whilst others were associated with negative stock returns in response to unexpected FFR cuts during the crisis. The β_2 coefficient is thereby unable to capture the full nature and complexity of equity market responses to FFR shocks during the crisis period across 43 countries. Nevertheless, we reject the null hypothesis for equality of coefficients using a Wald test $\beta_1 = \beta_2$, which indicates that a highly significant structural shift occurred. In Table 5.8 Panel B we re-estimate the three models excluding event-dates associated with employment release reports and find that the estimated coefficient are larger in magnitude in each case where statistically significant.

$$r_{it}^{\text{int}} = \alpha + \left[\beta_1\left(1 - D_{it}^{crisis}\right) + \beta_2\left(D_{it}^{crisis}\right)\right]\Delta i_{it}^{u} + \varepsilon_{it}, \quad (5.7)$$

5.4.4 Determinants of international transmission of FFR shocks

Several important observations can be made from the estimates in Section 5.4.2 and in Table 5.7 in particular. Firstly, we demonstrated that there is considerable cross country heterogeneity in international equity market responses to FFR shocks outside the crisis period and that this heterogeneity is comparatively greater during the 2007-2009 crisis. Secondly, we found that in countries where the equity market response to FFR shocks was statistically significant outside the crisis period, a hypothetical unexpected FFR cut (increase) was associated with positive (negative) stock return responses in the equity markets of those countries. Thirdly, we found that in countries where the equity market' response to FFR shocks is statistically significant during the crisis period, unexpected FFR cuts were associated with positive stock return responses in equity markets of some countries and negative stock return responses in others. Fourthly, and most importantly, we found that there was a highly significant structural shift in the relationship between international equity returns and FFR shocks characterised by the 2007-2009 financial crisis.

We now turn to the more difficult question of why unexpected FFR cuts during the 2007-2009 crisis period were associated with positive stock returns in some countries and negative stock returns in others. In particular, we augment the previous model (Equation 5.7) to account for potential factors which may explain differences in international equity market responses to FFR shocks. The complexity of this task is adequately presented in Figures 5.3 and 5.4 which demonstrate the considerable cross country heterogeneity in international equity market responses to FFR shocks during the crisis period. Upon closer examination of these maps, it is apparent that differences in equity market reactions cannot be entirely explained in terms of geographical location or in terms of differences attributable to responses of emerging market and advanced economies. Thus we continue our investigation by exploring other potential determinants in the international transmission of FFR shocks. In particular, we consider the role of real bilateral integration with the US economy and other macroeconomic, financial and geographic factors.

To evaluate whether differences in the responses of international equity markets to FFR shocks during the 2007-2009 crisis period can be explained by these factors, we augment the model outlined in Equation 5.7 to account for potential determinants in the transmission mechanism, extending upon the empirical methodology of Ehrmann and Fratzscher (2009). We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise[179]. We interact each of these terms with the crisis dummy variable $\left(D_t^{crisis}\right)$ which is set equal to one during the Sep-07 to Mar-09 sample period and zero otherwise as well as the unexpected FFR change (Equation 5.8).

$$r_{it}^{\text{int}} = \alpha + \begin{matrix} \beta_1\left(\Delta i_t^u\right)\left(1 - D_{it}^{crisis}\right)\left(X_{it}^{low}\right) + \beta_2\left(\Delta i_t^u\right)\left(1 - D_{it}^{crisis}\right)\left(X_{it}^{high}\right) \\ + \beta_3\left(\Delta i_t^u\right)\left(D_{it}^{crisis}\right)\left(X_{it}^{low}\right) + \beta_4\left(\Delta i_t^u\right)\left(D_{it}^{crisis}\right)\left(X_{it}^{high}\right) \end{matrix} + \varepsilon_{it} \tag{5.8}$$

Due to the complexity of this model, it is important to briefly outline how to interpret the coefficient estimates. In each case we assume X refers to an arbitrary determinant such as the degree of real integration with the US economy. The β_1 coefficient measure the average response of international equity markets, ranked in the bottom half of countries for a given determinant X_{it}, outside the crisis period; while the β_2 coefficient measures this response for the top half of countries. The β_3 coefficient measure the average response of international equity markets, ranked in the bottom half of countries for a given determinant X_{it}, during the 2007-2009 crisis period; while the β_4 coefficient measures this response for the top half of countries.

Our investigation begins by analysing the role of real bilateral integration with the US economy in the relationship between international equity returns and FFR shocks outside and during the crisis period. This is motivated by previous studies which have demonstrated that countries which are highly integrated with the US in terms of the real economy are likely to yield larger magnitude responses to FFR shocks compared to countries with a lower degree of real integration with the US (see Glick and Rose, 1999; Eichengreen, Barry and Rose, 1999; Forbes and Chinn, 2004). In this manner, conventional monetary policy shocks are more likely to influence stock returns in countries with higher real US trade links. This is because

[179] As we are estimating the impact of FFR shocks on international equity returns both outside and during the crisis period, and including potential determinants in the relationship, we do not use the low, med and high definition of Ehrmann and Fratzscher (2009) to preserve degrees of freedom, and to avoid estimating excessive numbers of coefficients.

FFR shocks affect not only the financing costs of internationally trading companies, but also signal the Fed's economic outlook, and therefore future economic prospects for these companies. For example, during the 2007-2009 crisis, unexpected FFR cuts not only reduced costs of international financing, but also signalled worsening economic and financial conditions in the US to domestic and international market participants. Hence, equity markets in countries with stronger macroeconomic ties with the US in terms of trade are more likely to respond to FFR shocks.

To evaluate whether differences in the responses of foreign equity indices to FFR shocks during the crisis period can be explained in terms of real bilateral integration with the US economy, we measure the determinant X_{it} using three proxies. As detailed in Section 5.3.3, we consider the ratio of US trade (imports plus exports) with each country relative to each country's GDP, the ratio of US imports from each country relative to each country's GDP and the ratio of US exports to each country relative to each country's GDP[180]. In Table 5.9 we report fixed-effects panel estimates of Equation 5.8 with robust MM-Estimator weighted least squares, in each case estimating the model defining the determinant X_{it} using one of the three proxies for real bilateral integration with the US.

In the first line of Table 9 Panel A, we find that outside the crisis period, a hypothetical unexpected 1% FFR cut is associated with an average 1.78% (2.31%) increase in returns across international equity markets with a lower β_1 (higher β_2) degree of real bilateral integration with the US, in terms of trade. At first glance there appears to be a marked difference between these two coefficients however we find that the difference between them is not shown to be statistically significant different using the Wald test for equality of coefficients $\beta_1 = \beta_2$. Nevertheless, both coefficients individually are shown to be statistically significant which implies that outside the crisis period, unexpected FFR cuts (increases) are on average associated with positive (negative) stock returns across international equity markets, regardless of each country's degree of real bilateral integration with the US in terms of trade. In Panel B we exclude event-dates associated with employment release reports as a robustness check, and yield very similar empirical conclusions however there is a markedly smaller difference between the β_1 (2.78) and β_2 (2.89) coefficients.

Interestingly, this response is not characterised during the 2007-2009 crisis period, as we find that equity markets across countries with a higher degree of real bilateral integration

[180] As Wongswan (2009) points out, this approach to measuring real bilateral integration with the US economy is common in the empirical literature.

with the US in terms of trade β_4 respond *significantly* to FFR shocks, while equity markets across countries with a lower degree of real bilateral integration with the US in terms of trade β_3 yield statistically *insignificant* responses to FFR shocks. This implies that real bilateral integration with the US economy can only explain cross country heterogeneity in international equity market responses to FFR shocks across countries with a higher degree of trade with the US. This evidence is also consistent with that presented in Table 5.7 and Figure 5.3 in the country by country analysis as we show that equity markets in Canada, Singapore and Mexico respond positively to unexpected FFR cuts during the crisis period. These countries have the highest degree of trade with the US relative to the other countries in our sample. Our results can also be explained in terms of the trade linkages literature (see Eichengreen, Barry and Rose, 1999; Forbes and Chinn, 2004) as countries with stronger macroeconomic ties with the US in terms of trading links are more likely to respond to respond to macroeconomic events in the US such as conventional monetary policy shocks. It is however important to note that this response is not shown to be significantly different from that outside the crisis β_2 using a Wald test $\beta_2 = \beta_4$. As the β_3 coefficient is shown to be statistically insignificant, this implies that this coefficient is unable to fully explain the cross country heterogeneity in equity market responses to FFR shocks during the crisis period for countries with a lower degree of real bilateral integration with the US[181].

These results are shown to be highly robust towards the definition of real bilateral integration with the US economy, as we obtain very similar empirical conclusions when using the ratio of US exports to each country relative to its GDP and the ratio of US imports from each country relative to its GDP as shown in Table 5.9. In both cases, we find that outside the crisis period there is no significant difference in equity market response to FFR shocks depending on the degree of real bilateral integration with the US in terms of exports or imports, as we do not reject the Wald test in either case $\beta_1 = \beta_2$. Similarly, we find that during the crisis period, equity markets across countries with a higher β_4 (lower β_3) degree of real

[181] Unexpectedly, the β_3 coefficient is positive in its sign, and although it is statistically insignificant across the three models, it is shown to be significantly different from that outside the crisis period $\beta_1 = \beta_3$. It is also shown to be significantly different from that during the crisis for equity markets across countries with higher degree of real bilateral integration with the US $\beta_2 = \beta_4$. The statistical significance of this coefficient would imply that equity markets in countries degree of trade, exports or imports with the US respond negatively to unexpected FFR cuts during the crisis period. As the coefficient is statistically insignificant, we do not continue this line of enquiry in the investigation.

bilateral integration with the US economy in terms of exports or imports yield statistically significant (insignificant) responses to FFR shocks.

Thus real bilateral integration with the US economy can explain some of the cross country heterogeneity in international equity market responses to FFR shocks during the crisis period, particularly for countries with a higher degree of real bilateral integration with the US economy. However, it does not fully address why in Table 5.7, equity markets across some countries were shown to respond negatively to unexpected FFR cuts during the crisis period[182]. We therefore continue our analysis by analysing a broader set of potential determinants in the international transmission of FFR shocks. More specifically, we investigate whether cross country heterogeneity in international equity market responses to FFR shocks can be explained in terms of financial and macroeconomic linkages, or in terms of geographical factors such as time zones. In Table 5.10 we report fixed-effects panel estimates of Equation 5.8 using robust MM-Estimator weighted least squares, and in each case defining the determinant using four measures of financial, macroeconomic and geographic linkages. As detailed in Section 5.3.3, these include the role of financial linkages through the banking sector, the role of business cycle correlation with the US and the role of international time zones and equity market opening times[183].

We begin our analysis by investigating the role of business cycle correlation with the US in explaining cross country heterogeneity in international equity market responses to FFR shocks during the crisis period. This is motivated by previous studies which have sought to measure cross country co-movement in business cycles and real economic variables (see Frankel and Rose, 1998; Kose, Ahyan and Otrok, 2008). In Table 5.10 we find that outside the crisis period, unexpected FFR cuts (increases) are associated with statistically significant positive (negative) equity market responses across countries regardless of their higher β_2 or lower β_1 degree of business cycle correlation with the US. The difference in equity market response is not shown to significantly depend on whether countries have higher or lower business cycle correlation with the US outside the crisis period, as we do not reject the Wald test $\beta_1 = \beta_2$. However, during the crisis period we find that unexpected FFR cuts are associated with positive equity market responses across countries with a lower degree of business cycle correlation with the US β_3, and a statistically insignificant response across

[182] In the robustness checks section (Section 5.4.5), we demonstrate that equivalent results can be yielded when considering real integration with the world economy akin to Ehrmann and Fratzscher (2009).

[183] We also tested the role of exchange rate regime, exchange rate volatility; geographic distance and financial sector liberalisation however did not obtain economically meaningful results.

countries with a higher degree of business cycle correlation with the US β_4. This implies that cross country heterogeneity in equity market responses to FFR shocks cannot be entirely explained in terms of business cycle correlation. In particular, whilst it can explain why equity markets across some countries responded positively to unexpected FFR cuts during the crisis period, it cannot adequately explain why others were shown to respond negatively. These conclusions are shown to be robust towards excluding event-dates associated with employment release reports in Panel B, although we find a markedly smaller difference between the β_1 and β_2 coefficients.

We continue our analysis by investigating the role of financial linkages through the banking sector in the international transmission of FFR shocks. This is motivated by the fact that previous studies in the financial linkages literature have argued this is an important channel through which macroeconomic announcements in the US can influence asset markets internationally (see Van Rijckeghem and Weder, 2001, 2003; Forbes and Chinn, 2004). As Forbes and Chinn (2004) argue, a priori there is an indeterminate effect of macroeconomic announcements in a large economy on the asset markets of another country and the effects need to be estimated empirically. To simplify terminology, we refer to countries with a lower (higher) degree of bank lending from the rest of the world simply as lower (higher) external borrowing. In the first line of Table 5.10, we find that outside the crisis period, a hypothetical 1% unexpected FFR cut is associated with a statistically significant average 1.69% (2.42%) increase in returns across equity markets with a *lower* β_1 *(higher* β_2*)* degree of external borrowing. The difference between these two coefficients is not shown to be significantly different using a Wald test $\beta_1 = \beta_2$, and this implies that unexpected FFR cuts (increases) are associated with significant positive (negative) international equity market responses across countries regardless of their degree of external borrowing. Similarly, during the crisis period, a hypothetical unexpected 1% FFR cut is shown to be associated with a statistically significant average 2.14% *increase* in equity market returns across countries with a *lower* β_3 degree of external borrowing. This response is not shown to be significantly different from that outside the crisis period β_3 using a Wald test $\beta_1 = \beta_3$ which implies that equity markets across countries with a lower degree of external borrowing respond positively to unexpected cuts both outside and during the crisis period.

Interestingly, during the 2007-2009 crisis period, we find that a hypothetical 1% unexpected FFR cut is associated with a statistically significant average 0.95% *decrease* in equity market returns across countries with a *higher* β_4 degree of external borrowing. Although the β_4 coefficient is only shown to be statistically significant at the 10% level, it is shown to be significantly different from the response outside the crisis period β_2 using a Wald test $\beta_1 = \beta_3$, and significantly different from the β_3 coefficient using another Wald test $\beta_3 = \beta_4$. This is a first step towards explaining why equity markets across some countries were shown to respond positively to unexpected FFR cuts during the crisis while others were shown to respond negatively as in Table 5.7 and Figure 5.3. Our estimates show that unexpected FFR cuts by the FOMC were interpreted as good (bad) news in equity markets across countries with a lower (higher) degree of external borrowing as they responded positively (negatively) to these shocks. These results require further explanation, and can be best explained using in the context of the financial linkages literature.

Forbes and Chinn (2004) for example argue that negative macroeconomic news concerning the future economic outlook of a large economy can have negative effects in their equity market and in the equity markets of countries with strong financial linkages to the large economy through the banking sector. This is because banks in the large economy would strengthen their balance sheets and increase reserves for the economic downturn, and this sharp decline in credit would have negative effects in the equity markets of countries more dependent on external borrowing. In the context of our results, this implies that unexpected FFR cuts during the crisis period were interpreted by market participants as signals from the Fed of deteriorating economic and financial conditions, thereby resulting in negative response in the US stock market, as documented in Chapter 3. As US banks sought to strengthen their balance sheets and increase reserves for the economic downturn, this resulted in a sharp decline in lending by US banks, as we witnessed during the credit crunch. The sharp decline in lending by US banks would thereby have significant negative repercussions for countries with a higher degree of external borrowing, and this is why we found that equity markets across countries with a higher degree of external borrowing responded negatively to unexpected FFR cuts during the crisis period β_4. In comparison, this significant decline in lending by US banks did not have as marked an impact on countries with a lower degree of external borrowing, hence equity markets across these countries continued to respond positively to unexpected FFR cuts during the crisis β_3, as they did outside the crisis period β_1. This helps to explain the cross country heterogeneity in equity market responses to unexpected FFR cuts during the crisis period shown in Figure 3, as equity markets across countries responded positively (negatively) partly due to their degree of higher (lower) external borrowing.

Lastly, having demonstrated that financial linkages through the banking sector is an important determinant in explaining the transmission of FFR shocks during the crisis period, we now consider a geographical factor in the relationship. We already established from Figure 3, that cross country heterogeneity in equity market responses to FFR shocks could not be entirely explained in terms of geographical location, however now we formally test whether this is the case. In particular, we consider the role of time zones and equity market opening hours in the relationship. This is motivated by the fact that some equity markets were open when the majority of FOMC announcements concerning the target FFR occurred and responded contemporaneously in real time to these announcements. However, countries in Asia-Pacific, Europe, Middle East and Africa responded to these announcements the following day when their equity markets were open. To simplify the terminology, we refer to countries which respond contemporaneously (the next day) to FOMC announcements concerning the target FFR simply as countries which respond contemporaneously (the next day) to FFR shocks.

In Table 5.10, we find that outside period, unexpected FFR cuts are associated with statistically insignificant responses to FFR shocks across countries which respond contemporaneously to FOMC announcements β_1. At first glance this result appears to be rather unusual, however in Panel B we show that this model is sensitive to event-dates associated with employment release reports. Upon excluding event-dates associated with employment reports in Panel B, we find that outside the crisis period, a hypothetical unexpected 1% FFR cut is associated with a statistically significant average 4.31% (2.67%) increase in returns across equity markets which respond contemporaneously β_1 (the next day β_2) to the shocks. This implies that there is a larger magnitude equity market response across countries which respond in real time to these announcements[184]. However, during the crisis period, we find that FFR shocks are associated with statistically significant (insignificant) responses across equity markets which respond contemporaneously β_3 (the next day β_4). To explain why the β_4 coefficient is statistically insignificant, we turn to Figure 3 which shows the country by country analysis. As this coefficient represents the response of equity markets

---

[184] This is a large and marked difference between the β_1 and β_2 coefficients however we do not reject the Wald test for equality of coefficients $\beta_1 = \beta_3$.

to FFR shocks outside the crisis period, it clearly cannot capture the full diversity of reaction across Asia-Pacific, Europe, Middle East and Africa in the way it was able to outside the crisis period.

5.4.5 Further robustness checks

Throughout this chapter we have examined the robustness of our findings in a number of ways; however we also consider several further robustness checks in this section. Firstly, Ehrmann and Fratzscher (2009) demonstrated that real integration with the world economy was more important than bilateral integration with the US economy in explaining cross country heterogeneity in international equity market responses to FFR shocks. However Wongswan (2009) found that bilateral integration with the US economy was significant in explaining cross country heterogeneity in international equity market responses to FFR shocks. Thus in Table A5.6, we report fixed-effects panel estimates of Equation 5.8 using robust MM-Estimator weighted least squares and in each case defining the determinant as the ratio of each country's trade (imports plus exports) to the rest of the world relative to its GDP.

In Table A5.6 Panel A, we find that outside the crisis period, a hypothetical unexpected 1% FFR cut is associated with an average 1.79% (2.31%) increase in returns across international equity markets with a lower β_1 (higher β_2) degree of real integration with the world in terms of trade. These estimates are in line with those yielded by Ehrmann and Fratzscher (2009), however the magnitude of each coefficient is lower as we consider a longer sample period. During the crisis period, we find that unexpected FFR cuts are associated with statistically insignificant responses across equity markets with β_4 higher or lower β_2 degree of real integration with the world economy. This implies that during the crisis period, real integration with the world economy is not a significant factor in explaining cross country heterogeneity in equity market responses to FFR shocks. In Panel B we find that conclusions are not significantly changes when we exclude event-dates associated with employment release reports.

Secondly, it is important to note that as the target FFR approached the zero-lower bound in late 2008, the FOMC began more non-conventional measures of monetary policy such as increasing forward guidance and large-scale asset purchase programmes. On the 25th Nov 08, the Fed announced the first round of Quantitative Easing, a plan to purchase \$500billion in agency mortgage backed securities and \$100billion in agency-debt. Furthermore on 16th Dec 08, the FOMC cut the target FFR by 75 basis points, effectively pushing it towards the zero lower bound. To demonstrate that our estimates are not significantly influenced by the use of non-conventional monetary policy, in Table A5.6 we re-estimate the models presented in Table A5.9 and Table A5.10 for the Jun-89 to Nov-08 sample period. We find that the empirical conclusions yielded in this chapter robust towards this alternative model specification[185]. Interestingly, during the 2007-2009 crisis period, we now find that a hypothetical 1% unexpected FFR cut is associated with a statistically significant average 1.13% *decrease* in equity market returns across countries with a *higher* β_4 degree of external borrowing. This response is also shown to be statistically significant at the 5% level.

Thirdly, we deviate from previous empirical literature by examining a broader set of variables which could explain the significant heterogeneity in stock market responses to FFR shocks across 43 countries outside and during the crisis period. In particular we use a series of measures which include financial development, governance and liquidity indicators. We rank countries in to higher and lower categories using; the total stock market capitalisation as a percentage of GDP as a proxy for the depth and liquidity of the market in each country, a measure concerning the percentage of people in a country who use electronic payments to make payments as a proxy of the financial development and financial infrastructure of each country, the Chinn-Ito index which measures the degree of a country's capital account openness as a proxy for financial development and governance in each country, the World Bank indicator for people's perception of the rule of law in each country as a proxy for governance in each country, and finally the World Bank indicator for people's perception of the quality of regulation in each country as a proxy for development and governance in each country[186].

In Table A5.6 Panels A, we find that outside the crisis period, an unexpected FFR cut is associated with greater positive stock return responses across countries with a higher degree of electronic payments, higher degree of capital account openness, higher market capitalisation relative to GDP, stronger regulatory framework and stronger rule of law.

[185] The estimates for time-zones are not reported as the model could not be estimated due to collinearity across coefficients.

[186] The Chinn-Ito index is obtained from http://web.pdx.edu/~ito/Chinn-Ito_website.htm and the corresponding paper is Chinn and Ito (2006). The remaining variables were obtained from the World Bank Indicators database. The 'rule of law' and 'regulatory quality' variables ranged from weak government (-2.5) to strong government (2.5) in each case. The former indicator 'reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence' whilst the latter indicator 'reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development'.

However, the difference in response is only shown to be significantly different between countries with a higher (2.61%) or lower (1.45) market capitalisation relative to GDP. During the crisis, we find that across countries with a lower degree of electronic payments, lower degree of capital account openness, higher market capitalisation relative to GDP, weaker regulatory framework and weaker rule of law, responded positively to unexpected FFR cuts throughout the 2007-2009 period. Whilst this enriches the discussion concerning countries in which stock markets responded positively to unexpected FFR during the crisis, it does not significantly help to explain why stock markets in other countries responded negatively to these cuts during the crisis. These estimates are qualitatively similar upon excluding event-dates associated with employment release reports in Panel B.

Lastly, it is important to point out that other variables may also play an important role in the international transmission of FFR shocks, particularly during the crisis period, however as Ehrmann and Fratzscher (2009) point out, it is clearly impossible to capture all potential omitted variables across 43 countries in this relationship. This chapter nevertheless makes a vigorous first attempt at explaining the considerable cross country heterogeneity in equity market responses to FFR shocks during the crisis period[187].

5.5 Conclusion

This chapter investigates the transmission of Federal Funds rate surprises to 43 foreign equity markets over the Jun-89 to Dec-12 sample period, with an emphasis on the impact of the 2007-2009 crisis. We demonstrate that a significant structural shift occurred during the crisis period which changes the nature of the relationship between foreign equity markets and FFR shocks across 26 countries. Our estimates confirm findings by previous studies by showing that outside the crisis period, there was significant cross country heterogeneity in equity market responses to FFR shocks. Nevertheless, unexpected FFR cut by the FOMC (increases) were shown to be associated with positive (negative) equity market responses across countries where the relationship was shown to be significant outside the crisis. In contrast, we demonstrate that during the crisis period, a hypothetical unexpected 1% FFR cuts during the crisis was associated with significant declines in the equity indices of 12 countries, and significant increases in the equity indices of 19 countries.

[187] We also recognise that during the 2007-2009 crisis period, financial markets globally were characterised by considerable uncertainty and the significant increase in cross country heterogeneity in equity market responses to FFR shocks may be characteristic of financial turmoil which ensued. It may therefore not be possible to clearly demonstrate which factors explain this relationship.

We make a first attempt to explain the significant cross country heterogeneity in equity market responses to FFR shocks during the crisis period, and therefore consider a broad set of variable including proxies for real bilateral integration with the US economy, financial linkages through the banking sector, business cycle correlation with the US economy and geographical factors such as time zones. Overall we find that cross country heterogeneity in equity market responses to FFR shocks cannot be entirely explained by a single factor, but rather several factors. In particular, we find that equity markets across countries with a higher degree of trade with the US economy on average responded positively to unexpected FFR cuts during the crisis, whilst on average countries with a higher degree of borrowing from the rest of the world on average responded negatively to unexpected FFR cuts during the crisis. Furthermore, we find that this heterogeneity in international equity market response to FFR shocks cannot be fully explained by trade and financial linkages. The responses are characteristic of greater investor uncertainty during the crisis period and this opens up an avenue for future research in the field.

5.6 References

Ammer, J., Vega, C., and Wongswan, J. 2010. International transmission of US monetary policy shocks: evidence from stock prices. *Journal of Money, Credit and Banking* 42(1), 179-198.

Andersen, T., Bollerslev, T., Diebold, F.X., Vega, C. 2003. Micro effects of macro announcements: real-time price discovery in foreign exchange. *American Economics Review* 93, 38–62.

Andrews, D.W. 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica* 62(6), 821-856.

Basistha, A., and Kurov, A. 2008. Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 32(12), 2606-2616.

Bernanke, B.S., & Kuttner, K.N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Bomfim, A.N. 2003. Pre-announcement effects, news effects, and volatility: Monetary policy and the stock market. *Journal of Banking & Finance* 27(1), 133-151.

Chinn, M. D., and Hiro, I. 2006.What Matters for Financial Development? Capital Controls, Institutions, and Interactions. *Journal of Development Economics* 81(1). pp163-192.

Christopherson, J.A., Cariño, D.R., and Ferson, W.E. 2009. *Portfolio Performance Measurement and Benchmarking*. McGraw-Hill Finance and Investing. Chapters 20-22

Conover, C.M., Jensen, G.R., & Johnson, R.R. 1999. Monetary environments and international stock returns. *Journal of Banking & Finance* 23(9), 1357-1381.

Cooke, K. 2008. US Stocks-Dow, S&P 500 slip after Fed rate cut. *Reuters Website*. Available from: http://uk.reuters.com/article/2008/10/29/markets-stocks-idUKN2949067020081029 [Accessed on: 3rd June 2013].

Ehrmann, M., and Fratzscher, M. 2005. Equal Size, Equal Role? Interest Rate Interdependence Between the Euro Area and the United States. *The Economic Journal* 115(506), 928-948.

Ehrmann, M., and Fratzscher, M. 2009. Global Financial Transmission of Monetary Policy Shocks. *Oxford Bulletin of Economics and Statistics* 71(6), 739-759.

Ehrmann, M., & Fratzscher, M. 2006. Global financial transmission of monetary policy shocks. *European Central Bank*. Working Paper No. 1710.

Eichengreen, Barry and Andrew Rose. 1999. Contagious Currency Crises: Channels of Conveyance" in Takatoshi, I. and Krueger, A.O. 1999. *Changes in Exchange Rates in Rapidly Developing Countries: Theory, Practice, and Policy Issues*. University of Chicago Press, pp29-56

Forbes, K. J., and Chinn, M. D. 2004. A decomposition of global linkages in financial markets over time. *Review of Economics and Statistics* 86(3), 705-722.

Frankel, K., and Rose, A. 1998. The Endogeneity of the Optimum Currency Area Criteria. *The Economic Journal* 108(449), 1009-1025.

Gibson, K. 2008. U.S. stocks end mostly lower after Fed cuts rates. *Market Watch: The Wall Street Journal Website*. Available from: http://www.marketwatch.com/story/us-stocks-end-mostly-lower-in-another-dramatic-finish?dist=msr_1. [Accessed on: 3rd June 2013]

Glick, R., and Rose, A. 1999. Contagion and Trade: Why Are Currency Crises Regional? *Journal of International Money and Finance* 18, 603-617.

Gürkaynak, R. S., Sack, B., and Swanson, E. 2002. Market-based measures of monetary policy expectations. *Board of Governors of the Federal Reserve System*, Working Paper No. 2002-40.

Gürkaynak, R.S., Sack, B., & Swanson, E.T. 2005. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking* 1(1), 55-93

Gürkaynak, R.S., Sack, B.P., and Swanson, E.T. 2007. Market-based measures of monetary policy expectations. *Journal of Business & Economic Statistics* 25(2), 201-212.

Hansen, B.E. 1997. Approximate Asymptotic P Values for Structural-Change Tests. *Journal of Business and Economic Statistics* 15(1), 60-67

Hausman, J., and Wongswan, J. 2006. Global asset prices and FOMC announcements. *FRB International Finance Discussion Paper*, (886).

Hausman, J., and Wongswan, J. 2011. Global asset prices and FOMC announcements. *Journal of International Money and Finance* 30(3), 547-571.

Husted, S., and Kitchen, J., 1985. Some evidence on the international transmission of U.S. money supply announcement effects. *Journal of Money, Credit, and Banking* 17, 456–466.

Johnson, R.R., and Jensen, G., 1993. The reaction of foreign stock markets to U.S. discount rate changes. *International Review of Economics and Finance* 2, 181–193.

Kose, M., Otrok, C., and Whiteman, C. H. 2008. Understanding the evolution of world business cycles. *Journal of International Economics* 75(1), 110-130.

Kurov, A. 2010. Investor sentiment and the stock market's reaction to monetary policy. *Journal of Banking & Finance* 34(1), 139-149.

Kuttner, K.N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Kuttner, K.N. 2003. Dating changes in the Federal Funds rate, 1989-92. *Oberlin College*, Working Paper.

Lau, D. 2007. FTSE rises 2.8 percent on Fed cut. *Reuters Website*. http://uk.reuters.com/article/2007/09/19/uk-markets-britain-stocks-idUKL1954748920070919 [Accessed on: 3rd June 2013].

Market Clocks. 2013. World Clocks. *Market Clocks Website*. http://www.marketclocks.com/?content=index# [Accessed on: 3rd June 2013]

Moore, M. 2008. FTSE 100 rises after US cuts rates. *The Telegraph Website*. Available from: http://www.telegraph.co.uk/finance/markets/3283662/FTSE-100-rises-after-US-cuts-rates.html [Accessed on: 3rd June 2013].

Mudd, D.R., 1979. Did discount rate changes affect the foreign exchange value of the dollar during 1978. *Federal Reserve Bank of St. Louis Review* 61, 20–26.

Patelis, A.D. 1997. Stock return predictability and the role of monetary policy. *The Journal of Finance* 52(5), 1951-1972.

Rigobón, R., & Sack, B. 2004. The impact of monetary policy on asset prices. *Journal of Monetary Economics* 51(8), 1553-1575.

Rosa, C. 2012. How 'unconventional' are large-scale asset purchases? The impact of monetary policy on asset prices. *FRB of New York Staff Report*. Working Paper 560.

Rudebusch, G.D. 1996. Do measures of monetary policy in a VAR make sense?. *Federal Reserve Bank of San Francisco*. Working Paper 96-05.

Rudebusch, G.D. 1998. Do Measures of Monetary Policy in a VAR Make Sense?. *International Economic Review* 39(4), 907-31.

Taylor, J. B. 2010. Getting back on track: macroeconomic policy lessons from the financial crisis. *Federal Reserve Bank of St. Louis Review* 92(3), 165-176.

Taylor, M. 2007. FTSE rises on Fed rate cut, Northern Rock dips. *Reuters Website*. Available from: http://uk.reuters.com/article/2007/09/19/markets-britain-stocks-idUKL1986085520070919 [Accessed on: 3rd June 2013].

Thorbecke, W. (1997). On stock market returns and monetary policy. *The Journal of Finance* 52(2), 635-654.

Van Rijckeghem, C., and Weder, B. 2001. Sources of Contagion: Is it Finance or Trade? *Journal of International Economics* 54(2), 293-308.

Van Rijckeghem, C., and Weder, B. 2003. Spillovers through banking centers: a panel data analysis of bank flows. *Journal of International Money and Finance*, 22(4), 483-509.

Verardi, V., and Croux, C. 2009. Robust regression in Stata. *The Stata Journal* 9(3), 439-453

Verardi, V., & Croux. C. 2010. Sire applied robust regression workshop. *The University of Strathclyde*. Course Notes from Three-Day Workshop.

Wang, T., Yang, J., and Wu, J. 2006. Central bank communications and equity ETFs. *Journal of Futures Markets* 26(10), 959-995.

Watt, L. 2008. World markets mixed after Fed's historic rate cut. *6abc Action News Website*. http://abclocal.go.com/wpvi/story?section=news/business&id=6559785 [Accessed on: 3rd June 2013]

Wongswan, J. 2009. The response of global equity indexes to US monetary policy announcements. *Journal of International Money and Finance* 28(2), 344-365.

Yohai, V.J. 1987. High breakdown-point and high efficiency robust estimates for regression. *The Annals of Statistics* 15(2), 642-656.

CHAPTER 5 – TABLES AND FIGURES

Table 5.1: List of international equity indices

Country	Equity Index Name	Start-Date	Obs
Australia	S&P/ASX 200	Jul-92	172
Austria	Austrian Traded Index (ATI)	Jun-89	213
Belgium	BEL 20	Feb-90	204
Brazil	Brazil Bovespa	Feb-90	204
Bulgaria	Bulgaria SE Sofix	Nov-00	102
Canada	S&P/TSX Composite Index	Jun-89	213
China	Shanghai SE A Share	Feb-92	176
Czech Republic	Prague SE PX	Apr-94	156
Denmark	OMX Copenhagen (OMXC20)	Dec-89	205
Egypt	Egypt Hermes Financial	Feb-95	149
Finland	OMX Helsinki (OMXH)	Jun-89	213
France	France CAC 40	Jun-89	213
Germany	DAX 30 Performance	Jun-89	213
Greece	Athex Composite	Jun-89	213
Hong Kong	Hang Seng	Jun-89	213
Hungary	Budapest (BUX)	Jan-91	193
India	S&P BSE (100) National	Jun-89	213
Indonesia	IDX Composite	Jun-89	213
Ireland	Ireland SE Overall (ISEQ)	Jun-89	213
Italy	FTSE MIB Index	Feb-98	125
Japan	Nikkei 225 Stock Average	Jun-89	213
Luxembourg	Luxembourg SE General	Feb-99	116
Malaysia	FTSE Bursa Malaysia KLCI	Jun-89	213
Mexico	Mexico IPC (Bolsa)	Jun-89	213
Netherlands	AEX Index (Aex)	Jun-89	213
New Zealand	NZX 50	Jan-01	100
Norway	Oslo Exchange All Share	Jun-89	213
Pakistan	Karachi SE 100	Jun-89	213
Peru	Lima Se General (IGBL)	Jan-91	193
Philippines	Philippine SE I (PSEI)	Jun-89	213
Poland	Warsaw General Index	May-91	188
Portugal	Portugal PSI-20	Feb-93	166
Russia	Russia RTS Index	Sep-95	144
Singapore	Straits Times Index	Oct-99	111
South Africa	FTSE/JSE All Share	Jul-95	146
South Korea	Korea Se Composite (KOSPI)	Jun-89	213
Spain	Madrid Se General (IGBM)	Jun-89	213
Sri Lanka	Colombo Se All Share	Jun-89	213
Sweden	Omx Stockholm (OMXS)	Jun-89	213
Switzerland	Swiss Market (SMI)	Jun-89	213
Thailand	Bangkok S.E.T.	Jun-89	213
Turkey	Bist National 100	Jun-89	213
UK	FTSE 100	Jun-89	213

Notes: Table 5.1 reports the country and name of each of the 43 international equity indices in our sample. The third column reports the first available data-point and the fourth column denotes the number of observation dates available.

Table 5.2: List of timing discrepancies

Date	Time
18-Dec-90	3.30pm
01-Feb-91	9.15am
30-Apr-91	9.30am
13-Sep-91	9.10am
06-Nov-91	8.45am
20-Dec-91	8.30am
02-Jul-92	9.15am
04-Feb-94	11.05am
18-Apr-94	10.06am
16-Aug-94	1.18pm
26-Mar-96	11.39am
15-Oct-98	3:15pm
18-Apr-01	10.54am
17-Sep-01	8.20am
22-Jan-08	8.21am
08-Oct-08	7.00am
27-Apr-11	12.33pm
22-Jun-11	12.27pm

Notes: From Feb-94, the FOMC has typically released a statement following scheduled FOMC meetings and unscheduled FOMC meetings with target FFR changes at around 2.15pm EST. Prior to Feb-94, target FFR changes were inferred by market participants through open market operations by the Federal Reserve Bank of New York Trading Desk as well as subsequent news reports in the financial media and press (see Kuttner, 2003) at around 11:30am EST (see Gürkaynak, Sack and Swanson, 2005). Table 5.2 lists significant deviations from this timing schedule over the Jun-89 to Dec-12 sample period. The timestamps for these event-dates are from Gürkaynak, Sack and Swanson (2005), Rosa (2012), and through searches of Reuters and Bloomberg News reports following FOMC meetings.

Table 5.3: Descriptive statistics for international equity index returns

Country	Min	Max	Mean	Std. Dev.	Corr. with USA
Australia	-2.66	4.26	0.30	1.07	0.50
Austria	-9.34	7.61	0.23	1.69	0.31
Belgium	-5.49	3.48	0.09	1.24	0.30
Brazil	-4.55	12.68	0.36	4.91	0.56
Bulgaria	-20.90	7.12	-0.02	2.83	0.17
Canada	-2.51	4.68	0.27	1.07	0.43
China	-7.92	7.52	0.41	5.95	0.19
Czech	-4.09	8.77	0.27	1.61	0.22
Denmark	-4.17	3.18	0.09	1.17	0.15
Egypt	-10.23	7.01	0.29	1.77	0.24
Finland	-8.97	8.60	0.08	1.90	0.21
France	-5.61	3.35	0.03	1.52	0.24
Germany	-5.27	6.27	0.11	1.60	0.22
Greece	-4.30	9.05	0.23	1.72	0.19
Hong Kong	-6.31	12.06	0.47	2.02	0.21
Hungary	-13.61	7.18	0.01	2.06	0.29
India	-5.23	6.14	0.24	1.43	0.09
Indonesia	-9.30	10.20	0.38	1.74	0.33
Ireland	-5.76	4.75	0.17	1.45	0.18
Italy	-6.88	3.18	-0.13	1.71	0.19
Japan	-6.02	9.49	0.37	1.74	0.18
Luxembourg	-30.05	5.75	-0.05	3.30	0.12
Malaysia	-7.70	8.44	0.31	1.44	0.39
Mexico	-8.40	6.35	0.45	1.70	0.55
Netherlands	-4.54	3.55	0.06	1.30	0.28
New Zealand	-1.51	3.22	0.16	0.79	0.58
Norway	-4.52	5.85	0.09	1.36	0.24
Pakistan	-8.91	6.17	-0.06	1.44	0.04
Peru	-9.18	5.48	0.21	1.83	0.22
Philippines	-6.85	6.81	0.34	1.66	0.46
Poland	-6.24	8.84	0.32	1.95	0.08
Portugal	-5.36	4.49	0.05	1.28	0.36
Russia	-9.90	16.39	0.25	3.24	0.07
Singapore	-2.68	7.53	0.26	1.45	0.03
South Africa	-3.21	5.60	0.40	1.34	0.27
South Korea	-5.27	11.28	0.31	1.78	0.16
Spain	-5.77	4.20	0.00	1.56	0.21
Sri Lanka	-3.84	2.97	0.02	0.92	0.08
Sweden	-4.82	8.82	0.16	1.58	0.18
Switzerland	-4.89	4.93	0.08	1.21	0.22
Thailand	-7.84	8.66	0.32	2.01	0.11
Turkey	-8.23	11.79	0.41	2.94	0.16
UK	-4.78	5.44	0.05	1.16	0.22

Notes: Table 5.3 reports descriptive statistics for one-day returns of equity indices associated with each of the 43 countries in our sample on FOMC event-dates, over the Jun-89 to Dec-12 sample period.

Table 5.4: Response of international equity index returns to target FFR changes, robust MM-estimates

Country	Obs	α	β_1	Adj R^2	s.e (α)	s.e (β_1)
Australia	169	0.21***	0.32	0.00	(0.06)	(0.29)
Austria	210	0.28***	0.25	0.00	(0.07)	(0.33)
Belgium	202	0.18***	0.63**	0.02	(0.06)	(0.26)
Brazil	199	0.74***	-0.69	0.00	(0.13)	(0.60)
Bulgaria	93	0.12	-0.37	0.01	(0.07)	(0.28)
Canada	207	0.14***	-0.25	0.00	(0.05)	(0.24)
China	171	-0.03	-0.53	0.00	(0.09)	(0.42)
Czech	155	0.17**	-0.03	-0.01	(0.08)	(0.37)
Denmark	205	0.14**	0.49	0.01	(0.07)	(0.30)
Egypt	145	0.14*	-0.26	0.00	(0.07)	(0.35)
Finland	210	0.18*	1.07**	0.02	(0.09)	(0.43)
France	213	0.17*	0.42	0.00	(0.09)	(0.39)
Germany	212	0.21**	0.22	0.00	(0.09)	(0.40)
Greece	211	0.18**	0.77**	0.01	(0.09)	(0.39)
Hong Kong	209	0.21**	-0.84**	0.02	(0.09)	(0.41)
Hungary	186	0.14	0.51	0.00	(0.08)	(0.38)
India	211	0.22***	0.15	0.00	(0.08)	(0.36)
Indonesia	208	0.28***	0.45	0.00	(0.07)	(0.34)
Ireland	212	0.25***	1.06***	0.04	(0.07)	(0.32)
Italy	124	0.05	0.63	0.00	(0.13)	(0.55)
Japan	209	0.24***	-0.47	0.00	(0.08)	(0.37)
Luxembourg	115	0.22*	0.25	-0.01	(0.11)	(0.48)
Malaysia	207	0.17***	-0.18	0.00	(0.05)	(0.22)
Mexico	209	0.40***	0.28	0.00	(0.07)	(0.35)
Netherlands	213	0.18**	0.58*	0.01	(0.08)	(0.34)
New Zealand	98	0.07	-0.03	-0.01	(0.06)	(0.25)
Norway	209	0.08	0.69**	0.02	(0.06)	(0.29)
Pakistan	210	0.02	0.04	0.00	(0.06)	(0.29)
Peru	191	0.14	-0.40	0.00	(0.09)	(0.40)
Philippines	210	0.27***	-0.35	0.00	(0.08)	(0.38)
Poland	180	0.29***	0.60*	0.01	(0.08)	(0.36)
Portugal	164	0.10	-0.03	-0.01	(0.07)	(0.32)
Russia	141	0.14	1.55*	0.02	(0.17)	(0.80)
Singapore	110	0.06	0.36	0.00	(0.09)	(0.42)
South Africa	143	0.27***	-0.34	0.00	(0.08)	(0.37)
South Korea	210	0.23***	0.19	0.00	(0.08)	(0.39)
Spain	211	0.16**	-0.28	0.00	(0.08)	(0.35)
Sri Lanka	212	-0.01	0.20	0.00	(0.05)	(0.2)
Sweden	211	0.16**	0.33	0.00	(0.08)	(0.35)
Switzerland	208	0.19***	0.57**	0.02	(0.06)	(0.27)
Thailand	207	0.26***	-0.19	0.00	(0.09)	(0.38)
Turkey	212	0.30*	0.20	0.00	(0.16)	(0.76)
UK	211	0.08	-0.02	0.00	(0.06)	(0.29)

Notes: Table 5.4 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation (5.2) on FOMC event-dates: $r_t^{\text{int}} = \alpha + \beta \Delta i_t + \varepsilon_t$, where Δi_t denotes target FFR changes and r_t^{int} denotes the equity index return for each country (i). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.5: Response of international equity index returns to unexpected FFR changes, robust MM-estimates

Country	Obs	α	β_1	Adj R^2	s.e (α)	s.e (β_1)
Australia	171	0.19***	-2.57***	0.06	(0.06)	(0.77)
Austria	210	0.25***	-1.93**	0.02	(0.07)	(0.87)
Belgium	202	0.18***	0.36	0.00	(0.06)	(0.64)
Brazil	199	0.67***	-5.11***	0.06	(0.13)	(1.37)
Bulgaria	93	0.13*	-0.05	-0.01	(0.07)	(0.63)
Canada	210	0.10**	-1.81***	0.04	(0.05)	(0.61)
China	171	-0.03	-0.05	-0.01	(0.10)	(1.11)
Czech	154	0.15*	-2.19*	0.01	(0.08)	(1.20)
Denmark	205	0.13*	-0.18	0.00	(0.07)	(0.71)
Egypt	144	0.12	-0.66	0.00	(0.07)	(1.12)
Finland	210	0.15	0.03	0.00	(0.10)	(1.04)
France	213	0.13	-1.17	0.00	(0.09)	(1.01)
Germany	212	0.18**	-0.65	0.00	(0.09)	(1.03)
Greece	210	0.16*	0.00	0.00	(0.09)	(0.99)
Hong Kong	208	0.11	-4.61***	0.08	(0.09)	(1.05)
Hungary	186	0.14	0.68	0.00	(0.08)	(0.86)
India	211	0.19**	-1.20	0.00	(0.08)	(0.96)
Indonesia	209	0.30***	0.78	0.00	(0.08)	(0.87)
Ireland	210	0.21***	-0.08	0.00	(0.07)	(0.74)
Italy	123	0.01	-4.12**	0.03	(0.13)	(1.86)
Japan	208	0.20**	-1.53*	0.01	(0.08)	(0.82)
Luxembourg	115	0.17	-3.28**	0.04	(0.12)	(1.34)
Malaysia	207	0.16***	-0.79	0.01	(0.05)	(0.53)
Mexico	210	0.39***	-0.28	0.00	(0.07)	(0.91)
Netherlands	212	0.14*	-1.37	0.01	(0.08)	(0.87)
New Zealand	98	0.07	-0.23	-0.01	(0.06)	(0.64)
Norway	212	0.07	0.27	0.00	(0.07)	(0.72)
Pakistan	210	0.03	0.32	0.00	(0.06)	(0.62)
Peru	191	0.10	-1.90*	0.01	(0.09)	(1.02)
Philippines	210	0.22***	-2.19**	0.03	(0.09)	(0.86)
Poland	181	0.25***	-0.93	0.00	(0.08)	(0.82)
Portugal	164	0.09	-2.37**	0.02	(0.07)	(1.07)
Russia	141	0.10	-6.12**	0.03	(0.17)	(2.78)
Singapore	110	0.06	-5.34***	0.22	(0.10)	(0.95)
South Africa	143	0.21***	-6.81***	0.17	(0.08)	(1.25)
South Korea	210	0.21**	-0.37	0.00	(0.08)	(0.90)
Spain	211	0.09	-3.79***	0.07	(0.08)	(0.94)
Sri Lanka	212	-0.02	-0.14	0.00	(0.05)	(0.52)
Sweden	211	0.11	-2.44**	0.02	(0.08)	(1.01)
Switzerland	208	0.18***	0.37	0.00	(0.06)	(0.63)
Thailand	207	0.23***	-0.96	0.00	(0.09)	(0.87)
Turkey	213	0.30*	-0.35	0.00	(0.17)	(1.87)
UK	211	0.04	-2.05***	0.03	(0.06)	(0.75)

Notes: Table 5.5 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation (5.3) on FOMC event-dates: $r_t^{\text{int}} = \alpha + \beta \Delta i_t^u + \varepsilon_t$, where Δi_t^u denotes unexpected FFR changes and r_t^{int} denotes the equity index return for each country (i). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.6: Quandt-Andrews structural breakpoint tests

	Excl 911				Excl 911 & Empl			
Country	Max F	Exp F	Ave F	Break-Date	Max F	Exp F	Ave F	Break-Date
Australia	2.71	0.75	1.38	Sep-98	2.02	0.58	1.09	Jun-03
Austria	1.39	0.22	0.41	Jan-01	2.16	0.38	0.66	Dec-99
Belgium	3.96	0.69	1.29	Oct-07	3.94	0.68	1.25	Oct-07
Brazil	2.68	0.31	0.55	Jan-09	2.74	0.48	0.80	Apr-09
Bulgaria	0.97	0.20	0.38	May-07	0.97	0.20	0.38	May-07
Canada	3.98	1.15	2.18*	Sep-08	7.66***	2.65***	4.26***	Mar-99
China	0.88	0.16	0.31	Sep-09	0.83	0.07	0.13	Sep-09
Czech	3.68	0.71	1.26	Jan-08	3.68	0.71	1.26	Jan-08
Denmark	2.96	0.30	0.55	Mar-08	2.76	0.33	0.61	Mar-08
Egypt	1.70	0.44	0.84	Oct-01	1.70	0.44	0.84	Oct-01
Finland	1.62	0.33	0.63	Oct-07	1.89	0.35	0.65	Apr-92
France	3.71	0.56	0.94	Oct-07	3.97	0.63	1.04	Oct-07
Germany	2.75	0.44	0.79	Oct-07	2.98	0.50	0.89	Oct-07
Greece	2.49	0.67	1.24	Nov-00	2.67	0.61	1.12	Aug-07
Hong Kong	4.53	1.35*	2.14*	Feb-95	3.49	0.67	1.19	Jun-08
Hungary	2.28	0.39	0.71	Jun-99	2.55	0.44	0.78	Jun-99
India	2.53	0.65	1.21	Dec-95	2.95	0.71	1.28	Dec-95
Indonesia	4.56	1.43*	2.66**	Nov-94	5.24*	1.56*	2.83**	Nov-94
Ireland	2.34	0.40	0.73	Oct-08	2.33	0.43	0.79	Jan-01
Italy	3.21	0.66	1.04	Aug-09	3.21	0.66	1.04	Aug-09
Japan	5.45*	1.36*	2.40**	Sep-05	5.09*	1.25	2.21*	Nov-05
Luxembourg	2.79	0.55	0.93	Nov-01	2.79	0.55	0.93	Nov-01
Malaysia	4.00	0.57	0.94	Apr-92	3.90	0.53	0.93	Apr-92
Mexico	2.14	0.40	0.74	Aug-08	2.17	0.37	0.69	Aug-08
Netherlands	3.51	0.57	0.98	Oct-07	4.07	0.61	1.01	Oct-07
New Zealand	2.13	0.49	0.93	Jan-08	2.13	0.49	0.93	Jan-08
Norway	5.46*	1.10	1.67	Oct-92	5.90**	1.11	1.57	Oct-92
Pakistan	0.89	0.15	0.28	Jan-01	1.23	0.17	0.33	Mar-94
Peru	2.66	0.65	1.17	Sep-07	2.72	0.69	1.23	Sep-07
Philippines	1.81	0.37	0.70	Oct-08	2.22	0.51	0.95	Sep-94
Poland	2.98	0.35	0.63	Apr-08	2.94	0.38	0.70	Apr-08
Portugal	6.92**	1.28*	1.92*	Nov-09	6.92**	1.28*	1.92*	Nov-09
Russia	2.07	0.26	0.46	Mar-01	2.07	0.26	0.46	Mar-01
Singapore	1.23	0.31	0.59	Jan-09	1.23	0.31	0.59	Jan-09
South Africa	3.15	0.83	1.55	Sep-98	3.15	0.83	1.55	Sep-98
South Korea	5.66*	1.47*	2.59**	Sep-92	4.91	1.44*	2.49**	Nov-92
Spain	2.17	0.34	0.61	Oct-92	2.58	0.33	0.59	Apr-92
Sri Lanka	2.50	0.37	0.66	Apr-01	2.35	0.31	0.55	Apr-01
Sweden	2.74	0.53	0.98	Sep-07	3.39	0.55	0.97	Sep-07
Switzerland	6.72**	1.54*	2.54**	Jun-07	6.61**	1.61**	2.67**	Jun-07
Taiwan	2.26	0.47	0.76	Aug-05	1.89	0.41	0.71	Nov-05
Thailand	1.88	0.28	0.49	Feb-98	1.66	0.21	0.38	Feb-98
Turkey	1.82	0.32	0.59	Oct-07	1.14	0.24	0.47	Aug-93
UK	3.06	0.63	1.15	Dec-08	3.78	0.68	1.25	Mar-09

Table 5.6 reports test statistics for the Quandt-Andrews test for structural breaks (Max F-Stat, Exp F-Stat, Ave F-Stat). The test considers the null hypothesis of no structural breaks versus the alternative of unknown structural breaks (Andrews, 1993). We use a trimming percentage of 15% and the probabilities are calculated using the methodology of Hansen (1997). The tests are performed on Equation (5.3) which is estimated using robust MM-weighted least squares on FOMC event-dates. For columns 2-5, we exclude the 17th Sep 01 event-date in estimation, and in columns 6-9 we further exclude event-dates associated with employment release reports. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.7: Response of international equity index returns to unexpected FFR changes, controlling for the 2007-2009 crisis, robust MM-estimates

Country	Obs	α	β_1	β_2	Adj R^2	[$\beta_1 = \beta_2$]	s.e (α)	s.e (β_1)	s.e (β_2)
Australia	171	0.19***	-1.70**	-5.55***	0.17	[0.00]	(0.06)	(0.84)	(0.97)
Austria	209	0.24***	-2.04**	3.16**	0.05	[0.00]	(0.07)	(0.89)	(1.25)
Belgium	202	0.18***	0.12	3.33***	0.04	[0.01]	(0.06)	(0.70)	(1.03)
Brazil	199	0.67***	-5.00***	-5.16**	0.05	[0.95]	(0.13)	(1.73)	(2.20)
Bulgaria	93	0.13*	-1.00	0.31	-0.01	[0.31]	(0.07)	(1.04)	(0.77)
Canada	209	0.10**	-1.64***	-5.68***	0.20	[0.00]	(0.05)	(0.63)	(0.82)
China	170	0.00	0.73	5.00	0.00	[0.27]	(0.09)	(1.26)	(3.70)
Czech	155	0.16*	-3.37**	5.47***	0.14	[0.00]	(0.08)	(1.30)	(1.24)
Denmark	204	0.11	-0.50	-9.08***	0.04	[0.01]	(0.07)	(0.82)	(2.99)
Egypt	145	0.12*	1.17	-4.77***	0.13	[0.00]	(0.07)	(1.32)	(0.99)
Finland	209	0.11	-0.78	-11.74***	0.03	[0.02]	(0.10)	(1.22)	(4.37)
France	213	0.13	-1.14	5.14***	0.04	[0.00]	(0.09)	(1.05)	(1.60)
Germany	213	0.19**	-0.66	6.27***	0.06	[0.00]	(0.09)	(1.07)	(1.58)
Greece	211	0.16*	-0.48	4.49***	0.03	[0.01]	(0.09)	(1.07)	(1.55)
Hong Kong	210	0.08	-4.29***	-14.04***	0.34	[0.00]	(0.08)	(1.06)	(1.43)
Hungary	186	0.13	0.13	1.55	0.00	[0.43]	(0.09)	(1.09)	(1.49)
India	212	0.19**	-1.33	-7.27***	0.10	[0.00]	(0.08)	(1.00)	(1.45)
Indonesia	210	0.29***	1.17	-9.48***	0.22	[0.00]	(0.07)	(0.88)	(1.25)
Ireland	210	0.21***	-0.23	0.21	-0.01	[0.77]	(0.07)	(0.89)	(1.25)
Italy	123	0.01	-3.97*	-5.69	0.03	[0.72]	(0.13)	(2.07)	(4.35)
Japan	208	0.21**	-1.21	-2.18	0.01	[0.57]	(0.08)	(0.99)	(1.41)
Luxembourg	115	0.17	-1.61	-5.33***	0.08	[0.12]	(0.12)	(1.78)	(1.56)
Malaysia	207	0.15***	-1.17*	-0.16	0.01	[0.33]	(0.05)	(0.62)	(0.86)
Mexico	211	0.38***	-0.33	-7.35***	0.13	[0.00]	(0.08)	(0.95)	(1.30)
Netherlands	213	0.15*	-1.46	4.86***	0.07	[0.00]	(0.08)	(0.88)	(1.29)
New Zealand	100	0.11*	-5.20***	0.11	0.20	[0.00]	(0.06)	(1.01)	(0.74)
Norway	211	0.07	-0.01	-13.82***	0.08	[0.00]	(0.07)	(0.81)	(3.09)
Pakistan	210	0.04	0.59	-0.16	-0.01	[0.56]	(0.06)	(0.75)	(1.05)
Peru	192	0.11	-1.29	7.50***	0.11	[0.00]	(0.09)	(1.02)	(1.54)
Philippines	210	0.22**	-1.89*	-2.79*	0.02	[0.60]	(0.08)	(1.03)	(1.42)
Poland	181	0.24***	-1.44	-0.22	0.00	[0.47]	(0.08)	(1.05)	(1.33)
Portugal	162	0.09	-1.69	-6.23**	0.03	[0.15]	(0.07)	(1.14)	(2.89)
Russia	142	0.10	-4.48	-9.84	0.01	[0.49]	(0.18)	(3.12)	(7.13)
Singapore	110	0.06	-4.90***	-5.59***	0.21	[0.73]	(0.10)	(1.54)	(1.24)
South Africa	142	0.21***	-3.88***	-14.43***	0.19	[0.00]	(0.08)	(1.36)	(2.75)
South Korea	210	0.22***	0.69	-1.40	0.00	[0.24]	(0.08)	(1.13)	(1.39)
Spain	212	0.09	-3.65***	4.92***	0.10	[0.00]	(0.08)	(0.99)	(1.48)
Sri Lanka	211	-0.02	-0.15	-3.32***	0.07	[0.00]	(0.05)	(0.54)	(0.78)
Sweden	212	0.12	-2.23**	3.56**	0.04	[0.00]	(0.08)	(1.04)	(1.39)
Switzerland	208	0.17***	-0.40	2.53**	0.02	[0.02]	(0.06)	(0.72)	(1.02)
Thailand	206	0.22**	-1.17	-7.55**	0.02	[0.09]	(0.09)	(1.06)	(3.73)
Turkey	213	0.27	-2.92	5.41*	0.02	[0.02]	(0.17)	(2.16)	(2.93)
UK	210	0.04	-1.83**	-6.38**	0.04	[0.13]	(0.06)	(0.77)	(2.94)

Notes: Table 5.7 reports robust MM-weighted least squares estimates of Yohai (1987) of Equation (5.4) on FOMC event-dates: $y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where Δi_t^u denotes unexpected FFR changes and r_t^{int} denotes the equity index return for each country (i). D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.8: Fixed-effects panel estimates, robust MM-estimates

Country	Obs	α	β_1	β_2	[$\beta_1 = \beta_2$]	Adj R^2
Panel A (All Meetings)						
Equation (5.5)	8316	0.19***	-0.16			0.00
		(0.02)	(0.10)			
Equation (5.6)	8316	0.16***	-1.50***			0.00
		(0.02)	(0.23)			
Equation (5.7)	8316	0.15***	-2.04***	-0.53	[0.00]	0.01
		(0.02)	(0.29)	(0.38)		
Panel B (Excl Empl)						
Equation (5.5)	8050	0.20***	-0.21**			0.00
		(0.02)	(0.10)			
Equation (5.6)	8050	0.17***	-1.86***			0.01
		(0.02)	(0.24)			
Equation (5.7)	8050	0.17***	-2.80***	-0.50	[0.00]	0.01
		(0.02)	(0.31)	(0.37)		

Notes: Table 5.8 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.5), Equation (5.6) and Equation (5.7) on FOMC event-dates, allowing for cross-sectional heterogeneity: $r_{it}^{\text{int}} = \alpha + \beta \Delta i_{it} + \varepsilon_{it}$ (5.5), $r_{it}^{\text{int}} = \alpha + \beta \Delta i_{it}^{u} + \varepsilon_{it}$ (5.6), $r_{it}^{\text{int}} = \alpha + \left[\beta_1\left(1 - D_{it}^{crisis}\right) + \beta_2\left(D_{it}^{crisis}\right)\right]\Delta i_{it}^{u} + \varepsilon_{it}$ (5.7), where Δi_t^{u} denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.9: Determinants of international transmission of FFR shocks: real integration with the US economy, robust MM-estimator weighted least squares fixed-effects panel estimates

Country	Obs	α	β_1	β_2	β_3	β_4	Adj R^2	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$
Panel A (All Meetings)											
(a) US Trade	8175	0.16***	-1.78***	-2.31***	0.90	-1.95***	0.01	[0.35]	[0.00]	[0.00]	[0.59]
		(0.02)	(0.42)	(0.39)	(0.55)	(0.54)					
(b) US Exports	8175	0.16***	-1.90***	-2.22***	0.82	-1.87***	0.01	[0.56]	[0.00]	[0.00]	[0.60]
		(0.02)	(0.40)	(0.40)	(0.55)	(0.54)					
(c) US Imports	8175	0.16***	-2.00***	-2.11***	0.56	-1.63***	0.01	[0.84]	[0.00]	[0.00]	[0.46]
		(0.02)	(0.42)	(0.39)	(0.55)	(0.54)					
Panel B (Excl Empl)											
(a) US Trade	7909	0.17***	-2.78***	-2.89***	0.92	-1.93***	0.01	[0.86]	[0.00]	[0.00]	[0.16]
		(0.02)	(0.46)	(0.43)	(0.56)	(0.53)					
(b) US Exports	7909	0.17***	-2.35***	-3.33***	0.84	-1.85***	0.01	[0.12]	[0.00]	[0.00]	[0.03]
		(0.02)	(0.44)	(0.44)	(0.54)	(0.53)					
(c) US Imports	7909	0.17***	-3.02***	-2.69***	0.58	-1.60***	0.01	[0.59]	[0.00]	[0.00]	[0.11]
		(0.02)	(0.46)	(0.43)	(0.54)	(0.53)					

Notes: Table 5.9 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.8) on FOMC event-dates: $r_{it}^{\text{int}} = \alpha + \beta_1 (1 - D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_2 (1 - D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \beta_3 (D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_4 (D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \varepsilon_t$. Where Δi_t^u denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. The determinant X is measured using: (a) the ratio of each country's trade with the US (imports plus exports) relative to each country' GDP, (b) the ratio of US exports to each country relative to each country's GDP, (c) the ratio of US imports from each country relative to each country's GDP. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5.10: Determinants of international transmission of FFR shocks: other macroeconomic and financial factors, robust MM-Estimator weighted least squares fixed-effects panel estimates

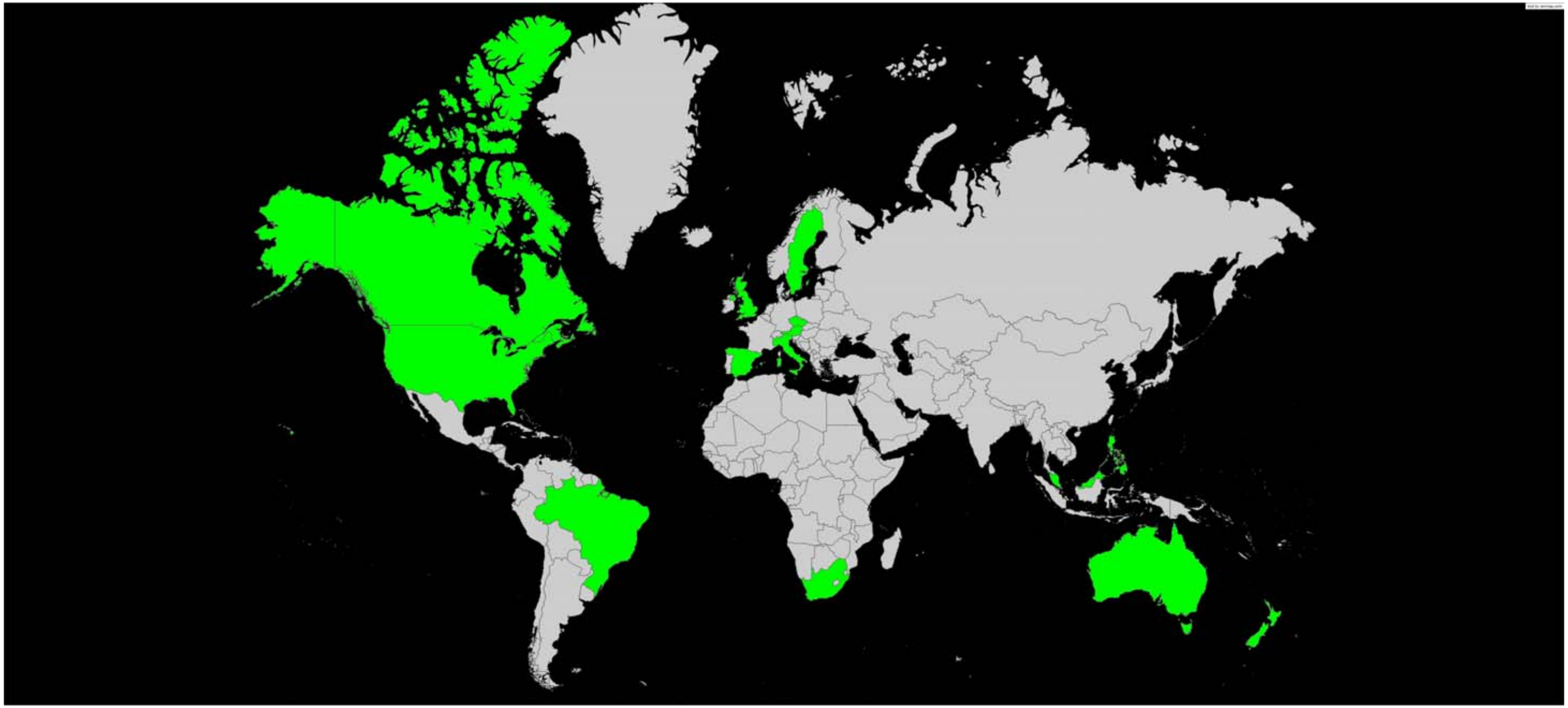
Country	Obs	α	β1	β2	β3	β4	Adj R^2	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$
Panel A (All Meetings)											
(a) GDP Growth Corr	8175	0.16***	-1.87***	-2.24***	-1.97***	0.79	0.01	[0.51]	[0.00]	[0.89]	[0.00]
		(0.02)	(0.41)	(0.40)	(0.55)	(0.54)					
(b) Borrower GDP World	8175	0.16***	-1.69***	-2.42***	-2.14***	0.95*	0.01	[0.20]	[0.00]	[0.51]	[0.00]
		(0.02)	(0.41)	(0.40)	(0.55)	(0.54)					
(c) Time Zone	8175	0.15***	-0.77	-2.16***	-6.39***	-0.10	0.01	[0.17]	[0.00]	[0.00]	[0.00]
		(0.02)	(0.96)	(0.30)	(1.45)	(0.39)					
Panel B (Excl Empl)											
(a) GDP Growth Corr	7909	0.17***	-2.82***	-2.86***	-1.95***	0.81	0.01	[0.94]	[0.00]	[0.21]	[0.00]
		(0.02)	(0.45)	(0.44)	(0.54)	(0.53)					
(b) Borrower GDP World	7909	0.17***	-2.59***	-3.08***	-2.12***	0.98*	0.01	[0.43]	[0.00]	[0.50]	[0.00]
		(0.02)	(0.45)	(0.44)	(0.54)	(0.53)					
(c) Time Zone	7909	0.15***	-4.31***	-2.67***	-6.37***	-0.08	0.01	[0.15]	[0.00]	[0.25]	[0.00]
		(0.02)	(0.02)	(0.32)	(1.41)	(0.38)					

Notes: Table 5.10 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.8) on FOMC event-dates: $r_{it}^{\text{int}} = \alpha + \beta_1\left(1 - D_t^{crisis}\right)\left(X_{it}^{low}\right)\Delta i_t^u + \beta_2\left(1 - D_t^{crisis}\right)\left(X_{it}^{high}\right)\Delta i_t^u + \beta_3\left(D_t^{crisis}\right)\left(X_{it}^{low}\right)\Delta i_t^u + \beta_4\left(D_t^{crisis}\right)\left(X_{it}^{high}\right)\Delta i_t^u + \varepsilon_t$. Where Δi_t^u denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. The determinant X is measured using: (a) the correlation of GDP growth rates in the US with each country (i), (b) the ratio of each country's (i) total level of bank lending from the rest of world relative to each country's GDP, (c) time zones and opening times, countries which respond contemporaneously in real time, and countries which respond the next trading day. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17^{th} Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Figure 5.1: International equity market time zones

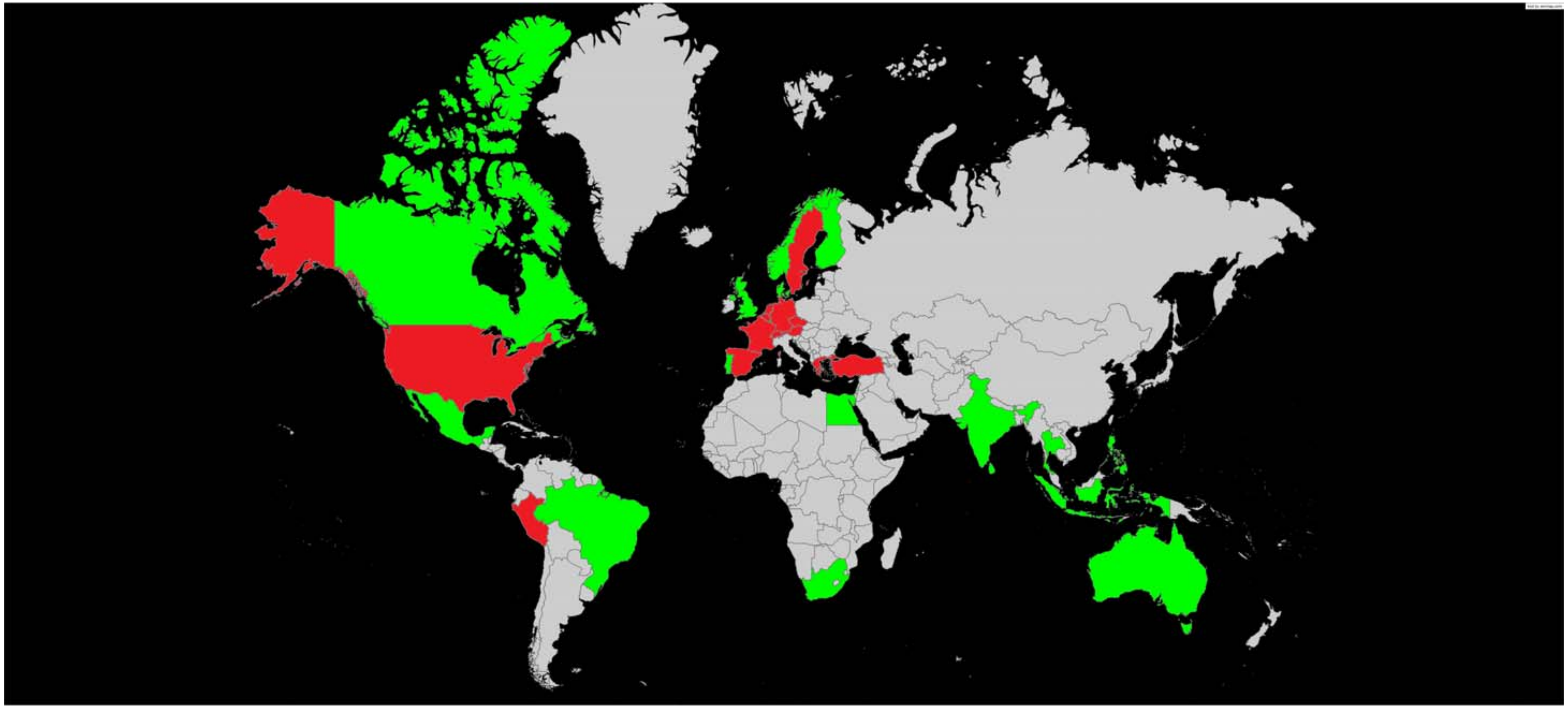
Notes: Figure 5.1 shows trading times for stocks in the benchmark equity index in each country. The data is obtained from Bloomberg and the Market Clocks Website (2013)

Figure 5.2: International equity index returns to unexpected FFR changes outside the 2007-2009 crisis, β_1 coefficient in Table 5.7



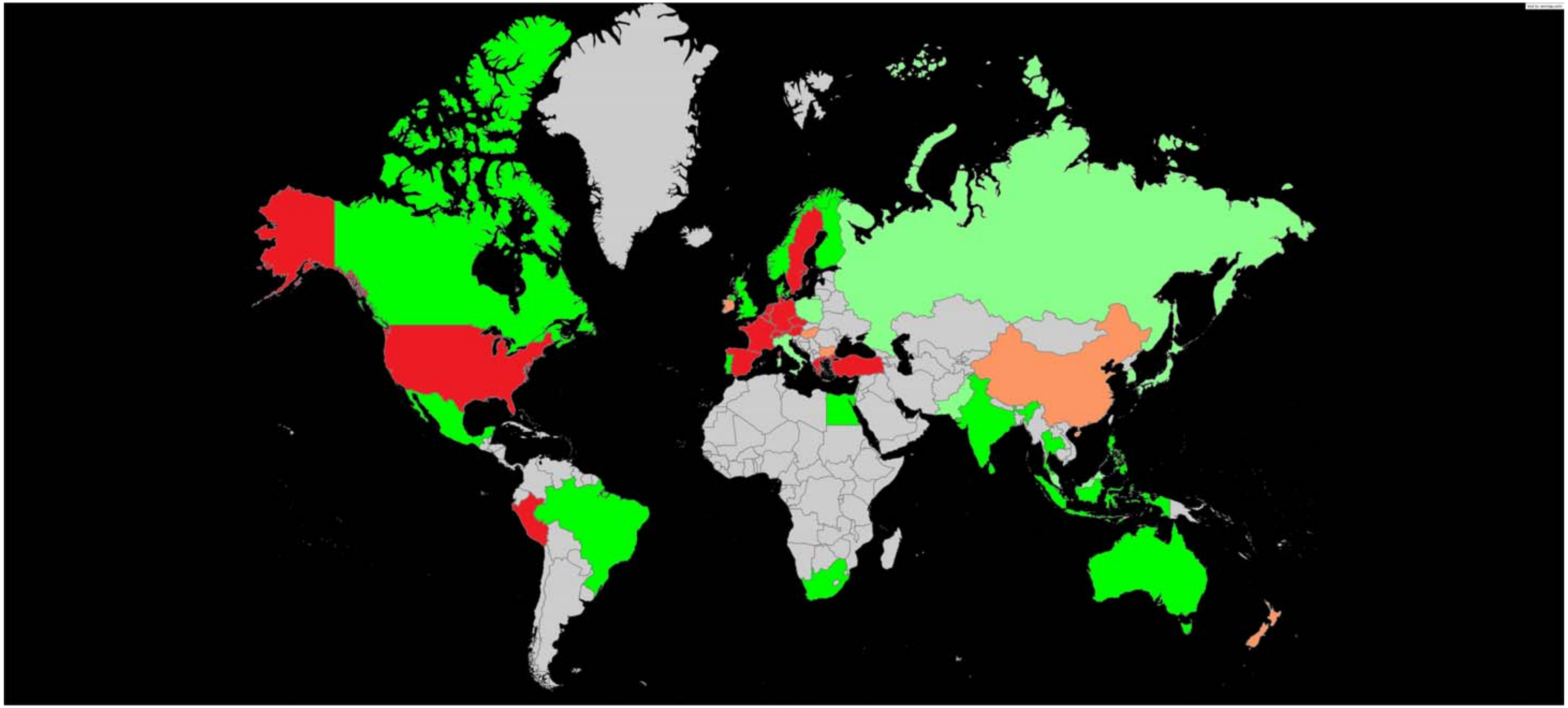
Notes: Figure 5.2 shows a world map which corresponds to Table 5.7. The countries highlighted in green correspond to equity markets which are associated with positive and statistically significant responses to unexpected FFR cuts outside the 2007-2009 crisis period; when the β_1 coefficient in Equation 5.4 is negative and statistically significant. The chart is constructed using amMAP software.

Figure 5.3: International equity index returns to unexpected FFR changes during the 2007-2009 crisis, significant β_2 coefficient in Table 5.7



Notes: Figure 5.3 shows a world map which corresponds to Table 7. The countries highlighted in green (red) correspond to equity markets which are associated with positive (negative) and statistically significant responses to unexpected FFR cuts during the 2007-2009 crisis periods; when the β_2 coefficient in Equation 5.4 is negative (positive) and statistically significant. The chart is constructed using amMAP software.

Figure 5.4: International equity index returns to unexpected FFR changes during the 2007-2009 crisis, significant and insignificant β_2 coefficient in Table 5.7



Notes: Figure 5.4 shows a world map which corresponds to Table 7. The countries highlighted in green (red) correspond to equity markets which are associated with positive (negative) and statistically significant responses to unexpected FFR cuts during the 2007-2009 crisis periods; when the β_2 coefficient in Equation 5.4 is negative (positive) and statistically significant. The countries highlighted in light green (light red) correspond to equity markets which are associated with positive (negative) and statistically insignificant responses to unexpected FFR cuts during the 2007-2009 crisis periods; when the β_2 coefficient in Equation 5.4 is negative (positive) and statistically insignificant.

CHAPTER 5 – APPENDIX

Table A5.1: Response of international equity index returns to unexpected FFR changes, excluding employment

Country	Obs	α	β_1	Adj R^2	s.e (α)	s.e (β_1)
Australia	168	0.20***	-3.88***	0.15	(0.06)	(0.71)
Austria	201	0.27***	-2.85***	0.03	(0.07)	(1.01)
Belgium	195	0.18***	0.12	-0.01	(0.06)	(0.77)
Brazil	194	0.67***	-4.69***	0.05	(0.13)	(1.43)
Bulgaria	93	0.13*	-0.05	-0.01	(0.07)	(0.63)
Canada	200	0.08	-4.50***	0.22	(0.05)	(0.59)
China	170	-0.02	0.92	0.00	(0.09)	(1.25)
Czech	154	0.15*	-2.19*	0.01	(0.08)	(1.20)
Denmark	198	0.12*	-0.65	0.00	(0.07)	(0.82)
Egypt	144	0.12	-0.66	0.00	(0.07)	(1.12)
Finland	201	0.14	-1.48	0.00	(0.10)	(1.27)
France	203	0.15*	-1.88	0.01	(0.09)	(1.15)
Germany	203	0.20**	-0.91	0.00	(0.09)	(1.19)
Greece	201	0.20**	0.97	0.00	(0.09)	(1.06)
Hong Kong	201	0.10	-6.98***	0.15	(0.09)	(1.17)
Hungary	180	0.14	0.67	0.00	(0.09)	(0.99)
India	202	0.21***	-0.65	0.00	(0.08)	(1.07)
Indonesia	199	0.30***	1.07	0.00	(0.08)	(0.98)
Ireland	201	0.21***	-0.15	0.00	(0.08)	(0.83)
Italy	123	0.01	-4.12**	0.03	(0.13)	(1.86)
Japan	200	0.22**	-1.82**	0.01	(0.09)	(0.92)
Luxembourg	115	0.17	-3.28**	0.04	(0.12)	(1.34)
Malaysia	198	0.16***	-0.72	0.00	(0.05)	(0.56)
Mexico	201	0.39***	-0.61	0.00	(0.07)	(1.04)
Netherlands	203	0.15*	-2.28**	0.02	(0.08)	(1.00)
New Zealand	98	0.07	-0.23	-0.01	(0.06)	(0.64)
Norway	201	0.07	-0.19	0.00	(0.07)	(0.82)
Pakistan	201	0.02	0.15	0.00	(0.07)	(0.68)
Peru	185	0.11	-2.01*	0.01	(0.09)	(1.15)
Philippines	201	0.21**	-1.93**	0.02	(0.08)	(0.90)
Poland	177	0.26***	-1.25	0.01	(0.09)	(0.89)
Portugal	164	0.09	-2.37**	0.02	(0.07)	(1.07)
Russia	141	0.10	-6.12**	0.03	(0.17)	(2.78)
Singapore	110	0.06	-5.34***	0.22	(0.10)	(0.95)
South Africa	143	0.21***	-6.81***	0.17	(0.08)	(1.25)
South Korea	202	0.23***	-0.41	0.00	(0.09)	(1.00)
Spain	202	0.10	-3.73***	0.05	(0.08)	(1.10)
Sri Lanka	202	-0.01	0.04	0.00	(0.05)	(0.61)
Sweden	202	0.13	-4.43***	0.06	(0.08)	(1.20)
Switzerland	199	0.19***	0.61	0.00	(0.06)	(0.69)
Thailand	198	0.22**	-0.84	0.00	(0.09)	(0.96)
Turkey	204	0.31*	-3.91*	0.01	(0.17)	(2.34)
UK	202	0.02	-2.26**	0.03	(0.07)	(0.89)

Notes: Table A5.1 reports robust MM-Estimator weighted least squares estimates of Yohai (1987) of Equation (5.3) on FOMC event-dates: $r_t^{\text{int}} = \alpha + \beta \Delta i_t^u + \varepsilon_t$, where Δi_t^u denotes unexpected FFR changes and r_t^{int} denotes the equity index return for each country (i). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. We exclude the 17th Sep 01 event-date, and event-dates associated with employment release reports from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A5.2: Response of international equity index returns to unexpected FFR changes, controlling for the 2007-2009 crisis, excluding employment

Country	Obs	α	β_1	β_2	Adj R^2	[$\beta_1 = \beta_2$]	s.e (α)	s.e (β_1)	s.e (β_2)
Australia	169	0.20***	-2.62***	-5.55***	0.19	[0.03]	(0.06)	(0.90)	(0.95)
Austria	201	0.26***	-2.99***	3.18**	0.06	[0.00]	(0.07)	(1.05)	(1.24)
Belgium	195	0.18***	-0.10	3.31***	0.04	[0.01]	(0.06)	(0.85)	(1.08)
Brazil	194	0.67***	-4.02**	-5.17**	0.04	[0.69]	(0.13)	(1.90)	(2.17)
Bulgaria	93	0.13*	-1.00	0.31	-0.01	[0.31]	(0.07)	(1.04)	(0.77)
Canada	201	0.10**	-2.28***	-5.67***	0.21	[0.00]	(0.05)	(0.77)	(0.83)
China	169	0.00	1.08	4.97	0.00	[0.33]	(0.10)	(1.39)	(3.75)
Czech	155	0.16*	-3.37**	5.47***	0.14	[0.00]	(0.08)	(1.30)	(1.24)
Denmark	197	0.11	-1.00	-9.08***	0.04	[0.01]	(0.07)	(0.95)	(3.02)
Egypt	145	0.12*	1.17	-4.77***	0.13	[0.00]	(0.07)	(1.32)	(0.99)
Finland	200	0.11	-2.35	-11.85**	0.03	[0.05]	(0.10)	(1.49)	(4.56)
France	204	0.15*	-1.88	5.24***	0.05	[0.00]	(0.09)	(1.20)	(1.58)
Germany	204	0.21**	-0.96	6.30***	0.07	[0.00]	(0.09)	(1.24)	(1.58)
Greece	201	0.19**	0.07	4.56***	0.03	[0.02]	(0.09)	(1.22)	(1.53)
Hong Kong	202	0.08	-6.63***	-14.04***	0.38	[0.00]	(0.09)	(1.19)	(1.42)
Hungary	181	0.14	-0.08	1.54	-0.01	[0.42]	(0.09)	(1.30)	(1.52)
India	203	0.21***	-0.82	-7.29***	0.11	[0.00]	(0.08)	(1.13)	(1.40)
Indonesia	201	0.29***	1.64	-9.48***	0.23	[0.00]	(0.08)	(1.01)	(1.25)
Ireland	202	0.21***	-0.52	0.17	-0.01	[0.68]	(0.08)	(1.07)	(1.30)
Italy	123	0.01	-3.97*	-5.69	0.03	[0.72]	(0.13)	(2.07)	(4.35)
Japan	200	0.22**	-1.57	-2.17	0.01	[0.75]	(0.09)	(1.17)	(1.45)
Luxembourg	115	0.17	-1.61	-5.33***	0.08	[0.12]	(0.12)	(1.78)	(1.56)
Malaysia	139	-0.01	-1.15**	0.35	0.02	[0.36]	(0.03)	(0.53)	(0.44)
Mexico	202	0.39***	-0.69	-7.34***	0.13	[0.00]	(0.08)	(1.10)	(1.28)
Netherlands	204	0.16**	-2.52**	4.86***	0.08	[0.00]	(0.08)	(1.04)	(1.32)
New Zealand	100	0.11*	-5.20***	0.11	0.20	[0.00]	(0.06)	(1.01)	(0.74)
Norway	202	0.07	-0.48	-13.83***	0.08	[0.00]	(0.07)	(0.93)	(3.08)
Pakistan	201	0.03	0.40	-0.18	-0.01	[0.67]	(0.06)	(0.86)	(1.06)
Peru	186	0.12	-1.18	7.53***	0.12	[0.00]	(0.08)	(1.15)	(1.51)
Philippines	201	0.22**	-1.28	-2.79*	0.01	[0.41]	(0.09)	(1.15)	(1.43)
Poland	177	0.25***	-2.14*	-0.21	0.01	[0.28]	(0.09)	(1.18)	(1.36)
Portugal	162	0.09	-1.69	-6.23**	0.03	[0.15]	(0.07)	(1.14)	(2.89)
Russia	142	0.10	-4.48	-9.84	0.01	[0.49]	(0.18)	(3.12)	(7.13)
Singapore	110	0.06	-4.90***	-5.59***	0.21	[0.73]	(0.10)	(1.54)	(1.24)
South Africa	142	0.21***	-3.88***	-14.43***	0.19	[0.00]	(0.08)	(1.36)	(2.75)
South Korea	201	0.25***	1.37	-1.36	0.00	[0.16]	(0.09)	(1.38)	(1.39)
Spain	203	0.09	-3.53***	4.93***	0.08	[0.00]	(0.08)	(1.17)	(1.49)
Sri Lanka	203	-0.02	0.03	-3.31***	0.07	[0.00]	(0.05)	(0.63)	(0.79)
Sweden	203	0.14*	-4.11***	3.64***	0.07	[0.00]	(0.08)	(1.24)	(1.38)
Switzerland	199	0.18***	-0.33	2.54**	0.02	[0.03]	(0.06)	(0.82)	(1.02)
Thailand	197	0.21**	-0.97	-7.65**	0.01	[0.09]	(0.09)	(1.23)	(3.76)
Turkey	204	0.30*	-5.32**	5.43*	0.03	[0.01]	(0.17)	(2.54)	(2.98)
UK	202	0.03	-1.95**	-6.27**	0.03	[0.17]	(0.07)	(0.93)	(3.02)

Notes: Table A5.2 reports robust MM-weighted least squares estimates of Yohai (1987) of Equation (5.4) on FOMC event-dates: $y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where Δi_t^u denotes unexpected FFR changes and r_t^{int} denotes the equity index return for each country (i). D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. We exclude the 17th Sep 01 event-date, and event-dates associated with employment release reports from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A5.3: Response of international equity index returns to unexpected FFR changes, controlling for the 2007-2009 crisis (NBER Crisis: Dec-08 to Jun-09)

Country	Obs	α	β_1	β_2	Adj R^2	[$\beta_1 = \beta_2$]	s.e (α)	s.e (β_1)	s.e (β_2)
Australia	171	0.20***	-1.94**	0.58	0.02	[0.50]	(0.06)	(0.85)	(3.67)
Austria	209	0.24***	-2.20**	3.25***	0.05	[0.00]	(0.07)	(0.89)	(1.24)
Belgium	202	0.18***	0.02	3.49***	0.05	[0.00]	(0.06)	(0.69)	(1.01)
Brazil	199	0.67***	-5.62***	-4.51**	0.06	[0.63]	(0.13)	(1.71)	(2.25)
Bulgaria	93	0.12*	-1.49	0.49	0.01	[0.12]	(0.07)	(1.01)	(0.77)
Canada	209	0.10**	-1.78***	-5.56***	0.19	[0.00]	(0.05)	(0.63)	(0.83)
China	171	-0.03	0.77	-3.32**	0.02	[0.05]	(0.10)	(1.27)	(1.62)
Czech	155	0.15*	-3.86***	5.87***	0.17	[0.00]	(0.08)	(1.26)	(1.21)
Denmark	204	0.11	-0.67	-7.29**	0.02	[0.06]	(0.07)	(0.82)	(3.43)
Egypt	145	0.13*	-0.20	-4.65***	0.11	[0.01]	(0.07)	(1.23)	(1.05)
Finland	210	0.14	-0.96	2.11	0.00	[0.15]	(0.10)	(1.22)	(1.78)
France	213	0.13	-1.34	5.59***	0.06	[0.00]	(0.09)	(1.04)	(1.54)
Germany	213	0.19**	-0.86	6.73***	0.08	[0.00]	(0.09)	(1.06)	(1.52)
Greece	210	0.15*	-0.59	4.88***	0.04	[0.00]	(0.09)	(1.06)	(1.51)
Hong Kong	209	0.08	-4.57***	-13.73***	0.34	[0.00]	(0.08)	(1.06)	(1.43)
Hungary	187	0.13	-0.14	2.04	0.00	[0.22]	(0.09)	(1.08)	(1.43)
India	211	0.19**	-1.59	4.74	0.01	[0.12]	(0.08)	(0.99)	(3.96)
Indonesia	210	0.29***	1.01	-8.97***	0.15	[0.00]	(0.08)	(0.88)	(1.44)
Ireland	210	0.21***	-0.27	0.25	-0.01	[0.73]	(0.07)	(0.89)	(1.25)
Italy	125	0.03	-4.63**	4.68***	0.08	[0.00]	(0.13)	(2.05)	(1.78)
Japan	209	0.20**	-1.38	-1.78	0.01	[0.82]	(0.08)	(0.99)	(1.49)
Luxembourg	114	0.20	-2.04	4.88	0.01	[0.14]	(0.12)	(1.77)	(4.35)
Malaysia	206	0.14***	-1.30**	0.03	0.01	[0.17]	(0.05)	(0.58)	(0.79)
Mexico	211	0.38***	-0.52	-7.01***	0.10	[0.00]	(0.08)	(0.95)	(1.42)
Netherlands	213	0.15	-1.62*	5.19***	0.08	[0.00]	(0.07)	(0.87)	(1.26)
New Zealand	100	0.10*	-5.44***	0.39	0.24	[0.00]	(0.06)	(0.95)	(0.82)
Norway	211	0.07	-0.17	-11.33***	0.04	[0.00]	(0.07)	(0.81)	(3.56)
Pakistan	210	0.03	0.46	0.04	-0.01	[0.75]	(0.06)	(0.75)	(1.09)
Peru	191	0.11	-1.48	13.08***	0.04	[0.02]	(0.09)	(1.04)	(4.81)
Philippines	210	0.22***	-2.01*	-2.42	0.02	[0.82]	(0.09)	(1.04)	(1.56)
Poland	181	0.24***	-1.73	0.22	0.00	[0.26]	(0.09)	(1.05)	(1.42)
Portugal	164	0.09	-2.17*	-3.76	0.02	[0.64]	(0.07)	(1.14)	(3.18)
Russia	141	0.11	-6.63**	5.06**	0.05	[0.00]	(0.17)	(2.99)	(2.48)
Singapore	110	0.06	-5.47***	-5.26***	0.21	[0.91]	(0.10)	(1.50)	(1.24)
South Africa	142	0.21***	-4.47***	-12.03***	0.15	[0.02]	(0.07)	(1.35)	(3.04)
South Korea	210	0.22**	0.43	-1.14	-0.01	[0.38]	(0.09)	(1.14)	(1.42)
Spain	212	0.08	-3.95***	5.24***	0.12	[0.00]	(0.08)	(0.99)	(1.44)
Sri Lanka	211	-0.02	-0.07	-3.50***	0.08	[0.00]	(0.05)	(0.53)	(0.76)
Sweden	212	0.12	-2.46**	3.89***	0.06	[0.00]	(0.08)	(1.03)	(1.34)
Switzerland	208	0.17***	-0.56	2.73***	0.03	[0.01]	(0.06)	(0.71)	(1.02)
Thailand	206	0.22**	-1.22	-8.78**	0.02	[0.09]	(0.09)	(1.06)	(4.26)
Turkey	213	0.27	-3.60*	6.09**	0.03	[0.01]	(0.17)	(2.15)	(2.88)
UK	211	0.04	-1.98**	-2.53**	0.04	[0.10]	(0.06)	(0.78)	(1.19)

Notes: Table A5.3 reports robust MM-weighted least squares estimates of Yohai (1987) of Equation (5.4) on FOMC event-dates: $y_t = \alpha + \left[\beta_1\left(1 - D_t^{crisis}\right) + \beta_2\left(D_t^{crisis}\right)\right]\Delta i_t^u + \varepsilon_t$, where Δi_t^u denotes unexpected FFR changes and r_t^{int} denotes the equity index return for each country (i). D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from all estimates. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A5.4: Determinants of international transmission of FFR shocks: real integration with the world economy, robust MM-estimator weighted least squares fixed-effects panel estimates

Country	Obs	α	β_1	β_2	β_3	β_4	Adj R^2	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$
Panel A (All Meetings)											
(a) Trade	8175	0.16***	-1.79***	-2.30***	-0.49	-0.63	0.01	[0.37]	[0.86]	[0.06]	[0.01]
		(0.02)	(0.42)	(0.39)	(0.55)	(0.54)					
Panel B (Excl Empl)											
(a) Trade	7909	0.17***	-2.75***	-2.92***	-0.47	-0.61	0.01	[0.78]	[0.85]	[0.00]	[0.00]
		(0.02)	(0.46)	(0.43)	(0.54)	(0.53)					

Notes: Table A5.4 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.8) on FOMC event-dates: $r_{it}^{\text{int}} = \alpha + \beta_1 (1 - D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_2 (1 - D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \beta_3 (D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_4 (D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \varepsilon_t$. Where Δi_t^u denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. The determinant X is measured using: (a) the ratio of each country's trade with the world (imports plus exports) relative to each country' GDP. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A5.5: Determinants of international transmission of FFR shocks: other macroeconomic and financial factors (Jun-89 to Nov-08), robust MM-Estimator weighted least squares fixed-effects panel estimates

Country	Obs	α	β_1	β_2	β_3	β_4	Adj R^2	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$
Panel A (All Meetings)											
(a) US Trade	6756	0.19***	-1.69***	-2.19***	1.04	-1.80***	0.01	[0.39]	[0.00]	[0.00]	[0.57]
		(0.03)	(0.43)	(0.40)	(0.64)	(0.56)					
(b) US Exports	6756	0.19***	-1.80***	-2.11***	0.91	-1.67***	0.01	[0.59]	[0.00]	[0.00]	[0.53]
		(0.03)	(0.41)	(0.41)	(0.57)	(0.56)					
(c) US Imports	6756	0.19***	-1.91***	-1.99***	0.68	-1.46***	0.01	[0.88]	[0.01]	[0.00]	[0.43]
		(0.03)	(0.43)	(0.40)	(0.57)	(0.56)					
(d) GDP Growth Corr	6756	0.19***	-1.75***	-2.15***	-1.88***	0.98	0.01	[0.48]	[0.00]	[0.86]	[0.00]
		(0.03)	(0.42)	(0.41)	(0.57)	(0.60)					
(e) Borrower GDP World	6756	0.19***	-1.57***	-2.32***	-2.03***	1.13**	0.01	[0.19]	[0.00]	[0.52]	[0.00]
		(0.03)	(0.42)	(0.41)	(0.57)	(0.56)					

Notes: Table A5.5 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.8) on FOMC event-dates: $r_{it}^{\text{int}} = \alpha + \beta_1\left(1 - D_t^{crisis}\right)\left(X_{it}^{\ low}\right)\Delta i_t^u + \beta_2\left(1 - D_t^{crisis}\right)\left(X_{it}^{\ high}\right)\Delta i_t^u + \beta_3\left(D_t^{crisis}\right)\left(X_{it}^{\ low}\right)\Delta i_t^u + \beta_4\left(D_t^{crisis}\right)\left(X_{it}^{\ high}\right)\Delta i_t^u + \varepsilon_t$. Where Δi_t^u denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. The determinant X is measured using: (a) the ratio of each country's trade with the US (imports plus exports) relative to each country' GDP, (b) the ratio of US exports to each country relative to each country's GDP, (c) the ratio of US imports from each country relative to each country's GDP, (d) the correlation of GDP growth rates in the US with each country (i), (e) the ratio of each country's (i) total level of bank lending from the rest of world relative to each country's GDP, (f) time zones and opening times, countries which respond contemporaneously in real time, and countries which respond the next trading day. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A5.6: Determinants of international transmission of FFR shocks: financial development, governance and liquidity measures, robust MM-estimator weighted least squares fixed-effects panel estimates

Country	Obs	α	β_1	β_2	β_3	β_4	Adj R^2	$\beta_1 = \beta_2$	$\beta_3 = \beta_4$	$\beta_1 = \beta_3$	$\beta_2 = \beta_4$
Panel A (All Meetings)											
(a) Electronic Payment	8175	0.16***	-1.78***	-2.33***	-1.21**	0.12	0.01	[0.33]	[0.08]	[0.40]	[0.00]
		(0.02)	(0.41)	(0.40)	(0.54)	(0.55)					
(b) Financial Openness	8175	0.16***	-1.71***	-2.41***	-1.41***	0.33	0.01	[0.21]	[0.02]	[0.65]	[0.00]
		(0.02)	(0.40)	(0.40)	(0.54)	(0.55)					
(c) Market Capitalisation	8175	0.16***	-1.45***	-2.61***	-0.13	-1.01*	0.01	[0.04]	[0.26]	[0.05]	[0.02]
		(0.02)	(0.41)	(0.39)	(0.54)	(0.55)					
(d) Regulatory Framework	8175	0.16***	-1.66***	-2.46***	-1.34**	0.26	0.01	[0.15]	[0.04]	[0.63]	[0.00]
		(0.02)	(0.40)	(0.40)	(0.54)	(0.55)					
(e) Rule of Law	8175	0.16***	-1.73***	-2.39***	-1.02*	-0.07	0.01	[0.24]	[0.22]	[0.30]	[0.00]
		(0.02)	(0.41)	(0.40)	(0.54)	(0.55)					
Panel B (Excl Empl)											
(a) Electronic Payment	7909	0.17***	-2.59***	-3.08***	-1.19**	0.15	0.01	[0.43]	[0.08]	[0.04]	[0.00]
		(0.02)	(0.45)	(0.44)	(0.53)	(0.54)					
(b) Financial Openness	7909	0.17***	-2.58***	-3.10***	-1.39	0.35	0.01	[0.41]	[0.02]	[0.08]	[0.00]
		(0.02)	(0.44)	(0.45)	(0.53)	(0.54)					
(c) Market Capitalisation	7909	0.17***	-2.34***	-3.31***	-0.11	-0.99*	0.01	[0.12]	[0.25]	[0.00]	[0.00]
		(0.02)	(0.45)	(0.44)	(0.53)	(0.54)					
(d) Regulatory Framework	7909	0.17***	-2.48***	-3.20***	-1.32**	0.28	0.01	[0.25]	[0.03]	[0.09]	[0.00]
		(0.02)	(0.44)	(0.44)	(0.53)	(0.54)					
(e) Rule of Law	7909	0.17***	-2.59***	-3.09***	-1.00*	-0.05	0.01	[0.42]	[0.21]	[0.02]	[0.00]
		(0.02)	(0.44)	(0.44)	(0.53)	(0.54)					

Notes: Table A5.6 reports robust MM-Estimator weighted least squares fixed-effects panel estimates of Equation (5.8) on FOMC event-dates: $r_{it}^{\text{int}} = \alpha + \beta_1 (1 - D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_2 (1 - D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \beta_3 (D_t^{crisis})(X_{it}^{low})\Delta i_t^u + \beta_4 (D_t^{crisis})(X_{it}^{high})\Delta i_t^u + \varepsilon_t$. Where Δi_t^u denotes unexpected FFR changes and r_{it}^{int} denotes the equity index return for each country (i) across our sample of 43 countries. D_t^{crisis} is a dummy variable equal to one during the Sep-07 to Mar-09 sample period and zero otherwise. We define a dummy variable X_{it}^{low} equal to one if the determinant X for each country (i) at time (t) is in the lowest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. Similarly, we define a dummy variable X_{it}^{high} equal to one if the determinant X for each country (i) at time (t) is in the highest half of the distribution across all countries over the Jun-89 to Dec-12 sample period and zero otherwise. The determinant X is measured using: (a) the value of all traded shares in a stock market exchange as a percentage of GDP, (b) the percentage of people aged 15 years or older in each country who used electronic payments in the past year to make payments, pay bills or make purchases from their accounts, (c) the Chinn-Ito index which measures each country's degree of capital account openness, (d) the Rule of Law index by the World Bank, (e) the Regulatory Quality index by the World Bank. These models are estimated using the codes of Verardi and Croux (2009). The sample period is from Jun-89 to Dec-12. Obs indicate the number of FOMC event-dates included in estimation. The 17th Sep 01 event-date is excluded from both Panels (A and B). Panel B further excludes FOMC event-dates associated with employment report releases. Standard errors are in parentheses. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Chapter 6: Thesis Conclusion

6.1 Outline

This thesis investigates the impact of conventional monetary policy shocks, i.e. Federal Funds rate surprises on asset prices over the Jun-89 to Dec-12 sample, with a particular emphasis on the 2007-2009 financial crisis. The thesis primarily focuses upon three main financial markets; the US stock market (see Chapter 3), the US Treasury market (see Chapter 4) and international stock markets (see Chapter 5). We conclude this thesis by outlining in detail the specific contribution of each chapter to the empirical literature, and subsequently outline the stakeholders to whom this research has important implications. We finally summarise potential avenues for future research.

6.2 Contribution of each chapter to the empirical literature

The first empirical chapter of this thesis (Chapter 3) investigates the relationship between US stock returns and FFR shocks over the financial crisis period. We find that over sample periods used in pre-crisis studies (i.e. Bernanke and Kuttner, 2005), US stock returns respond significantly to unexpected FFR changes. In each case, we observe an inverse relationship whereby unexpected FFR cuts (increases) are associated with positive (negative) stock returns. We firstly contribute to the existing empirical literature by demonstrating that extending the sample period beyond 2007 renders the relationship between US stock returns and FFR shocks statistically insignificant. The relationship is shown to remain statistically insignificant upon controlling for outliers, employment release reports, and unscheduled FOMC meetings.

Secondly, we explain this result by demonstrating that the relationship between US stock returns and FFR shocks is affected by a highly significant structural shift characterised by the recent 2007-2009 financial crisis. Using a series of endogenous tests for structural breaks and rolling robust mm-estimator regressions, we identify a highly significant abrupt discrete shift in the relationship in lieu of a time-varying shift. This is the first study to conclusively demonstrate a marked shift in the relationship between US stock returns and FFR shocks characterised by the financial crisis.

Thirdly, and most importantly, we find that stock market participants did not respond positively to unexpected FFR cuts during the financial crisis. These estimates are yielded by controlling for both broader (Sep-07 to Mar-09) and narrower (Jan-08 to Mar-09) measures of the crisis period, the former being motivated by financial events which transpired during the crisis and the latter being motivated by endogenous structural break tests. In either case, upon controlling for the crisis, we replicate pre-crisis findings from existing studies, that an unexpected 1% FFR cut is associated with a 4% increase in US stock returns outside the crisis period. This implies that outside the crisis period, unexpected FFR cuts are seen as 'good news' by investors. Interestingly, many of our estimates indicate a statistically significant negative stock market response to unexpected FFR cuts during the crisis period. This implies that during the crisis period, unexpected FFR cuts were seen as 'bad news' by investors.

Fourthly, we demonstrate that the type of state-dependence in the relationship between US stock returns and FFR shocks observed outside the crisis period did not materialise during the financial crisis. Previous pre-crisis studies had widely documented stronger positive stock market responses to unexpected FFR cuts during 'bad times' of recession, tightening credit market conditions and during bear markets. Given that the 2007-2009 financial crisis was characterised by all three simultaneously, one would expect a stronger positive stock market response to expansionary FFR shocks during the crisis. Whilst we confirm that outside the crisis period, US stock returns yielded stronger responses to FFR shocks during 'bad times,' this state-dependence does not persist during the crisis period. In fact, we find that US stock returns responded negatively to unexpected FFR cuts during the crisis. These estimates imply that during the crisis, investors ceased seeing expansionary FFR shocks as good news and rather interpreted them as signals from the Fed of rapidly declining financial and economic conditions, thereby prompting investors to sell stocks.

Lastly, we show that patterns observed in the broad stock market index (S&P500) are also present across the majority of industrial sectors. In line with estimates for the broad stock market, we find that industry sectors are also characterised by a state-dependent response, with the majority of industry sectors yielding larger responses to FFR shocks during 'bad times' outside the crisis. In line with previous pre-crisis studies, we find that outside the crisis period, cyclical and capital intensive industries (durables & technology) are most responsive to FFR shocks compared to non-cyclical and less capital intensive industries (energy & utilities). In contrast, during the crisis period, industry sectors which respond significantly to expansionary FFR shocks, respond negatively to these announcements in each case.

Overall, Chapter 3 contributes to the existing empirical literature in several ways. We demonstrate that the 2007-2009 financial crisis was characterised by tightening credit market conditions, a bear-market and a recession; and unexpected FFR cuts by the FOMC were associated with non-positive or negative stock return responses, while pre-crisis studies predicted euphoric positive stock responses. This implies that during the crisis period, unexpected FFR cuts ceased to be seen as good news by stock market investors and were rather interpreted as signals from the Fed of worsening financial and economic conditions. The cuts were seen as a sign of "*desperation of central bankers*" (Coggan, 2010) and signalled an indication that future profitability would be lower for some time. This in turn signalled bad news for equities.

The second empirical chapter of this thesis (Chapter 4) investigates the relationship between US Treasuries and FFR shocks over the financial crisis period. We begin by confirming the findings of previous studies and find that US Treasuries across the maturity spectrum have larger responses to FFR shocks than to raw target FFR changes. For each Treasury, from 3-Months to 30-Years, the relationship was shown to be positive, with unexpected FFR cuts (increases) being associated with negative (positive) changes in US Treasury yields. Consistent with pre-crisis studies, shorter-term maturity Treasuries were shown to exhibit greater responses to FFR shocks than longer-term maturity Treasuries. The magnitude and significance of the US Treasury response to FFR shocks was shown to decline as the term to maturity increased.

We firstly contribute to the existing empirical literature by demonstrating that US Treasuries have larger magnitude responses to FFR shocks during the financial crisis. Using rolling regression with robust mm-estimator models, we identify a discrete shift in the relationship between US Treasuries and FFR shocks rather than a time-varying shift for each Treasury (3-Month, 6-Month, 2-Year, 5-Year, 10-Year and 30-Year) with a slightly weaker shift for the 6-Month and 2-Year Treasuries.

Secondly, we show that flight to quality trading which was taking place during the financial crisis was reinforced following unexpected FFR cuts on FOMC event-dates during the crisis. As the US Treasury market was shown to be more forward looking than the US stock market, we controlled for forward guidance through FOMC statements[188] using the path factor of Wongswan (2009) and also controlled for the 2007-2009 financial crisis. Upon controlling for these measures, we found that outside the crisis period, 3-Month to 10-Year Treasuries responded negatively (positively) to unexpected FFR cuts (increases). This was

[188] FOMC statement typically outlined the rationale behind monetary policy decisions, contained language which evaluated economic risks and the economic outlook, and often included an evaluation of the likely future trajectory of monetary policy.

consistent with pre-crisis studies which also widely documented statistically insignificant responses of the 30-Year Treasury to FFR shocks. Interestingly, we find that US Treasuries across the maturity spectrum from 3-Months to 30-Years respond significantly to the path factor. This implies that the US Treasury market is indeed forward looking and responds to "*news that market participants have learned from the FOMC's statement about the expected future path of policy over and above what they have learned about the level of the target rate*" (Wongswan, 2009).

More importantly, we show that almost all US Treasuries have larger responses to expansionary FFR shocks during the financial crisis. The difference in response is shown to be significantly greater for very short-term (3-Month) and very long-term (5-Year and 10-Year) maturity Treasuries. The 30-Year Treasury was shown to respond significantly to FFR shocks only during the crisis period, in contrast to all pre-crisis studies which widely documented statistically insignificant responses. Overall, these estimates are consistent with flight to quality trading during the crisis. The stronger reaction of these Treasuries to expansionary FFR shocks during the crisis implies that investors interpreted these cuts as signals from the Fed of a prolonged downturn, thereby prompting market participants to sell higher risk financial assets such as equities (see Chapter 3) to lock away capital in longer-term maturity, lower-yielding, safe-haven assets. The significantly greater demand for the shorter-term 3-Month Treasury can be rationalised because it is one of the most highly liquid financial assets in the world.

Thirdly, in the latter part of the financial crisis (from Dec-08 onwards), the Fed began using more non-conventional monetary policy measures such as large-scale asset purchases to influence financial and economic conditions in the broader macroeconomy. We show that the aforementioned empirical conclusions were not significantly altered upon controlling for LSAP announcements by the Fed. In fact, we find that LSAP announcements by the Fed are associated with 17 to 18 basis point declines in 10-Year and 30-Year Treasury yields.

Fourthly, to illustrate that unexpected FFR cuts during the crisis indeed prompted flight to quality trading by investors, we extend our investigation to an alternative security which is widely perceived to be a safe-haven asset, a store of value, and a hedge against inflation; gold. We find a highly significant structural shift in the relationship between gold returns and FFR shocks characterised by the financial crisis. In fact, we find that gold returns respond significantly to FFR shocks only during the crisis period. A hypothetical unexpected 1% expansionary FFR shock is shown to be associated with a 6% one-day increase in gold returns. As one would expect, gold returns were not shown to respond significantly to the path factor which is concerned with the future trajectory of monetary policy, however an LSAP announcement by the Fed is shown to be associated with a 1% increase in gold returns. These estimates are consistent with flight to quality trading in the gold market during the crisis, as unexpected FFR cuts prompted significantly greater demand for safe-haven assets such as gold.

Overall, Chapter 4 contributes to the existing empirical literature in several ways. We demonstrate that during the 2007-2009 financial crisis, unexpected FFR cuts reinforced flight to quality trading which was taking place, with the prices of safe-haven assets such as US Treasuries and gold significantly increasing in response to these expansionary FFR shocks. In particular, the longer-end of the maturity spectrum (5-Year, 10-Year, and 30-Year) and highly liquid 3-Month Treasury and gold assets were shown to be most responsive.

The third and final chapter of this thesis (Chapter 5) investigates the international transmission of FFR shocks to foreign equity index returns over the financial crisis period. We consider an extensive sample of foreign equity indices across 43 advanced and emerging market economies. We begin by confirming the findings of previous studies and find that foreign equity indices exhibit greater responses to FFR shocks than to raw target FFR changes. Our estimates show that foreign equity indices respond positively (negatively) to unexpected FFR cuts (increases) in countries where the relationship is found to be statistically significant. Consistent with pre-crisis studies, we observe substantial differences in the responses of foreign equity indices to FFR shocks across both advanced and emerging market economies (see Ehrmann and Fratzscher, 2009). We firstly contribute to the existing empirical literature by demonstrating that the relationship between foreign equity index returns and FFR shocks is characterised by a significant structural shift characterised by the 2007-2009 crisis, across 26 countries. The structural break-tests confirm that break-dates cluster around the crisis period for the majority of countries.

Secondly, upon accounting for structural change in the relationship between foreign equity index returns and FFR shocks during the financial crisis, we find that there is substantial heterogeneity in the responses of foreign equity index returns to FFR shocks outside the crisis period, and this heterogeneity in significantly greater during the financial crisis. Our estimate show that foreign equity market across 15 countries responded significantly to FFR shocks, and in each case they responded positively (negatively) to unexpected FFR cuts (increases). Furthermore, equity markets across both emerging market and advanced economies responded significantly (UK & Philippines) or insignificantly (Japan & Indonesia) to FFR shocks.

More importantly, we demonstrate that during the financial crisis there is even greater cross country heterogeneity in foreign equity index responses to FFR shocks. In particular, a hypothetical unexpected 1% FFR cut is associated with significant positive stock responses across 19 countries, significant negative stock responses across 12 countries and statistically insignificant responses across 12 countries. There is a significant range of response, from 3% increases in the Philippines to a 14% increase in South Africa. Across countries where the equity index responded negatively, it ranged from a 3% decline in Switzerland to an 8% decline in Peru. Consistent with pre-crisis estimates, this heterogeneity in foreign equity index response to FFR shocks cannot be entirely explained in terms of differences between emerging market and advanced economies, as both responded positively (Canada & Indonesia) or negatively (France & Peru) to expansionary FFR shocks during the crisis. Given that equity markets in Canada and Mexico responded positively to these cuts, whilst the US responded negatively (see Chapter 3), this implies that geographical proximity and the degree of trade may not entirely explain the heterogeneity in response.

Thirdly, we show that the heterogeneity in foreign equity index response to FFR shocks cannot be explained by any single factor however can be partly explained by a combination of inter-related factors. Outside the crisis period, foreign equity indices responded positively to FFR shocks regardless of whether there was; higher or lower degree of integration with the US economy, higher or lower GDP correlation with the US, equity markets open at the time of announcement and higher or lower degree of borrowing from the rest of the world. However, during the 2007-2009 crisis period, foreign equity indices responded positively to expansionary FFR shocks if they had higher real integration with the US economy, lower GDP correlation with the US economy, and lower external borrowing from the rest of the world. We therefore provide important insights in to why equity markets across some countries may have responded positively to unexpected FFR cuts during the crisis, however this does not explain why equity markets across many other countries responded negatively to the same information by the FOMC.

Fourthly, we yield some evidence that countries with a higher degree of external borrowing from the rest of the world responded negatively to unexpected FFR cuts during the crisis. This implies that during the crisis, unexpected FFR cuts signalled deteriorating financial and economic condition in the US, and international banks strengthened their balance sheets by increasing reserves to prepare for the prolonged downturn. The subsequent decline in credit thereby had negative consequences for countries with higher levels of external borrowing from the rest of the world, thereby causing negative responses in the stock markets of those countries.

Overall, Chapter 5 contributes to the existing empirical literature in several ways. We demonstrate that during the 2007-2009 financial crisis, there was substantially greater heterogeneity in the responses of foreign equity index returns to FFR shocks compared to outside the crisis. During the crisis period, unexpected FFR cuts by the FOMC were met with positive equity market responses in some countries and negative stock market responses in others. The positive stock responses across some countries could be explained in terms of higher real integration with the US, higher business cycle correlation with the US, and lower external borrowing from the rest of the world. However, we yielded some evidence that countries with higher levels of borrowing from the rest of the world responded negatively to these cuts through the bank-lending channel. This implies that FOMC monetary policy should be classed as global risk factor outside the crisis period, however during the crisis it has less predictable and greater heterogeneous effects on international equity markets.

6.3 Implications of research

Thus so far, we have evaluated the contribution of each empirical chapter in this thesis to the existing literature in considerable detail. We continue by outlining the stakeholders to whom the research presented in this thesis has important implications. This includes; monetary authorities, financial market participants, economists and the general public. For policy makers such as the Federal Reserve, this is important because they are mandated by US Congress to achieve a broad set of macroeconomic objectives such as higher economic growth, stable inflation and maximum employment. The Fed primarily enacts monetary policy through open market operations at the New York trading desk, and the impact will be immediately observed in financial markets with a lagged effect on the broader macroeconomy. In this regard, the research in this thesis has important implications for the Fed because it helps them understand the first stage in the monetary policy transmission mechanism to financial markets. It is therefore important for policy makers to understand how financial markets respond to Fed decisions during ‘normal times’ and during periods of rapidly declining financial and economic conditions, with monetary policy operating close to the zero-lower bound.

The research presented in this thesis also has important implications for financial market investors. Bernanke (2009) characterised the financial crisis as being “*the worst* *financial crisis since the 1930s*." Given that the majority of market participants were not around during the Wall Street Crash and the Great Depression, they are unlikely to have experience of financial market responses to FFR shocks during periods of heightened uncertainty, tightening credit market conditions, and severely declining financial and economic conditions. Pre-crisis studies widely predicted positive stock market responses to unexpected FFR cuts under conditions of recession, tightening credit conditions and bear-markets; however we documented negative US stock responses. This research therefore has important implications for investors investing during such times.

There has been considerable debate amongst economists concerning the efficacy of conventional monetary policy in influencing financial and economic conditions during financial crises. Krugman (2008) argued that "*the usual tools of economic policy — above all, the Federal Reserve's ability to pump up the economy by cutting interest rates — have lost all traction*" however Mishkin (2009) contends that "the *fallacy that monetary policy is ineffective during financial crises is dangerous*." This thesis does not investigate the impact of FFR shocks on the broader macroeconomy; however it serves as preliminary discussion for economists concerning the efficacy of conventional monetary policy in influencing financial markets in the first stage of the monetary policy transmission mechanism. The research presented in this thesis provides detailed evidence concerning asset price responses to FFR shocks during 'normal times' and during the financial crisis, and makes some inroads in to addressing part of the question.

Lastly, this thesis has important implications for the general public. The impact of conventional monetary policy shocks on asset prices during the financial crisis has direct implications for borrowing costs, pensions, mortgage rates, and savings rates for firms and the general public. It is important for firms and the general public to understand how financial markets respond to announcements by the FOMC to more fully understand the implications for their finances both present and future.

6.4 Avenues for future research

I originally embarked upon research for this PhD thesis in September 2009. At this time, conventional monetary policy, i.e. the target FFR, was at the zero-lower bound. There had been several announcements concerning large-scale asset purchase announcements and the language of forward guidance had not significantly changed since December 2008. At this time there was very little data to undertake detailed research upon the impact of non-conventional monetary policy on asset prices during the crisis. Interestingly, whilst non-conventional monetary policy became an increasingly popular avenue of research, there was also a significant dearth of studies concerned with the impact of conventional monetary policy shocks on asset prices. A similar observation was made by Cenesizoglu, Larocque and Normandin (2012). We found this to be rather unusual because conventional monetary policy via the target FFR was the primary tool of the Fed for the majority of the crisis period (from Sep-07 to Dec-08). Non-conventional monetary policy was only used as a last resort when this primary tool had been exhausted. This partly explains the motivation behind the focus on conventional monetary policy shocks throughout the thesis.

There are several potential avenues for future research following this thesis. In Chapters 3 and 4 we demonstrated that unexpected FFR cuts during the 2007-2009 crisis period were associated with non-positive or negative US stock returns, and increases in US Treasury and gold prices. This was shown to be indicative of flight to quality trading as investors moved capital away from riskier assets towards safe-haven securities such as US Treasuries and gold. Each of these phenomena were examined separately in the thesis, beginning with US stocks in Chapter 3 and moving on to US Treasuries and gold in Chapter 4. For future research it would be interesting to investigate the dynamic relationship between US stock, US Treasuries and gold during the financial crisis, in lieu of a separate analysis of each.

Previous pre-crisis studies have demonstrated that US stock returns (see Hausman and Wongswan, 2011) and foreign stock returns (see Gürkaynak, Sack and Swanson, 2005) are generally associated with statistically insignificant responses to FOMC statements concerning the future trajectory of monetary policy. The US Treasury market in contrast was shown to respond significantly to such measures because it was more forward looking than the domestic and international equity market. As Chapter 4 was the last chapter of the thesis to be written (from 2011 to 2012), there was sufficient data at this time to control for non-conventional monetary policy measures on the estimates yielded. It would however be interesting for future studies to investigate the impact of non-conventional monetary policy measures such as increasing and more explicit use of forward guidance through FOMC statements and LSAP announcements on the US and foreign equity markets during the financial crisis.

Additionally, in Chapter 4 we controlled for forward guidance through FOMC statements using the path factor of Wongswan (2009). However from 2011, the FOMC became increasingly explicit with commitments to maintain exceptionally low levels of the

FFR at least through mid-2013 (9th Aug 11), at least through late-2014 (25th Jan 12), at least through mid-2015 (13th Sep 12), as long as the unemployment rate exceeded 6.5%, inflation 1-2 years ahead not exceed the longer-run 2% goal by 50 basis points, and have well anchored inflation expectations (12th Dec 12). It would be interesting to control for these interest rate commitments and investigate the impact upon asset prices not only during the financial crisis, but also over a longer-run period.

Furthermore, in Chapter 5 we found that unexpected FFR cuts during the financial crisis were associated with positive stock returns in some countries and negative stock returns in others. Although great effort was taken in to explaining these results, a deeper analysis would require a more complex dataset which controls for monetary policy shocks both conventional and non-conventional, both domestically in the US and internationally in other countries. For example, on the 8th Oct 08 the FOMC undertook co-ordinated monetary policy action with foreign central banks such as the Bank of England, European Central Bank and Bank of Japan; hence these event-dates should be controlled for in the analysis. Similarly, monetary policy decisions by monetary authorities across the 43 countries may also have coincided with event-dates in our analysis and it would be important to control for such events as well as significant macroeconomic events across these countries which may have influenced estimation. However this is a significantly greater project to undertake.

Lastly, the empirical approach to defining unexpected FFR changes outlined by Kuttner (2001) and Bernanke and Kuttner (2005) using CBOT futures contracts considered a set of event-dates which included scheduled FOMC meetings and unscheduled FOMC meetings with target FFR changes. This event-study approach has become the accepted convention in the empirical literature and is adequate for the pre-crisis literature however it misses important events which occurred on unscheduled FOMC meetings without target FFR changes during the crisis and thereafter. For example, on the 10th Aug 07 the FOMC announced it would provide further liquidity facilities, on the 11th Mar 08 they announced a new Term Securities Lending Facility and on 9th May 10 they released US dollar liquidity swap facilities in coordination with foreign central banks. These important events were effectively omitted from the analysis to the exclusion of unscheduled FOMC event dates without target FFR changes. A future investigation may consider expanding the dataset to also include such event-dates. There are therefore several avenues of additional research which could be undertaken following this thesis.

6.5 Publications

Finally we would like to point out that many of the estimates presented in Chapters 3 and 4 have been published in the Journal of Banking Finance (see Kontonikas, MacDonald and Saggu, 2013). We expect to also release working papers derived from the remainder of the thesis in due course.

6.6 References

Bernanke, B. S., & Kuttner, K. N. 2005. What explains the stock market's reaction to Federal Reserve policy?. *The Journal of Finance* 60(3), 1221-1257.

Bernanke, B.S. 2009. Financial Reform to Address Systemic Risk: Speech at the Council on Foreign Relations, Washington D.C. *The Federal Reserve Website*. Available from: http://www.federalreserve.gov/newsevents/speech/bernanke20090310a.htm. [Accessed on 22nd Aug 13].

Cenesizoglu, T., Montréal, H.E.C., Larocque, D., & Normandin, M. 2012. Conventional Monetary Policy and the Term Structure of Interest Rates during the Financial Crisis. *HEC Montreal Finance Department*. Working Paper.

Coggan, P. 2010. Another paradox of thrift. *The Economist Website*. Available from: http://www.economist.com/node/17043652/print. [Accessed on 22nd Aug 13].

Ehrmann, M., & Fratzscher, M. 2006. Global financial transmission of monetary policy shocks. *European Central Bank*. Working Paper No. 1710.

Gürkaynak, R.S., Sack, B., & Swanson, E.T. 2005. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking* 1(1), 55-93

Hausman, J., & Wongswan, J. 2011. Global asset prices and FOMC announcements. *Journal of International Money and Finance* 30(3), 547-571.

Kontonikas, A., MacDonald, R., & Saggu, A. (2013). Stock market reaction to fed funds rate surprises: state dependence and the financial crisis. *Journal of Banking and Finance* 37(11), 4025-4037

Krugman, P. 2008. Depression Economics Returns. *The New York Times Website*. Available from: http://www.nytimes.com/2008/11/14/opinion/14krugman.html. [Accessed on 22nd Aug 13].

Kuttner, K. N. 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics* 47(3), 523-544.

Mishkin, F. S. 2009. Is Monetary Policy Effective during Financial Crises?. *The American Economic Review* 99(2), 573-577.

Wongswan, J. 2009. The response of global equity indexes to US monetary policy announcements. *Journal of International Money and Finance* 28(2), 344-365.