

The impact of policy initiatives on credit spreads during the 2007-09 financial crisis

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Abstract

This paper assesses the impact of the various “unconventional” U.S. Federal Reserve policies and fiscal policies, introduced during the 2007-09 financial crisis period, on credit market spreads. I also examine the impact of the “conventional” monetary policy stance, defined as the difference between the effective Federal Funds rate and the rate implied by a Taylor rule. Examining policies initiated between July 2007 and early 2009, I find that fiscal policy announcements exerted a significant and destabilising influence on market spreads. I also find that while the multitude of “unconventional” monetary policy initiatives were effective in reducing market spreads, the efficacy of these policies was reduced by the sustained contractionary stance in conventional monetary policy. In short, the Federal Reserve’s success in reducing strains in U.S. credit markets appears to have been undermined by their inability (or, more provocatively, their unwillingness) to achieve their broader macroeconomic objectives.

Keywords: bond spread, event study, Federal Funds rate, London interbank offer rate, repurchase agreement, Taylor rule, vector autoregression
JEL Classification No: E52, E58, E63, G12, G14.

*Department of Accounting and Finance, Faculty of Business and Economics, Macquarie University, Balaclava Road, North Ryde, Australia, 2109. Ph: +61 2 9850 1169, email: alan.raimq.edu.au This paper is derived from the third chapter of my PhD thesis, completed at UNSW. I am grateful to Vijay Murik, Glenn Otto, Valentyn Panchenko, Scott Sumner, participants at seminars held at the University of New South Wales and the University of Sydney, and, in particular, Adrian Pagan. I thank Andrew Metrick for providing the data on repo yields. All errors and omissions are my responsibility.

1 Introduction

This paper assesses the impact of the various “unconventional” policies introduced by the U.S. Federal Reserve, during the 2007-09 financial crisis period, on market spreads. The crisis moved U.S. Federal Reserve policy from a well-established routine of interest-rate targeting to a multi-pronged triage that wedded traditional policy tools with new initiatives aimed at reviving an ailing financial system. The triage was controversial on two grounds: firstly, these initiatives required discretion over targeting particular markets and firms; and secondly, a fear that the liquidity provided may stoke higher inflation, undermining the central bank’s macroeconomic objectives. These changes in the operation of central bank policy have been especially jarring following a quarter-century of generally quiescent macroeconomic activity and policy, a period often characterized as the “Great Moderation”. The timing, size, appropriateness and effectiveness of the measures taken by the Federal Reserve during the 2007-09 crisis are the subject of much discussion, analysis, and controversy.

The number of studies examining the effectiveness of various policies has grown rapidly, with some studies having examined the effectiveness of the Federal Reserve’s Term Auction Facility (TAF), with conflicting findings (Taylor (2011) vs. McAndrews, Sarkar and Wang (2008)). Other papers have assessed the effectiveness of the U.S. dollar swap lines between the Federal Reserve and other central banks in alleviating dislocations in foreign currency markets (Baba and Packer (2009) and McAndrews (2009)). In contrast to these univariate-policy-centric studies, Aït-Sahalia, Andritzky, Jobst, Nowak, and Tamirisa (2010) found that central bank liquidity support and liability guarantees, along with bank recapitalisations by the public sector, led to a reduction in interbank risk premia.

Given the large number of “unconventional” policy initiatives introduced by the Federal Reserve to combat the crisis – between December 2007 and March 2009 the Federal Reserve initiated 16 programs – analysing the efficacy of these programs requires an organising framework. In this paper, I use the framework developed in Kroszner and Melick (2010), who classify the policy initiatives along three dimensions: (i) an expansion of the type of counterparties receiving support; (ii) a broadening of the collateral eligible for support; and (iii) a lengthening of the maturity of the support. This framework reveals that the various “unconventional” policies complement “conventional” monetary policy, for reasons outlined below.

Using this framework, this paper makes six important contributions to the literature. Firstly, I find that all three types of policies were effective in reducing market spreads, with the most effective being policies that broadened the range of collateral eligible for secured funding from the Federal Reserve. Secondly, I find that these policies were more effective in reducing unsecured and secured funding

costs than bond spreads. Thirdly, these policies were more effective in reducing the level of spreads than their conditional variances. Fourthly, I find that “implementation effects” and “flow-of-funds” effects – respectively, the effect on spreads at the time policies were implemented, and the effect on spreads from higher amounts loaned from these programs – were an order of magnitude larger than “announcement effects” – the effect on spreads at the time these policies were announced. Fifth, fiscal policy announcements did not have a stabilising influence on market spreads, and in some instances had significant destabilising effects, consistent with Taylor (2011).

Finally, I find that the stance of “conventional” monetary policy had a destabilising influence on spreads, with contractions in monetary policy associated with increases in market spreads. Following Rudebusch (2010), I measure the monetary policy stance as the deviation of the actual Federal Funds interest rate from the interest rate implied by a Taylor rule. As a Taylor rule relates the level of the Federal Funds rate to the objectives, as stated in Section 2A of the *Federal Reserve Act*, of price stability and maximum employment, measuring the policy stance as the difference between these two interest rates is more appropriate than using the level of the Federal Funds rate.

While the Federal Reserve’s various “unconventional” policies did reduce financial market strains, these policies were not sufficient to ensure that the Federal Reserve met its macroeconomic objectives, as enshrined in the Taylor rule. This, in turn, exacerbated market strains, and reduced the efficacy of the the unconventional policies. These findings are akin to Friedman and Schwartz (1963)’s argument that the Federal Reserve’s contractionary policy stance during the 1930s destabilised financial markets and exacerbated the Great Depression, a view subsequently upheld by the U.S. Federal Reserve (Bernanke, 2002).

The rest of the paper is organised as follows. Section 2 outlines the key conventional and unconventional Federal Reserve policy responses to the differing crisis events, and Section 3 reviews the relevant literature. Section 4 outlines the data used and the estimation of Taylor rules, and Section 5 discusses the empirical methodology employed. Section 6 discusses the estimated announcement effects of the various policy initiatives examined in this paper. Section 7 contains the results from the regime-switching VAR, while Section 8 discusses the implementation and flow-of-funds effects of the various Federal Reserve programs on market spreads. Section 9 concludes with a discussion of avenues for future research.

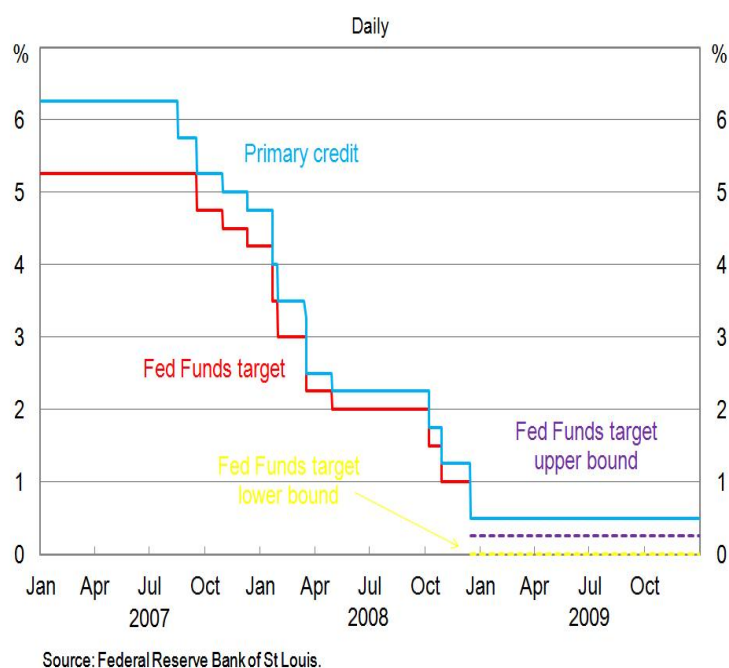
2 The U.S. Federal Reserve’s policy initiatives

2.1 “Conventional” policy responses

One aspect of the Federal Reserve’s response to the crisis involved its traditional tools of changing the target Federal Funds rate and primary credit rate.¹ Between the reforms to the discount window program in 2003 and the start of the financial crisis in mid 2007, the term of primary credit loans was always overnight, and its interest rate was set 100 basis points above the target Federal Funds rate (Figure 1). However, as the crisis unfolded, lending conditions became less restrictive: on August 17, 2007, the maximum term was lengthened to 30 days (and the spread lowered to 50 basis points) and then, on March 16, 2008, the maximum term was extended to 90 days (and the spread lowered to 25 basis points).

Kroszner and Melick (2010) note that the Federal Open Market Committee

Figure 1: Target Federal Funds Rate and Primary Credit Rate



(FOMC) followed “standard” procedure – reducing the Federal Funds rate and primary credit rate by 25 basis points at each meeting – in easing monetary policy

¹The primary credit rate is the interest rate charged by the Federal Reserve for secured, short-term loans to depository institutions. The lending facility offered by the Federal Reserve is termed the ‘discount window’.

from September 2007 through to the end of the year. As the market turmoil intensified around year-end, the FOMC reduced rates by a total of 125 basis points. Rates were cut an additional 75 basis points at the March 2008 meeting (along with the fall in the spread between the primary credit rate and the Federal Funds rate). October 2008 saw a further 100 basis point cut in interest rates, as well as an unprecedented internationally co-ordinated rate cut of 50 basis points, and another 100 basis point cut in December when the FOMC moved to targeting the Federal Funds rate within a range of 0 to 25 basis points (Figure 1).

The third traditional tool, reserve requirements, was not used by the Federal Reserve during the early stages of the crisis. However, on October 6, 2008, the Federal Reserve announced it would begin paying interest on depository institutions' required and excess reserve balances. The interest on reserves (IOR) program has allowed the Federal Reserve to maintain the effective Federal Funds rate within its target range, although some economists have considered it analogous to an increase in reserve requirements, and thus contractionary (Beckworth (2008); Woodward and Hall (2009)). These economists argue that the IOR program negated some of the stimulus provided by the use of conventional and "unconventional" monetary policy.

2.2 “Unconventional” policy responses

By December 2007 it was evident that the Federal Reserve's traditional policy tools were not achieving the desired economic and financial market goals. Kroszner and Melick (2010) note that, between December 2007 and March 2009, the Federal Reserve introduced 16 “unconventional” programs to combat the crisis. Since even describing, much less assessing, these initiatives can easily get bogged down in a long list of confusing and easily forgotten acronyms, Kroszner and Melick (2010) organise the various policies into one (or more) of three categories: (i) policies that expand the type of counterparties receiving support; (ii) policies that broaden the collateral required to access the support; and (iii) policies that lengthen the maturity of the support. Kroszner and Melick (2010) sort chronologically the various Federal Reserve policies into these three categories, and their table is reproduced below (Table 1).

Table 1: The U.S. Federal Reserve’s “unconventional” policy initiatives

As at November 18, 2009

Initiative	Description				Objectives			
	Announced	First used	Authorised until	Max. size ^(a)	Current size ^(a)	Lengthen maturity	Broaden collateral	Expand c’party
Term Auction Facility	Dec 12, 2007	Dec 17, 2007	Ongoing	493	109	x		
Central bank swap lines	Dec 12, 2007	Dec 20, 2007	Jan 2, 2010	583	28			x
Term Securities Lending Facility	Mar 11, 2008	Mar 27, 2008	Jan 2, 2010 ^(b)	234	0	x		
Maiden Lane (Bear Stearns)	Mar 14, 2008	June 26, 2008	Ongoing	30	26		x	x
Primary Dealer Credit Facility ^(c)	Mar 16, 2008	Mar 19, 2008 ^(d)	Jan 2, 2010	148	0			x
Term Securities Lending Facility Options	Jul 30, 2008	Aug 27, 2008	Suspended ^(e)	50	0	x		
<i>American International Group support</i>								
FRBNY lending to AIG	Sep 16, 2008	Sep 17, 2008 ^(d)	Ongoing	90	45		x	x
Maiden Lane II	Oct 11, 2008	Dec 12, 2008	Ongoing	20	16		x	x
Maiden Lane III	Oct 11, 2008	Nov 25, 2008	Ongoing	28	23		x	x
Asset-Backed Commercial Paper Money	Sep 19, 2008	Sep 24, 2008 ^(d)	Jan 2, 2010	152	0		x	
Market Mutual Fund Liquidity Facility	Oct 7, 2008	Oct 27, 2008	Jan 2, 2010	351	15		x	x
Commercial Paper Funding Facility	Oct 21, 2008	Unused	Oct 30, 2009	Unused	0			x
Money Market Investor Funding Facility	Oct 23, 2008	Unused	Unused	Unused	0			x
Citigroup support	Nov 25, 2008	Mar 25, 2009	Mar 31, 2010	44	44	x	x	x
Term Asset-Backed Securities Loan Facility	Nov 25, 2008	May 5, 2009	Jun 30, 2010 ^(f)	847	847			
Purchase of MBS guaranteed by GSEs	Nov 25, 2008	Dec 5, 2008	Mar 31, 2009 ^(g)	153	153	x		x
Purchases of direct GSE debt	Nov 25, 2008	Unused	Mar 31, 2009 ^(g)	Unused	0	x		x
Bank of America support	Jan 16, 2009	Mar 25, 2009	Oct 30, 2009 ^(g)	311	311	x		x
Purchases of longer-term U.S. Treasuries	Mar 18, 2009							

Source: Kroszner and Melick (2010).

Notes:

- (a) In U.S.\$ billions.
- (b) Auctions against Schedule 1 collateral suspended on January 7, 2009.
- (c) Includes transitional support for Goldman Sachs, Morgan Stanley, and Merrill Lynch announced on September 21, 2008.
- (d) Based on first appearance in the Federal Reserve Board’s H.4.1 statistical release.
- (e) Suspended on June 25, 2009.
- (f) Loans against newly issued ABS and legacy CMBS authorized through March 31, 2010, loans against newly issued CMBS through June 30, 2010.
- (g) Based on FOMC statements.

I adopt Kroszner and Melick (2010)’s categorical scheme to analyse the impact of the “unconventional” policies on market pricing. The authors note that their choice of organising framework reflects the Federal Reserve’s modification to their lender-of-last-resort (LOLR) facilities to reflect changes in the financial system over the past few decades. In order for the Federal Reserve to be able to use their LOLR facilities effectively, three changes to pre-existing policies needed to be adopted. First, dealing with new counterparties was critical to extending central bank assistance to important markets and firms in the intermediation chain, due to the interconnectedness of institutions and markets. Second, accepting a wider range of collateral reflected the reality of a financial system that had evolved from bank intermediation towards greater reliance upon securitisation and market-based intermediation. Finally, extending the maturity of the support was designed to instill confidence in market participants that institutions and counterparties will have a source of funding for longer periods, reducing the likelihood that negative liquidity shocks force fire-sales and compromise solvency.²

In this sense, the various unconventional policies can be seen as extensions of the Federal Reserve’s traditional toolkit to deal with the architecture of the modern financial system. The complementary nature of the nontraditional and traditional tools means we can gauge the effectiveness of the “unconventional” policies by the extent to which it allowed the Federal Reserve to meet its dual mandate of price stability and full employment. This provides one key justification for why I include the stance of conventional monetary policy in my analysis.

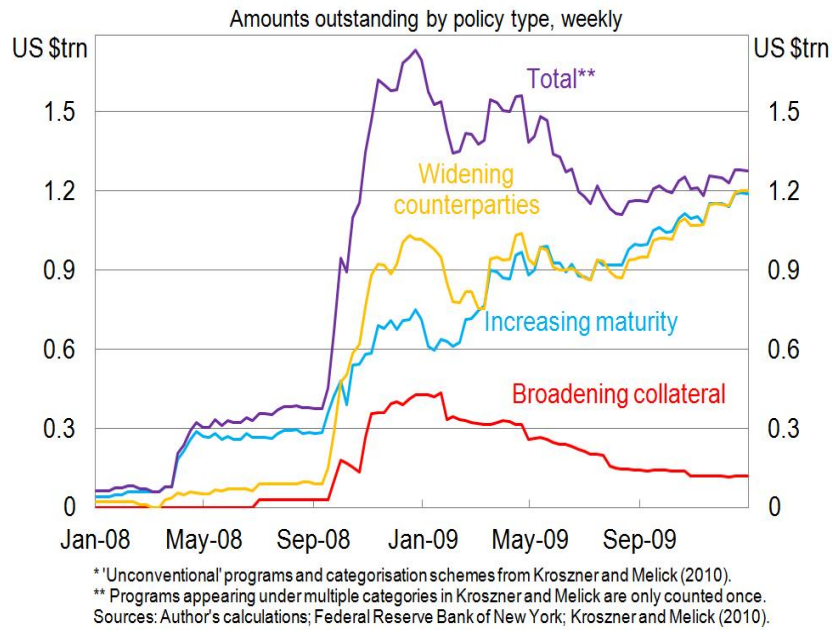
In terms of the size of the “unconventional” monetary policies, the largest were those that widened the counterparties to, and increased the maturity of, Federal Reserve support. The stock of securities acquired by the Federal Reserve under each of these programs was US\$1.2 trillion as at the end of 2009 (Figure 2). In contrast, the size of programs that broadened the collateral eligible for Federal Reserve support was only US\$0.1 trillion as at end-December 2009. The stock of securities acquired under all three types of programs was US\$1.3 trillion as at the end of 2009.³

Collectively, the size of the Federal Reserve’s “unconventional” programs rose the most in September 2008, reflecting the collapse of Lehman Brothers and AIG, the failure of large money market funds, and the systemic nature of market runs at this time. The stock of securities held reached a high of US\$1.73 trillion as at the end of 2008, before declining throughout 2009, due to declines in the size

²Bernanke (2009) presents an alternative framework that classifies each non-traditional initiative into three descriptive categories: lending to financial institutions; providing liquidity to key credit markets; and purchasing longer-term securities.

³The sum of the stock of securities held under the individual program categories typically exceeds the stock of securities held under all three program categories since the various Federal Reserve policy initiatives were typically classified under more than category (see Table 1).

Figure 2: U.S. Federal Reserve “unconventional” programs*



of programs that broadened the range of eligible collateral, as market conditions stabilised somewhat (Figure 2).

I also include policy initiatives that did not directly impact the Federal Reserve’s balance sheet, such as the Troubled Asset Relief Program (TARP), which was created through the *Emergency Economic Stabilization Act of 2008*. While these policies are more fiscal, than monetary, in nature, omitting these policies may bias the estimated impact of the various Federal Reserve policies on market pricing. I consider four policies, grouping them under the title “Fiscal policies”:

1. TARP;
2. the Temporary Liquidity Guarantee Program (TLGP), under which the Federal Deposit Insurance Corporation (FDIC) guaranteed the senior debt obligations of FDIC-insured depositories and their holding companies;
3. the Capital Purchase Program (CPP), under which the U.S. Department of the Treasury used TARP funds to purchase preferred stock and warrants of financial institutions; and
4. the use of the Exchange Stabilization Fund by the U.S. Treasury to provide a temporary guarantee of \$1 per share for money-market fund accounts.

3 Related literature

The theoretical literature on central banks' LOLR facilities is well-established, dating back to Thornton (1802) and Bagehot (1873), so only a summary of the literature's key elements is provided here. As Freixas, Giannini, Hoggarth and Soussa (1999) note, the key rationale for LOLR facilities is preventing the failure of illiquid-but-solvent institutions, as failure (or the threat of failure) has negative externalities on the broader financial system and the macroeconomy. The failure of a large institution, or a number of smaller ones, could result in system-wide financial instability, potentially threatening the ability of the financial system to perform its primary functions, such as the provision of the payments system, the efficient pricing of risk, and the allocation of resources. For a discussion of the theoretical literature up to the late 1990s, see Freixas et al. (1999); recent additions to the literature include Caballero and Krishnamurthy (2008) and Holmström and Tirole (2011).

The empirical literature on LOLR facilities is also well-established, with the financial crisis of 2007-09 having resulted in numerous studies examining the efficacy of policy initiatives. However, there is little consensus on the impact of the various policies. To a large extent, the different findings across the studies reflect: (i) differences in the specification of the dependent variable (levels or first differences); (ii) whether the entire amount of a credit spread should be used or just the liquidity component (the latter generating questions about the methods used to extract this component); (iii) the size of the time window around an event; and (iv) differences in ways of extracting a policy's "announcement effect". These last two points are perhaps the most important.

Limiting the size of the window can prevent a bias in the estimated announcement effects, when other events are erroneously included with a given event. As Frankel (2010) notes, the event study literature has long established that the event window should be less than one day. However, a longer event window allows for any pre- or post-event "drift", where the former reflects the possibility of information leakage, and/or insider trading, prior to the event, and the latter allows for any market under- or over-reaction at the time of the event. While I follow the literature in using public announcement dates to identify policy events, I focus on the 3-day interval around an event to allow for any pre- and post-event drift.

It is worth noting that my econometric estimations also used one 1-day event window, and two 2-day event windows. The 1-day window focused solely on the announcement day; the two 2-day windows used, respectively, the announcement day and the prior day, and the announcement day and the proceeding day. I found that the economic and statistical significance of the estimated announcement effects, across the various conditional mean and conditional variance models, were lower for these alternative windows. These results imply that the alternative time

intervals omit the behaviour of market spreads both preceding and proceeding the various policy announcements, and suggest that pre- and post-event drift were important aspects of the overall ‘announcement effect’. The results for the alternative event windows are available on request.

To examine the announcement effect, I use a larger set of conditioning variables than the related literature. The majority of the related literature focus on one market spread (typically, the LIBOR-OIS spread), and use lagged values of this variable to estimate the announcement effect of a particular policy. In contrast, as outlined in Section 5, I use three spreads and a larger set of conditioning variables to overcome the possibility of omitted variable bias in the estimates of the announcement effect.

Examining the effects of the Federal Reserve’s Term Auction Facility (TAF)⁴, Taylor (2011) finds no evidence that the TAF lowered the LIBOR-OIS spread, with only weak evidence that the TAF reduced other short-term debt spreads. In fact, in some instances, the TAF *increased* spreads. In contrast, McAndrews, Sarkar and Wang (2008) and Wu (2009) document that the TAF did ease market strains. Wu (2009) specifies a step function that equals 0 prior to the TAF being announced, and 1 thereafter, whereas Taylor (2011)’s step function equals 1 only at the time the TAF was announced. Wu’s specification assumes the TAF has a permanent impact on the LIBOR-OIS spread and allows for post-event drift in spreads. However, as Wu does not control for post-TAF announcements, the estimated coefficient on the TAF event is biased. While the smaller event window (1 day) used by Taylor (2011) reduces this bias, it does not allow for any examination of pre- or post-event drift.

Examining unconventional policy initiatives announced by the American, British, EU, and Japanese authorities, Ait-Sahalia, Andritzky, Jobst, Nowak, and Tamirisa (2010) find that announcements of domestic and foreign currency liquidity support were mostly associated with reductions in interbank lending spreads, while fiscal policy announcements had negligible effects. The authors also find that announcements of ad hoc bank bailouts had by far the largest impact, but not in a positive way; bailouts *aggravated* distress in interbank markets, with the negative response spilling over geographic borders. In contrast, systematic financial restructuring measures were more likely to be associated with a reduction in interbank risk premia. Furthermore, liability guarantee announcements had mixed effects, reducing interbank spreads during the subprime crisis, but widening spreads after the crisis deepened. Announcements of asset purchases (e.g. the TARP) were ineffective throughout the crisis, due to problems faced in implementing these measures.

⁴In order to remove the stigma associated with discount window borrowing, the TAF was introduced in December 2007 to allow depository institutions to borrow from the Federal Reserve without needing to disclose this to the market. The TAF was designed to mimic the tenders conducted by the European Central Bank.

In terms of other policies introduced during the crisis, Fleming, Hrung and Keane (2009) find that the Term Securities Lending Facility (TSLF)⁵ offset some of the spike in short-term funding spreads at the time, partly associated with the failure of Bear Stearns. Adrian, Burke and McAndrews (2009) show that the Primary Dealer Credit Facility (PDCF)⁶, introduced shortly after the TSLF, lowered credit default swap premia on dealers' and banks' senior bonds.

My paper's contribution to the literature is to include other Federal Reserve policy initiatives during the crisis using Kroszner and Melick (2010)'s organising framework (see Table 1), as well as an assessment of the impact of various fiscal policy initiatives. Focusing on the effect of a broad range of monetary and fiscal policy initiatives, aggregated categorically, rather than one particular policy, has three advantages. Firstly, it facilitates a comparison of the effectiveness of the various policy categories; secondly, it allows for a comparison of different fiscal and monetary policies; and thirdly, it minimises the potential for 'omitted policy bias' in the models' coefficients, which can arise in studies of single events, when other events are erroneously included with the given event.

This last point is particularly pertinent when undertaking research on the corporate bond market: in contrast to the equity market, corporate bond market price data are typically available at a daily frequency, while the various policies were typically announced close together – in some instances, in conjunction.⁷

4 Data

4.1 Financial market data

Data on the pricing of U.S. corporate bonds are from Thomson Reuters Datastream (and constructed by Bank of America Merrill Lynch). The data are available for six types of corporate bonds: (i) AAA- and AA-rated "vanilla" (i.e. non-asset-backed) bonds; (ii) A- and BBB-rated vanilla bonds; (iii) AAA- and AA-rated

⁵The TSLF, introduced on March 11, 2008, allowed primary dealers to borrow Treasury securities from the Federal Reserve, for 28 days, secured by a range of private securities. The TSLF was designed to limit the runs in the repo markets for private collateral, by allowing dealers to pledge Treasury securities as collateral in repos, making it easier for them to continue obtaining cash through repos.

⁶The PDCF effectively gave primary dealers discount window access, allowing them to borrow from the Federal Reserve at the primary credit rate. The fact that primary dealers could obtain funding at the same terms as depository institutions generated a large amount of controversy among market participants and in the media.

⁷For example, the Term Asset-Backed Securities Loan Facility (TALF) was announced on the same day, November 25, 2008, as the decision to start purchasing agency-guaranteed mortgage backed securities, and the decision to purchase agency-issued debt. Kroszner and Melick (2010)'s organisational framework can be used to estimate the separate effects of these policies.

asset backed securities, backed by automotive loans; (iv) AAA- and AA-rated asset backed securities, backed by credit cards; (v) AAA-rated mortgage backed securities (MBS); and (vi) A-rated MBS.

Figure 3 shows the evolution of the spreads on these six bond types between January 2006 and December 2009. Spreads on all bonds spiked noticeably in September 2008, following the failure of Lehman Brothers and AIG, and runs on money market mutual funds. Other notable events during this period included the uncertainty about whether the U.S. government had the capability to manage the crisis (Mishkin, 2011).⁸ Spreads remained elevated until March 2009, and then reversed much of their earlier rise as financial markets stabilised during 2009.

In this paper, I consider one form of secured funding, sale and repurchase agreements (“repos”), and one form of unsecured funding, U.S. interbank loans. I use 1-month repo-OIS spreads to measure the cost of secured funding, and the spread between the 1-month London Interbank Offer Rate (LIBOR) and the 1-month OIS rate to measure the cost of unsecured funding.

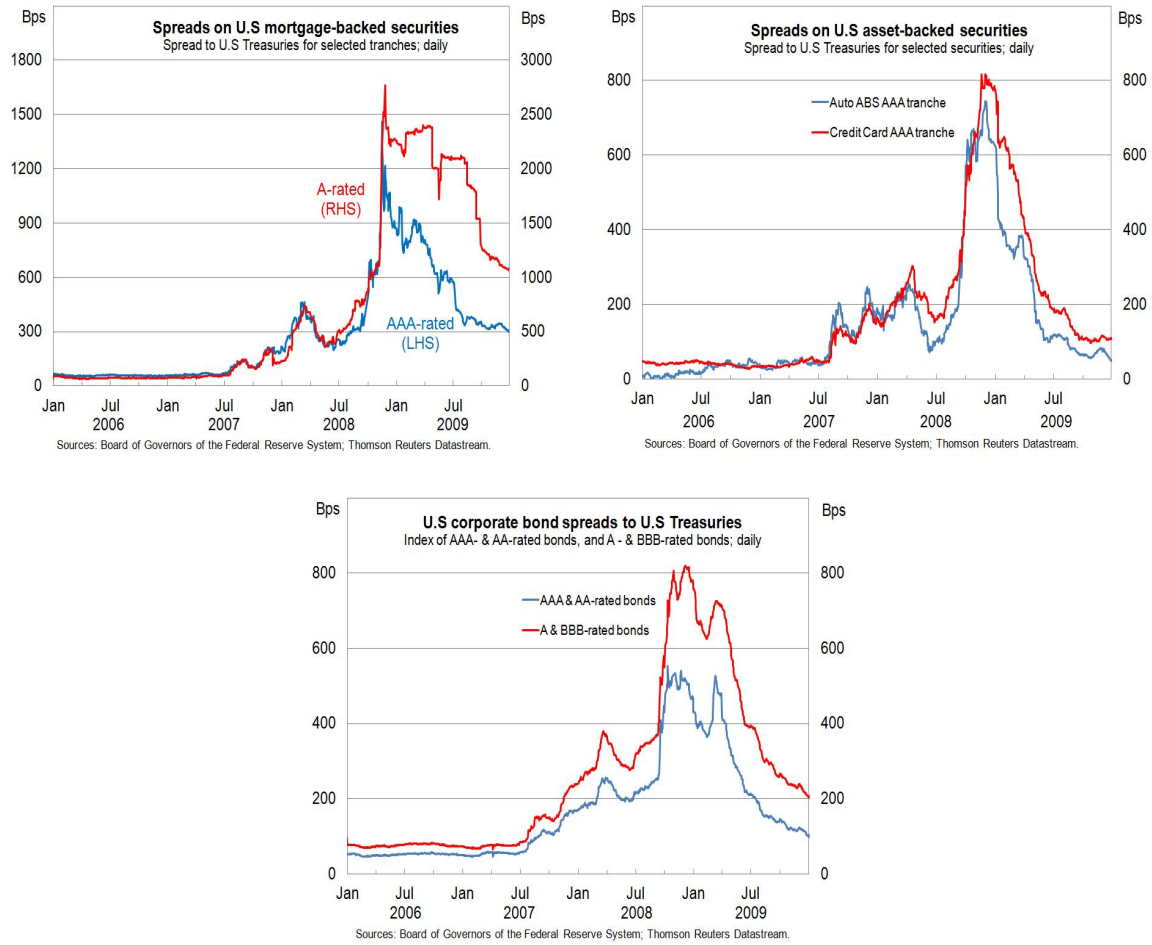
Since Bagehot’s dictum requires that LOLR facilities be targeted at illiquid-but-solvent institutions, one could argue that the efficacy of LOLR policies should be evaluated on the basis of whether it reduced illiquidity (rather than credit) premia. However, there are five reasons why this paper (as well as the related literature) does not attempt to decompose spreads into illiquidity and credit components.

Firstly, the methods used to decompose spreads assume that these two components are independent, that the recovery rate is constant (or independent of the default probability), and, most importantly, that the correlation between assets’ credit risks can be precisely estimated. The assumption that liquidity and credit risk are independent has no theoretical foundation, and is made purely for ease of estimation. Coval, Jurek and Stafford (2009) note that the default correlation is the key input into the valuation and credit rating of a tranching security. The sharp drop in valuations and credit ratings of tranching securities during the crisis reflected an increase in the presumed loss correlations, higher default probabilities and lower recovery rates. As the financial crisis made clear, these key inputs were far from independent or constant. Hence, any decomposition reliant on the above assumptions is subject to a large degree of model risk and parameter uncertainty.

Secondly, the decomposition methods typically use the premia on credit default swaps (CDSs) written on the bond to isolate the credit risk component. The difference between the bond’s spread and the credit risk component is defined as the illiquidity component. This method is feasible only for those bond markets

⁸Mishkin (2011) notes that the first version of the Troubled Asset Relief Program (TARP) failed on a bipartisan vote, which raised serious doubts about the government’s crisis management capabilities. The bill was eventually approved by Congress on October 3, though its passage through parliament required numerous “Christmas-tree” provisions.

Figure 3: Spreads on U.S. non-government bonds



with related CDS markets. However, my sample includes bonds for which data on CDS premia are not available, such as the markets for asset-backed securities (ABS) and commercial mortgage-backed securities (CMBS).

Thirdly, Ericsson and Renault (2006) find that liquidity risk comprises the vast bulk of short-term bonds' spreads. As my funding measures are for one month terms, focusing on the entire spread for these instruments is unlikely to bias my econometric results. The above-mentioned limitations of any spread decomposition provides further justification for this treatment.

In addition, a key motivation of bank recapitalisation policies, like the TARP, was to prevent defaults on banks' assets from affecting senior creditors. Hence,

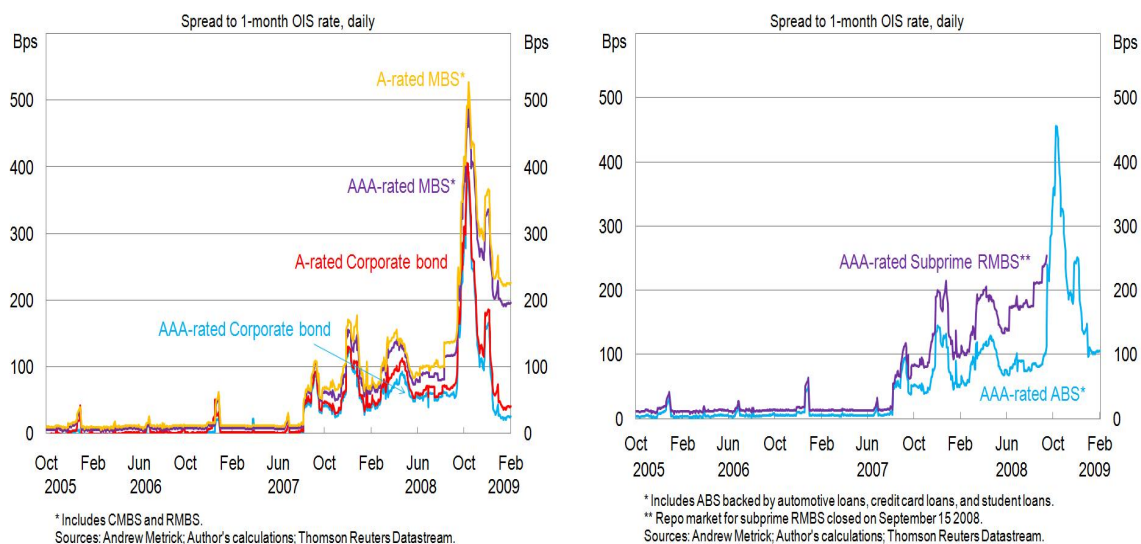
the intention of these policies was to reduce *credit risk*, along with liquidity risk. Moreover, some of the Federal Reserve’s LOLR facilities were aimed at reducing counterparty credit risk, in both secured and unsecured credit markets, by purchasing assets from banks and government-sponsored enterprises.

Finally, and perhaps most importantly, while Bagehot’s dictum has theoretical merit, Goodhart and Huang (1999) argue that a central bank is rarely able, in practice, to make the distinction between insolvent and illiquid-but-solvent institutions, especially in the short time-scale in which a lending decision may have to be made. Furthermore, while there are reputational and direct financial costs to a central bank from lending to a bank later revealed to be insolvent, this may be outweighed by the cost to the financial system if support was not provided and the bank subsequently failed.

Data for 1-month LIBOR and 1-month OIS rates are from Thomson Reuters Datastream. Data for 1-month repo yields are kindly provided by Andrew Metrick, and used in Gorton (2010) and Gorton and Metrick (2011). The data relates to repos between dealer banks, and are daily, from October 3 2005 to February 2 2009 (844 trading days). Figure 4 shows the evolution of repo spreads for the six chosen U.S. corporate bond markets.

Prior to August 2007, spreads across all six types of repo collateral were gen-

Figure 4: **Spreads on 1-month inter-bank repos**



erally stable and low, with the lowest spreads (average of -2 basis points) observed for repos collateralised by AAA-rated corporate bonds (Table 2). However, from

August 2007, repo spreads rose steadily across all collateral types; between August 2007 and February 2009 (when the sample ends), repo spreads were, on average, between 80 and 140 basis points higher than in the preceding period. The largest increase in repo spreads was observed for A-rated MBS (143 basis point increase), a 13-fold increase over the preceding period, with the smallest increase for repos collateralised by AAA-rated and A-rated corporate bonds (80 and 87 basis points, respectively). However, as repos backed by subprime RMBS ceased trading on September 15, 2008, if the above analysis was performed for the August 2007 – September 15, 2008 period, the largest increase in spreads were for repos backed by subprime RMBS (an increase of 126 basis points).

4.2 Measuring the monetary policy stance

As noted in Section 1, I also consider the impact of “conventional” monetary policy on market pricing and liquidity. I define the stance of monetary policy as the difference between the actual effective Federal Funds rate and the effective Federal Funds rate implied by a Taylor rule. Taylor (1993) developed a hypothetical policy rule for the Federal Funds rate, which closely approximated the target Federal Funds rate between the late 1980s and early 1990s. The general version of the rule is:

$$i_t = \pi_t + r_t^* + a_\pi (\pi_t - \pi_t^*) + a_y (y_t - \bar{y}_t) \quad (1)$$

where i_t is the target Federal Funds rate, π_t is the inflation rate, π_t^* is the desired inflation rate, r_t^* is the assumed equilibrium (Wicksellian) real interest rate, y_t is the natural logarithm of the level of real Gross Domestic Product (GDP), and \bar{y}_t is the natural logarithm of potential GDP, at time t . The Taylor rule thus specifies that i_t should respond to the divergence of the actual rate of inflation from the target inflation rate, and also to the divergence of actual real GDP from potential GDP.

The main issues associated with estimating equation (1) are estimating potential GDP, and specifying a target inflation rate. Over my period of analysis, the Federal Reserve did not have an explicit inflation rate target, unlike central banks like the Bank of England and the European Central Bank, specifying the value of π_t^* is not clear-cut. More importantly, estimating \bar{y}_t is not straightforward. The most common practice is the use of statistical filters, such as that proposed by Hodrick and Prescott (1980, 1997) (henceforth, HP). However, the use of an HP filter has been strongly criticised by Cogley and Nason (1993) as the filter can generate spurious cycles in non-cyclical data. Furthermore, equation (1) embodies a contemporaneous (or backward) Taylor rule, which is inconsistent with the forward looking nature in which the Federal Reserve and other central banks set monetary policy. In addition, the GDP series have historically been subject to

more revisions than other series, such as the unemployment rate (Koenig, 2005).

For these reasons, I estimate a forward-looking Taylor rule based on inflation forecasts and an unemployment rate gap. The specification is:

$$i_t = \alpha + \beta \hat{\pi}_t^{t+T} + \delta (u_t - n_t) \quad (2)$$

where $\hat{\pi}_t^{t+T}$ is the expected inflation rate at time $t+T$, with the expectation formed at time t , u_t is the unemployment rate, and n_t is the natural unemployment rate. The unemployment terms appear due to the use of Okun's law in equation (1). This version of the Taylor rule more closely embodies the Federal Reserve's dual objectives of low and stable inflation, and maximum employment. It is possible to obtain (1) from (2) under the assumption that π_t^* and r_t^* are both constant.

Equation (2) is based on the model used in Rudebusch (2010), in that I use the Congressional Budget Office (CBO)'s estimate of the natural unemployment rate.⁹ However, in contrast to Rudebusch (2010), I use inflation expectations not realised inflation. I use two measures of inflation expectations, setting $T = 5$ in equation (2): (i) the Federal Reserve Bank of Cleveland's measure of inflation expectations¹⁰; and (ii) the difference between the yield on a 5-year Treasury bond and the yield on a 5-year Treasury Inflation Protected Security (TIPS).¹¹

I estimate equation (2) between January 2, 2003 and the December 15, 2008, the latter date reflecting the day prior to the commencement of the targeting of the Federal Funds rate within the 0 to 25 basis point range. I use the estimated coefficients to estimate the Taylor-rule implied Federal Funds rate between December 17, 2008 and December 31, 2009. Figure 5 reveals the actual and Taylor-rule implied effective Federal Funds rates, based on the Federal Reserve Bank of Cleveland's measure of inflation expectations, while Appendix A contains the corresponding graphs using the 5-year Treasury bonds-TIPS spread. The profile of the series are broadly the same under both measures.

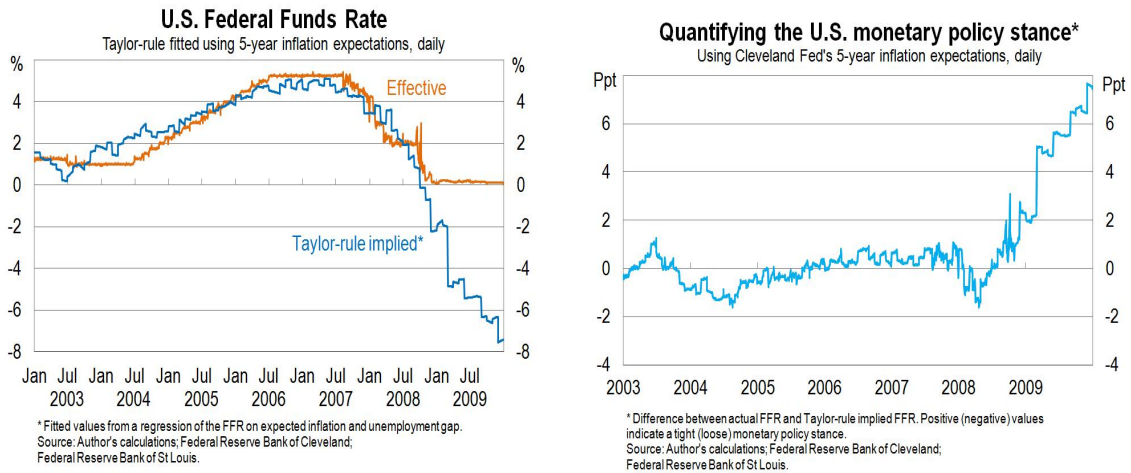
The Taylor rule closely approximated the actual effective Federal Funds rate between January 2003 and November 2008 (the \bar{R}^2 is 0.87), but the approximation error became increasingly large once the zero lower bound began to be a binding constraint (left panel, Figure 5). The Taylor rule implied rate continued to decline during 2009, reflecting a decrease in inflation expectations and a rise in the gap

⁹The data are obtained from the Federal Reserve Bank of St Louis.

¹⁰Inflation expectations are derived from an affine model, driven by state variables including the short-term real interest rate, expected inflation, and volatility factors that follow GARCH processes. The parameters are estimated using data on inflation swap rates, nominal yields and survey forecasts of inflation, in contrast to much of the existing literature which tends to use only the latter two variables. For more details, see Haubrich, Pennacchi, and Ritchken (2011).

¹¹In order to test the sensitivity of the results, I set $T = 1$ and $T = 10$ in (2), for both measures of inflation expectations. While the coefficient estimates of (2) differ for each of the chosen maturities, the Taylor rule estimates of i_t are broadly unchanged.

Figure 5: U.S. Federal Funds rate



between the actual and natural unemployment rate, reaching a low of -7.5 per cent during November 2009. The binding zero constraint on the Federal Funds rate meant that monetary policy became increasingly contractionary from July 2008, reaching a high of 7.5 per cent in late 2008 (right panel, Figure 5).

The consensus in macroeconomics, as embodied in Mishkin (2009), is that monetary policy retains its potency and ability to achieve a central bank's macroeconomic objectives even at the zero bound. I use these arguments as justification for defining the stance of U.S. monetary policy as the difference between the actual and Taylor-rule implied Federal Funds rate.

Once the Federal Funds rate hit the zero lower bound, the Federal Reserve engaged in various “unconventional” policy measures to try to fulfil its dual mandate. If these policies had been successful in achieving the Federal Reserve's dual mandate, the Taylor-rule implied Federal Funds rate would have been much higher. It is likely that this counterfactual value would have exceeded zero; I estimate that the effective Federal Funds rate consistent with a zero unemployment gap would have been, on average, 3.57 per cent between December 2008 and December 2009, with a corresponding expected average inflation rate of 2.33 per cent.¹² The counterfactual Federal Funds rate would have been consistent with the Federal Reserve's dual mandate.

¹²The counterfactual expected inflation rate is estimated from a regression of the unemployment gap on the expected 5-year inflation rate (from Haubrich et al., 2011), setting the unemployment gap to zero. I use this counterfactual inflation rate in equation (2) to estimate the counterfactual Federal Funds rate.

Hence, Figure 5 reveals that the Federal Reserve’s unconventional policies failed to achieve their dual mandate. Focusing solely on the level of the effective Federal Funds rate obscures this finding, and may lead to “the fallacy of identifying tight money with high interest rates and easy money with low interest rates” (Friedman, 1998).

5 Empirical methodology

To examine the relationship between bond spreads and conventional and “unconventional” monetary policy, I use a first-order Vector Autoregression (VAR):

$$\mathbf{X}_t = \alpha + \beta \mathbf{X}_{t-1} + \Theta D_t^{Fiscal} + \Gamma \mathbf{D}_t^{Unconv} + \eta Stance_t + \epsilon_t \quad (3)$$

where \mathbf{X}_t is a 3x1 vector containing bond spreads, 1-month repo-OIS spreads, and 1-month LIBOR-OIS spreads, \mathbf{D}_t^{Unconv} is a 1x3 vector of dummy variables for each of the three types of “unconventional” monetary policies. Each element of \mathbf{D}_t^{Unconv} equals 1 if a policy from the respective category was announced on day t , $t - 1$, or $t + 1$; or zero. D_t^{Fiscal} is a scalar dummy variable equal to 1 if a fiscal policy announcement was made on day t , $t - 1$, or $t + 1$; or zero. The specifications for \mathbf{D}_t^{Unconv} and D_t^{Fiscal} reflects the use of a 3 day interval around an event, to allow for pre- and post-event drift.

The use of a VAR reflects the fact that the three spread variables Granger cause each other (see Appendix B). For the AR terms, a one day lag is chosen on the basis of the Akaike and Schwartz-Bayesian information criterion, as well as a desire for parsimony.

The various LOLR facilities introduced by the Federal Reserve were typically aimed at alleviating strains in short-term funding markets, reflecting these markets’ greater susceptibility to investor runs, compared to longer-term funding markets. Hence, I include the cost of short-term funding in the VAR. These policies were also aimed at limiting fire-sales of assets, like corporate bonds, in response to liquidity problems in the secured and unsecured markets. Consequently, the VAR also includes spreads on corporate bonds.

The inclusion of conditioning variables – lagged values of the dependent variables, the monetary policy stance and various policy dummy variables – means that I focus on the surprise component of the separate policy announcements. This treatment is similar to that used by Aït-Sahalia, Andritzky, Jobst, Nowak, and Tamirisa (2010), who focus on the 3-month LIBOR-OIS spread and use a pure random walk model to extract the residual return. In contrast, I use a larger set of conditioning variables, since I focus on three key market spreads, and specify a stationary model, since there is no theoretical basis for a unit root in market spreads.

During the crisis, some unconventional policies involved the Federal Reserve purchasing risky assets. For example, on November 25, 2008, the Federal Reserve announced it would purchase MBS guaranteed by housing-related U.S. government sponsored enterprises (GSEs)¹³, and purchase the senior debt of these GSEs. These policies blurred the distinction between monetary and fiscal policy, since traditional monetary policy has revolved around investments in (risk-free) U.S. Treasury securities. In order to control for the effect of fiscal policy on market spreads, I include the dates of key fiscal policy announcements, which are identified below.

$Stance_t$ is defined as the difference between the effective and Taylor-rule implied Federal Funds rates (see Figure 5), and is measured using 5-year inflation expectations from Haubrich, Pennacchi and Ritchken (2011). α , β , Γ , Θ , and η are parameters to be estimated, while ϵ_t is a 3x1 vector of residuals, on day t .

The announcement dates for the various “unconventional” monetary policies are from Kroszner and Melick (2010) (see Table 1). To this, I add two dates associated with announcements of extensions to these policies, from Federal Reserve Bank of St. Louis (2011):

- December 2, 2008: extension of three key LOLR facilities (PDCF, AMLF¹⁴, and TSLF) through to April 30, 2009;
- February 3 2009: extension, to October 30, 2009, of those liquidity facilities scheduled to expire on April 30, 2009;

The dates of fiscal policy announcements are from Federal Reserve Bank of St. Louis (2011). The dates are: (i) September 19, 2008; (ii) September 29, 2008; (iii) October 3, 2008; (iv) October 14, 2008; and (v) November 12, 2008. The events relating to these dates are detailed in Appendix C.

These dates correspond to events that may have had both stabilising and destabilising effects on spreads. Mishkin (2011) argues that the initial rejection of the Troubled Asset Relief Program (TARP) bill (on September 23, 2008), its subsequent delay in finally being passed, and the various “Christmas-tree” provisions that were included in the bill in order for it to pass through both houses of Congress, were all events that aggravated market spreads. Taylor (2011) argues that the lack of detail in the original TARP bill (a total of $2\frac{1}{2}$ pages, with no

¹³The Federal National Mortgage Association (‘Fannie Mae’), Federal Home Loan Mortgage Corporation (‘Freddie Mac’), and the Federal Home Loan Banks.

¹⁴The Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility was announced on September 19, 2008 under which non-recourse loans were made to banks at the primary credit rate, to finance purchases of ABCP from money market funds (MMFs) at above-market prices. The cash obtained by the MMFs could then be used to meet redemption requests, thereby increasing their willingness to continue providing short-term secured funding, primarily via repos, to banks.

mention of oversight and few restrictions on the use of funds) created significant uncertainty about the TARP's stated aims and likely effects, which destabilised market spreads. On the other hand, Aït-Sahalia, Andritzky, Jobst, Nowak, and Tamirisa (2010), find that announcements of systematic bank recapitalisation policies, such as the eventual passage of the TARP bill on October 3, 2008, had a stabilising influence on interbank loan spreads. My inclusion of all dates related to the TARP announcements is designed to estimate the average impact of the TARP on market spreads.

The various fiscal and monetary policies were motivated on the basis of returning markets to “normal” functioning, with a desired reduction in both the level and volatility of spreads. I follow Frank and Hesse (2009) and estimate a multivariate (tri-variate) 1st-order GARCH model of the following form:

$$\mathbf{H}_t = \mathbf{C}\mathbf{C}' + \mathbf{A}\epsilon_{t-1}\epsilon'_{t-1}\mathbf{A}' + \mathbf{B}\mathbf{H}_{t-1}\mathbf{B}' + \mathbf{E}D_t^{Fiscal} + \mathbf{F}D_t^{Unconv} + \mathbf{G}Stance_t \quad (4)$$

where \mathbf{H}_t is the 3x3 covariance matrix of the VAR model's residuals at time t , ϵ_{t-1} is a 3x1 matrix of the VAR residuals (at time $t - 1$), and \mathbf{A} , \mathbf{B} , \mathbf{C} , \mathbf{E} , \mathbf{F} , and \mathbf{G} are parameter matrices to be estimated. D_t^{Unconv} , D_t^{Fiscal} , and $Stance_t$ are the same as in equation (3).

Equation (4) is the popular BEKK GARCH (1,1) model, developed by Engle and Kroner (1995), augmented with the policy variables as exogenous regressors. Even without including the parameters on the policy variables, a drawback of the BEKK model is the large number of parameters (24) that need to be estimated.¹⁵ However, its advantage, over other multivariate GARCH models, is that it ensures \mathbf{H}_t is positive definite.¹⁶ In order to avoid overfitting, I test whether the full BEKK model can be reduced to a ‘diagonal’ BEKK model, in which \mathbf{A} and \mathbf{B} are both diagonal, such that $\sigma_{jk,t} := Cov_{t-1}(\epsilon_{j,t}, \epsilon_{k,t})$ depends only on $\sigma_{jk,t-1}$ and $\epsilon_{j,t-1}, \epsilon_{k,t-1}$.

In addition to the guarantee of \mathbf{H}_t being positive definite, I choose the BEKK model in order to compare my results with Frank and Hesse (2009). While the choice of VAR and GARCH models are the same as Frank and Hesse (2009), I consider the contemporaneous impact of the policies on the level and volatility of spreads, while Frank and Hesse allow for 1- and 2-day lagged effects. However, Frank and Hesse (2009) provide no justification for why lagged effects might be more important than contemporaneous effects.

One possible justification might be that, to the extent that these policies were deemed “unconventional” or non-traditional, it might have taken some time for market participants to assess the policies' impact on spreads and volatility. A

¹⁵Excluding the policy variables, equation (4) requires estimating $(p + q)N^2 + N(N + 1)\frac{1}{2}$ parameters, where p and q are the number of lags of $\epsilon\epsilon'$ and \mathbf{H} , respectively, and N is the number of dependent variables. Here, $N = 3$ and $p = q = 1$.

¹⁶Bauwens, Laurent and Rombouts (2006), and Silvennoinen and Teräsvirta (2008) survey the extensive literature on multivariate GARCH models.

counterargument is that these policies, when viewed through the framework of Kroszner and Melick (2010), complemented the Federal Reserve’s traditional open market operations (OMOs), and so may not have been deemed unconventional. As OMOs have a contemporaneous effect on market prices, a rational expectation of the impact on the “unconventional” policies would consider only contemporaneous effects. Hence, a lagged effects formulation appears inconsistent with rational expectations. Moreover, it also assumes (implicitly) that markets are informationally inefficient.

In contrast to Frank and Hesse (2009), my construction of \mathbf{D}^{Unconv} and \mathbf{D}^{Fiscal} allows for both lagged and contemporaneous (and leading) effects, as I consider the 3-day window around each type of fiscal and “unconventional” monetary policy announcement. The results of this VAR(1)-GARCH(1,1) model are discussed in Section 6.

6 Non state-dependent VARs

6.1 All corporate bonds

Table 2 contains the parameter estimates from equation (3), with three important findings. Firstly, Federal Reserve policy announcements had modest impacts on spreads, with statistically significant (at the 5% level) announcement effects observed only for LIBOR-OIS spreads. For LIBOR-OIS spreads, Federal Reserve policies that broadened the eligibility of collateral (D^{Collat}) and the type of counterparties (D^{Cpart}) were more effective in reducing spreads, than policies that increased the maturity of support (D^{Mat}). However, the economic significance was modest, with spreads falling only around one basis point on each of the three days around each announcement (i.e. the cumulative effect is a 3-4 basis point decline in spreads).

Secondly, fiscal policy announcements were found to have an insignificant effect on bond spreads, but significant – though *destabilising* – announcement effects on repo and LIBOR-OIS spreads. In response to fiscal policy announcements, repo spreads and LIBOR-OIS spreads rose by around 40 basis points and 7 basis points, respectively, over the 3-day event window. This finding is consistent with Taylor (2011).

Finally, the monetary policy stance is found to have adversely affected credit spreads: a one-standard-deviation rise in *Stance* (a 92 basis point tightening of monetary policy) increased bond and interbank loan spreads by around 3 basis points, and repo spreads by 1 basis point. In contrast, a similar rise in D^{Collat} lowered repo spreads by a total of 1 basis point over the 3-day event window. These results suggest that the efficacy of the Federal Reserve’s unconventional policies

Table 2: VAR parameter estimates – all bonds

This table reports the parameter estimates from equation (3), with multivariate GARCH(1,1) corrected z-statistics in brackets. The multivariate GARCH model is equation (4). *LIB-OIS* is the spread between the 1-month LIBOR and the 1-month OIS rate, *Repo* is the 1-month repo-OIS spread, and *Bond* is the spread between duration-matched U.S. corporate bonds and U.S. Treasuries. D^{Fiscal} is a dummy variable that equals 1 when a fiscal policy announcement is made (or one day preceding or proceeding the announcement), while D^{Mat} , D^{Cpart} and D^{Collat} are dummy variables relating to a 3-day window around Federal Reserve policies to, respectively: lengthen the maturity of open market operations, expand the type of counterparties, and broaden the type of collateral eligible for secured lending. Finally, *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	<i>LIB-OIS</i> (-1)	<i>Repo</i> (-1)	<i>Bond</i> (-1)	D^{Fiscal}	D^{Mat}	D^{Cpart}	D^{Collat}	<i>Stance</i>	adj. R ²
<i>LIB-OIS</i>	0.953 [19.1]	0.001 [11.1]	0.001 [5.32]	0.023 [2.19]	-0.005 [-1.55]	-0.011 [-2.04]	-0.015 [-2.19]	0.047 [2.21]	0.98
<i>Repo</i>	0.018 [4.15]	0.972 [8.02]	0.004 [4.23]	0.135 [7.54]	-0.003 [-1.13]	-0.019 [-3.15]	0.008 [0.99]	0.007 [2.62]	0.98
<i>Sprd</i>	0.051 [0.52]	0.026 [0.11]	0.971 [8.21]	0.006 [0.14]	-0.040 [-0.89]	0.069 [0.25]	0.083 [1.31]	0.037 [2.16]	0.98

was reduced by the contractionary stance of conventional policy. Although the Federal Reserve’s unconventional policies were seemingly impressive in terms of its breadth, these policies were insufficient to ensure that the central bank satisfied its macroeconomic objectives, and thus exacerbated market strains.

Likelihood ratio tests suggest that the full BEKK model is more appropriate than a diagonal BEKK model. For the sake of brevity, I report only the parameter coefficients and Bollerslev-Wooldridge robust z-statistics corresponding to the policy variables in equation (4) with the full output available upon request.¹⁷

Collectively, the results reveal that the policy announcements had a weak impact on market volatility (Table 3). Announcements of policies that extended the counterparties to Federal Reserve support had a statistically significant (at the 1% level) negative effect on the conditional variance of LIB-OIS and repo spreads, but no significant impact on the conditional variances of bond spreads. Fiscal policy announcements had a *destabilising* impact on the conditional variance of repo spreads, similar to the evidence in Table 2, but no impact on other conditional variances. Fiscal policy announcements were associated with a 60 per cent (13 basis point) rise in the conditional volatility of repo spreads, an economically and statistically significant (at the 1% level) result.

Notably, a tightening in monetary policy (i.e. a rise in the value of *Stance*) led to a rise in both $\sigma_{LIB-OIS}^2$ and σ_{Repo}^2 , with these effects statistically significant at the 1% level. A one-standard-deviation positive shock to *Stance* raised the condi-

¹⁷Bollerslev and Wooldridge (1992) provide an adjustment to the covariance matrix which ensures that QML estimators of the parameters in equation (4) remain consistent and asymptotically normally distributed even when the residual conditional distribution is non-Gaussian.

Table 3: BEKK multivariate GARCH model estimates – all bonds

This table reports selected parameter estimates from equation (4), with Bollerslev-Wooldridge adjusted z-statistics in brackets. $\sigma_{LIB-OIS}^2$, σ_{Repo}^2 , and σ_{Bond}^2 is the conditional variance of residuals from equation (3) for, respectively, *LIB-OIS*, *Repo* and *Bond*. D^{Fiscal} is a dummy variable that equals 1 when a fiscal policy announcement is made (or one day preceding or proceeding the announcement), while D^{Mat} , D^{Cpart} and D^{Collat} are dummy variables relating to a 3-day window around Federal Reserve policies to, respectively: lengthen the maturity of open market operations, expand the type of counterparties, and broaden the type of collateral eligible for secured lending. Finally, *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	D^{Fiscal}	D^{Mat}	D^{Cpart}	D^{Collat}	<i>Stance</i>
$\sigma_{LIB-OIS}^2$	-0.002 [-0.64]	0.000 [1.59]	-0.006 [-4.82]	-0.001 [-2.20]	0.001 [5.54]
σ_{Repo}^2	0.017 [2.78]	-0.019 [-0.16]	-0.036 [-3.72]	0.000 [0.38]	0.001 [4.05]
σ_{Sprd}^2	0.081 [0.05]	0.034 [0.10]	-0.049 [-0.18]	-0.088 [-0.27]	-0.12 [-0.05]

tional variance of LIBOR-OIS and repo spreads by 3 basis points (7 per cent and 3 per cent, respectively). These findings are similar to those in Table 2.

6.2 Individual bond segments

The discussion in the previous subsection was based on the impact of policy initiatives on all six bond markets. However, it is possible that the impact of these initiatives differs across the various bond markets, since certain policies (such as the Term Asset-Backed Loan Facility) were targeted at specific bonds (such as asset-backed securities, or ABS), and so these policies may have had a greater impact on alleviating strains in these markets. The targeting of the ABS market reflected the fact that securitisation markets experienced greater stresses than vanilla bond markets, due to investors' loss of confidence in the valuation and ratings methodology of these securities, and the subsequent rise in 'model risk' (Coval, Jurek and Stafford, 2009).

To examine potential bond-specific heterogeneity, I group all ABS into one category (labeled 'All ABS') and all non-ABS into another ('Non-ABS'). The aggregation of all types of ABS reflects the fact that even for those Federal Reserve policies (like the TALF) which targeted securitisation markets, a wide range of ABS were eligible for support. I estimate equation (3) for each of these two categories, reporting the results in Table 4.

Table 4 reveals some evidence of bond-specific heterogeneity. While fiscal policy announcements have a destabilising affect on ABS spreads and ABS repo spreads, these policy announcements do not affect vanilla bond spreads. In addition, while all types of unconventional monetary policy announcements are insignif-

Table 4: VAR parameter estimates – bond categories

This table reports the parameter estimates from equation (3), with multivariate GARCH(1,1) corrected z-statistics in brackets. The multivariate GARCH model is equation (4). *LIB-OIS* is the spread between the 1-month LIBOR and the 1-month OIS rate, *Repo* is the 1-month repo-OIS spread, and *Bond* is the spread between duration-matched U.S. corporate bonds and U.S. Treasuries. D^{Fiscal} is a dummy variable that equals 1 when a fiscal policy announcement is made (or one day preceding or proceeding the announcement), while D^{Mat} , D^{Cpart} and D^{Collat} are dummy variables relating to a 3-day window around Federal Reserve policies to, respectively: lengthen the maturity of open market operations, expand the type of counterparties, and broaden the type of collateral eligible for secured lending. Finally, *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). Panels A and B report the results for all asset-backed bonds and non-asset-backed bonds, respectively. The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	<i>LIB-OIS</i> (-1)	<i>Repo</i> (-1)	<i>Bond</i> (-1)	D^{Fiscal}	D^{Mat}	D^{Cpart}	D^{Collat}	<i>Stance</i>
Panel A: All asset-backed bonds								
<i>LIB-OIS</i>	0.991 [10.5]	0.003 [3.48]	0.000 [1.69]	0.015 [6.36]	-0.001 [-1.55]	-0.011 [-7.40]	-0.002 [-5.55]	0.005 [2.32]
<i>Repo</i>	0.005 [0.19]	0.956 [51.6]	0.002 [4.41]	0.250 [15.6]	-0.004 [-1.12]	-0.062 [-6.54]	-0.003 [-0.96]	0.007 [1.97]
<i>Sprd</i>	0.028 [1.15]	-0.011 [-0.97]	0.994 [36.9]	0.207 [4.39]	0.074 [0.83]	0.138 [0.53]	0.158 [1.07]	0.022 [4.67]
Panel B: All non-asset-backed bonds								
<i>LIB-OIS</i>	0.945 [32.7]	0.008 [0.34]	-0.007 [-3.10]	0.137 [4.09]	-0.027 [-3.16]	-0.027 [-2.85]	0.004 [1.09]	0.009 [3.54]
<i>Repo</i>	-0.002 [0.57]	0.974 [31.1]	-0.002 [-1.02]	0.200 [5.16]	-0.018 [-1.54]	-0.022 [-1.81]	-0.036 [-1.92]	0.008 [2.81]
<i>Sprd</i>	-0.041 [-1.86]	0.127 [2.41]	0.983 [18.8]	-0.011 [-0.31]	-0.016 [-0.81]	0.037 [1.29]	0.020 [0.33]	0.008 [2.10]

icant for bond spreads, there are differences in announcement effects for repo-OIS spreads. Policies that expanded the type of counterparties have highly statistically significant (at the 1% level) announcement effects for spreads on ABS repos, with spreads declining by one-seventh (18 basis points) over the 3-day window (Panel A). These announcement effects are double in size of those for spreads on non-ABS repos, which decline by 7 per cent (6 basis points), and are also less statistically significant (Panel B).

The monetary policy stance remains a statistically significant influence on the spreads of both bond categories, though the economic significance remains modest. A 100 basis point tightening in monetary policy raises spreads on ABS and repos collateralised by ABS by 1-2 basis points, about the same as the increase in non-ABS spreads. In summary, the evidence in Table 4 suggests that while there is some evidence of bond-specific heterogeneity, reflecting the fact that some unconventional monetary policies were targeted at idiosyncratic segments of the bond market, these policies' effects were felt across the broader bond market.

It is also worth noting that equation (4) was estimated separately for all ABS, and all non-ABS. Similar to Table 4, I found little evidence of bond-specific heterogeneity in the significance of the policy variables, with the results omitted for the sake of brevity, though these results are available on request.

7 State-dependent VAR

While the categorical analysis used above helps to make the model fairly parsimonious, it assumes that individual policies within each category had the same effect on market spreads. It also assumes that the 3-day event window is appropriate for each policy announcement; that is, it assumes that each policy had, at most, only one day of pre- or post-event ‘drift’. These assumptions may not be realistic as some policies may have been anticipated by the market more than one day prior to the announcement, while some other policies may have taken longer to affect spreads. For example, announcements of new programs, as opposed to extensions of existing programs, may have been considered ‘untested’ by market participants, which may have both reduced the announcement-day effect and increased the post-event drift, as agents considered the pricing implications of these policies. In contrast, announcements of program extensions may not have had a drawn out effect on spreads, as these announcements, while possibly being ‘news’, were not novel.

To perform this “policy-specific” analysis, I estimate a Markov Switching VAR (MSVAR) model. For the sake of simplicity, I use a model in which two possible regimes exist, with fixed transition probabilities. The Markov-switching model differs from models with imposed breaks in that the timing of breaks is entirely endogenous. Indeed, breaks are not explicitly imposed, but inferences are drawn on the basis of probabilistic estimates of the most likely state prevailing at each point in time.¹⁸

Incorporating regime shifts in the VAR model leads to the state-contingent version of equation (3):

$$\mathbf{X}_t = \alpha(s_t) + \beta(s_t) \mathbf{X}_{t-1} + \eta \text{Stance}_t + \epsilon(s_t) \quad (5)$$

where $\epsilon(s_t) \sim NIID(0, \Sigma(s_t))$, and $\alpha(s_t)$, $\beta(s_t)$, and $\Sigma(s_t)$ are parameter shift functions describing the dependence of the parameters α , β , λ , η , and Σ on the existing regime, s_t . s_t denotes a latent state variable, which follows a continuous time Markov-chain with two different regimes ($s_t \in \{0, 1\}$) and transition probabilities:

$$P = \begin{bmatrix} p_{00} & 1 - p_{00} \\ 1 - p_{11} & p_{11} \end{bmatrix}.$$

To make the model fairly parsimonious, equation (5) is estimated allowing for regime shifts only in α (the intercept vector) and the conditional covariance matrix

¹⁸Technical details regarding Markov switching models can be found in Hamilton (1994). A BDS test of the various VAR models’ residuals rejects the null (at the 1% level) that a linear specification is appropriate, providing further justification for examining nonlinear models. In addition, Andrews (1993) test for regime change strongly rejects the null of no structural break in the estimated parameter coefficients.

of $\epsilon(\mathbf{H}_t)$. In the interests of parsimony, I confine my estimations to the MSVAR model, and do not estimate a Markov switching version of equation (4).¹⁹ The output is contained in Table 5.²⁰

The output reveals a strong presence of two regimes, one in which the inter-

Table 5: MSVAR parameter estimates – all bonds

This table reports the quasi-maximum likelihood parameter estimates of the intercept terms (denoted by α) from equation (5), with robust t-statistics in brackets. *LIB-OIS* is the spread between the 1-month LIBOR and the 1-month OIS rate, *Repo* is the 1-month repo-OIS spread, and *Bond* is the spread between duration-matched U.S. corporate bonds and U.S. Treasuries. The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Parameter	<i>LIB-OIS</i>		<i>Repo</i>		<i>Bond</i>	
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
α	-0.143 [-1.25]	0.564 [2.89]	-0.197 [-1.69]	0.723 [3.57]	-0.242 [-1.90]	2.811 [3.11]

cept terms are statistically insignificant (at the 5% level), and another regime in which the intercept terms are statistically significant (at the 1% level). I dub the former regime a ‘lower spread’ regime, reflecting the lower unconditional spreads in this regime, relative to the latter, ‘higher spread’ regime.

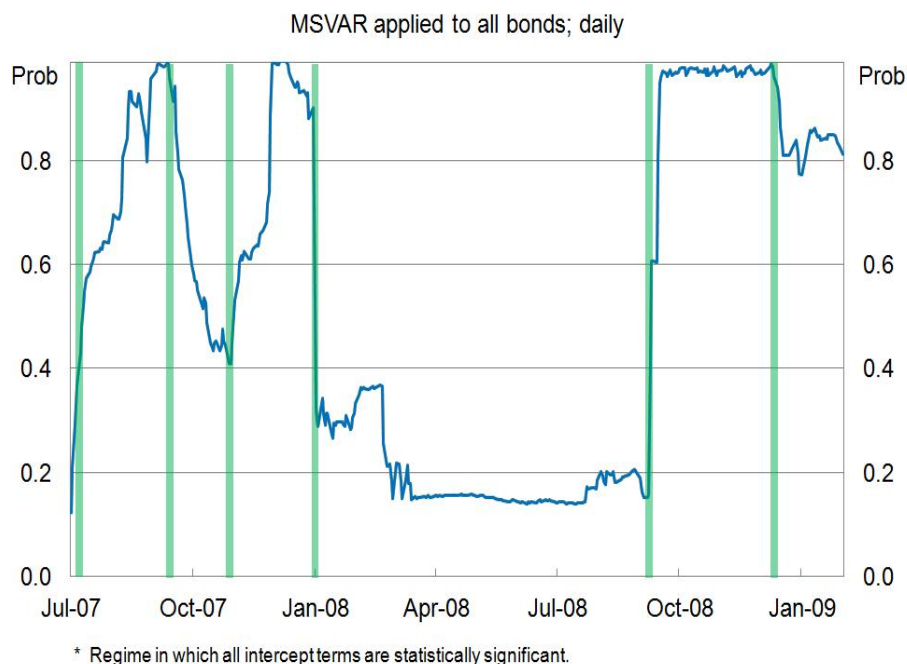
In order to assess the effectiveness of the various fiscal and monetary policies, I calculate the unconditional probability of being in the higher spread regime on each day, p^{illiq} , and then examine whether there were any fiscal or monetary policies announcements associated with key turning points in p^{illiq} . The unconditional probability arising from estimating equation (5) for all six corporate bond types are shown in Figure 6, with the key turning points shaded.

p^{illiq} rose sharply between July and September 2007, and then fell between late September and October 2007, before again rising sharply in November 2007. p^{illiq} fell significantly in 2008 and stabilised at low levels (around 0.2) during most of 2008, until a dramatic spike in September 2008. Following this, it remained at elevated levels close to 1.0 for the next three months, and then fell slightly during end 2008 and early 2009. The six shaded areas correspond to the following periods: (i) early July 2007; (ii) mid September 2007; (iii) late October 2007; (iv) early January 2007; (v) early September 2008; and (vi) December 2008.

¹⁹Allowing for regime shifts in only the intercept terms and the residual covariance matrix reduces the number of parameters to be estimated from 52 to 34. The MSVAR is estimated using Perlin (2011)’s algorithm. I estimate the standard errors using the ‘sandwich’ estimator (i.e. the outer products of the gradient vectors) which is robust to a failure of the assumption that the residuals are conditionally normally distributed.

²⁰The sup-Wald tests of Andrews (1993) reveal that the differences between the parameters for each regime are statistically significant. Since the regime switching parameters are unidentified under the null hypothesis of no switching, traditional Wald tests can not be used to test the statistical significance of parameter differences.

Figure 6: Unconditional probability of being in “higher spread” regime*



July - September 2007

There were no fiscal or unconventional monetary policy announcements associated with the movements in p^{illiq} between July and September 2007 (Table 1; Appendix C). Instead, the fall in p^{illiq} between late September and October 2007 likely reflected the use of conventional monetary policy: a reduction in the Federal Funds rate (Figure 1). However, during the second half of 2007, U.S. monetary policy was modestly contractionary; the effective Federal Funds rate was, on average, around 60 basis points higher than the Taylor-rule implied rate, over this period. This contractionary stance may have partly contributed to the rise in p^{illiq} between July and December 2007 (the correlation between *Stance* and p^{illiq} during this period was 0.17).

November 2007 - January 2008

p^{illiq} rose sharply between early November and December 2007, reaching a peak of 1.0 on December 4, before falling slightly from December 12, 2007, with an even larger decline observed in early January 2008. The initial drop in p^{illiq} likely

reflected the announcement, on December 12, 2007, of the Term Auction Facility (TAF) and U.S. dollar swap lines between the Federal Reserve and, respectively, the ECB and Swiss National Bank.²¹ These policies were implemented on December 17 and December 20 (both in 2007), respectively.

These policies had a modest impact on p^{illiq} , which fell slightly over December 2007. The larger decline in p^{illiq} , which occurred in early January 2008, may also have been due to these policies, though this would have required a drawn out response (over ten trading days). McAndrews, Sarkar and Wang (2008) and Wu (2009) document that the bulk of the TAF’s impact on market spreads occurred during the TAF’s operation, rather than upon its announcement, although, as noted in Section 3 these papers do not control for the influence of intervening fiscal and monetary policies.

September 2008

After stabilising at around 0.2 during most of 2008, p^{illiq} spiked sharply in September 2008, following the failure of Lehman Brothers and AIG, and runs on large U.S. money market funds. Mishkin (2011) and Taylor (2011) argue that fiscal policy aggravated, rather than stabilised, market strains during this time, an argument consistent with my empirical analysis (see Tables 2-4). Furthermore, the October 3, 2008 announcement that the TARP bill was passed into law did not appear to lead to a decrease in p^{illiq} , which remained elevated throughout October 2008. In addition, U.S. monetary policy became increasingly contractionary during this period (see Figure 5), another contributor to market instability. The fact that p^{illiq} remained at around 1.0 between September 2008 and early December 2008 suggests that fiscal and “unconventional” monetary policies announced during this time²² were largely ineffective in reducing market strains.

December 2008

p^{illiq} declined from 1.0 to 0.8 between early and mid December 2008. While there were no new fiscal or monetary policies announced at this time, the decline may have reflected the announcement, on December 2, 2008, that three LOLR facilities were being extended to the end of April 2009. The decline in p^{illiq} may also have been due to the implementation of those LOLR programs introduced in November

²¹Under these swap lines, the Federal Reserve sold U.S. dollars to foreign central banks, and bought Euros and Swiss dollars, respectively, at prevailing market exchange rates, with the transactions reversed at a pre-specified time (between one day and three months) in the future.

²²For example, the Federal Reserve announced, in November 2008, plans to purchase RMBS and collateralised debt obligations (CDOs) from AIG; and to purchase RMBS guaranteed by GSEs and GSE-issued debt.

2008. For example, the program of buying GSE-issued debt was implemented from December 5, 2008, and the purchase of RMBS from AIG was implemented from December 12, 2008.

In summary, instances where p^{illiq} fell were typically not associated with fiscal or monetary policy announcements. In fact, falls in p^{illiq} typically occurred during periods in which policies were implemented so that, if the various fiscal and monetary policy initiatives were important in reducing market strains, the effect came after these policies were announced. Furthermore, instances where large errors in fiscal and monetary policy occurred – such as the failures to pass the TARP bill in September 2008, and adhere to optimal monetary policy rules during the second half of 2007 and the final quarter of 2008 – were instances in which p^{illiq} rose sharply.

These findings are consistent with the statistical analysis in Section 6, which found that the efficacy of these LOLR policies was partly undermined by the stance of conventional monetary policy.

8 Implementation effects

The discussion in Sections 6 and 7 focused largely on the announcement effects of the various fiscal and monetary policies. The examination of announcement effects assumes a degree of informational efficiency, in that each of the LOLR programs only affect market spreads upon announcement, with no effect upon each program’s implementation, which may be a restrictive assumption.

There are two reasons for considering ‘implementation effects’. The first concerns the framing of “conventional” monetary policy as the targeting of overnight interbank interest rates on the basis of open market operations in low risk assets. Policies based on longer-term and riskier assets, in an environment of a virtually zero Federal Funds rate, were viewed as “unconventional” since they were outside the traditional paradigm, even though these policies, in essence, augmented the Federal Reserve’s traditional toolkit. Thus, there may have been a large degree of uncertainty about the potential effect of these policies on market spreads, at the time of announcement.

Secondly, there may have been doubts about the Federal Reserve’s credibility in implementing these policies, which also may have muted the policies’ announcement effects. On the one (extreme) hand, if the unconventional policies were deemed completely credible, spreads should have fallen upon announcement of these policies, such that subsequent implementation was not required; the mere fact that these policies were implemented suggests the announcements lacked complete credibility. On the other hand, even without dynamic inconsistency, the perceived “unconventional” nature of these policies may have muted their announcement

effects, such that subsequent implementation was required.

To examine the potential for implementation effects, I use the dates given in Kroszner and Melick (2010) (see Table 1), and augment equations (3) and (4) with 3 dummy variables relating to the three types of unconventional monetary policies. These dummy variables equal 1 on the implementation date of the various policies, and zero otherwise. The VAR(1)-GARCH(1,1) model becomes:

$$\mathbf{X}_t = \alpha + \beta \mathbf{X}_{t-1} + \Theta D_t^{Fiscal} + \Gamma \mathbf{D}_t^{Unconv, Ann} + \eta Stance_t + \mu \mathbf{D}_t^{Unconv, Imp} + \epsilon_t \quad (6)$$

where \mathbf{X}_t , D_t^{Fiscal} , and $Stance_t$ are the same as in equation (3). $\mathbf{D}_t^{Unconv, Ann}$ is a 1x3 vector of dummy variables that equal one when an “unconventional” monetary policy announcement occurs at time t , $t - 1$, or $t + 1$, and zero otherwise. $\mathbf{D}_t^{Unconv, Imp}$ is a 1x3 vector of dummy variables that equal one when one of the three types of unconventional monetary policies are implemented, and zero otherwise. ϵ_t is a 3x1 vector of residuals, with $\epsilon_t | \Sigma_{t-1} \sim N(0, \mathbf{H}_t)$. The conditional covariance matrix \mathbf{H}_t is given by:

$$\begin{aligned} \mathbf{H}_t = & \mathbf{C}\mathbf{C}' + \mathbf{A}\epsilon_{t-1}\epsilon'_{t-1}\mathbf{A}' + \mathbf{B}\mathbf{H}_{t-1}\mathbf{B}' + \mathbf{E}D_t^{Fiscal} + \mathbf{F}\mathbf{D}_t^{Unconv, Ann} \\ & + \mathbf{G}\mathbf{D}_t^{Unconv, Imp} + \mathbf{J}Stance_t \end{aligned} \quad (7)$$

For the sake of brevity, I report only the parameter coefficients corresponding to the policy variables. The results for equations (6) and (7) are given in Table 6 and 7, respectively.

All three categories of “unconventional” monetary policy initiatives had signif-

Table 6: VAR parameter estimates – all bonds

This table reports the parameter estimates from equation (6), with multivariate GARCH(1,1) corrected z-statistics in brackets. The multivariate GARCH model is equation (7). *LIB-OIS* is the spread between the 1-month LIBOR and the 1-month OIS rate, *Repo* is the 1-month repo-OIS spread, and *Bond* is the spread between duration-matched U.S. corporate bonds and U.S. Treasuries. D^{Fisc} is a dummy variable that equals 1 when a fiscal policy announcement is made (or one day preceding or proceeding the announcement), while $D^{Mat, Ann}$, $D^{Cpart, Ann}$ and $D^{Coll, Ann}$ are dummy variables relating to a 3-day window around announcements of the three types of Federal Reserve policies. $D^{Mat, Imp}$, $D^{Cpart, Imp}$ and $D^{Coll, Imp}$ are dummy variables equal to one on days when the respective Federal Reserve policy types are implemented. Finally, *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	D^{Fisc}	$D^{Mat, Ann}$	$D^{Cpart, Ann}$	$D^{Coll, Ann}$	<i>Stance</i>	$D^{Mat, Imp}$	$D^{Cpart, Imp}$	$D^{Coll, Imp}$
<i>LIB-OIS</i>	0.069 [4.62]	0.003 [0.59]	-0.025 [-2.78]	-0.021 [-2.07]	0.033 [2.31]	-0.021 [-4.07]	-0.037 [-4.93]	-0.085 [-5.62]
<i>Repo</i>	0.105 [4.25]	0.003 [0.25]	-0.009 [-0.54]	0.004 [0.24]	0.020 [2.14]	-0.033 [-2.77]	-0.053 [-2.33]	-0.117 [-4.92]
<i>Sprd</i>	0.107 [3.17]	-0.025 [-0.39]	0.068 [0.28]	-0.032 [-1.53]	0.048 [1.96]	0.013 [1.32]	-0.207 [-2.84]	-0.258 [-2.97]

icant implementation effects on LIBOR-OIS and repo spreads, with less significant

effects for bond spreads (Table 6). For all spreads, implementation effects greatly dominated announcement effects, across all three types of monetary policies. This finding is consistent with the graphical analysis of regime probabilities in Section 7, which revealed that the periods in which p^{illiq} declined were typically those periods in which monetary policies were implemented, rather than announced.

The implementation effects were greatest for programs that widened the collateral eligible for Federal Reserve liquidity support, with spreads falling between 10 and 26 basis points, upon the programs' implementation (Table 6). Announcement effects are statistically significant only for LIBOR-OIS spreads, and only for two of the three policy categories, which fell by $7\frac{1}{2}$ basis points over the 3-day window. The second largest implementation effects were observed for programs that broadened the range of counterparties to Federal Reserve support, with spreads declining by 5-20 basis points upon the programs' implementation.

Finally, even after controlling for the effects of "unconventional" monetary policies, fiscal policy announcements still had significant and destabilising influences on spreads. In addition, the monetary policy stance remains a significant influence on spreads, as was the case in Table 2.

Table 7 reveals that significant implementation effects occur only for the

Table 7: BEKK multivariate GARCH model estimates – all bonds

This table reports selected parameter estimates from equation (4), with Bollerslev-Wooldridge adjusted z-statistics in brackets. $\sigma_{LIB-OIS}^2$, σ_{Repo}^2 , and σ_{Bond}^2 is the conditional variance of residuals from equation (6) for, respectively, *LIB-OIS*, *Repo* and *Bond*. D^{Fisc} is a dummy variable that equals 1 when a fiscal policy announcement is made (or one day preceding or proceeding the announcement), while $D^{Mat,Ann}$, $D^{Cpart,Ann}$ and $D^{Collat,Ann}$ are dummy variables relating to a 3-day window around announcements of the three types of Federal Reserve policies. $D^{Mat,Imp}$, $D^{Cpart,Imp}$ and $D^{Collat,Imp}$ are dummy variables equal to one on days when the respective Federal Reserve policy types are implemented. Finally, *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	D^{Fisc}	$D^{Mat,Ann}$	$D^{Cpart,Ann}$	$D^{Collat,Ann}$	<i>Stance</i>	$D^{Mat,Imp}$	$D^{Cpart,Imp}$	$D^{Collat,Imp}$
$\sigma_{LIB-OIS}^2$	0.008 [0.92]	-0.021 [-2.72]	0.001 [0.93]	0.002 [0.62]	0.003 [3.91]	-0.001 [-0.27]	-0.013 [-3.40]	-0.029 [-6.85]
σ_{Repo}^2	0.010 [0.46]	-0.004 [-0.20]	0.006 [0.37]	0.000 [-0.01]	0.017 [1.77]	-0.003 [-0.16]	-0.023 [-0.87]	0.036 [1.27]
σ_{Sprd}^2	-0.089 [-0.32]	-0.001 [-0.16]	-0.331 [-3.34]	-0.007 [-0.09]	0.001 [0.92]	-0.201 [-0.61]	-0.197 [-4.11]	-0.317 [-2.98]

conditional variance of LIBOR-OIS and bond spreads, and only for Federal Reserve policies that expanded the range of counterparties and eligible collateral ($D^{Cpart,Imp}$ and $D^{Collat,Imp}$, respectively). In terms of announcements, the only policies with significant effects were those that increased the maturity of Federal Reserve support (for the LIBOR-OIS spread), and policies that expanded the range of counterparties (for bond spreads). In contrast to Table 3, neither $D^{Collat,Ann}$

nor $D^{Fiscal, Ann}$ are statistically significant.

In sum, the evidence in Tables 6 and 7 suggests that the implementation effects of Federal Reserve policies outweighed the announcement effects, with the statistical significance of these effects greater for conditional means. All three types of “unconventional” monetary policies were important in reducing market strains, though the most important were policies that expanded the range of eligible collateral in the Federal Reserve’s open market operations, followed by policies that broadened the range of counterparties. Notably, both fiscal policy announcements and the monetary policy stance continued to exert destabilising influences on conditional means, with the latter also exerting a destabilising influence on conditional variances.

8.1 Flow-of-funds effects

The above discussion focused on the effects of the Federal Reserve’s “unconventional” policies at the time these policies started (so-called “implementation effects”). However, it is possible that these policies also had “flow-of-funds” effects; market strains may not have eased until the Federal Reserve began lending sufficient amounts of funds to troubled institutions. Significant flow-of-funds effects would suggest that investors were not forward-looking and did not form rational expectations. An alternative possibility, as noted above, is that Federal Reserve policy may have been subject to a time inconsistency issue, so spreads did not fall until these programs were implemented.

In this section, I examine flow-of-funds effects by considering the correlation between market spreads and the outstanding value of the various Federal Reserve LOLR programs. A key empirical limitation with this analysis is that data on the size of the various programs are weekly, which makes it impossible to examine higher-frequency impacts of the Federal Reserve’s programs on market spreads. It also precludes examination of announcement and implementation effects, as the weekly dates typically do not coincide with the announcement and implementation dates in Table 1.²³ Consequently, the results below should be treated with some caution, since an inability to control for high-frequency announcement and implementation effects may bias the estimated flow-of-funds effects.

One possible way to include flow-of-funds effects into the prior analysis is to include them as exogenous variables in the VAR(1)-GARCH(1,1) model. However, I find strong evidence – on the basis of the test of Hausman (1978) – that \mathbf{Stock}_t is endogenous. Hence, I formulate a multivariate model in which the instrumental

²³Even if announcement or implementation dates coincided with the dates of the weekly lending data, the dummy variable specification would presume the effects last for one week. Using a 1-week event window would bias the estimated effects, since other events occurring during a particular week are erroneously included with the given policy event.

variable for \mathbf{Stock}_t is its 1-period lagged value, such that the model resembles the previous VAR(1)-GARCH(1,1), but with AR terms relating to the stock of Federal Reserve programs (in trillions of U.S. dollars) appearing as exogenous regressors:

$$\mathbf{X}_t = \alpha + \beta \mathbf{X}_{t-1} + \eta \text{Stance}_t + \nu \mathbf{Stock}_{t-1} + \epsilon_t \quad (8)$$

where \mathbf{X}_t and Stance_t are the same as in equation (3) (though observed at a weekly frequency), while \mathbf{Stock}_{t-1} is a 1x3 vector related to the weekly outstanding value of the three types of “unconventional” monetary policies. ϵ_t is again a 3x1 vector of residuals, with $\epsilon_t | \Sigma_{t-1} \sim N(0, \mathbf{H}_t)$. The conditional covariance matrix \mathbf{H}_t is given by:

$$\mathbf{H}_t = \mathbf{C}\mathbf{C}' + \mathbf{A}\epsilon_{t-1}\epsilon_{t-1}'\mathbf{A}' + \mathbf{B}\mathbf{H}_{t-1}\mathbf{B}' + \mathbf{J}\text{Stance}_t + \mathbf{K}\text{Stock}_{t-1} \quad (9)$$

The output of equations (8) and (9) are presented in Tables 8 and 9, respectively.

Table 8 reveals that there are highly statistically significant “flow-of-funds” ef-

Table 8: VAR parameter estimates – all bonds

This table reports the parameter estimates from equation (8), with multivariate GARCH(1,1) corrected z-statistics in brackets. The multivariate GARCH model is equation (9). *LIB-OIS* is the spread between the 1-month LIBOR and the 1-month OIS rate, *Repo* is the 1-month repo-OIS spread, and *Bond* is the spread between duration-matched U.S. corporate bonds and U.S. Treasuries. *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). *Stock^{All}* is the outstanding value (as at the end of each Wednesday) of securities held under all the various Federal Reserve LOLR programs. *Stock^{Mat}*, *Stock^{Cpart}*, and *Stock^{Collat}* is the weekly stock of securities held under Federal Reserve programs that, respectively, increase the maturity of support (*Mat*); widen the counterparties to the support (*Cpart*); and broaden the types of collateral eligible for secured funding (*Collat*). All outstanding values are in trillions of U.S. dollars. The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	<i>Stance</i>	<i>Stock^{All}</i> (-1)	<i>Stock^{Mat}</i> (-1)	<i>Stock^{Cpart}</i> (-1)	<i>Stock^{Collat}</i> (-1)
Panel A: All “unconventional” Federal Reserve programs					
<i>LIB-OIS</i>	-0.001 [-0.26]	-0.012 [-1.32]			
<i>Repo</i>	-0.001 [-0.03]	-0.036 [-1.56]			
<i>Sprd</i>	0.181 [11.7]	-0.617 [-10.4]			
Panel B: Individual types of “unconventional” Federal Reserve programs					
<i>LIB-OIS</i>	0.044 [2.35]		-0.017 [-0.78]	-0.176 [-1.70]	-0.108 [-2.44]
<i>Repo</i>	0.022 [-1.37]		0.160 [0.96]	-0.256 [-3.89]	-0.167 [-3.56]
<i>Sprd</i>	0.191 [1.81]		-1.292 [-2.11]	0.109 [1.36]	-0.585 [-2.05]

fects on bond spreads, with less significant effects on LIBOR-OIS and repo spreads. A U.S. \$1 trillion rise in the stock of securities obtained through the Federal Reserve’s “unconventional” policies leads to a 62 basis point (12 per cent) fall in bond spreads, an economically significant result, but has no significant effect on

LIBOR-OIS and repo spreads (Panel A).²⁴

While the flow-of-funds effects are, in aggregate, insignificant for LIBOR-OIS and repo spreads, there are significant effects for specific policies. In particular, those Federal Reserve programs that expanded the range of counterparties (*Cpart*) and eligible collateral (*Collat*) led to significant declines in LIBOR-OIS and repo spreads. A U.S.\$0.3 trillion rise in the stock of securities acquired under *Cpart* led to a decline in LIBOR-OIS and repo spreads of 5 basis points and 8 basis points, respectively, while a similar rise in the stock of securities acquired under *Collat* led to a decline of 3 and 5 basis points, respectively (Panel B). In terms of bond spreads, policies that increased the maturity of support (*Mat*) had the largest flow-of-funds effects; a \$0.3 trillion rise in the stock of assets obtained under *Mat* led to a 38 basis point decline in bond spreads.

The policies with the largest flow-of-funds effects are not necessarily the biggest policies by U.S. dollar value; for example, although *Collat* was the smallest of the three policy categories (see Figure 2), it had greater flow-of-funds effects on LIBOR-OIS and repo spreads, than the larger *Mat* programs.

The flow-of-funds effects are weaker for conditional variances than for con-

Table 9: BEKK multivariate GARCH model estimates – all bonds

This table reports selected parameter estimates from equation (4), with Bollerslev-Wooldridge adjusted z-statistics in brackets. $\sigma_{LIB-OIS}^2$, σ_{Repo}^2 , and σ_{Bond}^2 is the conditional variance of residuals from equation (8) for, respectively, *LIB-OIS*, *Repo* and *Bond*. *Stance* is the monetary policy stance, defined as the difference between the actual effective Federal Funds rate and the effective rate implied by a Taylor rule (equation (2)). *Stock^{All}* is the outstanding value (as at the end of each Wednesday) of securities held under all the various Federal Reserve LOLR programs. *Stock^{Mat}*, *Stock^{Cpart}*, and *Stock^{Collat}* is the weekly stock of securities held under Federal Reserve programs that, respectively, increase the maturity of support (*Mat*); widen the counterparties to the support (*Cpart*); and broaden the types of collateral eligible for secured funding (*Collat*). All outstanding values are in trillions of U.S. dollars. The estimations are based on daily data from July 1, 2007 to February 2, 2009 (397 trading days).

Dep. var	<i>Stance</i>	<i>Stock^{All}</i> (-1)	<i>Stock^{Mat}</i> (-1)	<i>Stock^{Cpart}</i> (-1)	<i>Stock^{Collat}</i> (-1)
Panel A: All “unconventional” Federal Reserve programs					
$\sigma_{LIB-OIS}^2$	0.008 [7.73]	-0.014 [-3.48]			
σ_{Repo}^2	0.018 [2.57]	0.022 [1.31]			
σ_{Sprd}^2	0.013 [1.72]	-0.001 [-0.14]			
Panel B: Individual types of “unconventional” Federal Reserve programs					
$\sigma_{LIB-OIS}^2$	0.004 [4.89]		-0.008 [-1.98]	-0.023 [-1.32]	0.006 [0.95]
σ_{Repo}^2	0.018 [3.21]		0.001 [1.55]	-0.013 [-0.71]	0.018 [0.46]
σ_{Sprd}^2	0.570 [20.4]		-0.081 [-1.63]	0.543 [0.29]	-0.048 [-0.82]

²⁴The U.S dollar values chosen for the comparative static analysis are based on the stock of securities held under the three Federal Reserve program categories (see Figure 2).

ditional means. Collectively, the Federal Reserve’s LOLR programs only had a significant impact on the conditional variance of LIBOR-OIS spreads (Panel A, Table 9). A U.S.\$1 trillion dollar rise in the stock of securities held by the Federal Reserve led to a 12 basis point (11 per cent) fall in LIBOR-OIS spreads’ conditional volatility. Individually, only programs that increased the maturity of Federal Reserve support had a flow-of-funds effect, with the only dependent variable affected being the conditional variance of LIBOR-OIS spreads (Panel B, Table 9). While this effect is statistically significant (at the 5% level), its economic significance is modest; a U.S.\$0.3 trillion dollar rise in *Mat* leads to a 8 basis point (7 per cent) fall in conditional volatility. The lack of economic significance in the size of the estimated coefficients is consistent with Frank and Hesse (2009), though they focus on one policy (the Term Auction Facility) and one spread (the LIBOR-OIS spread).

These findings are consistent with the possibility that the Federal Reserve faced a time-consistency problem when announcing their policies. Moreover, since these programs were viewed as “unconventional”, since they were outside the traditional framing of monetary policy as the targeting of overnight interest rates via investments in low-risk government securities, there may have been uncertainty about their efficacy in reducing market spreads. It may also suggest that investors’ expectation formation evolved in an adaptive, non-rational manner, as well as evidence of informational inefficiency, since any time consistency issues would have been resolved once the Federal Reserve implemented their policies. Consequently, if investors were forming rational expectations and markets were informationally efficient, the policies’ effects on spreads should have occurred at the time of implementation; subsequent amounts loaned through these programs should not have constituted new information. Since these alternative views have observationally equivalent implications for market spreads, it is not clear which, if any, of these views were the dominant forces during this period.

Baba and Packer (2009) note that there were large and sustained deviations from covered interest rate parity during the crisis, which suggests a large degree of informational inefficiency (at least in the FX market). Baba and Packer find that U.S. dollar funding from the ECB, supported by U.S. dollar swap lines with the Federal Reserve, lowered the volatility (though not the level) of deviations from CIP. Disentangling the separate effects of policy credibility, non-rational expectations, and informational inefficiency, on the estimated announcement, implementation and flow-of-funds effects, is outside the scope of this paper, and is an important, though challenging, exercise for future research.

9 Conclusion

In this paper I assessed the impact of the various “unconventional” policies, introduced by the U.S. Federal Reserve during the 2007-09 financial crisis period, on market spreads. This paper has a key differentiating feature from the related literature – rather than focus on one or two policy initiatives, I examined the market impact of all major fiscal and unconventional monetary policies announced between mid-2007 and early 2009. Due to the large number of policies – between December 2007 and March 2009 the Federal Reserve initiated 16 programs – I used Kroszner and Melick (2010)’s organising framework to classify the various policies into three categories: (i) an expansion of the type of counterparties receiving support; (ii) a broadening of the collateral eligible for support; and (iii) a lengthening of the maturity of the support.

Using this framework, this paper presented six key findings. Firstly, all three types of Federal Reserve policies were effective in reducing market spreads, with the most effective being policies that broadened the range of collateral eligible for secured funding from the Federal Reserve. This finding is consistent with Gorton (2010)’s argument that asset markets – especially the markets for bonds securitised by U.S. residential mortgages – rather than specific institutions, precipitated the onset of the global financial crisis. Thus, policies that broadened the range of eligible collateral to include broader segments of securitised bond markets were more effective in alleviating market strains than either of the other two types of policies.

Secondly, I find that these policies were more effective in reducing short-term unsecured and secured funding costs, rather than spreads on longer-term bonds. This finding is consistent with Ericsson and Renault (2006), who find that liquidity risk represents the largest component of short-term debt spreads, with the opposite true for longer-term securities. Hence, the liquidity support offered by the Federal Reserve may have been more effective in reducing liquidity risk premia, rather than credit risk premia. Consequently, these policies had a larger impact on funding costs than bond spreads.

Thirdly, these policies were more effective in reducing the level of spreads rather than their conditional variances. These findings contrast those of Baba and Packer (2009), who, focusing on the effects of one particular policy initiative (U.S. dollar swap lines between central banks), find greater effects on conditional variances than conditional means. One point of difference between my findings and those of Baba and Packer (2009) is that I focus on the effect of all key unconventional policies, as well as fiscal policy announcements, rather than individual policies.

Fourthly, I find that “implementation effects” and “flow-of-funds” effects – respectively, the effect on spreads at the time policies were implemented, and the effect on spreads from higher amounts loaned from these programs – were an order

of magnitude larger than “announcement effects” – the effect on spreads at the time these policies were announced. These findings have three key implications.

Firstly, these findings suggest that the Federal Reserve may have faced a time-consistency issue at the time their LOLR policies were announced. Secondly, as these policies were outside the typical framing of monetary policy, these policies may have been perceived as “unconventional”, creating uncertainty about these policies’ effects on market spreads. Thirdly, the findings may imply investor irrationality (in the form of myopia) and/or markets’ informational inefficiency. Disentangling these separate effects, and identifying which, if any, dominate(s) is an important exercise for future research.

Fifth, fiscal policy announcements had either insignificant, or significant but destabilising, effects on market spreads. Taylor (2011) found that the Troubled Asset Relief Program (TARP) bill created greater market uncertainty and exacerbated market strains. In contrast to Taylor (2011), I examined a broader range of fiscal policies, but reached a similar conclusion.

Following Rudebusch (2010), I measured the monetary policy stance as the deviation of the actual Federal Funds interest rate from the interest rate implied by a Taylor rule. This measure of the policy stance implied that policy became increasingly contractionary during the crisis. My final finding in this paper was that the policy stance had a destabilising influence on spreads, offsetting some of the stabilising influence of the various unconventional policies and thereby limiting the effectiveness of the Federal Reserve’s overall response to the crisis. In short, the Federal Reserve’s success in reducing strains in U.S. credit markets was undermined by their inability (or, more provocatively, their failure) to achieve their macroeconomic objectives.

These findings have a further two research extensions, the first being an examination of the impact of the monetary policy stance on U.S. equity markets, commodities, and other assets sensitive to growth expectations. Secondly, as this paper focused on U.S. monetary policy and U.S. credit markets, a cross-country analysis should be undertaken, examining the effect of both local central bank and foreign central banks’ monetary policy settings on asset prices. Krugman (2008) argues that the ‘international finance multiplier’ – the process by which changes in asset prices are transmitted internationally through their effects on the balance sheets of leveraged financial institutions – played a key role in transmitting the U.S. crisis to a systemic run, in addition to international trade linkages. As Krugman notes, an implication of a large international finance multiplier is that monetary and fiscal policy initiatives have positive cross-border externalities. To investigate the importance of these externalities, the analysis undertaken in this paper should be extended to consider the various fiscal and monetary policy initiatives on global credit markets.

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11 Appendix

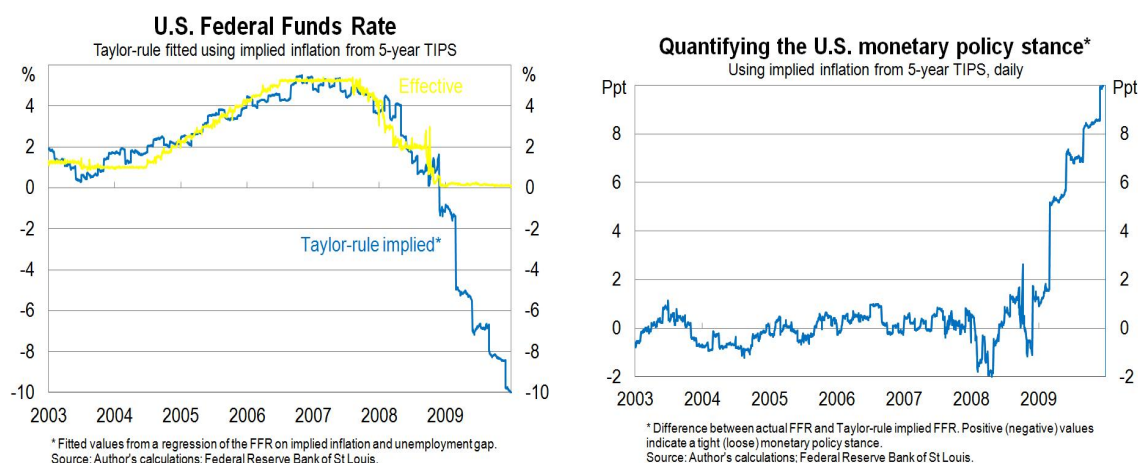
Appendix A: Alternative Taylor rules

Unemployment-based Taylor-rules

I estimated equation (2) using the difference between T-year Treasury bond yields, and T-year TIPS yields. I first set $T=5$; and then $T=10$. The implied Taylor rule and associated monetary policy stance are presented below. It is notable that the levels of the two alternative monetary policy stances differ, particularly after December 15, 2008 (when the zero lower bound was reached); between December 15, 2008 and December 31, 2009, the 10-year series was, on average, around two-fifths below the 5-year series (Figures 7 and 8).

However, the correlation is very high (0.98). Similar correlations apply when

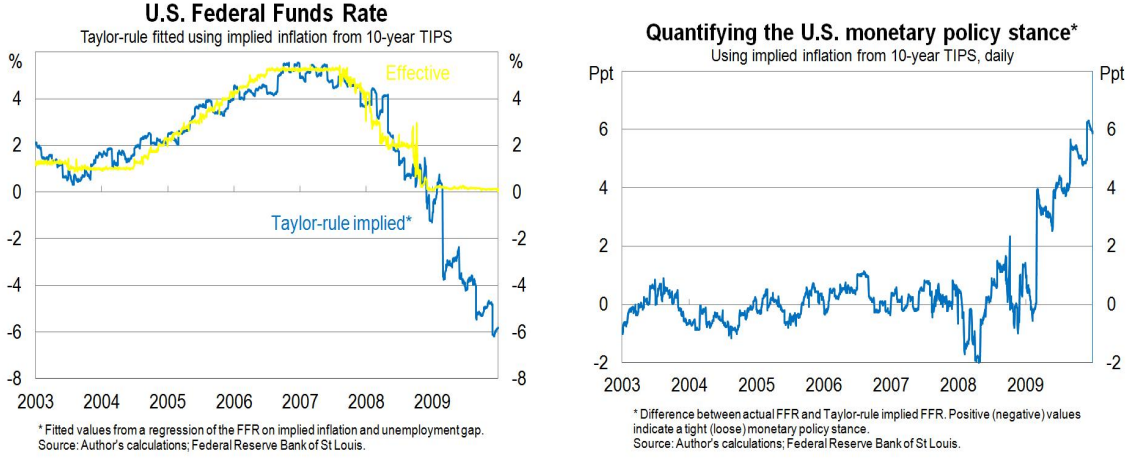
Figure 7: **Effective Federal Funds rate based on 5-year TIPS yields**



comparing the 5-year and 10-year TIPS measures against 5-year inflation expectations from Haubrich, Pennacchi and Ritchken (2011).

This implies that although the size of the VAR model's estimated coefficients would differ across the two measures, the statistical significance of these estimates, and the size of impulse response functions (whose values are standardised), would be largely unchanged. Thus, the findings of the paper are insensitive to the choice of TIPS tenor, or the choice of tenor from Haubrich, Pennacchi and Ritchken (2011)'s inflation expectations.

Figure 8: Federal Funds rate based on 10-year TIPS yields



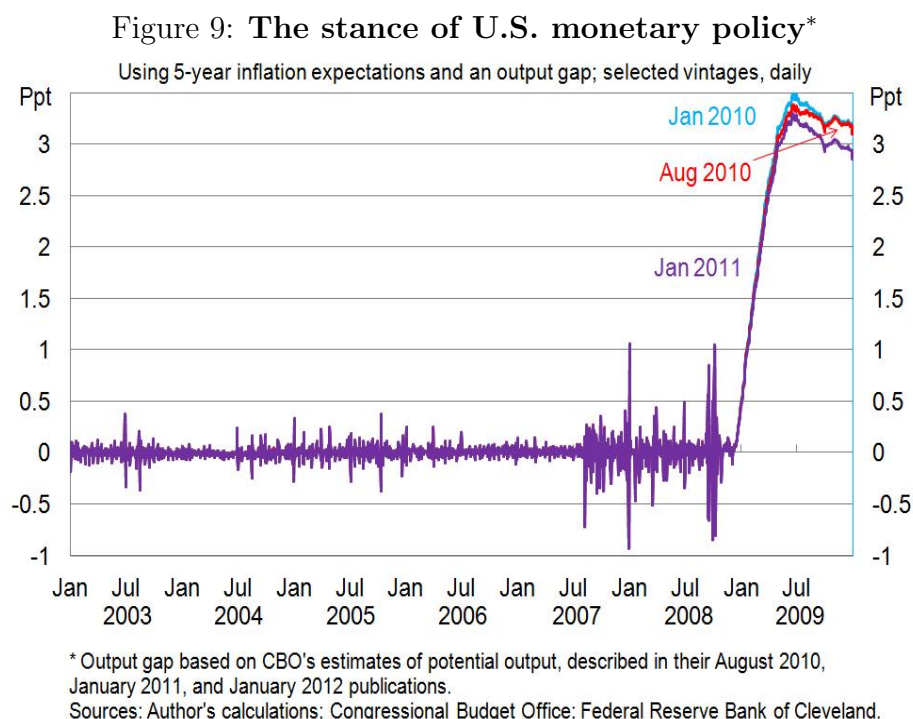
Output-gap-based Taylor rule

Since Taylor (1993)'s original formulation is based on output gaps, in this section I estimate Taylor rules using an output gap defined as the difference between real GDP and the Congressional Budget Office (CBO)'s estimate of real potential GDP. I use Haubrich, Pennacchi, and Ritchken (2011)'s estimate of 5-year inflation expectations, and I also include an AR(1) term in equation (1) in order to improve the explanatory power of the Taylor rule.²⁵ Since estimates of actual and potential real GDP estimates are both subject to larger revisions than estimates of actual or natural unemployment rates, output-gap based Taylor rules (and the associated monetary policy stance) differ across the different published GDP vintages.

Focusing on three randomly selected data publications – August 2010, January 2011 and January 2012 – all three estimates of the policy stance are highly positively correlated with each other, with pairwise correlations close to 1. However, there are some differences in the levels of the series, particularly from late 2008, reflecting the differences in the output gap estimates between these three publications. Despite these differences, U.S. monetary policy became increasingly contractionary, under all three measures, from late 2008; by June 2009, the actual Federal Funds rate was around $3\frac{1}{2}$ percentage points above the Taylor-rule implied rate (Figure 9).

²⁵Excluding an AR(1) term, the \bar{R}^2 is around 0.5 for each of the three models estimated in this section. With an AR(1) term, the \bar{R}^2 rises to 0.99. In contrast, adding an AR(1) term to equation (2) increases the model's \bar{R}^2 from 0.87 to 0.99.

Notably, the pairwise correlations between the output-gap and unemployment-



gap estimates of the policy stance are around 0.94. This implies that though the magnitude of the VAR model's estimated coefficients may differ between the output-gap and unemployment-gap measures, the statistical significance of these estimates would be unchanged. Combining the results from the previous section, this suggests that this paper's findings are largely insensitive to the choice of inflation expectations measure, as well as the choice of an output-gap or unemployment-gap measure of the policy stance.

Appendix B: Granger causality tests

Bivariate Granger causality tests between the three financial market variables were performed, with the test statistics in the below table.

Table 10: Granger causality tests

Repo is the 1-month repo-OIS spread, *Bond* is bond spreads to U.S. Treasuries, and *LIB-OIS* is the 1-month LIB-OIS spread. The sample period is July 2 2007 to December 31 2009 (626 trading days), and all data are daily. The null hypothesis tested is that the variable in a particular row does not Granger cause the variable in a particular column ('dependent variable'). For each test, the number of lags is equal to one. *, ** and *** denote rejection of the null at the 10%, 5% and 1% significance levels, respectively.

	Dependent variable		
	<i>Repo</i>	<i>Bond</i>	<i>LIB-OIS</i>
<i>Repo</i>		14.59***	5.30**
<i>Bond</i>	1.23		3.73**
<i>LIB-OIS</i>	1.15	15.56***	

Appendix C: Fiscal policy announcements

- September 19, 2008: first proposal of the Troubled Asset Relief Program (TARP) by U.S. Treasury Secretary Paulson. The U.S. Treasury Department announces a temporary guarantee program that will make available up to U.S.\$50 billion from the Exchange Stabilization Fund to guarantee investments in participating money market funds.
- September 29, 2008: TARP bill rejected by the U.S. House of Representatives.
- October 3, 2008: passage of the TARP bill into law, called the *Emergency Economic Stabilization Act of 2008*.
- October 14, 2008: announcement of the Capital Purchase Program (CPP) under which the U.S. Treasury would use TARP funds to buy preferred stock and warrants of nine financial institutions²⁶.
- October 14, 2008: The Federal Deposit Insurance Corporation (FDIC) guarantees senior debt obligations of depository institutions and their holding companies under the Temporary Liquidity Guarantee Program (TLGP).
- November 12, 2008: U.S. Treasury Secretary Paulson announces that the U.S. Treasury would not use TARP funds to buy mortgage-related assets from financial institutions.

²⁶Citigroup, Wells Fargo, JP Morgan, Bank of America, Goldman Sachs, Morgan Stanley, State Street, Bank of New York Mellon, and Merrill Lynch.