Unconventional monetary policy and the behavior of shorts

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Abstract

We investigate the behavior of shorts, considered sophisticated investors, before and after a set of Federal Reserve unconventional monetary policy announcements that spot bond markets did not fully anticipate. Short interest in agency securities systematically predicts bond price changes and other asset returns on the days of monetary announcements, particularly when growth or monetary news is released, indicating shorts correctly anticipated these surprises. Shorts also systematically adjusted their positions after announcements in the direction of the announcement surprise when the announcement released growth news, suggesting that shorts interpreted monetary events to imply further yield changes in the same direction.

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1. Introduction

The collapse of international housing prices in 2006-2008 produced extreme credit market disturbances that culminated in the September 2008 bankruptcy of Lehman Brothers, a major investment bank, and a severe downturn in real economic activity. In response, the Federal Reserve (Fed) first initiated emergency measures to stabilize the global economy and later turned to unconventional monetary policy to stimulate the economy and maintain stable prices. The unconventional actions included "forward guidance" about the path of the federal funds rate target and a series of announcements of asset purchases that totaled several trillion dollars over the following ten years.[1]

Researchers have extensively studied the reactions of market prices to unconventional monetary policy actions but have paid much less attention to expectations formation and portfolio adjustment.[2] In particular, we ask whether some sophisticated investors understand the relatively opaque unconventional monetary decision process better than marginal investors in spot/futures bond markets. Did these shorts successfully predict changes in term premia, expected short rates, neither, or both? What sort of news content did the shorts predict? How did shorts adjust the maturity of their portfolios in these transactions?[3]

[1] Conventional policy influences the economy through the management of short-term interest rates. The Federal Reserve typically used the federal funds rate, an interbank interest rate, along with policy statements to influence the economy prior to December 2008 and from 2015 to 2020.

[2] Bhattarai and Neely (2020) survey the literature on international unconventional monetary policy. Joyce, Liu, and Tonks (2017) and Koijen et al. (2017) study the portfolio choices of financial institutions in the wake of unconventional monetary policy announcements.

[3] Our research question is whether sophisticated investors anticipated unconventional monetary policy announcements. Because assets are always owned by someone, there are always long investors, but we do not know the identities or characteristics of these longs that are adding to or reducing their positions prior to these announcements. Hence, we turn to the fact that some investors speculate on a decline in asset prices by holding short positions. Studies have shown that shorts are better informed than longs about asset valuation. However, some shorts are better informed than others. This is why we find some short covering prior to announcements, some after, and

Predicting important monetary policy surprises is a stringent test for any class of investors because publicly available information almost entirely determines the path of monetary policy.[4] To earn abnormal returns, shorts must out-predict the marginal spot/futures investor in very deep markets with little or no private information, but abundant public information. The short investor cannot simply follow market sentiment, which the spot price should immediately reflect, or the short investor would never foresee an abnormal risk-adjusted return and would never have a speculative incentive to increase or decrease his/her position. Although there have been some findings of delayed reactions to monetary policy expectations in forex and equity markets, which we discuss in Section 2.3, this is the first study to identify a class of investors who systematically out-predict the spot bond market with respect to monetary surprises.

Consistently out-predicting the marginal investor in spot bond markets is probably much more difficult than predicting the fortunes of a single company better than the limited group of analysts who focus on it. Indeed, futures markets appear to anticipate the federal funds target efficiently. Piazzesi and Swanson (2008) show that implied federal funds rates from futures are only modestly biased predictors of the federal funds target, slightly over-predicting the rate implied by final futures settlement by 3 to 6 basis points per month of the forecast horizon, on average. These

that short interest remains positive after each announcement. And unlike the case for longs, it is sufficient for our research question to measure what shorts are doing at the margins.

[4] Many types of public information potentially inform monetary policy. For example, the Fed releases minutes of FOMC meetings after three weeks and FOMC participants frequently publicly express their policy views, which are largely based on publicly available information. Bernanke (2002), for example, presaged the use of quantitative easing in the context of the Japanese economy, 6 years before it was attempted in the United States: "*To stimulate aggregate spending when short-term interest rates have reached zero, the Fed must expand the scale of its asset purchases or, possibly, expand the menu of assets that it buys.*"
https://www.federalreserve.gov/boarddocs/speeches/2002/20021121/

authors interpret this small bias as reflecting risk premia rather than a systematic forecasting error (Piazzesi and Swanson 2008).[5]

The discovery of predictable components in monetary "surprises" is important because it implies that the impact of monetary "shocks" on asset price and macro changes might need to be recalculated and that financial markets are heterogeneous with the "smart money" segment anticipating the surprise component of even widely watched events based on public information.

After investigating the ability of shorts to anticipate yield changes associated with Fed decisions, we then go on to ask if Fed announcements provided credible signals to these sophisticated short investors.[6] That is, we investigate whether shorts managed their portfolios in a manner reflecting the belief that announcements with surprise expansionary (contractionary) components indicate that yields will remain low (high).

We also investigate the role of central bank news in the behavior of shorts. Specifically, we ask if the type of news released by monetary announcements affects the accuracy of shorts' predictions of policy and their ex post behavior. In this endeavor, we use the procedures of Cieslak and Schrimpf (2019), who argued that patterns of realized covariances of stock returns with yield changes reveal the type of news—monetary, growth, or risk news—released by a policy decision.

Our sample comprises data on borrowed quantity of bonds (*BQ*)—a proxy for shorting—around a set of 42 unconventional monetary policy announcements (UMPAs), consisting of FOMC statements, speeches, press releases, and announcements, during QE1, QE2, the maturity extension

[5] In contrast to analysts predicting monetary policy, equity analysts can gather information from a variety of primary, non-public sources including employees, suppliers, and customers (e.g., channel checks, surveys, etc.). In addition to conducting primary research, they often privately communicate with management. Brown et al. (2014) find that such communication is a more useful input to analysts' forecasts than their own primary research.

[6] We hypothesize that if the Fed eases, then it is sending a signal that it will keep yields low for the immediate future. The Fed wishes to send such a signal about future policy because otherwise it would be undercutting its own attempts at easing. If shorts believe this signal (i.e., if they find it "credible") then they will anticipate no reductions in bond prices and will reduce their shorts. The same can be said for Fed tightening.

program (MEP), and QE3. This set of events from news reports and existing event studies reflects all important information releases about unconventional policy from November 2008 through July 2013, when expectations of further purchases started declining. Although we omit 37 FOMC-minutes releases from our data set because they appear to have minimal information content, inclusion of these does not significantly alter inference.

To presage our results, changes in borrowed quantity (ΔBQ) show that shorts correctly anticipate yield changes from UMPAs. ΔBQ predicts changes in term premia but not changes in expected future short rates, as inferred from swap rate changes when VIX is included to control for volatility.[7] This pattern of predictive effects indicates that shorts' ΔBQ predicts portfolio balance but not signaling effects. We find that the shorts' portfolio adjustments accurately anticipate UMPAs that release growth or monetary news, but not necessarily risk news. Shorts are particularly adept in anticipating the direction of growth news. These findings are consistent across variations on the sample. To our knowledge, ours is the only work showing that a set of sophisticated investors systematically outperformed the spot market in predicting unconventional monetary policy actions by a central bank. It is, therefore, a unique result.[8]

Also, shorts found Fed actions to be credible in the sense that surprisingly expansionary (contractionary) UMPAs produced yield declines (increases) that predicted that shorts would cover (expand) their short position in anticipation of further changes in the same direction. Again, growth news was strongly associated with such later rebalancing.

[7] The swap rates almost certainly contain a risk premium but we hypothesize that changes in this risk premium are relatively small compared to changes in the expectations component on days of FOMC announcements.
[8] Investors in the spot market may be faced with liquidity considerations and regulatory restrictions that may confine their ability to respond quickly to market impacting news. Further, the spot market is widely believed to include a larger mix of unsophisticated investors than the shorting market.

We study the behavior of shorts, rather than other sophisticated investors, such as hedge funds, mutual funds, or insiders, because trading data for these other classes of investors are either unavailable or available only with a delay. Fortunately, data on securities borrowing are available daily and cover individual CUSIPs of both Treasuries and agencies. The use of Markit data as our proxy for short interest allows us to examine the trades of these sophisticated investors.[9]

There are at least three other ways to profit from falling bond prices—selling futures, using repurchase agreements (repos) to borrow securities to short, and purchasing credit default swaps (CDSs). However, each of these has disadvantages for studying the behavior of shorts compared to our approach. Futures data is problematic for two reasons. Traders cannot use futures to short specific individual CUSIPs because many securities are potentially deliverable on each futures contract.[10] In addition, the CFTC's Commitments of Traders Reports (COT) describing the reasons for traders' open interest are inadequate for our purposes because the classifications are self-reported and based on the traders' predominant business purpose so than hedging and speculative positions can be comingled.[11] Repos can also be used to borrow securities for short selling but data on repos for individual CUSIPs are not readily available. Further, identifying which repos are used to borrow securities to short can be difficult because repos are commonly used for other purposes, such as to borrow funds or upgrade collateral. Traders may use CDSs to benefit from

[9] The data examined in our paper are available for purchase to market participants with a one-day delay, which could contribute to herding behavior. To the extent that there is herding, the market would be pushed in the direction of the shorts and would reinforce the idea that shorts are sophisticated. The availability of the shorting data—although with a delay and at a cost—also indicates a potentially valuable source of information for market participants who can short at reasonable cost.

[10] Market participants cannot count on being able to short a specific bond. The CBOT-CME permits delivery of multiple bonds to maintain sufficient liquidity and deter market manipulation. The final contract settlement price is adjusted according to a formula that depends on which bond is delivered. This formula generally implies the existence of a single bond that is cheapest-to-deliver. This bond can change with market conditions, however. Thus, any attempt to short some specific bond with a futures contract is subject to severe basis risk between the price of the specific bond and the cheapest-to-deliver bond.

[11] See https://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm

falling bond prices caused by deteriorating credit, but we seek to study yield changes caused by U.S. monetary policy, not yield changes that result from changes in the very low expected probability of a U.S. default. Because each strategy has its requirements, traders typically do not switch between these four ways of profiting from falling bond prices.[12] These disadvantages in studying futures, repos, or CDS prices support our conviction that the Markit database is a uniquely useful tool with which to examine shorting in bond markets.

2. Literature review

We contribute to three streams of literature: 1) research that examines short selling, 2) research studying unconventional monetary policy effects on asset prices and portfolios, and 3) asset price patterns around monetary announcements. This section briefly reviews this literature to frame the unique contribution of the current paper.

2.1. The short-selling literature

Short sellers are widely viewed as informed, sophist+icated investors. In equity markets, short sales correctly predict negative returns (Aitken et al. 1998; Boehmer, Jones, and Zhang 2008; Diether, Lee, and Werner 2009; Cohen, Diether, and Malloy 2007), aid price discovery (Boehmer and Wu 2013), and exploit profit opportunities provided by downgrade announcements (Christophe, Ferri, and Hsieh 2010). Engelberg, Reed, and Ringgenberg (2012) find that, rather than anticipating news, news provides valuable trading opportunities for short sellers because they are skilled information processors.

[12] Several institutional features constrain trading methods: participants in the securities lending market might be required to enter into the Overseas Securities Lender's Agreement or the Global Master Securities Lending Agreement. Many institutions are prohibited from dealing in futures contracts. To trade CDSs directly, an institution needs an International Swaps and Derivatives Association (ISDA) master agreement, which might be difficult for smaller institutions to obtain. To some extent, these limitations could be overcome by dealing through financial intermediaries.

Researchers similarly find that fixed-income short sellers anticipate the release of useful information, although shorting in such markets has received much less attention than in equity markets. Nashikkar and Pedersen (2007) show that short selling of corporate bonds increases before a rating downgrade and Hendershott, Kozhan, and Raman (2020) argue that corporate bond shorts predict future bond returns. In contrast, Asquith et al. (2013) find that heavily-shorted corporate bonds do not earn abnormal returns, indicating that investors' private information does not motivate these short sales.

Anecdotal evidence suggests that some sophisticated investors initiated short positions prior to the financial crisis to profit from it.[13] The Big Short (Lewis 2011) chronicles four such investors who predicted bond defaults that would be triggered by a credit and housing market collapse. Lewis (2011) suggests that at least a few individuals were discerning enough to foresee macro events, but it is also true that the counterparties were often other sophisticated institutions that failed to predict those events.

2.2. The effect of unconventional monetary policy surprises on asset prices

Bond yields can be tautologically decomposed into an expected future short rate and a term premium. The theoretical literature on unconventional monetary policy suggests several channels by which such policies could influence yields through one of these components. The most widely cited channels are the signaling, portfolio balance, and local supply (substitution) channels.

Signaling refers to the possibility that Fed announcements change long bond yields through expected short-term interest rates. Forward guidance—Fed communication with markets about future rates or economic conditions—presumably produces only signaling effects and no portfolio

[13]Short positions included shorting stocks and bonds that were exposed to the subprime market, such as those issued by large investment banks (e.g., Citigroup, Lehman Brothers, and UBS), as well as credit default swaps on subprime mortgage bonds.

balance effects. The FOMC has offered forward guidance in at least nine different ways to shape expectations of future policy. Six of those events occurred during our sample; Table 1 describes those events, among others.[14]

In contrast to the single-channel through which forward guidance may be effective, asset purchase announcements may both signal future interest rates and directly affect term premia. That is, asset purchases can signal a path for interest rates by changing the Fed's incentives to raise rates quickly in the future. A central bank with a large portfolio of long-maturity bonds will incur significant capital losses—at least on paper—if it rapidly raises short rates, which tends to push up all yields (Bhattarai, Eggertsson, and Gafarov 2015).

The Fed's asset purchases can also directly affect bond term premia through the portfolio balance channel (Tobin 1958). Portfolio balance arguments about QE most common reason that a purchase of long bonds reduces yields by reducing the amount of duration risk in the market, thereby reducing the required premium to hold it. Another version of the portfolio balance channel suggests that removing certain maturities of very safe assets will have strong effects on the yields of similar, very safe assets. Purchases of particular bond issues may also produce "local supply effects"—i.e., differential price reactions—for securities that have very similar maturity characteristics to those purchased. In summary, unconventional monetary policy should affect all bond yields in the same direction, although not necessarily to the same extent.

Event studies provide strong evidence that unconventional monetary policies influence a broad variety of bond and other asset prices through signaling, portfolio balance, and local supply channels. Gagnon et al. (2011) calculate that a surprise announcement of a one trillion USD purchase of long-term bonds reduced 10-year U.S. Treasury yields by about 32 to 53 basis points

[14] The six forward guidance events during our sample took place on 12/16/2008, 3/18/2009, 8/9/2011, 1/25/2012, 9/13/2012, and 12/12/2012.

and produced a similar fall in yields of low-grade corporates. Krishnamurthy and Vissing-Jorgensen (2011) and Hancock and Passmore (2011) demonstrate that mortgage-backed securities' (MBS) yields and retail mortgage rates fell further still. D'Amico and King (2013) present evidence that Fed Treasury purchases in 2009 produced local supply effects of 30 basis points across the yield curve and even larger effects at 6-14 year maturities.

The effect of U.S. unconventional policy is not confined to U.S. bonds. Bauer and Neely (2014) show that a purchase of U.S. bonds can both reduce expected future short rates and the term premia for international bonds. Unconventional policy announcements also increase stock prices (Kiley 2014) and substantially reduce the foreign exchange value of the USD and international bond yields (Neely 2015). These bond and stock-price effects also extend to emerging markets (Bowman, Londono, and Sapriza 2015).[15]

2.3 Asset price movements before FOMC announcements

A series of papers have discovered fascinating asset price patterns around FOMC meetings. Lucca and Moench (2015) established that the stock market did exceptionally well in the 24 hours before the FOMC meeting announcements after 1994. This is called "pre-FOMC drift." Cieslak, Morse, and Vissing-Jorgensen (2019) find an even more elaborate pattern in the equity premium related to the event schedule around FOMC meetings over 1994-2016. These authors attribute these patterns to the risk associated with FOMC decisions. Neither of these works shows that equity investors anticipate the surprise component of the FOMC decision.

More surprisingly, Karnaukh (2018) shows that the fed funds spread—the spread of the futures rate over the current fed funds target—predicts the U.S. dollar's value over the 48 hours before

[15] However, we have determined that the international Markit data has insufficient coverage to allow us to investigate international aspects of our research question.

FOMC meetings. Karnaukh (2018) argues that this information could produce significant, excess USD trading returns after accounting for transaction costs. This observation suggests that forex markets exhibit a delayed adjustment to money market expectations of monetary policy.

Finally, Mamaysky (2018) argues that equity markets exhibit delayed reactions—of 3 weeks or more—to FOMC decisions and stocks with high bond betas (more bond-like stocks) react more quickly to QE announcements than do other stocks. Again, this suggests that inattention produces variable delays in news impact across asset classes.

While this literature characterizes interesting asset-price patterns around FOMC meetings, only one paper has shown any anticipation of the surprise components of FOMC decisions that we show. Neuhierl and Weber (2018) show that the sign of stock returns up to 25 days prior to FOMC announcements from 1994 to 2009 predicts the surprise component of such decisions. We will show that this intriguing result during a period of (almost all) conventional policy does not drive our results for the unconventional period but that our findings are consistent with theirs.

3. Data

3.1. Data collection and definition of variables

We use daily lending data from Markit Securities Finance for November 2008 through June 2013 for Treasury and agency securities and Lehman Brothers stock.[16] Participants in the securities lending market, including prime brokers, custodians, asset managers, and hedge funds, report these lending data. Available quantity (*AQ*) is the inventory available to lend (based on par value) and, hence, to short. Our proxy for short interest, borrowed quantity (*BQ*), is the total debt on loan, net

[16] We focus on the shorting of agency debt and not the shorting of the agency mortgage-backed securities which is typically executed through a credit default swap. See the introduction for additional information on the ways to profit from falling bond prices.

of double counting (based on par value). When we refer specifically to agencies or Treasuries borrowed (available) quantity, we denote these as *ABQ* and *TBQ* (*AAQ* and *TAQ*), respectively.

Datastream provides bond-level characteristics: issue size, coupon rate, duration, time-to-maturity, time-since-issuance, and yield-to-maturity. Our sample comprises securities with (1) issue size in DataStream, (2) mean *AQ* greater than $10 million over the sample period, (3) mean *BQ* greater than $1 million over the sample period, and (4) at least 30 daily observations.[17]

We examine all 42 of the UMPAs during the QE1-QE3 period. Table 1 describes the dates and times of these FOMC statements, conference calls, selected speeches, and selected press releases.[18] We note that 40 of the 42 announcements were scheduled well in advance, so their timing is exogenous to economic conditions. Figure 1 shows the daily changes in 10-year-Treasury yields around the 42 announcements over the same sample. The figure identifies the 42 daily changes according to whether the announcement was associated with the release of monetary, risk, or growth news. Many studies have examined market price reactions to subsets (or all) of these UMPAs, but there has been no research on the extent to which sophisticated investors might have anticipated these price shocks.

Table 2 provides means of bond-level characteristics of the 479 Treasuries and 3,714 agencies in our sample. The Treasuries and agencies have similar coupon rates and duration. There are far more agency bond issues, and the agencies pay a much higher yield, on average, but the fewer

[17] Our results are generally robust to including or excluding securities with time-to-maturity of less than 5 years. Such exclusion might be appropriate because the zero lower bound constrained movement of those yields during the period of our study. Swanson and Williams (2014), however, show that 5- and 10-year Treasuries remained sensitive to news until the last weeks of 2012. In addition to the effects of the zero lower bound, we considered excluding short-term securities because we believe that non-speculative reasons are more likely to motivate borrowing of such assets.

[18] Papers such as Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Neely (2015) or Wright (2012) have previously studied asset price reactions to many events in Table 1.

Treasury issues have much greater value (approximately $14 trillion versus $6 trillion). The Treasuries have a longer time-to-maturity, but a lower yield-to-maturity.

We examine price changes in a short window (1 hour), a medium window (open-to-close), and a longer window (daily) to investigate the impact of window length. Tickwrite provides futures prices. We construct two types of futures returns: 15-minutes-before-to-45-minutes-after each announcement and open-to-close. We construct one-day changes around events from daily 10-year Treasury yields, Kim and Wright (2005) term premia, swap rates, four types of MBS yields, exchange rates and gold prices from FRED. We hypothesize that shorts may be able to predict both term premia and swap rates because there is no a priori reason to think that their acuity should be confined to one part of the yield curve. We do not expect the window length to have much of an impact on results, although a shorter window might be less predictive as it can take the markets time to respond to an unexpected or complex announcement fully.

3.2. Policy responses to the Great Financial Crisis (GFC)

By late 2008, delayed indirect effects from the collapse of the housing price bubble had rendered financial markets dysfunctional, real activity weak, and short-term interest rates close to zero. The Fed's stabilization/lender-of-last-resort actions, in the weeks following the Lehman bankruptcy on September 15, 2008, were the first actions to unusually expand the monetary base. To supplement these interventions, the FOMC repeatedly reduced the federal funds target from 525 basis points in September 2007, finally reaching 0-25 basis points on December 16, 2008.

With the federal funds rate virtually at zero, the Fed shifted to stimulating growth and preventing undesirable disinflation by reducing long yields with forward guidance and asset purchases. On November 25, 2008, the FOMC announced its first asset purchase plans: $100 billion in government-sponsored enterprise (GSE) debt and $500 billion in MBS issued by those

GSEs. On March 18, 2009, the FOMC doubled down by announcing additional purchases of $100 billion in GSE debt, $750 billion in MBS, and $300 billion in long-term Treasury securities. These November 2008 and March 2009 asset purchase programs, together commonly called QE1 totaled $1.725 trillion, which roughly tripled the U.S. monetary base. Speeches by Chairman Bernanke and forward guidance from the FOMC statements were intended to create expectations of future bond purchases and thereby supplement these asset purchase efforts to lower long yields.

On November 3, 2010, the FOMC announced QE2: the Fed would purchase $600 billion worth of longer-term Treasuries during 2010-11. In conjunction with such buys, the FOMC issued statements to reduce expectations of the federal funds rate.[19] The Fed introduced the Maturity Extension Program (MEP) on September 21, 2011, which funded $400 billion in long-term Treasury note purchases through sales of Treasury bills. The FOMC extended the MEP on June 20, 2012, to combat stubbornly weak housing and labor market conditions. In September 2012, the FOMC announced QE3, an ongoing housing-support program that would initially purchase $40 billion in MBSs each month. In December 2012, the FOMC added $45 billion in Treasuries to monthly QE3 purchases.

Positive economic reports in the winter and spring of 2013 caused the FOMC to consider reducing QE3. Markets interpreted Chairman Bernanke's June 19 remarks as indicating that the Fed would soon begin reducing, i.e., "tapering," QE3. Bond yields, and the foreign exchange value of the dollar surged. After a delay of some months, and with PCE inflation near 1.5 percent and strong job growth, the FOMC finally began reducing QE3 purchases on December 18, 2013. The FOMC continued reductions at subsequent meeting, finally ending QE3 on October 29, 2014.

[19] https://www.federalreserve.gov/newsevents/pressreleases/monetary20110809a.htm

3.3. Descriptive statistics for the borrowing market

Figure 2 illustrates the time series of total daily *TBQ* and *TAQ* (Panel A) and *ABQ* and *AAQ* (Panel B). Panel A shows that the available quantity for Treasuries (*TAQ*, the black line) has no trend during the sample, with some modest diminution during the heart of the crisis in the fall of 2008 and some recovery later. Panel A also shows that borrowed quantity for Treasuries (*TBQ*, the light gray line) declines only very modestly through August 2008, but then falls sharply at the beginning of September as Lehman Brothers goes bankrupt, and risk aversion soars. The decline levels off in January 2009, and Treasury borrowing remains at a lower level than pre-crisis through July 2013. Panel B shows that the *AAQ* and *ABQ* (black and light gray lines, respectively) similarly decline from September 2008 to March 2009, when the *ABQ* decline starts to moderate. *AAQ* continues to decline from 2009 to the end of our sample period in July 2013. It is difficult to tell from the figure, however, whether the UMPAs are associated with significant changes in these quantities.

3.4. Release of news by central banks

Using high-frequency asset prices and policy announcements from the four major central banks (i.e., the Federal Reserve, the European Central Bank, the Bank of Japan and the Bank of England) Cieslak and Schrimpf (2019) convincingly argued that one could infer the type of news—monetary, output growth, or risk—in a central bank announcement by studying the pattern of realized covariances of stock returns with bond yields around monetary policy announcements. Monetary news could be described as a deviation from or a revision to the central bank's perceived reaction function. In contrast, growth and risk news represent revisions to the public's perception of the central bank's view on those variables. Specifically, Cieslak and Schrimpf (2019) argue that monetary news should produce a negative correlation between stock returns and yields. For

example, an expansionary monetary shock should raise stock returns through both cash flow and discount channels but reduce yields at all maturities. In contrast, growth and risk news should produce a positive covariance between stock returns and yield changes. Growth effects are likely to produce greater covariances at the short end of the yield curve, while risk effects are likely to produce large positive covariances between stock returns and the long end of the yield curve.

The average covariance, from 2-years to 30-years, over the yield curve, between stock returns and yield changes during announcement windows, is defined as follows:

$$\overline{Cov} = [\text{Cov}(R_{S\&P}, \Delta Y2) + \text{Cov}(R_{S\&P}, \Delta Y5) + \text{Cov}(R_{S\&P}, \Delta Y10) + \text{Cov}(R_{S\&P}, \Delta Y30)]/4 \quad (1)$$

where $R_{S\&P}$ denotes the S&P 500 futures return, and $\Delta Y2$, $\Delta Y5$, $\Delta Y10$, and $\Delta Y30$ denote the respective changes in normalized yields to 2-, 5-, 10- and 30-year bond futures over the window. The indicators for the three types of news shocks (M, G, and R) are defined as follows: News is monetary if the average stock return covariance with the yield curve is negative. That is,

$$I^M = \begin{matrix} 1 \text{ if } \overline{Cov} < 0 \\ 0 \text{ otherwise} \end{matrix} \quad (2)$$

The announcement reveals news about growth if the average stock return/yield covariance is positive and the sum of the 2- and 5-year bond futures return covariances is greater than the sum of those for 10- and 30-year bond futures returns. That is,

$$I^G = \begin{matrix} 1 & \text{if } \text{Cov}(R_{S\&P}, \Delta Y2) + \text{Cov}(R_{S\&P}, \Delta Y5) > \text{Cov}(R_{S\&P}, \Delta Y10) + \text{Cov}(R_{S\&P}, \Delta Y30) \;\&\; \overline{Cov} > 0 \\ 0 & Otherwise \end{matrix} \quad (3)$$

The announcement reveals news about risk if the average stock return/bond return covariance is positive and the covariances for 2- and 5-year bonds are less than those for 10- and 30-year bond yields. I_t^R equals 1 if the average stock-yield covariance is positive and the sum of the covariances with the long end is greater than the sum of those at the short end. That is,

$$I^R = \begin{matrix} 1 & \text{if } \text{Cov}(R_{S\&P}, \Delta Y2) + \text{Cov}(R_{S\&P}, \Delta Y5) < \text{Cov}(R_{S\&P}, \Delta Y10) + \text{Cov}(R_{S\&P}, \Delta Y30) \text{ and } \overline{Cov} > 0 \\ 0 & Otherwise \end{matrix} \quad (4)$$

Figure 1 shows daily 10-year yield changes around the 42 events, which include 16, 12, and 14 monetary, risk, and growth events, respectively. All types of events are associated with both positive and negative shocks. There seems to be some tendency for growth events to dominate early in the sample and risk events to be more common later in the sample. We use these indicators to study the type of news that *BQ* predicts.

4. Hypotheses of interest

In this paper, we will study the behavior of short investors around unconventional monetary announcements from 2008-2013.[20] This section describes hypotheses to test the behavior of shorts with respect to UMPAs. Our first set of hypotheses concerns how shorts behave before announcements, and our second set concerns how they react to those announcements.

If short-sellers think they have more accurate bond yield expectations than the risk-adjusted expectations of the marginal investor, then such short sellers will cover (expand) their short positions before surprisingly expansionary (contractionary) UMPAs, as they come to believe that bond prices will rise (fall). In an efficient market, current spot/futures bond prices fully reflect the marginal investor's discounted, risk-adjusted expectation of the future bond price, so—unless they take on more systematic risk—the short investor must predict bond prices better than the marginal investor to earn abnormal returns. It is not sufficient for short sentiment to mirror that of the spot/futures market. In that case, the short investor's risk-adjusted expectation would track the spot/futures price, and the former would have no speculative incentive to change his/her portfolio.

[20] An obvious extension to our paper would be to study the behavior of shorts around conventional monetary policy announcements as well. We reserve this for the future as we believe that the intersection of the shorting data sample and the period of conventional policy is still too short to be useful.

Our hypotheses are the same for Treasuries and agencies. While the magnitude of the changes of BQ might differ, we expect yields for Treasuries and agencies to move in similar directions and, hence, responses of shorts to UMPAs to be similar in both markets.[21]

Our first set of hypotheses concerns how—if at all—changes in short interest (i.e., ΔBQ) predict price and yield changes on days of UMPAs.

Hypothesis 1: Changes in short interest predict bond yield changes associated with UMPAs.

Hypothesis 2: Short interest anticipates both changes to term premia and expected short rates. That is, shorts predict both portfolio balance and signaling effects.

Hypotheses 1 and 2 are motivated by findings in other contexts that shorts are sophisticated investors. We hypothesize that shorts can predict bond yield changes as well as both components of such changes. One should note that neither we nor shorts need to estimate the latent monetary shocks but merely observe the changes in the prices/yields of medium and long-term securities.

Hypothesis 3: Changes in short interest predict UMPA-associated changes in foreign exchange rates and stock prices.

UMPAs have influenced foreign exchange prices and stock prices as well as bond yields, so we hypothesize that shorts' bond trading anticipates the reactions of correlated assets.

Hypothesis 4: Shorts trade with bonds of all maturities to prepare for announcements. UMPAs have broadly influenced medium and long-term yields. Therefore we hypothesize that shorts trade in bonds across all but short maturities to prepare for UMPAs.

Hypothesis 5: Predictive accuracy is similar for monetary, growth, and risk news.

[21] Flight-to-quality would increase the Treasury-agency yield spread. Agencies trade at a higher yield than Treasuries because they are less liquid, and they carry additional political risk given that their government guarantee could be modified or revoked. Agencies' yield spread over Treasuries waxes and wanes over our sample period. Hence, we do not believe that flight-to-quality is important for our study. Gagnon et al. (2011) state that the large decline in agency yields during QE1 demonstrate that LSAPs helped decrease Treasury-agency yield spreads. Further, the authors point to a reversal of flight-to-quality contributing to an uptick in Treasury yields starting in early 2009. The correlation between 10-year Treasuries and 10-year agencies is 0.96 over our sample period.

We have no a priori reason to think that the ability of shorts to predict news should depend on the type of news; however, we believe it is possible that shorts can predict some types of news better than other types of news. For example, if shorts have a particular advantage at understanding the inner workings of the Fed, then they may be able to predict outcomes that release information about monetary outcomes, which are essentially deviations from the Fed's reaction function or a clarification of such a function.

Our second set of hypotheses relates to short portfolio rebalancing after an UMPA.

Hypothesis 6: Shorts find Fed actions credible.

That is, shorts rebalance their portfolios in the days and weeks following FOMC UMPAs in a way that anticipates further actions in the same direction. For example, expansionary surprises should prod shorts to cover their positions.

Research on UMPAs indicates that they affect expectations of future monetary policy. While price effects should be immediate, portfolio rebalancing need not be. Thus, if shorts believe that Fed policies will persistently keep yields down (or up), they will rebalance on the belief in the weeks after the announcement.

Hypothesis 7: Growth news should most strongly affect post-announcement rebalancing.

Growth news will strongly affect views of future monetary policy and yields because business conditions are persistent. In contrast, monetary news, i.e., deviations to a reaction function, or response to risk are more likely to be transitory.

Hypothesis 8: Shorts transact in bonds of all maturities when they rebalance after an UMPA.

Because UMPAs have broadly influenced yields, we hypothesize that shorts trade in bonds across the curve after UMPAs occur.

5. Empirical results

5.1. Did the shorts correctly anticipate UMPAs?

We answer our questions using a broad sample of 42 QE1, QE2, MEP, and QE3 UMPAs from 11/25/2008 to 6/19/2013, which Table 1 describes. Although the Fed only transacted in some bond issues, initial FOMC UMPAs did not indicate which specific securities would be purchased. Hence, our analysis focuses on changes in borrowed quantity for all agencies (ΔABQ) and Treasuries (ΔTBQ).[22]

We turn to our investigation of Hypotheses 1 and 2. For simplicity, we regress measures of announcement surprises—i.e., announcement-day changes in yield, futures prices, term premia, or expected future short rates—on several combinations of lagged ΔABQ and ΔTBQ for all issues. We considered two event windows for changes in futures prices: {-15, +45} minutes around the announcement and open-to-close on day *t*. The announcement window is daily for 10-year yields, term premia, and swap rates. We interpret the latter variable to measure short-rate expectations.

A priori, the appropriate lag length of pre-announcement ΔTBQ and ΔABQ is not obvious. We choose fifteen trading days before the announcement (day t-16 to day t-1), but the results are robust to modest perturbations of period length.

We considered several regressors that might potentially predict announcement surprisess. We found that lagged yield changes and changes in VIX do not predict announcement effects, so we omit them from our specifications. A lagged level of VIX, however, predicts announcement-day surprises and so we include it in our specifications. Contemporaneous values of VIX and other

[22] Although the Fed does not announce the exact issues that it will buy at the announcement of the program, eventually the securities purchased become known. The System Open Market Account (SOMA) Holdings report, which is publicly available on the Federal Reserve Bank of New York's (FRBNY) website, details open market securities purchases by CUSIP. Some experimentation has convinced us that because they do not transact to a greater degree in purchased securities, shorts either do not know or do not care which specific securities the Fed will purchase.

measures of financial market implied volatility provided similar results. To account for the possible ability of stock returns to predict monetary shocks, as found by Neuhierl and Weber (2018) during a period of conventional monetary policy, we considered including lagged 15-day changes in the S&P 500 total return index in the predictive regressions. The swap rate is the only variable that the 15-day lagged stock return predicts to a statistically significant degree. Therefore we omit the lagged stock return from our benchmark analysis. Our finding that stock returns predict monetary-announcement revisions to the expected future path of short rates (i.e., swap rates) is consistent with Neuhierl and Weber's (2018) result that stock returns predict announcement-day changes in overnight rates.

For concreteness, we write the regression of the 10-year futures note price change (ΔP_t^{10yr}) on *ΔABQ*, *ΔTBQ,* and *VIX* as follows:

$$\Delta P_t^{10yr} = b_0 + b_1 \Delta ABQ_{t-16,t-1} + b_2 \Delta TBQ_{t-16,t-1} + b_3 VIX_{t-1} + \varepsilon_t \quad (5)$$

The first ten rows on each panel of Table 3 show the results of regressions of intraday futures price changes around UMPAs on combinations of lagged 15-day *ΔABQ*, *ΔTBQ,* and *Δ*(*ABQ*+*TBQ*). Panel A of Table 3 shows predictive regression results for 60-minute futures returns: 2-, 5-, and 10-year note futures, 30-year bond futures, and S&P 500 stock futures. Panel B similarly shows results for the open-to-close returns for the 5- and 10-year note futures, and changes in daily 10-year constant-maturity Treasury yields, changes in daily 10-year term premia, and changes in daily 10-year swap rates. We continue to interpret swap rates as a proxy for expected future short rates. Table 3, Panel C, displays evidence on the ability of *BQ* to forecast MBS variables. Finally, Panel D depicts similar results for *BQ* predictions of daily log changes in 5 exchange rates and gold. The exchange rates are all expressed as USD prices of euros (EUR), Japanese yen (JPY), Swiss francs (CHF), Canadian dollars (CAD), Australian dollars (AUD), and gold.

Table 3, Panel A, shows that *ΔABQ* predicts announcement window changes in 2-, 5-, and 10-year futures prices. *ΔABQ* generally predicts price changes both on its own and when paired with *ΔTBQ*.[23] The signs on *ΔABQ* coefficients are negative, indicating that a decline in *ABQ* (less shorting) predicts a rise in futures prices (lower yields or expansionary monetary policy). In other words, the shorts adjust their positions correctly in anticipation of monetary policy surprises. As the *ΔBQ* regressors are expressed in billions of dollars, and the dependent variables are expressed in basis points, the coefficient of -1.23 on *ΔABQ* in the 2-year futures regression indicates that a $10 billion (2.8 standard deviations) increase in agency *BQ* in the 15 days prior to an UMPA predicts a 12.3 basis point reduction in the 2-year futures price in the announcement window.

The inclusion of VIX in these regressions eliminates any statistically significant impact of *ΔABQ* or *ΔTBQ* on the 30-year Treasury futures return and significantly reduces the statistical significance of *ΔTBQ* in all models. Because VIX reduces the predictive power of both *ΔBQ* variables, we include it in our benchmark results.

Panel B of Table 3 shows that *ΔABQ* still has predictive power even with daily announcement windows. Average R^2s for the 5- and 10-year securities are typically higher for the daily and open-to-close in Panel B than for the 1-hour windows in Panel A. *ΔABQ* consistently and strongly predicts bond futures and yield changes, with almost all specifications being significant at conventional significance levels. It should not be too surprising that longer windows modestly improve predictability as the unconventional monetary policy events are often complex and probably require hours or even days for markets to absorb the information fully. Neither *ΔBQ* predicts the swap rates to a statistically significant degree. The coefficients in the futures price regressions are negative as in Panel A, again indicating that the shorts adjust their positions

[23] Figure 2 shows that the change (decrease) in agency yield was much greater than the change in treasury yield over the period of our study.

correctly in anticipation of monetary policy surprises. In contrast, the correctly-signed coefficients for the yield and term premia regression are positive because yields and futures prices should react in opposite ways to a monetary announcement. The ability of shorts' ΔABQ to predict changes in both yields and term premia but not swap rates indicates that shorts can predict portfolio balance surprises. Still, it fails to support the idea that they can predict signaling surprises. Thus, the data support one part of hypothesis 2 but not the other.

In Panel A of Table 3, the coefficient on the lagged value of the VIX is also sometimes statistically significant, but never simultaneously with a *BQ* coefficient. In contrast, it is always statistically significant in Panel B, where the dependent variables are either open-to-close futures prices or daily changes in yields, term premia, and swap rates. Its positive value for futures prices is consistent with the interpretation that higher volatility predicts higher futures prices on the days of UMPA. We conclude that both the VIX and ABQ have independent information that predicts spot and futures bond price changes on UMPA days.

Table 3, Panel C shows that *ABQ* similarly predicts four types of daily MBS variables: ICE Bank of America US MBS Index, ICE Bank of America US FNMA MBS Index, Current Coupon ICE Bank of America US MBS, FNMA 30-Year, Current Coupon, and Bloomberg-Barclays US MBS Index Yield-to-Worst. These results are generally comparable to those for the 10-year Treasury yield, with similar significance levels and slightly higher R^2s overall.

Finally, Table 3 clearly illustrates that ABQ also predicts non-bond asset price changes. The last columns of Panel A show that ΔABQ predicts 60-minute stock futures price changes around UMPA, although not quite as strongly as it predicts bond futures price changes. Panel D shows that ΔABQ very consistently predicts daily changes in exchange rates and gold. The coefficient of -0.24 in the leftmost column implies that a $10 billion increase in *ABQ* in the 15 days before an

UMPA predicts a 240 basis point reduction in the dollar price of foreign exchange, i.e., a USD appreciation.[24] Inexplicably, the lagged value of VIX is almost never a statistically significant predictor of these non-bond asset returns.

We investigated the robustness of Table 3 results with a sensitivity test, i.e., removing one observation at a time from the sample. The basic inference was unaffected. We also applied a Wald test for a structural break between the halves of the sample; it could not reject stability.

Table 3 supports hypotheses 1 and 3: Shorts correctly adjust their portfolios before UMPA to profit from yield changes. Those portfolio adjustments also predict stock prices, foreign exchange, and gold prices. There is only partial support of hypothesis 2; however: Short rebalancing predicts changes in term premia but not swap rates, which we take as a proxy for expected interest rates. This combination indicates that shorts predict portfolio balance effects but not signaling effects.

Hypothesis 4 predicts that shorts adjust their portfolios using bonds of all remaining maturities in anticipating monetary policy. To investigate this issue, we calculate bivariate correlations between announcement-day changes in 10-year yields, term premia, and swap rates on lagged 15-day changes (-16 to -1) in ΔABQ or ΔTBQ by time-to-maturity of the borrowed bonds. If shorts anticipate monetary shocks entirely by transacting in long bonds, for example, we expect to see large correlations on long times to maturity and essentially zero coefficients elsewhere.

The three panels of Figure 3 show the correlations of the lagged 15-day changes in daily 10-year yield (Panel A), term premium (Panel B), and swap rate (Panel C) with the ΔABQ and ΔTBQ series by remaining years-to-maturity. Positive correlations indicate that shorts correctly anticipate Fed-induced price changes with bonds of that maturity. Casual inspection suggests that shorts operate throughout the yield curve, but not uniformly, preferring certain times to maturity. For

[24] Log exchange rate changes are expressed in percentage terms, rather than basis points, to reduce the size of the coefficients in Table 3, Panel D.

example, the blue bars in Panel A show that 10-year yield changes on monetary policy announcement days are the most highly correlated with *ΔABQ* with bond times to maturity of 0-to-1, 4-to-5, 7-to-8, 9-to-10, and more-than-14 years. Correlation patterns are similar across yields and term premia because those variables are strongly positively correlated. *ΔABQ* of 4-to-5, 5-to-6, 9-to-10, and 11-to-12 years remaining maturity is most strongly correlated with swap rates. Curiously, *ΔABQ* with 8-to-9 years of remaining maturity is strongly negatively correlated with all dependent variables. Patterns for *ΔTBQ* are weaker than those of *ΔABQ* over the short- and medium-term instruments in Figure 3. We view Figure 3 as supporting the hypothesis that shorts trade across the yield curve.

Hypothesis 5 states that the accuracy of the implicit predictions in shorts' ex-ante rebalancing is invariant to the type of Cieslak-Schrimpf news released by the announcement. Before turning to this issue, recall that Cieslak and Schrimpf (2019) convincingly argues that one can infer the type of news (i.e., monetary, growth, or risk) in a central bank announcement by studying the realized covariances of stock returns with bond yields in windows around UMPAs. We calculate the Cieslak and Schrimpf (2019) news measures for our sample, categorizing each announcement as a monetary, growth, or risk shock, and then ask how *ΔBQ*-prediction accuracy varies with the sort of news released. That is, we estimate the predictive regressions from Table 3 over the whole sample and use the single set of estimated coefficients and data to calculate R^2s for three subsamples defined by the type of news. These conditional R^2s need not be positive as they pertain to only a subsample and need not sum or average to the unconditional R^2s.

Rows 11 to 14 of each panel of Table 3—labeled "R^2 M", "R^2 R", and "R^2 G"—show these conditional R^2s for the asset returns. The conditional R^2s in both Panels A and B of Table 3 show that *ΔABQ*'s predictive ability for bond prices/yields comes from monetary and growth news

releases. Risk releases are often associated with negative conditional R^2s for bond futures prices and yields, indicating that the shorts do not correctly anticipate the release of news later in the sample, as the marginal investor in spot/futures markets became more knowledgeable about the FOMC's unconventional policies. In particular, conditional R^2s for medium and long-term bond futures prices and yields tend to be higher during monetary and growth events than during risk events. To take a crude measure, in Panel A the average "R^2 M" and "R^2 G" for the 4 bond price regressions are 33% and 22%, respectively, but the average "R^2 R" is negative, indicating a worse-than-naïve forecast for this subsample. One peculiarity is that the predictive ability for swap rates diverges from that of the other variables, with *ΔBQ* having good predictive ability during risk and growth events but not monetary events. Of course, *ΔBQ* does not predict changes in swap rates to a statistically significant degree.

ΔBQ predicts bond futures returns somewhat better than stock returns or forex. Table 3 shows that the R^2 over all specifications averages 27% for bond futures (Panel A) but only 12% for stock futures (Panel A) and only 16 percent for foreign exchange (Panel C). This is consistent with the idea that bond shorts are primarily concerned with bond market behavior, and the predictive ability of *BQ* for other asset returns is a byproduct of the covariation of other returns with yield changes.

In addition to computing R^2s and conditional R^2s, we also compute the "% correctly signed" for each regression, that is, the percentage of observations in which the regression specification correctly anticipates the sign of the deviation of the return from its sample mean. Although linear regression does not maximize this statistic, it provides a useful supplementary diagnostic because it would reveal instances in which a regression's seemingly good fit was not indicative of the majority of observations. Rows 17 to 20 of each panel of Table 3 show the "% correctly signed" for each specification. Dark gray shaded cells in Table 3 show such percentages that are

statistically different than 50% at the 5 percent, one-sided level, using the standard normal approximation to the binomial distribution.[25]

Table 3, Panels A and B, show that *ΔBQ* tends to correctly predict the sign of intraday futures returns, open-to-close prices and changes in daily yields and term premia. The great majority of the estimates for bonds are greater than 50%, and many are statistically significantly different from this benchmark. Panel C shows that the forex and gold regressions correctly predict the signs of changes less often, and few of those estimates are statistically significantly different from 50 %.

The medium and long-term bond regressions in Panels A and B of Table 3 predict the highest percentage of correct returns during growth events, consistent with the strong conditional R^2s during such events. The specification with *ΔABQ* alone, for example, predicts the correct direction of 10-year yield during an impressive 86 percent of growth events. Risk and monetary news events yielded good but lesser predictive performance—but still almost always greater than 50% correct. The regressions predicted the correct sign of changes in the 10-year swap rate 75 to 83 percent of the time during risk events, consistent with the relatively good conditional R^2s during risk events.

In summary, *ΔABQ* predicts changes in bond futures prices, 10-year yields, and 10-year term premia on UMPA days to a statistically significant degree. The signs of the coefficients are consistent with portfolio adjustments that correctly anticipated the direction of the announcement news on bonds of all maturities. *ΔABQ* similarly predicts changes in stock prices, forex, and gold on those days, although the predictive power is somewhat less. In contrast, *ΔABQ* and *ΔTBQ* do not strongly predict daily changes in swap rates. The predictive power of shorts is remarkable in a

[25] For the full sample, this critical value is 62.65%. Of course, for the smaller samples associated with the conditional statistics—i.e., conditional on monetary, risk and growth news—the critical values for the statistical significance of the "% correctly signed" grow to 70.5, 73.7, and 71.9, for each set of news because there are fewer observations in the news-based subsamples. Some observations in Table 3 are unshaded but appear to meet these critical values because of rounding.

very wide market in which the policy event is based on public information.

When one uses conditional R^2 to break the predictive power down by the type of Cieslak-Schrimpf news released, one finds that *ΔABQ* has the most predictive ability during days when FOMC decisions released growth or monetary news. *ΔABQ* had no positive predictive ability by conventional regression metrics during days when FOMC decisions contain risk information. This is not consistent with hypothesis 5 that shorts' predictive ability should be independent of the type of news released. In contrast, the metric of percentage-correctly-signed indicates more consistent predictability across types of news, although the medium- and long-bond regressions still do relatively well during periods of growth news. Thus, hypothesis 5 receives mixed support.

5.2. How shorts respond just after the purchase announcements

We next consider hypothesis 6: Shorts find Fed actions to be credible. That is, shorts rebalance their portfolios in the days and weeks following FOMC UMPAs in a way that anticipates further actions in the same direction. To investigate this, we regress *ΔABQ* and *ΔTBQ* from t+1 to t+16 on the 42 announcement-day changes in intraday futures prices and daily changes in yields, term premia, and swap rates. We choose to examine changes from t+1 to t+16 because that appears to show a reasonably good fit for a variety of asset prices/yields and *BQ* measures. We again include the event-day value of the VIX in the regression to control for risk. The response of *ABQ* to policy-induced changes in the 10-year Treasury yield, for example, can be written as follows:

$$\Delta ABQ_{t+1,t+16} = b_0 + b_1 \Delta P_t^{10yr} + b_2 VIX_t + \varepsilon_t \quad (6)$$

Table 4, Panel A, shows the responses of the ex-post 15-day changes in the sums of agency (left subpanel) and Treasury (right subpanel) *ΔBQ* to policy-induced futures returns and changes in yields and term premia. All but one of the coefficients on returns/yield changes are statistically significant for the *ΔABQ* specifications. The signs of the coefficients are consistent with a credible

impact of policy. That is, the coefficients on futures prices are generally negative, indicating that higher bond futures prices (an expansion) is followed by a decline in *ABQ* (i.e., *ΔABQ* is negative), consistent with the hypothesis that shorts expect further declines in yields. The -0.025 coefficient on 5-year futures prices would be interpreted to mean that a ten basis point 5-year futures return would be associated with a post-announcement reduction of $0.25 billion in agency BQ. The coefficients on yield changes are positively signed in the bivariate regressions, again indicating that an expansion is followed by a decline in *ABQ*, i.e., covering by shorts. Announcement price/yield changes predict *ΔABQ* much more strongly than *ΔTBQ*, producing much higher R^2s for the former. Only one *ΔTBQ* specification includes statistically significant coefficients and the coefficients of that multivariate specification are not jointly significant.

The VIX coefficients are always statistically significant in Table 4. Without VIX, the bond returns would show much greater predictive ability in Table 4. Specifically, nearly every coefficient on returns/yield changes would be statistically significant for both *ΔTBQ* and *ΔABQ*. We omit those results for brevity.

Table 4, Panel B addresses hypothesis 7: Growth news should most strongly affect post-announcement rebalancing. That is, we again regress 15-day ex-post *ΔBQ* on announcement-day changes in the 10-year yield, but we interact that change in the 10-year yield with indicator variables—$I(M_t), I(R_t)$ and $I(G_t)$—that take the value 1 if the announcement in question releases monetary, risk, or growth news. For the response of *ABQ* to policy-induced changes in the 10-year treasury yield, we write the regression as follows:

$$\Delta ABQ_{t+1,t+16} = b_0 + b_1 \Delta P_t^{10yr} I(M_t) + b_2 \Delta P_t^{10yr} I(R_t) + b_3 \Delta P_t^{10yr} I(G_t) + b_4 VIX_t + \varepsilon_t \quad (7)$$

If all types of news produce similar rebalancing in *ΔBQ*, we might expect to find similarly sized, positive coefficients in Table 4, Panel B. Because there are relatively few observations for each

type of news, one might expect less precision and statistical significance than for the whole sample of 42 observations. Panel B shows, however, that yield changes during growth news produce practically all the predictive power for ΔBQ regressions. The positive coefficient on the yield changes means that an expansionary (contractionary) monetary shock, i.e., a decline (rise) in the 10-year yield, is associated with a post-announcement reduction in BQ. The coefficient of 0.0015 is small, however. It can be interpreted to mean that a 10 basis point increase in yields is associated with an increase of only \$0.015 billion (\$15 million) in ABQ. Shorts cover (expand) their short positions following monetary-induced changes in yields that are expansionary (contractionary) and are accompanied by growth news releases. We interpret this fact to support hypothesis 6 partially and fully support hypothesis 7: Shorts do not find Fed actions credible in themselves, but they act on Fed actions that have implications for expected growth.

Finally, we turn to hypothesis 8: When the shorts rebalance in the wake of an UMPA, they will transact in bonds of all remaining maturities. We investigate this hypothesis in a manner similar to that with which we examined hypothesis 4. That is, we compute correlations between announcement-day changes in 10-year yields and post-announcement 15-day ΔABQ and ΔTBQ by time-to-maturity of the borrowed bonds. If shorts adjust their portfolios entirely or mainly through their holdings of bonds with long times-to-maturity, for example, then we expect large coefficients on long times to maturity and essentially zero coefficients elsewhere.

Figure 4 shows these correlations between announcement day 10-year yield changes and ex-post portfolio adjustment by time-to-maturity. That is, it shows how shorts adjust their holdings by time-to-maturity in the wake of UMPAs. Positive coefficients indicate that shorts find Fed signals to be credible in the sense that reduced yields are associated with lower BQ as shorts presumably anticipate further declines in yields. Shorts adjust their portfolios in the wake of

UMPAs throughout the yield curve for both agencies and Treasuries, supporting hypothesis 8. *ΔABQ* and *ΔTBQ* of less than six years maturity tend to be strongly correlated with changes in 10-year yields, consistent with the finding that *ΔABQ* and *ΔTBQ* rebalancing is most sensitive to growth news, which will affect interest rate expectations over that horizon. *ΔTBQ* is generally less correlated with previous 10-year yield changes than is *ΔABQ*.

6. Conclusion

In response to the financial and economic crisis resulting from the collapse of the housing bubble, in November 2008, the Federal Reserve began unconventional monetary policy programs that included forward guidance and asset purchases to reduce long-term interest rates and to stimulate investment and consumption. A series of studies persuasively showed that these programs successfully reduced long yields and term premia and moved other asset prices, such as stock prices and foreign exchange rates, in desired directions. The unprecedented size and success of these unconventional programs have rendered them one of the most important episodes in bond market history.

We investigate the bond-market behavior of shorts, widely regarded as among the most sophisticated investors, before and after Federal Reserve monetary policy announcements. We find that pre-announcement changes in the borrowed quantity of agency bonds systematically predict changes in bond futures prices/yields throughout the yield curve during the Federal Reserve's 42 unconventional monetary policy announcements from November 2008 through July 2013. That is, shorts tended to cover (expand) their short positions in agencies and Treasuries in the weeks prior to expansionary (contractionary) monetary announcements. Agency borrowed quantity has a somewhat greater predictive power than Treasury borrowed quantity. Changes in agency borrowed quantity predict changes in term premia but not expected short rates (swap rates). Using the

methods of Cieslak-Schrimpf (2019) to construct the news content of monetary actions, we find that changes in agency borrowed quantity best predict bond futures prices and yields during events that release monetary or (especially) growth news. Shorts generally transact throughout the yield curve when rebalancing their portfolios before announcements.

Anticipating monetary policy surprises is a stringent test for the forecasting ability of shorts who must out-predict marginal investors in very deep spot/futures bond markets whose prices are determined almost entirely by public information. We believe that the fact that a set of sophisticated investors systematically outperformed marginal investors in spot and futures markets in predicting unconventional monetary policy actions is an exceptional result with respect to market efficiency and monetary policy expectations. We believe that the shorts use public information in a more sophisticated way than the marginal spot/futures market investor rather than having access to private information, but we must admit that this is conjecture.

We also examine the behavior of shorts after monetary policy announcements. Shorts found the announcements "credible" in the sense that expansionary (contractionary) announcements would lead them to cover (expand) their positions in the weeks following the event, but this pattern only existed when the Fed released growth news. Shorts made their post-event portfolio adjustments in bond positions across the yield curve but particularly in agencies from 0 to 6 years, which is consistent with greater sensitivity of positions in 0-6-year bonds to growth news.

Our research extends and complements previous research on the acuity of shorts as sophisticated investors to a new context. Our results also indicate that sophisticated investors understood the Federal Reserve's unconventional monetary policies better than did the marginal bond market investor.

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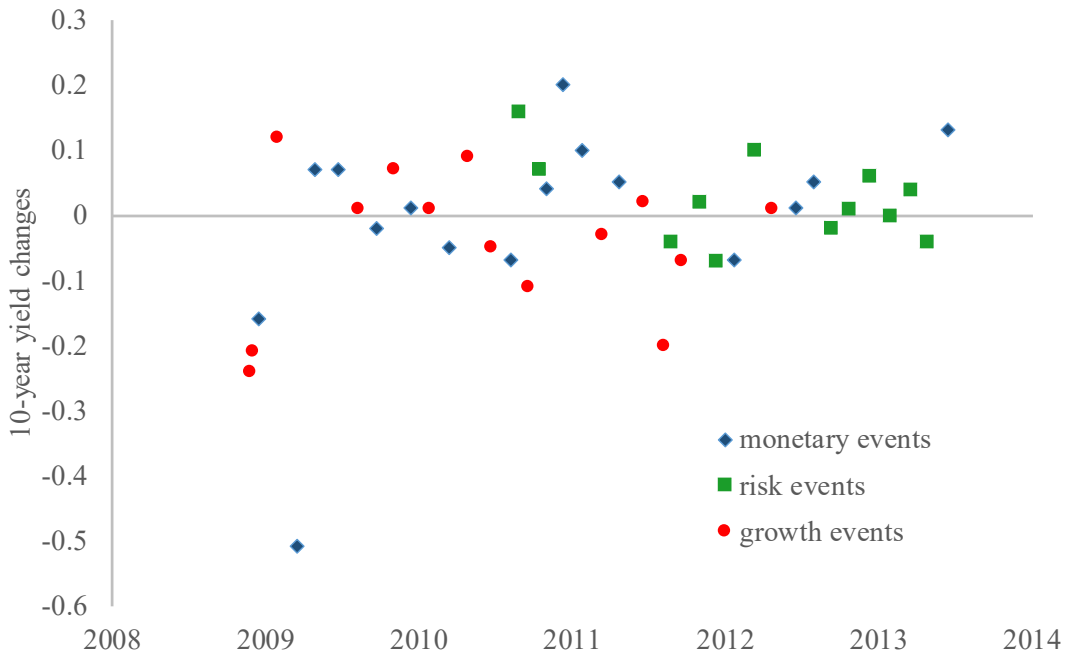
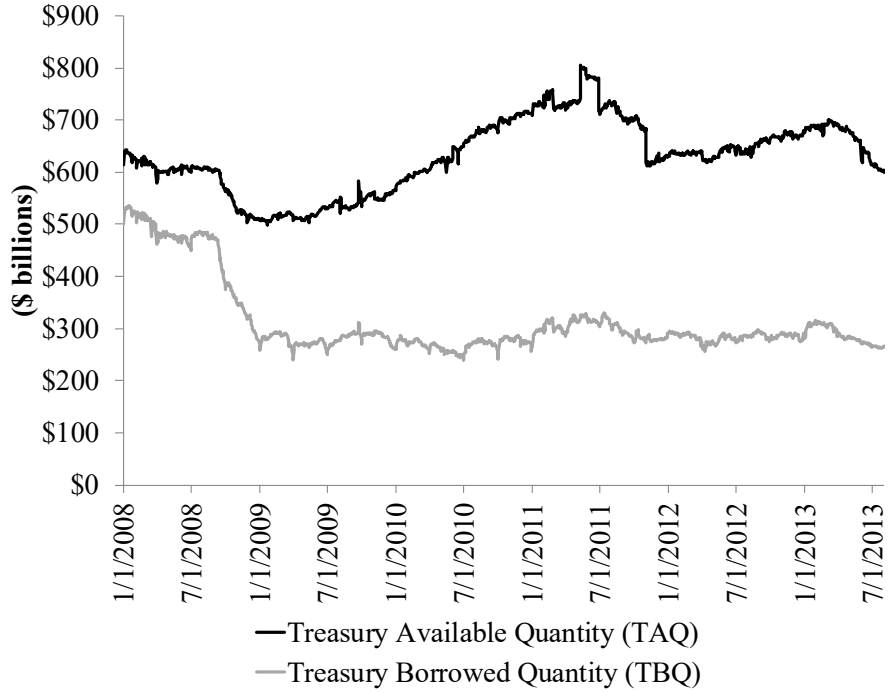
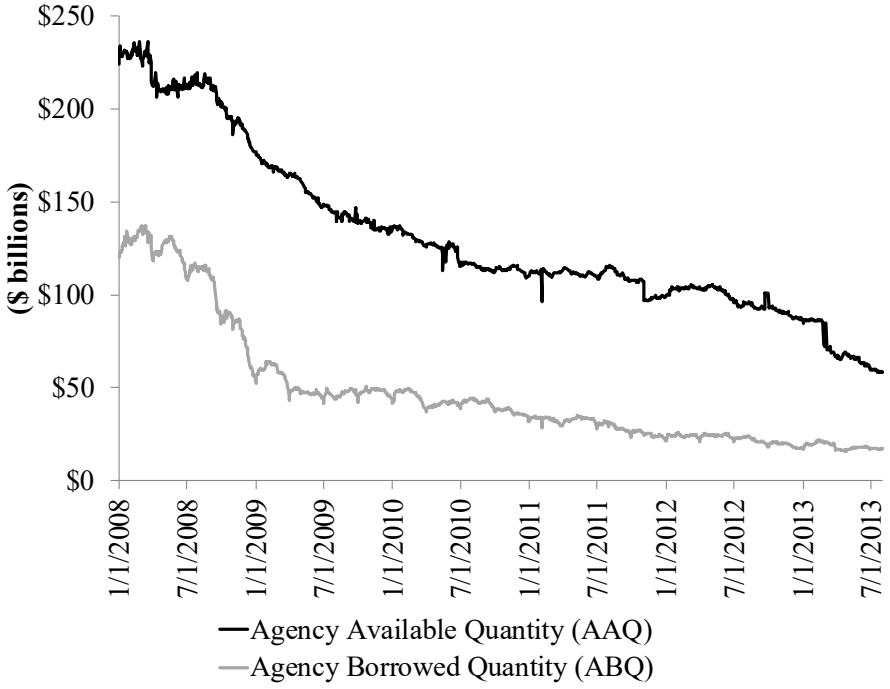


Figure 1. Daily 10-year Treasury yield changes around 42 unconventional monetary policy announcements
We present changes in nominal yields in percent for 10-year constant maturity U.S. Treasuries, 10-year agencies (FMC 84), in 1-day windows around 42 unconventional monetary policy announcements from 11/25/2008 to 7/31/2013.



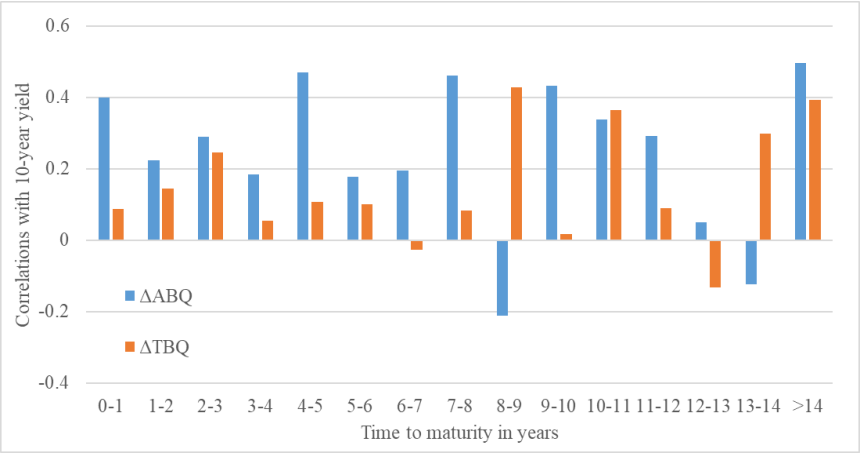
Panel A. Treasuries



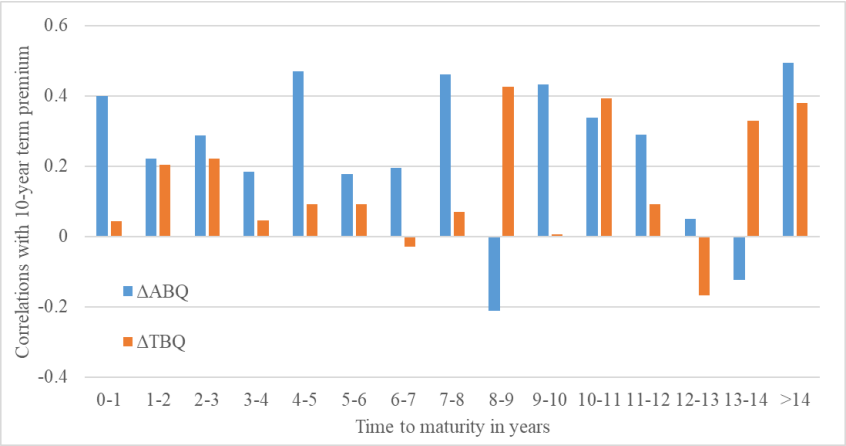
Panel B. Agencies

Figure 2. Quantity of Treasuries and agencies available to short and shorted, by day

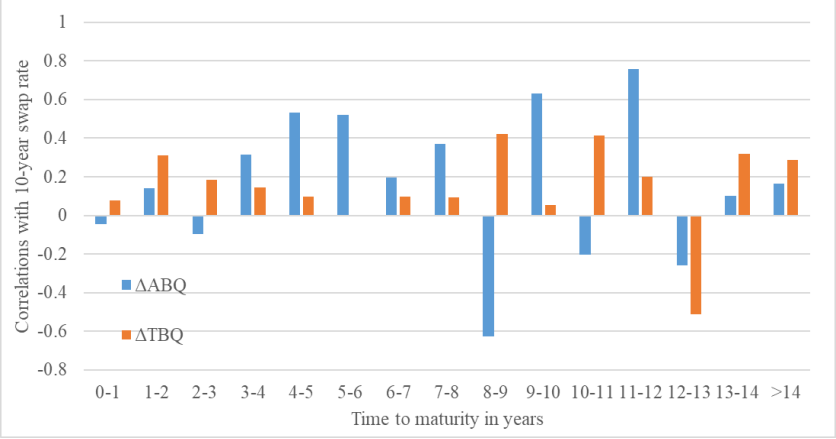
We present the total daily quantity available and borrowed (our proxies for securities available to be shorted and actually shorted, respectively) for Treasuries (Panel A) and agencies (Panel B) from 1/1/2008 to 7/31/2013. Values are in billions of USD and based on par value. In the text, Treasuries (agencies) available and borrowed quantity in Panel A (Panel B) are referred to as *TAQ* and *TBQ* (*AAQ* and *ABQ*), respectively.



Panel A. 10-year-Treasury yields



Panel B. 10-year term premia



Panel C. 10-year swaps

Figure 3. Standardized coefficients of 15-day lags of ΔBQ

We show the standardized coefficients for regressions of each of the three dependent-variable (Panel A, 10-year-Treasury yields; Panel B, 10-year term premia; and Panel C, 10-year swaps) on *ΔABQ* and *ΔTBQ* for varying times to maturity.

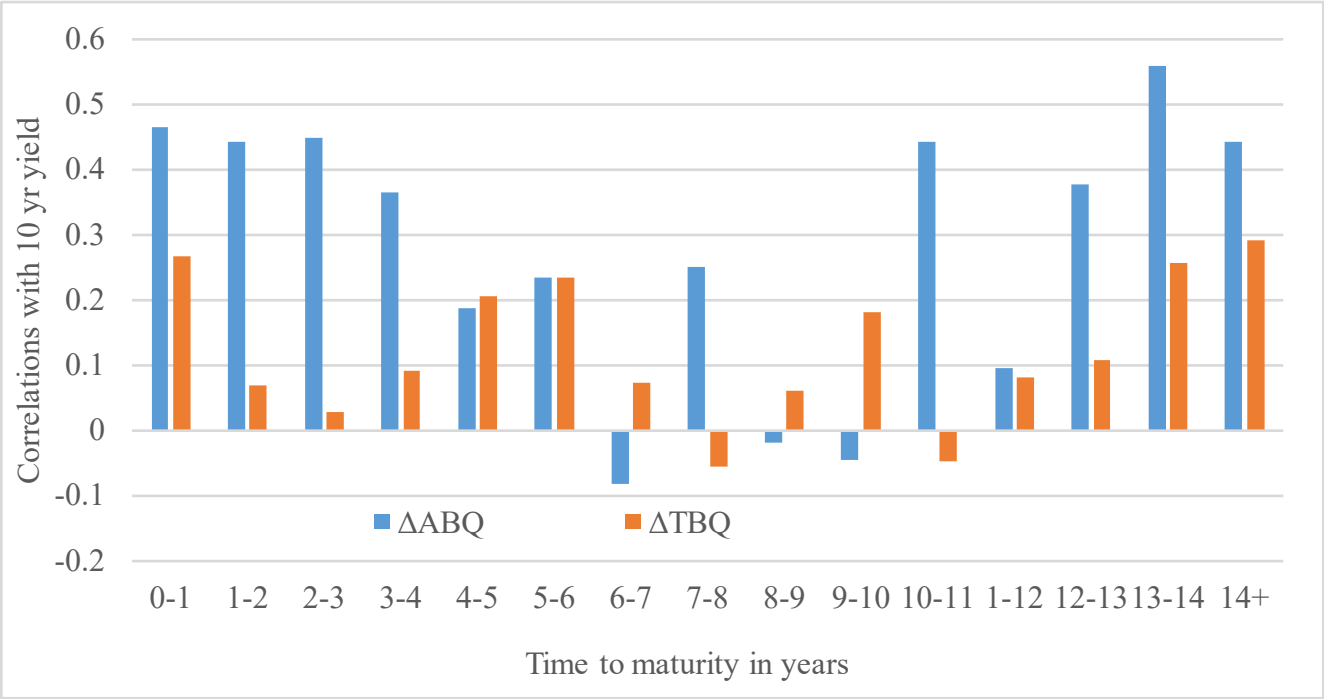


Figure 4. Standardized coefficients of the 15-day lead of *ΔBQ*

We show the standardized coefficients for the regression of 15-day leads of *ΔABQ* and *ΔTBQ*, for varying times to maturity, on daily changes in 10-year yields on days of monetary policy events.

Table 1
Unconventional monetary policy announcements (UMPAs)
The 42 UMPAs during QE1, QE2, MEP, and QE3 from November 2008 through June 2013. The UMPAs consist of FOMC statements, speeches, press releases, and announcements.

Date	Time	Type	Program	Description
11/25/2008	8:15 AM	Press Release	QE1	Large scale asset purchases (LSAP) announced: Fed will purchase $100 billion in GSE debt and $500 billion in MBS.
12/1/2008	1:45 PM	Speech	QE1	Chairman Bernanke says in a speech that the Fed could purchase long-term Treasuries.
12/16/2008	2:15 PM	Meeting	QE1	First suggestion of extending QE to Treasuries by FOMC. Fed cuts fed funds rate to 0-0.25 percent. FOMC expects exceptionally low rates “for some time.”
1/28/2009	2:15 PM	Meeting	QE1	Fed stands ready to expand QE and buy Treasuries.
3/18/2009	2:15 PM	Meeting	QE1	LSAP expanded: Fed will purchase $300 billion in long-term Treasuries and $750 and $100 billion in MBS and GSE debt, respectively. Fed expects exceptionally low rates for "an extended period."
4/29/2009	2:15 PM	Meeting		No change in policy.
6/24/2009	2:15 PM	Meeting		No change in policy.
8/12/2009	2:15 PM	Meeting	QE1	LSAP slowed: All purchases will finish by the end of October, not mid-September.
9/23/2009	2:15 PM	Meeting	QE1	LSAP slowed: Agency debt and MBS purchases will finish at the end of 2010Q1.
11/4/2009	2:15 PM	Meeting	QE1	LSAP downsized: Agency debt purchases will finish at $175 billion.
12/16/2009	2:15 PM	Meeting		No change in policy.
1/27/2010	2:15 PM	Meeting		No change in policy.
3/16/2010	2:15 PM	Meeting		No change in policy.
4/28/2010	2:15 PM	Meeting		No change in policy.
6/23/2010	2:15 PM	Meeting		No change in policy.
8/10/2010	2:15 PM	Meeting	QE1	Balance Sheet Maintained: Fed will reinvest principal payments from LSAP purchases in Treasuries.
8/27/2010	10:00 AM	Speech	QE2	Bernanke suggests role for additional QE, "should further action prove necessary."
9/21/2010	2:15 PM	Meeting	QE2	FOMC emphasizes low inflation, which is "is likely to remain subdued for some time."
10/15/2010	2:15 PM	Conference Call	QE2	Bernanke reiterates that Fed stands ready to ease policy further.
11/3/2010	2:15 PM	Meeting	QE2	QE2 announced: Fed will purchase $600 billion in Treasuries.
12/14/2010	2:15 PM	Meeting		No change in policy.
1/26/2011	2:15 PM	Meeting		No change in policy.

Table 1—Continued

Date	Time	Type	Program	Description
3/15/2011	2:15 PM	Meeting		No change in policy.
4/27/2011	12:30 PM	Meeting		No change in policy.
6/22/2011	12:30 PM	Meeting	QE2	QE2 finishes: Treasury purchases will wrap up at the end of the month; principal payments will continue to be reinvested.
8/9/2011	2:15 PM	Meeting		FOMC expects low rates "at least through mid-2013."
8/26/2011	10:00 AM	Speech		Bernanke offers no specifics on future plans but says Fed has tools it can use if necessary.
9/21/2011	2:15 PM	Meeting	MEP	MEP ("Operation Twist") announced.
11/2/2011	12:30 PM	Meeting		No change in policy.
12/13/2011	2:15 PM	Meeting		No change in policy.
1/25/2012	12:30 PM	Meeting		FOMC expects low rates "at least through late 2014."
3/13/2012	2:15 PM	Meeting		No change in policy.
4/25/2012	12:30 PM	Meeting		No change in policy.
6/20/2012	12:30 PM	Meeting	MEP	MEP extended until end of 2012.
8/1/2012	2:15 PM	Meeting		No change in policy.
9/13/2012	12:30 PM	Meeting	QE3	QE3 announced: Fed will purchase $40 billion of MBS per month as long as "the outlook for the labor market does not improve substantially…in the context of price stability." FOMC expects low rates “at least through mid-2015.”
10/24/2012	2:15 PM	Meeting		No change in policy.
12/12/2012	12:30 PM	Meeting	QE3	QE3 expanded: Fed will continue purchasing $45 billion of long-term Treasuries per month but will no longer sterilize purchases through the sale of short-term Treasuries. FOM expects low rates to be appropriate while unemployment is above 6.5 percent, and inflation is forecasted below 2.5 percent.
1/30/2013	2:15 PM	Meeting		No change in policy.
3/20/2013	2:00 PM	Meeting		No change in policy.
5/1/2013	2:00 PM	Meeting		No change in policy.
6/19/2013	2:00 PM	Meeting	QE3	FOMC will "continue purchasing additional agency mortgage-backed securities at a pace of $40 billion per month and longer-term Treasury securities at a pace of $45 billion per month." Statement indicates no funds target rises in 2013.

Table 2
Issue characteristics of Treasuries and agencies
This table summarizes the bond-level characteristics of the 479 Treasuries and 3,714 agencies in our sample.

	Treasuries	Agencies
N	479	3,714
Issue Size (mill. $)	29,637	1,584
Coupon rate (%)	3.93	3.11
Duration (years)	4.55	4.05
Time-to-maturity (years)	5.94	3.16
YTM (%)	2.44	4.45

Table 3

Regression results

Panel A: Results from regressing 60-minute futures price changes around UMPAs on combinations of lagged 15-day *ΔABQ*, *ΔTBQ*, and *Δ(ABQ+TBQ)*.

	2-yr				5-yr				10-yr				30-yr				S&P 500 stock			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ΔABQ	-1.23			-1.57	-4.43			-5.66	-7.07			-8.91	-5.98			-7.18	-7.56			-10.38
SE	(0.41)			(0.47)	(1.47)			(1.68)	(2.72)			(3.14)	(3.78)			(4.43)	(4.09)			(4.72)
ΔTBQ		-0.04		0.21		-0.14		0.75		-0.28		1.13		-0.40		0.74		0.09		1.73
SE		(0.14)		(0.15)		(0.51)		(0.52)		(0.92)		(0.98)		(1.21)		(1.38)		(1.33)		(1.47)
Δ(ABQ+TBQ)			-0.11				-0.41				-0.68	0.00			-0.69				-0.46	
SE			(0.12)				(0.42)				(0.77)	(0.00)			(1.02)				(1.12)	
VIX(-1)	0.03	0.22	0.16	0.08	0.50	1.18	0.97	0.68	1.04	2.09	1.76	1.31	1.97	2.78	2.51	2.15	0.33	1.66	1.30	0.75
SE	(0.12)	(0.13)	(0.13)	(0.12)	(0.42)	(0.46)	(0.47)	(0.43)	(0.78)	(0.83)	(0.86)	(0.81)	(1.08)	(1.10)	(1.14)	(1.14)	(1.17)	(1.20)	(1.25)	(1.22)
Constant	-0.1	-3.5	-2.5	-1.0	-11.5	-23.8	-20.1	-14.9	-25.3	-44.6	-38.6	-30.5	-56.4	-71.1	-66.1	-59.8	3.5	-20.8	-14.2	-4.5
SE	3.0	3.3	3.3	3.0	10.6	11.8	11.9	10.8	19.7	21.3	21.6	20.2	27.4	28.1	28.5	28.4	29.7	30.8	31.4	30.3
F stat	8.2	2.8	3.3	6.4	12.1	5.8	6.4	9.1	10.3	5.7	6.2	7.4	7.5	5.9	6.1	5.0	3.4	1.4	1.5	2.8
p-value	0.00	0.08	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.26	0.23	0.06
R^2 All	30	12	14	34	38	23	25	42	35	23	24	37	28	23	24	28	15	7	7	18
R^2 M	60	25	29	67	45	27	28	52	35	23	24	39	18	16	15	20	32	18	19	39
R^2 R	-10	17	4	-31	-17	-15	-26	-22	-11	-7	-16	-9	-7	-7	-10	-3	4	-15	-12	-4
R^2 G	-36	-18	-20	-37	29	18	24	22	47	28	36	38	58	48	52	55	-1	0	-1	1
% All	48	64	62	62	52	62	57	64	74	67	62	69	64	62	60	64	57	48	48	60
% M	63	56	56	81	50	44	38	56	69	63	56	63	56	50	50	50	56	50	44	63
% R	42	83	83	50	50	83	83	67	67	67	67	67	58	58	58	67	58	50	58	58
% G	36	57	50	50	57	64	57	71	86	71	64	79	79	79	71	79	57	43	43	57

NOTES: Panel A of Table 3 shows results from regressing announcement-day log changes in (i) 2-year, 5-year, 10-year and 30-year Treasury futures prices, against the lagged 15 -day change in agencies borrowed quantity, *ΔABQ*, Treasuries borrowed quantity, *ΔTBQ*, and *Δ(ABQ+TBQ)* and lagged VIX. The changes in futures prices are constructed for {-15, +45} minute windows, and standard errors (SE) are in parentheses. Light gray shaded cells denote significance at the 5 percent, one-sided level.

Table 3—Continued

Panel B: Results from regressing open-to-close futures prices, daily yields, term premia and swap rates on combinations of lagged 15-day *ΔABQ*, *ΔTBQ*, and *Δ(A+TBQ)*

	Futures (Δopen-to-close)								Spot Δdaily											
	5-yr				10-yr				10-yr yields				10-yr term premia				10-yr swap			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ΔABQ	-6.07			-7.65	-10.32			-12.69	1.08			1.22	0.82			0.98	-0.07			-0.30
SE	(1.81)			(2.11)	(3.27)			(3.83)	(0.54)			(0.64)	(0.43)			(0.51)	(0.33)			(0.38)
ΔTBQ		-0.34		0.95		-0.72		1.43		0.12		-0.09		0.07		-0.09		0.09		0.14
SE		(0.66)		(0.67)		(1.17)		(1.22)		(0.18)		(0.20)		(0.14)		(0.16)		(0.10)		(0.12)
Δ(ABQ+TBQ)			-0.67				-1.23				0.16	0.00			0.11				0.06	
SE			(0.54)				(0.96)				(0.15)	(0.00)			(0.12)				(0.09)	
VIX(-1)	0.87	1.65	1.38	1.11	1.70	2.95	2.50	2.05	-0.38	-0.49	-0.44	-0.40	-0.29	-0.38	-0.35	-0.31	-0.32	-0.27	-0.27	-0.29
SE	(0.52)	(0.60)	(0.60)	(0.54)	(0.93)	(1.06)	(1.07)	(0.98)	(0.15)	(0.16)	(0.17)	(0.16)	(0.12)	(0.13)	(0.13)	(0.13)	(0.09)	(0.09)	(0.10)	(0.10)
Constant	-23.5	-37.7	-32.6	-28.1	-46.9	-69.8	-61.3	-53.9	10.2	12.2	11.3	10.6	7.6	9.3	8.6	8.0	7.3	6.2	6.4	6.6
SE	13.7	15.7	15.7	13.9	24.6	27.9	27.8	25.2	4.0	4.3	4.3	4.2	3.2	3.4	3.5	3.4	2.5	2.5	2.5	2.5
F stat	15.3	7.4	8.3	11.2	14.9	7.8	8.7	10.5	11.8	9.0	9.6	7.8	10.6	8.1	8.5	7.1	8.4	9.0	8.7	6.1
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R^2 All	44	27	30	47	43	29	31	45	38	32	33	38	35	29	30	36	30	31	31	33
R^2 M	36	28	27	42	40	29	29	44	31	27	27	32	28	25	24	31	-93	-96	-98	-84
R^2 R	-11	-31	-35	-12	-3	-12	-15	-6	-4	-10	-11	-3	-6	-12	-13	-6	27	30	30	30
R^2 G	77	41	53	72	76	43	56	71	66	55	60	64	65	53	58	61	50	52	52	52
% All	67	64	62	57	67	62	60	64	69	64	62	67	67	62	62	62	60	60	60	62
% M	63	56	50	56	56	56	50	63	63	63	56	63	56	56	56	56	44	44	44	50
% R	58	67	67	42	67	58	58	58	67	58	58	67	67	58	58	58	75	75	75	83
% G	79	71	71	71	79	71	71	71	79	71	71	71	79	71	71	71	64	64	64	57

NOTES: Panel B shows results from regressing FOMC-announcement-day open-to-close changes in log futures prices (left two panels) and log changes in daily yields, term premia and swap rates (right three panels) on lagged 15-day changes in agencies borrowed quantity, *ΔABQ*, Treasuries borrowed quantity, *ΔTBQ*, *Δ(ABQ+TBQ)*, and VIX.

Table 3—Continued

Panel C: Results from regressing of daily MBS yield changes around UMPAs on combinations of lagged 15-day *ΔABQ*, *ΔTBQ*, and *Δ(A+TBQ)*

	ICE BoA MBS				ICE BoA MBS CC				ICE BoA MBS 30 yr CC				BB MBS			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Sum agency BQ	1.22	0.00	0.00	1.28	1.95	0.00	0.00	2.12	2.24	0.00	0.00	2.41	1.60	0.00	0.00	1.65
(s.e.)	(0.82)	(0.00)	(0.00)	(0.98)	(0.87)	(0.00)	(0.00)	(1.04)	(1.01)	(0.00)	(0.00)	(1.21)	(0.63)	(0.00)	(0.00)	(0.76)
Sum Treasury BQ	0.00	0.18	0.00	-0.03	0.00	0.26	0.00	-0.10	0.00	0.30	0.00	-0.11	0.00	0.25	0.00	-0.03
(s.e.)	(0.00)	(0.27)	(0.00)	(0.31)	(0.00)	(0.29)	(0.00)	(0.33)	(0.00)	(0.34)	(0.00)	(0.39)	(0.00)	(0.21)	(0.00)	(0.24)
Sum agency+Treasury BQ	0.00	0.00	0.21	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.29	0.00
(s.e.)	(0.00)	(0.00)	(0.22)	(0.00)	(0.00)	(0.00)	(0.24)	(0.00)	(0.00)	(0.00)	(0.28)	(0.00)	(0.00)	(0.00)	(0.18)	(0.00)
VIX(-1)	-0.67	-0.76	-0.72	-0.67	-0.73	-0.90	-0.82	-0.75	-0.71	-0.90	-0.81	-0.73	-0.43	-0.56	-0.50	-0.44
(s.e.)	(0.23)	(0.24)	(0.25)	(0.25)	(0.25)	(0.26)	(0.27)	(0.26)	(0.29)	(0.31)	(0.31)	(0.31)	(0.18)	(0.19)	(0.20)	(0.19)
constant	15.2	17.0	16.1	15.4	16.4	19.6	18.1	16.9	15.8	19.4	17.7	16.3	10.6	12.8	11.6	10.7
(s.e.)	6.2	6.4	6.4	6.4	6.5	7.0	7.0	6.8	7.6	8.1	8.1	7.9	4.8	5.1	5.1	5.0
F stat	11.3	9.9	10.3	7.4	15.9	12.3	13.1	10.4	12.8	9.6	10.3	8.3	14.3	10.3	11.4	9.3
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R^2 All	37	34	35	37	45	39	40	45	40	33	35	40	42	35	37	42
R^2 M	35	31	31	36	48	41	42	49	50	41	41	51	45	36	37	46
R^2 R	-5	-5	-4	-5	-11	-15	-14	-12	-10	-12	-11	-11	-12	-15	-14	-12
R^2 G	59	56	58	59	69	63	66	69	60	54	57	59	59	50	54	58
% All	64	64	64	67	76	71	69	74	76	69	67	76	76	67	67	76
% M	50	50	50	50	75	75	69	75	69	75	69	75	75	63	63	75
% R	67	67	67	75	67	58	58	67	67	58	58	67	75	67	67	75
% G	79	79	79	79	86	79	79	79	93	71	71	86	79	71	71	79

NOTES: Panel C shows results from regressing FOMC-announcement-day changes for 4 types of MBS yields on lagged 15-day changes in agencies borrowed quantity,(ΔABQ), Treasuries borrowed quantity (*ΔTBQ*, *Δ(ABQ+TBQ)*, and VIX. ICE Bank of America US MBS Index, ICE Bank of America US FNMA MBS Index, Current Coupon ICE Bank of America US MBS, FNMA 30-Year, Current Coupon, and Bloomberg-Barclays US MBS Index Yield-to-Worst.

Table 3—Continued

Panel D: Results from regressing of daily exchange rate changes around UMPAs on combinations of lagged 15-day *ΔABQ*, *ΔTBQ*, and *Δ(A+TBQ)***

	ΔUSD/EUR				ΔUSD/JPY				ΔUSD/CHF				ΔUSD/CAD				ΔUSD/AUD				ΔUSD/GOLD			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ΔABQ	-0.24			-0.30	-0.13			-0.19	-0.24			-0.30	-0.10			-0.13	-0.21			-0.29	-0.15			-0.24
SE	(0.06)			(0.07)	(0.06)			(0.07)	(0.06)			(0.07)	(0.05)			(0.06)	(0.08)			(0.09)	(0.09)			(0.10)
ΔTBQ		-0.01		0.04		0.01		0.04		-0.01		0.04		0.00		0.02				0.05				0.06
SE		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.03)		(0.03)		(0.03)		(0.03)
Δ(ABQ+TBQ)			-0.02				0.00				-0.02	0.00			-0.01				-0.01				0.00	
SE			(0.02)				(0.02)				(0.02)	(0.00)			(0.01)				(0.02)				(0.02)	
VIX(-1)	-0.01	0.03	0.01	0.00	0.01	0.04	0.03	0.02	-0.01	0.02	0.01	0.00	-0.01	0.00	0.00	-0.01	-0.02	0.01	0.00	-0.01	-0.02	0.01	0.00	-0.01
SE	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	0.0	-0.7	-0.5	-0.2	-0.3	-0.8	-0.7	-0.5	0.2	-0.5	-0.3	0.0	0.1	-0.2	-0.1	0.0	0.2	-0.5	-0.3	0.0	0.3	-0.3	-0.2	0.0
SE	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6
F stat	10.1	1.8	2.6	8.1	5.3	2.5	2.5	4.8	9.8	1.5	2.2	8.0	2.0	0.1	0.3	1.6	4.0	0.2	0.4	3.9	1.5	0.2	0.0	2.3
p-value	0.00	0.17	0.09	0.00	0.01	0.09	0.10	0.01	0.00	0.25	0.12	0.00	0.16	0.88	0.74	0.21	0.03	0.80	0.68	0.02	0.23	0.79	0.99	0.09
R^2 All	34	9	12	39	21	11	11	28	34	7	10	39	9	1	2	11	17	1	2	24	8	1	0	16
R^2 M	44	18	19	56	26	16	15	39	51	17	21	61	18	4	4	25	23	8	6	38	15	3	0	35
R^2 R	1	-19	-20	-13	26	26	25	15	0	-17	-21	4	4	-2	6	-24	8	-9	-3	-29	-5	-3	0	-26
R^2 G	16	-10	1	6	-10	-28	-18	-33	-42	-33	-21	-66	-4	-5	-4	-6	8	-10	-6	4	-3	0	-1	0
% All	60	52	50	67	57	60	62	52	62	50	52	64	40	40	45	50	57	52	48	60	43	62.5	58	73
% M	63	63	56	69	50	56	56	50	63	63	56	69	44	50	50	69	63	69	56	69	44	75	75	94
% R	50	58	50	67	67	58	67	50	58	50	42	75	50	42	58	25	67	33	50	58	30	60	60	50
% G	64	36	43	64	57	64	64	57	64	36	57	50	29	29	29	50	43	50	36	50	50	50	36	64

NOTES: Panel D shows results from regressing FOMC-announcement-day log changes in daily exchange rates and gold prices on lagged 15-day changes in agencies borrowed quantity (*ΔABQ)*, Treasuries borrowed quantity (*ΔTBQ*, *Δ(ABQ+TBQ*), and VIX. All exchange rates are expressed as USD per unit of foreign exchange.

Table 4
Regression results

Panel A: 15-day ex-post ΔABQ and ΔTBQ on open-to-close changes in futures price and changes in daily yields, term premia, and swaps

	ΔABQ						ΔTBQ					
Open-to-close												
Δ5-yr futures	-0.025					-0.135	-0.034					-0.596
SE	(0.013)					(0.050)	(0.048)					(0.207)
Δ10-yr futures		-0.010				0.083		-0.002				0.372
SE		(0.007)				(0.030)		(0.027)				(0.124)
Daily												
Δ10-yr yields			0.081			0.235			0.083			0.975
SE			(0.047)			(0.256)			(0.176)			(1.064)
Δ10-yr Term premia				0.101		-0.119				0.101		-0.786
SE				(0.059)		(0.370)				(0.219)		(1.539)
Δ10-yr swap					0.241	0.246					0.069	0.085
SE					(0.078)	(0.070)					(0.315)	(0.293)
VIX(0)	-0.19	-0.21	-0.20	-0.20	-0.16	-0.11	-0.47	-0.53	-0.49	-0.50	-0.52	-0.45
SE	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.17)	(0.17)	(0.17)	(0.17)	(0.18)	(0.19)
Constant	3.88	4.13	3.86	3.94	3.10	2.02	11.20	12.49	11.56	11.67	12.13	10.95
SE	(1.22)	(1.25)	(1.26)	(1.24)	(1.17)	(1.19)	(4.54)	(4.61)	(4.68)	(4.60)	(4.72)	(4.97)
F stat	23.03	21.17	22.30	22.31	29.27	14.54	7.88	7.52	7.68	7.67	7.55	4.72
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.17	0.15	0.16	0.17	0.13
R^2	54	52	53	53	60	71	29	28	28	28	28	45

NOTES: The table shows results of regressing *ΔABQ* and *ΔTBQ*, in turn, against VIX and changes in (1) futures prices, (2) yields, (3) term premia, and (4) expected future short rates (in Panel A). In Panel B, we regress *ΔABQ* and *ΔTBQ*, in turn, on announcement-day changes in the 10-year yield interacted with the indicator variables—$I(M_t)$, $I(R_t)$, and $I(G_t)$—that take the value 1 if the announcement releases Monetary, Risk, or Growth news, respectively. Standard errors (SE) are in italics. Light gray shaded values are significant at the 5 percent, one-sided level. N = 42.

Table 4—Continued

Panel B: 15-day ex-post ΔABQ and ΔTBQ on VIX and daily changes in 10-year Treasury yield interacted with $I(M_t)$, $I(R_t)$, and $I(G_t)$, respectively

	ΔABQ				ΔTBQ			
Δ 10-yr yields* $I(M_t)$	0.0013			0.0189	-0.0007			0.0658
SE	(0.0542)			(0.0532)	(0.1944)			(0.1814)
Δ 10-yr yields* $I(R_t)$		-0.0874		-0.0812		-0.7786		-0.7541
SE		(0.1399)		(0.1361)		(0.4879)		(0.4639)
Δ 10-yr yields* $I(G_t)$			0.0015	0.0015			0.0061	0.0062
SE			(0.0007)	(0.0007)			(0.0025)	(0.0026)
VIX(0)	-0.24	-0.24	-0.20	-0.20	-0.54	-0.57	-0.37	-0.38
SE	(0.04)	(0.04)	(0.04)	(0.05)	(0.15)	(0.14)	(0.15)	(0.16)
constant	4.92	5.07	4.14	4.16	12.66	13.95	9.41	10.26
SE	(1.17)	(1.15)	(1.14)	(1.24)	(4.21)	(4.02)	(4.02)	(4.24)
F stat	19.2	19.6	23.7	11.5	7.5	9.4	11.8	6.8
p-value	0.00	0.00	0.00	0.00	0.17	0.05	0.01	0.03
R^2	50	50	55	55	28	33	38	42