Unconventional monetary policy and the behavior of shorts

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Abstract

In November 2008, the Federal Reserve announced the first of a series of unconventional monetary policies, which would include asset purchases and forward guidance, to reduce long-term interest rates. We investigate the behavior of shorts, considered sophisticated investors, before and after a set of these unconventional monetary policy announcements that spot bond markets did not fully anticipate. Short interest in Treasury and agency securities systematically predicts bond price changes 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.

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) initiated a variety of emergency measures to stabilize the global economy and unconventional monetary policy actions 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. Kohn (2009) calls these "large-scale asset purchases" (LSAP).[1] The Federal Open Market Committee (FOMC) announced and implemented these policies in four phases: Quantitative Easing 1 (QE1) in 2008-2010, QE2 in 2010-2011, the Maturity Extension Program (MEP) in 2011-2012 and QE3 in 2012-2014.

Anecdotal evidence suggests that some sophisticated investors initiated short positions prior to the financial crisis to profit from it.[2] 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 foresee those events.

[1] The Fed tried similar long-bond purchases before, but on a much smaller scale. The best-known example occurred in the early 1960s when the Fed attempted to influence the long end of the yield curve in "Operation Twist." Using an event study approach, Swanson, Reichlin and Wright (2011) find that "Operation Twist" moderately reduced Treasury yields and had smaller effects on corporate yields.

[2] 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.

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.[3] 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?

Predicting important monetary policy surprises is a stringent test for any class of investor 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.

[3] Bhattarai and Neely (2018) 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.

[4] There are many types of public information that potentially informs 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/

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 be efficient in anticipating changes to the federal funds target. 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 authors interpret this small bias as reflecting risk premia rather than a systematic forecasting error (Piazzesi and Swanson 2008).[5]

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. 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 policy announcements could affect 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 the pattern in realized covariances of stock returns with yield changes reveals the type of news—monetary, growth, or risk news—released by a central bank's monetary policy decision.

[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.

Our sample comprises data on borrowed quantity of bonds (*BQ*)—a proxy for shorting—around a set of 42 unconventional policy announcements (UMPAs), consisting of FOMC statements, speeches, press releases, and announcements, during QE1, QE2, MEP, and QE3. We chose this set of events from news reports and existing event studies to reflect all important information releases about unconventional policy from November 2008 through June 2013. Although we omit 37 FOMC-minutes releases from our data set, inclusion of these provides essentially the same inference.

To presage our results, changes in borrowed quantity (ΔBQ) show that shorts correctly anticipate yield changes from UMPAs. ΔBQ predicts both changes in term premia and changes in expected future short rates, as inferred from swap rate changes. The fact that shorts' ΔBQ predicts both term premia and swap rates is consistent with predictive power for both signaling and portfolio balance effects. We find that the shorts' portfolio adjustments accurately anticipate UMPAs that release growth or monetary news, but not 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.[6]

In addition, 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.

[6] 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 that 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.[7]

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.[8] In addition, it is difficult to distinguish speculative from hedging futures trades because these classifications are self-reported and may be unreliable, according to conversations with industry participants. Repos can also be used to borrow securities for short selling. However, 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 falling bond prices caused by deteriorating credit, but we seek to study yield changes caused by U.S. monetary

[7] 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.

[8] 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.

policy, not yield changes that result from changes in the very low expected probability of a U.S. default. Because each strategy has its own requirements, traders typically do not switch between these four ways of profiting from falling bond prices.[9] 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 literatures: 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 these literatures to frame the unique contribution of the current paper.

2.1. The short selling literature

Short sellers are widely viewed as informed, sophisticated 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.

[9] Several institutional features constrain trading methods: participants in the securities lending market might be required to enter into the Overseas Securities Lending 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 (2018) 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.

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 by changing expected future short-term interest rates. Forward guidance—Fed communication with markets about future rates or economic conditions—presumably produces only signaling effects and no portfolio 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. [10]

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

[10] 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.

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 commonly 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. But Krishnamurthy and Vissing-Jorgensen (2011) offer another version of the portfolio balance channel in which removing duration is less important than removing certain maturities of very safe assets. Carpenter et al. (2015) present evidence that the effects of Fed purchases differ by type of investor and cause key participants to rebalance their portfolios toward more risky assets.

Either version of the portfolio balance channel predicts larger changes in expected returns to assets that are more like those of the purchased asset. Purchases of particular issues may also produce "local supply effects"—i.e., differential price reactions—for securities that have very similar 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 30 to 50 basis points 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 long maturities.[11] Carpenter et al. (2015) report that the counterparties to Fed purchases are mostly households, including hedge funds.

2.3 Asset price movements prior to 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 termed "pre-FOMC drift." Cieslak, Morse, and Vissing-Jorgensen (2018) find an even more elaborate pattern in the equity premium related to the event schedule around FOMC meetings over 1994-2015. These authors attribute these patterns to risk associated with FOMC decisions. Neither of these works shows that equity investors anticipate the surprise component of the FOMC decision.

More surprisingly, Karnaukh (2016) 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 prior to FOMC meetings. Karnaukh (2016) 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

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

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 very interesting patterns in asset prices around FOMC meetings, it does not show any anticipation of the surprise components of FOMC decisions that we show.

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. 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 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 information 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.[12]

[12] 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 exclude short-term securities because we believe that non-speculative reasons are more likely to motivate borrowing of such assets.

We examine all 42 of the UMPAs during the QE1-QE3 period of unconventional monetary policy. Table 1 describes the dates and times of these FOMC statements, conference calls, selected speeches, and selected press releases.[13] Figure 1 shows the 10-year-Treasury, 10-year agency, and Federal Funds yields from November 1, 2008, through July 31, 2013, which is our sample period.[14] 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 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 construct one-day changes around events from daily 10-year Treasury yields, term premia, and swap rates from FRED. Tickwrite provides futures prices. We construct two types of futures price changes: 15-minutes-before-to-15-minutes-after each announcement and open-to-close.

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 left short-term interest rates close to zero. The initial policy responses included the creation of the TSLF, the government takeover of the Federal Housing Agencies, Fannie and Freddie, the purchase of American International

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

[14] Agency yields are based on the Bloomberg U.S. Government Agency Zero Coupon Yield 10 Year (F08410Y Index).

Group (AIG), and the passage of the Troubled Asset Relief Program (TARP). The Fed's stabilization/lender-of-last-resort actions—creating temporary facilities to fund purchases of short-term private debt—in the weeks following the Lehman bankruptcy on September 15, 2008, were the first actions to unusually expand the monetary base.[15]

To supplement these unusual policy interventions by both the Treasury and the Fed, the FOMC repeatedly reduced the federal funds target from 525 basis points in September 2007, finally reaching a 0-25 basis point range on December 16, 2008. Long yields, however, did not follow short-rates down prior to November 2008.

After initially focusing on restoring dysfunctional financial markets through its lender-of-last-resort role, the Fed soon shifted its attention to stimulating real growth and preventing undesirable disinflation with forward guidance and asset purchases. The FOMC announced its first asset purchases on November 25, 2008, releasing plans to purchase $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, eventually totaled $1.725 trillion and roughly tripled the size of the U.S. monetary base almost entirely through an increase in excess bank reserves. In addition to these two explicit QE1 purchase announcements, a speech by Chairman Bernanke on December 1, 2008, and forward guidance from the FOMC statements on December 16, 2008, and March 18, 2009, lowered long yields on those dates by creating expectations of future bond purchases.

[15] These facilities included the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF) and the Money Market Investor Funding Facility (MMIFF).

On November 3, 2010, the FOMC announced QE2: the Fed would purchase $600 billion worth of longer-term Treasuries during 2010-11. The August 2011 FOMC statement reduced expectations of the federal funds rate by stating, "The Committee currently anticipates that economic conditions--including low rates of resource utilization and a subdued outlook for inflation over the medium run--are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."[16] The Fed introduced the Maturity Extension Program (MEP)—nicknamed "Operation Twist"—on September 21, 2011. The MEP funded purchases of $400 billion in long-term Treasury notes through equal sales of short-term Treasury bills.

Stubbornly weak housing and labor market conditions motivated the FOMC to ease further in 2012. On June 20, 2012, the FOMC extended the MEP to December 2012. In September 2012, the FOMC announced QE3, an ongoing program to purchase $40 billion in MBSs each month, to support housing markets. In December 2012, the FOMC announced that it would increase monthly QE3 purchases by $45 billion per month in Treasuries.

Positive economic reports in the winter and spring of 2013 reflected an improving U.S. economy and caused the FOMC to consider reducing QE3. Markets interpreted Chairman Bernanke's remarks of June 19, 2013 as indicating that the Fed would soon begin reducing, i.e., "tapering," QE3. Treasury yields and the foreign exchange values of the dollar surged. The FOMC delayed reducing the unusual monetary ease for some months, finally announcing an actual tapering of QE3 purchase on December 18, 2013, with a backdrop of PCE inflation near 1.5 percent and strong job growth. The FOMC continued this gradual reduction by reducing its monthly Treasury and MBS purchases by $5 billion each at each of its next seven meetings, finally officially ending QE3 on October 24, 2014.

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

3.3. Borrowing market descriptive statistics

Figure 2 illustrates the time series of total daily *TBQ* and *TAQ* (Panel A) and *ABQ* and *AAQ* (Panel B). Panel A shows that 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) is roughly constant through August 2008, but then declines sharply at the beginning of September as Lehman Brothers goes bankrupt and risk aversion soars. The decline levels off in January 2009. From early 2009 through July 2013, Treasuries borrowing remains at a much lower level than pre-crisis. Panel B shows that the *AAQ* and *ABQ* (black and light gray lines, respectively) similarly decline from September 2008 to March 2009 when their decline moderates. *ABQ* 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, 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 revision to the central bank's reaction function while 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:

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

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 in nature if the average stock return covariance with the yield curve is negative. That is:

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

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

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

The news reveals risk if the average stock return/yield 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 are greater than the sum of those at the short end. That is,

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

The 42 events in our sample include 17, 11, and 14 monetary, risk, and growth events, respectively.[17] We use these indicators to study the type of news that *BQ* predicts.

4. Questions of interest

This section describes hypotheses to test the behavior of shorts with respect to UMPAs. Our first set of questions concerns how shorts behave prior to announcements and our second set concerns how they react to those announcements.

If short sellers think they have more accurate expectations than the risk-adjusted expectations of the marginal investor, then such short sellers will cover (expand) their short positions prior to 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.

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 (Figure 1).[18]

[17] In the sample that includes FOMC minutes releases, there are 24, 28, and 27 monetary, risk and growth events, respectively.

[18] 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. Figure 1 shows that 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

Our first set of questions concerns how—if at all—*BQ* predicts price and yield changes on days of UMPAs.

Question 1: Do changes in short interest (i.e., *ΔBQ*) predict bond yield changes in the period prior to UMPAs?

Question 2: Does short interest anticipate UMPAs changes to term premia or expected short rates? That is, do shorts predict portfolio balance or signaling effects?

Question 3: Do short positions in long- or short-time-to-maturity securities best reflect shorts' expectations of monetary policy? That is, how does *ΔBQ*'s predictive ability vary with the time-to-maturity of the borrowed bonds?

Question 4: How does the accuracy of predictions vary with the type of Cieslak-Schrimpf news released by UMPAs? That is, what sort of news does *ΔBQ* predict?

Our second set of questions relate to the effect of UMP shocks on short portfolio rebalancing after an UMPA. Our first such question is motivated by the idea that FOMC actions are designed to signal markets about future policy.

Question 5: Do shorts find Fed actions credible? That is, do 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, do shorts cover their short positions (so that *ΔBQ* is negative) in the weeks following an expansionary surprise?

Question 6: How does Cieslak-Schrimpf announcement news affect post-announcement rebalancing? That is, do shorts react differently to different sorts of news releases?

Question 7: When the shorts rebalance in the wake of an UMPA, in what time-to-maturity bonds do they transact?

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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.

5. Empirical results

This section characterizes the shorts' responses to UMPAs.

5.1. The shorting of Lehman Brothers

Before turning to evidence regarding the shorting of Treasuries and agencies during QE episodes, we informally illustrate the power of short investors to anticipate asset price changes by examining shorting of Lehman common stock prior to its bankruptcy. Figure 3, Panel A, illustrates that borrowed quantity for Lehman equity increased dramatically prior to the Lehman bankruptcy and only fell below beginning-of-2008 levels after the bankruptcy, likely reflecting both profit taking and reduced ability to borrow the equity. In other words, shorts anticipated the Lehman bankruptcy by increasing their short interest.

In contrast to the strong rise in short interest in Lehman equity prior to September 2008, short interest in Treasury and agency bonds, as proxied by *BQ*, showed no trend over the same period. That is, from January 1, 2008 to late August, the cumulative change in borrowed quantity for Treasuries (*ΔTBQ,* the black line in Figure 3, Panel B) fluctuates, but does not dip below -12%. However, this variable begins to decline sharply a few days prior to Lehman's bankruptcy and continues to decline through the early QE1 events. Cumulative change in borrowed quantity for agencies (*ΔABQ,* the gray line in Figure 3, Panel B) followed a similar pattern, fluctuating until early September, then declining rapidly in fits and starts for the next few months.

5.2. 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*).[19]

We turn to our investigation of Questions 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, +15} 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 prior to the announcement (day t-16 to day t-1), but the results are robust to modest perturbations of period length.

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

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

The first 10 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* and *ΔTBQ* and *Δ*(*ABQ*+*TBQ*). From left to right, Table 3, Panel A, shows results for 30-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

[19] Although the Fed does not announce the exact issues that it will buy at the announcement of the program, eventually the securities actually purchased becomes 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.

10-year constant-maturity Treasury yields, changes in daily 10-year term premia, and changes in daily 10-year swap rates. We interpret swap rates as a proxy for expected future short rates.

Table 3, Panel A, shows that *ΔABQ* predicts announcement window changes in 2-, 5-, 10- and 30-year futures prices. *ΔABQ* generally predicts both on its own and in combination (i.e., *Δ*(*ABQ +TBQ*).[20] Neither *ΔABQ* nor *ΔTBQ* strongly predicts high-frequency stock futures price changes, although one might claim marginal significance for *Δ(ABQ + TBQ)*. The signs on *ΔBQ* coefficients are negative, indicating that a decline in *BQ* (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.

Table 3, Panel B, shows that longer announcement windows generally strengthen the predictive ability of *ΔBQ*. Average R^2s are almost twice as high in Panel B as Panel A. *ΔBQ* consistently and strongly predicts bond futures and yield changes, with all specifications being significant at the ten percent level and almost all being significant at the five percent level. It should not be too surprising that longer windows improve predictability as the unconventional monetary policy events are often complex and probably require hours or even days for markets to fully absorb the information. When used by themselves, both *ΔABQ* and *ΔTBQ* predict all the variables to a statistically significant degree, and their coefficients are also often statistically significant when the variables enter as a sum. Specifications that include both agencies and Treasuries sums jointly—which are highly correlated—produce an insignificant Treasury coefficient, except for the 10-year swap. The coefficients in the futures price regressions are negative, again indicating that the shorts adjust their positions correctly in anticipation of monetary policy surprises. But the correctly signed coefficients for the yield and term premia regression are positive because yields

[20] Figure 3 shows that the change (decrease) in agency yield was much greater than the change in treasury yield over the period of our study.

and futures prices should react in opposite ways to a monetary announcement. The ability of shorts' ΔBQ to predict changes in both term premia and swap rates supports the hypotheses that shorts can predict both portfolio balance surprises and signaling surprises.

Table 3 clearly answers our first two questions: Shorts correctly anticipate monetary policy decisions by adjusting their portfolios prior to the decisions to profit from yield changes, and their actions predict changes in both term premia and expected future interest rates, indicating that they predict both the portfolio balance and signaling effects.

Question 3 asks how shorts vary the time-to-maturity of their portfolios in anticipating monetary policy? That is, how does ΔBQ's predictive ability vary with its time-to-maturity? To investigate this issue, we regress standardized changes in 10-year yields, term premia, and swap rates on 15-day ΔABQ or ΔTBQ and time-to-maturity of the borrowed bonds. We standardize both the dependent and independent variables by subtracting their means and giving them unit variance to easily compare coefficients and interpret them as correlations. We regress each specification independently to estimate bivariate relations. If shorts anticipate monetary shocks entirely by transacting in long bonds, for example, we expect to see large coefficients on long times to maturity and essentially zero coefficients elsewhere.

The three panels of Figure 4 show the standardized coefficients for regressions of standardized daily 10-year yield (Panel A), term premium (Panel B), and swap rate (Panel C) on the standardized ΔABQ and ΔTBQ series by remaining years-to-maturity. Positive coefficients indicate that shorts correctly anticipate Fed-induced price changes. Casual inspection suggests that shorts operate throughout the yield curve, but not uniformly, preferring certain times to maturity. For example, the blue bars in Panel A show that 10-year yield changes on monetary policy announcement days are 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. Coefficient patterns are similar across yields and term premia because they are strongly positively correlated. *ΔABQ* of 4-to-5, 5-to-6, 9-to-10, and 11-to-12 years remaining maturity predicts swap rates. Curiously, *ΔABQ* with 8-to-9 years of remaining maturity is strongly negatively correlated with all dependent variables. Patterns for *ΔTBQ* coefficients (orange bars) in Figure 4 are somewhat like those for *ΔABQ*, but the *ΔTBQ* patterns are weaker over the short- and medium-term instruments.

Question 4 asks how the accuracy of predictions varies with 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 regression over the whole sample and use the single set of estimated coefficients and data to calculate R^2s for three subsamples defined by 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 *ΔBQ*'s predictive ability for bond prices/yields comes entirely from monetary and growth news releases. Risk releases are often associated with negative conditional R^2s for bond futures prices and yields, probably indicating that the shorts do not correctly anticipate the release of risk news. Conditional R^2s for medium and long-term bond futures prices and yields tend to be higher

during growth events than during monetary events, but both statistics are reliably positive. To take a crude measure, in Panel A the average "R^2 M" and "R^2 G" are 14.7% and 18.1%, respectively, but the average "R^2 R" is -14.2%, indicating a worse-than-naïve forecast for this subsample. One peculiarity is that predictive ability for swap rates diverges from that of the other variables, with *ΔBQ* having negative predictive ability during monetary events.

ΔBQ predicts bond futures returns better than stock returns, for which overall predictability is very modest. The average R^2 overall specifications for bond futures is 13.4% while it is 3.9% for stock futures (Table 3, Panel A). This is consistent with the idea that bond shorts are primarily concerned with bond market behavior, rather than predicting the overall impact of monetary shocks.

In addition to computing R^2s and conditional R^2s, we also compute the "% correctly signed," 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. Rows 15 to 18 of both Panels A and B 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. 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 69.9, 74.7, and 71.9, for each set of news because there are fewer observations in the news-based subsamples.

The results using the "% correctly signed" metric are basically consistent with those using the regression coefficients and R^2s. Table 3, Panel A, shows that *ΔBQ* tends to predict the sign of

intraday futures returns, especially for medium and long bonds, but Panel B shows that "% correctly signed" statistics of predictions in open-to-close prices and changes in daily yields and term premia are more consistently statistically significant. Panel B shows that point estimates for the "% correctly signed" of swap rates are greater than 50% but not statistically significant.

The specifications tend to predict a higher percentage of correct returns during monetary and growth events, consistent with the stronger regression metrics during such events. Table 3, Panel B, shows that the specification with *ΔTBQ* alone, for example, predicts the correct direction of 10-year yield and term premia changes for an impressive 92.9 percent of growth events. Risk news events yield *ΔBQ*'s weakest predictive performance—sometimes less than 50% correct—for changes in bond futures, yields and term premia. For the 10-year swap rate, *ΔBQ*'s weakest predictive performance is associated with monetary news, but *ΔBQ* still correctly predicts the sign of more than 50% of swap changes during monetary events.

In summary, both *ΔABQ* and *ΔTBQ* predict daily changes in bond 10-year yields and 10-year term premia on days of monetary events. Only *ΔABQ* predicts futures price changes during 30-minute windows to a statistically significant degree, however. The signs of the coefficients are consistent with portfolio adjustments that correctly anticipated the direction of the announcement news on bonds of all maturities. In contrast, *ΔABQ* and *ΔTBQ* do not strongly predict 30-minute changes in stock futures. The predictive power of shorts is remarkable in a market in which the policy event is based on public information and very widely watched.

When one breaks the predictive power down by the type of news released, following Cieslak and Schrimpf's (2019) methods, one finds that *ΔBQ* has the most predictive ability during days when FOMC decisions released growth or monetary news. *ΔBQ* had no positive predictive ability during days when FOMC decisions contain risk information.

5.3. How shorts respond just after the purchase announcements

We now turn to the behavior of shorts in the wake of monetary surprises.

We first consider Question 5: Do shorts rebalance their portfolios in the days and weeks following UMPAs in a way that anticipates further actions in the same direction? To investigate Question 5, we regress *ΔABQ* and *ΔTBQ* from t+1 to t+16 on changes in intraday futures prices and daily changes in yields, term premia, and swap rates on the days of the 42 UMPAs. We choose a change 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. The response of *ABQ* to policy-induced changes in the 10-year treasury yield, for example, can be written as follows:

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

Table 4, Panel A, shows the responses of the 15-day changes in the sums of agency (left subpanel) and Treasury (right subpanel) *ΔBQ* to policy-induced price, yield, and term premia changes. All the specifications for *ΔABQ* are statistically significant at the one-percent level. All but one of the specifications on yield/price changes for predicting *ΔTBQ* are statistically significant at the five-percent level, and even that exception approaches significance at the five-percent level. The signs of the coefficients are consistent with a credible impact of policy. That is, the coefficients on futures prices are negative, indicating that a rise in bond futures prices (an expansion) is followed by a decline in *BQ* (i.e., *ΔBQ* is negative), as shorts come to expect further declines in yields. For the single-variable regressions, the coefficients on yield changes are positively signed, again indicating that an expansion is followed by a decline in *BQ*, consistent with covering by shorts.

Table 4, Panel B addresses the question of how the type of news affects the response of *BQ* to monetary policy shocks (Question 6). 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:

$$\Delta ABQ_{t+1,t+16} = b_0 + b_1 \Delta P_t^{10yr} I(M_t) + b_2 \Delta P_t^{10yr} I(R_t) + b_3 \Delta P_t^{10yr} I(G_t) + \varepsilon_t \qquad (6)$$

If all types of news produce similar *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 practically all the predictive power for *ΔBQ* regressions comes from growth news and the coefficients on that news are positive. This means that when the Fed releases growth news, an expansionary (contractionary) monetary shock, i.e., a decline (rise) in the 10-year yield, is associated with a later reduction in *BQ*. 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 mean that the shorts do not necessarily find Fed actions credible in themselves, but they do find that Fed actions that have implications for growth to be credible.

Finally, we turn to Question 7: When the shorts rebalance in the wake of an announcement, in what time-to-maturity bonds do they transact? We answer this question in a manner like that with which we resolve Question 3. That is, we regress standardized 15-day *ΔABQ* and *ΔTBQ* and time-to-maturity of the borrowed bonds on announcement-day changes in 10-year yields. As in the similar previous exercise (Figure 4), we transform both the dependent and independent variables to zero-mean, unit-variance scale, to compare coefficients and easily interpret them as correlations. We regress each dependent variable independently on each independent variable to estimate

bivariate relations. If shorts adjust their portfolios entirely or mainly by changing their holds 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 5 shows the standardized coefficients for the regression of 15-day leads of agency and Treasury BQ, for varying times to maturity, on daily changes in 10-year yields on days of monetary policy events. In other words, the chart 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 a fall in yields is associated with a decline in *BQ* as shorts presumably anticipate further declines in yields. The evidence shows that shorts adjust their portfolios in the wake of UMPAs throughout the yield curve for both agencies and Treasuries. Short-term ΔABQ tends to be strongly correlated with changes in 10-year yields, consistent with greater sensitivity of relatively short expectations. Changes in Treasury *BQ* are less correlated with previous 10-year yield changes than are changes in agencies.

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 event studies and other types of analysis persuasively show 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 nearly 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 and Treasury bonds portfolio systematically predict changes in bond futures prices/yields throughout the yield curve during the Federal Reserve's 42 unconventional monetary policy announcements during 2008-2013. 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 borrowed quantity also predict both changes in term premia and expected short rates (swap rates). In adjusting their portfolios, shorts transact throughout the yield curve. Using the methods of Cieslak-Schrimpf (2019) to construct the news content of monetary actions, we find that changes in borrowed quantity best predict bond futures prices and yields during events that release monetary or (especially) growth news.

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 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 4 years, which is consistent with greater sensitivity of positions in 0-4-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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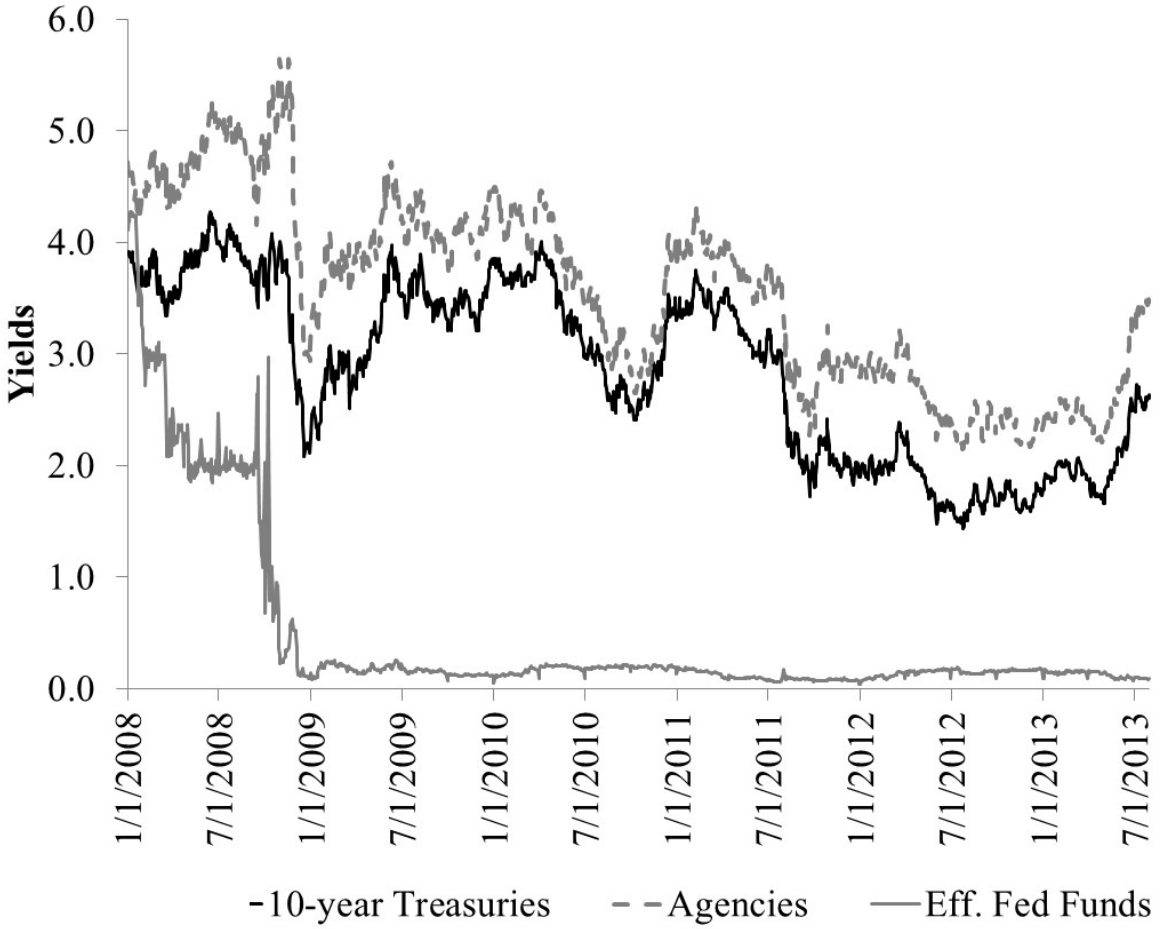
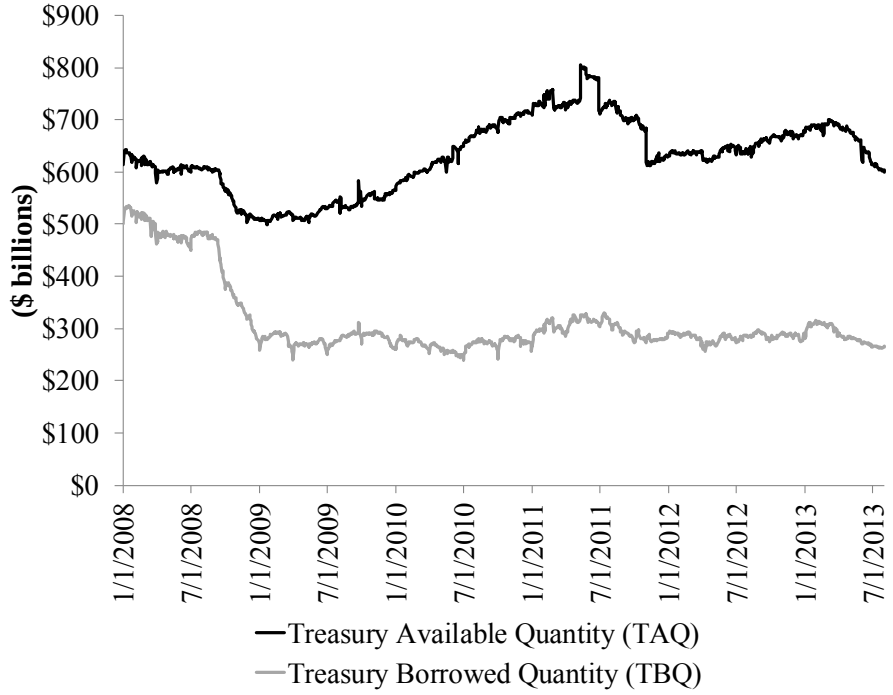
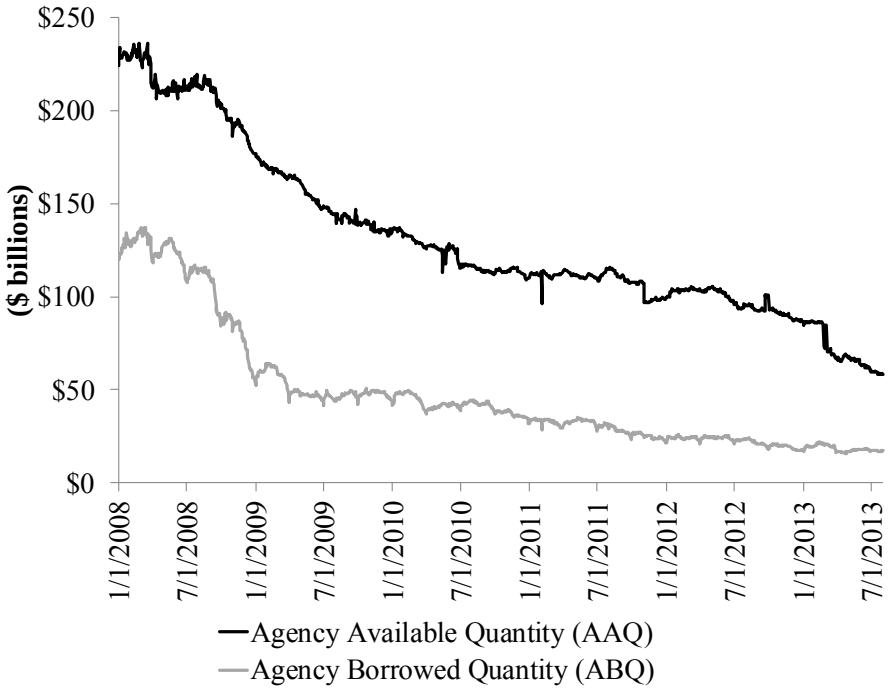


Figure 1. Behavior of yields during and following the Great Recession

We present nominal yields in percent for 10-year constant maturity U.S. Treasuries, 10-year agencies (FMC 84), and overnight federal funds from 1/1/2008 to 7/31/2013.

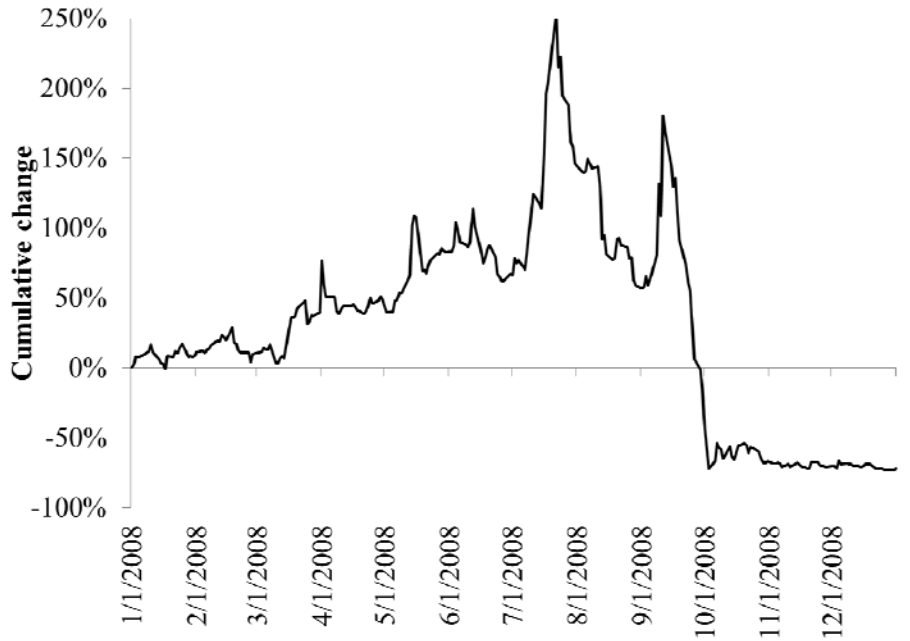


Panel A. Treasuries

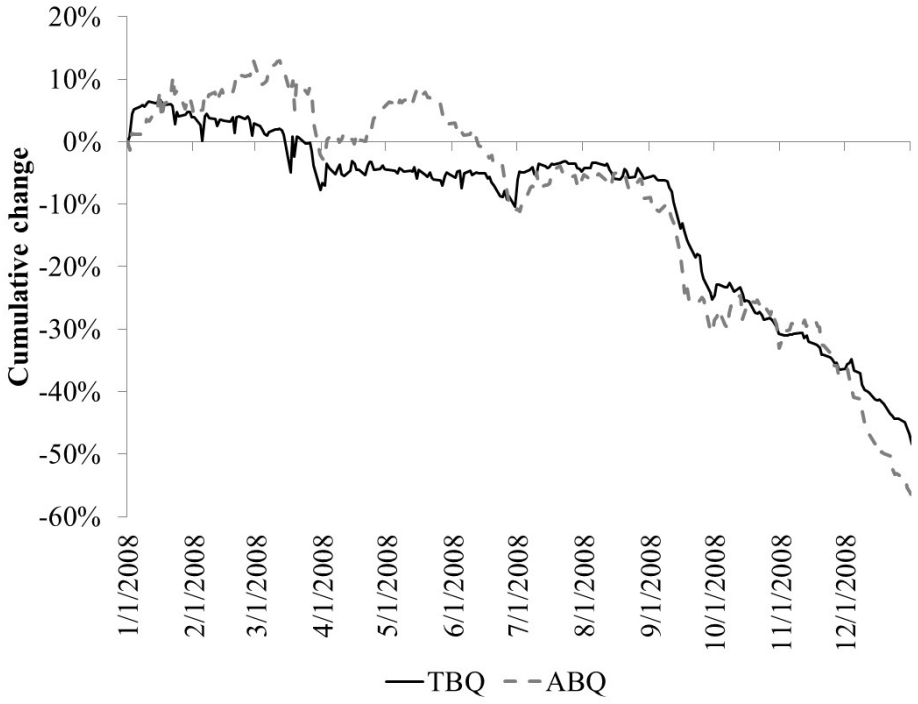


Panel B. Agencies

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.

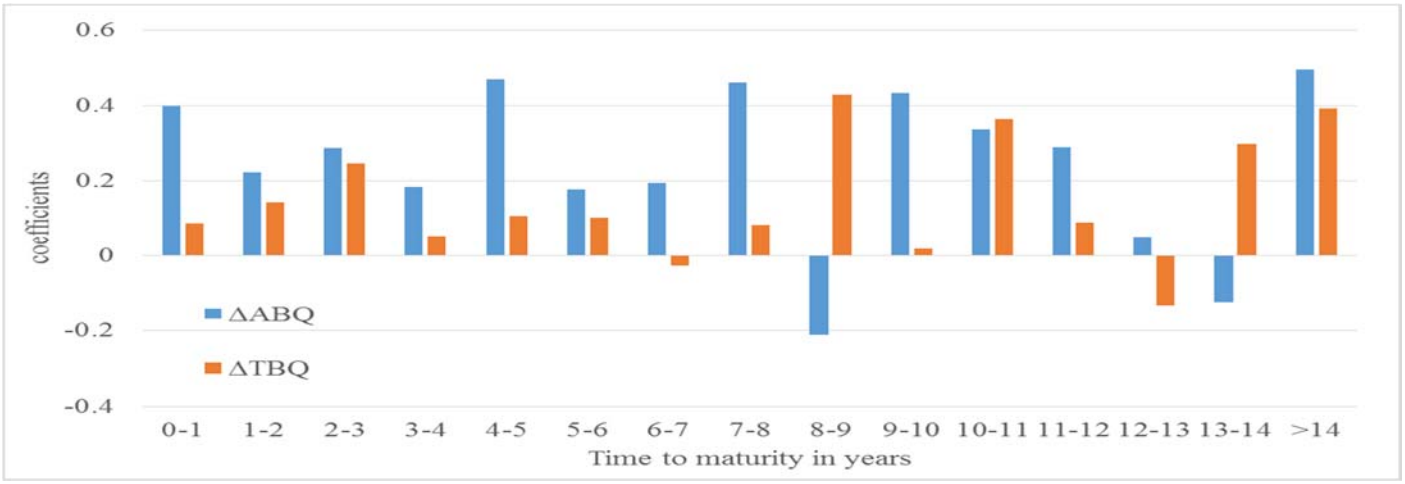


Panel A. Lehman equity

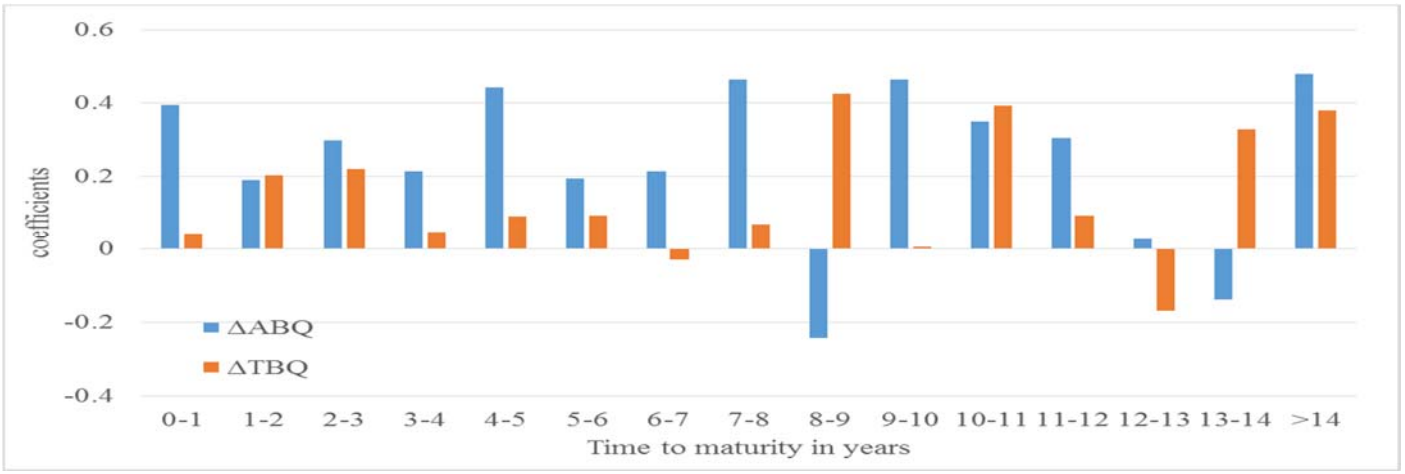


Panel B. Treasuries and agencies

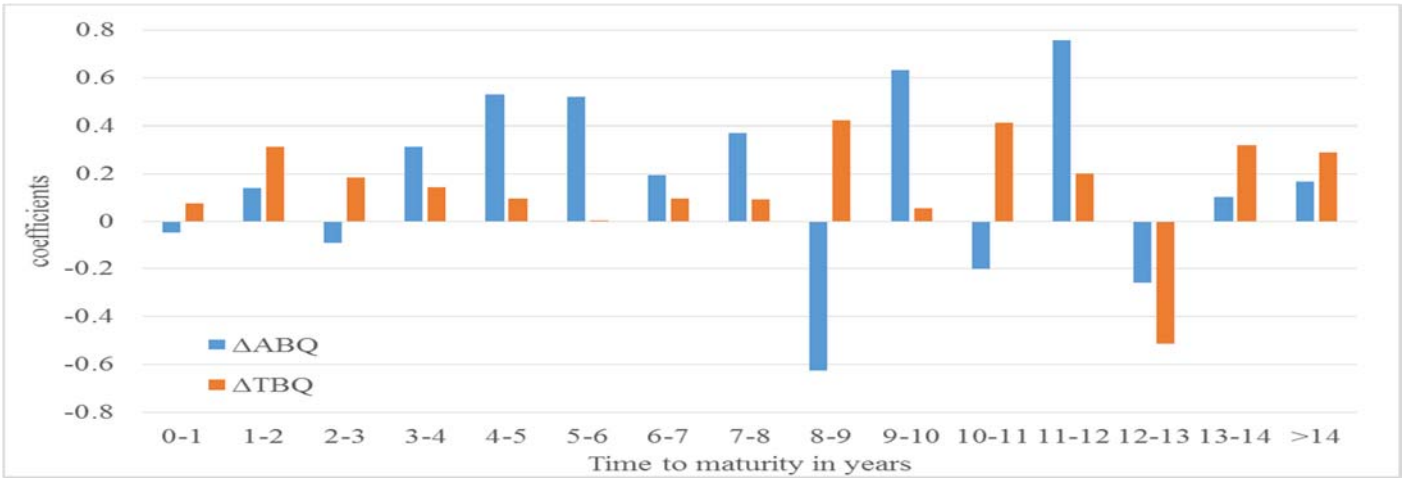
Figure 3. Cumulative change in borrowed quantity (shorting)
We present the daily cumulative percentage change in total available quantity and borrowed quantity (our proxy for shorting) for Lehman equity (Panel A) and Treasuries and agencies (Panel B) from 1/1/2008 to 1/1/2009. In the text, changes in Treasuries and agencies borrowed quantity in Panel B are referred to as ΔTBQ and ΔABQ, respectively.



Panel A. 10-year-Treasury yields



Panel B. 10-year term premia



Panel C. 10-year swaps

Figure 4. 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.

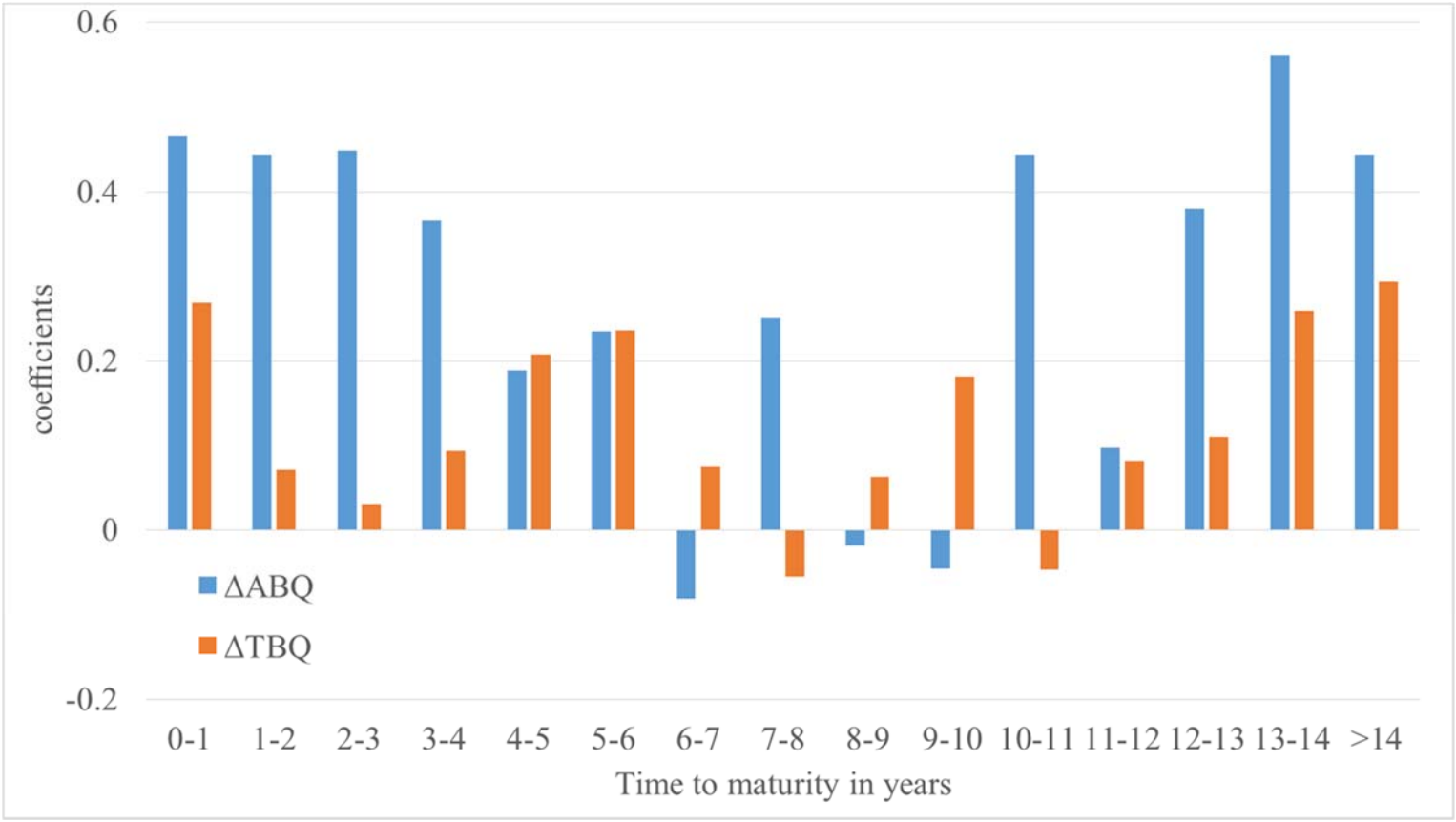


Figure 5. Standardized coefficients of 15-day lead of *ΔBQ*
We show the standardized coefficients for the regression of 15-day leads of *ΔABQ* and *ΔTBQ*, for varying times to maturity, on daily changes in 10-year yields on days of monetary policy events.

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 further ease policy.
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.

Tale 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 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 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
We regress announcement-day changes in (i) futures prices, (ii) yields, (iii) term premia, and (iv) swap rates, in turn, against the change in agencies borrowed quantity, *ΔABQ*, Treasuries borrowed quantity, *ΔTBQ*, and *Δ(ABQ+TBQ)*. For the LHS variables, Panel A presents changes for {-15, +15} minute windows and Panel B presents changes for open-to-close and daily. The RHS variables are measured over a three-week period (15 days) prior to the announcement. We calculate three Cieslak and Schrimpf (2019) news measures—Monetary (M), Risk (R), or Growth (G). First, we calculate conditional R^2s for our predictive regressions after conditioning on the type of news revealed. Then, we estimate the predictive regression over the whole sample and use the estimated coefficients and data to calculate R^2s for three subsamples defined by type of news. The lower rows of each panel (R^2 Monetary, R^2 Risk, and R^2 Growth) show these conditional R^2s and "%" correctly signed for the 10 asset returns. The futures price data are from Tickwire and the daily 10-year Treasury yields, term premia, and swap rates are from FRED. Standard errors (SE) are in italics. Light gray shaded values are significant at the 5 percent, one-sided level. Dark gray shaded cells show percentages that are statistically different than 50% at the 5 percent, one-sided level, using the standard normal approximation to the binomial distribution. N = 42.

Panel A: 30-minute futures price changes around UMPAs on combinations of lagged 15-day *ΔABQ*, *ΔTBQ*, and *Δ*(*ABQ+TBQ*)

	Futures (Δ30-minute)																			
	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	-0.75			-0.97	-3.65			-4.54	-6.71			-8.24	-9.08			-10.7	-2.91			-4.54
SE	*0.24*			*0.33*	*1.02*			*1.38*	*2.11*			*2.87*	*3.99*			*5.45*	*1.87*			*2.53*
ΔTBQ		-0.10		0.10		-0.55		0.42		-1.04		0.72		-1.52		0.76		-0.20		0.76
SE		*0.08*		*0.10*		*0.36*		*0.44*		*0.73*		*0.91*		*1.32*		*1.73*		*0.61*		*0.80*
Δ(ABQ+TBQ)			-0.12				-0.60				-1.12				-1.59				-0.32	
SE			*0.07*				*0.29*				*0.58*				*1.06*				*0.49*	
Intercept	0.03	0.58	0.39	0.13	-0.82	1.67	0.76	-0.43	-1.94	2.52	0.88	-1.27	-5.83	-0.19	-2.36	-5.12	4.54	7.35	6.53	5.26
SE	*0.91*	*0.99*	*0.98*	*0.91*	*3.81*	*4.25*	*4.17*	*3.83*	*7.89*	*8.59*	*8.48*	*7.98*	*14.9*	*15.5*	*15.4*	*15.1*	*6.99*	*7.14*	*7.17*	*7.04*
F stat	10.1	1.62	3.27	5.58	13.6	2.41	4.62	7.28	10.7	2.13	3.95	5.64	5.52	1.40	2.40	2.81	2.57	0.12	0.46	1.77
p-valueX100	0.3	21.1	7.8	0.7	0.1	12.9	3.8	0.2	0.2	15.2	5.4	0.7	2.4	24.4	12.9	7.3	11.7	73.4	50.1	18.4
R^2 All	20.2	3.9	7.5	22.2	25.3	5.7	10.4	27.2	21.1	5.1	9.0	22.4	12.1	3.4	5.7	12.6	6.0	0.3	1.1	8.3
R^2 M	34.8	5.2	11.5	41.2	28.6	4.8	10.2	33.0	19.5	3.8	7.5	22.1	10.8	2.4	4.5	11.8	15.9	1.6	4.4	19.7
R^2 R	-13.9	-26.6	-34.8	-15.2	-4.9	-28.8	-34.8	-4.6	-5.4	-26.4	-31.6	-6.5	-4.2	-10.6	-12.6	-5.6	-7.6	-6.0	-10.8	6.4
R^2 G	-0.7	5.1	5.6	-5.5	19.2	17.6	22.3	11.1	50.3	33.2	44.2	40.1	40.7	25.4	33.7	35.8	-6.0	0.9	0.7	-12.2
% All	45.2	50.0	52.4	57.1	50.0	50.0	52.4	64.3	52.4	61.9	64.3	61.9	61.9	61.9	64.3	69.0	57.1	47.6	50.0	57.1
% M	47.1	52.9	52.9	58.8	52.9	47.1	47.1	58.8	52.9	58.8	58.8	58.8	64.7	58.8	58.8	70.6	58.8	52.9	52.9	58.8
% R	36.4	36.4	45.5	63.6	36.4	36.4	45.5	72.7	54.5	54.5	63.6	72.7	54.5	54.5	63.6	72.7	36.4	18.2	27.3	72.7
% G	50.0	57.1	57.1	50.0	57.1	64.3	64.3	64.3	50.0	71.4	71.4	57.1	64.3	71.4	71.4	64.3	71.4	64.3	64.3	42.9

Table 3—Continued

Panel B: Price changes for futures (left columns) and around UMPAs (right columns) 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	-7.74			-8.86	-13.6			-15.0	65.8			62.3	137			132	0.55			0.01
SE	*1.56*			*2.11*	*2.82*			*3.85*	*17.9*			*24.5*	*38.2*			*52.4*	*0.31*			*0.41*
ΔTBQ		-1.36		0.53		-2.54		0.65		14.9		1.64		30.7		2.58		0.25		0.25
SE		*0.59*		*0.67*		*1.06*		*1.22*		*6.15*		*7.8*		*13.1*		*16.6*		*0.09*		*0.13*
Δ(ABQ+TBQ)			-1.40				-2.56				14.1				29.2				0.20	
SE			*0.46*				*0.82*				*4.83*				*10.3*				*0.08*	
constant	-2.55	2.03	0.21	-2.06	-6.17	1.32	-1.82	-5.57	36.3	9.04	23.2	37.8	65.9	7.34	37.1	68.3	-0.44	-0.21	-0.15	-0.20
SE	*5.81*	*6.95*	*6.70*	*5.87*	*10.5*	*12.3*	*11.9*	*10.7*	*66.8*	*71.8*	*70.3*	*68.1*	*143*	*153*	*150*	*145*	*1.16*	*1.10*	*1.11*	*1.13*
F stat	26.3	5.56	9.83	13.4	24.7	6.15	10.4	12.3	14.4	6.27	9.06	7.04	13.8	5.84	8.50	6.73	3.27	7.77	7.48	3.79
p-valueX100	0.00	2.34	0.32	0.00	0.00	1.75	0.25	0.01	0.05	1.65	0.45	0.25	0.06	2.03	0.58	0.31	7.79	0.81	0.93	3.14
R^2 All	39.6	12.2	19.7	40.7	38.1	13.3	20.6	38.6	26.4	13.6	18.5	26.5	25.6	12.7	17.5	25.7	7.6	16.3	15.8	16.3
R^2 M	32.1	4.8	10.9	35.9	36.1	8.1	15.1	38.3	28.0	7.2	12.8	27.1	22.9	4.1	8.7	22.2	-18.5	-32.3	-34.8	-32.5
R^2 R	4.4	-43.7	-46.5	4.9	-0.6	-25.2	-26.6	-2.5	-1.5	-19.0	-17.8	-1.9	-4.0	-25.5	-24.5	-4.0	7.1	7.9	11.6	8.2
R^2 G	62.2	37.6	49.9	56.9	56.7	42.7	53.5	52.0	32.1	36.1	40.9	34.3	37.1	38.4	44.2	38.8	12.2	26.1	25.2	26.1
% All	59.5	59.5	61.9	54.8	61.9	61.9	64.3	57.1	64.3	64.3	66.7	66.7	61.9	61.9	64.3	64.3	59.5	59.5	61.9	59.5
% M	64.7	58.8	58.8	64.7	70.6	52.9	52.9	70.6	76.5	58.8	58.8	76.5	70.6	52.9	52.9	70.6	58.8	52.9	52.9	52.9
% R	45.5	45.5	54.5	36.4	45.5	45.5	54.5	36.4	36.4	36.4	45.5	36.4	36.4	36.4	45.5	36.4	54.5	54.5	63.6	54.5
% G	64.3	71.4	71.4	57.1	64.3	85.7	85.7	57.1	71.4	92.9	92.9	78.6	71.4	92.9	92.9	78.6	64.3	71.4	71.4	71.4

Table 4
Regression results
We regress *ΔABQ* and *ΔTBQ*, in turn, against 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.

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	-54.70				-110	-108						-573
SE	*13.07*				*54.78*	*44.02*						*228*
Δ10-yr futures		-28.23			71.22		-49.03					345
SE		*7.55*			*32.47*		*25.27*					*135*
Daily												
Δ10-yr yields			4.71		-3.18			9.02				10.24
SE			*1.31*		*5.68*			*4.31*				*23.67*
Δ10-yr Term premia				2.39	3.86				4.48			0.79
SE				*0.60*	*3.41*				*2.01*			*14.2*
Δ10-yr swap					*408.3*	*340.8*					*612*	*494*
SE					*71.9*	*65.37*					*276.1*	*272*
Constant	-842	-925	-1,010	-974	-766	-569	-386	-618	-729	-670	-448	303
SE	*574*	*591*	*595*	*579*	*5,108*	*443*	*1,933*	*1,978*	*1,956*	*1,944*	*1,958*	*1,845*
F stat	18.63	14.85	13.74	16.89	34.31	13.37	6.41	4.00	4.67	5.26	5.23	3.44
p-valueX100	0.01	0.04	0.06	0.02	0.00	0.00	1.54	5.23	3.68	2.71	2.76	1.21
R^2	31.8	27.1	25.6	29.7	46.2	65.0	13.8	9.1	10.5	11.6	11.6	32.3

Table 4—Continued

Panel B: 15-day ex post ΔABQ and ΔTBQ on 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)	2.26			2.36	4.01			4.32
SE	*1.92*			*1.58*	*5.83*			*5.05*
Δ 10-yr yields* I(R_t)		1.90		1.47		-9.86		-10.97
SE		*5.12*		*4.13*		*15.29*		*13.22*
Δ 10-yr yields* I(G_t)			0.04	0.04			0.12	0.12
SE			*0.01*	*0.01*			*0.03*	*0.03*
constant	-1,158	-1,239	-683.82	-643.49	-1,021	-989.8	289.8	550.7
SE	*675.83*	*688.50*	*567.90*	*569.34*	*2,049*	*2,056*	*1,795*	*1,823*
F stat	1.47	0.15	21.12	7.98	0.50	0.44	14.95	5.42
p-valueX100	23.26	70.45	0.00	0.03	48.27	51.01	0.04	0.33
R^2	3.5	0.4	34.6	38.7	1.2	1.1	27.2	30.0