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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 rebalanced after announcements in the direction of the announcement surprise when the announcement released monetary or growth news, suggesting that shorts interpreted these announcements 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 and a severe downturn in real economic activity. In response, the Federal Reserve (Fed) initiated emergency measures to stabilize financial markets and later turned to unconventional monetary policy (UMP) to stimulate the economy and maintain stable prices. The unconventional actions included "forward guidance" about the federal funds rate target path and a series of announcements of asset purchases that totaled several trillion dollars to 2015.[1]

Researchers have extensively studied the reactions of market prices to such unconventional monetary policy actions but have paid much less attention to expectations formation and portfolio adjustments.[2] We shed light on expectations formation by investigating whether some sophisticated investors, i.e., shorts, understood the 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 monetary policy surprises is a stringent test for any class of investors because publicly available information almost entirely determines the path of monetary policy. To earn abnormal returns, shorts must out-predict the marginal spot/futures investor in very deep markets

[1] Conventional monetary policy influences the economy through 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 December 2015 to March 2020.
[2] Bhattarai and Neely (2020) survey the UMP literature. Joyce, Liu, and Tonks (2017) and Koijen et al. (2017) study the portfolio choices of financial institutions in the wake of UMP announcements.

with no obvious source of private information but much public information. The short investor cannot simply follow market sentiment and news because the spot price should immediately reflect that sentiment and news so that the short investor would never foresee an abnormal risk-adjusted return and would never have a speculative incentive to change their position. Although there is evidence 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 that have systematically predicted monetary surprises better than the spot/future bond markets.

Consistently out predicting the marginal investor in spot/future bond markets is probably much more difficult than out predicting the limited group of analysts who focus on the fortunes of a single company.[3] 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. The authors interpret this bias as reflecting risk premia rather than a systematic forecasting error.

The discovery of predictable components in monetary "surprises" is important because it implies 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 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). Such behavior leads us to term Fed announcements as "persistent."

[3] Equity analysts can gather information from a variety of primary, non-public sources including employees, suppliers, customers (e.g., channel checks, surveys, etc.). In addition to conducting primary research, they often privately communicate with management. Brown et al. (2015) find that such communication is a more useful input to analysts' forecasts than their own primary research.

We also investigate 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). They argue that central bank policy decisions reveal specific types of news—monetary, growth, or risk—identified by specific patterns of realized covariances of stock returns with yield changes.

Our sample comprises data on the borrowed quantity (*BQ*) of agency and Treasury bonds—a proxy for shorting—a set of 117 UMP announcements (UMPAs), consisting of Federal Open Market Committee (FOMC) statements, speeches, press releases, and minutes releases during QE1, QE2, the maturity extension program (MEP), and QE3. This event set comprises all important official communication about UMP from November 2008 until December 2015, when the FOMC returned to conventional policy by raising the federal funds rate from zero.

To presage our results, changes in agency borrowed quantity (*ΔABQ*) show that shorts correctly anticipate yield changes from UMPAs. *ΔABQ* predicts changes in both term premia and expected future short rates, as inferred from term structure models (TSMs) and swap rates. This pattern indicates that shorts' *ΔABQ* anticipates both portfolio balance and signaling effects. We find that the shorts' portfolio adjustments accurately anticipate yield changes from UMPAs that release growth or monetary news but not those that release risk news. Shorts are particularly adept at anticipating yield changes during growth news. To our knowledge, ours is the only work showing that a set of sophisticated investors outperformed the spot market in predicting UMP actions.

Shorts expect Fed actions to be persistent in the sense that UMPA-produced yield declines (increases) predicted that shorts would cover (expand) their short position in anticipation of further changes in the same direction. Again, such post-announcement rebalancing strongly responded to monetary and (especially) growth news.

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 unavailable or available only with a delay. Fortunately, daily Markit data on borrowing of individual Treasury and agency CUSIPs provides a proxy for short interest that allows us to examine the aggregate trading patterns of these sophisticated investors.[4]

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.[5] 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. Therefore hedging and speculative positions can be comingled.[6] 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. Traders may use CDSs to take positions on

[4] The Markit shorting data 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 shorting data—although available with a delay and at a cost—is a potentially valuable source of information for participants who can short at reasonable cost.

[5] 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 CUSIP is delivered. This formula generally implies the existence of a single CUSIP that is cheapest-to-deliver. This CUSIP changes with market conditions, however. Thus, any attempt to short some specific CUSIP with a futures contract is subject to severe basis risk between the price of the specific CUSIP and the cheapest-to-deliver bond.

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

deteriorating credit, which will raise yields. But we seek to study yield changes caused by U.S. monetary policy, not yield changes from variation in the very low expected probability of a U.S. default. Because each of these four shorting strategies has specific requirements, traders typically do not switch between them.[7] These disadvantages in studying other instruments support our conviction that the Markit database is a uniquely helpful tool 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 UMP effects on asset prices and portfolios, and 3) asset price patterns around monetary announcements. This section briefly reviews this literature to frame the unique contributions of the current paper.

2.1. The short-selling literature

Institutions and individuals short for both speculative and hedging purposes, as well as to make a market. Shorting for hedging or liquidity provision will generally have no predictive content, while shorting for speculative purposes might, because short sellers are widely viewed as informed, sophisticated investors. Researchers have shown that the trades of shorts have predictive power for returns in several contexts. 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). Such

[7] 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.

studies of the information content of shorts' trading must implicitly assume that there is enough informed, speculative, short trading to predict equities in aggregate shorts trading.

Researchers similarly find that fixed-income short sellers anticipate information releases, although shorting in bond 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. Anecdotes suggest that some sophisticated investors initiated speculative short positions before the financial crisis (Lewis 2011). Shorts' success is consistent with the fact that shorts are disproportionally institutional traders, which are usually considered relatively sophisticated investors.

Few researchers have explored the difficult issue of whether access to private information or better processing of public information provides shorts' trading advantage. Micro studies claim conflicting answers. Christophe, Ferri, and Hsieh (2010) find an abnormally high proportion of short trading before unscheduled ratings downgrades, suggesting that brokerage firms gave shorts non-public information. In contrast, Engelberg, Reed, and Ringgenberg (2012) argue that shorts do not anticipate news events but process the information from those events more efficiently.

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

The theoretical literature on UMP suggests several channels by which such policies could influence yields. 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 the expected short rate component of long yields, while portfolio balance and local supply channels operate by influencing the term premium.

Forward guidance—Fed communication about future rates or economic conditions—presumably produces only signaling effects. The FOMC has offered forward guidance in at least nineteen different ways. Thirteen of these nineteen events occurred during our sample; Table 1 describes those events, among the other UMPAs from November 2008 through November 2015.[8]

In contrast to the single channel through which forward guidance may function, asset purchase announcements may both signal future interest rates and directly affect term premia. That is, asset purchases can signal a credible commitment to a path for interest rates by changing the Fed's incentives to raise rates quickly in the future (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 most commonly reason that a long-bond purchase reduces the total duration risk in the market, thereby reducing the required term premium to hold a given long bond. Another portfolio balance channel suggests that purchases of particular bonds may produce "local supply effects"—i.e., differential price reactions—for securities with very similar characteristics to those purchased.[9] In summary, UMPAs should affect all yields in the same direction, although not necessarily to the same extent.

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

[8] The forward guidance events during our sample took place on 12/16/2008, 3/18/2009, 8/9/2011, 1/25/2012, 9/13/2012, 12/12/2012, 12/18/2013, 3/19/2014, 10/29/2014, 12/17/2014, 3/18/2015, 7/29/2015, and 10/28/2015.
https://www.federalreserve.gov/monetarypolicy/timeline-forward-guidance-about-the-federal-funds-rate.htm

[9] Gorodnichenko and Ray (2017) show that local supply effects of Treasury demand shocks are most obvious during periods of elevated risk, but local supply effects occur during transactions, not announcements. We study announcement effects.

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 of substantial local supply effects. Fed UMPAs also affect international bond yields (Bauer and Neely 2014), exchange rates (Neely 2015), stock prices (Kiley 2014), and even emerging market asset prices (Bowman, Londono, and Sapriza 2015).[10]

2.3 Asset price movements before FOMC announcements

Researchers 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 a 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 FOMC meetings. Such excess USD trading returns imply that forex market expectations of monetary policy are delayed compared to those of money markets. Finally, Mamaysky (2018) argues that equity markets exhibit delayed reactions—of 3 weeks or more—to FOMC decisions. These papers suggest that inattention produces variable delays in news impact across asset classes.

While this literature characterizes interesting asset-price patterns around FOMC meetings, only Neuhierl and Weber (2018) have shown any anticipation of the surprise components of FOMC decisions. These authors show that the sign of stock returns up to 25 days before FOMC

[10] The Markit data has insufficient coverage to investigate international aspects of our research question.

announcements from 1994 to 2009 predicts the surprise component of such decisions. We will show that this intriguing result during a period of (almost entirely) conventional policy does not drive our results for the unconventional period (2008-2015).

3. Data

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

By late 2008, delayed effects from the collapse of housing prices 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. The FOMC repeatedly reduced the federal funds target to supplement these interventions, starting from 525 basis points in September 2007, finally reaching 0-25 basis points on December 16, 2008.

With the federal funds rate nearing zero, the Fed shifted to stimulating growth and preventing undesirable disinflation by reducing long yields with forward guidance and asset purchases. The FOMC announced $1.725 trillion in asset purchases in November 2008 and March 2009, which roughly tripled the U.S. monetary base and were together commonly called QE1. On November 3, 2010, the FOMC announced QE2: purchases of $600 billion of longer-term Treasuries during 2010-11. In conjunction with such buys, the FOMC issued statements to reduce future federal funds rate expectations. 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. In September 2012, the FOMC announced QE3, an ongoing housing-support program consisting of MBS and Treasury purchases. The FOMC began reducing QE3 purchases on December 18, 2013, and ended QE3 on October 29, 2014. The committee would not move the federal funds rate away from zero until December 2015, however. Fawley and Neely (2013) and

Neely and Karson (2021) detail these events.

Table 1 describes the 117 UMPAs— FOMC statements, selected speeches, minutes releases, and selected press releases—during our sample, the unconventional period of November 2008 through November 2015.[11] Almost all the announcements were scheduled well in advance, so their timing is exogenous to economic conditions. Many studies have examined price reactions to subsets (or all) of these UMPAs. Yet, no research has explored the extent to which sophisticated investors might have anticipated these price shocks.

3.2. Shorting and asset price data

Markit Securities Finance provides daily lending data for Treasury and agency securities for November 2008 through November 2015. 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, *BQ*, is the total debt on loan, net of double counting (based on par value).

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. Results are almost identical without filters 2 and 3.

Figure 1 illustrates the time series of daily *TBQ* and *TAQ* (Panel A) and *ABQ* and *AAQ* (Panel B). Panel A shows that *TAQ* (the black line) fluctuates but remains within the $550 billion to $900 billion range from 2008-2015. *TBQ* (the light gray line) declines modestly through August 2008

[11] An obvious extension to our paper would be to study the behavior of shorts around conventional monetary policy announcements. 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.

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 *TBQ* remains lower than pre-crisis through 2015. Panel B shows that the *AAQ* and *ABQ* (black and light gray lines, respectively) decline throughout the sample, with the steepest declines in 2008-2009. However, Figure 1 does not reveal whether the UMPA*s* are associated with significant changes in these quantities.

Table 2 displays the means of bond-level characteristics of the 873 Treasuries and 6,284 agencies in our sample. There are far more agency bond issues, and the agencies pay a much higher yield, on average. The Treasuries have a much larger issue size and a longer duration.

Tickwrite provides intraday futures prices, from which we construct 60 minute {-15, +45} and open-to-close event windows. We construct one- and two-day yield changes for 10-year Treasury yields, MBS yields, swap rates, and TSM -implied expected short rates and term premia. We use expected short rates and term premia from three prominent TSMs: those of Kim and Wright (2005), Christensen and Rudebusch (2012), and Adrian, Crump, and Moench (2013). These daily series are available from FRED or online data sources. We consider windows as long as two days because Boyarchenko, Haddad, and Plosser (2018) argue that longer-maturity Treasuries respond to relatively hard-to-process FOMC announcements (mostly) with a one-day lag.

3.3. Release of news by central banks

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 after the 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 a negative correlation between stock returns and yields implies monetary news. 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 move stock prices and yields in the same direction. 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 at the long end.

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 $\Delta Y30$ indicate 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,

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

Figure 2 shows 1-day changes in 10-year yields around the 117 events, including 52 monetary, 39 risk, and 26 growth events (Cieslak and Schrimpf (2019)). Growth, risk, and monetary events are relatively more common in the sample's first, second, and third parts, respectively. All types of events are associated with both positive and negative shocks.

4. Hypotheses of interest

This section describes hypotheses to test the behavior of shorts with before and after UMPAs from 2008-2015.

Suppose short-sellers think they have more accurate bond yield expectations than the risk-adjusted expectations of the marginal investor. In that case, such short sellers will cover (expand) their speculative short positions before surprisingly expansionary (contractionary) UMPAs, as they come to believe that bond prices will rise (fall). In an efficient market, current 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. If short sentiment merely mirrored that of the spot/futures market, the short investor's risk-adjusted expectation would track the spot/futures price, and the former would have no speculative incentive to change their portfolio.

Our hypotheses are the same for Treasuries and agencies. While the magnitude of Treasury and agency yield changes might differ, we expect them to move in similar directions. Hence, the responses of shorts to UMPAs to be identical in both markets.[12]

[12] Although flight-to-quality would increase the Treasury-agency yield spread, *ΔABQ* predicts all sorts of long yields in practice. The correlation between announcement-day changes in 10-year Treasuries and BB MBS yields is 0.78 over our sample period.

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

Hypothesis 1: Changes in short interest (i.e., ΔBQ) predict bond yield changes, including term premia and expected short rates, associated with UMPAs.

Findings in other contexts that shorts are sophisticated investors motivate hypothesis 1.

The following two hypotheses relate to short portfolio rebalancing after a UMPA.

Hypothesis 2: *Shorts expect Fed actions to be persistent. That is, shorts rebalance after FOMC UMPAs in a way that anticipates further yield changes in the same direction.*

While price effects should occur quickly, portfolio rebalancing can be slower. Thus, if a UMPA leads shorts to believe that Fed policies will persistently keep yields down (or up), that belief will cause them to rebalance in the weeks after the announcement. For example, expansionary surprises should prod shorts to cover their positions.

Hypothesis 3: *Growth news most strongly affects post-announcement rebalancing.*

Growth news will strongly affect views of future monetary policy and yields because business conditions are persistent but monetary news, i.e., deviations to a reaction function or response to risk, are likely to be transitory. In contrast to our rebalancing expectations, we have no reason to expect shorts to better predict some type(s) of news—i.e., monetary, growth or risk. While shorts may be adept at forecasting some types of news, we have no ex-ante view of what that would be.

Hypothesis 4: *Shorts transact across maturities both in preparing for announcements and in rebalancing after a UMPA.*

UMPAs have broadly influenced yields across the curve for much of the sample.[13] Therefore we hypothesize that shorts trade across maturities.

[13] Short yields were close to the zero lower bound throughout the sample, but even 1- and 2-year Treasury yields were above 20 and 40 basis points, respectively, for most of our sample.

5. Empirical results

5.1. Did the shorts correctly anticipate UMPAs?

Although the Fed only transacted in some bond issues, initial FOMC UMPAs did not indicate which specific securities would be purchased, and the UMPAs broadly affected yields. Hence, our analysis uses the sum of changes in *BQ* for all agencies (ΔABQ) and Treasuries (ΔTBQ).[14]

To investigate Hypotheses 1—that ΔBQ anticipates UMPA-induced yield changes—we regress announcement-day changes in yields, futures prices, term premia, and expected future short rates on combinations of lagged ΔABQ and ΔTBQ. We considered one-hour changes in futures prices: {-15, +45} minutes around the announcement and one- and two-day announcement windows.

A priori, the appropriate length of pre-announcement changes for ΔTBQ and ΔABQ is not obvious. We choose a lagged fifteen trading day change before the announcement (day t-16 to day t-1), but the results are robust to modest perturbations of this length.

To control for risk and other potential predictors of UMPA shocks, we considered six lagged control variables: implied bond market volatility (*MOVE*), implied stock market volatility (*VIX*), the CitiBank Economic Surprise Index (*Citi*), the Economic Policy Uncertainty Index (*EPUI*), 15-day (t-16 to t-1) changes in 10-year Treasury yields, and 15-day (t-16 to t-1) S&P500 returns. The findings of Neuhierl and Weber (2018) that lagged S&P500 returns predicted swap rate changes during a period of conventional monetary policy suggested its inclusion. We use the Bayesian information criterion (BIC) to select among all possible combinations of these controls. In practice, the BIC most frequently selected *VIX(-1)* to include in regressions of price/yield changes on ΔBQ.

[14] The System Open Market Account (SOMA) Holdings report, which is publicly available on the Federal Reserve Bank of New York's (FRBNY) website, details past open market purchases by CUSIP. 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.

We use a limited set of control variables because we assume that bond markets are approximately efficient for public information. That is, the yields just before the UMPA reflect the risk-adjusted expectation of the marginal spot market investor, which incorporates all relevant news. Therefore, yield/price changes at the time of the UMPA should be approximately unpredictable, except by risk-related variables, such as *VIX* or *MOVE*. To the extent that lagged *ΔTBQ* or *ΔABQ* predicts announcement-day yield changes, it supports the view that shorts are sophisticated investors and that efficiency imperfectly describes the bond market.

Bond prices and yields move in opposite ways by construction. If shorts can predict bond price changes, then one would expect the *BQ* coefficient in a regression of futures prices on *ΔBQ* to have a negative coefficient, as a rise in *BQ* (shorting) predicts a decline in bond prices. Similarly, one would expect a positive coefficient on *BQ* in predicting yield changes. To reduce confusion for the reader in interpreting coefficients on futures prices and yield changes, we reverse the signs of futures returns in all regressions so that positive coefficients for *BQ* variables are consistent with the ability of shorts to predict either yield or price changes. To facilitate interpretation and coefficient comparisons, we also divide the *ABQ* and *TBQ* 15-day change series by their respective sample standard deviations—approximately 2.76 and 12.80 billion.

For concreteness, we can write the regression of the 10-year Treasury yield change (Δy_t^{10yr}) on *ΔABQ*, *ΔTBQ,* and *VIX* as follows:

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

Table 3 shows results for such predictive regressions of announcement-day, 60-minute returns on 5-, 10- and 30-year futures contracts, daily changes in 10-year constant-maturity Treasury yields, and the Bloomberg-Barclays MBS yield on combinations of lagged 15-day *ΔABQ* and *ΔTBQ*. [15]

[15] Other MBS series provided similar inference.

Coefficients labeled "*ΔABQ*" in Table 3 show that *ΔABQ* always predicts futures price and yield changes, both on its own and when paired with *ΔTBQ.* All *ΔBQ* coefficients are positive, indicating that a rise in *BQ* (more shorting) predicts higher yields, i.e., a contractionary surprise. In other words, the shorts adjust their positions correctly in anticipation of monetary policy surprises. *ΔABQ* coefficients remain significant in the presence of controls, indicating that both sets of variables have independent information about bond price/yield changes on UMPA days. The R^2s in the *ABQ* models were substantial, ranging from approximately 0.09 to 0.35.

What is the economic impact of these predictions? Recalling that futures price change signs are reversed in the regressions and accounting for the contribution of the constant (-1.4), the coefficient of 16.68 on *ΔABQ* in the 10-year futures regression indicates that a one standard deviation ($2.76 billion) increase in *ABQ* in the 15 days before a UMPA predicts a (16.68-1.4=) 15.28 basis point reduction in the 10-year futures price in the announcement window. Such a reduction is greater in absolute value than about 50% of all announcement day changes. As the *ΔABQ* and *ΔTBQ* regressors are kurtotic, a one-standard-deviation change is less likely than it would be from a normal distribution.

In addition to standard regression metrics, we also compute the percentage of observations in which the regression prediction matches the sign of the deviation of the return from its sample mean ("% correctly signed"). This statistic provides an additional diagnostic of the fit. Table 3 shows that all the bond price/yield models predict the correct direction more than 50% of the time. However, the predictions of the signs of 60-minute changes are not statistically significantly different than 50 percent.

The inference that *ABQ* significantly predicts UMPA bond price/yield changes is robust to both tests for structural breaks and sensitivity tests, i.e., after removing one observation at a time from

the sample to see if the *ΔABQ* coefficients become insignificant. However, the significance of the *TBQ* coefficient estimate in the 30-year futures regression is not robust to the removal of any observation. We omit the complete robustness checks for brevity.

5.2 How did the type of news release affect predictive accuracy?

We calculate the Cieslak and Schrimpf (2019) news indicators for our sample, categorizing each of the 117 events as a monetary, growth, or risk shock. Then, we ask how the *ΔBQ*-prediction accuracy varies with the sort of news released. 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.

The conditional R^2s —rows labeled "*R^2 Money*", "*R^2 Risk*", and "*R^2 Growth*"—in Table 3 show that *ΔABQ*'s predictive ability for bond prices/yields comes from monetary and growth news releases. *ABQ* and *TBQ* show similar patterns of predictability for the three types of events: conditional R^2s for the changes in bond futures prices and yields tend to be higher during monetary and growth events than during risk events, during which they are often negative.[16] Perhaps appropriately, *BQ's* ability to predict MBS (a riskier asset) yields during risk events is the exception to this tendency.

In summary, *ΔABQ* consistently predicts bond yields/prices. Events when FOMC decisions release growth or monetary news drive this ability. This supports hypothesis 1.

[16] Predictability—i.e., conditional R^2—is also higher-than-average during periods of above-average monetary policy uncertainty, which we measured by *MOVE*. Growth announcements, however, are correlated with *MOVE* and are more closely associated with predictability than *MOVE*. Therefore, we think that the growth announcements better explain the heightened predictability.

5.3 Does BQ predict expected short rates, term premia, or both?

We now investigate whether the shorts have special insight into expected short rates, term premia, or both. Specifically, we regress yield changes on four measures of expected short rates, one shadow short rate, and four measures of term premia on 15-day lagged *ΔABQ*. We only present results for *ABQ* models, as it has much greater predictive content than *TBQ*. Three of our measures of expected short rates/term premia come from the TSMs of Kim and Wright (2005), Christensen and Rudebusch (2012), and Adrian, Crump, and Moench (2013). We also use the 10-year swap rate to directly measure the expected short rate, and we construct a swap-implied term premium as the 10-year yield less the associated swap rate. We consider multiple measures of expected short rates/term premia because the true model is unknown. Finally, we consider the Krippner (2013) shadow short rate (SSR) as a measure related to (but not equal to) the expected future short rate.

Table 4 shows results of regressing 1- and 2-day changes in these five expected-short-rate measures and four term-premia measures on 15-day lagged *ΔABQ* and selected control variables. The *ABQ* coefficient was significant for each dependent variable (column) at either the 1- or 2-day horizons or both. For example, the *ABQ* coefficient in the *ACM E(i)* regression is significant for the 1-day horizon (1.51) but not the 2-day horizon (0.54). The *ABQ* coefficients for the Kim-Wright expected-short-rate and term-premia regressions are significant at both window lengths.

Except for the *ABQ* coefficient in the 2-day SSR regression (0.94), the significance of each *ABQ* coefficient in Table 4 is robust to the removal of any observation from the regression. Tests failed to reject structural stability in every case but the 2-day *ACM TP* regression.

In summary, *ΔABQ* robustly predicts both term premia and expected rates, consistent with the idea that shorts anticipate portfolio balance and signaling effects, supporting hypothesis 1.

5.4. Discussion: Why does shorts' trading in the agency market predict returns?

Section 2.1 described mixed conclusions from the very limited research on the source of shorts' trading acumen. Our data does not contain the structure to directly test whether bond-market shorts obtain private information on FOMC decisions or process public information better. Two facts suggest to us, however, that better processing of public information is more likely: First, the shorts in our data best predict yield changes from growth news and then monetary news. They do not have predictive power for risk news. This dependence on the type of news suggests that shorts are not receiving inside information, as that would provide more uniform success. Second, the limited scope of private knowledge of future FOMC actions leads us to think that information leakage is an unlikely explanation.

Curiously, *ABQ* predicts yield changes better than *TBQ*, despite the former market's smaller size. (See Table 3 and Figure 1.) As discussed previously, speculative shorting may have predictive content, while hedging does not. With this in mind, shorting in the agency market may have greater predictive content than that in the Treasury market because the latter may have a higher proportion of shorting for hedging purposes, or may be less likely to draw informed speculators. (There are no public data that breaks down the participants between hedgers and speculators for agency and Treasury shorting.)

5.5. How do shorts respond to purchase announcements?

We next consider hypothesis 2: Shorts rebalance their portfolios following 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 117 announcement-day changes in intraday futures prices and daily changes in yields, term premia, and swap rates. We again chose a 15-day change because it seems to be a reasonable time frame for rebalancing, and it fits reasonably well for a variety of asset

prices/yields and *BQ* measures. For each dependent variable, i.e., *ΔABQ* and *ΔTBQ* from t+1 to t+16, we again used the BIC to choose combinations of the six control variables — *MOVE*, *VIX*, *EPUI*, *Citi*, lagged 15-day yield changes, and lagged 15-day S&P percentage returns—to isolate the marginal effects of the announcement surprise on portfolio rebalancing.

The regression of *ABQ* on the policy-induced 60-minute negative return in the 10-year Treasury futures price, for example, can be written as follows:

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

Table 5 shows the results of regressing the ex-post 15-day changes in the sums of *ΔABQ* (left subpanel) and *ΔTBQ* (right subpanel) on policy-induced (negative) futures returns. All of the futures-return coefficients are statistically significant for both the *ΔABQ* and *ΔTBQ* specifications. The positive signs of the coefficients on (negative) futures returns are consistent with a persistent impact of policy because they indicate that a monetary expansion is followed by a decline in *ABQ* (i.e., *ΔABQ* is negative), consistent with the hypothesis that shorts expect further decreases in yields. The bond futures prices retain predictive ability in the presence of controls, indicating independent information in both controls and the monetary shock.

The dependent *BQ* variables are measured in standard deviations and multiplied by 100 for coefficient presentation in Table 5. The 0.95 coefficient on the 5-year futures price in an *ABQ* regression implies that an announcement-day, 24 basis point (one announcement-window standard deviation) 5-year futures return would be associated with a post-announcement reduction of (0.95*24/100=) 0.228 standard deviations or (0.228*2.76 billion =) $0.63 billion in *ABQ*.

Although all the formulations pass sensitivity tests to remove any observation, all the *ABQ* formulations in the left panel of Table 5 show structural instability—the coefficient estimates are small for the second half of the sample. The *TBQ* coefficients in the right-hand panel show no

break. Thus, the portfolio adjustments support hypothesis 2— i.e., shorts expect persistent policy—for both *BQ* variables for the first part of the sample but not for *ABQ* in the second half.

Hypothesis 3 claimed that growth news is most likely to affect rebalancing because business conditions are persistent. To investigate the impact of types of news on *ΔBQ* rebalancing, we regress 15-day ex-post *ΔBQ* on announcement-day 10-year futures price changes interacted 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. We write the regression of *ΔABQ* to policy-induced changes in the (negative) 10-year futures price as follows:

$$\Delta ABQ_{t+1,t+16} = b_0 + b_M(-\Delta P_t^{10yr})I(M_t) + b_R(-\Delta P_t^{10yr})I(R_t) + b_G(-\Delta P_t^{10yr})I(G_t) + b_4 Control_t + \varepsilon_t \quad (7)$$

The coefficients b_M, b_R and b_G describe the impact of monetary, risk, and growth news, respectively, on rebalancing.

Table 6 confirms hypothesis 3: Growth news most strongly affects post-announcement rebalancing (see the rows labeled "b_G [10-yr fut*I(G)]").[17] That is, the growth indicator coefficients (b_G) are the largest and most statistically significant predictors of future *ΔABQ* and *ΔTBQ*. In addition, the coefficients on monetary events (b_M) are also generally positive and statistically significant. The positive coefficients on the negative futures price changes during growth events mean that an expansionary (contractionary) monetary shock, i.e., a rise (decline) in the 10-year futures price, is associated with a post-announcement reduction (increase) in *BQ*. The coefficient of 2.23 on "10-year future*I(G)" (column 2 of Table 6) can be interpreted to mean that a 40 basis point (one announcement-window standard deviation) decline in 10-year futures prices is associated with an increase of (2.23*40/100 =) $0.89 billion (about 1/3 of an unconditional standard deviation) in *ABQ* in the next 15 days.

[17] 5- and 30-year futures price changes produce inference very similar to that from the 10-year futures.

In summary, Table 6 shows that shorts cover (expand) their short positions following monetary-induced changes in expansionary (contractionary) yields and are accompanied by growth and monetary news releases. These results partially support hypothesis 2 and fully support hypothesis 3: Shorts do not find that all Fed actions necessarily imply persistence, but actions that release monetary or (especially) growth news lead them to expect persistence.

5.6 With what maturities did the shorts trade before UMPAs?

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.

Figure 3 shows the correlations of the lagged 15-day ΔABQ and ΔTBQ by remaining years-to-maturity with the 1-day announcement-day changes in 10-year yields.[18] Positive correlations indicate that shorts correctly anticipate Fed-induced price changes with bonds of that maturity. We caution the reader that each full-sample correlation estimate will have a standard error of about 0.09-0.10.[19] One can only draw broad conclusions from general patterns over the yield curve.

[18] Correlations with the Kim-Wright expected short rate and the Kim-Wright term premia were nearly identical to those with yields that are shown in Figure 3. Correlations with the Adrian-Crump-Moench or Christensen-Rudebusch expected interest rates and term premia data were not identical but were similar to those of the Kim-Wright model. We omit these results for brevity.

[19] For bivariate normal variables, the following function of a Pearson correlation estimate (r) has a t distribution with T-2 df: $r * \sqrt{(T-2)/(1-r^2)}$ (Hogg and Craig (1978)). This means that, with 117 observations, a 5 percent, ones-sided test rejects the null that a given sample correlation equals zero if the estimated correlation is greater than about 0.16. The analytic distribution slightly understates the bootstrapped dispersion on average.

The correlations in Figure 3 range from about -0.l to 0.4, with almost all being positive. The correlation patterns for yields, expected interest rates, and term premia are very similar, so we only present those for yields. Consistent with the much greater significance of *ABQ* in Table 3, the yield change correlations with *ABQ* are slightly larger than those with *TBQ,* but the patterns are somewhat similar. There are some unusually large or small correlations, but these are often adjacent to very different correlations, which suggests that sampling variation is at work. For example, the yield-*ABQ* correlations for 8-9 years are negative but adjacent to large, positive correlations for the 7-8 year and 10+ year bins. This pattern suggests random variation rather than a true preference for certain maturities. We conclude that shorts appear to operate throughout the yield curve in preparing for announcements with no apparent pattern of preference for short, medium, or long yields, supporting Hypothesis 4.

5.6 With what maturities did the shorts trade following UMPA*s?*

To investigate what maturities shorts use when they rebalance in the wake of a UMPA, 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, for example, shorts adjust their portfolios entirely or mainly through their holdings of bonds with long times-to-maturity, then we expect large correlations only with long time-to-maturity *BQ*.

Recall that Table 6 showed that shorts condition their aggregate portfolio adjustment on the type of information in the UMPAs, i.e., monetary, risk, or growth news. That is, shorts tended to rebalance systematically only after monetary and especially growth news. Because of this tendency, we condition the time-to-maturity correlations on the type of announcement news.

The three panels of Figure 4 show these correlations between announcement day 10-year yield changes and ex-post portfolio adjustment (15-day *ΔABQ* and *ΔTBQ*) by time-to-maturity,

conditional on the release of monetary, risk or growth news, respectively.[20] The positive signs of the vast majority of the correlations in panels A and C —for monetary and growth news — indicate that shorts find Fed signals to be persistent in the sense that reduced yields during monetary or (especially) growth periods are associated with lower *BQ,* as shorts presumably anticipate further declines in yields. In contrast, the correlations for risk news (Panel B) have mixed signs and appear to be approximately mean zero, meaning that shorts do not respond systematically to UMPAs that release risk news. We interpret Figure 4 to indicate that shorts trade both agencies and Treasuries across the yield curve while rebalancing after UMPAs, supporting Hypothesis 4.

6. Conclusion

In response to the financial and economic crisis resulting from the housing bubble's collapse, in November 2008, the Federal Reserve began UMP programs to reduce long-term interest rates and stimulate investment and consumption. These large and novel programs substantially reduced long yields, expected short rates, and term premia, raised stock prices, and depreciated the dollar on foreign exchange markets.

We investigate the bond-market behavior of shorts, widely regarded as sophisticated investors, before and after Federal Reserve monetary policy announcements. We find that pre-announcement changes in *ABQ* robustly predict announcement-day changes in bond futures prices/yields throughout the yield curve during the Federal Reserve's 117 UMPAs from November 2008 through November 2015. That is, shorts tended to cover (expand) their short positions in agencies and Treasuries in the weeks before expansionary (contractionary) monetary announcements. *ABQ* has much greater predictive power than *TBQ*. Changes in *ABQ* predict both changes in term premia

[20] Recall that Wald tests for the *ABQ* coefficients in Table 6 rejected stability at the sample midpoint, and the coefficients for the *ABQ* regressions were essentially zero for the second half of the sample, so the *ABQ* correlations in Figure 4 are informative for only the first part of the sample.

and expected short rates, which are associated with portfolio balance and signaling effects, respectively. This predictive power occurs for UMPA 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 because they must out-predict marginal investors in very deep spot/futures bond markets whose prices are determined almost entirely by public information on the macroeconomy. A set of sophisticated investors systematically outperforming marginal investors in spot and futures markets in predicting UMP actions is an exceptional result with implications for market efficiency and monetary policy expectations.

We also examine the behavior of shorts after monetary policy announcements. Shorts' rebalancing behavior was consistent with the belief that some UMPAs signal persistent changes in policy. That is, expansionary (contractionary) announcements would lead shorts to cover (expand) their positions in the weeks following the event. But this pattern only existed when the Fed released monetary or growth news. Shorts adjusted their post-event portfolios across the yield curve.

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 the marginal bond market investor.

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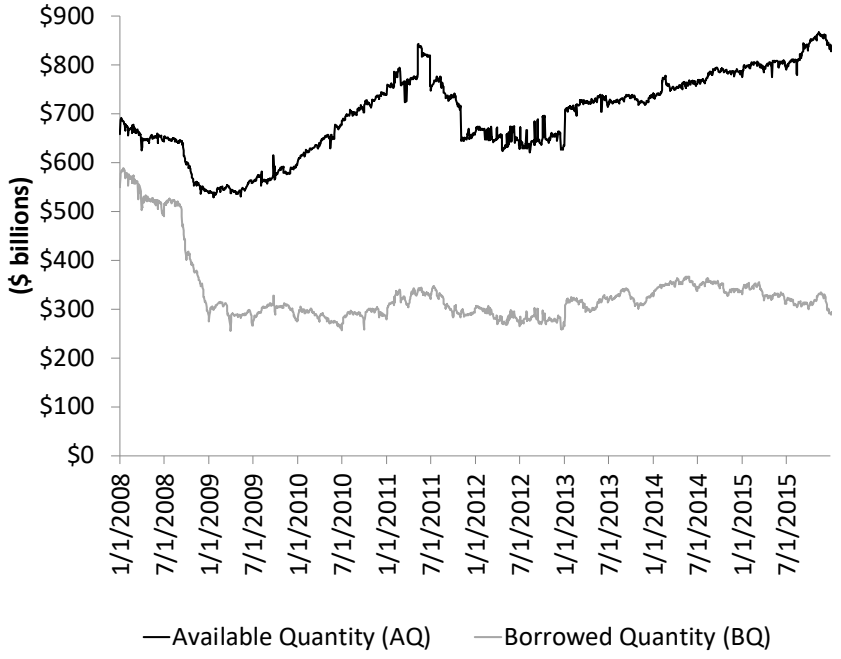
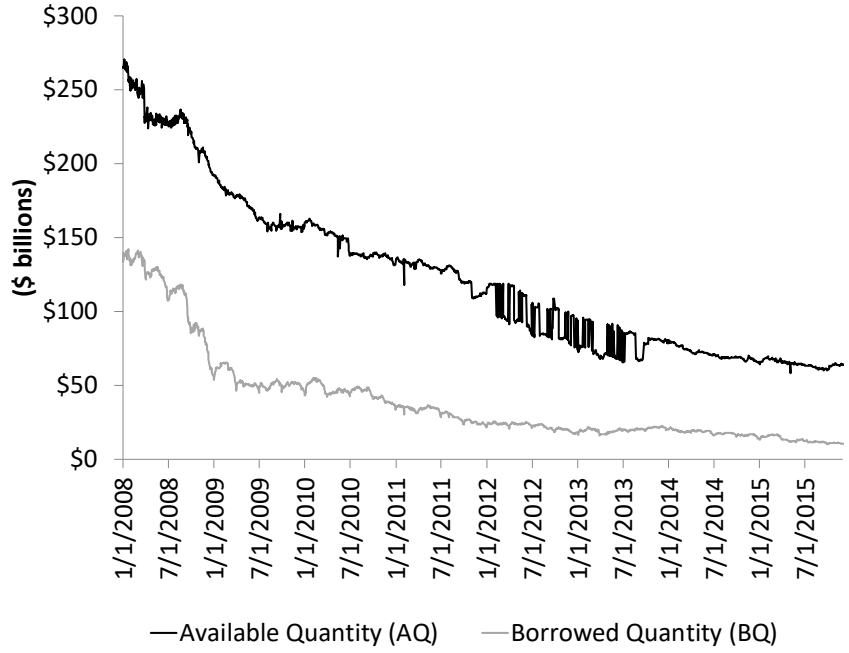


Panel A. Treasuries



Panel B. Agencies

Figure 1. 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 11/30/2015. Values are in billions of USD and based on par value. In the text, Treasuries (agencies) available and *BQ* in Panel A (Panel B) are referred to as *TAQ* and *TBQ* (*AAQ* and *ABQ*), respectively.

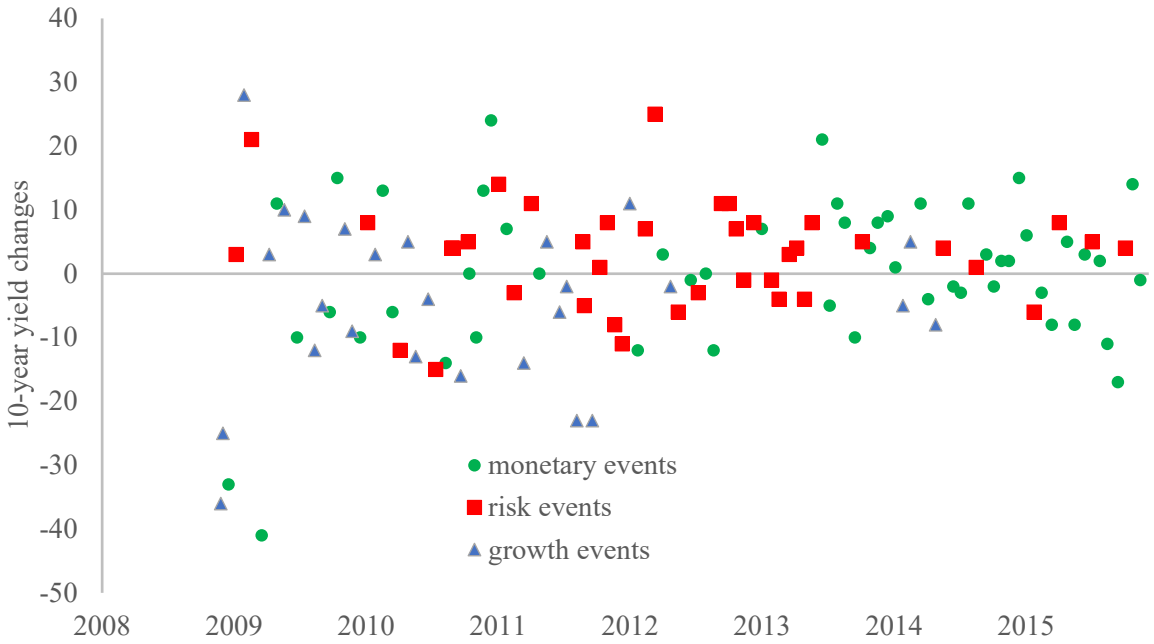


Figure 2. Daily 10-year Treasury yield changes around 117 unconventional monetary policy announcements

We present 1-day changes in nominal yields in percent for 10-year constant maturity U.S. Treasuries, 10-year agencies (FMC 84), around 117 unconventional monetary policy announcements from 11/25/2008 through 11/18/2015.

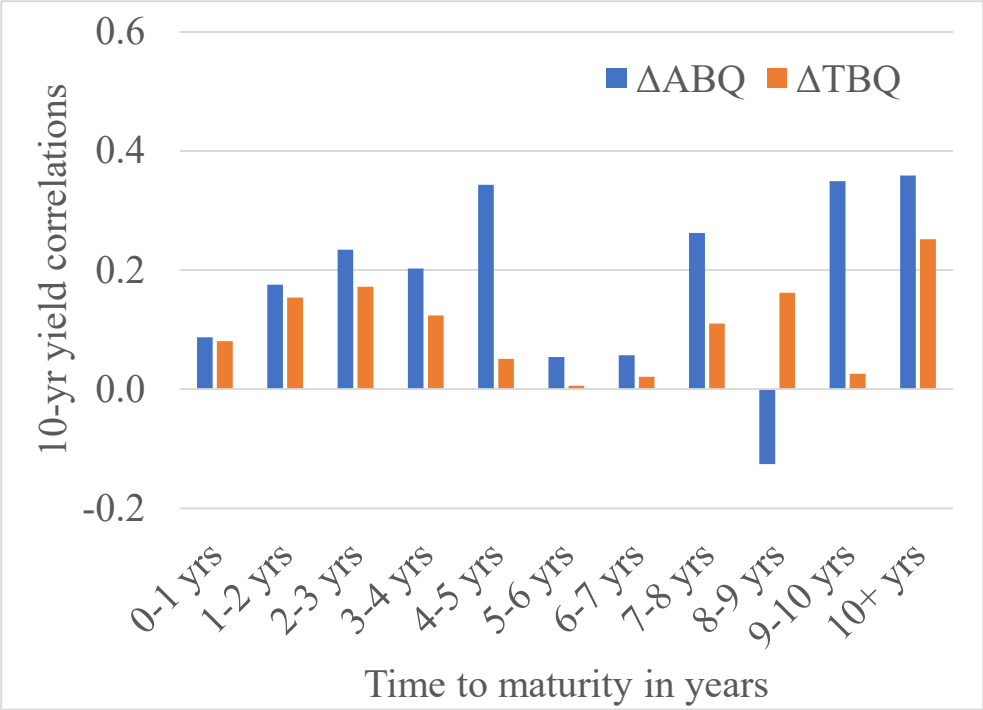
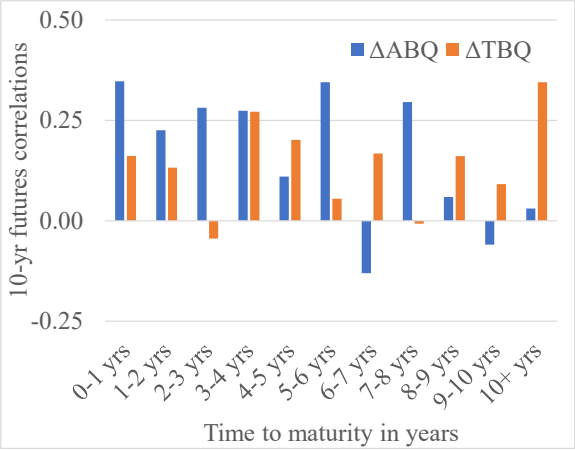
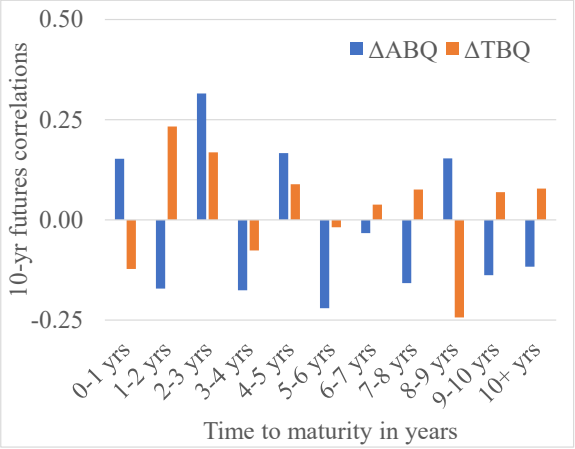


Figure 3. Correlations of yield changes with 15-day lags of *ΔBQ* by the time of remaining maturity

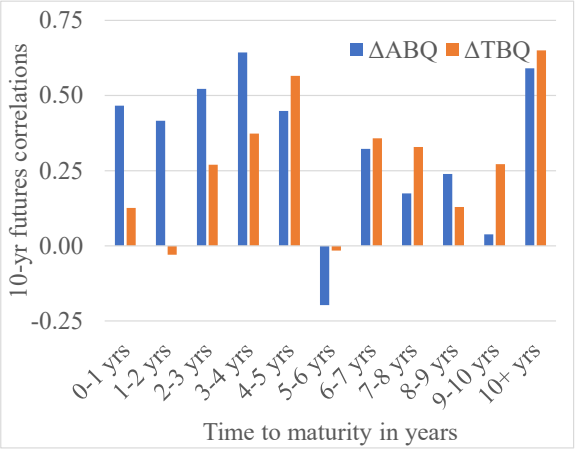
The figure shows the correlations of the 10-year-Treasury yields on *ΔABQ* and *ΔTBQ* for varying times to maturity. For example, the blue bar in the bin labeled "0-1 yrs" depicts the correlation between announcement-day yield changes and 15-day changes in pre-event borrowings of agency bonds with less than 1-year remaining maturity.



Panel A. 10-year-Treasury futures correlations with leads of *BQ*, conditional on the release of monetary news



Panel B. 10-year-Treasury futures correlations with leads of *BQ*, conditional on the release of risk news



Panel C. 10-year-Treasury futures correlations with leads of *BQ*, conditional on the release of growth news

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 table describes the 117 UMPAs during QE1, QE2, MEP, and QE3, from November 2008 through November 2015. The UMPAs consist of FOMC statements, speeches, press releases, and minutes releases.

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	The first suggestion of extending QE to Treasuries. Fed cuts fed funds rate to 0-0.25 percent. FOMC expects exceptionally low rates “for some time.”
1/6/2008	2:00 PM	Minutes	QE1	
1/28/2009	2:15 PM	Meeting	QE1	Fed stands ready to expand QE and buy Treasuries.
2/18/2009	2:00 PM	Minutes	QE1	
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."
4/8/2009	2:00 PM	Minutes		
4/29/2009	2:15 PM	Meeting		No change in policy.
5/20/2009	2:00 PM	Minutes		
6/24/2009	2:15 PM	Meeting		No change in policy.
7/15/2009	2:00 PM	Minutes		
8/12/2009	2:15 PM	Meeting	QE1	LSAP slowed: All purchases will finish by the end of October, not mid-September.
9/2/2009	2:00 PM	Minutes		
9/23/2009	2:15 PM	Meeting	QE1	LSAP slowed: Agency debt and MBS purchases will finish at the end of 2010Q1.
10/14/2009	2:00 PM	Minutes		
11/4/2009	2:15 PM	Meeting	QE1	LSAP downsized: Agency debt purchases will finish at $175 billion.
11/24/2009	2:00 PM	Minutes		
12/16/2009	2:15 PM	Meeting		No change in policy.
1/6/2010	2:00 PM	Minutes		
1/27/2010	2:15 PM	Meeting		No change in policy.
2/17/2010	2:00 PM	Minutes		
3/16/2010	2:15 PM	Meeting		No change in policy.
4/6/2010	2:00 PM	Minutes		
4/28/2010	2:15 PM	Meeting		No change in policy.

Table 1—Continued

Date	Time	Type	Program	Description
5/19/2010	2:00 PM	Minutes		
6/23/2010	2:15 PM	Meeting		No change in policy.
7/14/2010	2:00 PM	Minutes		
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	Chairman Bernanke suggests a role for additional QE "should further action prove necessary."
8/31/2010	2:00 PM	Minutes		
9/21/2010	2:15 PM	Meeting	QE2	FOMC emphasizes low inflation, which is "is likely to remain subdued for some time."
10/12/2010	2:00 PM	Minutes		"[additional] accommodation may be appropriate before long."
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.
11/23/2010	2:00 PM	Minutes		
12/14/2010	2:15 PM	Meeting		No change in policy.
1/4/2011	2:00 PM	Minutes		
1/26/2011	2:15 PM	Meeting		No change in policy.
2/16/2011	2:00 PM	Minutes		
3/15/2011	2:15 PM	Meeting		No change in policy.
4/5/2011	2:00 PM	Minutes		
4/27/2011	12:30 PM	Meeting		No change in policy.
5/18/2011	2:00 PM	Minutes		
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.
7/12/2011	2:00 PM	Minutes		
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 plans but says Fed has tools it can use if necessary.
8/30/2011	2:00 PM	Minutes		
9/21/2011	2:15 PM	Meeting	MEP	MEP ("Operation Twist") announced.
10/12/2011	2:00 PM	Minutes		
11/2/2011	12:30 PM	Meeting		No change in policy.

Table 1—Continued

Date	Time	Type	Program	Description
11/22/2011	2:00 PM	Minutes		
12/13/2011	2:15 PM	Meeting		No change in policy.
1/3/2012	2:00 PM	Minutes		
1/25/2012	12:30 PM	Meeting		FOMC expects low rates "at least through late 2014."
2/15/2012	2:00 PM	Minutes		
3/13/2012	2:15 PM	Meeting		No change in policy.
4/3/2012	2:00 PM	Minutes		
4/25/2012	12:30 PM	Meeting		No change in policy.
5/16/2012	2:00 PM	Minutes		
6/20/2012	12:30 PM	Meeting	MEP	MEP extended until the end of 2012.
7/11/2012	2:00 PM	Minutes		
8/1/2012	2:15 PM	Meeting		No change in policy.
8/22/2012	2:00 PM	Minutes		FOMC members “judged that additional monetary accommodation would likely be warranted fairly soon….”
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.”
10/4/2012	2:00 PM	Minutes		
10/24/2012	2:15 PM	Meeting		No change in policy.
111/4/2012	2:00 PM	Minutes		
12/12/2012	12:30 PM	Meeting	QE3	QE3 expanded: Fed will purchase $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 forecast below 2.5 percent.
1/3/2013	2:00 PM	Minutes		
1/30/2013	2:15 PM	Meeting		No change in policy.
2/20/2013	2:00 PM	Minutes		
3/20/2013	2:00 PM	Meeting		No change in policy.
4/10/2013	9:00 AM	Minutes		
5/1/2013	2:00 PM	Meeting		No change in policy.
5/22/2013	2:00 PM	Minutes		
6/19/2013	2:00 PM	Meeting	QE3	FOMC will purchase “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 increases in 2013.

Table 1—Continued

Date	Time	Type	Program	Description
7/10/2013	2:00 PM	Minutes		
7/31/2013	2:15 PM	Meeting		No change in policy.
8/21/2013	2:00 PM	Minutes		
9/18/2013		Meeting	QE3	Tapering postponed
10/9/2013	2:00 PM	Minutes		Minutes Release
10/30/2013	2:00 PM	Meeting		Further postponement of tapering.
11/20/2013	2:00 PM	Minutes		Minutes Release
12/18/2013	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $35 billion and $40 billion. Unemployment lift-off threshold of 6.5 % abandoned.
1/8/2014	2:00 PM	Minutes		Minutes Release
1/29/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $30 billion and $35 billion.
2/19/2014	2:00 PM	Minutes		Minutes Release
3/19/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $25 billion and $30 billion; Expand the information assessed in determining lift-off date.
4/9/2014	2:00 PM	Minutes		Minutes Release
4/30/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $20 billion and $25 billion.
5/21/2014	2:00 PM	Minutes		Minutes Release
6/18/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $15 billion and $20 billion.
7/9/2014	2:00 PM	Minutes		Minutes Release
7/30/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $10 billion and $15 billion.
8/20/2014	2:00 PM	Minutes		Minutes Release
9/17/2014	2:00 PM	Meeting	QE3	Cut monthly purchases of MBS and Treasuries to $5 billion and $10 billion
10/8/2014	2:00 PM	Minutes		Minutes Release
10/29/2014	2:00 PM	Meeting	QE3	End of QE.

Table 1—Continued

Date	Time	Type	Program	Description
11/19/2014	2:00 PM	Minutes		Minutes Release
12/17/2014	2:00 PM	Meeting		No change in policy.
1/7/2015	2:00 PM	Minutes		Minutes Release
1/28/2015	2:00 PM	Meeting		No change in policy.
2/18/2015	2:00 PM	Minutes		Minutes Release
3/18/2015	2:00 PM	Meeting		Drops pledge to be patient and reduced the projected path for interest rate increases amid weakened growth forecasts.
4/8/2015	2:00 PM	Minutes		Minutes Release
4/29/2015	2:00 PM	Meeting		No change in policy.
5/20/2015	2:00 PM	Minutes		Minutes Release
6/17/2015	2:00 PM	Meeting		No change in policy.
7/8/2015	2:00 PM	Minutes		Minutes Release
7/29/2015	2:00 PM	Meeting		No change in policy.
8/19/2015	1:50 PM	Minutes		Minutes Release
9/17/2015	2:00 PM	Meeting		No change in policy.
10/8/2015	2:00 PM	Minutes		Minutes Release
10/28/2015	2:00 PM	Meeting		No change in policy.
11/18/2015	2:00 PM	Minutes		Minutes Release

Table 2
Issue characteristics of Treasuries and agencies
This table summarizes the bond-level means of the 873 Treasuries and 6,284 agencies in our sample.

	Treasuries	Agencies
Issue Size (mill. $)	28,643	1,494
Coupon rate (%)	2.15	2.93
Duration (years)	5.94	3.38
Time-to-maturity (years)	8.09	6.20
YTM (%)	2.34	3.64

Table 3
Regression results

	5-yr fut 60 min			10-yr fut 60 min			30-yr fut 60 min			10-yr yields (t-1 to t)			BB MBS (t-1 to t)		
ΔABQ	10.37		10.63	16.68		16.35	16.53		14.59	2.40		2.19	3.18		3.31
(s.e.)	(2.15)		(2.43)	(3.62)		(4.08)	(4.99)		(5.61)	(0.86)		(0.92)	(1.07)		(1.15)
ΔTBQ		1.28	-0.63		3.48	0.81		12.27	4.81		1.55	0.70		1.21	1.09
(s.e.)		(2.75)	(2.73)		(4.58)	(4.59)		(5.77)	(6.32)		(0.98)	(1.02)		(1.22)	(1.28)
VIX(-1)		-0.75			-1.21					-0.25	-0.29	-0.23	-0.36	-0.54	-0.41
(s.e.)		(0.23)			(0.39)					(0.08)	(0.08)	(0.08)	(0.10)	(0.11)	(0.11)
Citi(-1)													0.05	0.07	
(s.e.)													(0.02)	(0.02)	
S&P (-16 to -1)														-0.75	
(s.e.)														(0.27)	
R^2 Money	21.0	11.8	21.2	18.1	12.0	18.0	7.7	2.1	7.5	18.1	15.7	18.5	31.2	25.6	27.4
R^2 Risk	-59.7	-43.7	-57.6	-63.5	-53.5	-65.2	-25.8	-21.8	-30.3	-18.3	-25.3	-19.7	23.0	31.5	16.7
R^2 Growth	25.9	26.3	24.6	34.9	34.0	36.1	29.1	21.2	33.9	46.8	42.0	47.9	50.9	48.5	53.0
R^2 All	17.1	11.1	17.1	15.9	11.5	15.9	8.9	3.9	9.4	20.8	17.1	21.1	34.2	34.7	31.3
%sign All	53.0	54.7	52.1	53.8	54.7	53.8	55.6	55.6	53.0	62.4	55.6	60.7	67.5	68.4	61.5

NOTES: The table shows results from regressing announcement-day changes in 5-year, 10-year, and 30-year Treasury futures prices, 10-year Treasury yields, and Bloomberg Barclays MBS yields, on lagged 15 -day changes in *ΔABQ*, *ΔTBQ*, and control variables chosen for each regression. All regressions are estimated with constants, but those estimates are omitted for brevity. To present consistent expected signs on *ΔABQ* and *ΔTBQ* coefficients for both futures price and yield regressions, we estimate the regressions with the negative of the changes in futures prices. The changes in futures prices are constructed for {-15, +45} minute windows around the event time. Standard errors (SE) are in parentheses. Light gray shaded cells denote significance at the 5 percent, one-sided level.

Table 4
Results from regressing expected short rates, including swap rates and the shadow short rate, and term premia on combinations of lagged 15-day *ΔABQ* and *ΔTBQ*

1-day horizon	ACM E(i)	CR E(i)	KW E(i)	10-yr swap	SSR	ACM TP	CR TP	KW TP	Swap TP
ΔABQ	1.51	1.63	1.29	0.32	0.63	1.31	1.11	1.12	2.23
(s.e.)	(0.43)	(0.40)	(0.50)	(0.54)	(0.27)	(0.72)	(0.72)	(0.39)	(0.80)
VIX(-1)			-0.13	-0.21		-0.20	-0.12	-0.12	
(s.e.)			(0.05)	(0.05)		(0.07)	(0.04)	(0.04)	
10-year yield(-16 to -1)					0.05				
(s.e.)					(0.01)				
R^2	9.9	13.1	18.0	17.8	21.3	15.2	13.8	22.1	6.5

2-day horizon	ACM E(i)	CR E(i)	KW E(i)	10-yr swap	SSR	ACM TP	CR TP	KW TP	Swap TP
ΔABQ	0.54	-0.67	2.19	3.96	0.94	4.91	4.66	1.80	-0.85
(s.e.)	(0.49)	(0.60)	(0.53)	(0.98)	(0.53)	(1.01)	(1.19)	(0.59)	(0.53)
VIX(-1)				-0.37		-0.29	-0.17		
(s.e.)				(0.09)		(0.11)	(0.06)		
10-year yield(-16 to -1)					0.09				
(s.e.)					(0.02)				
R^2	1.0	1.1	13.1	32.7	19.0	17.2	24.7	21.4	2.2

NOTES: The upper and lower panels of the table respectively show results from regressions of announcement-day changes in expected short-term interest rates and term premia on lagged 15-day changes in *ABQ* using 1-day (t-1 to t) and 2-day (t-1 to t+1) event windows, respectively. The left panels display results using expected short rates as the dependent variable, while the right panels show analogous measures using term premia as the dependent variable. Estimated constants are omitted for brevity. Three sets of expected short rates (E(i)) and term premia (TP) are from TSM data published by Adrian, Crump, and Moench (2013) (ACM), Christensen and Rudebusch (2012) (CR), and Kim and Wright (2005) (KW). We use the 10-year swap rate as an expected short rate (10-yr swap) and measure an implied term premium as the yield less the swap rate (Swap TP). Krippner's (2013) shadow short rate (SSR) is a measure related to— but not identical with—expected future short rates. Standard errors (SE) are in parentheses. These TSM data are posted online. Light gray shaded cells denote significance at the 5 percent, one-sided level.

Table 5
Results from regressing leads of 15-day *ΔABQ* and *ΔTBQ* on announcement-day high-frequency futures price returns.

	ABQ			*TBQ*		
HF 5-year fut	0.95			1.42		
(s.e.)	(0.35)			(0.31)		
HF 10-year fut		0.67			0.77	
(s.e.)		(0.21)			(0.19)	
HF 30-year fut			0.53			0.52
(s.e.)			(0.16)			(0.15)
VIX(-1)	-3.78	-3.55	-3.76			
(s.e.)	(0.95)	(0.95)	(0.92)			
S&P (-16 to -1)	7.41	7.67	6.61	8.38	8.39	7.60
(s.e.)	(2.34)	(2.32)	(2.27)	(1.94)	(1.97)	(2.02)
R2 Money	-8	-5	-13	16	10	6
R2 Risk	-18	-14	-16	0	-1	-1
R2 Growth	54	55	58	48	47	45
R2 All	37	39	40	26	24	22
%sign All	64	63	64	62	62	57

NOTES: The table shows results of regressing15-day leads of *ΔABQ* (left panel) and *ΔTBQ* (right panel) on selected control variables and UMPA-day changes in futures prices. Standard errors (SE) are in parentheses. Light gray shaded cells denote significance at the 5 percent, one-sided level.

Table 6
Regression results from 15-day ex-post Δ*ABQ* and Δ*TBQ* on *VIX* and daily changes in the 10-year Treasury yield interacted with $I(M_t)$, $I(R_t)$, and $I(G_t)$.

	ABQ	*TBQ*
b_M [10-yr fut*I(M)]	0.50	0.58
(s.e.)	(0.22)	(0.21)
b_R [10-yr fut*I(R)]	-0.09	0.56
(s.e.)	(0.86)	(0.84)
b_G [10-yr fut*I(G)]	2.23	1.81
(s.e.)	(0.53)	(0.49)
VIX(-1)	-2.81	
(s.e.)	(0.94)	
S&P (-16 to -1)	6.47	6.90
(s.e.)	(2.29)	(2.06)
R^2 All	44.2	27.4
%sign All	66.7	62.4

NOTES: The table shows results of regressions of leads of 15-day *ΔABQ* and *ΔTBQ* on announcement-day changes in the 10-year futures price 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. Standard errors (SE) are in parentheses. Light gray shaded cells denote significance at the 5 percent, one-sided level.