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ESSAYS IN FINANCE

by

Jade Planchon

A Dissertation

Submitted in Partial Fulfillment of the

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Preface

Essays 1 of this dissertation titled “Unconventional monetary policy and the behavior of shorts” with Thomas H. McInish and Chris Neely is prepared for submission to Journal of Banking and Finance. Essay 2 “Supply and demand shifts of shorts prior to Fed announcements during QE1 – QE3” with Thomas H. McInish and Chris Neely in this dissertation is prepared for submission to Economic Letters.

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Abstract

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This dissertation presents two papers that examine fixed income shorting during periods of unconventional monetary policy. Specifically, I explore whether shorts predicted Federal Reserve policy following the financial crisis as well as their reactions following Fed announcements of large scale asset purchases of Treasuries and agencies.

Essay 1 studies short selling during periods of unconventional monetary policy. 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. I investigate the behavior of shorts, considered sophisticated investors, before Fed announcements that were not fully anticipated in spot bond markets. Short interest in Treasury and agency securities declined prior to expansionary surprises, indicating shorts anticipated these news, and declined further after these announcements. The failure of shorts to reinstitute their positions after the last purchase announcement confirms that the Fed convinced sophisticated investors that interest rates would remain low.

Essay 2 extends the work of Cohen, Diether, and Malloy (*Journal of Finance*, 2007), who find that shifts in the demand curve predict negative stock returns, to examine changes in supply and demand at the time of Fed announcements. I show that shifts in the demand for borrowing Treasuries and agencies predict quantitative easing. A reduction in quantity demanded at all points along the demand curve predicts expansionary quantitative easing announcements.

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Chapter 1

Introduction

This dissertation comprises two essays in finance. The first essay studies short selling of Treasuries and agencies during periods of unconventional monetary policy. I focus on short sellers because they are viewed as informed, sophisticated investors. The second essay examines the supply and demand for borrowing Treasuries and agencies (a proxy of short selling) prior to Fed expansionary (“buy”) announcements.

In the first essay, I investigate whether shorts anticipated the surprise components of Fed bond purchase announcements and how they reacted following the announcements. That is, I examine whether the Fed convinced sophisticated short investors that interest rates would remain low. I initially focus on a broad set of unconventional policy announcements during QE1, QE2, MEP, and QE3. I later shift the focus to four early and particularly surprising, expansionary announcements during QE1. Focusing on these events should be a more stringent test of shorts ability to predict policy surprises given the magnitude of the change in long yields following these announcements. Additionally, I study short sellers response to Fed announcements that indicated reduced or slowed purchases of Treasuries and agencies.

In the second essay, I use a unique approach developed by Cohen, Diether, and Malloy (Journal of Finance, 2007) to test whether shorts predicted Fed announcements during QE1 – QE3. I find that the majority of Treasury and agency securities experience a demand shift inward one week and one month prior to Fed buy announcements. Further, the distribution of shifts prior to buy announcements is statistically different than for the control period.

Chapter 2

Unconventional monetary policy and the behavior of shorts

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 unconventional measures to stabilize the global economy. 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 unconventional policies in four phases: Quantitative Easing 1 (QE1) in 2008-2010, QE 2 in 2010-2011, the Maturity Extension Program (MEP) in 2011-2012 and QE 3 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.

Using *securities borrowing* as a proxy for short interest, we empirically investigate whether shorts anticipated the surprise components of Fed bond purchase announcements and how they

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.

²Short positions included shorting stocks and bonds exposed to the subprime market, such as large investment banks (e.g., Citigroup, Lehman Brothers, and UBS), as well as credit default swaps on subprime mortgage bonds.

reacted to those moves. That is, we examine whether the Fed convinced sophisticated short investors that interest rates would remain low.

Specifically, we initially focus on a broad set of 21 unconventional policy announcements during QE1, QE2, MEP, and QE3 (Figure 1). We later shift our focus to four early and particularly surprising, expansionary announcements during QE1—labeled 1, 2, 3, and 4, in Figure 1. Focusing on these events should be a more stringent test of shorts ability to predict policy surprises given the magnitude of the change in long yields following these early announcements. In other words, they are events that the marginal investor in spot and futures markets did not fully anticipate.

Figure 1 shows the 10-year-Treasury yield and future price changes surrounding each of 21 events pertaining to FOMC statements, speeches or press releases or announcements associated with unconventional policy during the four phases.³ Futures prices rise by \$1.547, on average, for the four announcements compared to \$0.297 for all other announcements. The 10-year-Treasury yield falls 28.4 bps, on average, over these four announcement windows, compared to an average of fall of 6.9 bps for other announcements. To further show the importance of the four buy announcements that we study, Appendix 1 compares the magnitude of the $\Delta Borrowed Quantity$ for our events to net changes over subperiods. The $\Delta Borrowed Quantity$ for the windows around the four announcements is accounted for 43.8% of the decrease from Period 1-Control through Period 4-Post. Further, the $\Delta Borrowed Quantity$ for the windows around four

³ The 10-year Treasury yields data are from Bloomberg and the change is the one-day change around the event. The futures price data are from Tickwrite quotes and the change is calculated based on the futures price 15 minutes before to 90 minutes after each announcement. Most events in Figure 1 have been previously studied in papers such as Gagnon, Raskin, Remache, and Sack (2011), Krishnamurthy and Vissing-Jorgensen (2011), Neely (2015) or Wright (2012).

chosen announcements is larger, on average, than the Δ *Borrowed Quantity* around the Lehman bankruptcy.

To presage our results, we find significant short covering prior to and following asset purchase announcements. These findings are consistent between the focused study of four events and the broader regression study of all 21 events. Short interest remained low throughout 2009 and early 2010 (following the initial set of QE announcements), indicating that the Fed did convince shorts that interest rates would remain low.

We examine short interest because data are available for these sophisticated investors. Data on trades of other sophisticated investors such as hedge funds, mutual funds, and insiders are either not available or available only with delay.

Predicting important monetary policy surprises is a particularly stringent test for shorts because publicly available information almost entirely determines the path of monetary policy.⁴ To earn abnormal returns, shorts must outpredict 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.

Consistently outpredicting 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, markets appear to be fairly efficient in anticipating changes to the

⁴ There are many examples of public information that potentially sheds light on 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/>

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 overpredicting the rate implied by final futures settlement by 3 to 6 basis points per month of forecast horizon, on average. These authors interpreted this small bias as reflecting risk premia rather than a systematic forecasting error (Piazzesi and Swanson, 2008).

In contrast, 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, Call, Clement, and Sharp (2014) find that such communication is a more useful input to analysts' forecasts than their own primary research. These proprietary inputs (primary research and private communication with management) as well as other publicly available information (earnings guidance and previous 10-Q/10-K reports) inform earnings predictions before audited financials are publicly released. Shorts have proved themselves to be adept at discerning whether these earnings announcements will affect stock prices.

We use securities borrowing obtained from Markit as our proxy for short interest. These data are available daily and cover individual CUSIPs of both Treasuries and agencies.

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). But each of these has disadvantages for studying the behavior of shorts compared to our approach.

Traders cannot, for example, use futures to short individual CUSIPs because many securities are potentially deliverable on each futures contract.⁵ Another difficulty with futures data is that

⁵ One might argue that the cheapest to deliver is a single bond, but which bond is cheapest to deliver can change.

separating the trades of short speculators from those of hedgers is problematic because these classifications are self-reported. Private conversations with industry participants suggest that these classifications are often unreliable.

Repos can also be used to borrow securities for short selling. However, data on repos for individual CUSIPs are not readily available. 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 use CDSs to benefit from falling bond prices caused by deteriorating credit, but since the U.S. is unlikely to default CDSs are not a substitute for shorting Treasuries and agencies.

Because each strategy has its own particular requirements, traders typically do not switch between these four ways of profiting from falling bond prices.⁶ 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 contract. To trade CDSs directly, institutions need an International Swaps and Derivatives Association (ISDA) master agreement, which might be difficult for smaller institutions to obtain.

2. Literature review

This paper unites two literatures: research that examines the characteristics and information content of short selling and research studying asset market reactions to unconventional monetary policy. This section briefly reviews these literatures to frame the unique contribution of the current paper.

⁶ To some extent, these limitations could be overcome by dealing through financial intermediaries.

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, Frino, McCorry, and Swan, 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 profitable opportunities provided by downgrade announcements (Christophe, Ferri, and Hsieh, 2010). Short sellers do not anticipate news, but have superior ability to process news (Engelberg, Reed, and Ringgenberg, 2012).

Researchers similarly find that short sellers adjust their portfolios prior to the release of useful information in fixed income markets, although shorting in such markets has received much less attention than in equity markets. Nashikkar and Pedersen (2007) find short selling of corporate bonds increases before a rating downgrade, which indicates that certain investors anticipate the rating change. However, these authors cannot discern whether the increased short selling is due to private information, superior research ability, or whether prices react slowly to public information. Additionally, Hendershott, Kozhan, and Roman (2017) find that corporate bond shorts predict future bond returns. In contrast, Asquith, Au, Covert, and Pathak (2013) find that heavily-shortened corporate bonds do not earn abnormal returns, indicating that investors' private information does not motivate these short sales.

2.2. Literature related to unconventional monetary policy

By definition, bond yields can be 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 signaling, portfolio balance, and local supply (substitution) channels.

Signaling effects refer to the possibility that Fed announcements change expected future short-term interest rates. That is, the Fed might commit to zero interest rates beyond its normal horizon, which Eggertsson (2006) refers to as “committing to be irresponsible.” To the extent that signaling affects expected short yields, it should affect all bond yields, whether the Fed purchased those bonds or not.

Forward guidance presumably produces only signaling effects and no portfolio balance effects. The FOMC has offered forward guidance through at least five variations of “extended period” language to restrain expectations of policy rate hikes.

In contrast to the single channel through forward guidance may be effective, asset purchase announcements may both signal future interest rates and directly affect term premia. That is, asset purchases can signal a path for interest rates by changing the Fed’s incentives to raise rates quickly in the future. A central bank with a large quantity of long-maturity bonds will incur capital losses when bond yields increase; this reduces the central bank’s incentive to raise quickly policy rates (Bhattarai, Eggertsson, and Gafarov, 2015).

If short bonds were perfect substitutes for long bonds, then *ex ante* term premia would be zero and signaling would be the only active transmission channel; the Fed’s unconventional policy could only affect long yields through the expected future short rate. Short bonds are imperfect substitutes for long bonds, however, and therefore the Fed’s unconventional policy actions can also affect the term premia on bonds through the portfolio balance channel (Tobin, 1958). This channel allows a bond purchase to directly affect term premia by reducing quantities of certain types of risk in the public’s hands and therefore reducing the required premium to hold this risk. 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. But Krishnamurthy and

Vissing-Jorgensen (2011) argue that removing duration is less important than removing certain maturities of very safe assets. This “safety channel” is a version of the portfolio balance channel in which some investors strongly prefer certain maturities of very safe assets.

Either version of the portfolio balance channel predicts larger changes in expected returns to assets that are more similar to those of the purchased asset. In other words, Fed asset purchases that change term premia of purchased assets will also change term premia of related assets to the extent that they are substitutes. Purchases of particular issues may also produce “local supply effects”—i.e., differential price reactions—for purchased and not-purchased securities that have very similar characteristics. In summary, unconventional monetary policy should affect all bond yields in the same direction, although not necessarily to exactly the same extent.

Event studies provide strong evidence that unconventional monetary policies influence a broad variety of bond and other asset prices through both signaling and portfolio balance channels. Gagnon, Raskin, Remache, and Sack (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, partly through reductions in default risk and prepayment risk.

D’Amico and King (2013) present evidence that agents consider broad classes of long bonds to be significantly, but not perfectly, substitutable. These authors show that bond prices for all Treasuries and agencies increase at the time of the LSAP announcements, regardless of whether

the Fed actually purchases a particular security. However, these authors also show that the actual transactions have local supply effects on specific issues, as described previously.⁷

The effect of 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 substitutes. 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 boosts to bond and stock prices also affected emerging markets (Bowman, Londono and Sapriza, 2015).

3. Data

3.1. Data collection and definition of variables

We use daily lending data from Markit Securities Finance for January 2008 to 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* is the quantity of inventory available to lend (based on par value) and, hence, to short. Our proxy for short interest, *Borrowed Quantity*, is the total quantity of debt on loan, net of double counting (based on par value). We also use *Utilization (Borrowed Quantity/Available Quantity)* as a proxy for short interest for our robustness tests (Appendix 2) and our results are quantitatively similar.

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

⁷ D'Amico and King (2013) focus on the Treasury market following the March 18, 2008 announcement. The authors find that the average purchase operation temporarily reduced yields by 3.5 basis points in the sector of the purchase and that the program as a whole (beginning with the announcement and concluding with the final purchase) shifted the yield curve down by up to 30 basis points.

purchases by CUSIP.⁸ *Amount Purchased* is the amount the Fed purchases each week (based on par value). The FRBNY website also provides Term Securities Lending Facility (TSLF) lending data.⁹

Datastream is the source for 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) time-to-maturity of greater than five years at least once during the sample, (3) mean *Available Quantity* of greater than \$10 million over the sample period, (4) mean *Borrowed Quantity* greater than \$1 million over the sample period, and (5) at least 30 daily observations.¹⁰

Initially, we examine announcements during QE1-QE3. Then we focus on four important QE1 announcements that conveyed important information and raised expectations of easier monetary policy in asset markets. We denote these four announcements as follows: LSAP-B1, 11/25/2008; LSAP-B2, 12/1/2008; LSAP-B3, 12/16/2008; and LSAP-B4, 3/18/2009. Collectively, we label these as “All announcements.”

We divide the QE1 sample into four sub-periods:

- Period 1-Control (1/1/2008–8/31/2008);
- Period 2-Heart of the Crisis (9/1/2008–11/17/2008);
- Period 3-Announcements (11/18/2008–3/25/2009); and

⁸ https://www.newyorkfed.org/markets/soma/sysopen_accholdings.html

⁹ <https://apps.newyorkfed.org/markets/autorates/tslf/historical/search>

¹⁰ We exclude securities with time-to-maturity of less than 5 years because the zero lower bound constrained movement of those yields during the period of our study. According to Swanson and Williams (2014), however, 5- and 10-year Treasuries remained sensitive to news until the last few 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.

- Period 4-Post-announcements (3/26/2009–3/31/2010).¹¹

Hereafter, we refer to these four periods as P1-Control, P2-Heart, P3-Announce, and P4-Post, respectively. P1-Control begins January 1, 2008. P2-Heart begins just prior to the spate of events in September 2008. P3-Announce begins with LSAP-B1. P4-Post begins just after LSAP-B4 and ends at the conclusion of QE1 purchases.

Table 1 summarizes bond-level characteristics of the 124 Treasuries and 716 agencies in our QE1 sample.

All statistical tests are at the 0.05 level or greater unless otherwise stated.

3.2. Important QE1 events

By late 2008, delayed indirect effects from the 2006-2008 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 Insurance Group (AIG), and the passage of the Troubled Asset Relief Program (TARP) program. The first actions to expand unusually the monetary base were 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, 2008.¹² Table 2 shows a timeline of important events associated with the crisis.¹³

¹¹ D'Amico and King (2013) refer to 2009-2010 as the Fed intervention period and 2000-2008 and the non-intervention period.

¹² 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).

¹³ The Fed's SOMA operates a securities lending program (SLP) that allows primary dealers to borrow securities through the Fed's competitive auction held each business day at noon Eastern Time. The SLP for Treasuries operated throughout our sample period, but only began for agencies July 9, 2009. Given that the SLP is designed to

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 to a 0-25 basis point range on December 16, 2008. Long yields, however, did not follow short-rates down prior to November 2008. Figure 2 shows no overall trend in long yields during P1-Control and P2-Heart, but a substantial decline in the first half of P3-Announce. During P4-Post, Treasury yields trended up while agency yields were stable.¹⁴

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 took the first step in asset purchases on November 25, 2008, with a press release that announced 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 that it would purchase an additional \$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, 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 the two explicit QE1 purchase announcements, monetary policy announcements on December 1, 2008 and December 16, 2009 (LSAP-B2 and LSAP-B3) lowered long yields immediately by creating expectations of future bond purchases.

Table 3, Panel A, shows the four most important QE1 announcements on which we focus our study. Table 2, Panel B, shows the periods during which the Fed purchased bonds under QE1.

aid overnight clearing and that the average tenor of securities loans for our Treasuries and agencies exceeds 75 days, we do not believe that the SOMA SLP is relevant for our research design.

¹⁴ Agency yields are based on the Bloomberg-Barclays U.S. aggregate agency debt index.

Under QE1, the FRBNY purchased agencies from November 25, 2008, until March 31, 2010 and Treasuries from March 18, 2009, until October 30, 2009. Figure 3 illustrates the cumulative interest rate change for Treasuries and agencies. While some of the purchase announcements only mentioned Treasuries and not agencies (LSAP-B2 and LSAP-B3) or mentioned agencies but not Treasuries (LSAP-B1), Figure 3 shows that both Treasury and agency yields immediately declined in response to *all four* announcements. This is consistent with event study evidence that strongly implies that asset purchase announcements affected a wide range of yields. Therefore, while we report the tests of these securities separately, we expect to find similar changes in the borrowing market during the announcement period.

3.3. Borrowing market descriptive statistics

Figure 4 illustrates the time series of total daily *Borrowed Quantity* and *Available Quantity* for Treasuries (Panel A) and agencies (Panel B). The vertical lines indicate the four LSAP announcement days described in Table 2, which we consider in our study. Figure 4, Panel A, shows that Treasuries' *Available Quantity* (black line) shows no particular trend during the sample, with some modest diminution during the heart of the crisis in the fall of 2008 and then some recovery later. Panel A also shows that Treasuries' *Borrowed Quantity* (light gray) 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. Figure 4, Panel B, shows that the *Available Quantity* and *Borrowed Quantity* (black and light gray, respectively) of agencies similarly decline from September 2008 to March 2009 when their decline moderates. It is difficult to tell from the figure, however, whether the policy announcements are associated with significant changes in these quantities.

Table 4 describes the average daily *Available Quantity*, *Borrowed Quantity*, and *Utilization* by period of Treasuries (Panel A) and agencies (Panel B). For Treasuries, all three variables decrease monotonically in the four sample periods. For agencies, *Utilization* decreases monotonically while *Borrowed Quantity* and *Available Quantity* decrease period-to-period except during P2-Heart where we find an uptick. The flight to quality during P2-Heart probably explains these differing patterns between Treasury and agency borrowing markets. The agency market faced uncertainty which could have increased the amount of shorting.

4. Hypotheses development

This section describes hypotheses to test the effects of the LSAP announcements and purchases on the behavior of shorts.

If short sellers are sophisticated investors with more accurate expectations than the risk-adjusted expectations of the marginal investor, then such short sellers will cover their short positions prior to announcements, as soon as they come to believe that bond prices will rise. When markets are efficient, the spot/futures bond prices reflect the risk-adjusted expectation of the marginal investor, so the short investor must predict bond prices better than the marginal investor to earn abnormal returns. . It is not sufficient for short sentiment to simply mirror that of the spot market. In that case, the spot price would always mirror the risk-adjusted expectation of the short investor and the latter would have no incentive to change his/her portfolio.

Hypothesis 1: Short interest declines in the five days prior to LSAP buy announcements.

We further hypothesize that expansionary Fed announcements credibly signal that long rates, and therefore short interest, will remain low as long as short sellers do not believe bond prices will fall. That is, a credible expansionary announcement will produce further declines in short

interest in the days that follow. In addition, we hypothesize that shorts will believe that the Fed intends to keep interest rates low over longer horizons.

Hypothesis 2: Short interest declines in the five days just after LSAP buy announcements.

Initially, we test Hypothesis 1 and 2 using a full set of QE1, QE2, MEP, and QE3 announcements (Section 5.1). In the Section 5.2 through 5.3, we turn our analysis to the four early and particularly surprising, expansionary announcements. These should be easier to discern if shorts can predict large policy surprises (see Figure 1).

Hypothesis 3: Short interest remains low during the whole P4-Post period.

We test Hypothesis 3 in Section 5.4. In Section 5.5, we also examine announcements for which the Fed surprised the market by indicating the possibility of reduced purchases, increasing long yields. If shorts are able to anticipate such surprises, they should either increase or at least not decrease short interest before such contractionary announcements.

At the time of announcements, the Fed does not indicated which specific securities will be purchased. Hence, our analysis focuses on all Treasuries and agencies. But eventually the securities actually purchased is known. We extend our analysis to examine whether announcements differently affected purchased vs. not-purchased securities in Appendix 3.

5. Empirical results

This section characterizes the shorts' responses to LSAP announcements we initially study the extended set of unconventional monetary policy announcements and then focus on a subset of the most surprising announcements.

5.1. The impact of unconventional monetary policy shocks on Borrowed Quantity for QE1, QE2, MEP, and QE3

To assess whether our hypotheses apply to a broader sample, we test a broad sample including 21 QE1, QE2, MEP, and QE3 announcements from 11/25/2008 to 6/19/2013 (see Appendix 4 for announcement descriptions). We use time-series regressions to test Hypotheses 1a and 1b, that is, whether (1) $\% \Delta \text{Borrowed Quantity}$ before each announcement predicts the monetary shock (ΔYield) and (2) whether the monetary shock explains $\% \Delta \text{Borrowed Quantity}$ after each announcement. We measure the monetary policy shock as the daily change in 10-year Treasury yields (ΔYield) following each announcement and $\% \Delta \text{Borrowed Quantity}$ as the five-day percentage change in borrowed quantity before and after each announcement.¹⁵ Specifically we run following regressions:

$$\Delta \text{Yield} = \beta_0 + \beta_1 * \% \Delta \text{Borrowed Quantity}_{\text{before}} + \beta_2 * \text{TimeTrendDummy} + \varepsilon \quad (1)$$

$$\% \Delta \text{Borrowed Quantity}_{\text{after}} = \beta_0 + \beta_1 * \Delta \text{Yield} + \beta_2 * \text{TimeTrendDummy} + \varepsilon \quad (2)$$

All variables are defined in Table 5.

Table 5, Columns (1) to (3), show the results of predicting the monetary policy shock (proxied by ΔYield) with $\% \Delta \text{Borrowed Quantity}_{\text{before}}$. Columns (1) and (2) show that the both the Treasury and agency $\% \Delta \text{Borrowed Quantity}_{\text{before}}$ predict the monetary shock with the correct

¹⁵ Our results are quantitatively similar when using the intraday change—15 minutes before to 90 minutes after announcement—in 10-year Treasury futures prices as the monetary shock variable.

sign and to a statistically significant degree. A change of 1% in *Borrowed Quantity* before the announcement is related to a $\Delta Yield$ of 2.6 bps and 1.1 bps, for Treasuries and agencies, respectively. Because Treasury and agency $\% \Delta Borrowed Quantities$ are significantly correlated ($\rho = 0.62$) and both are somewhat correlated with the time trend, we orthogonalize the Treasury $\% \Delta Borrowed Quantity_before$ with respect to the agency $\% \Delta Borrowed Quantity_before$ when using both in a joint regression.¹⁶ Column (3) shows that agency $\% \Delta Borrowed Quantity_before$ and the orthogonal component of Treasury $\% \Delta Borrowed Quantity_before$ strongly jointly predict the monetary shock.

Table 5, Columns (4) to (7), analyze the impact of the monetary shock on $\% \Delta Borrowed Quantity$ following each announcement. An expansionary monetary shock (a decrease in interest rates) significantly reduces $\% \Delta Borrowed Quantity$ of both Treasuries and agencies in the week following the announcement, when one controls for $\% \Delta Borrowed Quantity$ before the announcement. These findings are consistent with our results in Section 5.3 that shorts further reduced their positions following monetary policy shocks. That is, the unconventional monetary announcements credibly reduce expected yields over the longer term.

5.2. Did the shorts anticipate the LSAP purchase announcements?

Before turning to Treasuries and agencies, 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 5, Panel A illustrates that *Borrowed Quantity* for Lehman equity increased dramatically prior to the Lehman bankruptcy and only fell below beginning-of-2008

¹⁶ The orthogonalization prevents the coefficient on the agency *Borrowed Quantity* from becoming perversely negative because of the correlation with Treasury *Borrowed Quantity* and the time trend.

levels after the bankruptcy, likely reflecting both profit taking and reduced ability to borrow the equity. In other words, a strong rise in short interest anticipated the Lehman bankruptcy.

In contrast to the strong rise in short interest in Lehman equity prior to September 2008, short interest in Treasury and Agency bonds showed no particular trend over the same period. That is, from January 1, 2008 to late August, the cumulative Δ *Borrowed Quantity* for Treasuries (black line Figure 5, Panel B) fluctuates but remains mostly positive. However, this variable begins to decline a few weeks prior to the Lehman bankruptcy, reaches beginning-of-2008 levels a few days prior to Lehman's bankruptcy, and continues declining through the first three LSAP events before leveling off in January 2009. Cumulative Δ *Borrowed Quantity* for agencies (gray line, Figure 5, Panel B) fluctuated more and had a modest uptrend until August 2008, a few weeks prior to the Lehman bankruptcy, when it began to decline, in fits and starts, until May 2009.

Figure 5 provides suggestive evidence that both Treasuries' and agencies' Δ *Borrowed Quantity* anticipated monetary policy shocks. Treasuries' cumulative Δ *Borrowed Quantity* declines sharply in the few days before a big expansionary move, LSAP-B4, on March 18, 2009, which announced purchases of \$750 billion of agency MBS, \$100 billion of agencies and up to \$300 of Treasuries. Similarly, the sudden decrease in agencies' Δ *Borrowed Quantity* a few days prior to November 25, 2008 (LSAP-B1), the date on which the Fed announced large purchases of agencies, indicates that shorts anticipated the direction of the surprise component of the announcement. Although Figure 5 provides preliminary evidence that Hypothesis 1 is correct — i.e., short interest in long bonds appears to have declined prior to surprisingly expansionary LSAP announcements—one must carefully examine Δ *Borrowed Quantity* movements around to each announcement to provide more conclusive evidence.

Table 6, Columns (1) and (3) (labeled “Before”), show that *Borrowed Quantity* declines in the five days before each of the four events for Treasuries and agencies, except for a slight increase prior to December 1, 2008 (LSAP-B2) for Treasuries.¹⁷ For the Table 6 tests our control is 34 five-day changes during P1-control; the last row of Table 6 shows that Treasuries and agencies have an average change of 0.17% and 0.82%, respectively, during the control period.

Table 6, Column (1), shows that short interest in Treasuries declines by 1.88% in the five days prior to the November 25, 2008 LSAP purchase announcement. The March 18, 2009, announcement (LSAP-B4) has the biggest effect on Treasuries’ *Borrowed Quantity* with a 10.93% decline in short positions (Column (1)). We believe that this very large decline occurred because short investors anticipated, to some degree, the LSAP-B4 announcement of a massive buy, with purchases of \$750 billion in MBS, \$100 billion of agencies and \$300 billion of Treasuries. Considering all announcements together, Table 6, Column (1), shows that Treasuries’ short interest declines by a statistically significant 3.79%, on average, prior to the announcements.

The mean percentage decline in agency short positions, for all announcements, was even larger than that for Treasuries. Table 6, Column (3), shows agencies’ short interest declines by an average of 5.19% prior to the announcements. Hence, we reject the null hypothesis of no-change in favor of Hypothesis 1, indicating that sophisticated short sellers reduced their short positions prior to announcements.

The findings in Table 6 support Hypothesis 1.¹⁸

¹⁷ We use a five-day window for our event study. For announcements that occur at the end of the day, the day after the announcement is t_0 . For announcements that occur at the beginning of the day, the announcement day is t_0 . We measure the “Before” period from t_{-5} to t_0 and the “After” period as t_0 to t_5 . A five-day window allows time for traders to react to the announcement (which sometimes occurs at the end of the day) and for delays in settlement.

¹⁸ In addition to *Borrowed Quantity*, we also use *Utilization* as a proxy for short interest and find similar results (see Appendix 3).

5.3. *How shorts respond just after the purchase announcements?*

Table 6, Column (2) (labeled “After”), shows that Treasuries’ *Borrowed Quantity* declines in the 5-days *after* each announcement, except the first.¹⁹ For all announcements combined, *Borrowed Quantity* of Treasuries declines by a statistically significant 3.44%. The *Borrowed Quantity* of agencies declines, on average, by a statistically significant 5.44% in the five days after each announcement, although the decline for the first announcement is only significant at the 0.1 level. These results support the hypothesis that shorts cover both Treasury and agency positions following the LSAP announcements (Hypothesis 2). That is, the LSAP announcements convince short investors that yields will stay low or decline further.

5.4. *Did the shorts reinstate their positions following purchase announcements?*

We have demonstrated that shorts reduced their positions prior to announcements that reduced yields / raised bond prices, which is consistent with the view that some shorts anticipated the surprise components of these announcements. We have also shown that shorts further reduced their positions immediately after the announcements, suggesting that the announcements credibly induced expectations of low yields in the short-term. These findings support Hypothesis 1 and Hypothesis 2, respectively.

The Fed’s announcement of March 18, 2009 (LSAP-B4) was the last purchase announcement of the QE1 program and the Fed paused for 20 months before embarking on further unconventional policies. If the shorts anticipated that the Fed would maintain low interest rates after LSAP-B4, then short interest should remain low after LSAP-B4. Table 7 shows means in *Borrowed Quantity* on the first day of P4-Post (3/26/2009) and the last day of P4-Post

¹⁹ Given that LSAP-B1 and LSAP-B2 are one week apart, LSAP-B1 after and LSAP-B2 before reflect the same time window; therefore, the Δ *Borrowed Quantity* for LSAP-B1 after and LSAP-B2 before are equal.

(3/31/2010). For Treasuries, the *Borrowed Quantity* mean declines by \$228.5 million from \$1,269 million to \$1,040 million from the first day to the last day. The difference is not statistically significant but its sign is consistent with Hypothesis 3. For agencies, the *Borrowed Quantity* declines significantly from \$48.8 million to \$33.6 million over the same period. Clearly, short interest does not increase during P4-Post. These results reinforce our conclusions, based on Figure 5, that the Fed was successful in convincing shorts that interest rates would remain low, supporting Hypothesis 3.

5.5. *Shorts' reactions to Fed announcements of slowed buying*

We also investigate short behavior around three Fed announcements that indicated reduced or slowed purchases of Treasuries and agencies (“Slow Events”).²⁰ We do not expect short interest to decline prior to these announcements, whose surprise component was ambiguous or disappointing.

Evidence in Table 8 confirms this expectation for both Treasuries and agencies. For Treasuries, *Borrowed Quantity* increases an average of 1.52% and 0.65%, before and after the announcements, respectively. For agencies, *Borrowed Quantity* increases an average of 0.26% and 0.76%, before and after the announcements, respectively. Only three of the 12 changes in borrowed quantity are negative and the overall changes are positive for both Treasuries and agencies. These results reinforce our view that our proxy for short interest captures changes in the sentiment of shorts.

²⁰ While the language in the 1/28/2009 announcement was expansionary the market did not view it that way. Prior to this date, Federal Reserve officials had mentioned the possibility of purchasing Treasuries, but in the actual FOMC communication the Fed failed to announce a purchase and therefore the episode disappointed the markets and increased yields. Given that the 1/28/2009 announcement did not lead to a decrease in yields we categorize it as a “Slow Event”.

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. The Fed's immediate goal was to reduce long-term interest rates and term premia to stimulate investment and consumption. A series of event studies persuasively showed that these programs successfully reduced long yields and term premia and moved other asset prices, such as stock prices and foreign exchange rates, in desired directions. The nearly unprecedented size and success of these quantitative easing programs has rendered them one of the most important episodes in bond market history.

We investigate how shorts, widely regarded as among the most sophisticated investors, reacted to the Federal Reserve's LSAPs of Treasury and agency securities during QE1. Monetary policy decisions are a stringent test for the forecasting ability of shorts who must outpredict marginal investors in very deep spot/futures bond markets.

Specifically, we examine the behavior of short interest around four LSAP announcements that produced unusually large interest rate changes. We find that short interest declined significantly prior to surprisingly expansionary LSAP announcements, confirming that short sellers are sophisticated investors who anticipated the unconventional announcements to some degree. Similarly, short interest generally increased prior to LSAP announcements that failed to contain a surprisingly expansionary component. We also find that short interest declined further following the surprisingly expansionary announcements. The fact that short interest continued at lower levels during the remainder of the Great Recession indicates that sophisticated market participants believed that long yields were likely to remain low, either because of economic conditions or unconventional policies.

We then use time series regressions to reexamine these findings in a broader sample of 21 unconventional policy announcements, from 2008-2013. Regressions on this broader sample confirm our conclusions: changes in short interest predict monetary policy shocks and expansionary monetary shocks predict further reductions in short interest for both Treasuries and agencies.

This research extends and complements previous research on the acuity of shorts as sophisticated investors to a new context. It also indicates that the Federal Reserve unconventional monetary policies were better understood by sophisticated investors than by the marginal bond market investor and that expansionary announcements convinced those sophisticated investors that yields would remain low for some time.

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Table 1

Issue characteristics of Treasuries and Agencies

Using data for our entire 27-month sample period, we present issue characteristics for Treasury agency securities. We present means of issue size in Row 2. We weight the remaining variables by issue size.

	Treasuries	Agencies
N	124	716
Issue Size (mill. \$)	22,240	733
Coupon rate (%)	4.53	4.56
Duration (years)	6.26	6.76
Time-to-maturity (years)	10.47	9.03
Time since issue	6.15	4.69
YTM (%)	3.27	4.35

Table 2

Important events during the Great Recession

We describe important events occurring during the Great Recession excluding the announcements described in Table 2.

Event	Date	Note
FOMC reduces the federal funds target	12/11/2007	From 450 bps to 425 bps
Beginning of the Great Recession	12/1/2007	From NBER
FOMC reduces the federal funds target	1/22/2007	From 425 bps to 350 bps
FOMC reduces the federal funds target	1/30/2007	From 350 bps to 300 bps
TSLF announced	3/11/2008	Fed introduced Term Securities Lending Facility (TSLF); allows banks to borrow Treasuries while posting impaired collateral
FOMC reduces the federal funds target	3/18/2008	From 300 bps to 225 bps
First TSLF auction	3/27/2008	
FOMC reduces the federal funds target	4/30/2008	From 225 bps to 200 bps
Government Fannie and Freddie takeover	9/7/2008	
Bank of America acquires Merrill Lynch	9/14/2008	
Lehman bankruptcy	9/15/2008	
AIG bailout	9/17/2008	Worth \$85 billion
House rejects bailout plan	9/29/2008	Dow plunges.
TARP announcement	10/3/2008	Congress approves a \$700 billion bank bailout Friday, but stocks tumbled as investors worried that the plan is insufficient to stem the credit crisis.
FOMC reduces the federal funds target	10/8/2008	From 200 bps to 150 bps
AIG bailout	10/8/2008	Worth \$37.8 billion
Wells Fargo acquires Wachovia	10/12/2008	
FOMC reduces the federal funds target	10/29/2008	From 150 bps to 100 bps
FOMC reduces the federal funds target	12/16/2008	From 100 bps to 0-25 bps
End of the Great Recession	6/1/2009	From NBER
TSLF closed	2/1/2010	
End of QE1, Start of QE2	8/10/2010	

Table 3

Important QE1 buy announcements

In Panel A, we identify and describe four days during QE1 when the Fed announced the forthcoming LSAPs of Treasuries and agencies. Panel B identifies the beginning and ending dates for the LSAPs.

Panel A: Announcements (focus of our study)

LSAP-B1	11/25/2008	FOMC announces intention to purchase \$100 billion in agency debt and up to \$500 billion in agency MBS
LSAP-B2	12/1/2008	Chairman Bernanke says in a speech that the Fed could purchase long-term Treasuries
LSAP-B3	12/16/2008	FOMC first mentions possible purchase of long-term Treasuries
LSAP-B4	3/18/2009	In a meeting statement, the FOMC says it will purchase an additional \$750 billion in agency MBS, increase its purchases of agency debt by up to \$100 billion, and buy up to \$300 billion in long-term Treasuries

Panel B: Purchases of securities

Agency purchases

Begin	11/25/2008
End	3/31/2010

Treasury purchases

Begin	3/18/2009
End	10/29/2009

Table 4

Lending data for Treasuries and Agencies, by period

We present the means of the amount available to borrow—*Available Quantity*—and the amount actually borrowed—*Borrowed Quantity*— (both in millions of USD based par value). We also present *Utilization (%)* which is the amount borrowed divided by the amount available to borrow. We weight all variables by issue size. We classify issues by whether or not they are purchased by the Fed as part of the LSAP program and by period. Using a Wilcoxon rank sum test, we test the null hypothesis that the means for the securities purchased and not-purchased are equal and present the resulting p-values. We present results for Treasuries in Panel A and for agencies in Panel B.

	P1-Control	P2-Heart	P3-Announce	P4-Post
	Initial phase (Control period)	Heart of the crisis	Announcement Period	Post-Announcement
	1/1/2008 to 8/31/2008	9/1/2008 to 11/17/2008	11/18/2008 to 3/25/2009	3/26/2009 to 3/31/2010
Panel A: Treasuries				
N	95	98	105	123
Available Qty	4,236	3,733	3,481	3,338
Borrowed Qty	3,461	2,616	1,996	1,690
Utilization	79	70	58	49
Panel B: Agencies				
N	603	484	505	456
Available Qty	464	528	496	475
Borrowed Qty	250	254	199	162
Utilization	50	45	38	34

Table 5Time-series regression monetary shocks and *Borrowed Quantity*

We extend our analysis beyond QE1 to include all QE and MEP announcements from 11/25/2008 to 6/20/2013 (n=21). Appendix I lists these events. This table reports results for the relation between $\% \Delta \text{Borrowed Quantity}$ and 10-year treasury yield. We use the change in 10-year Treasury yield as a proxy for monetary shock but the results are quantitatively similar if we use an intraday change in the 10-year Treasury futures price as the proxy for monetary shock. ΔYield (in basis points) is the change in daily 10-year Treasury yield from the announcement date to the following day. $\% \Delta \text{Borrowed Quantity}_{\text{Treasury_after}}$ and $\% \Delta \text{Borrowed Quantity}_{\text{Agency_after}}$ are the five-day $\% \Delta \text{Borrowed Quantity}$ following the announcement for Treasuries and agencies, respectively. $\% \Delta \text{Borrowed Quantity}_{\text{Treasury_before}}$ and $\% \Delta \text{Borrowed Quantity}_{\text{Agency_before}}$ are the five-day $\% \Delta \text{Borrowed Quantity}$ prior to the announcement for Treasuries and agencies, respectively. We include a time trend dummy (1=first event; 21=last event). Column (3) reports the results of the second stage of a two-stage residual inclusion model. $\text{Res_}\% \Delta \text{Borrowed Quantity}_{\text{Treasury_before}}$ is the residuals from the first-stage regression of $\% \Delta \text{Borrowed Quantity}_{\text{Treasury_before}}$ on $\% \Delta \text{Borrowed Quantity}_{\text{Agency_before}}$. * Indicates significance at the 5% level. Robust standard errors are shown in parentheses.

Dependent Variable	ΔYield			$\% \Delta \text{Borrowed Quantity}_{\text{Treasury_after}}$		$\% \Delta \text{Borrowed Quantity}_{\text{Agency_after}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\% \Delta \text{Borrowed Quantity}_{\text{Treasury_before}}$	2.59 (0.56)*				-0.60 (0.25)*		
$\text{Res_}\% \Delta \text{Borrowed Quantity}_{\text{Treasury_before}}$			3.07 (0.75)*				
$\% \Delta \text{Borrowed Quantity}_{\text{Agency_before}}$		1.09 (0.58)*	1.09 (0.43)*				-0.07 (0.17)
ΔYield				0.02 (0.05)	0.15 (0.07)*	0.17 (0.06)*	0.18 (0.06)*
Time Trend Dummy	1.06 (0.35)*	0.70 (0.50)	0.70 (0.37)*	-0.04 (0.14)	-0.17 (0.13)	0.03 (0.14)	0.04 (0.14)
Constant	-13.22 (4.37)*	-9.58 (6.69)	-9.58 (4.93)*	-0.84 (1.76)	0.44 (1.63)	-2.27 (1.83)	-2.53 (1.94)
Adj. R-squared	0.61	0.31	0.63	0.01	0.24	0.36	0.37

Table 6

The effect of LSAP announcements on short interest for all Treasury and agency issues

We analyze the four Fed announcements of LSAPs indicated below. For each announcement, we present the five-day dollar and percentage Δ Borrowed Quantity before and after the announcement. We also present these two variables (1) averaged over these four events, which we label “All Buy Events,” and (2) for our P1-Control which comprises 34 five-day periods. Values are in millions of USD based on par value. For Treasuries and agencies, we jointly rank the $\% \Delta$ Borrowed Quantity for each CUSIP for the control observations and the before-announcement and the after-announcement observations. We test the null hypothesis that the means of the ranks for the two samples are equal against the alternate hypothesis that the means for the announcements declined more and report the p-values. This is equivalent to a Wilcoxon rank sum test.

	Treasuries		Agencies	
	(1) Before	(2) After	(3) Before	(4) After
LSAP-B1, 11/25/2008				
\$ Δ Borrowed Quantity	-\$3,686	\$256	-\$2,275	-\$697
% Δ Borrowed Quantity	-1.88	0.13	-6.26	-2.05
p-values	0.02	0.16	<0.01	0.05
LSAP-B2, 12/1/2008				
\$ Δ Borrowed Quantity	\$256	-\$12,952	-\$697	-\$2,955
% Δ Borrowed Quantity	0.13	-6.74	-2.05	-8.85
p-values	0.16	<0.01	0.05	<0.01
LSAP-B3, 12/16/2008				
\$ Δ Borrowed Quantity	-\$4,373	-\$12,039	-\$1,969	-\$1,184
% Δ Borrowed Quantity	-2.46	-6.96	-6.68	-4.30
p-values	0.17	<0.01	<0.01	<0.01
LSAP-B4, 3/18/2008				
\$ Δ Borrowed Quantity	-\$19,178	-\$295	-\$1,415	-\$1,511
% Δ Borrowed Quantity	-10.93	-0.19	-5.77	-6.55
p-values	<0.01	0.64	<0.01	<0.01
All Buy Events				
\$ Δ Borrowed Quantity	-\$6,745	-\$6,258	-\$1,589	-\$1,587
% Δ Borrowed Quantity	-3.79	-3.44	-5.19	-5.44
p-values	<0.01	<0.01	<0.01	<0.01
P1-Control				
\$ Δ Borrowed Quantity		\$360		\$289
% Δ Borrowed Quantity		0.17		0.82

Table 7

Post-announcement period change in short interest

For *Borrowed Quantity*, we present the mean for 3/26/2009, the first day of P4-Post, and 3/31/2010, the last day of P4-Post. Values are in millions of USD based on par value. Using a Wilcoxon rank sum test, we test the null hypothesis that the means for these two dates are equal against the alternate hypothesis that the mean of last date is less and present the resulting p-values.

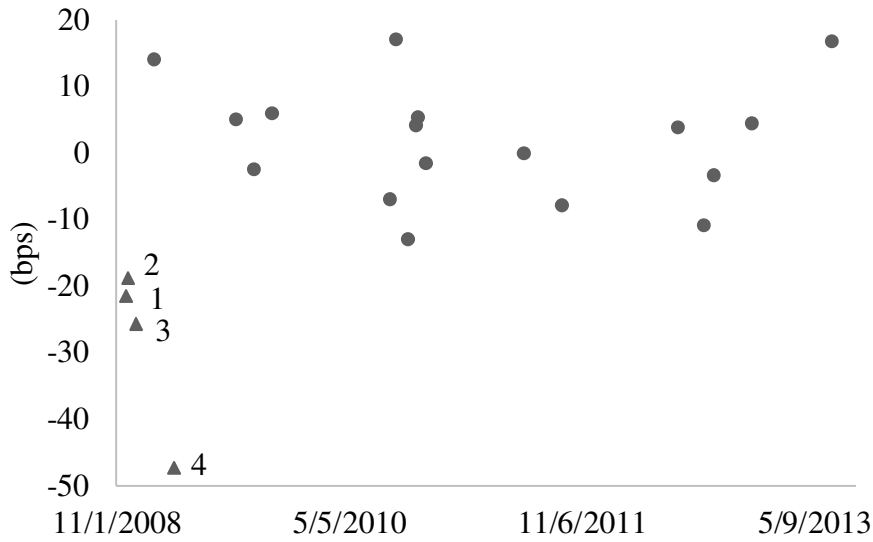
	Borrowed Quantity	
	Treasuries	Agencies
3/26/2009	\$1,268.8	\$48.8
3/31/2010	\$1,040.3	\$33.6
Difference (Δ Borrowed Quantity)	\$228.5	\$15.2
p-value	0.16	<0.01

Table 8

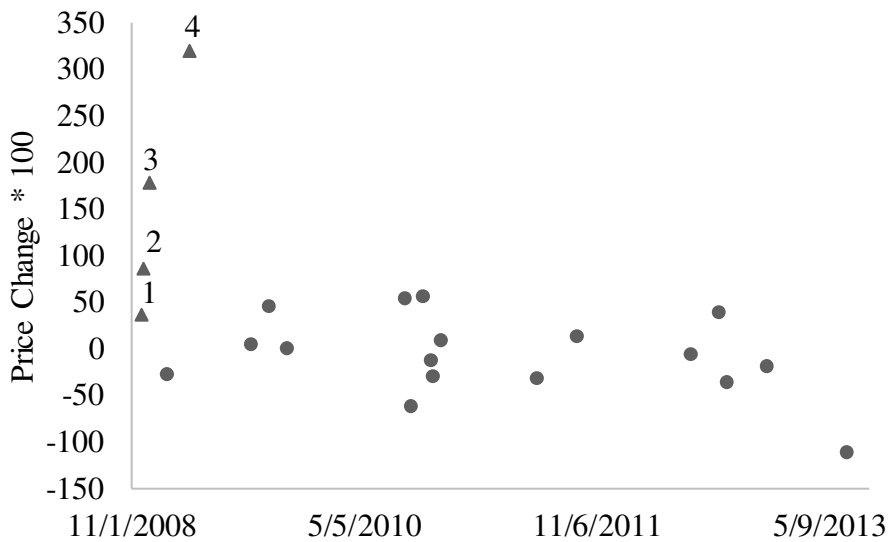
The effect of LSAP announcements of slowed purchases on short interest

The Fed made several announcements that indicated reduced purchases or that failed to raise expectations of future expansions. For each announcement, we present the five-day dollar and percentage Δ Borrowed Quantity before and after the announcement. We also present these two variables (1) averaged over these four events, which we label “All Slow Events,” and (2) for our P1-Control for the 34 five-day periods for all Treasuries and agencies. Values are in millions of USD based on par value. For Treasuries and agencies, we jointly rank the $\% \Delta$ Borrowed Quantity for each CUSIP for the control observations and the before-announcement and the after-announcement observations. We test the null hypothesis that the means of the ranks for the two samples are equal against the alternate hypothesis that the means for the announcements decline more and report the p-values. This is equivalent to a Wilcoxon rank sum test.

	Treasuries		Agencies	
	(1)	(2)	(3)	(4)
	Before	After	Before	After
LSAP-S1, 1/28/2009				
\$ Δ Borrowed Quantity	\$3,859	\$2,407	-\$106	\$682
$\% \Delta$ Borrowed Quantity	2.32	1.41	-0.39	2.49
p-values	1.00	0.90	0.37	0.96
LSAP-S2, 8/12/2009				
\$ Δ Borrowed Quantity	\$2,359	\$711	-\$33	\$198
$\% \Delta$ Borrowed Quantity	1.39	0.41	-0.16	0.95
p-values	0.24	0.39	0.46	0.95
LSAP-S3, 11/4/2009				
\$ Δ Borrowed Quantity	\$1,447	\$222	\$293	-\$258
$\% \Delta$ Borrowed Quantity	0.84	0.13	1.32	-1.15
p-values	0.98	0.24	0.89	0.23
All Slow Events				
\$ Δ Borrowed Quantity	\$2,555	\$1,114	\$51	\$207
$\% \Delta$ Borrowed Quantity	1.52	0.65	0.26	0.76
p-values	0.99	0.58	0.66	0.93
P1-Control				
\$ Δ Borrowed Quantity		\$360		\$289
$\% \Delta$ Borrowed Quantity		0.17		0.82



Panel A. 10-year Treasury yields change



Panel B. Futures price change

Fig 1. 10-year Treasury yields and futures price changes associated with QE announcements

We present 10-year Treasury yields and futures price changes around quantitative easing announcements from November 2008 to June 2013. Treasury yields changes are the one-day change around each announcement. Futures price changes are calculated from the quoted futures price 15 minutes before to 90 minutes after each announcement. The announcements identified by triangle marker are the four QE1 announcements that are the focus of our study. The labeled announcements are: 1, 11/25/2008; 2, 12/1/2008; 3, 12/16/2008; and 4, 3/18/2009.

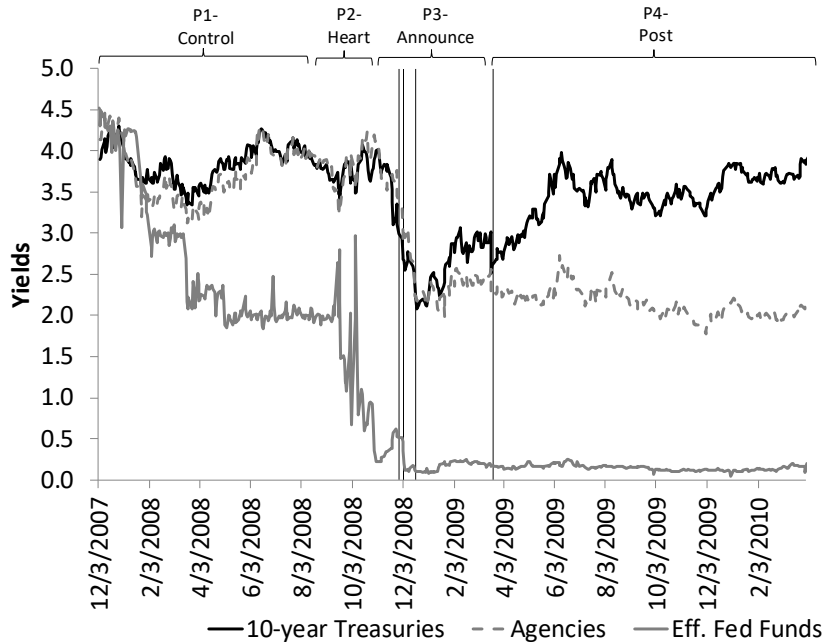


Fig 2. Behavior of interest rates during and following the Great Recession
 We present nominal yields for 10-year U.S. Treasuries, agencies, and Federal Funds. The vertical lines indicate the four LSAP announcement days that are the focus of our study.

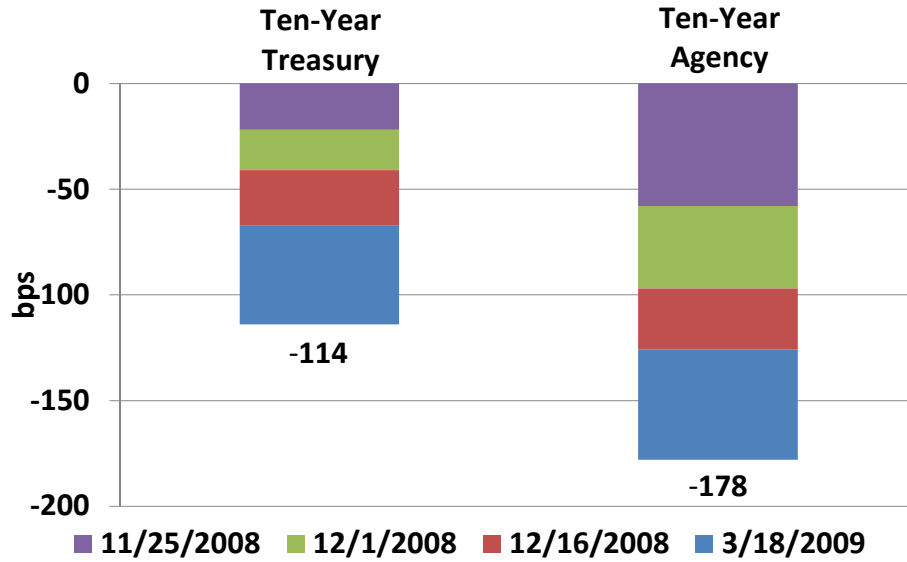
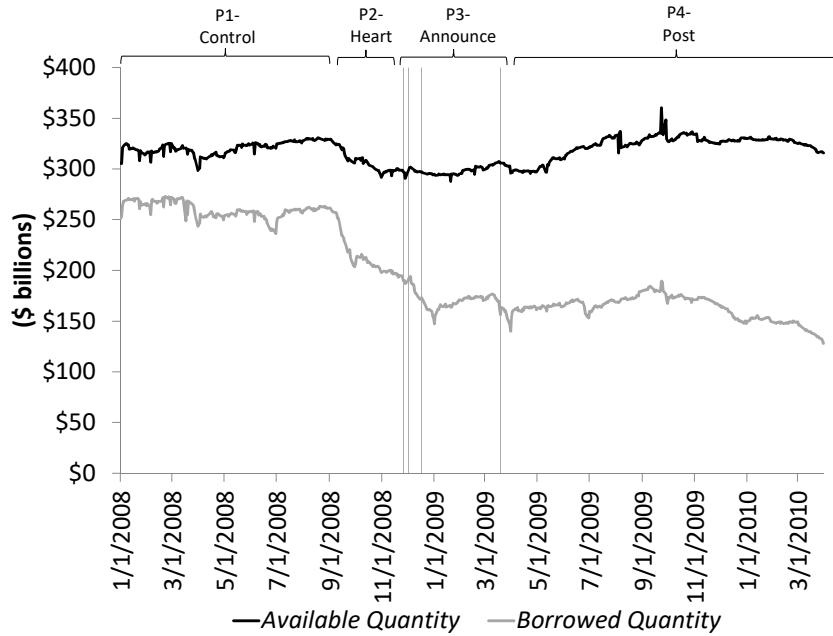
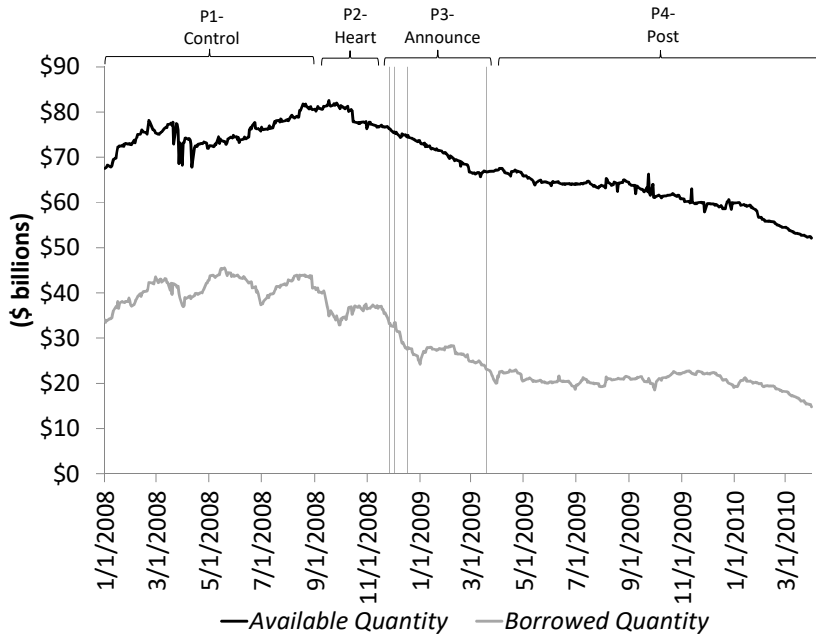


Fig 3. Cumulative interest rate changes on LSAP announcement dates
 We present the cumulative daily interest rate changes on the four LSAP announcement days that are the focus of our study.

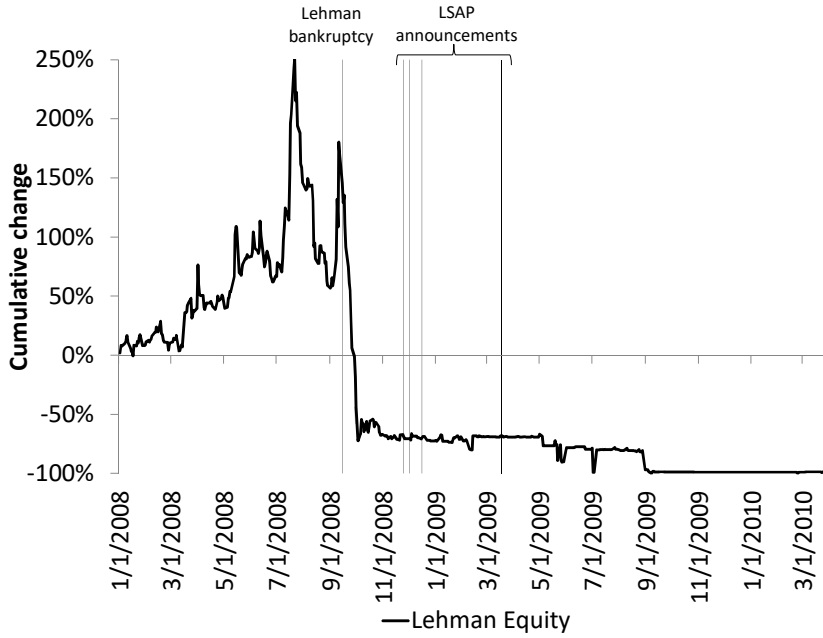


Panel A: Treasuries

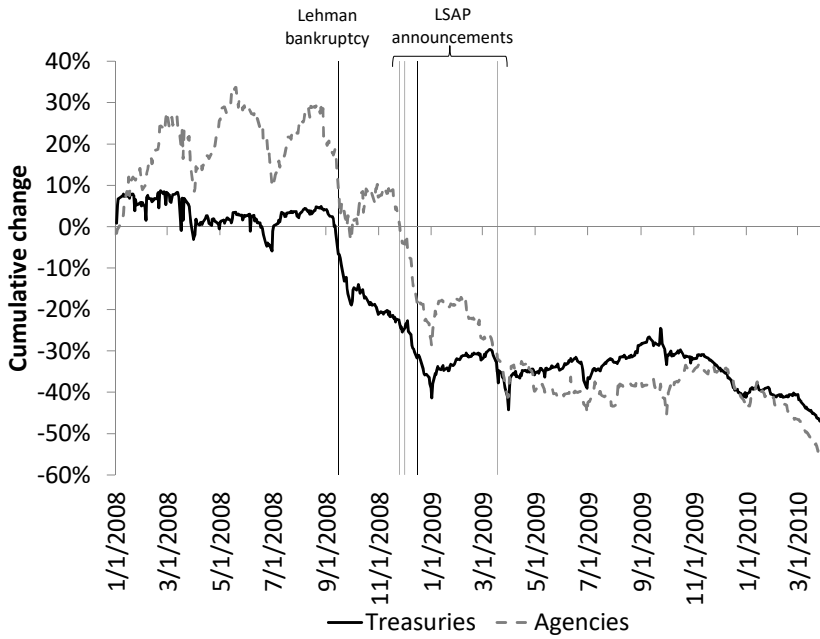


Panel B: Agencies

Fig 4. Quantity of Treasuries and agencies available to short and shorted, by day
 We present the total daily *Available Quantity* and *Borrowed Quantity* (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 3/31/2010. The vertical lines indicate the four LSAP announcement days that are the focus of our study. Values are in billions of USD and based on par value.



Panel A. Lehman equity



Panel B. Treasuries and agencies

Fig 5. Cumulative change in shorting

We present the daily cumulative $\% \Delta \text{Borrowed Quantity}$ (our proxy for shorting) for Lehman equity (Panel A) and Treasuries and agencies (Panel B) from 1/1/2008 to 3/31/2010.

Appendix 1. Δ Borrowed Quantity for our study period and for selected events

To show the importance of the four buy announcements that we study, Table A1-1 compares the magnitude of the Δ Borrowed Quantity for these events to net changes over subperiods. For the 823 days from the beginning of Period 1-Control through Period 4-Post, the Δ Borrowed Quantity falls \$123 billion for Treasuries and \$19 billion for agencies (Panel A). As shown in Panel B, for Treasuries and agencies the 44 days surrounding our four announcements account for 43.9% and 67.5%, respectively, of the Δ Borrowed Quantity over the 823-day period.

For comparison, Table A1, Panel B, also shows the change in short interest the week after several other major events—the government takeover of Fannie and Freddie, the Lehman bankruptcy, and the AIG bailout. Of these events, the Lehman bankruptcy was associated with the largest impact on shorting with a \$12 billion decrease in Borrowed Quantity. Although omitted from the table, the Δ Borrowed Quantity for Treasuries and agencies from five-days before the government takeover of Fannie and Freddie (9/1/2008) to five-days after the AIG bailout (9/24/2008) accounted for 33.46% (agencies) and 34.47% (Treasuries) of the total net change during our sample period.

Table A1-1

Δ Borrowed Quantity for our study period and for selected events

To show the importance of the four buy announcements that we study, Panel A presents for comparison, the Δ Borrowed Quantity during each of our four periods and for the four periods collectively. For each of our four announcements, in Panel B, we present the cumulative Δ Borrowed Quantity from five days before each announcement to five days after the announcements, which comprises changes over (4 X 11 =) 44 days. Also, to highlight the importance of our four announcements, Panel B also presents the Δ Borrowed Quantity for three particularly important days. We present data for both Treasuries and agencies. Borrowed Quantity is reported in millions of USD based on par value.

	Borrowed Quantity			
	Treasuries		Agencies	
	Δ	Percentage	Δ	Percentage
Panel A: Study periods				
Period 1-Control	10,037	-8.15	7,036	-36.65
Period 2-Heart	-63,910	51.89	-4,000	20.84
Period 3-Announce	-41,163	33.43	-15,491	80.69
Period 4-Post	-28,113	22.83	-6,742	35.12
Period 1-Control through Period 4-Post	-123,149	100.00	-19,197	100.00
Panel B: Crisis events (+/- 5 days)				
All 4 announcements (+/- 5 days)	-54,024	43.87	-12,963	67.53
Takeover of Fannie and Freddie	-272		-37	
Lehman bankruptcy	-12,725		-2,953	
AIG bailout	-1,256		-1,256	

Appendix 2: Robustness check for the effect of LSAP announcements on short interest

To supplement Table 6 in the body of the paper, we use *Utilization* (instead of *Borrowed Quantity*) as our proxy for short interest in Table A2-1. These findings are consistent with Table 6.

Table A2-1

The effect of LSAP announcements on Utilization for all Treasury and agency issues

We analyze the four Fed announcements of LSAPs indicated below. For each announcement, we present the five-day dollar and percentage $\Delta Utilization$ before and after the announcement. We also present these two variables (1) averaged over these four events, which we label “All Buy Events,” and (2) for our P1-Control that comprises 34 five-day periods. Values are in millions of USD based on par value. For Treasuries and agencies, we jointly rank the $\% \Delta Utilization$ for each CUSIP for the control observations and the before-announcement and the after-announcement observations. We test the null hypothesis that the means of the ranks for the two samples are equal against the alternate hypothesis that the means for the announcements declined more and report the p-values. This is equivalent to a Wilcoxon rank sum test.

	Treasuries		Agencies	
	(1)	(2)	(3)	(4)
	Before	After	Before	After
LSAP-B1, 11/25/2008				
<i>ΔUtilization</i>	-0.11	0.26	-2.77	-0.50
<i>%ΔUtilization</i>	-0.16	0.40	-6.32	-1.23
p-values	0.39	0.88	<0.01	1.00
LSAP-B2, 12/1/2008				
<i>ΔUtilization</i>	0.26	-3.56	-0.50	-1.83
<i>%ΔUtilization</i>	0.40	-5.46	-1.23	-4.51
p-values	0.85	<0.01	1.00	0.00
LSAP-B3, 12/16/2008				
<i>ΔUtilization</i>	-0.91	-3.67	-1.44	-1.12
<i>%ΔUtilization</i>	-1.51	-6.21	-3.96	-3.21
p-values	0.08	<0.01	0.01	0.01
LSAP-B4, 3/18/2008				
<i>ΔUtilization</i>	-5.56	0.69	-3.44	-2.36
<i>%ΔUtilization</i>	-9.62	1.31	-10.72	-8.24
p-values	<0.01	0.67	0.28	<0.01
All Buy Events				
<i>ΔUtilization</i>	-1.58	-1.57	-2.04	-1.45
<i>%ΔUtilization</i>	-2.72	-2.49	-5.56	-4.30
p-values	<0.01	<0.01	0.01	0.03
P1-Control				
<i>ΔUtilization</i>		0.02		0.09
<i>%ΔUtilization</i>		0.04		0.26

Appendix 3: Changes in shorting for purchased and not-purchased securities

At the time of the announcements, the Fed typically discloses the type of security (Treasury or agency) and the dollar amount of the forthcoming purchases, but does not disclose specific CUSIPs. In addition, with the exception of the last QE1 announcement on 3/18/2009 (LSAP-B4), the Fed does not disclose the security characteristics (such as time-to-maturity) of targeted securities at announcement time.²¹ Therefore, at the time of the announcement, we expect to see no differences in the reaction of *Borrowed Quantity* for the securities that are eventually purchased and not-purchased.

Do announcements affect the Borrowed Quantity of purchased/not-purchased differently?

Table A3-1 reports the results of Hypothesis 2—that short sellers do not distinguish between purchased and not-purchased securities after policy announcements. For each announcement and for all announcements, for both Treasuries and agencies, we cannot reject the hypothesis that the means of the $\% \Delta$ *Borrowed Quantity* of purchased versus not-purchased are equal (except for agencies for LSAP-B4). Hence, we find no difference in the short sellers' reactions for securities purchased and not-purchased either before or after the policy announcements. We conclude that shorts either cannot discern or do not care which securities will be purchased around announcement times.

Is there a differential effect on securities purchased and not-purchased following the purchases?

We now shift away from examining behavior around announcements to examining behavior over the entire purchase period. The data on bond purchases are weekly. Table A3-2 shows the effect of the Fed's purchases on *Available Quantity* and *Borrowed Quantity* of agencies at the

²¹ Following LSAP-B4, the Open Market Trading Desk announced that it “will concentrate purchases in the 2- to 10-year sector of the nominal Treasury curve, although purchases will occur across the nominal Treasury and TIPS yield curves.”

beginning and end of the purchase period. We restrict our analysis to agencies because the Fed purchased some of almost every Treasury CUSIP during the period of our study. During the purchase period, *Available Quantity* declined about 31% and *Borrowed Quantity* declined about 57%. There is little difference between the declines for securities purchased and not-purchased. Hence, we conclude that there was no difference in the effect of the Fed's unconventional policies on *Available Quantity* or *Borrowed Quantity* of securities purchased and not-purchased.

Table A3-1

The effect of LSAP announcements on short interest of Treasuries and agencies, purchased versus not-purchased

For issues purchased and not-purchased as part of the LSAP program, we present mean *%ΔBorrowed Quantity* for Treasuries and agencies, in turn, for each of the four LSAPs announcements and for all announcements. We weight the *%ΔBorrowed Quantity* based on issue size. We test the null hypothesis that the means of the *%ΔBorrowed Quantity* are equal for issues purchased and not-purchased against the alternate hypothesis that the means for the purchased issues declined more. We present results for the five days before each announcement in columns 2-4 and for the five days after each announcement in columns 5-7. We report p-values for these tests. To minimize the effects of outliers, we winsorize the data at the 0.01 and 0.99 levels.

	%ΔBorrowed Quantity					
	Before			After		
	Purchased			Purchased		
	Yes	No	p-value	Yes	No	p-value
Panel A: Treasuries						
LSAP-B1	-1.51	-6.54	0.96	-0.89	13.93	0.08
LSAP-B2	-0.90	2.67	0.17	-5.97	-5.64	0.48
LSAP-B3	-1.18	0.24	0.27	-6.45	-4.98	0.37
LSAP-B4	-9.81	-12.44	0.87	2.47	-5.86	0.98
All	-3.57	-4.01	0.61	-2.56	-0.63	0.28
Panel B: Agencies						
LSAP-B1	-0.69	-12.43	1.00	-0.24	-1.39	0.72
LSAP-B2	-0.58	-1.64	0.72	-5.06	-8.16	0.87
LSAP-B3	-8.05	-4.86	0.11	-3.79	-6.32	0.84
LSAP-B4	-8.15	-3.51	0.03	-1.79	-8.84	0.97
All	-4.42	-5.64	0.85	-2.70	-6.18	0.99

Table A3-2

Effect during the purchase period of Fed purchases of agencies for securities purchased and not-purchased

For agencies that are and are not purchased, we present the *Available Quantity* (Panel A) and *Borrowed Quantity* (Panel B) on the first (12/10/2008) and last day (3/31/2010) of the purchase period and both the dollar and percentage change of each variable. For agencies purchased, we include the 55 securities that are in our sample on both dates. For agencies not purchased, we include the 55 largest securities in our sample on both dates. Values are in millions of USD based on par value. Using CUSIP-level data (winsorized at the 0.01 and 0.99 levels), we test the null hypothesis that the mean percentage changes of the two samples are equal against the alternate hypothesis that the means for the securities purchased declined more and report the p-values.

	Purchased		p-value
	Yes	No	
Panel A: Available Quantity			
12/10/2008	\$37,768	\$2,120	
3/31/2010	\$25,900	\$1,454	
\$ Δ Available Quantity	-\$11,868	-\$665	
% Δ Available Quantity	-31.42	-31.38	0.38
Panel B: Borrowed Quantity			
12/10/2008	\$19,398	\$509	
3/31/2010	\$8,417	\$212	
\$ Δ Borrowed Quantity	-\$10,980	-\$297	
% Δ Borrowed Quantity	-56.61	-58.37	0.29

Appendix 4. Federal Reserve unconventional monetary policy announcements from 2008 to mid-2013

Table A4-1

Unconventional monetary policy announcements

Date	Program	Description
11/25/2008	QE1	LSAP announced: Fed will purchase \$100 billion in GSE debt and \$500 billion in MBS
12/1/2008	QE1	Chairman Bernanke says in a speech that the Fed could purchase long-term Treasuries
12/16/2008	QE1	First suggestion of extending QE to Treasuries by FOMC. Fed cuts Fed Funds rate
1/28/2009	QE1	Fed stands ready to expand QE and buy Treasuries
3/18/2009	QE1	LSAP expanded: Fed will purchase \$300 billion in long-term Treasuries and an additional \$750 and \$100 billion in MBS and GSE debt, respectively. Fed expects low rates for "an extended period."
8/12/2009	QE1	LSAP slowed: All purchases will finish by the end of October, not mid-September
9/23/2009	QE1	LSAP slowed: Agency debt and MBS purchases will finish at the end of 2010Q1
11/4/2009	QE1	LSAP downsized: Agency debt purchases will finish at \$175 billion
8/10/2010	QE1	Balance Sheet Maintained: Fed will reinvest principal payments from LSAP purchases in Treasuries
8/27/2010	QE2	Bernanke suggests role for additional QE, "should further action prove necessary"
9/21/2010	QE2	FOMC emphasize low inflation, which is "is likely to remain subdued for some time"
10/12/2010	QE2	FOMC members "sense" is that "[additional] accommodation may be appropriate before long"
10/15/2010	QE2	Bernanke reiterates that Fed stands ready to further ease policy
11/3/2010	QE2	QE2 announced: Fed will purchase \$600 billion in Treasuries
6/22/2011	QE2	QE2 finishes: Treasury purchases will wrap up at the end of month; principal payments will continue to be reinvested
9/21/2011	MEP	MEP ("Operation Twist") announced
6/20/2012	MEP	MEP extended until end of 2012
8/22/2012	QE3	FOMC members "judged that additional monetary accommodation would likely be warranted fairly soon..."
9/13/2012	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"
12/12/2012	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
6/19/2013	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

Chapter 3

Supply and demand shifts of shorts prior to Fed announcements during QE1 – QE3

1. Introduction

Cohen, Diether, and Malloy (2007) show that shorting demand is an important predictor of future stock returns. We investigate whether shorting demand is a predictor of unconventional Fed policy announcements during Quantitative Easing 1 (QE1), 2008-2010; QE 2, 2010-2011; the Maturity Extension Period (MEP), 2011-2012; and QE 3, 2012-2014.

Short sellers are widely viewed as informed, sophisticated investors. In equity markets, short sales correctly predict negative returns (Aitken, Frino, McCorry, and Swan, 1998; Boehmer, Jones, and Zhang, 2008; Diether, Lee, and Werner, 2009; Cohen, Diether, and Malloy, 2007) and shorts have superior ability to process news (Engelberg, Reed, and Ringgenberg, 2012). In bond markets, Hendershott, Kozhan, and Roman (2017) find that corporate bond shorts predict future bond returns; Nashikkar and Pedersen (2007) find that shorts anticipate rating changes. In contrast, Asquith, Au, Covert, and Pathak (2013) find that heavily-shortened corporate bonds do not earn abnormal returns.

We find the demand for short positions for Treasuries and agencies decreases prior to Fed buy announcements.

2. Data and research methodology

Our sample of Treasuries and agencies comes from Markit Securities Finance. Prime brokers, custodians, asset managers, and hedge funds, report these lending data. Our proxies are: short

interest, *Borrowed Quantity*, the par value of debt on loan; shorting cost, *Borrowing Fee*, the bps fee. We collect data for 2007-2017. Intervals without an announcement are our control period.

We obtain time-to-maturity from Datastream. Our sample comprises securities with (1) time-to-maturity > 5 years at least once, (2) mean *Available Quantity* of greater than \$10 million, (3) mean *Borrowed Quantity* greater than \$1 million, and (4) at least 30 daily observations.

We focus on important Fed announcements during QE1, QE2, MEP, and QE3. We classify these announcements as “buy” and “slow” based on the announcement language and the change on the 10-year Treasury yield the day after the announcement. Buy announcements have both expansionary language and decreased yields. Slow announcements have contractionary or decreased policy actions and increased yields. We eliminate announcements that do not fit into either of these categories. A list and description of buy and slow announcements is provided in Table 1.

To understand the ability of shorts to predict Fed announcements, we employ a technique developed in Cohen, Diether, and Malloy (2007) that infers shifts in supply and demand curves by examining combinations of price and quantity changes. Securities are classified as follows: increase in *Borrowed Quantity* and *Borrowing Fee* indicates a demand curve shift out (*DOUT*); decrease in *Borrowed Quantity* and *Borrowing Fee* indicates a demand shift in (*DIN*); increase in *Borrowed Quantity* and a decrease in *Borrowing Fee* indicates a supply curve shift out (*SOUT*); and decrease in *Borrowed Quantity* and an increase in *Borrowing Fee* indicates a supply curve shift in (*SIN*). If there is a decline in the demand for borrowing following the LSAP announcements, we expect a *DIN*. Aggarwal, Bai, and Laeven (2016) employ a similar technique in their study of European government bond lending markets during periods of market stress. We test two hypotheses:

Hypothesis 1: Securities experience a *DIN* prior to buy announcements

Buy announcements reduce the demand for securities to short, reducing the *Borrowing Fee* and *Borrowed Quantity*.

Hypothesis 2: Securities experience a *DOUT* prior to slow announcements

Slow announcements increase the demand for securities to short, increasing the *Borrowing Fee* and *Borrowed Quantity*.

Given that shorts are believed to be informed, we expect that the changes will occur prior to the announcements. To test these hypothesis, we compare the distribution of shifts prior to the announcements with the distribution for a control sample using the chi-squared test of equality.

3. Empirical results

We test our hypotheses using one week and one month intervals prior to the announcements. The results are broadly consistent across time periods, but become slightly more pronounced for slow announcements when looking at months, indicating that shorts anticipate Fed moves farther out than one week.

In Table 2, Panels A and B, we assess shifts in supply and demand one week prior to the announcements. For buy announcements, *DIN* is the largest shift category with 44% for agencies and 42% for Treasuries. The second largest group is *SOUT* (25%) for agencies and *SIN* (23%) for Treasuries. Using the chi-squared test, we reject the null hypothesis that the shift categories distribution for buy announcements is equal to the control distribution for both agencies and Treasuries (p-value <0.001), supporting Hypothesis 1. For slow announcements, *DOUT* is the largest shift category for agencies (31%) and *SOUT* is the largest shift category for Treasuries (27%). For agencies, we fail to reject the null hypothesis that the distribution of the slow announcements is the same as that of the control group; however, for Treasuries, we reject the

null at the 10% level based on the chi-squared test. Therefore, we reject Hypothesis 2 for *DOUT* prior to slow announcements for both agencies and Treasuries using a one week window.

Table 2, Panels C and D, report results for the longest shift window in our study: one month. For buy announcements, we find support for Hypothesis 1. The distributions are significantly different than the control and the largest category is *DIN* for agencies and Treasuries (52% and 37%, respectively). For slow announcements, we do not find support for Hypothesis 2 as the largest category agencies and Treasuries is not *DOUT*.

4. Conclusion

The unique approach of Cohen, Diether, and Malloy (2007) provides a tool to test whether shorts predicted Fed announcements during QE1 – QE3. To summarize our findings, for both agencies and Treasuries, we find that the majority of securities experience a demand shift inward one week and one month prior to Fed buy announcements. Further, the distribution of shifts prior to buy announcements is statistically different than for our control period.

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Table 1

QE announcements and classification.

<i>Buy Events</i>	
11/25/2008	FOMC announces intended purchases of \$100 billion in GSE debt and up to \$500 billion in MBS.
12/1/2008	Bernanke speech Chairman Bernanke says that the Fed could purchase long-term Treasuries.
12/16/2008	FOMC statement FOMC first mentions possible purchase of long-term Treasuries.
3/18/2009	FOMC statement FOMC says it will purchase an additional \$750 billion in agency MBS, increase its purchases of agency debt by up to \$100 billion, and buy up to \$300 billion in long-term Treasuries.
8/10/2010	FOMC statement FOMC states that it will continue to roll over the Federal Reserve holdings of Treasury securities as they mature.
9/21/2010	FOMC statement FOMC states that the Federal Reserve will continue to roll over its holdings of Treasury securities as they mature.
9/21/2011	"The Fed kept policy rates unchanged and exceptionally low but the Fed also decided to engage in a form of Operation Twist."
8/22/2012	"The debate within the Fed about potential additional policy actions has heated up according to the latest FOMC minutes. Many participants said more accommodation is needed unless there is substantial improvement in the economy. But participants also indicated that discussion of the costs and benefits of additional quantitative easing was useful. Some questioned the efficacy of a QE3."
12/12/2012	Maturity Extension Program concludes. FOMC to begin purchasing longer-term Treasuries at an initial pace of \$45 billion per month
6/18/2014	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"
<i>Slow Events</i>	
1/28/2009	FOMC is ready to expand agency debt and MBS purchases, as well as to purchase long-term Treasuries; however, this event is regarded as disappointing markets
8/27/2010	Bernanke suggests role for additional QE; however, this event is regarded as disappointing markets
10/15/2010	Bernanke speech
12/18/2013	"Beginning in January, the Committee will add to its holdings of agency mortgage-backed securities at a pace of \$35 billion per month rather than \$40 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of \$40 billion per month rather than \$45 billion per month."
6/19/2013	"...Fed Chairman Bernanke stated that if the members' forecasts were correct, economic conditions would improve to the point that by the end of this year, the Fed could start tapering their purchases of securities."
3/19/2014	Fed will further reduce monthly asset purchases to \$25 billion in MBS and \$30 billion in Treasuries.

Table 2

Supply and demand shifts.

We present statistics for shifts in supply and demand following the announcements for Treasuries one week before (Panels A), agencies one week before (Panels B), Treasuries one month before, and agencies one month before (Panel D) the buy and slow announcements and during the control period. For each security, we calculate the change for quantity demanded (*Borrowed Quantity*) and borrowing cost (*Borrowing Fee*). Following Cohen, Diether and Malloy (2007), we define four mutually-exclusive demand-supply shifts for securities: *DIN*, a decrease in *Borrowed Quantity* and a decrease in *Borrowing Fee*; *DOUT*, an increase in *Borrowed Quantity* and an increase in *Borrowing Fee*; *SIN*, a decrease in *Borrowed Quantity* and an increase in *Borrowing Fee* and *SOUT*, an increase in *Borrowed Quantity* and a decrease in *Borrowing Fee*. Securities that did not experience a shift are excluded. We report the number and percent of bonds in each category. Using a Chi-squared test, we test the null hypothesis that the shift categories distribution for buy and slow announcements, respectively, is equal to the control distribution and present the resulting p-values.

		DIN	DOUT	SIN	SOUT	Total	p-value
<i>Panel A: Agencies (One week)</i>							
Control	N	3,199	3,370	3,321	3,097	12,987	
	%	25%	26%	26%	24%	100%	
Buy	N	156	48	59	88	351	
	%	44%	14%	17%	25%	100%	<.0001
Slow	N	31	48	36	40	155	
	%	20%	31%	23%	26%	100%	0.3303
<i>Panel B: Treasuries (One week)</i>							
Control	N	10,768	11,389	11,067	10,510	43,734	
	%	25%	26%	25%	24%	100%	
Buy	N	401	140	219	186	946	
	%	42%	15%	23%	20%	100%	<.0001
Slow	N	154	143	121	158	576	
	%	27%	25%	21%	27%	100%	0.0576

Table 2 —Continued

<i>Panel C: Agencies (One month)</i>							
Control	N	1,214	1,092	1,272	969	4,547	
	%	27%	24%	28%	21%	100%	
Buy	N	386	57	91	212	746	
	%	52%	8%	12%	28%	100%	<.0001
Slow	N	41	37	25	38	141	
	%	29%	26%	18%	27%	100%	0.0419
<i>Panel D: Treasuries (One month)</i>							
Control	N	3,877	3,186	3,726	3,423	14,212	
	%	27%	22%	26%	24%	100%	
Buy	N	558	235	473	261	1,527	
	%	37%	15%	31%	17%	100%	<.0001
Slow	N	263	158	125	267	813	
	%	32%	19%	15%	33%	100%	<.0001