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Learning from the shorts

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Unconventional monetary policy and long yields during QE1: Learning from the shorts

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Abstract

In November 2008, the Federal Reserve announced the first of a series of unconventional monetary policies, which would include asset purchases and forward guidance, to reduce long-term interest rates. We investigate the behavior of shorts, considered sophisticated investors, before and after FOMC announcements not fully anticipated in spot bond markets. Short interest in Treasury and agency securities declined prior to expansionary announcements, indicating shorts anticipated these surprises, 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.

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1. Introduction

The collapse of international housing prices in 2006-2008 produced extreme credit market disturbances that culminated in the September 2008 bankruptcy of Lehman Brothers, a major investment bank, and a severe downturn in real economic activity. In response, the Federal Reserve (Fed) 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 Fed’s announcements of QE1 bond purchases and how they reacted to those

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

² Short positions included shorting stocks and bonds 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.

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

Specifically, we initially focus on four early and particularly surprising, expansionary announcements—labeled 1, 2, 3, and 4, in Figure 1. At first, we focus on these announcements for most purposes because it should be easier to discern if shorts can predict large policy surprises, that is, important events that the marginal investor in spot and futures markets did not 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 For futures prices, the average change is \$1.547 for the four announcements compared to \$0.297 for all other announcements. These four announcements on which we focus have an average 10-year-Treasury yield change of 28.4 bps compared to an average of 6.9 bps for all other announcements. We later supplement our focus on these four announcement with a regression study on a broader sample of all 21 unconventional policy announcements shown in Figure 1.

To presage our results, we find significant short covering prior to and following each asset purchase announcement. Short interest remained low throughout 2009 and early 2010, indicating that the Fed did convince shorts that interest rates would remain low. We find no difference in short covering at the times of the announcements for individual securities that the Fed purchased or not, suggesting that shorts either did not know or did not care which specific issues the Fed

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).

would purchase. These findings are consistent between the focused study of four events and the broader regression study of all 21 events.

We examine short interest because shorts have been shown to be sophisticated investors for whom data are available. 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 events—as opposed to earnings announcements, ratings or other types of news—is a particularly stringent test for shorts because shorts are attempting to out predict the marginal spot / futures investor in very deep markets with little or no private information. The minutes of FOMC meetings are released after three weeks and FOMC participants frequently publicly express their policy views, which are largely based on publicly available information. For example, Bernanke (2002) 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.”*⁴

We focus on shorts who borrow securities in the securities lending market using Markit data because these data allow us to identify directly short sellers by using securities borrowing as a proxy. Further, 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—futures, using repurchase agreements (repos) to borrow securities to short, and 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

⁴ <https://www.federalreserve.gov/boarddocs/speeches/2002/20021121/>

deliverable on each futures contract.⁵ Another difficulty with futures data is that 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. And repos are commonly used as a way of borrowing funds or upgrading collateral so that identifying which repos are used to borrow securities to short can be difficult.

Traders might benefit from falling bond prices due to deteriorating credit using CDSs, which are potentially available on individual CUSIPs for all types of securities. While purchasing CDSs is not directly comparable to shorting, the two strategies are likely to be highly correlated.

Because each channel has its own particular requirements, traders typically do not switch between these four ways of profiting from falling bond prices.⁶ Participation in the securities lending market might require entering 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

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

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

policy. This section briefly reviews these literatures to frame the unique contribution of the current paper.

2.1. The short selling literature

Short sellers are widely viewed as informed, sophisticated investors. In equity markets, short sales correctly predict negative returns (Aitken, 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).

Although there is less study of shorting behavior in bond markets, researchers similarly find that short sellers adjust their portfolios prior to the release of useful information in fixed income 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. The FOMC has offered forward guidance through at least five variations of “extended period” language to restrain expectations of policy rate hikes. 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 suggests that a bond purchase can affect term premia by reducing 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.

There is strong evidence that unconventional monetary policies influence a broad variety of asset prices through both signaling and portfolio balance channels. Event studies provide much of this evidence. 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 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 Bonds are imperfect substitutes, however. Krishnamurthy and Vissing-Jorgensen (2011) argue that the effect of LSAP critically depends on whether the Fed buys Treasuries or agencies.

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 and these effects are stronger on those international bonds that are closer substitutes for U.S. bonds. Unconventional policy announcements also increase stock prices (Kiley 2014) and substantially reduce the foreign exchange value of the USD and international bond yields (Neely 2015). These 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 obtain daily lending data from Markit Securities Finance for the 27 months beginning January 1, 2008, for 124 Treasury securities, 716 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).

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.

The System Open Market Account (SOMA) Holdings report, which is publicly available on the Federal Reserve Bank of New York’s (FRBNY) website, provides amounts of securities purchased in open market operations 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

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.”

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.

We divide the sample period 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
- Period 4-Post-announcements (3/26/2009–3/31/2010).¹⁰

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

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

¹⁰ D’Amico and King (2013) refer to 2009-2010 as the Fed intervention period and 2000-2008 and the non-intervention period.

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.

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 variables weak, and 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 in the weeks following the Lehman bankruptcy on September 15, 2008. Table 1 shows a timeline of important events associated with the crisis.¹¹

To supplement these unusual policy interventions by both the Treasury and the Fed, the FOMC repeatedly reduced the federal funds target from a level of 525 basis points in September 2007 to a final level of 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

¹¹ 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 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.

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.¹²

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) could also have affected expectations of asset purchases. Table 2, 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. Under QE1, the FRBNY purchased agencies from November 25, 2008, until March 31, 2010 and Treasuries from March 18, 2009, until October 30, 2009.

¹² Agency yields are based on the Bloomberg-Barclays U.S. aggregate agency debt index.

3.3. Descriptive statistics

Table 3 summarizes bond-level characteristics of Treasuries and agencies, conditioning on purchased versus not-purchased in LSAPs.¹³ Table 3, Columns 2-4, show that issue size and coupon rate for Treasuries purchased and not-purchased are not economically or statistically different. But purchased Treasuries had significantly longer duration and significantly lower yields (at the 0.10 level). After controlling for duration, however, D'Amico and King (2013) report that the Fed purchased higher-yield, underpriced securities.

Table 3, Columns 5-7, show that all the characteristics of agency securities purchased differ significantly from those not-purchased. Purchased agencies have a larger issue size, higher coupon rate, lower duration, lower time-to-maturity, and lower yield-to-maturity. In particular, the mean issue size is \$4.1 billion for purchased agencies, but only \$0.4 billion for not-purchased agencies. The Fed focused its agency purchases on shorter-duration and underpriced securities (Gagnon, Raskin, Remache, and Sack 2011).

Figure 3 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 3, Panel A, shows that Treasuries' *Available Quantity* (black line) shows no particular trend during the sample, with some 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 begins to decline sharply at the beginning of September as Lehman Brothers goes bankrupt and risk aversion soars. The decline levels off in January 2009. Figure 3, Panel B,

¹³ Table 3 shows statistics for differences-in-means between purchased vs. not-purchased securities. By testing for differences in these two groups of securities, we implicitly treat these groups as random samples from two larger populations with unknown characteristics.

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 dollar amounts of *Available Quantity* and *Borrowed Quantity* of Treasuries (Panel A) and agencies (Panel B), broken down by purchased / not-purchased, during each of the four sub-periods of our sample. Table 4, Panel A, shows that the *Available Quantity* and *Borrowed Quantity* are similar for Treasury securities purchased and not-purchased in most of the sub-periods. Table 4, Panel B, shows that purchased agencies differ in statistically significant ways from not-purchased. Because the purchased agency securities have larger issue sizes than those not-purchased (see Table 3), it is not surprising to find that they also have a larger *Available Quantity* and *Borrowed Quantity*.

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. We also examine announcements for which the Fed indicated the possibility of reduced purchases (Section 5.4). For these announcements, we expect either no change or an increase in short interest.

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

We further hypothesize that Fed expansionary announcements credibly signal that 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 1b: Short interest declines in the five days just after LSAP buy announcements.

Hypothesis 1c: Short interest remains low during the whole P4-Post period.

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.¹⁴ Therefore, at the time of the announcement, we expect to see no differences in the reaction of *Borrowed Quantity* for the securities purchased and not-purchased. That is, we hypothesize that the market either cannot anticipate or is indifferent to which specific securities the Fed will purchase.

Hypothesis 2: There is no difference in short sellers' reactions for securities purchased and not-purchased following the policy announcements.

Sections 5.5 and 5.6 investigate whether purchased and not-purchased securities react differently to announcements and actual transactions.

Although we examine four important buy events in some detail, Section 5.7 also analyzes the extent to which Hypotheses 1a and 1b hold for an extended set of events, including QE1, QE2, MEP, and QE3 announcements.

¹⁴ 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.”

5. Empirical results

This section characterizes (1) the shorts' responses to LSAP announcements, (2) any differences in the shorts' responses between securities purchased and not-purchased, and (3) the impact of the purchases on securities purchased and not-purchased.

5.1. 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 4, Panel A), which was a major event of the crisis. We see that *Borrowed Quantity* for Lehman equity increased dramatically prior to the Lehman bankruptcy and only fell below beginning-of-2008 levels after the bankruptcy, likely reflecting both profit taking and reduced ability to borrow the equity.

In 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. That is, from January 1, 2008 to late August, the cumulative Δ *Borrowed Quantity* for Treasuries (black line Figure 4, 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. Additionally, Treasuries' cumulative Δ *Borrowed Quantity* also 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.

Cumulative Δ *Borrowed Quantity* for agencies (gray line, Figure 4, Panel B) fluctuated more and had a modest uptrend until August 2008, a few weeks prior to the Lehman bankruptcy, when it began a steep decline that continued, in fits and starts, until May 2009. The sudden decrease a

few days prior to November 25, 2008 (LSAP-B1), which announced large purchases of agencies, indicates anticipation of the announcement.

Figure 4 thus provides preliminary evidence that Hypothesis 1a is correct: Short interest in long bonds appears to have declined prior to LSAP announcements. However, it is important to examine carefully movements around to each announcement to provide more conclusive evidence.

Table 5 compares the magnitude of the $\$ \Delta \text{Borrowed Quantity}$ for the four announcements, on which we focus, to net changes over subperiods. For the 823 days from the beginning of Period 1-Control through Period 4-Post, the $\$ \Delta \text{Borrowed Quantity}$ 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 $\$ \Delta \text{Borrowed Quantity}$ over the 823 day period.

For comparison, Table 5, 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*. While not included in the table, we also calculate the $\$ \Delta \text{Borrowed Quantity}$ 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). This change accounted for 33.46% (agencies) and 34.47% (Treasuries) of the total net change during our sample period.

If shorts anticipate that future policy announcements will reduce yields, they will act beforehand to cover their short positions.¹⁵ Table 6, Columns (1) and (3) (labeled “Before”), show that

¹⁵ 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”

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. For the Table 6 tests, our control is 34 five-day changes during P1-control that have an average change of 0.17% and 0.82% for Treasuries and agencies, respectively.

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 decline occurred because short investors anticipated, to some degree, the LSAP-B4 announcement of a very large 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 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 1a, indicating that sophisticated short sellers reduced their short positions prior to announcements.

5.2. 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. For all announcements combined, *Borrowed Quantity* of Treasuries declines by a statistically significant 3.44%. The *Borrowed Quantity* of

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.

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 short positions following the LSAP announcements (Hypothesis 1b). That is, the LSAP announcements appear to convince short investors that yields will stay low or decline further.

To ensure that the $\% \Delta \text{Borrowed Quantity}$ is due to shifts in demand and not shifts in supply (i.e., $\% \Delta \text{Available Quantity}$) that result from the LSAP announcements, we regress the five-day $\% \Delta \text{Borrowed Quantity}$ on announcement dummies, for each of the four announcements in Table 2, and the contemporaneous five-day $\% \Delta \text{Available Quantity}$. *Announcement Dummy* takes the value of one if the date corresponds with the five-day period before or after an announcement and zero if the date corresponds with the control period (P1-Control). That is, the model we estimate for week w is:

$$\begin{aligned} \% \Delta \text{Borrowed Quantity}_w = & \beta_0 + \beta_1 * \text{Announcement Dummy}_w \\ & + \beta_2 * \% \Delta \text{Available Quantity}_w + \varepsilon_w. \end{aligned} \quad (1)$$

$\% \Delta \text{Available Quantity}$ and $\% \Delta \text{Borrowed Quantity}$ are measured over five days.

Table 7 presents the results of these regressions. For Treasuries and agencies, the coefficients for both the *Announcement Dummy* and $\% \Delta \text{Available Quantity}$ are statistically significant.¹⁶ That is, announcements significantly reduce *Borrowed Quantity* after controlling for $\% \Delta \text{Available Quantity}$.

¹⁶ As a robustness check, we alter the treatment dummy to only include the five-day change before the announcement and to only include the five-day change after the announcement. Our results are consistent with the findings of the model specification tested in Table 7.

5.3. *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 these announcements. We have also shown that shorts further reduced their positions just following the announcements, suggesting that the announcements credibly induced expectations of low yields in the short-term. These findings support Hypothesis 1a and Hypothesis 1b, 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 8 shows means in *Borrowed Quantity* on the first day of P4-Post (3/26/2009) and the last day of P4-Post (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 1C. 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 4. Thus, we conclude that the Fed was successful in convincing shorts that interest rates would remain low, supporting Hypothesis 1c.

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

We also investigate short behavior around Fed announcements that reduce or fail to raise expectations of future expansions ("Slow Events"). Hence, we analyze three Fed announcements

that indicated reduced or slowing of purchases of Treasuries and agencies.¹⁷ For these ambiguous or disappointing announcements, we do not expect short interest to decline.

Evidence in Table 9 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 is capturing changes in the sentiment of shorts.

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

Table 10 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 $\% \Delta \text{Borrowed Quantity}$ 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, supporting Hypothesis 2. We conclude that shorts either cannot discern or do not care which securities will be purchased around announcement times.

¹⁷ 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”.

5.6. 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 11 shows the effect of the Fed's purchases on *Available Quantity* and *Borrowed Quantity* of agencies at the 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.

5.7. The impact of unconventional monetary policy shocks on Borrowed Quantity for an extended sample

To assess whether our basic conclusions apply to a broader sample, we extend our sample to include 21 QE1, QE2, MEP, and QE3 announcements from 11/25/2008 to 6/19/2013. We do not have access to Markit data after mid-2013. Appendix I describes these 21 announcements. 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.¹⁸

Columns (1) to (3) of Table 12 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 sign and to a statistically significant degree. A change of 1% in *Borrowed Quantity* before the announcement is related to a ΔYield of 2.6 bps and 1.1 bps, for Treasuries and agencies, respectively. Because Treasury and agency $\% \Delta \text{Borrowed Quantities}$ are significantly correlated ($\rho = 0.62$) and both are somewhat correlated with the time trend, we orthogonalize the Treasury $\% \Delta \text{Borrowed Quantity}_{\text{before}}$ with respect to the agency $\% \Delta \text{Borrowed Quantity}_{\text{before}}$ when using both in a joint regression.¹⁹ Column (3) shows that agency $\% \Delta \text{Borrowed Quantity}_{\text{before}}$ and the orthogonal component of Treasury $\% \Delta \text{Borrowed Quantity}_{\text{before}}$ strongly jointly predict the monetary shock. That is, the results in Table 12 are consistent with our previous findings that shorts reduced their positions in anticipation of monetary policy shocks (Section 1.1).

Table 12, Columns (4) to (7), analyze the impact of the monetary shock on $\% \Delta \text{Borrowed Quantity}$ following each announcement. An expansionary monetary shock (a decrease in interest rates) significantly reduces $\% \Delta \text{Borrowed Quantity}$ of both Treasuries and agencies in the week following the announcement, when one controls for $\% \Delta \text{Borrowed Quantity}$ before the announcement. These findings are consistent with our results in Section 5.3 that shorts further

¹⁸ 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.

¹⁹ 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.

reduced their positions following monetary policy shocks. That is, the unconventional monetary announcements credibly reduce expected yields over the longer term.

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 a series of 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 out predict marginal investors in very deep spot/futures markets in which the event is determined almost entirely by public information.

Specifically, we examine the behavior of short interest around four LSAP announcements that resulted in unusually large interest rate changes. We find that short interest declined significantly prior to LSAP announcements, confirming that short sellers are sophisticated investors who anticipated the unconventional announcements to some degree. We also find that short interest declined further following the 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 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.

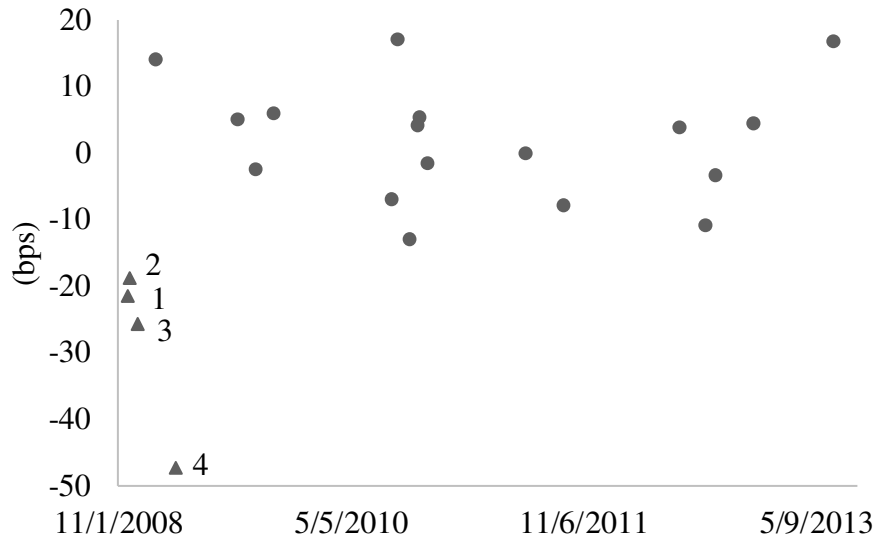
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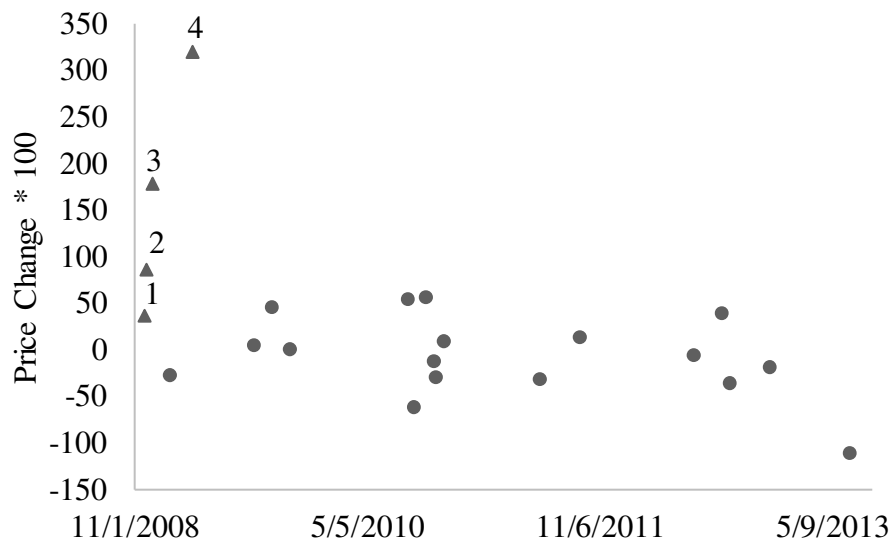
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Appendix I. Federal Reserve unconventional monetary policy announcements from 2008 to mid-2013

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



Panel A. 10-year Treasury yields change



Panel B. Futures price change

Figure 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.

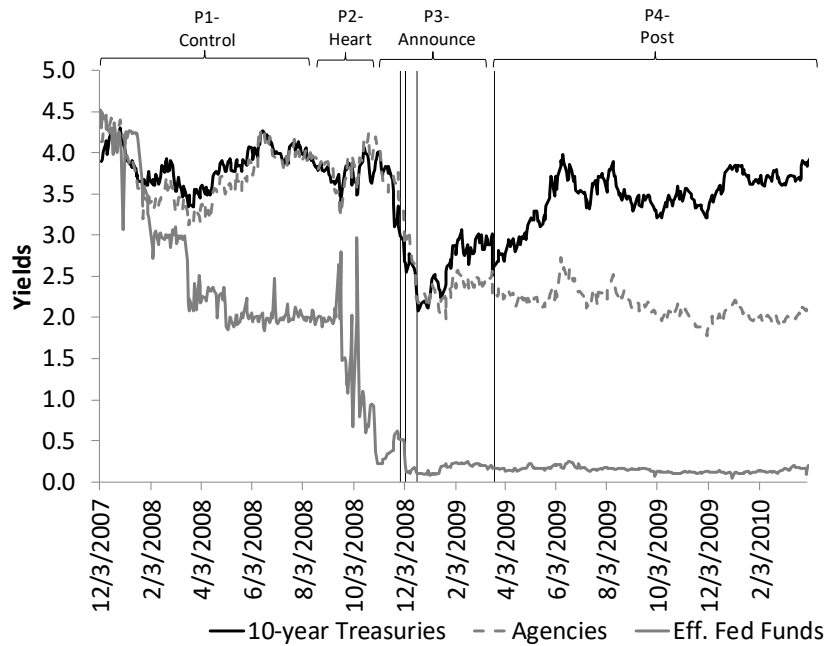
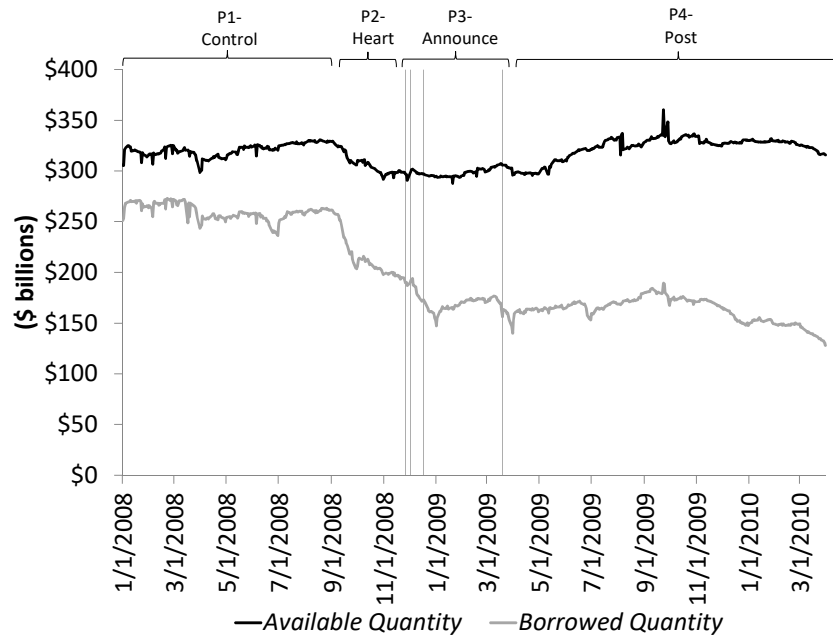
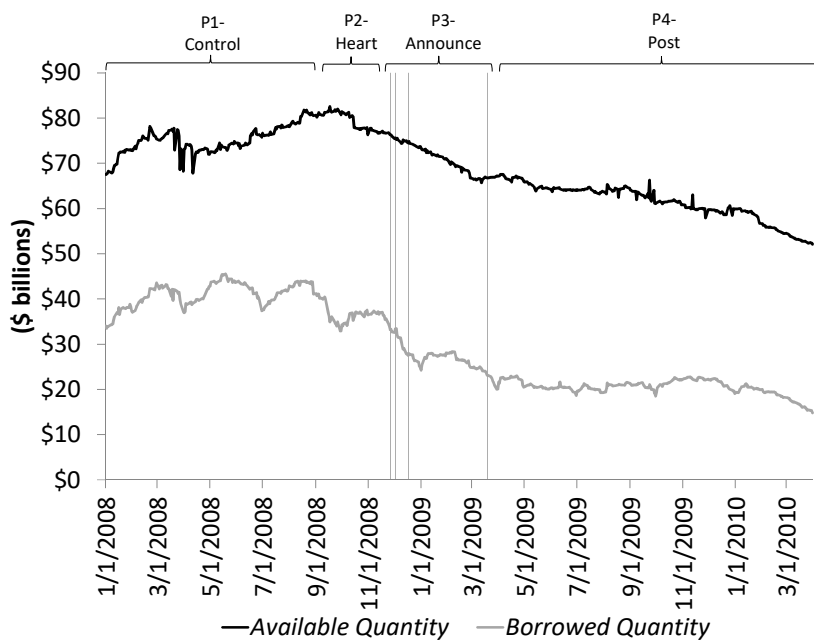


Figure 2. Behavior of interest rates during and following the Great Recession

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.



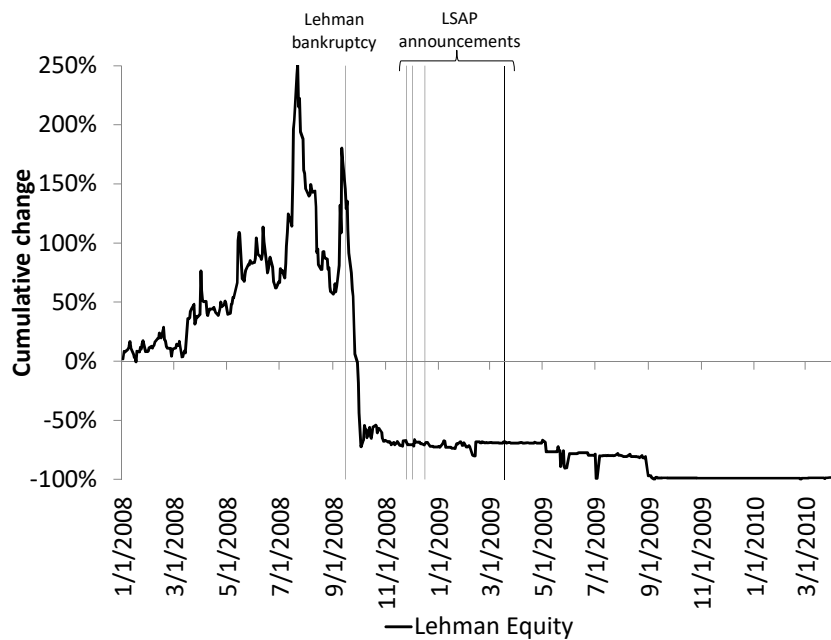
Panel A: Treasuries



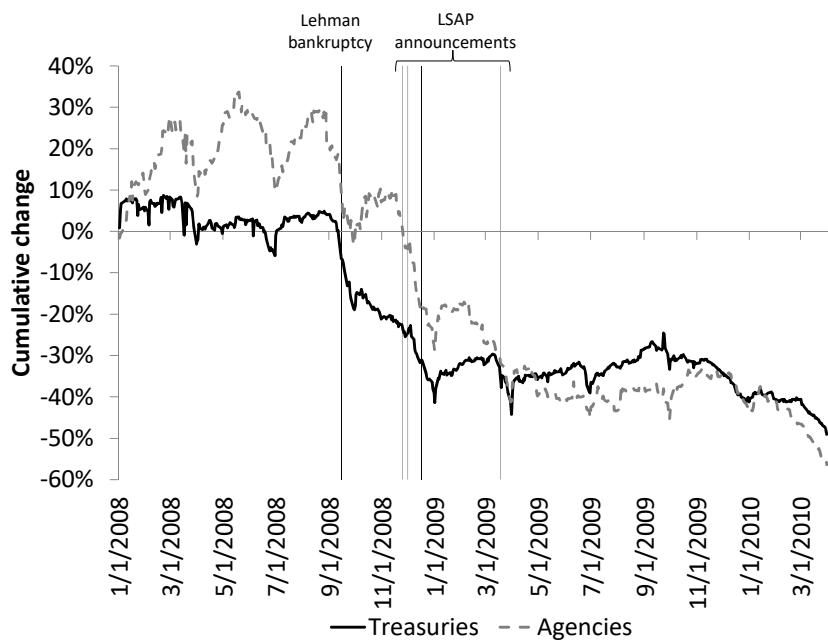
Panel B: Agencies

Figure 3. 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

Figure 4. 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.

Table 1. 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 2. 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 3. Issue characteristics of securities purchased and not-purchased during QE1

Using data for our entire 27-month sample period, we present issue characteristics for Treasury securities that are (Column 2) and are not (Column 3) purchased by the Fed under the LSAP program. We present similar data for agencies in Columns 5 and 6, respectively. We present means of issue size in Row 2. We weight the remaining variables by issue size. Using a Wilcoxon rank sum test, we test the null hypothesis that the means are equal and present the resulting p-values in Columns 4 (Treasury) and 7 (agencies).

	Treasury			Agencies		
	Purchased		p-value	Purchased		p-value
	Yes	No		Yes	No	
N	107	17		64	652	
Issue Size (mill. \$)	22,165	22,712	0.82	4,103	402	<0.01
Coupon rate (%)	4.64	3.85	0.52	4.76	4.30	<0.01
Duration (years)	6.53	4.58	0.02	5.70	7.66	<0.01
Time-to-maturity (years)	10.73	8.84	0.20	7.95	10.46	<0.01
Time since issue	6.51	3.97	0.75	3.46	6.31	<0.01
YTM (%)	3.17	4.10	0.08	3.95	4.69	<0.01

Table 4. Lending data for securities purchased and not-purchased under the LSAP program, 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 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		
	Purchased		p-value	Purchased		p-value	Purchased		p-value	Purchased		p-value
	Yes	No		Yes	No		Yes	No		Yes	No	
Panel A: Treasuries												
N	80	15		82	16		90	15		107	16	
Available Qty	4,177	4,621	0.88	3,574	4,455	0.73	3,231	4,700	0.41	3,252	3,918	0.36
Borrowed Qty	3,406	3,819	0.83	2,453	3,280	0.69	1,822	2,846	0.42	1,675	1,801	0.32
Panel B: Agencies												
N	54	549		55	429		59	443		64	392	
Available Qty	616	308	<0.01	733	286	<0.01	683	255	<0.01	611	262	<0.01
Borrowed Qty	393	104	<0.01	406	73	<0.01	312	52	<0.01	240	41	<0.01

Table 5. 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	

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)	(2)	(3)	(4)
	Before	After	Before	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. Regression analysis of LSAP announcements effects on short interest for all Treasuries and agencies

For Treasuries and agencies, in turn, we calculate *%ΔBorrowed Quantity* and *%ΔAvailable Quantity* for the 34 five-day periods in our P1-Control sample (n = 34) and for each five-day period before and after each announcement (n = 8). *Announcement Dummy* = 1 for each five-day period before and after each announcement and 0 otherwise. We estimate:

$$\% \Delta \text{Borrowed Quantity}_w = \beta_0 + \beta_1 * \text{Announcement Dummy}_w + \beta_2 * \% \Delta \text{Available Quantity}_w + \varepsilon_w$$

where *w* refers to the five-day period. We report p-values in parentheses.

	Treasuries	Agencies
Announcement Dummy	-3.44 (<0.01)	-5.72 (<0.01)
%ΔAvailable Quantity	1.19 (<0.01)	0.75 (0.02)
Adj. R-squared	0.60	0.42

Table 8. 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 9. 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
% Δ 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
% Δ 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
% Δ 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
% Δ 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
% Δ Borrowed Quantity		0.17		0.82

Table 10. 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 *% Δ Borrowed Quantity* for Treasuries and agencies, in turn, for each of the four LSAPs announcements and for all announcements. We weight the *% Δ Borrowed Quantity* based on issue size. We test the null hypothesis that the means of the *% Δ Borrowed 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.

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

Table 12. Time-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 *%ΔBorrowed 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. $\Delta Yield$ (in basis points) is the change in daily 10-year Treasury yield from the announcement date to the following day. *%ΔBorrowed Quantity_Treasury_after* and *%ΔBorrowed Quantity_Agency_after* are the five-day *%ΔBorrowed Quantity* following the announcement for Treasuries and agencies, respectively. *%ΔBorrowed Quantity_Treasury_before* and *%ΔBorrowed Quantity_Agency_before* are the five-day *%ΔBorrowed 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. *Res_%ΔBorrowed Quantity_Treasury_before* is the residuals from the first-stage regression of *%ΔBorrowed Quantity_Treasury_before* on *%ΔBorrowed Quantity_Agency_before*. * Indicates significance at the 5% level. Robust standard errors are shown in parentheses.

Dependent Variable	$\Delta Yield$			%ΔBorrowed Quantity_Treasury_after		%ΔBorrowed Quantity_Agency_after	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
%ΔBorrowed Quantity_Treasury_before	2.59 (0.56)*				-0.60 (0.25)*		
Res_%ΔBorrowed Quantity_Treasury_before			3.07 (0.75)*				
%ΔBorrowed Quantity_Agency_before		1.09 (0.58)*	1.09 (0.43)*				-0.07 (0.17)
$\Delta Yield$				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