The Costs of Quantitative Easing: Liquidity and Market Functioning Effects of Federal Reserve MBS Purchases

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Abstract

In this paper, I evaluate a potential cost of large-scale asset programs, also known as quantitative easing (QE). Specifically, I assess the effect of ongoing Federal Reserve mortgage-backed security (MBS) purchases on liquidity conditions in the MBS market. Considering several indicators of liquidity and market functioning, I show that Federal Reserve MBS purchases negatively affected volumes, trade sizes, and implied financing rates in dollar roll transactions. Additionally, I present some evidence that bid-ask spreads briefly widened as a result of Federal Reserve purchases that occurred early on in the "QE3" program. Notably, the adverse liquidity effects of Federal Reserve purchases appear to be most evident shortly after new purchase programs are initiated. However, the magnitude of the liquidity effects resulting from Federal Reserve purchase operations is quite modest, short-lived, or both. Finally, I demonstrate that the apparent liquidity-impairing effects of Federal Reserve MBS purchases did not translate into a deterioration of price discovery in the MBS market.

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[b] Disclaimer: The analysis and conclusions set forth are those of the author and do not indicate concurrence by other members of the research staff or the Board of Governors.

1. Introduction

The Federal Reserve's use of large-scale asset purchases since the recent financial crisis has been the focus of a rapidly expanding body of literature. Thus far, a large majority of the studies composing this body of literature has concentrated on evaluating the efficacy of the large-scale asset purchases—also known as quantitative easing (QE). In light of the unprecedented nature of QE, the state of the economy and financial markets, and the stated goals of QE, the early focus on the efficacy of these programs was necessary and understandable.[1] Furthermore, evaluating the efficacy of these programs is tremendously important in light of the Federal Reserve's frequent reliance on QE to achieve its mandate in the years after the zero lower bound on interest rates was reached.

Conversely, the potential costs of QE have garnered substantially less attention in the scholarly literature to this point. This relative inattention stands in contrast to the increased awareness of the potential risks and costs of QE expressed by policymakers as QE purchases continued. During early QE programs, Federal Reserve officials suggested potential risks, but rather than pointing to costs associated with ongoing purchases, the risks cited tended to focus only on how to optimally implement the programs, or on concerns which never materialized. For instance, in August of 2010, Chairman Bernanke pointed to potential risks of Federal Reserve balance sheet expansion that included the "difficulty of calibrating and communicating policy responses," and "reduce[d] public confidence in the Fed's ability to execute a smooth exit from its accommodative policies… lead[ing] to an undesired increase in inflation expectations," (Bernanke, 2010). Downplaying this risk, he went on to explain the high degree of confidence

[1] Studies that evaluate the efficacy of QE programs initiated by the Federal Reserve and their effects on asset prices include Neely (2010), Gagnon, et al. (2011), Hancock and Passmore (2011), Krishnamurthy and Vissing-Jorgensen (2011), Fuster and Willen (2012), Hamilton and Wu (2012), Stroebel and Taylor (2012), D'Amico and King (2013), and Kandrac and Schlusche (2013). Analyses that include other central banks' recent experience with QE include Joyce, et al. (2011), and Christensen and Rudebusch (2012).

among the FOMC that exit from highly accommodative policies could be smoothly accomplished. Similarly, the minutes of the November 2010 FOMC meeting (which resulted in the announcement of QE2) note that "several participants saw a risk that a further increase in the size of the…asset portfolio…could cause an undesirably large increase in inflation. However, it was noted that the Committee had in place tools that would enable it to remove policy accommodation quickly if necessary to avoid an undesirable increase in inflation."

As QE programs continued to be used to support a stronger economic recovery and help ensure that inflation remained at mandate-consistent levels, potential costs of QE came into sharper focus and were more clearly defined. The first mention of concern for these potential costs within the FOMC came in the minutes of the April 2012 meeting, which state that "…one participant noted the potential risks and costs associated with additional balance sheet actions." Although the FOMC continued to signal a willingness to take further action to promote a stronger recovery in its statements, the concern surrounding the costs of QE seemingly spread over the next two meetings. According to the minutes, more members began expressing interest in the potential costs of QE in June, and a more thorough discussion of the costs of large-scale asset purchases was entertained at the July/August 2012 meeting. Later that month, Chairman Bernanke enumerated several potential costs of ongoing purchases at the high-profile Economic Symposium in Jackson Hole, Wyoming. These costs included the possible impairment of market functioning, an unanchoring of inflation expectations, risks to financial stability, and the potential for Federal Reserve financial losses (Bernanke, 2012). Those comments apparently reflected mounting concern within the FOMC regarding the costs of LSAPs, which for the first time promised to "take appropriate account of the likely efficacy and costs of such purchases," in the statement released following the September 2012 FOMC meeting, at which the beginning of

the open-ended "QE3" program was also announced. Underscoring the FOMC's concern about the costs of LSAPs, the 2012 annual report of the Board of Governors included a section entitled "Efficacy and Costs of Large-Scale Asset Purchases," (Board of Governors, 2013) in which the potential costs identified in Chairman Bernanke's Jackson Hole speech were reiterated.

In this paper, I aim to evaluate the first of four potential costs outlined by Chairman Bernanke and later described in the 2012 annual report of the Board of Governors as follows:

> One potential cost of conducting additional [large-scale asset purchases] is that the operations could lead to a deterioration in market functioning or liquidity in markets where the Federal Reserve is engaged in purchasing. More specifically, if the Federal Reserve becomes too dominant a buyer in a certain market, trading among private participants could decrease enough that market liquidity and price discovery become impaired. (Board of Governors, 2013)

Using data collected over nearly two and a half years of continuous Federal Reserve mortgage-backed security (MBS) purchases, I test the effect of regular QE intervention on several indicators of liquidity and market functioning. Notably, most of the purchases in my sample were conducted during the open-ended MBS purchases of QE3 when concerns surrounding the costs of QE appeared to grow. By examining different aspects of MBS market liquidity, I am able to achieve a more complete picture of the liquidity effects of MBS purchases conducted as part of QE programs. Further, I consider the extent to which QE purchases were coincident with changes in price discovery in the MBS market in order to gauge the severity of the liquidity effects of MBS purchases.

As mentioned previously, existing work along these lines is relatively scarce. Prior studies in this area focus predominantly on Treasury purchases by the Federal Reserve. For instance, Kandrac and Schlusche (2013) find that purchases of nominal Treasury securities as part of QE have no discernable effect on the bid-ask spreads of the traded securities. The authors show that this result persists even if the Federal Reserve holds sizable amounts of the purchased

securities, or if purchases are large relative to the amount of the security outstanding. Christensen and Gillan (2014) present some evidence that Federal Reserve purchases of TIPS during QE2 did not impair TIPS market functioning, and in fact may have improved liquidity in this market. Of course, the liquidity and depth of the market for U.S. Treasury securities may mask liquidity impairments that would be present in less liquid markets. Investigating the impact of QE on market functioning in the MBS market, Kandrac (2013) finds evidence that Federal Reserve MBS purchases had modest negative effects on market functioning and liquidity, and that these effects were most evident subsequent to the expansion of MBS purchases that began in September 2012 as part of QE3. Unfortunately, the author's sample period includes relatively little of QE3, so the persistence of that result could not be evaluated.

In this study, I use the unannounced variation in the securities purchased by the Federal Reserve to show that regular MBS purchases conducted after QE1 have negative effects on some indicators of market functioning. First, Federal Reserve purchases lead to decreases in implied financing rates on dollar roll transactions, potentially indicating a scarcity of deliverable collateral caused by QE. However, this effect appears to be most pronounced in the months immediately following the initiation of an MBS purchase program, and dissipates over time. Second, third party trading activity is reduced in securities purchased by the Federal Reserve, with measurable reductions in both trading volumes and trade sizes. However, I also find that similar securities that may be viewed as substitutes see increased activity. Combined, these results could demonstrate evidence of a portfolio balance channel, through which QE is (at least in part) often claimed to work. Third, I fail to find evidence that dealers' indicative bid-ask spreads respond in a systematic way to ongoing central bank MBS purchases, though there is some indication that MBS purchases near the beginning of the QE3 period were associated with

slightly wider bid-ask spreads. Finally, I evaluate the extent to which the apparent deterioration in liquidity conditions as a result of Federal Reserve purchases impaired price discovery. Ultimately, I find that MBS prices responded in a normal manner to both economic news and shocks to Treasury rates throughout the sample period. To the best of the author's knowledge, these findings represent the first thorough study of the liquidity and market functioning effects of ongoing Federal Reserve MBS purchases.

The remainder of the paper proceeds as follows. Section 2 describes the history and pertinent details of the Federal Reserve's MBS purchases programs. Section 3 discusses ways in which ongoing purchases can affect market functioning, and Section 4 describes the liquidity and market functioning measures that are used in the empirical analysis presented in Section 5. Section 6 presents tests to evaluate changes in MBS price discovery, and Section 7 concludes.

2. The Federal Reserve's MBS Purchases

The Federal Reserve's recent experience with MBS purchases began with the FOMC announcement on November 25, 2008 that it would initiate a program to purchase up to $500 billion in MBS. In March of the following year, this amount would be increased to $1.25 trillion, and in September 2009, the FOMC committed to purchase the full $1.25 trillion of agency MBS and explained that the purchase program—which came to be known as QE1—would be completed in March of 2010. Notably, the MBS market was essentially frozen at the time of the announcement, but by the completion of QE1 markets were functioning much more normally (Hancock and Passmore, 2011). As will be discussed in more detail in the next section,

a consensus emerged that the Federal Reserve's MBS purchases were an important component in the restoration of order to the agency MBS market.[2]

However, although market liquidity had normalized by the end of 2010, the sluggish economic recovery prompted the FOMC to announce an additional LSAP program—known as QE2—that consisted solely of Treasury security purchases. In September of the following year (three months after the end of QE2), the FOMC again announced balance sheet actions to help stimulate the economy. First, the FOMC decided to extend the average maturity of its Treasury securities holdings—a QE program known as the maturity extension program (MEP) or "operation twist." Second, the FOMC decided to reinvest principal payments from its holdings of agency MBS and agency debt into agency MBS, a policy aimed at supporting conditions in mortgage markets, which would presumably also help to achieve the goal of supporting a stronger economic recovery.[3] Thus, MBS purchases were conducted in an environment of normal market functioning for the first time under this "Reinvestment program" that began in October 2011.[4] Reinvestment purchases were the only source of Federal Reserve demand for MBS until, in September 2012, the FOMC agreed to purchase an additional $40 billion of agency MBS per month, and to continue these purchases if the outlook for the labor market did not substantially improve. This program—which came to be known as QE3—continued purchases at that pace until the FOMC first agreed to decrease monthly purchases at its December 2013 meeting.

[2] See, for example, Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and Hancock and Passmore (2011). Additionally, Stroebel and Taylor (2012) argue that it is also possible that market participants viewed QE1 as a signal that the implicit Federal government guarantees of Fannie Mae and Freddie Mac had become explicit.
[3] This altered the existing policy of reinvesting principal payments into Treasury securities.
[4] For the remainder of the paper, I will refer to the Reinvestment program to indicate the period in which principal payments were invested into MBS, beginning in October 2011.

Figure 1 shows daily MBS purchases by the Federal Reserve, demonstrating the substantial increase in MBS purchases as a result of QE3. In addition to the new outright purchase program, interest rates fell for several months after the announcement of the open-ended purchases of QE3, which led to higher principal prepayments on existing MBS holdings. Consequently, total monthly MBS purchases by the Open Market Trading Desk (the Desk) rose to as much as $82 billion in the period after the announcement of QE3.

Because the focus of the present study is on liquidity and market functioning effects of securities purchases in relatively *normal market environments*, I focus only on Federal Reserve MBS purchases conducted since the start of the reinvestment period. In this way, I am able to evaluate potential costs associated with the regular use of QE outside of acute crises and market freezes, which is a unique feature of this study.

Although most Federal Reserve MBS purchases during QE1 were conducted by outside investment managers, all later MBS purchases were conducted by FRBNY staff at the Desk. As outline in FRBNY operating policies and FAQs, all MBS transactions in the sample were concentrated in newly-issued agency MBS in the to-be-announced (TBA) market, which is a highly liquid market that allows for the forward trading of agency MBS based on a handful of parameters under which mortgage pools can be considered interchangeable (see Vickery and Wright (2013) for more information). Furthermore, Desk MBS trades were conducted over TradeWeb, a popular electronic dealer-to-customer trading platform.[5] Through TradeWeb, Desk staff can solicit bids from up to four primary dealers in auctions that are conducted throughout the day. In the sample period covered by this study (October 2011 through February 2014), the Desk conducted an average of about 15 auctions per day.

[5] In November 2013 the Desk began a series of small-value MBS transactions conducted over FedTrade, the Desk's proprietary trading system. Given their very small size, I ignore these purchases in the sample below. In April of 2014, the Desk began conducting an increasing share of MBS purchases over FedTrade.

Compared with purchases of Treasury securities, the Desk has released relatively little information in advance of agency MBS operations. Specifically, around the last business day of the month, the Desk posts the total amount of QE3 MBS purchases that would occur in the following calendar month, as directed previously by the FOMC.[6] Planned purchases associated with the Reinvestment program expected to take place over each monthly period were announced on or around the 8th business day of the month. This delay allowed the Desk to estimate prepayments from monthly "factors" reports released by the agencies around that time. Notably, the Desk would announce neither the mix of products, coupons, and issuers nor the dates on which those purchases would occur. In a succession of FAQs posted to the FRBNY website, the Desk only indicated that "purchases will be conducted on a frequent basis over the course of each month, and will be guided by general MBS market conditions, including, but not limited to, supply and demand conditions, market liquidity, and market volatility." In practice, however, the Desk traded agency MBS on all weekdays since the start of the Reinvestment period except for days affected by Hurricane Sandy and days listed on the SIFMA recommended holiday calendar. Total amounts of purchased securities were made public (during normal trading hours) via the FRBNY website on the day of the transaction, but additional operational details such as the price at which the trades were executed were released only at a monthly frequency.

Table 1 provides descriptive statistics for Federal Reserve MBS purchases for the entire sample and for sub-periods defined by QE regime labeled "Reinvestment" and "QE3." There are several notable features of Federal Reserve MBS purchases demonstrated in Table 1. First, Fannie Mae and Freddie Mac 30-year securities composed the majority of purchases in each

[6] For much of the sample this amount was simply $40 billion per month. Coincident with the announcement of QE3 in September 2012, though, the Desk announced that it would purchase approximately $23 billion over the remainder of the month, which represents the prorated share of the agreed-upon $40 billion monthly purchase.

program due to their liquidity and depth. Fannie Mae and Freddie Mac 30-year securities are also known as "Class A" securities because they share monthly settlement days. Second, the variation in purchased coupons was substantial over the course of the programs, partly reflecting the fluctuation in interest rates over the course of the programs. However, 3.0% and 3.5% coupon securities composed the majority of purchases in each sub-period. Finally, other operational details are reported in the bottom of Table 1, demonstrating the changes to purchase operations as a result of the introduction of QE3. Average daily purchase amounts were about 2.5 times higher during QE3, and the number of trades per day more than doubled. The number of securities purchased by the Desk per day increased notably (6.8 to 10.6), as did the average purchase per security ($196 million to $304 million). Note that here, as in the remainder of the paper, a "security" refers to a unique issuer-maturity-coupon combination (e.g. a Freddie Mac 30-year 4.0% coupon). These characteristics uniquely identify a deliverable security in a TBA contract, with the other agreed-upon trade characteristics being the price, par amount, and settlement date.

3. Potential Effects of Ongoing Federal Reserve Purchases on Market Functioning

Federal Reserve securities purchases can potentially generate contrasting effects on market functioning and liquidity depending on the type of asset purchased and the market environment at the time of purchases. As briefly mentioned above, it is possible for large central bank purchases to *improve* measures of liquidity and market functioning. This outcome is most likely during a time of severe market disruption and insufficient demand for the purchased securities, such as a financial crisis. As outlined in Gagnon et al. (2011), QE can provide an ongoing source of demand for illiquid assets. As a result of this persistent flow of demand,

dealers and other investors may be more willing to take larger positions in the purchased securities or make markets in them more actively. In this way, QE can provide assurance to market participants that they will be able to sell assets to the Federal Reserve. Thus, even if relatively few market participants are willing to trade, measures of liquidity such as bid-ask spreads and trading volumes may improve. This dynamic is the most likely explanation for the improvement in market functioning (in both Treasurys and MBS) observed during the first half of QE1. Indeed, as Krishnamurthy and Vissing-Jorgensen (2013) point out, many researchers accept that this mechanism was in operation during QE1, and Federal Reserve purchases helped to thaw the MBS market freeze.[7]

However, liquidity premiums have been relatively low since 2010. How might QE affect liquidity when there is substantially less turmoil? To answer this question, it may useful to consider the effect of QE purchases on the stock of the purchased asset available to the public. If QE purchases substantially reduce the supply of securities available to the public, QE could have deleterious consequences for market functioning. For instance, if a more scarce security trades less frequently and/or increases market makers' costs to pursue offsetting trades, lower supply engendered by QE can result in longer inventory holding periods, higher costs for market-makers, and reduced overall trading as dealers and other investors become less willing to hold an increasingly scarce security. In this scenario, QE can lead to a less robust market in the purchased securities, causing measures of market functioning to deteriorate. Notably, the sheer size of the purchases required to carry out QE programs may cause deterioration in liquidity and market functioning for similar reasons, even if the supply of the traded security is ample. For instance, if market makers' incur higher costs as a result of hedging or offsetting very large

[7] Further, theoretical work explaining the beneficial effect of central bank purchases of distressed assets is described in Curdia and Woodford (2011), Gertler and Karadi (2011), and He and Krishnamurthy (2013).

Federal Reserve trades, trading activity that would have otherwise taken place may be crowded out.[8]

Thus, the effect of QE on liquidity and market functioning is not theoretically clear and remains an empirical question.

4. Measures of Agency MBS Liquidity and Market Functioning

In the subsections below, I detail the indicators of liquidity and market functioning that I will later relate to Federal Reserve MBS purchases. Because there is no single measure of liquidity that receives widespread acceptance, I consider a range of indicators that are typically assumed to reflect liquidity conditions for a given market.[9]

The liquidity of a traded asset such as an MBS can be evaluated along at least three different components. The first important component of market liquidity is "trade immediacy," or the ability to quickly trade securities. The second important component of market liquidity is "market depth," which measures the ability to trade without having large effects on the prices of the securities that are traded. The third component of market liquidity is known as "market breadth," which represents the ability to transact at a price that is near a security's true value.

In addition to measures of market liquidity, I also examine measures of market functioning. Although there is no clear consensus on the distinction between liquidity and market functioning in the literature and they are often used interchangeably, I evaluate market functioning by focusing on the extent to which MBS are delivered and settled in a normal manner. Because the Federal Reserve transacts in the forward-delivery TBA market and provides relatively limited information regarding the purchases in advance, it is possible that a

[8] I thank Yuriy Kitsul for pointing this out.
[9] Fleming (2003) provides an excellent summary of commonly cited measures of market liquidity, several of which are also used in the present study.

scarcity of deliverable collateral can develop. Thus, it is possible to detect the effects of QE on general market functioning even if there are no implications for the more traditional measures of liquidity outlined above.

4.1. Implied Financing Rates

In order to measure general market functioning, I examine effects of Federal Reserve purchases on implied financing rates of dollar roll transactions. Implied financing rates are frequently monitored by TBA market participants, but are unique to the TBA market and less widely known than the more common measures of liquidity I describe below. For this reason, I provide a more detailed description of implied financing rates in order to explain how they can potentially signal impaired market functioning.

A dollar roll transaction comprises two simultaneous TBA trades in which the seller agrees to deliver an MBS in an earlier ("front") month, and agrees to purchase a similar MBS in the subsequent ("back") month. Although similar to a collateralized loan, or "repo" transaction, the roll seller does not receive the interest and principal payments in the intervening period, and the mortgage pool returned to the seller in the back month—though possessing the same TBA characteristics—need not be the same as the one delivered by the seller in the front month. Consequently, the roll seller may receive a security with less favorable characteristics, so the back month purchase will take place at a lower price than the front month purchase.[10] However, the roll seller can earn interest on the proceeds from the dollar roll received in the front month.

Using an assumption for both the interest rate on the proceeds from the dollar roll and the unscheduled principal payments on the delivered MBS, a roll seller can compare (1) the cash return from engaging in a dollar roll with (2) the return from simply holding the MBS over the

[10] This price difference, known as the "drop," also exists because of the principal and interest payment that the roll seller forfeits over the tenor of the dollar roll.

tenor of the dollar roll. The interest rate earned on the front month proceeds that *equates* the returns from those two options is referred to as the implied financing rate (IFR). As IFRs trade below prevailing short-term interest rates, dollar rolls become more attractive to the roll seller.[11] Thus, lower IFRs indicate higher expected returns to roll sellers, who are able to command higher returns when deliverable collateral is relatively scarce and roll buyers must, for example, acquire MBS in order to cover a short position or to fulfill market-making responsibilities. Scarcity of deliverable collateral can thus be alleviated as IFRs trade lower and the incentive to offer collateral through dollar rolls increases.

Figure 2 provides a timeline of a hypothetical dollar roll, describing the roll seller's cash outlays and receipts for the transaction described at the top of diagram. All of the parameters of dollar roll transactions are determined at the time of the trade, which typically occur within two months of the first delivery of MBS, as TBA contracts generally trade up to three months before settlement.

Figure 3 depicts the history of IFRs for two 30-year securities that were regularly traded during the sample period—the Fannie Mae and Freddie Mac 3.5% securities—as calculated by J.P. Morgan. IFRs for these securities were roughly unchanged over the entire sample period, but traded increasingly negative in the summer of 2012, well below prevailing short-term funding rates. If Federal Reserve MBS purchases are substantial enough, the price of the front-month contract could rise and IFRs can be pushed lower as a result, indicating a scarcity of deliverable collateral. Thus, if Federal Reserve MBS purchases correlate with lower IFRs, this may provide an indication that QE can induce scarcity in the MBS market leading to a deterioration in market functioning.

[11] Note that IFRs trading below short-term rates do not necessarily represent arbitrage opportunities. This is principally due to the redelivery risk faced by the roll seller mentioned above.

4.2. Trade Sizes

Trade size is a commonly cited measure of liquidity (see, for instance, Fleming, 2003) and can proxy for both market depth and trade immediacy, with lower trade sizes possibly indicating worse liquidity conditions. My source for daily security-level volumes in TBA contracts is the Financial Industry Regulation Authority (FINRA). FINRA is an independent, nonprofit organization authorized by Congress to ensure transparent and fair practices in the securities industry. In 2011, prior to the beginning of the Reinvestment program, the Securities and Exchange Commission approved a measure requiring broker/dealers to begin reporting ABS and MBS transactions to the FINRA-developed Trade Reporting and Compliance Engine (TRACE).

Combining the transactions in TRACE with Federal Reserve purchase data provided by the FRBNY, I construct a series of average daily trade sizes for each security excluding Federal Reserve transactions.[12] Figure 4 plots the time series of trade sizes for the Fannie Mae and Freddie Mac 3.5% securities over the sample period. Figure 4 demonstrates that trade sizes exhibit a slight downward trend in the latter half of the sample.

4.3. Trading Volumes

Next, I consider trading *volume* for each security. Similar to trade size, trading volume is a commonly referenced measure of liquidity, and can proxy for both market depth and trade immediacy, with lower volumes indicating worse liquidity conditions (Fleming, 2003). Furthermore, changes in trade volume in response to Federal Reserve MBS purchases may reveal portfolio balance effects if investors are found to substitute out of a purchased security and into a

[12] Note that TRACE—unlike the trading platform TradeWeb—includes dealer-to-dealer transactions in addition to dealer-to-customer transactions. As a result, TradeWeb transactions are a subset of those reported in TRACE, which covers substantially more trading activity. Using participant identification numbers supplied in the TRACE database, I am able to remove duplicate transactions that arise when two dealers transacting with one another report the same transaction as a purchase or sale.

similar security. In this sense, lower trading volume in response to Federal Reserve purchases may be viewed not as a cost of QE, but as an artifact of the mechanism through which QE is theorized to increase asset prices and lower yields.

Figure 5 plots the time series of trading volume for the same securities displayed in Figure 4. As with trade size, TRACE trade data and Federal Reserve purchases are used to construct a measure trading volume excluding Federal Reserve transactions in order to isolate private trading patterns. Figure 5 demonstrates that volumes have trended down slightly over the sample period for the Fannie Mae and Freddie Mac 3.5% coupon securities.[13] However, much of this effect appears to coincide with the sharp increase in interest rates through the summer of 2013. Notably, agency MBS volumes appear to exhibit a seasonal lull toward the end of each calendar year.

4.4. Bid-Ask Spreads

In order to measure the effect of QE purchases on market breadth, I consider changes in bid-ask spreads. The bid-ask spread for each security is compiled from data provided by TradeWeb—a popular dealer-to-customer MBS trading platform—which aggregates dealer-reported indicative quotes each day to form a composite bid-ask spread for each security. Unfortunately, the indicative nature of the quotes may make this measure a less-reliable indicator of liquidity than in other markets, such as Treasurys (Fleming, 2003). Unlike quotes in the market for Treasury securities, dealers do not commit to transact at the bids and offers reported in TradeWeb. Nevertheless, bid-ask spreads are one of the most commonly cited measures of market liquidity, and if the indicative spreads are assiduously reported by dealers on a best-efforts basis, a wider spread will indicate deterioration in market breadth and liquidity

[13] Note that trading volume in a particular coupon will also fluctuate as a result of movements in the "current coupon," which represents the hypothetical coupon rate at which an MBS would trade at par. Securities with coupons closer to the current coupon tend to have more trading activity.

conditions. Figure 6 plots bid-ask spreads for the Fannie Mae and Freddie Mac 3.5% securities. As demonstrated in the chart, bid-ask spreads are typically 1.5 ticks (one and a half 32^{nds} of one point) or lower. The most notable increases in bid/ask spreads occurred around the time of the QE3 announcement, during the sharp increase in interest rates in the summer of 2013, and around the end of 2013 when the reduction in asset purchases was announced.

5. Empirical Analysis

In this section, I present estimates of the effect of Federal Reserve intervention in the MBS market on liquidity and market functioning indicators described above. In general, I proceed by regressing daily changes in each of the indicators on Federal Reserve MBS purchases. A discussion of general relevance to these analyses proceeds below to avoid excess repetition.

Importantly, I am most interested in how Federal Reserve QE programs *as actually implemented* by the Desk affect market functioning. In other words, I do not attempt to measure the effect of a wholly unexpected and random Federal Reserve open market operation on market liquidity. Rather, I argue that if policymakers wish to assess the cost of QE, it is important to do so in a context that reflects the way in which purchases are actually conducted. For example, although the Desk does not announce the mix of securities to be purchased each month and for which settlement days, a combination of past trading patterns and the announcement of the total monthly purchases could lead to at least a partial anticipation of the Desk's purchases before they occur. On the other hand, many trades in the TBA market are agreed upon well over a month in advance, which could make prediction of Federal Reserve purchases much more difficult. Nevertheless, if market participants are able to anticipate some portion of Federal

Reserve MBS purchases thereby reducing the liquidity impact at the time of the trade, this does not pose an issue for the present study. This is because the counterfactual outcome is less relevant for policymaking, since the costs of a fully unexpected purchase will never be realized if the Desk regularly announces purchase amounts and does not trade erratically.[14]

Alternatively, one potential concern regarding the analysis presented below is the possibility of the endogeneity of the Desk's purchases. If the Desk reacts to worsening liquidity positions by purchasing other securities, coefficient estimates will be biased. However, several factors mitigating this concern are worth noting. First, because my analysis is at the daily frequency, the Desk must respond to intra-day liquidity conditions. This is likely impractical, as purchases are relatively large, generally occur early in the day, and require a response to many different liquidity indicators simultaneously. Moreover, although the Desk's operating policy allows for the suspension of trading in response to deteriorating market conditions, the Desk has traded MBS on all possible days since the start of the reinvestment program. Second, the first discussion of MBS market functioning and liquidity in an FRBNY annual report did not appear until the 2013 report (released in early 2014). Although market functioning was discussed in general, there is no indication that purchases were adjusted to accommodate disruptions in market functioning. Rather, the report notes that, "[t]he market appeared to absorb the volume of the Desk's agency MBS operations without significant disruptions," and, despite the large volume of purchases in 2013, "there were few signs of significant market disruptions in 2013" (FRBNY, 2014). Lastly, I note that if the Desk substitutes away from securities experiencing worsening liquidity conditions, this would bias *against* finding liquidity effects of Federal Reserve purchases. Consequently, even if endogeneity issues were a concern, the magnitude of

[14] This does not imply that current policy cannot be improved or should necessarily be maintained. In fact, as I explain below, some results suggest a potential way in which QE implementation can be altered to lessen market functioning effects.

the effects reported below can be interpreted as lower bounds for purchases that are conducted without such substitution.

With these points in mind, I proceed below by describing the effects of Federal Reserve MBS purchases on each of the liquidity and market functioning indicators in turn.

5.1. Implied Financing Rates

As a first test of the effects of Federal Reserve purchases on market functioning, I estimate the relationship between Desk purchases and changes in IFRs. Specifically, I employ a cross-sectional time series model with panel-corrected standard error estimates as follows:

$$\Delta IFR_{it} = \beta \times Fed\ \ Purchase_{it} + \chi_t + \alpha + \varepsilon_{it} \qquad (1)$$

In equation (1), *i* indexes a security so that *Fed Purchase* represents the total amount (in billions) of security *i* purchased on day *t*. In order to capture a host of potential factors influencing IFRs across securities, I include daily fixed effects, χ_t. For example, time fixed effects can control for daily movements in short term rates and changes in conditional prepayment expectations.[15] Additionally, because I am including only Class A securities in the estimation of (1), day fixed effects are more likely to be correctly specified since all of the securities have the same settlement calendar and original term to maturity. The errors in (1) are allowed to be heteroskedastic and contemporaneously correlated across panels.[16]

The results from estimation of (1) are reported in the first column of Table 2. The point estimate implies that a purchase of $1 billion by the Federal Reserve since the start of

[15] Changes in prepayment expectations need not affect the IFR, however, if the drop adjusts to account for the difference in expected prepayments.

[16] Prais-Winsten estimates of the parameters allowing for panel-specific first-order autocorrelation in the disturbances yield very similar results to those reported below.

Reinvestment lead to only a 0.07 basis point decline in the IFR for a given Class A security on average. However, as shown in Kandrac (2013), the effect of Federal Reserve purchases on IFRs varied by program. Thus, I proceed by estimating the following regression, which multiplies *Fed Purchase* by program dummies to capture differential effects of MBS purchases across the two purchase regimes:

$$\begin{aligned}\Delta IFR_{it} = &(\beta_{\text{Reinv}} \times Fed\ \ Purchase_{it})D_{\text{Reinv}} + (\beta_{\text{QE3}} \times Fed\ \ Purchase_{it})D_{\text{QE3}} \\ &+\gamma\Phi_{it} + \chi_t + \alpha + \varepsilon_{it}\end{aligned} \tag{2}$$

Moreover, I include controls, Φ, in some specifications to demonstrate robustness. Control variables include daily issuance, which (together with the amount of Federal Reserve purchases) controls for the primary source of daily changes in the supply of each security available to the private investors.[17] As an additional control, I include the absolute value of the difference between the coupon of security *i* and the current coupon on day *t*, matched by agency. Controlling for this spread may be important, because current trading activity and banks' origination pipelines can be driven by the current coupon, with larger values likely being associated with worse liquidity conditions.

The second specification in Table 2 demonstrates that during the Reinvestment program, a $1 billion purchase led to a (statistically insignificant) decline in the IFR of about 1.2 basis points. This result is consistent with the findings in Kandrac (2013), and is not meaningfully affected by the inclusion of other controls (columns three and four). However, Kandrac (2013) also finds a statistically significant effect of a similar magnitude during the QE3 period.

[17] Including the remaining principal balance net of Federal Reserve holdings for each security (which changes once per month) does not significantly change the results.

Evidently, the longer sample period used in the present study reveals an impermanence of the documented effect.

In order to investigate the time dependence of this result, Figure 7 plots the coefficient on *Fed Purchase* from a rolling random effects panel regression with a constant 90-day window. In other words, the first point in Figure 7 represents the value of the key coefficient in equation (1) generated from a regression for the first 90 days of the Reinvestment program. For this exercise, a random effects estimator is used due to the inability to consistently compute panel-corrected standard errors. A vertical line indicates the point at which observations from QE3 begin entering the rolling window. Figure 7 demonstrates an interesting pattern: Shortly after the commencement of a new purchase program, Federal Reserve purchases have scarcity-inducing effects on purchased securities.[18] However, these effects appear to dissipate over time. This pattern could result from the forward-trading nature of the TBA market. When a new purchase program is announced, market participants have already engaged in transactions that are due to settle well after the beginning of the program. Moreover, the inability to immediately expand mortgage origination pipelines for current settlement can also generate tightness in the market. Eventually, however, market participants appear able to adjust to the new source of MBS demand, which alleviates the scarcity effects resulting from Federal Reserve purchases. This could also explain the larger effects observed (per $1 billion) for the beginning of the Reinvestment period, since the announcement of these purchases came as a greater surprise to the market than did the additional purchases associated with QE3.

Thus, it appears that Federal Reserve purchases have negative effects on market functioning early on in purchase programs, but these effects dissipate over time. However, even

[18] Note that the ability to observe statistical significance at any particular point in Figure 7 is restrained by limiting the sample to 90 days.

in the early stages of each purchase regime, point estimates from Figure 7 imply that the average Federal Reserve purchase operation resulted in relatively small effects on IFRs that are swamped by normal daily fluctuations. Nevertheless, it may be the case that the Federal Reserve could lessen the market functioning effects of its MBS purchases by announcing MBS programs well in advance of the start of purchases, or gradually increasing monthly purchase amounts to the desired level. Of course, this strategy would need to be balanced against the policy goal of the QE program, which—especially in light of the modest IFR effects document above—would likely overwhelm any market functioning concerns.

5.2. Trade Sizes

Next, I present a similar analysis for average daily trade sizes by estimating cross-sectional time series regressions analogous to those above, as follows:

$$\Delta \ln(Trade\ Size_{it}) = \beta \times Fed\ \ Purchase_{it} + \chi_t + \alpha + \varepsilon_{it} \tag{3}$$

$$\begin{aligned} \Delta \ln(Trade\ Size_{it}) = {} & (\beta_{\text{Reinv}} \times Fed\ \ Purchase_{it}) D_{\text{Reinv}} + (\beta_{\text{QE3}} \times Fed\ \ Purchase_{it}) D_{\text{QE3}} \\ & + \gamma \Phi_{it} + \chi_t + \alpha + \varepsilon_{it} \end{aligned} \tag{4}$$

In equations (3) and (4), trade sizes are measured excluding Federal Reserve purchases. Furthermore, securities are excluded from the sample on days in which they witnessed less than $200 million in total trading volume in either the prior or current day. The results reported below are not sensitive to the precise threshold used, but applying such a filter ensures that changes in trade sizes are defined and reflect the outcome of regular trading by market participants.

Table 3 presents the estimation results from (3) and (4). The first specification indicates that, all else equal, $1 billion in purchases reduces trade sizes by about 12% from the previous day. Alternate specifications in columns two and three—which separate the effect of purchases for each program—indicate that, as with IFRs, the point estimate is higher for the Reinvestment period. Perhaps counterintuitively, higher daily issuance correlates with lower daily trade sizes. However, securities with coupons that are farther from the current coupon have slightly worse liquidity, as expected.

Figure 8 again plots the coefficient of interest from equation (3) using a random effects estimator for a 90-day rolling regression over the sample period. As with IFRs, the marginal effects of Federal Reserve purchases on liquidity and market functioning were most pronounced after the start of Reinvestment purchases. However, the relatively modest size of purchases during this program (see Table 1) restrains the overall effect. Nevertheless, if the effect of Federal Reserve purchases on trade size accumulates each day, even modest daily purchase amounts can ultimately result in a large reduction in trade sizes. In order to test the persistence of the effect identified in Table 3, I demonstrate that the results from the baseline specification of equation (3) dissipate over time in Figure 9. Figure 9 shows that the cumulative two-day effect of Federal Reserve purchases on trade size is no longer statistically different from zero, and the total effect on the three-day percent change in trade volumes is positive, albeit very imprecisely estimated with zero contained well within the displayed confidence interval. In total, it appears that the effects identified in Table 3 do not persist beyond the day on which trades occur.

Finally, the last two columns of Table 3 include the volume of purchases of near-substitute securities. In these specifications, I include total Federal Reserve purchases of "similar" securities, which I define as those securities that have the same coupon as security *i*,

but a different issuer. For example, total substitute purchases for the Fannie Mae 30-year 3.5% coupon security include the sum of purchases of the Freddie Mac 30-year 3.5% coupon. Although selecting substitute securities is a somewhat ad hoc exercise, this definition is likely to include the most closely related purchases. As indicated in columns four and five of Table 3, substitute purchases have large positive effects on trade sizes. Thus, it appears that Federal Reserve purchases crowd out third party trading activity that then finds an outlet in similar securities. Using average values for *Fed Purchase* and *Substitute Purchase* in each purchase program (conditional on purchase) and multiplying by the coefficient estimates in the last column of Table 3 it is possible to calculate the effect of average daily purchases conducted by the Desk. For the Reinvestment period, the effect average daily purchases resulted in a very small but statistically insignificant *increase* in trade size for the average security. Alternatively, the effect of average purchase operations during QE3 resulted in a (statistically significant) three percent *decrease* in trade sizes for the average security. However, the negative coefficient on *Fed Purchase* in each purchase regime indicates that securities purchased by the Desk do indeed experience adverse liquidity effects as a result.

5.3. Trading Volume

As a further test of the effects of Federal Reserve purchases on liquidity, I relate purchases to daily trading volume by estimating regressions (5) and (6):

$$\Delta \ln(Trade\ Volume_{it}) = \beta \times Fed\ \ Purchase_{it} + \chi_t + \alpha + \varepsilon_{it} \tag{5}$$

$$\Delta \ln(Trade\ Volume_{it}) = (\beta_{\text{Reinv}} \times Fed\ \ Purchase_{it}) D_{\text{Reinv}} + (\beta_{\text{QE3}} \times Fed\ \ Purchase_{it}) D_{\text{QE3}} + \gamma \Phi_{it} + \chi_t + \alpha + \varepsilon_{it} \tag{6}$$

As with the trade size regressions, I exclude Federal Reserve purchases from daily trade volume, and securities are excluded when there was less than $200 million in total trading volume in either the prior or current day.

Table 4 displays regression results using the same specifications as those presented in Table 3. The pattern of results in Table 4 is very similar to the results for trade size, but coefficient estimates on Federal Reserve purchases are, in general, about double the size. Of particular note, the final two specifications exhibits similar evidence of crowding out caused by Federal Reserve purchases, consistent with portfolio balancing effects that cause investors to move into similar securities in response to Federal Reserve purchases. Although the coefficients in Table 4 appear rather large, the estimates from the final specification in Table 4 imply that the net result of average daily Federal Reserve purchases during the Reinvestment period led to only about a two percent increase in trade volume for the average security. Conversely, average QE3 daily purchases resulted in a three to four percent decrease in volume for the average security.

Similar to the analysis in the previous sections, Figure 10 presents the key coefficient from a rolling regression of equation (5). As with average daily trade size, volumes (excluding Federal Reserve purchases) appear to decrease in securities that see purchases by the Federal Reserve. Finally, similar to the results from the previous section, Figure 11 demonstrates the lack of persistence of the effect identified in Table 4. However, the negative coefficient on *Fed Purchase* that persists in Table 4 again indicates adverse liquidity effects of Federal Reserve purchases.

Finally, I note that the large effect on trade volume compared with trade size implies that the number of (non-Federal Reserve) trades was also reduced by Federal Reserve MBS

purchases. Indeed, unreported results confirm the adverse effect of Federal Reserve MBS transactions on the number of daily transactions. Of course, the number of trades in a market can also be used as a measure of liquidity (Fleming, 2003) and thus the effect of Federal Reserve purchases on trades serves as further confirmation of the finding that QE purchases can reduce liquidity conditions for purchased securities.

5.4. Bid-ask spread

As a final test of the effects of Federal Reserve purchases on liquidity, I consider one of the most commonly cited measures of liquidity across asset classes—bid-ask spreads—and estimate the following regressions:

$$\Delta(Bid - Ask_{it}) = \beta \times Fed\ \ Purchase_{it} + \chi_t + \alpha + \varepsilon_{it} \tag{7}$$

$$\begin{aligned}\Delta(Bid - Ask_{it}) = (\beta_{\text{Reinv}} \times Fed\ \ Purchase_{it})D_{\text{Reinv}} + (\beta_{\text{QE3}} \times Fed\ \ Purchase_{it})D_{\text{QE3}} \\ + \gamma\Phi_{it} + \chi_t + \alpha + \varepsilon_{it}\end{aligned} \tag{8}$$

In equations (7) and (8), the dependent variable is the change in the end-of-day composite bid-ask spread as reported by TradeWeb, measured in 32^{nds} of a point (also referred to as "ticks"). Point estimates of the estimation results, presented in Table 5, indicate that during the Reinvestment program, $1 billion of Federal Reserve purchases increased bid-ask spreads by between 0.03 and 0.09 ticks, while the increase during the QE3 period is much smaller at only 0.003 to 0.04 ticks. However, none of these estimates achieves statistical significance in any of the specifications.

In Figure 12, I again plot the results from a rolling regression of the baseline specification, represented by equation (7). The most notable feature of the rolling regression is

the spike in the response of the bid-ask spread to Federal Reserve purchases at the start of the QE3 period.[19] Moreover, rolling regressions reveal statistically significant effects of Federal Reserve purchases in the months following the start of QE3. However, the magnitude of the effect over this time indicates that $1 billion in purchases increased bid-ask spreads by a half of a tick or less. Overall, it appears that there is some evidence that Federal Reserve purchases induced worse liquidity conditions (as measured by bid-ask spreads) after the start of QE3, but the size of the effect was relatively modest and short-lived.

6. Price discovery in the MBS TBA market

The previous section presents evidence that Federal Reserve MBS purchases are associated with worse liquidity and market functioning. Although poor liquidity conditions can lead to higher costs for some market participants, liquidity deterioration would perhaps become most costly if it precipitated impairment in price discovery. Indeed, interference with price discovery in the MBS market could be seen as a possibly substantial cost of QE given the importance of U.S. debt markets to the transmission of monetary policy. For example, if the Federal Reserve wished to put downward pressure on interest rates through a commitment to keep short-term interest rates near zero for an extended period of time, this would normally be reflected in lower MBS yields, which could lead to lower primary mortgage rates. If, however, MBS prices did not fully respond to lower interest rates due to substantial liquidity impairments, primary mortgage rates may not fall as much as they otherwise would, muting the efficacy of monetary policy. Thus, having documented the negative liquidity effects of Federal Reserve

[19] This result is not driven by outliers. Removing bid-ask changes that are in the top 1% of the sample in absolute value yields nearly identical results.

MBS purchases in the previous section, this section examines the evolution of price discovery in the MBS market during the course of QE purchases.

As an initial test of MBS price discovery, I first estimate a standard vector autoregression of the following form:

$$y_t = \alpha + \sum_{i=1}^{3} \beta_i y_{t-i} + \varepsilon_t \tag{9}$$

where y_t is a vector consisting of the daily change in the 5-year Treasury yield and the percentage change in the price of the Fannie Mae 30-year 3.5% coupon TBA security, which was regularly traded throughout the sample period.[20] If price discovery diminished during ongoing Federal Reserve QE purchases, impulse response functions (IRFs) of MBS prices to shocks in the 5-year Treasury yield could become more drawn out over time, indicating that MBS prices take more time to reflect changes in Treasury yields. Several earlier studies have noted the potential that price discovery in fixed income markets could extend to a period beyond a single day. For example, Joyce et al. (2011) use a two-day window for their event study analysis, and Krishnamurthy and Vissing-Jorgensen (2011) note that prices of assets may react more slowly during a period of low liquidity. Thus, if liquidity conditions deteriorate sufficiently, MBS prices could take more time to reflect changes evident in the more liquid U.S. Treasury market.

In Figure 12, I plot Cholesky orthogonalized IRFs from the estimation of equation (9) for several different sample periods. The first sample period—shown in panel A—limits the sample to the 18-month period after the completion of QE1 MBS purchases but prior to the initiation of the MBS purchases under the Reinvestment program. During this time, a five basis point shock

[20] All of the analysis and conclusions of this section hold if the change in the Fannie Mae 30-year current coupon is used in place of the price change of the 3.5% TBA contract.

to the 5-year Treasury yield resulted in a contemporaneous decline in the price of the Fannie Mae 3.5% coupon security of approximately 30 basis points. The IRFs estimated over the Reinvestment and QE3 sub-periods are presented in panels B and C, respectively, and demonstrate a very similar pattern. However, in contrast to the pre-QE period, the point estimate of the MBS price change for the second day after the shock to the 5-year Treasury yield remains negative during MBS QE purchase periods. Furthermore, the MBS price response three days after the shock is positive and statistically significant during Reinvestment, though only marginally so. Ultimately, these differences appear relatively minor if not statistically insignificant, and the IRFs estimated across sub-samples do not indicate worsening price discovery in the MBS market during Federal Reserve MBS purchases.

As a second test of price discovery during Federal Reserve MBS market intervention, I estimate a time series regression in which I regress price changes in the Fannie Mae 3.5% coupon on an economic surprise index:

$$\Delta \ln(\text{Price}_t) = \alpha + \beta \times \text{Economic Surprise Index}_t + \phi \times \text{Economic Surprise Index}_{t-1} + \varepsilon_t \qquad (10)$$

Similar to the previous exercise, I estimate equation (10) for sample periods corresponding to the pre-QE, Reinvestment, and QE3 periods. If the response of MBS prices to economic surprises changed dramatically during the course of the Federal Reserve's MBS purchases, this could indicate impairment in price discovery. In particular, if the lagged value of the economic surprise index does not load in the pre-QE period, but does produce significant explanatory power for MBS price changes during QE purchases, weakened price discovery may be inferred.

To construct an index of economic surprises, I compare regular economic releases with the median expectation from a Bloomberg survey of economic forecasters. Mathematically, I compute the economic surprise index as follows:

$$\text{Economic Surprise Index}_t = \sum_j \frac{v_{jt} - \tilde{x}_{jt}}{\sigma_{jt}} \tag{11}$$

where v represents the initial print of economic indicator j, $\tilde{x}$ is the median forecast from a survey conducted by Bloomberg, and σ is the standard deviation of the survey forecasts. As indicated by the summation operator, the standardized economic surprises of different economic indicators are added together on days in which more than one release occurs. I use five monthly economic indicators to construct the economic surprise index: nonfarm payrolls, retail sales, industrial production, personal income, and personal spending. Thus, the economic surprise index takes a value of zero for days in which none of the aforementioned indicators were released, and a value equal to the standardized surprise for days on which releases occur.

Table 6 reports the results from estimating equation (10) over the pre-QE, Reinvestment, and QE3 sub-periods. The estimates shown in the first column of each time period demonstrate that MBS prices responded to economic surprises with the expected sign in all three sub-periods. Although the strength of the response was slightly weaker during the Reinvestment period, lagged economic surprises were not related to MBS price changes in any of the three regimes.

To demonstrate how MBS prices responded to economic indicators individually, I decompose the economic surprise index into its individual components, and report the results in the second column beneath each time period. Perhaps predictably, surprises in nonfarm payrolls are significant in each sub-period. Moreover, surprises in retail sales—another important and

timely economic indicator—also appear to influence MBS prices. However, the strength of the price response to retail sales surprises weakened during the Reinvestment period compared with the pre-QE period, and (though the point estimate was similar to the Reinvestment period) failed to achieve conventional levels of statistical significance during QE3 purchases. The insignificance of retail sales and the stronger response to nonfarm payroll surprises during QE3 could indicate a shift in focus by market participants during this period. This explanation seems plausible in light of the FOMC's explicit commitment to tie QE3 purchases to the outlook for employment.

Overall, the evidence presented in this section suggests that there is little, if any, indication that price discovery in the MBS market was affected by ongoing Federal Reserve purchases.

7. Conclusions

As has become evident in more recent debates surrounding QE, rigorous analyses of the potential costs of large-scale asset purchases is required if central banks are to rely on these programs to achieve their mandates in the future. Indeed, an assessment of the potential costs associated with QE can be an important input into the decision to cease or begin these programs. For example, since the global financial system relies on deep and liquid markets for U.S. debt securities, liquidity impairment can be tremendously costly. Moreover, sufficiently large disruptions in price discovery could potentially impede the transmission of monetary policy. Thus, empirical evaluations of the effect of QE on market functioning, liquidity, and price discover are required for policymakers to make informed decisions regarding the use of ongoing asset purchases. Unfortunately, though, the effect of central bank purchases on market liquidity

in normal environments is not theoretically clear, and studies examining the potential costs of QE are scarce.

This paper attempts to help fill this gap in the literature. I show that Federal Reserve MBS purchases since 2011 have led to deterioration in measures of liquidity and market functioning, particularly in the months after the commencement of a new purchase program. Measures of collateral scarcity, trade sizes, and trade volumes all showed notable declines that were contemporaneous with Federal Reserve purchases. Similarly, bid-ask spreads appear to have briefly widened as a result of Federal Reserve purchases shortly after QE3 purchases began. However, the magnitude of liquidity and market functioning effects of Federal Reserve purchases—conditional on Desk operating policy—appear to be quite modest. Furthermore, the influence of Federal Reserve purchases on implied financing rates and bid-ask spreads disappeared entirely a few quarters after the start of the Reinvestment program and/or QE3. In total, it appears that Federal Reserve QE purchases have noticeable effects on market functioning, but these effects appear to be relatively modest in size, short-lived, or both. Moreover, I demonstrate that the liquidity-impairing effects of Federal Reserve MBS purchases did not translate into a deterioration of price discovery in the MBS TBA market. Throughout the ongoing QE programs, MBS prices responded normally to both surprises in economic indicators and shocks to U.S. Treasury yields, suggesting that the costs of regular QE purchases were not large.

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Figure 1. Daily Federal Reserve MBS purchases (Oct. 3, 2011 – Feb. 20, 2014)

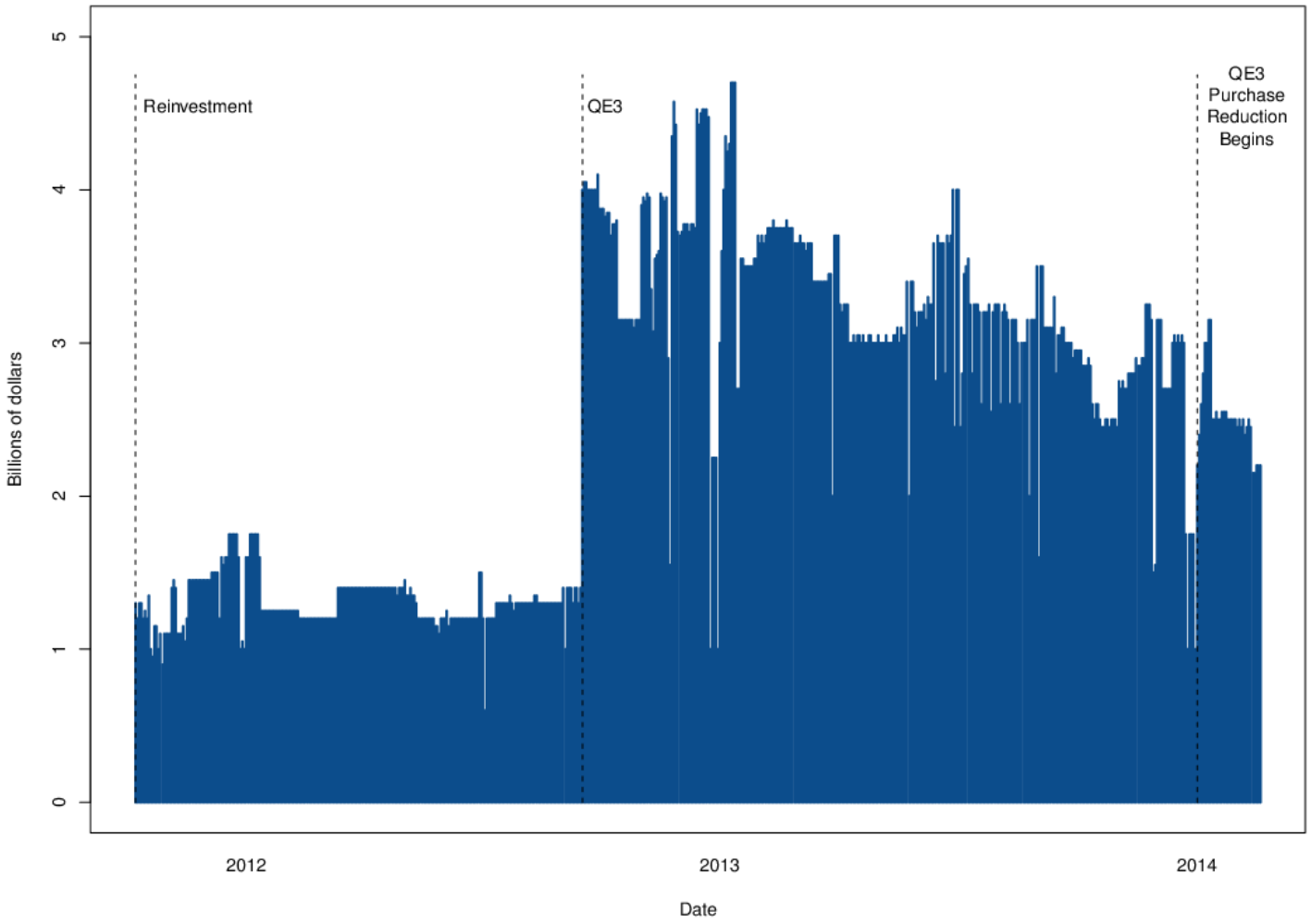


Figure 2. Timeline of a hypothetical dollar roll transaction.

Notes: A TBA dollar roll transaction occurs on October 1, at which point no funds are exchanged. At the time of the trade, the roll seller can calculate the rate at which funds received in the front month can be invested—the so-called implied financing rate "IFR"—that will generate the same expected return as simply holding the MBS between October 14 and November 13.

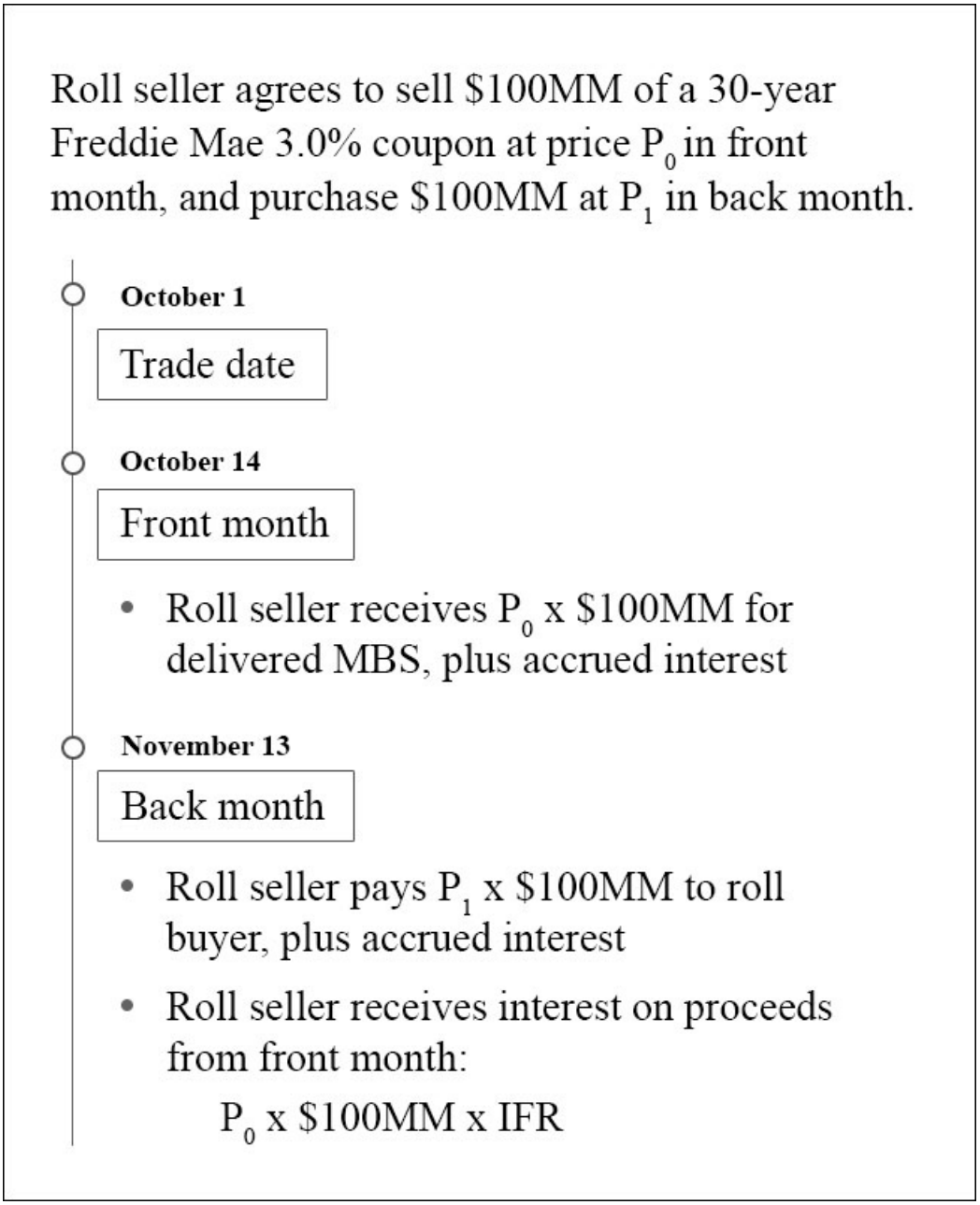


Figure 3. Implied financing rates for Fannie Mae and Freddie Mac 30-year 3.5% coupon TBA securities

Notes: Implied financing rates are calculated by J.P. Morgan using a model for conditional prepayment rates on TBA securities. IFRs trading well below prevailing short-term interest rates can indicate scarcity of deliverable collateral.

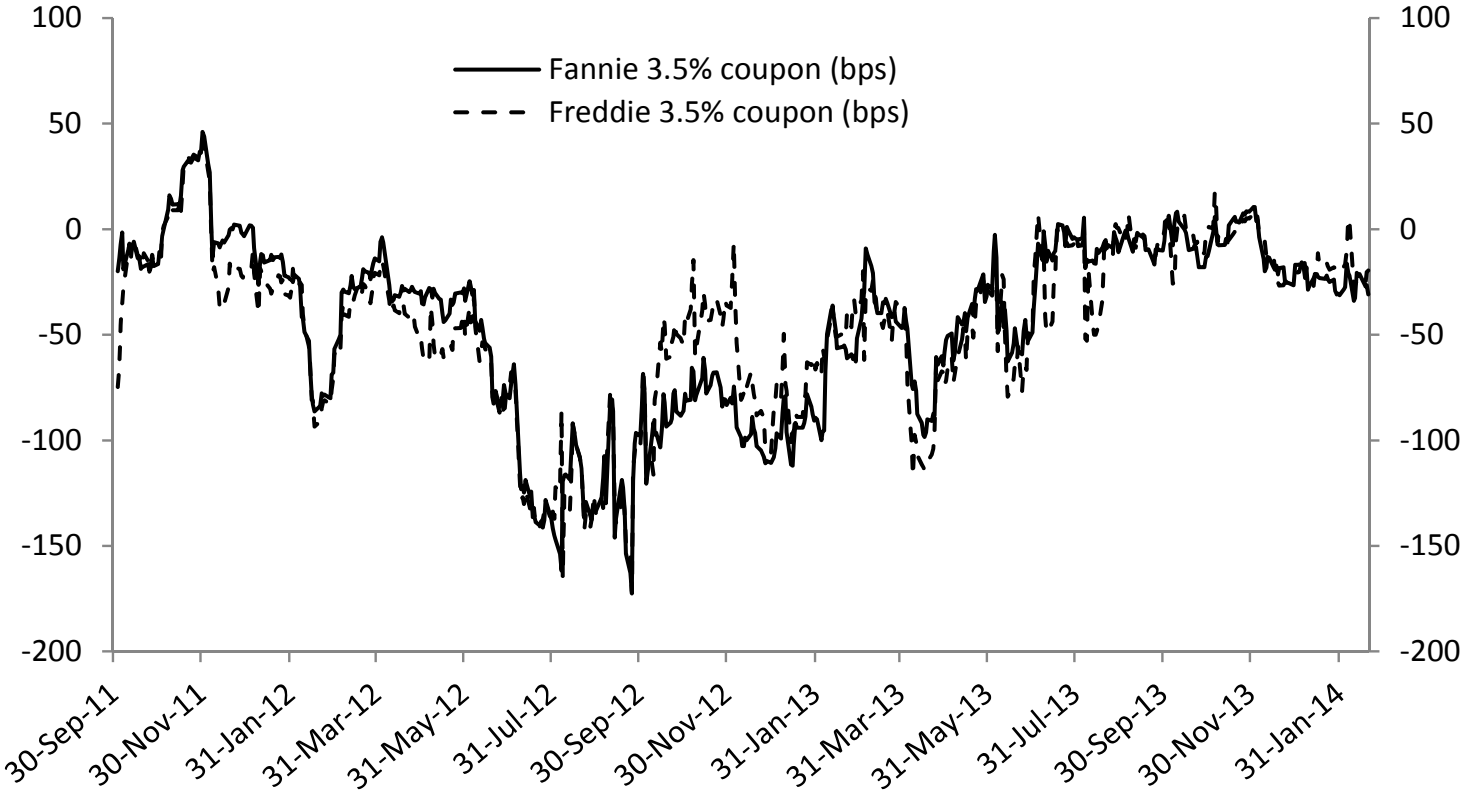


Figure 4. 20-day moving average of trade sizes for Fannie Mae and Freddie Mac 30-year 3.5% coupon TBA securities

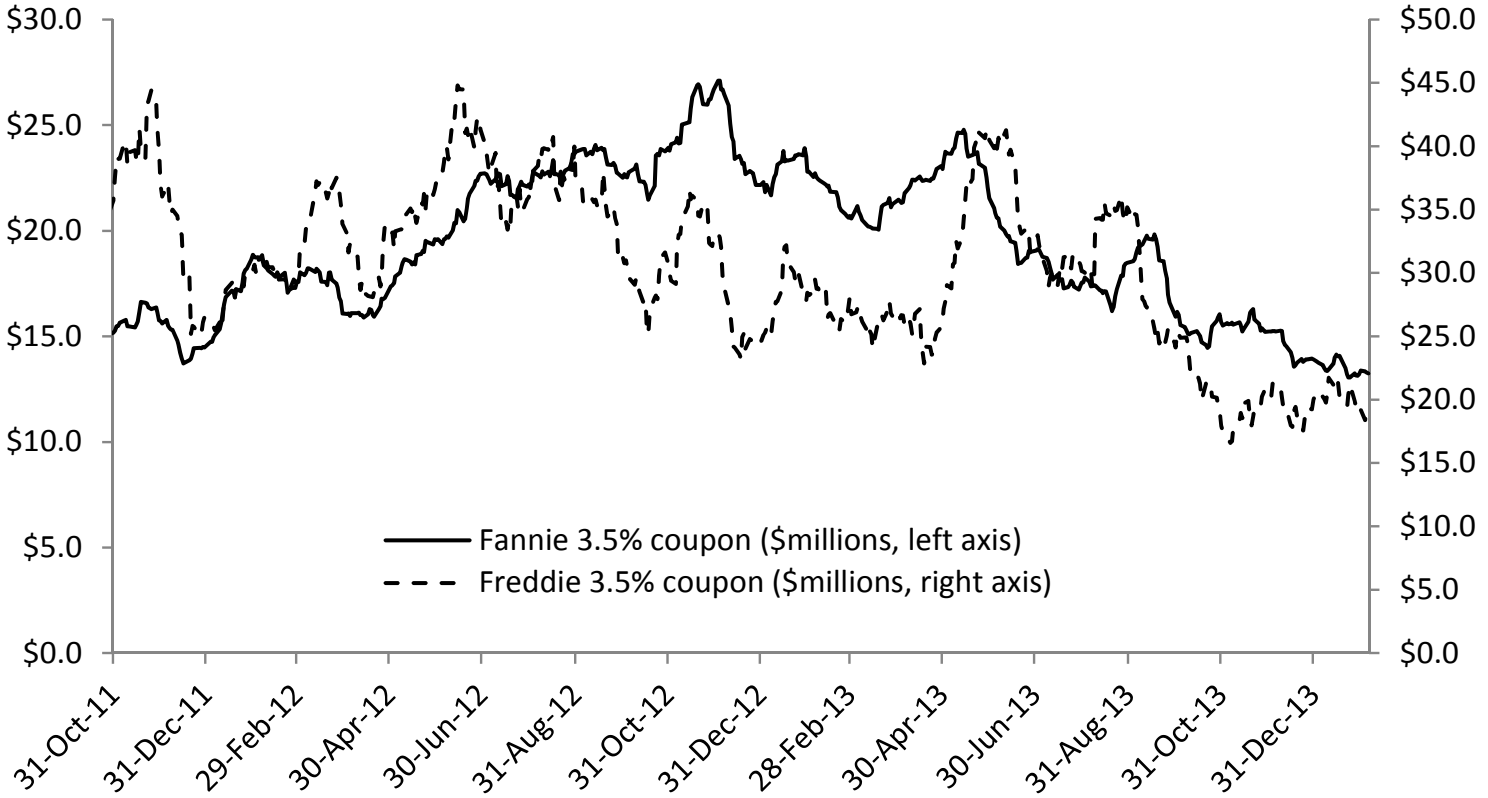


Figure 5. 20-day moving average of trading volume for Fannie Mae and Freddie Mac 30-year 3.5% coupon TBA securities

Notes: 20-day moving averages of trading volumes are reported to smooth through the TBA settlement cycle.

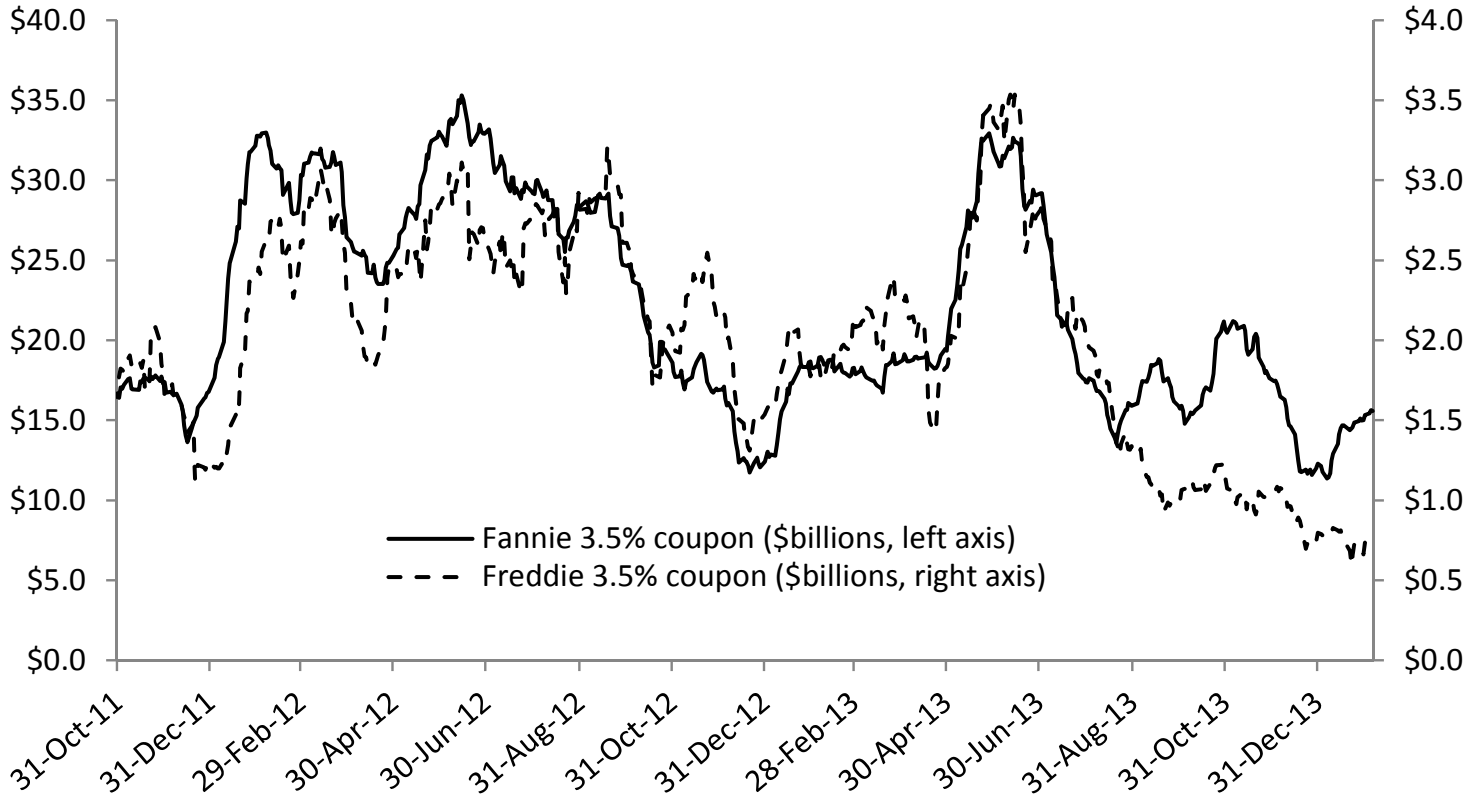


Figure 6. TradeWeb daily composite indicative bid/ask spreads (in ticks) for Fannie Mae and Freddie Mac 30-year 3.5% coupon TBA securities

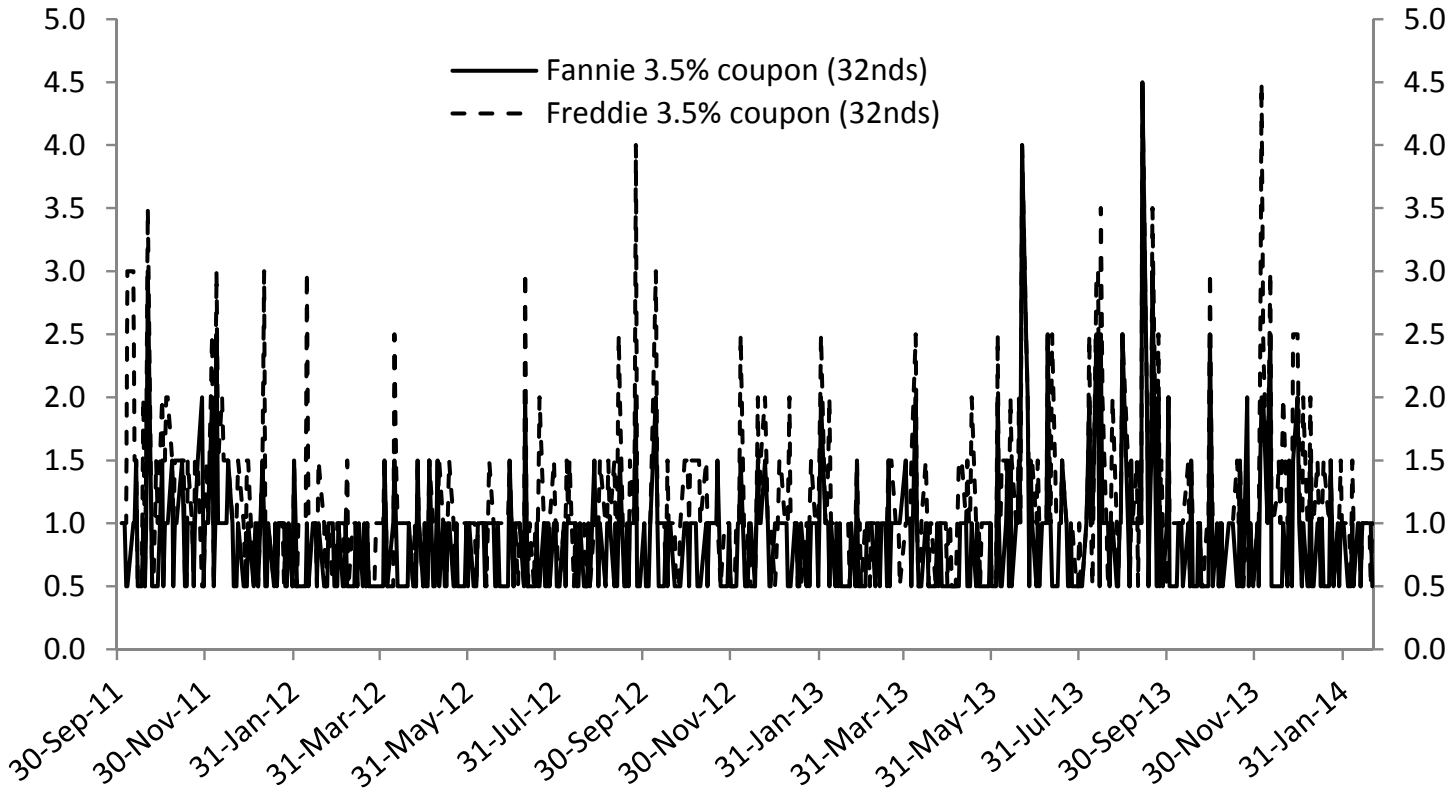


Figure 7. Rolling regression—the effect of Federal Reserve purchases on implied financing rates

Notes: This graph plots the coefficient on the *Fed Purchase* variable in equation (1) from a rolling regression. The rolling window is 90 days, and is re-estimated in ten-day increments using a random effects estimator. The final day of the rolling window is listed on the horizontal axis. Points to the right of the "QE3" line include purchases that occurred during the QE3 program. The value on the vertical axis can be interpreted as the basis point change in a security's IFR as a result of a $1 billion purchase by the Federal Reserve.

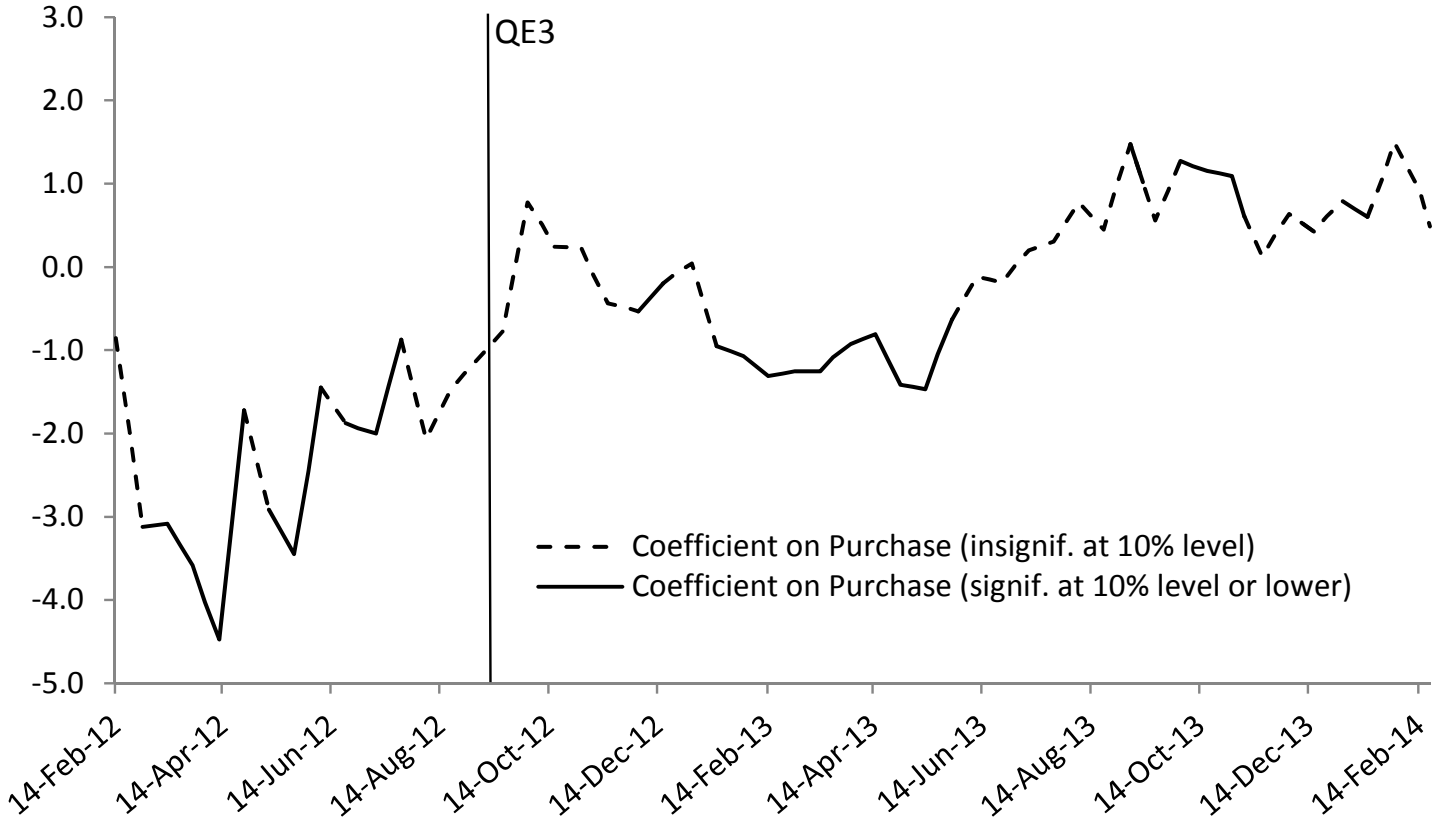


Figure 8. Rolling regression—the effect of Federal Reserve purchases on trade size

Notes: This graph plots the coefficient on the *Fed Purchase* variable in equation (3) from a rolling regression. The rolling window is 90 days, and is re-estimated in ten-day increments using a random effects estimator. The final day of the rolling window is listed on the horizontal axis. Points to the right of the "QE3" line include purchases that occurred during the QE3 program. The value on the vertical axis can be interpreted as the percent change in a security's trade size as a result of a $1 billion purchase by the Federal Reserve.

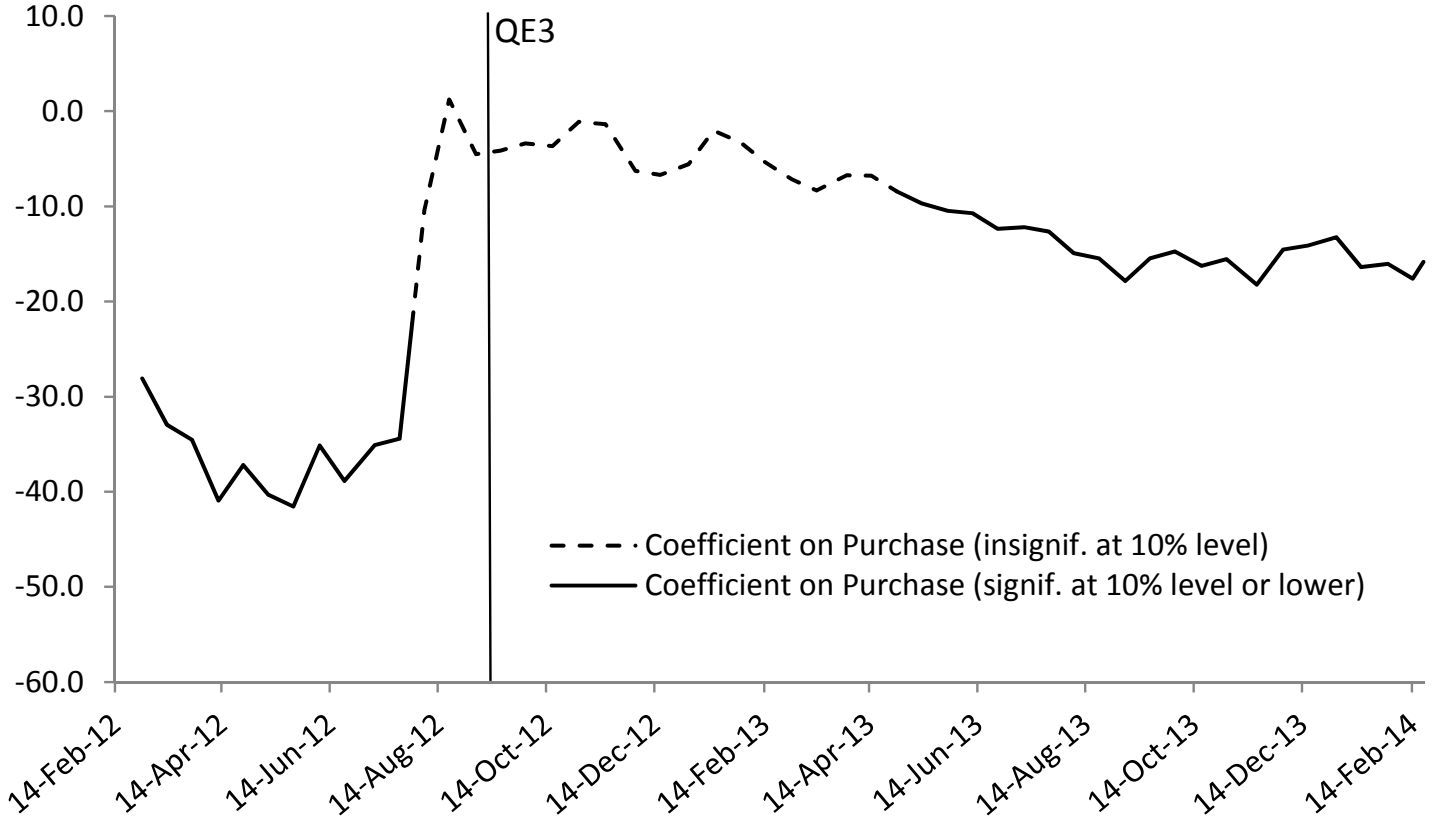


Figure 9. Evaluating the persistence of the effect of Federal Reserve purchases on trade size

Notes: This figure plots the coefficient on *Fed Purchase* from the first specification in Table 3. The first point corresponds to the estimate provided in the table. The second point (*Day t+1*) reports the coefficient from the same regression, with a dependent variable (percent change in trade size) calculated over a two-day window. Similarly, the last point is produced from a regression of the three-day percent change in trade size on *Fed Purchase* and a full set of time fixed effects. Since future purchases may be correlated with purchases on day *t*, the multi-day horizon regressions also include the amount of the security purchased during the horizon.

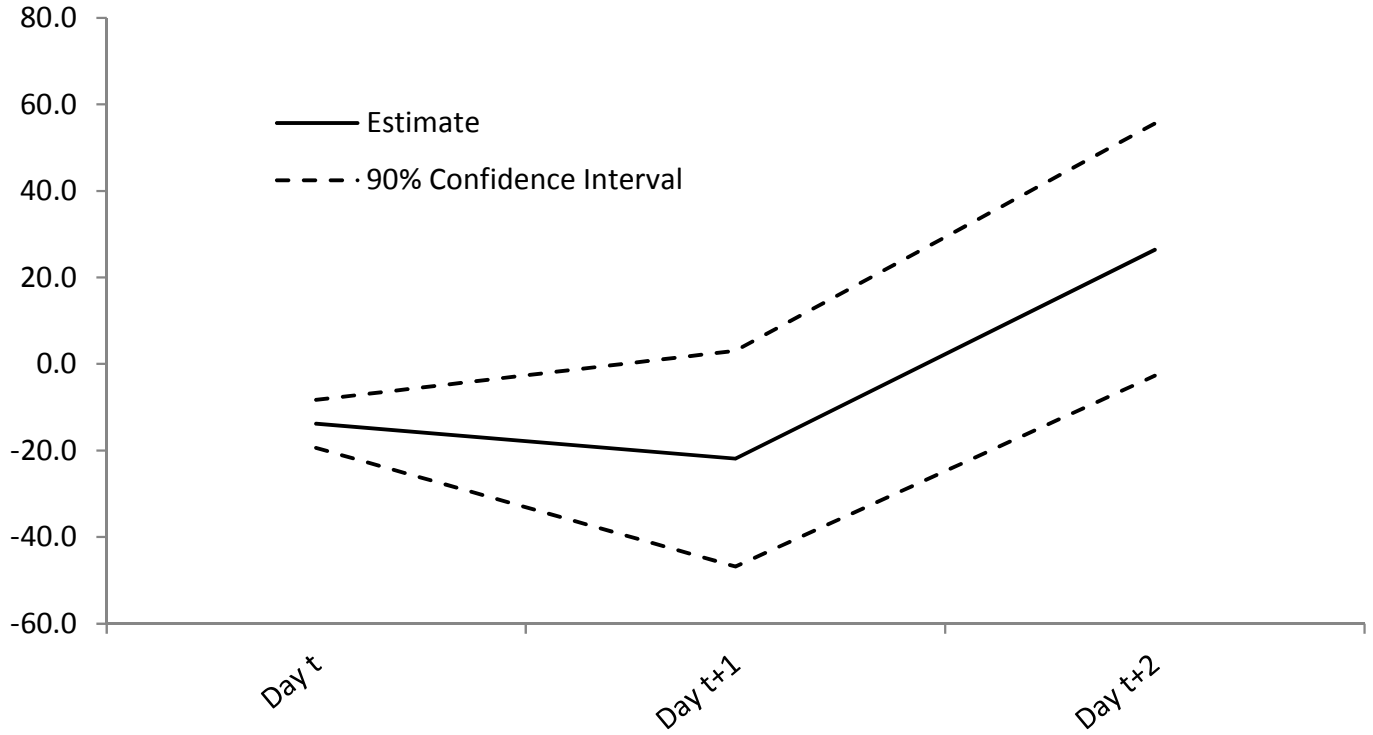
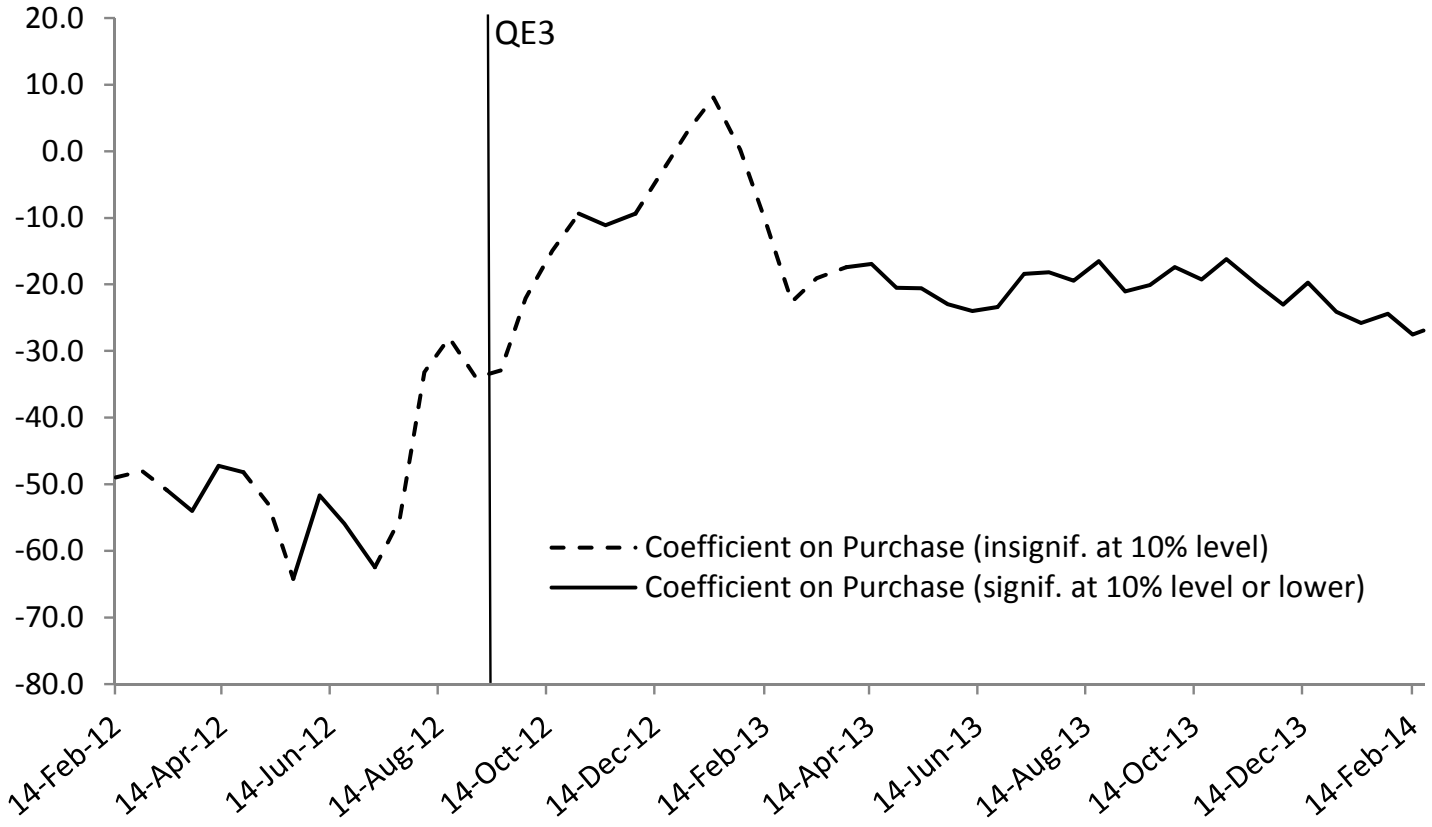


Figure 10. Rolling regression—the effect of Federal Reserve purchases on trade volume

Notes: This graph plots the coefficient on the *Fed Purchase* variable in equation (5) from a rolling regression. The rolling window is 90 days, and is re-estimated in ten-day increments using a random effects estimator. The final day of the rolling window is listed on the horizontal axis. Points to the right of the "QE3" line include purchases that occurred during the QE3 program. The value on the vertical axis can be interpreted as the percent change in a security's daily trading volume as a result of a $1 billion purchase by the Federal Reserve.



<u>Figure 11</u>. Evaluating the persistence of the effect of Federal Reserve purchases on trade volume

Notes: This figure plots the coefficient on *Fed Purchase* from the first specification in Table 4. The first point corresponds to the estimate provided in the table. The second point (*Day t+1*) reports the coefficient from the same regression, with a dependent variable (percent change in trade volume) calculated over a two-day window. Similarly, the last point is produced from a regression of the three-day percent change in trade volume on *Fed Purchase* and a full set of time fixed effects. Since future purchases may be correlated with purchases on day *t*, the multi-day horizon regressions also include the amount of the security purchased during the horizon.

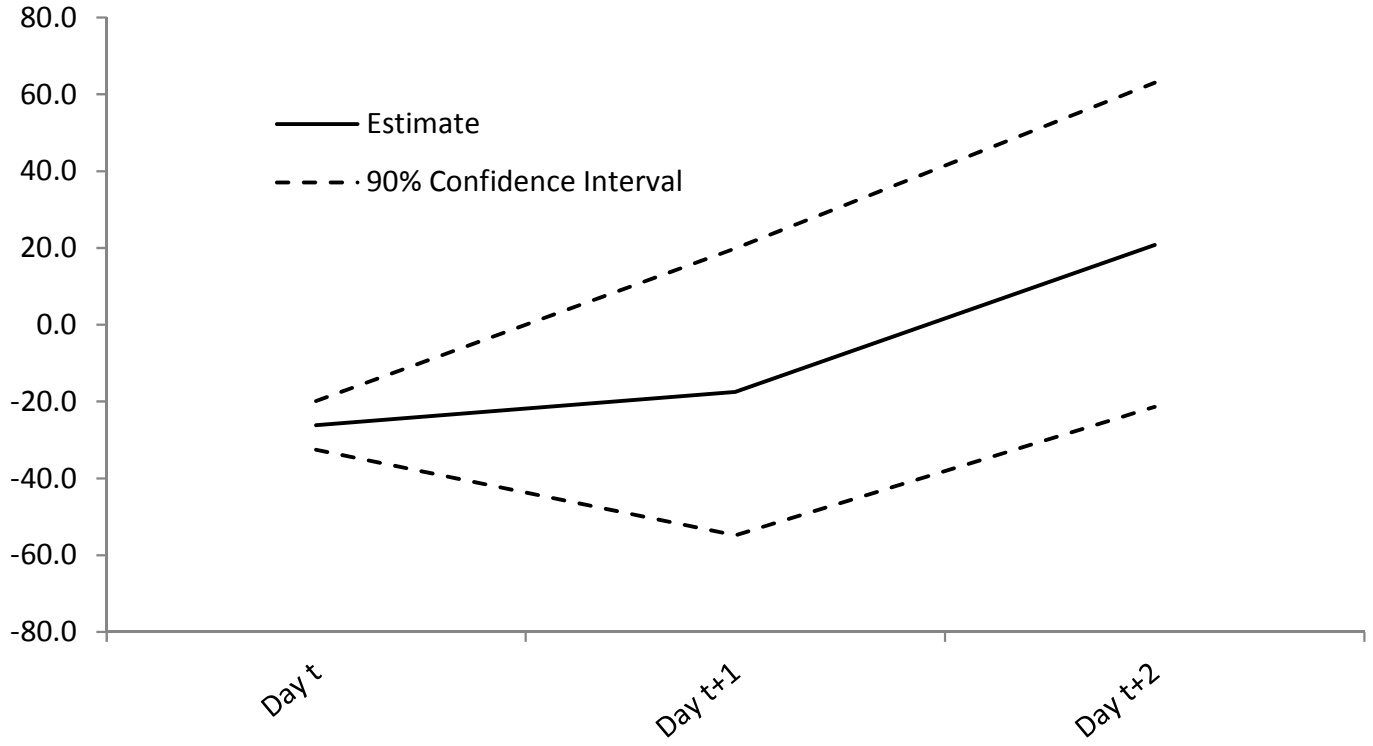


Figure 12. Rolling regression—the effect of Federal Reserve purchases on bid-ask spreads

Notes: This graph plots the coefficient on the *Fed Purchase* variable in equation (7) from a rolling regression. The rolling window is 90 days, and is re-estimated in ten-day increments using a random effects estimator. The final day of the rolling window is listed on the horizontal axis. Points to the right of the "QE3" line include purchases that occurred during the QE3 program. The value on the vertical axis can be interpreted as the change (in ticks) in a security's bid/ask spread as a result of a $1 billion purchase by the Federal Reserve.

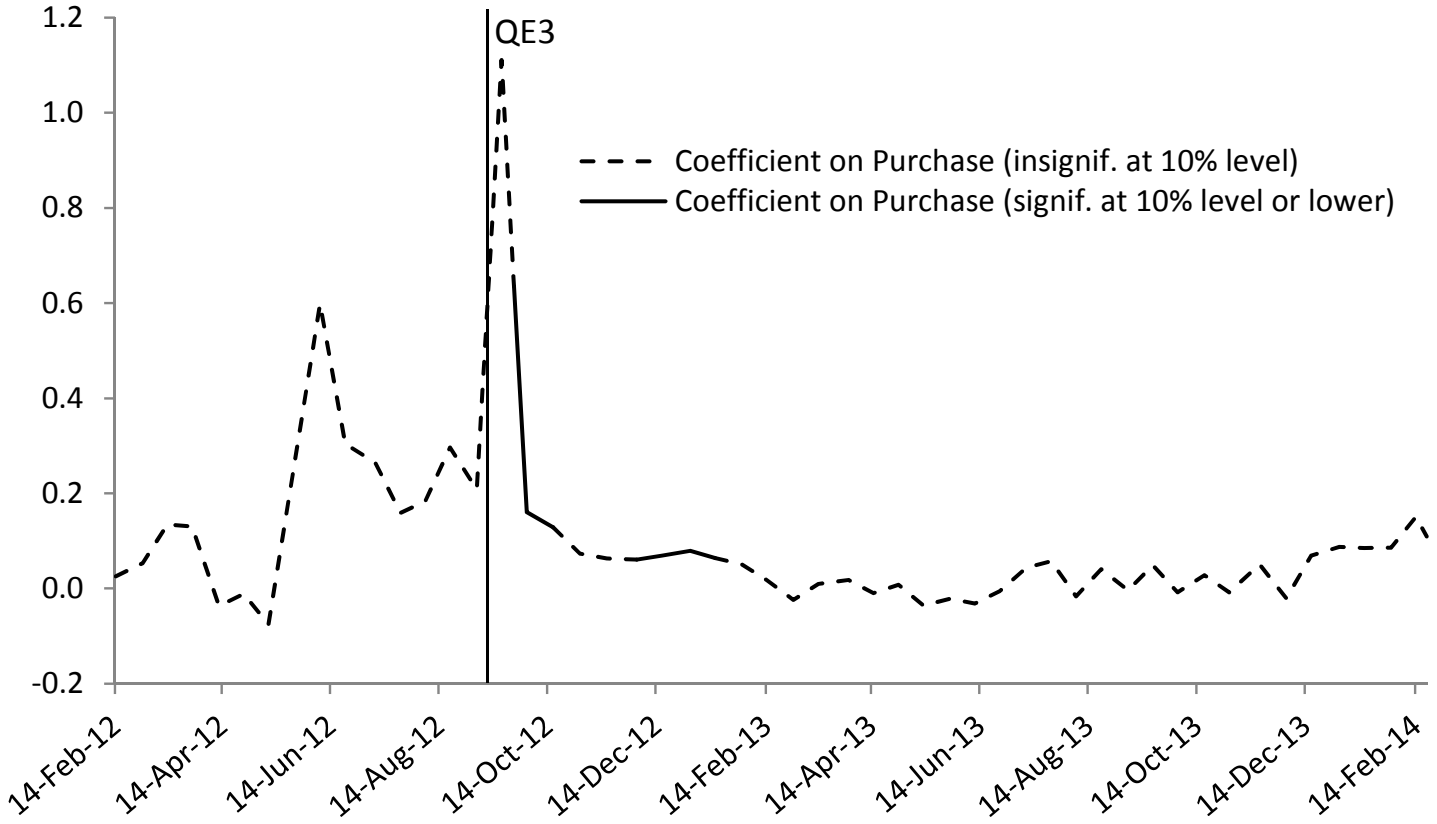


Figure 13. Impulse responses of MBS prices to a shock to the 5-year Treasury yield

Notes: Each panel plots a one week impulse response function for the percent change in price of the Fannie Mae 3.5% coupon to an orthogonalized five basis point shock to the 5-year U.S. Treasury yield. Each panel corresponds to a different estimation period, as indicated. Vertical axes are in percent.

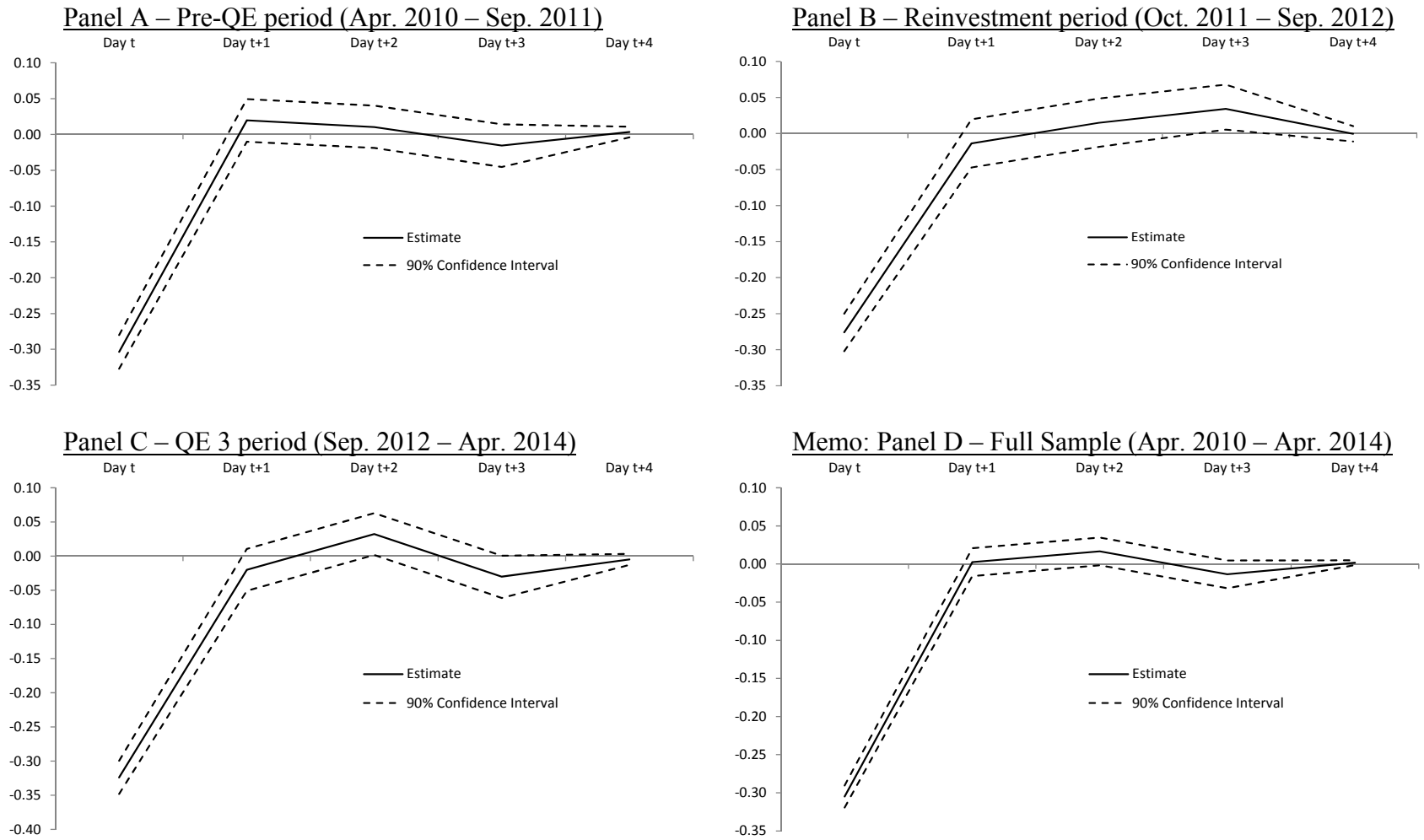


Table 1. Summary of Federal Reserve MBS purchases under Reinvestment and QE3

Notes: The Reinvestment period includes purchases from Oct. 3, 2011 through Sep. 13, 2012. The QE3 period begins Sep. 14, 2012 and continues through Feb. 20, 2014. The total face value purchased during QE3 includes those purchases that occurred as a result of the practice of reinvesting principal payments from agency securities into agency MBS.

	Reinvestment	QE3	Full Sample
Agency Distribution			
Fannie Mae	55.3%	51.8%	52.5%
Freddie Mac	29.1%	26.8%	27.3%
Ginnie Mae	15.6%	21.5%	20.2%
Term Distribution			
30-year	89.9%	83.2%	84.7%
15-year	10.1%	16.8%	15.3%
Coupon Distribution			
2.0	-	1.3%	1.0%
2.5	3.1%	11.0%	9.3%
3.0	19.0%	43.5%	38.2%
3.5	57.0%	23.2%	30.4%
4.0	20.9%	19.5%	19.8%
4.5	-	1.5%	1.2%
Other Operational Details			
Total face value purchased ($bil.)	306.1	1,128.7	1,434.8
Avg. daily purchase amount ($bil.)	1.3	3.2	2.4
Avg. # of trades per day	8.6	19.1	14.9
Avg. daily purchase per trade ($mil.)	152.6	166.3	163.1
Avg. # of securities purchased per day	6.8	10.6	9.1
Avg. daily purchase per security ($mil.)	195.6	303.5	260.7

Table 2. The effect of Federal Reserve purchases on implied financing rates

Notes: The dependent variable in all specifications is the change in the IFR for each security in the sample, measured in basis points. *Fed Purchase* represents total daily Federal Reserve purchases of each security, measured in billions. *Reinvestment* and *QE3* dummies take a value of one for each day in the associated purchase program. *Issuance* measures the reported daily issuance of each security in billions, and *Distance to Current Coupon* is the absolute value of the difference between each security's coupon and the daily current coupon for the relevant agency, measured in percentage points.

	(1)	(2)	(3)	(4)
Fed Purchase	-0.07			
	(0.46)			
Fed Purchase*Reinvestment		-1.15	-1.07	-1.07
		(1.28)	*(1.33)*	*(1.33)*
Fed Purchase*QE3		0.03	0.08	0.12
		(0.48)	*(0.52)*	*(0.50)*
Issuance			-0.04	-0.04
			(0.17)	*(0.17)*
Distance to Current Coupon				0.60
				(3.72)
Observations	4,972	4,972	4,972	4,972
Securities	10	10	10	10
R-squared	0.340	0.340	0.340	0.341

Table 3. The effect of Federal Reserve purchases on trade size

Notes: The dependent variable in all specifications is the percent change in the average daily trade size for each security in the sample, excluding Federal Reserve purchases. *Fed Purchase* represents total daily Federal Reserve purchases of each security, measured in billions. *Reinvestment* and *QE3* dummies take a value of one for each day in the associated purchase program. *Issuance* measures the reported daily issuance of each security in billions, and *Distance to Current Coupon* is the absolute value of the difference between each security's coupon and the daily current coupon for the relevant agency, measured in percentage points. For each security, *Substitute Purchase* measures the sum of Federal Reserve purchases of MBS that have the same coupon but a different issuer. All specifications include day fixed effects, and a suppressed constant.

	(1)	(2)	(3)	(4)	(5)
Fed Purchase	-11.8***				
	(2.32)				
Fed Purchase*Reinvestment		-19.8**	-21.3***	-38.7***	-37.1***
		(7.60)	*(7.88)*	*(7.71)*	*(8.11)*
Fed Purchase*QE3		-11.2***	-14.0***	-23.9***	-23.8***
		(2.43)	*(2.91)*	*(3.08)*	*(3.31)*
Issuance			-2.22**		-2.36**
			(1.14)		*(1.16)*
Distance to Current Coupon			-0.08***		-0.05**
			(0.02)		*(0.02)*
Substitute Purchase*Reinvestment				50.8***	47.99***
				(11.73)	*(11.66)*
Substitute Purchase*QE3				18.2***	16.5***
				(4.99)	*(5.17)*
Observations	3,824	3,824	3,824	3,824	3,824
Securities	9	9	9	9	9
R-squared	0.194	0.194	0.197	0.200	0.201

Table 4. The effect of Federal Reserve purchases on trade volume

Notes: The dependent variable in all specifications is the percent change in the daily trade volume for each security in the sample, excluding Federal Reserve purchases. *Fed Purchase* represents total daily Federal Reserve purchases of each security, measured in billions. *Reinvestment* and *QE3* dummies take a value of one for each day in the associated purchase program. *Issuance* measures the reported daily issuance of each security in billions, and *Distance to Current Coupon* is the absolute value of the difference between each security's coupon and the daily current coupon for the relevant agency, measured in percentage points. For each security, *Substitute Purchase* measures the sum of Federal Reserve purchases of MBS that have the same coupon but a different issuer. All specifications include day fixed effects, and a suppressed constant.

	(1)	(2)	(3)	(4)	(5)
Fed Purchase	-22.3***				
	(3.43)				
Fed Purchase*Reinvestment		-49.6***	-49.6***	-87.4***	-82.8***
		(12.75)	*(12.8)*	*(13.34)*	*(13.6)*
Fed Purchase*QE3		-20.3***	-20.3***	-52.8***	-51.2***
		(3.56)	*(3.6)*	*(4.74)*	*(4.99)*
Issuance			-3.69**		
			(1.65)		
Distance to Current Coupon			-0.12***		
			(0.03)		
Substitute Purchase*Reinvestment				101.8***	98.5***
				(17.4)	*(17.2)*
Substitute Purchase*QE3				46.7***	44.9***
				(7.55)	*(7.72)*
Observations	3,824	3,824	3,824	3,824	3,824
Securities	9	9	9	9	9
R-squared	0.345	0.346	0.348	0.356	0.357

Table 5. The effect of Federal Reserve purchases on bid-ask spreads

Notes: The dependent variable in all specifications is the change in the end-of-day composite bid-ask spread as reported by TradeWeb. *Fed Purchase* represents total daily Federal Reserve purchases of each security, measured in billions. *Reinvestment* and *QE3* dummies take a value of one for each day in the associated purchase program. *Issuance* measures the reported daily issuance of each security in billions, and *Distance to Current Coupon* is the absolute value of the difference between each security's coupon and the daily current coupon for the relevant agency, measured in percentage points. All specifications include day fixed effects, and a suppressed constant.

	(1)	(2)	(3)	(4)
Fed Purchase	0.043			
	(0.083)			
Fed Purchase*Reinvestment		0.088	0.025	0.027
		(0.189)	*(0.198)*	*(0.197)*
Fed Purchase*QE3		0.039	0.003	0.017
		(0.089)	*(0.090)*	*(0.122)*
Issuance			0.032	0.032
			(0.026)	*(0.026)*
Distance to Current Coupon				0.000
				(0.001)
Observations	4,778	4,778	4,778	4,778
Securities	10	10	10	10
R-squared	0.191	0.191	0.191	0.191

Table 6. The effect of surprises in economic indicators on MBS prices

Notes: The dependent variable in all specifications is the percent change in the price of the Fannie Mae 3.5 percent coupon security. *Economic Surprise Index* is calculated by differencing the announced value of an economic indicator from the median expected forecast from a Bloomberg survey, and dividing by the standard deviation of the survey responses. The individual components of the index are reported in additional rows of the table.

	Pre-QE (Apr. '10 - Sep. '11)		Reinvestment (Oct. '11 - Sep. '12)		QE 3 (Sep. '12 - Apr. '14)		Memo: Full Sample (Apr. '10 - Apr. '14)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Economic Surprise Index$_t$	-0.078***		-0.056***		-0.070***		-0.070***	
	(0.027)		*(0.018)*		*(0.018)*		*(0.013)*	
Economic Surprise Index$_{t-1}$	-0.013		0.002		0.001		-0.004	
	(0.027)		*(0.018)*		*(0.018)*		*(0.013)*	
Nonfarm Payroll Surprise		-0.080*		-0.115***		-0.217***		-0.134***
		(0.045)		*(0.029)*		*(0.033)*		*(0.022)*
Retail Sales Surprise		-0.173**		-0.078*		-0.076		-0.112***
		(0.070)		*(0.041)*		*(0.048)*		*(0.033)*
Industrial Production Surprise		-0.020		0.019		-0.008		-0.08
		(0.056)		*(0.041)*		*(0.037)*		*(0.027)*
Personal Income Surprise		-0.144		0.026		0.005		-0.029
		(0.092)		*(0.058)*		*(0.036)*		*(0.033)*
Personal Spending Surprise		-0.024		0.014		0.057		0.000
		(0.070)		*(0.056)*		*(0.054)*		*(0.037)*
Observations	378	378	239	239	404	404	1,021	1,021
Adjusted R-squared	0.017	0.032	0.030	0.060	0.031	0.105	0.028	0.042
Durbin-Watson statistic	2.16	2.15	1.92	1.94	1.97	1.98	2.09	2.08