Expectations about the Federal Reserve's Balance Sheet and the Term Structure of Interest Rates[1]

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Abstract

This paper provides a systematic assessment of the effect of the Federal Reserve's asset purchase programs on Treasury yields, with particular emphasis on the role of market expectations of the Federal Reserve's balance sheet and of interest rates on the impact of the programs. We construct measures of such market expectations based on Blue Chip survey forecasts, Congressional Budget Office projections, and information from formal FOMC communications. Those measures are combined with a no-arbitrage term structure model, in which yields are driven by current and expected future private Treasury holdings, among other factors. This approach allows us to provide estimates of the term premium effects of the asset programs both at the time of the announcements and in the future as expectations about the economy and the Federal Reserve's balance sheet gradually evolve. We find the program with the largest initial impact on the ten year Treasury yield was the first purchase program, which held down rates by about 40 basis points in early 2009, and the maturity extension program had the second largest impact at its implementation, pushing rates down by about 20 basis points in 2011. Currently, all programs combined are holding down the 10-year yield by about 50 basis points, of which about half is attributable to the first purchase program.

Keywords: Balance Sheet Projections, Term Structure of Interest Rates, Supply Effects; Treasury Yields; Large-Scale Asset Purchases (LSAP); Survey Forecasts

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[1] The opinions expressed in this paper are those of the authors and do not necessarily reflect views of the Federal Reserve Board or the Federal Reserve System. All errors are our own.

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1 Introduction

Through the financial crisis and subsequent recession, the Federal Reserve introduced unconventional monetary policy actions in order to "promote a stronger pace of economic recovery" and to help ensure that "inflation, over time, is at levels consistent with its mandate."[3] To this end, the Federal Reserve embarked on a number of asset programs to purchase, sell, or reinvest securities that dramatically changed the Federal Reserve's securities holdings across all dimensions – size, composition, and maturity structure. Each asset program was implemented in part to put downward pressure on longer-term interest rates, aimed to support a stronger recovery.

But how much did these asset programs affect longer-term interest rates? There is a growing body of work on this subject, which can be divided into three broad categories. The first strand of research depends on event study methodology to determine the effect of the asset programs on interest rates.[4] The second uses reduced-form regression analysis (either in a time series or using panel methods) to evaluate the effect of Federal Reserve purchases on interest rates over time.[5] Finally, the third strand incorporates changes in the net supply of different assets into a structural model of the economy or the yield curve.[6] The dynamic nature of this third type of model allows one to incorporate information not only about the current level of System Open Market Account (SOMA) holdings, but also their expected future path. In this paper, we take the third approach.

Most studies mentioned above model the Federal Reserve's asset purchases and sales as either occurring instantly or spread out evenly over time. In reality, the purchases and sales were announced ahead of time, followed a pre-determined time table, and were commonly expected to be unwound at a future point of time, resulting in expected changes not only to the contemporaneous level of the Federal Reserve's balance sheet and private holdings of Treasury securities and agency MBS but also to their future dynamics. To capture the projected time series patterns of these holdings at any point in time we use interest rate and macroeconomic projections consistent with the Blue Chip Economic Forecasters release at that time, Treasury issuance projections by the Congressional Budget Office (CBO), as well as a possible path for the unwinding of monetary policy accommodation consistent with the exit strategy

[3] Statement of the Federal Open Market Committee, November 3, 2010.
[4] Refer to Gagnon, Raskin, Remache, and Sack (2011), Krishnamurthy and Vissing-Jorgensen (2011), and Swanson (2011).
[5] Refer to D'Amico and King (2010), D'Amico, English, Lopez-Salido, and Nelson (2011), and Meaning and Zhu (2011).
[6] Refer to Chung et al (2011), Hamilton and Wu (2011), and Li and Wei (2012).

principles outlined in the minutes of the June 2011 Federal Open Market Committee (FOMC) meeting. We project private holdings of securities by recognizing that privately-held securities are simply the total stock of the securities outstanding minus the Federal Reserve's holdings.[7]

To construct our market expectations-consistent projections of Federal Reserve holdings, and hence private holdings, we lean on the methodology outlined in Carpenter, Ihrig, Klee, Quinn and Boote (2012). Their study considers how the Federal Reserve's balance sheet evolves with respect to both the Federal Reserve's projected unwinding of unconventional monetary policy accommodation, as well as the "natural" evolution of the balance sheet that accounts for increases in currency and Federal Reserve bank capital growth. The dollar amount of each asset purchase program and the maturity structure of the purchases and sales of securities also affect the expected evolution of the balance sheet, which is critical for determining the term premium effect (TPE). These characteristics are embedded in the estimates presented below and provide a view of how market participants perceived each asset program when it was implemented; in addition, the estimates provide information on the current effects of these programs.

When assessing the interest rate effects of the Federal Reserve's asset programs, we focus on the "duration" channel through which Federal Reserve purchases reduce the quantity and the average maturity of long-term safe assets held by private investors and lower the term premiums on these assets. In particular, we adopt the model of Li and Wei (2012), which was motivated by empirical evidence that bond returns appear to be predictable by the amount and the average maturity of Treasury outstanding, as well as the theoretical work of Vayanos and Vila (2009), which shows that differences in maturity preferences of Treasury investors can generate supply effects in the government bond market. In the Li and Wei (2012) model, Treasury yields are driven by both yield factors and Treasury and agency MBS supply factors. They use the model to evaluate the magnitude of supply effects on term premiums, and find that a one-percentage-point decline in the private holdings of Treasury ten-year equivalents-to-GDP ratio or the MBS par-to-GDP ratio would reduce the ten-year Treasury yield by about 10 basis points, while a one-year shortening of the average effective duration of private MBS holdings would lower the ten-year Treasury yield by about 7 basis points. By combining estimates of market expectations constructed above with this term structure model, we are able to take

[7] In this context (and as defined by the U.S. Treasury), all marketable Treasury debt that is not held by the Federal Reserve is considered to be "privately held," even if that debt is held by foreign official accounts. In addition, currently there is a small amount of marketable debt held by U.S. state and local governments; however, the level of these holdings (about $300 billion) relative to total marketable Treasury debt (more than $10 trillion) is small.

a cohesive view of both the term structure of interest rates and the size and composition of the Federal Reserve balance sheet. As a result, the estimated interest rate effects of the Federal Reserve's asset programs would be consistent with market expectations about how private holdings will evolve at the onset of an asset purchase program. This approach also allows us to track the expected "decay" of the program, and also allows us to evaluate the current TPE of the program using updated market expectations.

The main contribution of this paper is therefore to provide a more systematic estimate of the TPE than other structural models by explicitly modeling the effects of an asset program on the Federal Reserve's balance sheet, contemporaneously and over time. These effects include not only the size of the program, but also maturity structure and composition. In addition, we incorporate a projection for the evolution of the balance sheet that is consistent with the parameters of each program, allowing us to trace out future changes in interest rates that might result from the program. In comparison, Chung et al (2011) uses the par value of the Federal Reserve's Treasury and agency MBS holdings to estimate their TPE. Because some of the asset programs hold the level of securities constant, but change the composition of holdings, the Chung methodology is not equipped to provide a TPE for this type of asset program. Li and Wei (2012) use a rule-of-thumb proxy for the evolution of private holdings of securities and, therefore, focus only on the contemporaneous impact of the asset programs when they are implemented. Here, we align our projections of private holdings with market participants' views about the expected path of Treasury issuance and future Federal Reserve holdings of securities and, as a result, have a contemporaneous estimate of the TPE of each asset program at implementation that is consistent with market expectations, have a projection of the expected path of decay of the TPE based on those expectations, and have the ability to evaluate the TPE with updated expectations at any point in time.

We evaluate the term premium effect of each of the five asset programs conducted by the Federal Reserve – the outright purchase programs announced on November 2008 and expanded in March 2009 (LSAP1); the reinvestment program announced in August 2010; the outright purchase program announced in November 2010 (LSAP2); the maturity extension program (MEP) announced in September 2011; and the change to the reinvestment program announced in September 2011. We look at how the ten year Treasury yield was pushed down at the time of the program's implementation based on rate expectations that were in place at the time, and we also examine how each program is affecting interest rates today, using current expectations.

All told, our estimates suggest that the first LSAP program resulted in a reduction in the 10-year Treasury yield term premium of about 40 basis points in the second quarter of 2009. At that time, based on market expectations, the TPE was estimated to drop at a moderate pace to about 10 basis points at the end of the second quarter of 2012, and then toward zero thereafter. The second LSAP program reduced the term premium in the fourth quarter of 2010 by 10 to 15 basis points. The maturity extension program, announced in September 2011, brought down the term premium in the fourth quarter of 2011 by about 20 basis points. The two reinvestment programs are estimated to have held down rates by 8 and 3 basis points in the third quarter of 2010 and the third quarter of 2011, respectively.

These estimates of the term premium effect are based on market participants' views of the evolution of the economy at the time that each asset program was implemented. However, what was expected in 2009 did not always subsequently occur – for example, the June 2009 Blue Chip Forecast reported the federal funds rate was expected to rise above 25 basis points by June 2010. So, our model allows us to update the TPEs of each program for current market expectations. The current effect of all programs combined is estimated to be about 50 basis points. We attribute about half of this effect to the first large-scale asset purchase program, between 5 to 10 basis points to the second; a little over 10 basis points to the maturity extension program, and the remainder to the reinvestment programs.

The rest of the paper proceeds as follows. Section 2 presents background, including a brief explanation of the theory used in this paper and a short literature review, as well as a basic summary of the Federal Reserve's actions during the financial crisis. Section 3 discusses the theoretical term structure model with supply factors used to produce the term premium estimates of the balance sheet programs, and also reviews the methodology for constructing the balance sheet projections. Section 4 reviews the results of these efforts, and reports the interest rate effects of each program individually at the time of the program's implementation, as well as the interest rate effect of all programs together, taken at the present. Section 5 concludes.

2 Background

This section reviews both the theory behind our model and the events during the financial crisis that shaped the Federal Reserve's balance sheet. We discuss each in turn.

2.1 Theory and literature review

Vayanos and Vila (2009) formulated a modern arbitrage-free preferred-habitat term structure model that shows a direct relationship between the term premium and the total duration risk faced by investors, in particular by the arbitrageurs. To the extent that LSAP programs remove duration risk from the market by withdrawing a portion of long-term securities, the risk premium built into the price of such assets should decline, and as a result, their yield should decline. The removal of duration risk should generate reactions of yields across much of the maturity spectrum – not just on the yields of purchased securities, but those of adjacent maturities as well.

Following on this theory, Li and Wei (2012) propose and estimate such an arbitrage-free term structure model with supply factors including the private holdings of Treasury and agency MBS securities. They show supply factors have important explanatory power on the term premium beyond that embedded in traditional yield curve factors. They also derive a formula that links the term premium to current and expected future shocks to these supply factors. As a result, their model can be used to evaluate an asset purchase program's term premium effect based on the program's projected impacts over time on these supply factors.

Of course, there are other plausible modeling approaches that differ from the one we have chosen here. While the Li-Wei paper emphasizes the duration risk channel that the Federal Reserve's asset programs work on reducing longer term rates as shown in the Vayanos and Vila (2009) preferred habitat term structure model, other papers have emphasized different channels. For example, Krishnamurthy and Vissing-Jorgensen (2010) offer evidence that there is another important channel that Treasury supplies could also affect interest rates, which they call "the safety premium channel." Another example is D'Amico and King (2010); their work emphasizes the "scarcity channel," or the available supply of nearby maturities. D'Amico, English, Lopez-Salido, and Nelson (2012) also focus on the scarcity channel in their analysis; they couple this channel with the duration channel to arrive at their final estimates of the term premium effects of the programs.

There are also alternative choices for modeling private holdings of securities. One example is in Chung et al (2011), which uses the differences in the SOMA-to-GDP ratio from a long-run average as a proxy for changes in private holdings of securities. While this methodology likely gives similar results to those presented here for the LSAP1 and LSAP2 purchase programs, it cannot evaluate the effect of the MEP or the change in the reinvestment policy in the same way as the modeling approach does here.

2.2 The Federal Reserve's balance sheet and the SOMA portfolio

In order to have a cohesive estimate of how the Federal Reserve's asset programs affected private sector holdings of securities, one must consider how the SOMA evolves over time both with and without these programs. To do this properly, one has to ensure that the size of SOMA is consistent with the Federal Reserve's full balance sheet, as SOMA holdings are naturally affected by other factors, such as Federal Reserve actions associated with credit and liquidity facilities, demand for U.S. currency, and changes in Reserve Bank capital. To understand this point, we begin this section with a review of the historical composition of the balance sheet as well as how it changed as a result of the financial crisis.[8]

2.2.1 The Federal Reserve's balance sheet: Post-war to 2006

For most of the post-war period, the largest asset on the Federal Reserve's balance sheet was the SOMA, and the largest liability was Federal Reserve notes (FR Notes), or paper currency, in circulation outside of reserve banks. Growth of the Federal Reserve's balance sheet reflected growth in currency outstanding, as well as increases in Reserve Bank capital. As currency and capital grew, the Federal Reserve purchased Treasury securities in the open market to keep assets on the Federal Reserve's balance sheet equal to liabilities plus capital. The SOMA portfolio grew at a moderate pace in line with currency and capital for many years. And overall, changes in the SOMA portfolio were fairly small and growth was pretty steady.

In addition to steady growth, the composition of the SOMA portfolio was fairly steady as well. Over time, the Federal Reserve held a few types of securities in the SOMA portfolio; and from 2004 through the financial crisis, the portfolio held only Treasury securities.[9] In particular, the SOMA usually had a substantial fraction of bills, in order to provide the Desk flexibility in managing its liquidity position. The weighted average maturity of the portfolio ranged from three to four years, rising a little around the year 2000 date change ("Y2K") and dropping some during the middle part of the last decade. Still, these changes were small, and implied a relatively steady weighted average maturity of the portfolio. In addition, as expressed in ten year equivalents, or duration equivalents of the on-the-run ten year note,

[8] For a more detailed discussion of specific line items on the balance sheet see Carpenter et. al. (2012).

[9] The authorization and directive for open market operations, typically renewed at the January FOMC meeting, stipulates that the Federal Reserve Bank of New York conducts open market operations in U.S. government securities or in securities that are direct obligations of, or fully guaranteed as to principal and interest by, any agency of the United States.

the SOMA portfolio grew at a pace similar to the par growth rate of the portfolio, although fluctuated some as the duration of the ten year note changed.[10]

The remainder of the assets on the balance sheet, for example, borrowings from the discount window, other assets, and foreign exchange assets, were relatively small when compared with the SOMA portfolio. Even around Y2K and September 11, 2001, the asset side of the balance sheet was fairly steady. The liabilities side of the balance sheet saw a pickup in currency growth around Y2K, but again, changes were relatively small and not much in terms of a percentage of the balance sheet.

2.2.2 The credit and lending facilities

The Federal Reserve's balance sheet changed markedly with the start of the financial crisis. The first actions the Federal Reserve took in August 2007 were to engage in reserve-adding repurchase agreements and to lower the rate on discount window loans.[11] This had the effect of increasing reserve balances available to depository institutions – on August 10, reserve balances were double what they had been the day before. Although reserve balances quickly returned to usual levels, on August 20, the Desk announced that it would redeem $5 billion in Treasury bill holdings in order to provide the Desk with greater flexibility in managing reserve balance levels "to offset factors that may add reserves to the banking system, such as additional discount window borrowings."

Strains continued in financial markets for most of the fall, and as year-end approached, the Federal Reserve introduced long-term repurchase agreements and the Term Auction Facility (TAF), both of which granted banks term loans of central bank funds. As these loans expanded the asset side of the balance sheet, reserve balances would necessarily increase if there was no offsetting change to other assets. Consequently, the Desk redeemed maturing securities throughout December in order to counteract the reserve-adding loan operations.[12]

With the near-failure of Bear Stearns and its subsequent takeover by JPMorgan Chase in March 2008, the Federal Reserve introduced the Primary Dealer Credit Facility (PDCF) to provide loans of central

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[10] A Treasury security expressed in ten-year equivalents is the par value of security times the duration of security divided by the duration of the on-the-run ten year Treasury note.

[11] Many market observers point to the failure of two BNP Paribas hedge funds on August 9, 2007 as the start of the financial crisis. Refer to http://timeline.stlouisfed.org/index.cfm?p=timeline for more information.

[12] A consequence of these actions is that "nonborrowed reserves," or reserves not provided through bank borrowings, were actually negative for some time during this period. This phenomenon is basically an artifact of the classification of, and increase in, TAF borrowing as "borrowed reserves," along with discount window credit, and the drop in Treasury holdings, which contributes to "nonborrowed reserves."

banks funds to primary dealers.[13] In addition, the spread of the primary credit rate over the target rate was narrowed again to 25 basis points. Furthermore, TAF auctions continued, with the total amount offered by the Federal Reserve climbing from $20 billion in December 2007 to $150 billion in October 2008.[14] Again, all of these actions expanded the asset side of the balance sheet. Although reserve balances remained elevated relative to their previous levels as a result, the Desk allowed some Treasury bills to mature and sold other securities in order to sterilize these reserve-adding actions. As a result of the sterilization, Treasury bill holdings in the SOMA dropped to a little less than $20 billion in June 2008. Importantly, these actions on the asset side of the balance sheet implied that SOMA was, in fact, now only about half the size of Federal Reserve notes and capital. This point is quite important, as the sterilization dropped SOMA below what would be the level consistent with its fundamental driving factors and, all else equal, implied that as credit and lending decreased, ceteris paribus, SOMA would need to be replenished.[15]

2.2.3 The asset programs

After the collapse of Lehman Brothers in the fall of 2008, the Federal Reserve continued to lend funds through its various facilities. In addition, the Federal Reserve also started its first foray into actively changing the size and composition of the SOMA portfolio through purchase, sales, and reinvestment programs. From that time to the present, the Federal Reserve announced five different asset programs, summarized in table 1. In very broad terms, two changed the size of the balance sheet, and three focused mainly on composition, although all five had some elements of both. The first LSAP program, announced on November 25, 2008, focused on purchases of agency MBS and agency debt. This action "[was] taken to reduce the cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally." In the expansion of this program, announced March 18, 2009, the target purchase amounts for agency MBS and agency debt were increased, and Treasury securities purchases were added to the program. Once LSAP1 was complete, the size of the SOMA portfolio began to shrink, reflecting maturing and prepaying securities. Since the economic recovery was not as robust as the FOMC wanted, it directed the SOMA manager to reinvest the proceeds of maturing and prepaying agency securities into Treasury securities in an effort to keep the size of the SOMA portfolio roughly constant. The second

[13] Refer to Adrian, Burke, and McAndrews (2009).
[14] -Also of note is the level of $150 billion remained through June 2009. The TAF then proceeded to wind down until the last auction in March 2010.
[15] As will be discussed in detail later in the paper, ignoring this fact when constructing counterfactuals may produce misleading estimates.

LSAP program, announced in November 2010, entailed only purchases of Treasury securities. In the maturity extension program (MEP), which began in September 2011, the Federal Reserve sold shorter-dated securities and bought longer-dated ones. And finally, the Committee agreed to switch reinvestment of agency securities from Treasuries into agency MBS on the same date that it announced the MEP.

The next section lays out how we estimate the TPE of each of these five asset programs when they were announced, and also estimates the current effect of these programs.

3 The model

This section reviews the two aspects of our modeling efforts: the term structure model with supply factors, and the construction of private sector holdings of securities. We discuss each in turn.

3.1 Modeling the term premium effect

In Li and Wei (2012), yields are assumed to be driven by a number of state variables. Let f_t denotes the vector of five state variables in this economy, which consists of two yield curve factors (level and slope), one Treasury supply factor, and two agency MBS factors (level and duration), numbered 1 through 5. These factors are assumed to follow a first-order vector autoregressive process:

$$f_{t+1} = c + \rho f_t + \Sigma \varepsilon_{t+1}, \tag{1}$$

with the following restrictions:

$$\rho = \begin{bmatrix} \rho_{11} & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} \\ \rho_{21} & \rho_{22} & \rho_{23} & \rho_{24} & \rho_{25} \\ 0 & 0 & \rho_{33} & 0 & 0 \\ 0 & 0 & 0 & \rho_{44} & 0 \\ \rho_{51} & 0 & 0 & 0 & \rho_{55} \end{bmatrix}, \quad \Sigma = \begin{bmatrix} \sigma_{11} & 0 & 0 & 0 & 0 \\ 0 & \sigma_{22} & 0 & 0 & 0 \\ 0 & 0 & \sigma_{33} & 0 & 0 \\ 0 & 0 & 0 & \sigma_{44} & 0 \\ \sigma_{51} & 0 & 0 & 0 & \sigma_{55} \end{bmatrix},$$

where the non-zero ρ_{51} captures the feedback effect from the level of interest rates to average MBS duration.

The one-period nominal short rate is assumed to be linear in the factors

$$y_{1t} = a_1 + b_1' f_t, \tag{2}$$

with the restriction that it only loads on the yield factors:

$$b_1 = \begin{bmatrix} b_{11} & b_{12} & 0 & 0 & 0 \end{bmatrix}'.$$

The stochastic discount factor is conditionally log-normal,

$$\log M_t = -y_{1t} - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\varepsilon_{t+1}, \tag{3}$$

with the market prices of risk also assumed to be affine in the factors:

$$\lambda_t = \lambda_0 + \lambda_1 f_t\,. \tag{4}$$

We impose the restriction that the supply factors do not carry their own risk premiums, but can affect term premiums by changing the risk premiums on the yield factors. As a result, we can restrict the last three rows of b_1 to be zero.

Under all these assumptions, it is relatively easy to solve for the price P_t^n of an *n*-period zero-coupon bond at time *t* by recursively solving the relation

$$P_t^n = E_t(M_t P_{t+1}^{n-1}), \tag{5}$$

with the terminal condition $P_t^1 = 1$. The resulting bond prices are exponential linear functions of the state vector:

$$P_t^n = \exp\,(A_n + B_n f_t), \tag{6}$$

with

$$A_{n+1} = A_n + B_n'(c - \Sigma\lambda_0) + \tfrac{1}{2}B_n'\Sigma\Sigma'B_n \text{ and} \tag{7}$$

$$B_{n+1} = (\rho - \Sigma\lambda_1)'B_n - e_1, \tag{8}$$

where $e_1 = [1 - 1\ 0\ 0\ 0]'$ and the initial conditions $A_1 = 0$ and $B_1 = -e_1'$. Bond yields are then given by

$$y_t^n = a_n + b_n f_t. \tag{9}$$

where $a_n = -\frac{A_n}{n}$ and $b_n = -\frac{B_n}{n}$

Li and Wei (2012) estimate this model using monthly data on Treasury yields and private holdings of Treasury and agency MBS from March 1994 to July 2007, which provides model-implied loadings of term premium on the factors b_n. Given these loading estimates, the impact of an asset purchase program can then be easily calculated by calculating the program's shock to the supply factors and multiplying it by the term premium loadings. This simple approach, however, treats the shocks as one-period shocks to the supply variables with the implicit assumption that following the shocks, those supply variables will resume their evolution over time according to their historical dynamics. In contrast, the asset purchase programs are usually implemented over a period of time, resulting in predictable changes to both the levels and the dynamics of the supply factors during and after the purchases.

Given the observation that the programs are implemented over time and therefore represent a series of shocks to supply factors, Li and Wei (2012) model the LSAP programs as generating a series of shocks to the supply variables, which become known to the investors once the programs are announced. They show that the cumulative effect of a series of supply shocks on yields over the life of the bond can be measured by the following formula:

$$\begin{aligned} \tilde{y}_t^n - y_t^n &= b_n^s u_t^s + \sum_{i=1}^{T-t} \frac{n-i}{n} b_{n-i}^s \left(u_{t+i}^s - \rho^{ss} u_{t+i-1}^s\right) \\ &\approx b_n^s u_t^s + \sum_{i=1}^{T-t} \frac{n-i}{n} b_{n-i}^s \left(u_{t+i}^s - u_{t+i-1}^s\right), \end{aligned} \tag{10}$$

where $\tilde{y}_t^n - y_t^n$ is the difference in the bond yield with and without the supply shock, b_n^s denotes the loadings of yields on supply factors, u_t^s denotes the shocks to supply factors at time t, and ρ^{ss} denotes the autoregressive matrix of the supply variables. For Treasury securities, u_t^s is the deviation of the expected ratio of ten-year equivalents of Federal Reserve holdings of Treasury securities to nominal GDP for a scenario with as asset program from a scenario without the asset program, while for agency MBS, u_t^s is the par values of Federal Reserve agency MBS holdings to nominal GDP for the scenario with the asset program relative to a scenario without the program.

As noted in equation (10), the term premium effect depends on not only the current supply shock u_t^s, but also on the expected future path of u^s. In Li and Wei (2012), the u^s path is constructed simply as three phases for each asset program: a smooth increase during the program duration phase, then staying at this level for two years, and then smooth decline over time that dissipates over five years. Here, we model the evolution of the u^s by making it consistent with market participants' views on the

evolution of Treasury issuance and Federal Reserve holdings, with the latter accounting for the expected unwind of the extraordinary monetary policy accommodation.[16]

3.2 Modeling the Federal Reserve's balance sheet

As discussed above, the term premium effect relies on the projected path of shocks to private-sector holdings of securities. We construct this path by projecting the evolution of total Treasury issuance and Federal Reserve holdings of securities.[17] Our approach is a more complete version of Chung et al (2011) who also use balance sheet projections to evaluate LSAPs. They approximate the balance sheet contours by looking at the current par value of SOMA holdings and assume that SOMA holdings in excess of one year remaining maturity trend towards a long-run level of 5 percent of nominal GDP. This approximation is reasonable for a "rough estimate" of the TPE associated with the LSAP programs, but the results depend critically on the assumption for the steady-state SOMA to GDP ratio, which changes over time. More importantly, however, is that this methodology was created prior to the MEP and the model is not able to estimate the term premium effect of this type of program, which reflects a change the duration of SOMA, as short-term Treasury securities were swapped for longer-term Treasury securities, but not the nominal value of the portfolio.

This remainder of this section reviews the construction of the Federal Reserve's holdings of securities; many of the specifics of the methodology are reviewed in Carpenter et al (2012) and in the appendix.

To estimate the TPE for a given asset program upon implementation, we project how the SOMA portfolio evolved in two scenarios: (1) a projection of SOMA holdings immediately after at the onset of the program (using expectations by market participants at that point in time); and (2) a projection of SOMA holdings immediately prior to the implementation of the asset program under consideration (the counterfactual). For each scenario, we project the evolution of the balance sheet, and in particular, an exit strategy from policy accommodation. We base our projections on the general principles for the exit strategy that the FOMC outlined in the minutes of the June 2011 FOMC meeting.[18] The Committee stated that it intended to take steps in the following order:

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[16] More details of the construction of u^s are discussed below.

[17] We assume that total securities outstanding are exogenous to the Federal Reserve's asset programs. This is consistent with the Treasury not altering their funding patterns after the initiation of the various Federal Reserve's asset purchase programs.

[18] Minutes of the Federal Open Market Committee, June 21-22, 2011, available at http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20110622.pdf.

(1) Cease reinvesting some or all payments of principal on the securities holdings in the SOMA;
(2) Modify forward guidance on the path of the federal funds rate and initiate temporary reserve-draining operations aimed at supporting the implementation of increase in the federal funds rate when appropriate;
(3) Raise the target federal funds rate;
(4) Sell agency securities over a period of three to five years; and
(5) Once sales begin, normalize the size of the balance sheet over two to three years.

To complete the exit strategy we make a few additional assumptions. We tie changes in the SOMA portfolio to the date the federal funds rises from its effective lower bound.[19] We assume that the reinvestment of securities ends six months before this date. We do not explicitly model the use of reserve-draining tools. We assume that sales of agency securities begin six months after the federal funds rate begins to rise and that the balance sheet has returned to normal size over about four years. In interpreting "normal size" we rely on an assumption that $25 billion in reserve balances, the average level before the crisis, is about "normal." The exit strategies and timing for each scenario are summarized in table 2.

In addition to these exit strategy assumptions, we need assumptions on interest rates and debt outstanding in order to construct the Federal Reserve's and then the private-sector holdings of ten-year equivalents, with the latter being the supply input for the term structure model. For interest rates, we rely on the Blue Chip Survey of Professional Forecasters for their views on the paths of the federal funds and 10 year Treasury rates immediately before the implementation of the policy action we consider. The five-year long-run annual projections from this data source are released twice a year, in June and December. In addition, these projections include a five year average for the selected variables for the years after the individual annual projections, resulting in a ten-year projection. As a result, for policy interventions announced in intervening months, we inspect the short-run projections that cover six quarters into the future that are produced monthly and interpolate these projections on a case-by-case basis, as described in table 3. Furthermore, for each of the balance sheet scenarios, we project total Treasury debt outstanding as well as the composition of Treasury debt so we can project ten year equivalents of both SOMA holdings and private-sector holdings. We use the Congressional Budget Office's deficit forecast close to the time of the inception of the program to project Treasury debt

[19] We use the same timing assumptions as in the Federal Reserve Bank of New York publication "Domestic Open Market Operations in 2011" when discussing projected SOMA net interest income.

outstanding. For the construction of the maturity structure of Treasury debt, we rely on forecasts by Wrightson Research for Treasury issuance, as well as policy statements by the Treasury on the expected evolution of the maturity of Treasury debt over time.

4 The effect of the asset programs

Given the models and assumptions outlined in section 3, we now construct the term premium effect of each of the five programs upon implementation, as well as an estimate of the current TPE of all the asset programs combined and their individual contributions. A little balance sheet history is included with each program in order to inform the construction of the counterfactual.

4.1 LSAP1: November 2008 and March 2009

The first large-scale asset purchase program, announced in November 2008, included purchases of agency mortgage-backed securities (MBS) and agency debt. Initially, the intended amounts for purchase were $500 billion in agency MBS and $100 billion in agency debt. After the Federal Open Market Committee (FOMC) lowered the federal funds rate to the current 0-25 basis point range in December 2008, and as the financial crisis wore on through the winter of 2009, the Federal Open Market Committee announced an expansion of the program in order to foster additional declines in longer-term interest rates. In March 2009, the FOMC revised its plan for the first LSAP program, and all together, the first round of purchases included $1.25 trillion of agency MBS, about $175 billion of agency debt, and $300 billion in longer-dated Treasury securities.[20]

Markets reacted to these actions. Upon the first announcement of the program, as documented in Gagnon et al (2011), the 10 year Treasury rate declined 7 basis points. However, the second announcement generated a 40 basis point decline in the 10 year Treasury rate. These reductions in the 10-year rate may have reflected changes in investor's beliefs about the size and composition of the Federal Reserve's balance sheet, expectations for privately-available securities in the future, and general improvement in market functioning. To estimate the TPE associated with LSAP1, we need two projections – the counterfactual scenario where no LSAP1 was implemented, and the scenario with LSAP1.

[20] Holdings of agency MBS actually peaked at a lower level than the $1.25 trillion, owing to prepayments on securities that were purchased earlier in the program.

We now turn to estimating the TPE for LSAP1. To do this, first, we construct a projection of how the Federal Reserve's balance sheet was expected to have evolved at the time the LSAP1 program was implemented. Next, we construct a projection of how the Federal Reserve's balance sheet would have evolved without a LSAP1 program.[21] The difference between the paths of SOMA holdings in these two scenarios represents supply shocks to private investors that were generated by the LSAP1 program; i.e, the u^S path in our term premium model. Finally we plug the u^S path into our model for the estimated TPE.

4.1.1 LSAP1 projection

The projection for the Federal Reserve's balance sheet at the time when the first LSAP occurred is constructed using expectations for interest rates and other key variables at the time of the implementation of the program. It is helpful to remember that at the inception of LSAP1, the Committee stated that all purchases would be completed by December 2009. As the program wore on, the Committee revised its estimate to the first quarter of 2010 "in order to promote a smooth transition in markets."[22] As a result, the projections here reflect the earlier completion date of the LSAP1 program. Another assumption at the time of LSAP1 was that as the agency securities prepaid or matured, that these securities would roll off the portfolio, i.e., there was no expectation of reinvestment at this time.

As shown by the solid line in the top left panel of figure 1, the Federal Reserve's portfolio, the System Open Market Account (SOMA), rose dramatically between late 2008 and end-2009. Treasury holdings, shown in the top right panel, moved up by $300 billion, while MBS holdings, shown in the bottom left panel, jumped from zero to nearly $1.25 trillion.

Our projection for how the Federal Reserve's balance sheet would have evolved after the purchases were complete depends critically on market expectations. There was no intention of further asset purchases, no expectation of reinvestment, and the assumed lift off date of the funds rate was not that much later than when the purchases were completed. As shown in the top panel of figure 2, the liftoff of the federal funds rate—the date at which the federal funds rate was projected to rise above the 0-to-25 basis point range—was projected to occur in June 2010, about six months after the Committee had stated that the LSAP1 purchase programs would be finished. The ten year rate, the bottom panel, was

[21] Projections for GDP, interest rates, and Public debt use forecasts immediately prior to LSAP1.
[22] FOMC statement, December 19, 2009, http://www.federalreserve.gov/newsevents/press/monetary/20091216a.htm.

expected to fall a bit further from its April 2009 level, but then slowly approach the same long-run average a few quarters later than investors projected in October.

The projection of the path of the federal funds rate affects the contours of the balance sheet projection, as we anchor our projected exit from monetary policy accommodation off this date as noted in table 2. Under the Blue Chip projection, liftoff occurs in June 2010, and using the June 2011 exit principles as a guide as noted in section 3.2, agency MBS sales begin in December 2010. This assumption leads to a normalization of the size of the portfolio – defined as the size for which the implied level of reserve balances is $25 billion – in October 2012, as listed in table 4. After that point, the portfolio grows in line with Federal Reserve notes and capital. Furthermore, when these purchases occur to increase the size of the portfolio, we assume that the purchases are at first only in Treasury bills until SOMA bills reach 1/3 of total Treasury securities held in the portfolio—roughly in line with the composition of the portfolio before the start of the financial crisis. Once this 1/3 bills, 2/3 notes and bonds ratio is reached, purchases continue so that this ratio stays constant. These assumptions are embedded in the projections shown in figure 1.

Putting the interest rate paths together with SOMA Treasury holdings gives us a path for SOMA Treasury ten year equivalents, shown in the bottom right panel of figure 2. This and SOMA MBS (par value) holdings are the two inputs into the term premium model for LSAP1.

4.1.2 LSAP1 counterfactual

To estimate the TPE associated with LSAP1, we need to look at how much larger SOMA holdings were with the asset purchases than in a scenario where no LSAP1 was implemented. In this scenario we assume the past actions of the FOMC would have been enough to move the economy (and the FR's balance sheet) back toward its steady state growth path. This projection is consistent with what was assumed by Blue Chip forecasters immediately prior to LSAP1. We take the Federal Reserve's balance sheet as it appeared immediately prior to LSAP1, in October 2008, and make three assumptions regarding the evolution of the portfolio. First, because the SOMA portfolio comprised only Treasury securities, as had been the case for many years before the beginning of the crisis, we project a Treasury-only portfolio.[23] Second, we assume the balance sheet expands at roughly the growth rate of currency and capital, its historical pattern for many years. Third, we assume that the path of unwinding of the

[23] Although there was some market commentary at the time that an LSAP might take place, we assume that those expectations were closer to the beginning of the program.

credit and lending facilities followed its actual path.[24] As shown by the dashed line in figure 1, because the level of securities in November 2008 was in fact lower than its long-run growth path as a result of the runoff of securities that occurred during the time when the credit and lending facilities were sterilized, we forecast that SOMA's holdings of Treasury securities begin to climb around October 2009.[25] After the unwind of the credit and liquidity facilities, the SOMA portfolio grows at a constant rate, in line with growth of currency (which is in line with growth of nominal GDP as reported in the table appendix)) and capital.

To generate the supply shocks for this scenario we use the interest rate forecasts shown in figure 2, which are the October 2008 and June 2008 Blue Chip forecasts for the near term (six quarters) and longer term respectively. The target federal funds rate was expected to decline 25 basis points from its level at the time, and bottom out at 1 percent. The funds rate was then expected to climb steadily to about 4.5 percent, near its long-run average and somewhat lower than it had been immediately preceding the crisis. As shown in the bottom panel, the ten year rate was expected to climb as well, reaching a long-run value of about 5.25 percent by the end of 2012. Using these interest rates with the projected SOMA Treasury holdings path, the SOMA Treasury 10-year equivalents projection is shown in the bottom right panel of figure 2.

4.1.3 LSAP1 term premium effect

With the LSAP1 and LSAP1 counterfactual projections, we can construct our supply shocks for our TPE model as the LSAP1 value minus the counterfactual value for both SOMA MBS holdings and SOMA Treasury ten-year equivalents as displayed in the bottom panels of figure 1. Since the Federal Reserve never held MBS prior to the financial crisis, the value of $u^s$is just the amount of Federal Reserve holdings normalized by nominal GDP. For Treasury ten-year equivalents, one can see that Treasury holdings are actually lower in the LSAP1 scenario than those in the counterfactual from mid-2010 through mid-2014, reflecting the fact that LSAP1's purchases of MBS holdings boost the SOMA value and Treasury holdings are not needed to offset growth in currency and capital. Looking at the long-run, actual currency growth

[24] While there is some question as to whether the credit and lending facilities would have unwound quite as quickly without the LSAP programs, we abstract from that issue in this paper.

[25] The forecast assumes that the Federal Reserve has perfect information regarding the amount outstanding in the credit and lending facilities. Therefore the projections for the facilities contains actual data through November 2011, which include: Repurchase agreements; term auction facility (TAF) credit; central bank liquidity swaps; support to American International Group (AIG); the Primary Dealer Credit Facility (PDCF); primary, secondary, and seasonal credit; the asset-backed money market mutual fund liquidity facility (AMLF); the , the term asset-backed securities loan facility (TALF); Maiden Lane holdings; and the commercial paper funding facility (CPFF). Because some of the credit and lending facility activity was sterilized, after an initial runoff, Treasury holdings will necessarily increase one-for-one with the decline in credit and lending facilities.

was much faster than what would have been projected in October 2008 – likely a result of precautionary demand for dollar-denominated banknotes. Consequently, the balance sheet is permanently larger in the LSAP1 scenario than in the counterfactual.

As shown in figure 3 and reported in row 1, column 1 of table 5, the initial impact of the LSAP1 program on the ten-year Treasury yield was to push down the rate by about 40 basis points. This estimate is almost identical to the original announcement effect, as discussed above, and our estimate is certainly well within confidence bands around other studies' estimates. In particular, D'Amico and King report a 20 basis point decline attributable to the Treasury portion of the LSAP, while Krishnamurthy and Vissing-Jorgensen (2011) estimate a 100 basis point fall for all types of securities purchased under this program. The similarity between the original announcement effect and our estimate suggests that our modeling approach captures the change in expectations for the balance sheet at that time, and gives us a reasonable estimate of the term premium effect of the program.

Figure 3 also shows the expected path of decay of the TPE. As the Federal Reserve's balance sheet is projected to slowly return to a more normal level over time, securities are returned to private investors and the TPE becomes less negative. As reported in column 3 of table 5, by early 2013 the TPE associated with the first LSAP program is -6 basis points. This reduction primary reflects two factors: first, the Federal Reserve was not reinvesting the proceeds from prepayments of agency securities and so those securities were essentially returned to private investors; and second, markets expected the funds rate to rise above 25 basis points in June 2010, implying the unwind of unconventional monetary policy well before 2013.

4.2 MBS reinvestment program into Treasury securities: August 2010

After the first round of LSAPs were completed in March 2010, and final settlements of agency MBS were finished in June 2010, the balance sheet began to contract. Much of this contraction was due to prepayments on holdings of agency MBS: when a mortgage borrower refinances a mortgage or sells a home with a mortgage, the borrower pays off the outstanding mortgage balance, and consequently, the MBS associated with the mortgage "prepays" before the stated maturity of the security. With mortgage rates near historical lows, the incentive for borrowers to refinance was fairly strong, and as a result, there were substantial prepayments on the Federal Reserve's agency MBS holdings. Indeed, over July 2010, the Federal Reserve's holdings of agency securities fell by $6 billion.

This contraction in the balance sheet was implicitly offsetting LSAP1's TPE and pushing up interest rates at a time when the economic recovery was still not robust. In order to address the contraction of the balance sheet and the upward pressure on interest rates due to agency securities prepayments, the FOMC announced an agency securities reinvestment program in August 2010. The program worked as follows: After the monthly release of agency MBS prepayment factors, on or around the eighth business day of the month the Desk announced a target amount of Treasury securities purchases from equal to the amount of projected prepayments over the next month. The targeted maturities for this program were concentrated in sectors less than 10 years, with an average targeted maturity of a little over six years. Market participants reacted to this announcement, and the 10 year Treasury yield fell 5 basis points at the start of the program.

We now turn to estimating the TPE for the MBS reinvestment, following similar steps as outlined for the LSAP1 program.

4.2.1 Reinvestment projection

The balance sheet projections associated with the reinvestment program are shown in figure 4. While agency securities holdings declined as they prepaid or matured, Treasury securities holdings climbed (both par amount and in terms of ten year equivalents) with the reinvestment of the agency securities into Treasury securities, and total SOMA holdings held relatively steady. Using the expectations that were likely in place at the time of the start of the program, a notable amount of agency securities were expected to be reinvested before rolloff begins in late 2010.[26] From that point forward, the SOMA contracts. Sales start in December 2011, six months after the funds rate lifts off, and as shown in table 4, all agency MBS are sold or prepay from the portfolio as of November 2015.

As reported in table 2, investors became increasingly pessimistic about the economy in the months leading up to the reinvestment program. By the time of the reinvestment decision, the federal funds liftoff date shifted out to mid-2011 and, as shown in figure 5, the ten year rate fell dramatically from June 2010 to September 2010.[27] This not only changed the pace of the run off of LSAP1 securities, but also affected the expected timing of the FOMC's exit strategy.

[26] For projected MBS prepays, we use a prepayment speed in line with actual prepayments in the near term projection and then converge to a standard prepayment assumption later in the projection. For details, please see the appendix.

[27] Part of the decline in the ten year rate during that period may be attributable to market expectations for a second LSAP program, as will be discussed in the next section.

4.2.2 Reinvestment counterfactual

For this counterfactual, we use interest rates and balance sheet projections starting in June 2010, the end of the first LSAP program. As shown in the top panel of figure 5, investors expected the federal funds rate to remain at its lower bound until October 2010. The ten year rate was expected to climb as well, and reach its steady-state level by mid-2014.

These interest rate paths inform the evolution of the balance sheet. The balance sheet projection starts with how it looked at the end of LSAP1: agency MBS were close to their peak holdings, agency debt was around $170 billion, and Treasury notes and bonds were $753 billion. The balance sheet is poised to decline in size from that point forward as a result of prepayments on agency MBS holdings as well as maturities of agency debt holdings. We project agency MBS prepayments using the SOMA holdings of agency MBS as of June 2010, and then apply the actual prepayment speeds on those securities reported by Barclays for the first few months of the projection. We then gradually allow the prepayment speed approach that which is implied by the agency MBS market standard prepayment assumption. By contrast to agency MBS, agency debt maturities are known with certainty and we use this schedule in our projections. Because liftoff occurs in October 2010, Treasury securities begin to decline immediately, both in par levels and ten year equivalents.[28] Prepayments on agency MBS securities are expected to be rapid in the short run, but then prepays began to return to normal speeds by liftoff. Combining together all of these paths, the size of the balance sheet normalizes around mid-2013 and no agency securities remain in the SOMA portfolio after November 2015.

4.2.3 Reinvestment term premium effect

The term premium effect estimate of the reinvestment program is shown in figure 6 as the deviation between the TPE with and without reinvestment and row 2, column 1 of table 5. Using the expectations of the balance sheet in place at the time of the program, the estimates suggest that the reinvestment program was pushing down the 10-year Treasury yield by almost 10 basis points. The joint effect of both the LSAP1 and reinvestment program as of June 2011 was to depress the 10 year by 30 basis points, column 2. Importantly, this is not the sum of the LSAP1 and reinvestment TPEs at the onset of each program. Between June 2010 and June 2011, agency MBS prepaid which reduced the TPE associated with LSAP1, which, as noted above, was a factor in the FOMC's decision to begin the

[28] Our assumption is that roll off of securities begins six months before liftoff. Because there are only four months between liftoff and the projection date, we assume rolloffs begin immediately.

reinvestment program. As noted above, at the time of the announcement of the reinvestment program, the ten year Treasury yield declined about 5 basis points, again, roughly in line with our estimate of the term premium effect of the program.

4.3 LSAP2: November 2010

Starting with the Chairman's speech at Jackson Hole at the end of August 2010, there was some expectation in financial markets that another round of LSAPs might occur. Over the next couple of months, the 10 year Treasury rate fell about 10 basis points perhaps reflecting, in part, an anticipation of an asset program. On November 3, 2010, the FOMC announced that it intended to purchase $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, implying a pace of about $75 billion per month. In addition, the agency MBS reinvestment program was slated to continue. On net on the announcement, 10 year Treasury yields actually rose about 4 basis points. Part of this rise was attributable to the Desk's announcement of the targeted maturities for purchases in the program, which reportedly were somewhat shorter-dated than investors had expected. Over the course of the two programs, Treasury holdings increased $716 billion through June 2011.

4.3.1 LSAP2 projection

The effect of the LSAP2 program on the balance sheet is depicted in figure 7. In par amounts and in ten-year equivalents, Treasury holdings reach a peak in mid-2011, at the end of the purchase program. The weighted average maturity of the portfolio was projected to decline a little bit after the completion of the program, as the $600 billion in purchases were concentrated between 2 and 10 years of maturity, with the weighted average maturity hovering around 6 ½ years. As a result of the lowering of longer-term interest rates, the prepayment speed on the portfolio picked up a little bit, which contributed to a lower amount of agency MBS holdings and a higher amount of reinvested securities. Because more securities prepaid and the prepay rate is faster, there are fewer to sell during the sales period.

Despite the announcement of additional policy accommodation through the LSAP program, investors pushed back the expected liftoff date, to December 2011. The path of the ten year rate followed suit, with the rate exceeding 5 percent in the second quarter of 2015.

4.3.2 LSAP2 counterfactual

For this counterfactual, we used the short-run Blue Chip forecast from September 2010 smoothed into the Blue Chip forecast from December 2010. Although this forecast may have contained some expectation of an upcoming LSAP program, we would like the forecast to contain the effect of the

reinvestment program announced in August 2010. As shown in the top panel of figure 8, under this scenario, the federal funds rate lifts off in the second quarter of 2011. The ten year rate reaches its steady state level of about 5 percent in late 2014.

As with the other programs, the liftoff date dictates the contour of the balance sheet projection. Because liftoff occurs in June 2011, reinvestment continues through November 2010, after which the balance sheet begins to contract. The size of the portfolio is normalized about two years after liftoff, in mid-2013, after which point Treasury holdings climb as MBS continue to be sold. MBS holdings reach zero in November 2015, and after that point, growth in the portfolio reflects the expansion of currency and capital. The weighted average maturity of the Treasury portfolio holds relatively steady through most of the projection, until purchases of coupon securities resume.

4.3.3 LSAP2 term premium effect

Similar to the other programs, these two projections enable us to estimate the term premium effect of the second LSAP program. As shown in figure 9 and row 3, column 1 of table 5, the announcement effect of the LSAP2 program is estimated to be about 15 basis points. While this is quite a bit larger than the actual announcement effect at the time of the program, it probably accurately reflects the effect of the program on private investors' holdings of duration, as this program was highly anticipated. That is, in the days leading up to the FOMC announcement, market participants priced in an LSAP2 program of similar size to that which was implemented, and thus, little news was learned by investors on the announcement of the program. Indeed, the ten year rate had moved down 21 basis points in the roughly two months between the discussion of the program at Jackson Hole and its implementation in November 2010.

Our LSAP2 TPE estimate is in line with Swanson (2011), while D'Amico, English, Lopez-Salido, and Nelson (2012) estimate a much larger decline of about 55 basis points.[29] Other estimates fall somewhere between those two values.

As shown in figure 9 and reported in column 2 of the table, the total TPE at the inception of LSAP2 was 40 basis points. So, with the continuation of the reinvestment program and the introduction of LSAP2, the FOMC kept the same downward pressure on the ten year Treasury yield at this point in time as it did in June 2010 when it completed LSAP1. One can also see that the TPE was projected to decay quite

[29] In their framework, they attribute part of the decline in the term premium to a duration effect and the other part to a scarcity effect. The duration effect component estimate is a little smaller than that reported here. In addition, our model likely captures at least some of the scarcity effect.

quickly, with the TPE being only -14 basis points by 2013:Q1, reflecting market expectations that the funds rate would be lifting off from the zero bound in December 2011.

4.4 Maturity extension program and agency MBS reinvestment program

By the summer of 2011, the purchase programs had increased the size of the balance sheet well above what would have been expected by the growth rate of currency and capital, but the pace of economic recovery was not as fast as desired by the FOMC. The next two programs implemented by the Federal Reserve kept the size of the balance sheet the same, but changed its composition and duration to lower interest rates and help support a stronger recovery. On September 22, 2011, the Committee announced the maturity extension program (MEP) and the reinvestment of agency securities payments into MBS. In this section we focus on the impact of the MEP and the MBS reinvestment, together and individually, on the term premium.

For the MEP, the Desk sold $400 billion of shorter-dated Treasury securities and purchased an equal amount of long-dated Treasury securities. For the MBS reinvestment program, which had the stated objective of supporting conditions in mortgage markets, both maturing and prepaying agency securities (both debt and MBS) were rolled over into MBS. This latter policy replaced the reinvestment program where these securities were rolled over into Treasury securities. These two policies combined had the effect of keeping roughly constant the holdings of each security type in the SOMA portfolio, but at the same time, lengthening the maturity of the portfolio. On the announcement of the two programs, the 10 year yield dropped 7 basis points.[30]

4.4.1 MEP and MBS reinvestment projection

Although the par value of SOMA is roughly the same under the MEP and agency MBS reinvestment programs as without the two programs, the composition of the balance sheet is notably different. To start, as shown in figure 10, in the MEP projection, the Treasury holdings remained constant but the weighted average maturity increases over the 9 months of the program; when measured in terms of ten year equivalents, the MEP Treasury portfolio is boosted by almost $300 billion. Second, agency MBS holdings incrementally increased as a result of the reinvestment of agency debt into agency MBS. Because of these factors, the balance sheet is “larger” for longer with the MEP and reinvestment policy than without, and the normalization of the balance sheet is pushed out to 2017.

[30] More specifically, the yield curve flattened, with the 2-year yield rising 4 basis points and the 30-year yield dropping 16 basis points. Yield changes in intermediate-dated securities were more modest.

4.4.2 MEP and MBS reinvestment counterfactual

Our assumptions on interest rates are similar with and without the MEP and reinvestment. According to the Blue Chip forecast, there was little change in expectations of the liftoff in the federal funds rate from the Blue Chip forecast between August 2011 and September 2011. By contrast, the ten year rate, as shown in the bottom panel of figure 11, was pushed down, and remained near the lower bound through 2013. For all series, we used the same longer-run forecast from June 2011, which was taken at the end of LSAP2, but before the change in the reinvestment policy or the MEP.

The projection of total SOMA without the MEP and change in reinvestment policy looks quite similar to the projection with these additional programs in the near term. However, by comparing the dotted red line (no MEP and no MBS reinvestment) to the solid line (MEP and MBS reinvestment) in figure 10 one can see there is a difference in the composition of securities holdings. As noted in the top right panel, prior to the MEP and change in reinvestment strategy, Treasury holdings would have increased almost $300 billion from their level in August 2011 as a result of the reinvestments of agency securities into *Treasury* securities. As shown in the bottom left panel, agency MBS holdings would have run off more quickly as there was no reinvestment into MBS. Further out in the projection, returning to the top left panel, without these last two programs SOMA holdings would have declined quicker and normalization of the balance sheet would have occurred in the first half of 2016. This reflects the fact that MBS holdings would have been much smaller in the medium term without the MBS reinvestment program in place. As shown in the bottom right panel, ten year equivalents for Treasury securities follow the same general contour as that for par holdings.

4.4.3 Decoupling the MEP and MBS reinvestment projections

Although disentangling an announcement effect from the agency MBS reinvestment program from that of the MEP is not possible in the actual data, we can use our framework for an approximate estimate of each program's effect on the 10-year Treasury yield. We do this by projecting the balance sheet with and without the MEP, as shown in figure 10. The MEP, by extending the maturity of the Treasury securities holdings, has an obvious effect on the evolution of the SOMA portfolio, both in par value and ten year equivalents that can be seen by comparing the black solid lines with the blue dashed lines. Since the projections are as would be expected, we do not discuss them further, but use the deviations between these two projections to estimate the TPE associated with the MEP.

4.4.4 MEP and MBS reinvestment term premium effect

The change in the composition of the balance sheet has a notable impact on the estimated term premium effect. As shown in figure 12 and column 1 of table 5, the maximum effect of the MEP and MBS reinvestment programs combined was -20 basis points. The vast majority, 17 basis points, is attributed to the MEP. Therefore, although the par amount of the MEP program was less than the second LSAP program, the impact on the term premium was about 1 ½ times as large.

Estimates reported in other research for the interest rate effects of the MEP are fairly close together. Hamilton and Wu (forthcoming) report a 22 basis point reduction in the 10-year yield of a swap program in similar size as the MEP, and Meaning and Zhu (2011) estimate a -17 basis point effect. The convergence of these results likely rests on the lack of anticipation of the MEP in markets, as well as a more structured methodology in each of these studies.

4.5 Present day: All programs

Since the start of the asset programs, expectations of how monetary policy accommodation will unwind have changed. As a result, the calculation of term premium effects associated with each of the asset programs may no longer be consistent with current policy expectations. That is, the estimated term premium effects for, say, the first quarter of 2012 reported in the above figures were those associated with what market participants thought monetary policy accommodation would look like at the time of the implementation of the asset program. One can easily see that some assumptions made at the onset of these programs do not hold today. Consider what market participants thought at the time of when LSAP1 was implemented. As reported in table 2, in April 2009, the Blue Chip forecast expected the federal funds rate to rise above 25 basis points by June 2010. Of course, the federal funds rate remains in the 0-25 basis point range today, about two years later. Over time, therefore, the term premium effect associated with LSAP1 would have been adjusted for changes in market participants' views of the unwinding of monetary policy.

In order to control for this effect in our analysis, we construct program and counterfactual balance sheet projections for each program, shown in figure 13, using the Blue Chip forecast for interest rates as of November 2011, figure 14. This allows us to decompose the current term premium effect into the individual effect of each program, standardized by current expectations for policy. In addition, we also used "realized" paths for items on the balance sheet through November 2011. For example, rather than agency MBS prepayments relying on an assumed model through November 2011, we use actual

outstanding agency MBS balances outstanding; for Treasury securities, we use actual holdings rather than projected; and for all other assets on the balance sheet, we again use actual figures. The difference resulting from this change is relatively small; our estimates suggest not more than 5 basis points.

Figure 15 displays the term premium effect associated with each program. As indicated by the solid black line, we estimate that the Federal Reserve's asset programs are currently depressing the 10-year Treasury yield by 50 basis points.[31] About half of this effect can be associated with LSAP1 actions, another 8 basis points is a result of LSAP2 actions, 15 basis points reflects the MEP, and the remainder is associated with reinvestment. Although one of the main drivers in differences of the programs is the change in expectations regarding interest rates, there are also differences that result from using realized balance sheet quantities instead of projected ones. For example, the projection at the time of LSAP1 had much slower agency MBS prepayments than what actually occurred, as interest rates declined much more than what was expected at the time of the implementation of LSAP1. Consequently, the realized term premium effect was a bit smaller than the projected term premium effect at the inception of the program.

More generally, the yield on the 10-year Treasury has fallen about 140 basis points since the start of the LSAP1 program. Although there have been many factors that have affected yields over the financial crisis, we would attribute slightly more than a one-third of the drop to the asset programs by the Federal Reserve.

5 Conclusion

This paper provides a novel application of a term structure model that includes supply effects to evaluate the effect of the Federal Reserve's recent unconventional monetary policy on interest rates. Overall, we find that a large portion of the decline in interest rates since April 2009 may be attributed to the Federal Reserve's asset programs. In doing so, we highlight the importance of expectations of the Federal Reserve's balance sheet and of interest rates on the impact of the asset programs, as well as the importance of careful application of an implied Federal Reserve portfolio strategy to calculating these effects. That said, we expect that our results are relatively robust to our assumptions, although any

[31] In this exercise, we kept all assumptions constant other than the interest rate contours. In particular, we did not adjust the assumed prepayment speed on agency MBS. This implies that our projection for prepayments on agency MBS bought under the LSAP1 program was slower than actual, realized prepayment rates. Consequently, the term premium effect of LSAP1 is likely to be overstated a little.

change that would expand (contract) the SOMA portfolio would lead to a higher (lower) interest rate effect.

Going forward, this framework can be easily applied to study the effects of purchase programs by other central banks, in addition to, with some tweaks, the effect of higher-or-lower than expected debt issuance by the Treasury. In general, however, the results in this paper seem to suggest that the central bank can use asset programs to influence market interest rates, even when the target federal funds rate is at the zero lower bound.

6 Appendix

This section reviews a few of the key inputs into the balance sheet construction. Details on other factors are available in Carpenter et al (2012).

6.1 Assets and liabilities

In order to form a complete balance sheet through time, we need a projection of each element of the balance sheet.

6.1.1 Assets

6.1.1.1 Treasury securities

SOMA Treasury holdings are assumed to evolve through a combination of outright purchases and outright sales in the secondary market, reinvestment at auction, and maturities.

- For past programs,
    - Outright purchases for the $300 billion LSAP1 program were according to the following maturities:

LSAP1 distribution (percent), 2009							
Nominal securities							TIPS
1½ -2½ Years	2½-4 Years	4-5½ Years	5½-7 Years	7-10 Years	10-17 Years	17-30 Years	1½-30 Years
21	17	19	21	9	8	5	

    - Outright purchases for the $600 billion LSAP2 program were according to the following maturities:

LSAP2 distribution (percent), 2010							
Nominal Securities							TIPS
1½ -2½ Years	2½-4 Years	4-5½ Years	5½-7 Years	7-10 Years	10-17 Years	17-30 Years	1½-30 Years
5	20	20	23	23	2	4	3

    - Reinvestment purchases for the first agency MBS program were according to the following maturities:

MBS reinvestments into Treasuries program distribution (percent), 2010	
Nominal Securities	TIPs

1½ -2½ Years	2½-4 Years	4-5½ Years	5½-7 Years	7-10 Years	10-17 Years	17-30 Years	1½-30 Years
21	17	19	21	9	8	5	

- For ongoing programs,
    - Outright purchases for the $400 billion Maturity Extension Program (MEP) are simulated according to the maturity buckets and targets as announced by the Federal Reserve Bank of New York (FRBNY):

Maturity extension program purchase distribution (percent)				
Nominal coupon securities				TIPS
6-8 years	8-10 years	10-20 years	20-30 years	
32	32	4	29	3

    - Securities assumed to be available for purchase reflect those outstanding on the Monthly Statement of the Public Debt as of November 30, 2011 as well as forecasts for future issuance. Holdings of any particular CUSIP are limited to 70 percent of the CUSIP outstanding, consistent with the Desk's current practice.
    - Sales associated with the MEP will take place in Treasury securities with remaining maturities of 3 months to 3 years. Roughly three quarters of System Open Market Account (SOMA) holdings of Treasury securities in this maturity range will be sold.
- For all programs,
    - The total par value of Treasury securities outstanding reflects the Congressional Budget Office's (CBO) projections for total debt held by the public that was in place at the time of the program.
    - The average maturity of Treasury debt extends from its current value of 60 months to 70 months, consistent with statements made by the Treasury Borrowing Advisory Committee in November 2011.[32]
    - The proceeds from maturing securities are reinvested at auction at rates consistent with the Blue Chip forecast for interest rates, as discussed in Appendix 2. Auction sizes are determined by the amount of total debt necessary to match CBO projections and follow the actual Treasury auction distribution in November 2011. This distribution is then altered as necessary to extend the average maturity of Treasury debt. The CBO's debt

[32] Refer to http://www.treasury.gov/press-center/press-releases/Pages/tg1349.aspx.

projections along with the maturity distribution of Treasury securities auctioned in November 2011 are summarized in the tables below.

Year	CBO debt held by the public ($ billions)
2010	9,018.94
2011	10,164.11
2012	11,152.93
2013	11,773.39
2014	12,148.09
2015	12,462.72
2016	12,839.81
2017	13,169.09
2018	13,473.33
2019	13,820.23
2020	14,180.64
2021	14,541.09

Source: CBO, Aug. 2011 "The Budget and Economic Outlook: An Update"

Maturity	November 2011 Issuance by maturity ($ billions)	Initial shares of issuance
1 month	140	0.25
3 month	116	0.21
6 month	108	0.19
1 year	25	0.04
2 year	35	0.06
3 year	32	0.06
5 year	35	0.06
7 year	29	0.05
10 year	24	0.04
30 year	16	0.03

Source: Wrightson, Auction Calendar

6.1.1.2 Agency securities

The agency securities portfolio is assumed to evolve due to a combination of purchases, sales, and prepayments.

- Consistent with the FOMC's statement after the September 2011 FOMC meeting, principal payments from SOMA agency MBS and debt and are reinvested in agency MBS. We use a current coupon model to estimate the coupon on newly purchased MBS securities based on the consensus long-run Blue Chip forecast for the 10-year Treasury rate.
- Prepayments on settled agency MBS holdings are generated by applying the realized prepayment rate on the SOMA holdings of MBS for historical values, then smoothed into a standard prepayment rate for projected values. This prepayment rate is notably faster than what would be predicted using the standard Public Securities Administration (PSA) prepayment model – an MBS market benchmark—likely a result of the historically low level of mortgage rates. (The PSA model assumes that the prepayment rate increases from 0 percent by 0.2 percentage points each month until the prepayment rate reaches 6 percent at 30 months.)

After the federal funds rate lifts off, we gradually smooth the prepayment rate back to the long-run PSA model over a five year period.

- Prepayments on anticipated future purchases of agency MBS follow the long-run PSA model for the life of the security.
- Sales of agency securities begin six months after the first increase in the federal funds rate and last for four years. This timing is consistent with that laid out in the June 2011 FOMC Minutes; however, the exact timing is merely illustrative and chosen so as to be easily implementable in our projections.
- Under these assumptions, and given the maturity schedule for agency debt securities, the volume of sales necessary to reduce holdings of these securities to zero over the four year period only requires a six month period of minimal sales near the end of those four years.

6.1.1.3 Premiums and discounts

A premium (discount) is the amount paid above (below) the par value of a security. We use straight-line amortization of these premiums and discounts over the expected life of current SOMA holdings. We derive new premiums and discounts from outright Treasury purchases by using the difference between the assumed coupon of the security being purchased and the corresponding market interest rate, as given by the yield curve estimates shown below.[33]

Parameters for the Yield Curve Estimates

Tenor	1	2	3	4	5	10	15	20	30
Constant	-0.0143	-0.0183	-0.0178	-0.0155	-0.0124	0.0018	0.0084	0.0096	0.0050
Fed Funds	0.7264	0.5363	0.3923	0.2822	0.1958	-0.0394	-0.1206	-0.1487	-0.1682
10 yr T coupon	0.4907	0.7460	0.8773	0.9455	0.9803	1.0000	0.9953	1.0134	1.0830

- We assume that agency MBS are purchased at a price 2 percent above par value, and therefore book some premiums on these asset purchases.

6.1.1.4 Other assets

- We make the simplifying assumption that all discount window lending over the projection period is zero.

[33] There is a slight inconsistency in our methodology: the yield curve used to price securities purchases is different from the yield curve used to determine the term premium effect of these purchases. No matter what, there would be some inconsistency between the two, unless we solved for a fixed point for the yield change (changes in the term premium affect the level of premiums, which in then affects the size of the Federal Reserve's balance sheet, which then affects the level of the term premium.) In addition, we only have Blue Chip projected rates to construct a forward-looking yield curve. To solve this problem, we use a simple yield curve based on historical relationships between the federal funds rate, the ten year rate, and various tenors of the yield curve.

- Assets held by TALF LLC consist of investments of commitment fees collected by the LLC and the U.S. Treasury's initial funding. In this projection, the LLC does not purchase any asset-backed securities received by the FRBNY in connection with a decision of a borrower not to repay a TALF loan. The assets held by TALF LLC remain at their current level of about $1.0 billion through 2013 before declining to zero the following year.
- The assets held by Maiden Lane LLC, Maiden Lane II LLC and Maiden Lane III LLC decline gradually over time at a rate consistent with the declines in these assets over 2011. Holdings for all three LLCs fall to zero by early 2015.

6.1.2 Liabilities

6.1.2.1 Reserve balances

- Reserve balances are the residual of assets less other liabilities less capital in the balance sheet projection.
- In general, increases in the level of Federal Reserve assets add reserve balances. By contrast, increases in the levels of liability items, such as Federal Reserve notes in circulation or other liabilities, or increases in the level of Reserve Bank capital, drain reserve balances.
- A minimum level of $25 billion is set for reserve balances, roughly equal to the level of reserve balances before the start of the financial crisis.
- To maintain reserve balances at this level, first Treasury bills are purchased. Purchases of bills continue until these securities comprise one-third of the Federal Reserve's total Treasury security holdings–about the average level prior to the crisis.
- Once this level is reached, the Federal Reserve buys notes and bonds in addition to bills to maintain an approximate composition of the portfolio of one-third bills and two-thirds coupon securities.

6.1.2.2 Currency

- Federal Reserve notes in circulation are assumed to grow at the same rate as nominal GDP.
- We use the consensus Blue Chip forecasts for real GDP growth and the price level to form the forecast for nominal GDP growth. Because this is an annual forecast, we use the annual growth rate as the annualized quarterly growth rate for the 2nd and 3rd quarters of each year, and then interpolate growth rates for the 1st and 4th quarters of the year. The growth rates for each scenario are displayed in the appendix table on nominal GDP growth.

6.1.2.3 Other liabilities

- The Federal Reserve conducts RRPs with foreign official, international accounts, and other counterparties. The volume of RRPs that is conducted with foreign official and international accounts is assumed to stay constant at its most recent level of approximately $93 billion in November 2011. The portion that is conducted with others is assumed to stay at zero over the projection period.
- The TGA cash balance is projected to stay constant at $90 billion, in line with recent levels.
- We maintain the (SFA) balance at its current level of zero throughout the forecast, consistent with the Treasury Borrowing Advisory Committee's recommendation not to resume the program at this time.[34]

6.1.3 Capital

- Federal Reserve capital grows 15 percent per year, in line with the average rate of the past ten years.

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[34] Refer to "Minutes of the Meeting of the Treasury Borrowing Advisory Committee, the Securities Industry and Financial Markets Association, November 1, 2011," available for download at http://www.treasury.gov/press-center/press-releases/Pages/tg1349.aspx.

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Table 1: Asset Programs

Program name	Type of securities being purchased	Program effects on SOMA			Date announced	Date operations began	Date operations ended
		Size of program	Composition over life of program	Maturity			
LSAP1	Treasury securities, agency debt, agency MBS	"Up to" $200 billion in agency debt, $300 billion in Treasury securities, and $1.25 trillion in agency MBS	Share of agency securities increased from zero to 68 percent	Maturity of portfolio lengthened	Nov-08	Nov-08	Jun-10
Reinvestments into Treasuries	Treasury securities	Maintained size of SOMA	30 percent increase in Treasury securities, share of agency MBS decreased 20 percent.*	Treasuries remained steady, MBS maturity lengthened	Aug-10	Aug-10	Sep-11
LSAP2	Treasury securities	Increased size of SOMA by about $600 billion	Share of Treasury securities increased from 50 percent to 62 percent.	Maturity slightly shortens	Nov-10	Nov-10	Jun-11
Reinvestments into Agency MBS	Agency MBS	Maintained size of SOMA	Share of agency MBS slightly increases	Maturity of portfolio lengthened	Sep-11	Sep-11	Ongoing
MEP	Treasury securities	$400 billion of shorter-term Treasury securities sold, $400 billion of longer-term Treasury securities purchased	Weighted average maturity of Treasury portfolio increases from 70 months in mid-2011 to 100 months by mid-2012.	Maturity of portfolio lengthened	Sep-11	Sep-11	Jun-12

* Share of Treasury securities also include reinvestments from agency debt.

Table 2 - Assumptions

FOMC policy	Date of projection	Lift-Off	Roll-Off	MBS Sales
LSAP 1				
Immediately prior to LSAP 1	Oct-08	N/A	N/A	N/A
Announcement of extension of LSAP 1	Apr-09	Jun-10	N/A	Dec-10
Treasury Security reinvestments				
Immediately prior to reinvestments into Treasuries	Jun-10	Oct-10	N/A	Apr-11
Announcement of reinvestments into Treasuries	Sep-10	Jun-11	Dec-10	Dec-11
LSAP 2				
Announcement of LSAP 2	Nov-10	Dec-11	Jun-11	Jun-12
MEP and MBS reinvestments				
Immediately prior to reinvestments into MBS	Aug-11	Oct-13	Apr-13	Apr-14
Announcement of reinvestments into MBS	Sep-11	Oct-13	Apr-13	Apr-14
Announcement of MEP	Sep-11	Oct-13	Apr-13	Apr-14
Current policy	Nov-11	Jun-13	Dec-12	Dec-13

Table 3 - Publication Dates of Data Sources

FOMC policy	Blue Chip Interest Rates		Blue Chip real GDP growth		CBO Forecast
	Short-term*	Long-term	Short-term	Long-term	Fiscal Year
LSAP 1					
Immediately prior to LSAP 1	Nov-08	Jun-08	Nov-08	Jun-08	2009
Announcement of extension of LSAP 1	Apr-09	Jun-09	Apr-09	Jun-09	2009
Treasury Security reinvestments					
Immediately prior to reinvestments into Treasuries	Jun-10	Jun-10	Jun-10	Jun-10	2009
Announcement of reinvestments into Treasuries	Sep-10	Dec-10	Sep-10	Dec-10	2010
LSAP 2					
Announcement of LSAP 2	Dec-10	Dec-10	Dec-10	Dec-10	2011
MEP and MBS reinvestments					
Immediately prior to reinvestments into MBS	Sep-11	Dec-11	Sep-11	Dec-11	2011
Announcement of reinvestments into MBS	Sep-11	Dec-11	Sep-11	Dec-11	2011
Announcement of MEP	Oct-11	Dec-11	Oct-11	Dec-11	2011
Current policy	Nov-11	Dec-11	Nov-11	Dec-11	2012

* Short term is defined as 6 quarters.

Table 4 - Dates for Key Balance Sheet projections

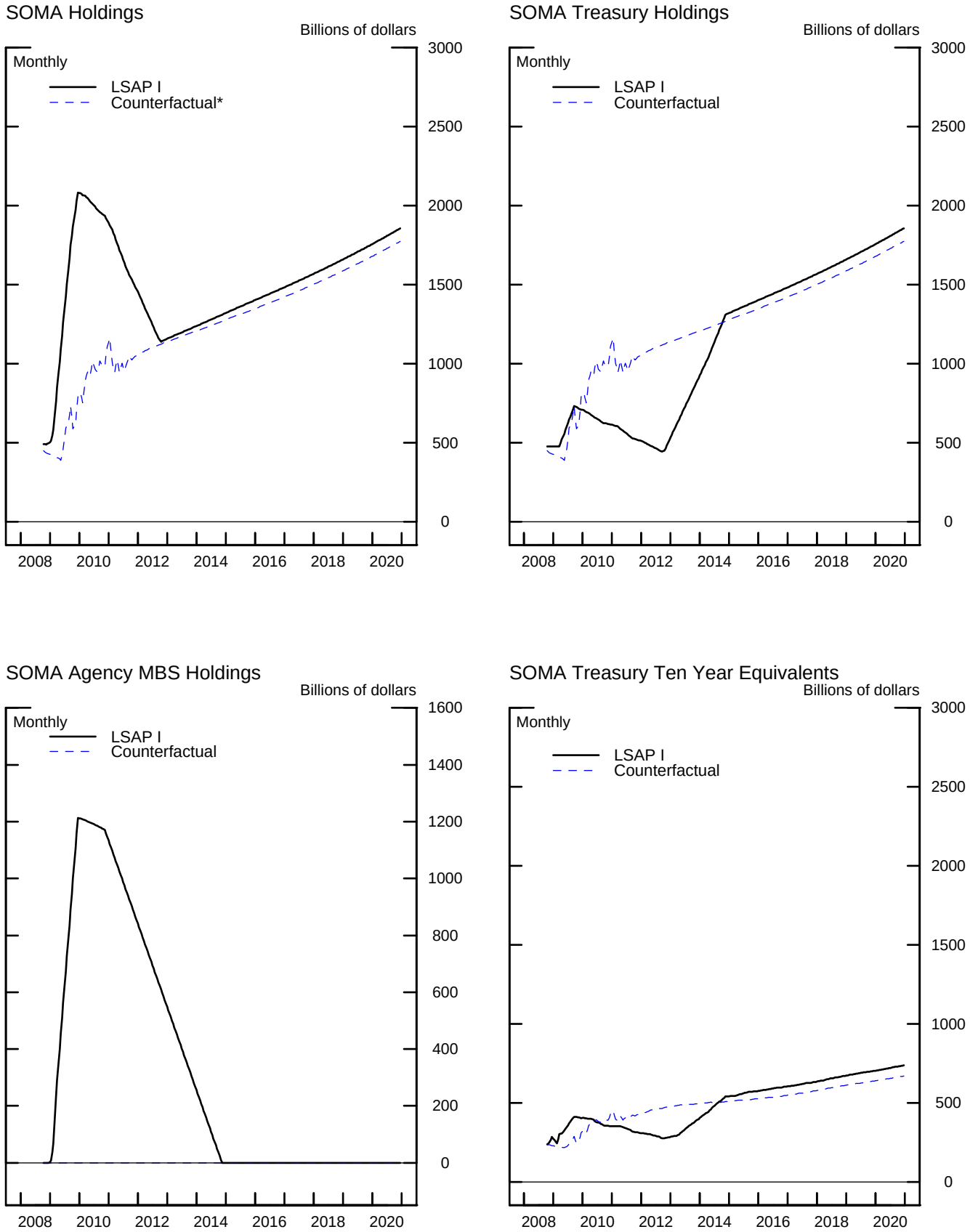
FOMC policy	Date	Reserves = $25B	MBS = 0	Treasury bills are 1/3 of portfolio
LSAP I	Apr-09	Oct-12	Nov-14	Apr-13
Reinvestment into Treasury securities	Sep-10	Jun-13	Nov-15	Feb-14
LSAP II	Nov-10	Jan-15	May-16	Dec-15
Reinvestment into Agency MBS securities	Sep-11	Apr-16	Mar-18	Feb-17
MEP	Sep-11	Jan-17	Mar-18	Jan-18
Current Policy	Nov-11	Sep-16	Nov-17	Oct-17

Table 5 - TPE estimates at inception of the asset program

FOMC policy	Marginal TPE from program	TPE at onset of program	Expected TPE as of 2013:Q1
	(basis points)		
LSAP I	-38	-38	-6
Reinvestment into Treasury securities	-8	-30	-9
LSAP II	-13	-40	-14
Reinvestment into Agency MBS securities	-3	-48	-30
MEP	-17	-64	-44
Current Policy	N/A	-50*	-40

*As of June 2012.

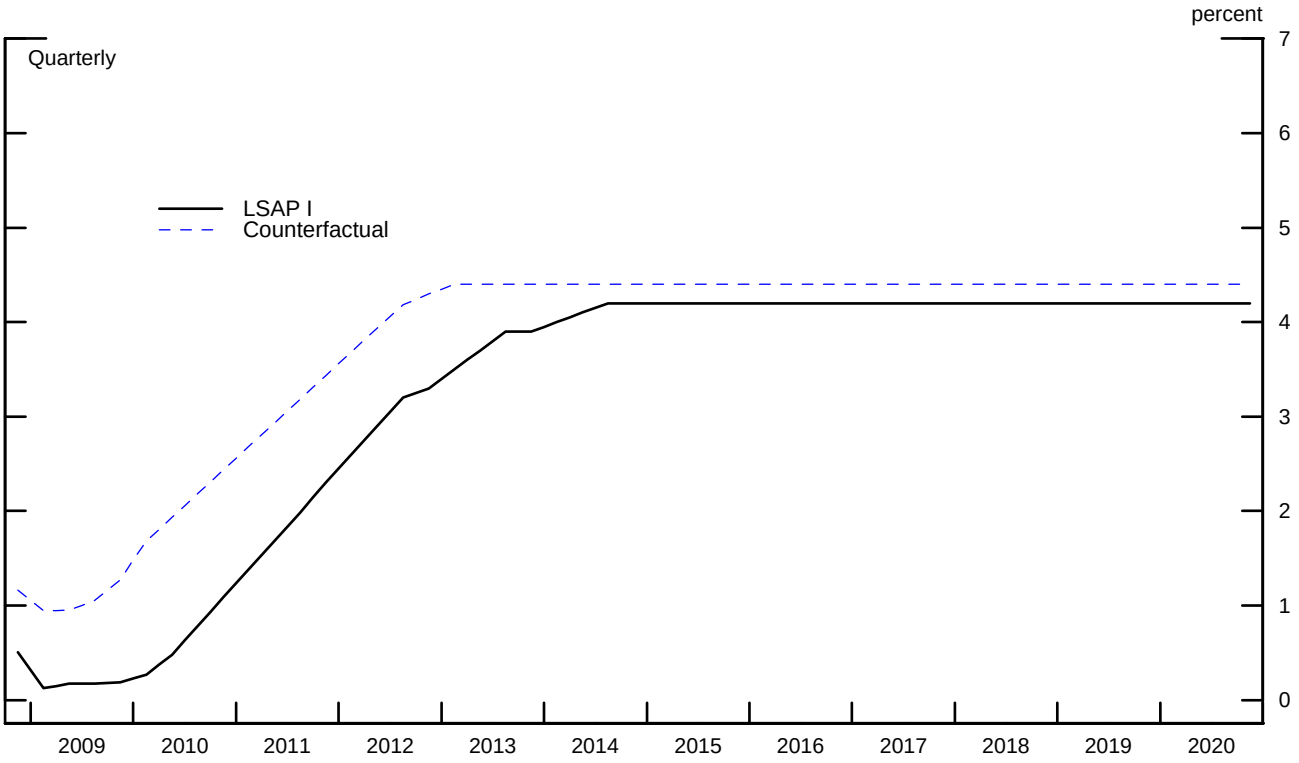
Figure 1 - LSAP I
Select Assets of the Balance Sheet



* Evolution of the Federal Reserve's balance sheet assuming no asset programs.

Figure 2 - LSAP I
Interest Rates

Federal Funds Rate



10 year Treasury Rate

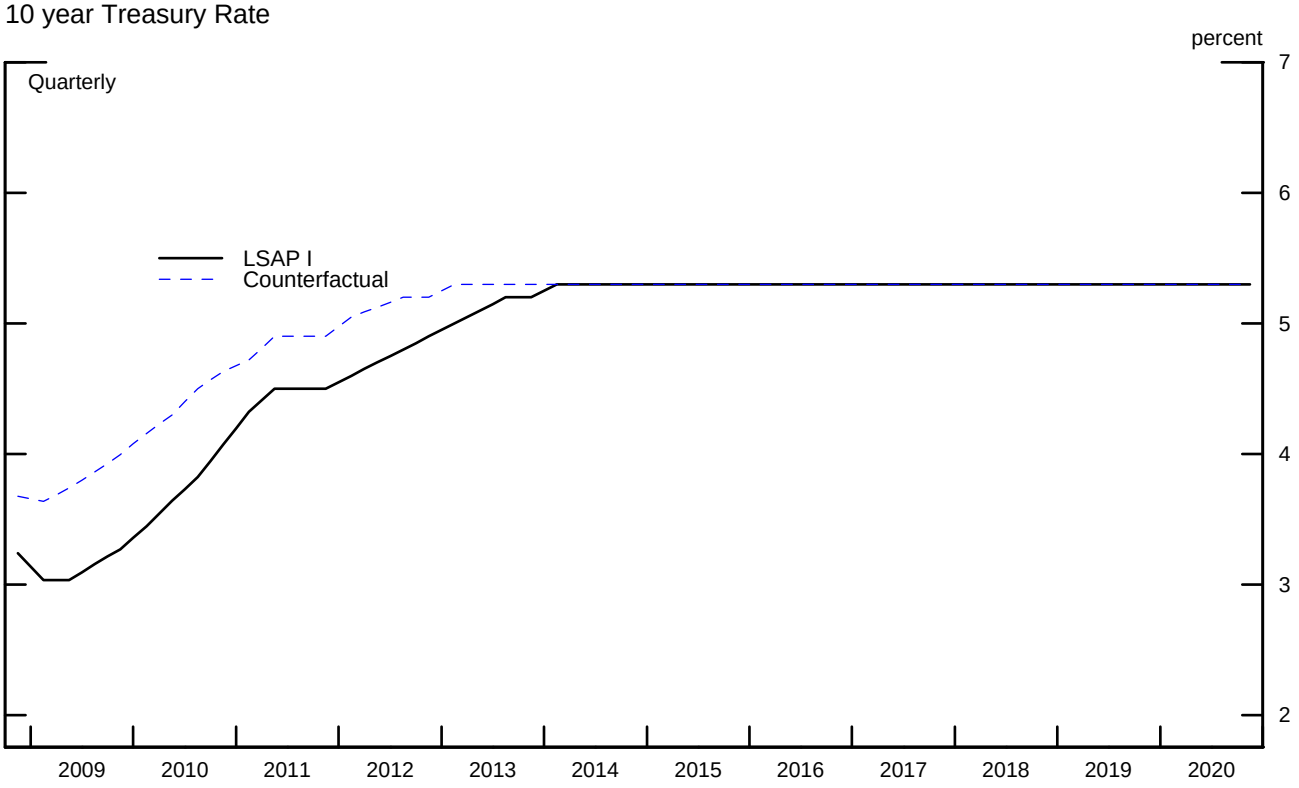


Figure 3 - LSAP I
Term Premium Effects

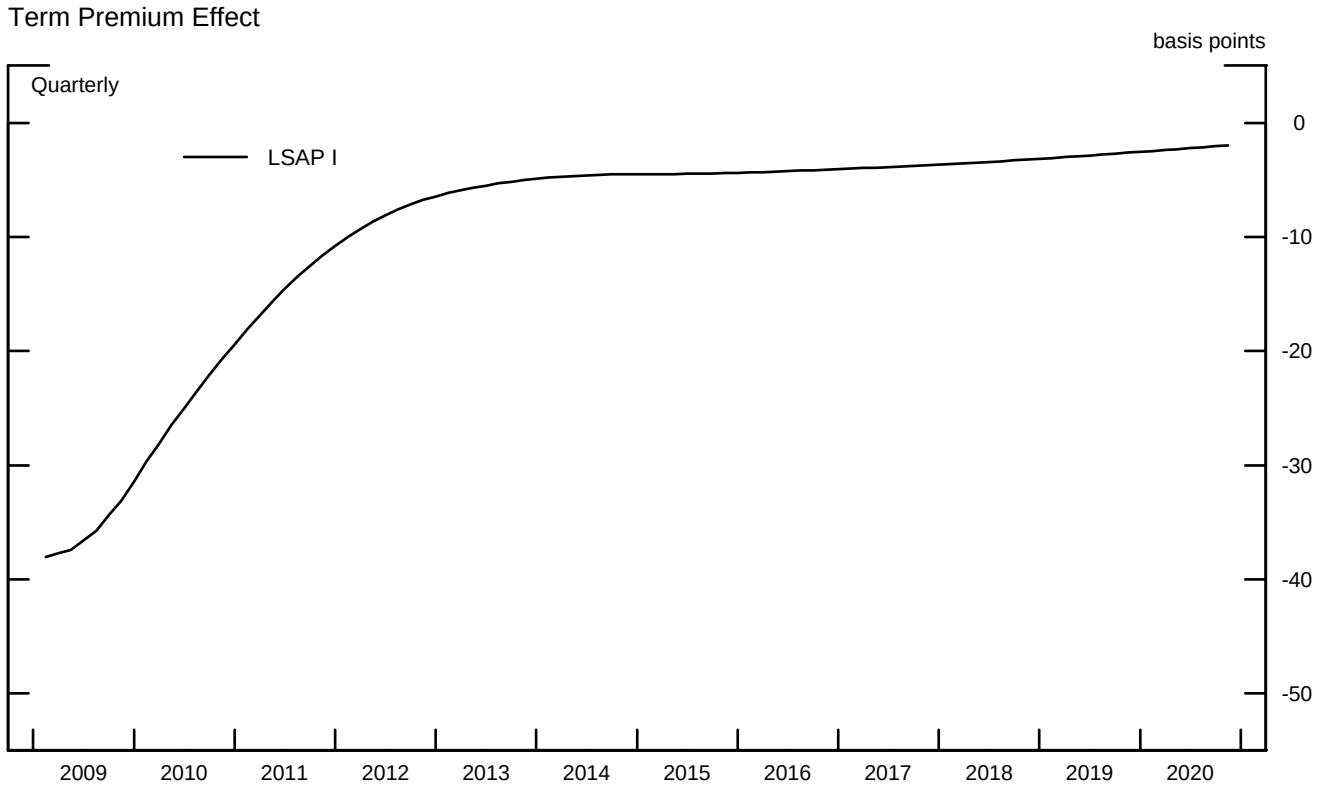


Figure 4 - Reinvestments into Treasury Securities

Select Assets of the Balance Sheet

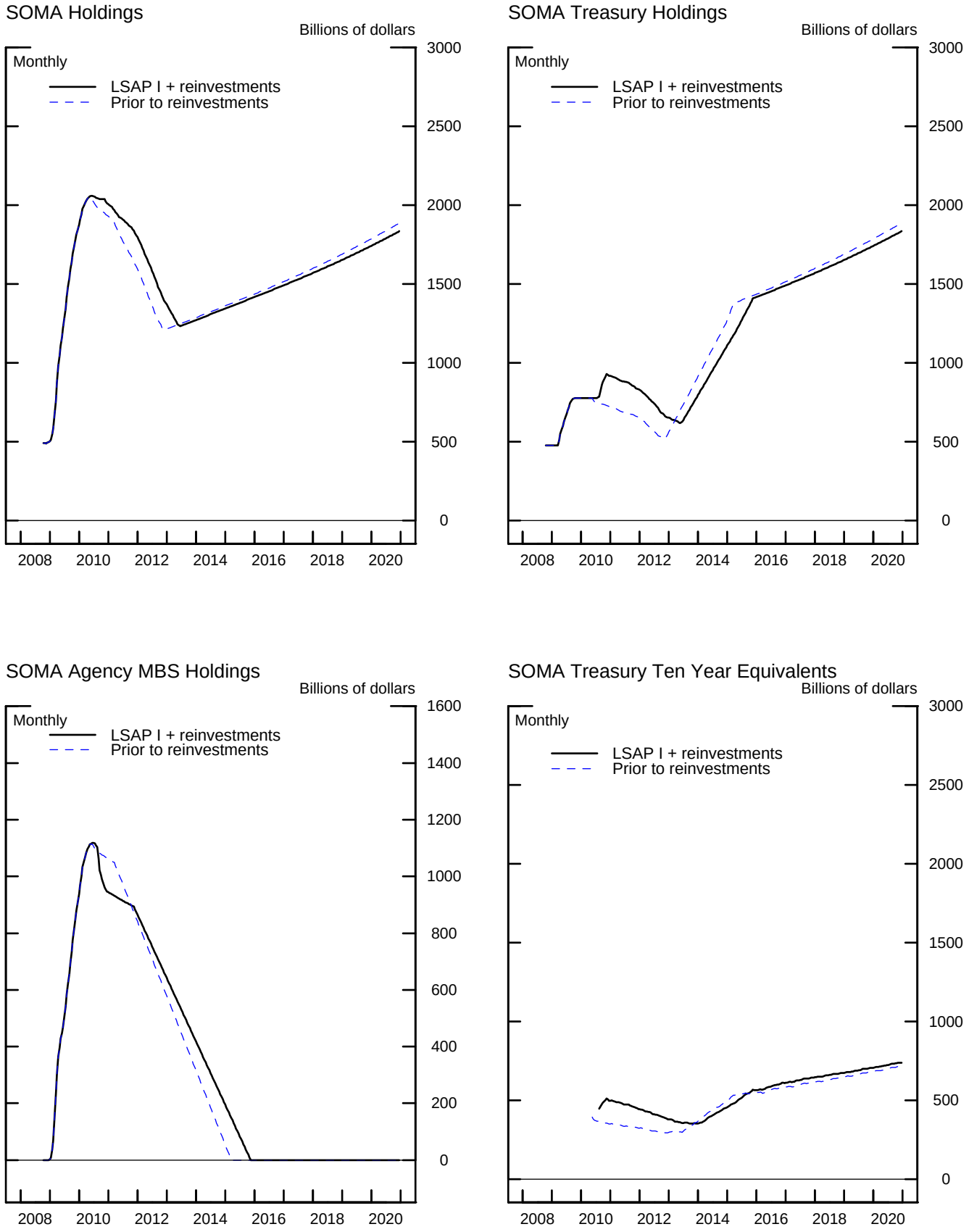
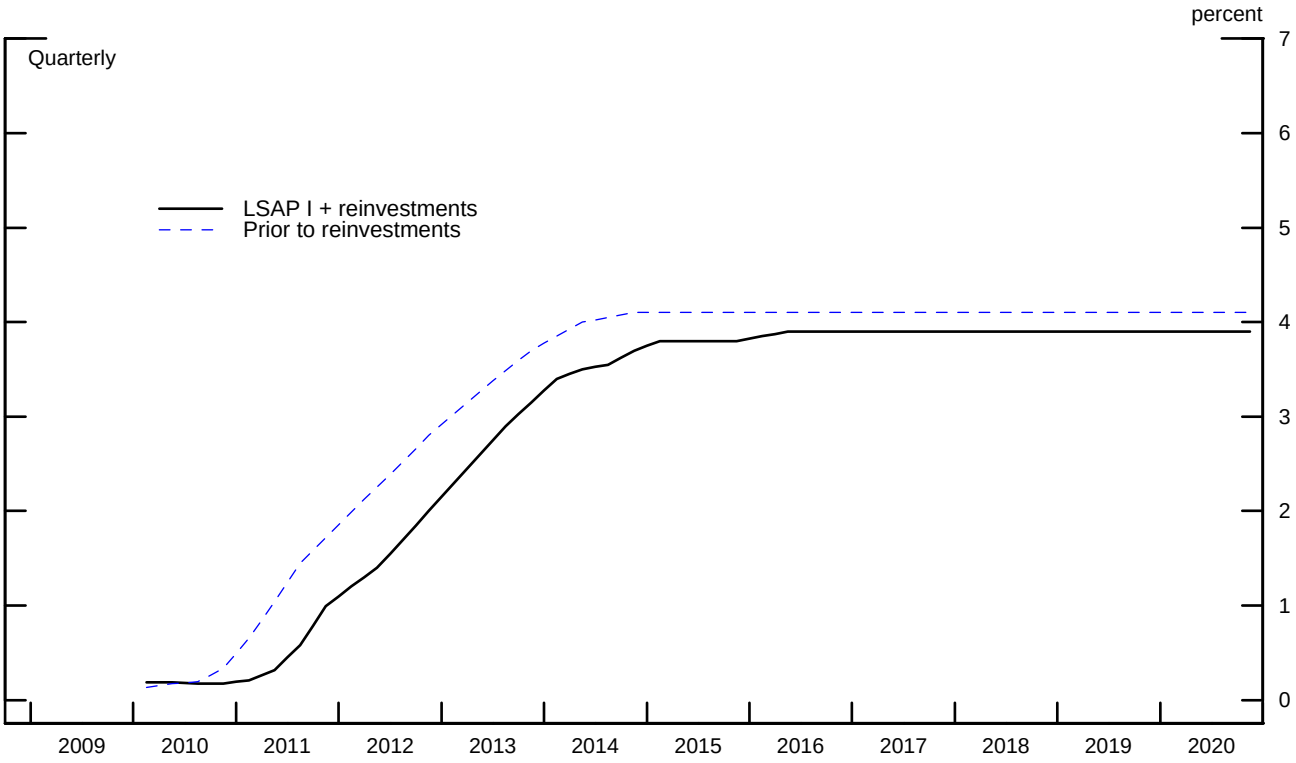


Figure 5 - Reinvestments into Treasury Securities
Interest Rates

Federal Funds Rate



10 year Treasury Rate

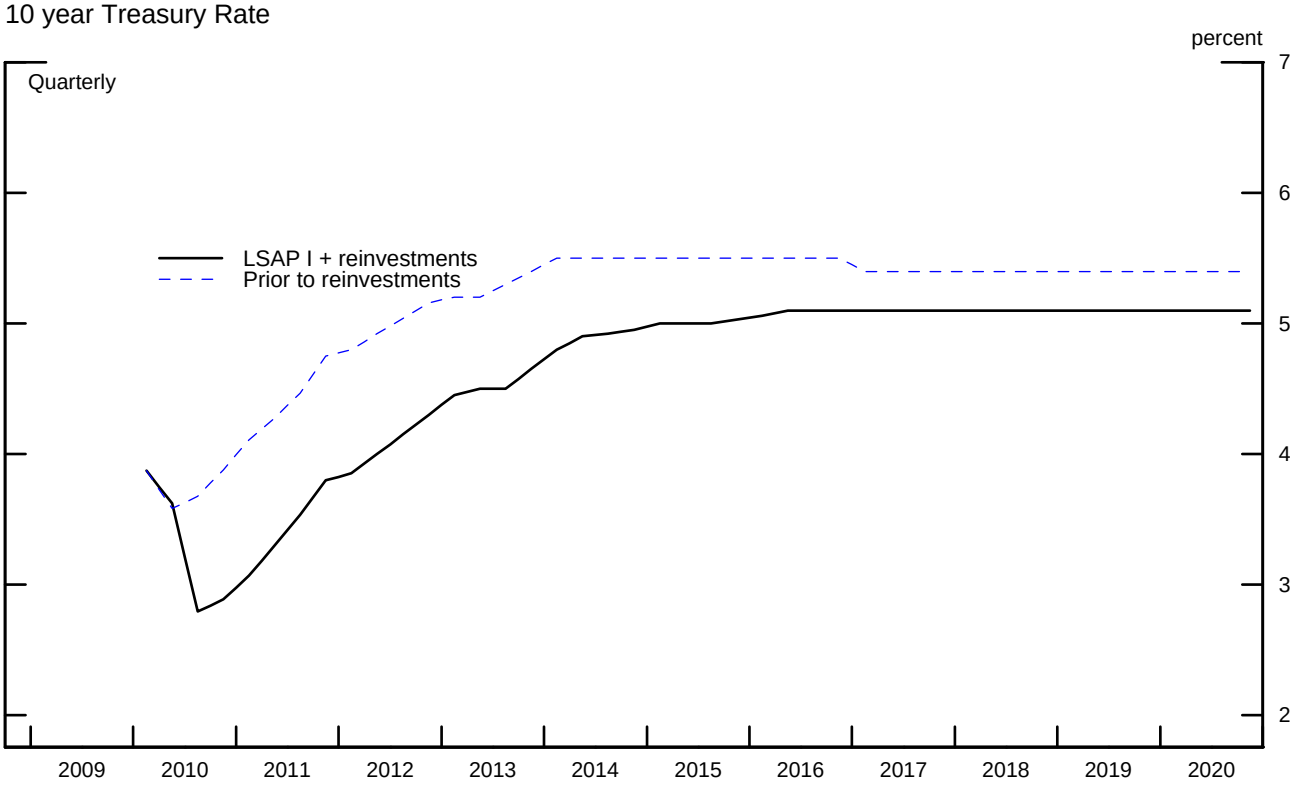


Figure 6 - Reinvestments into Treasury Securities
Term Premium Effects

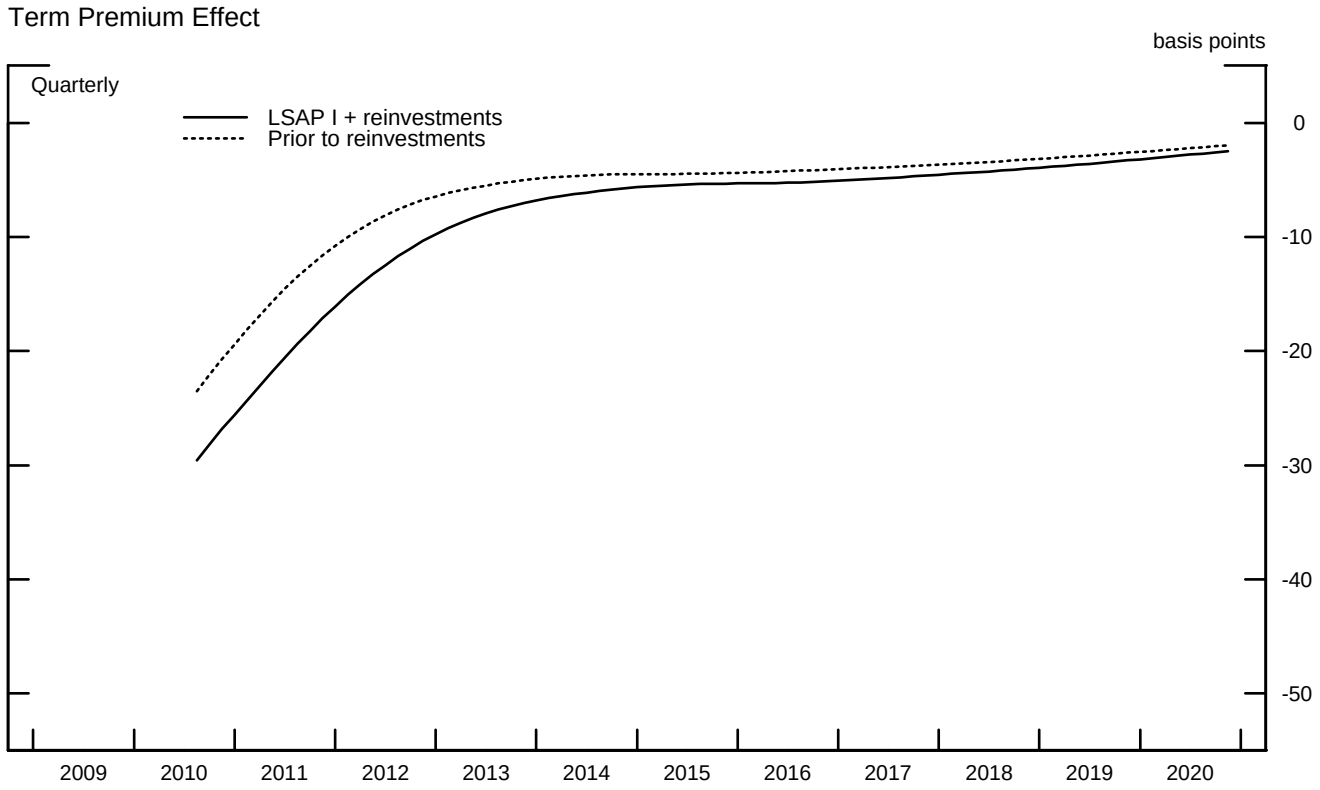


Figure 7 - LSAP II
Select Assets of the Balance Sheet

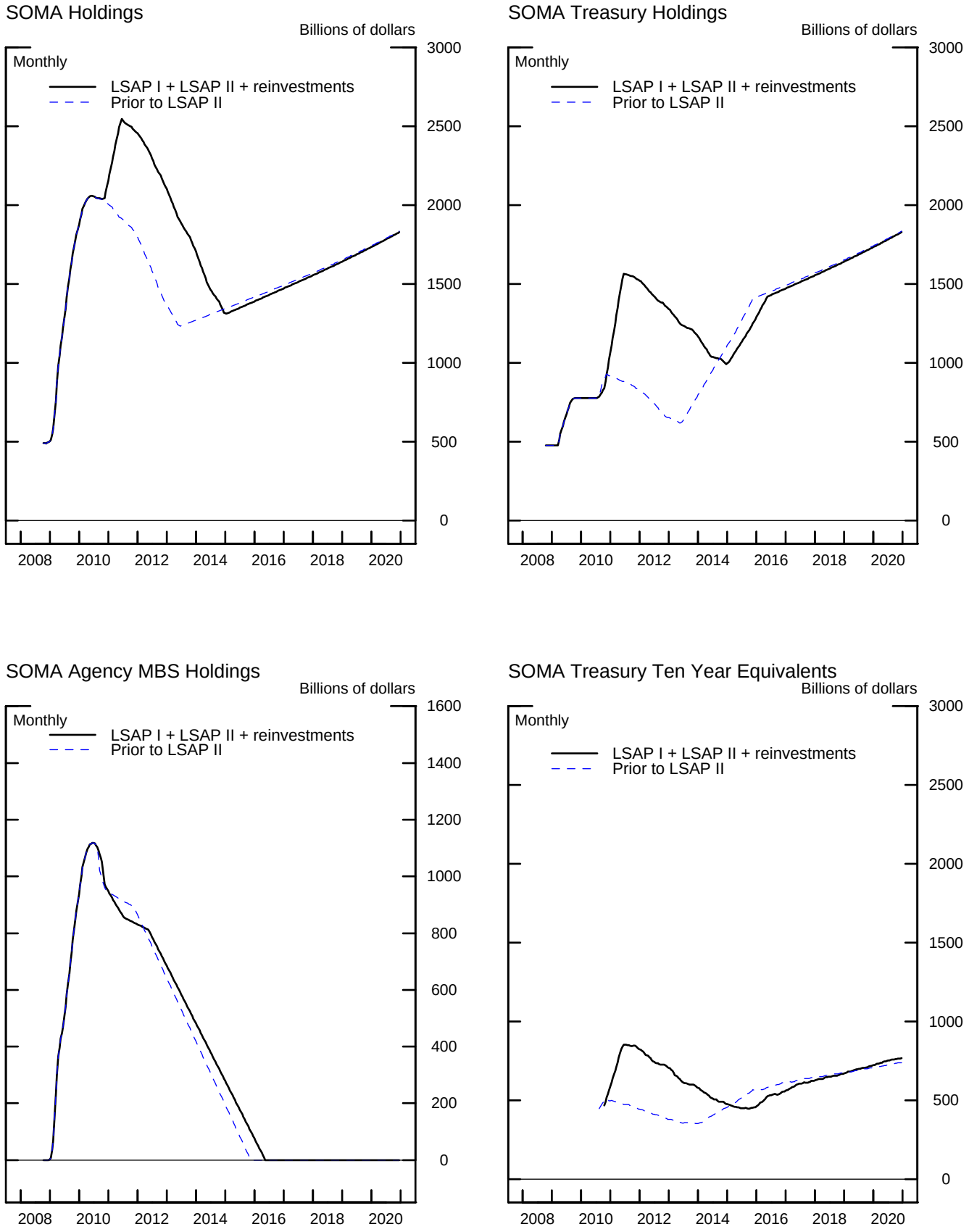
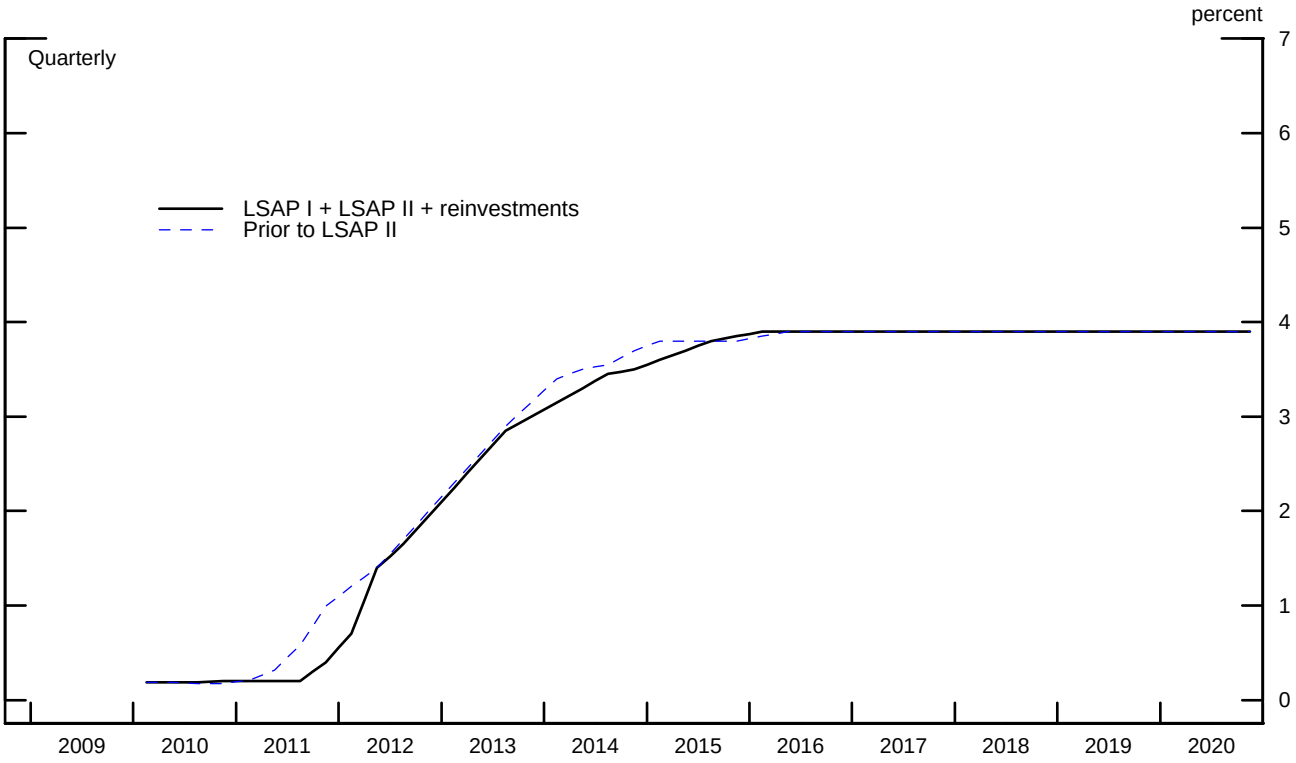


Figure 8 - LSAP II
Interest Rates

Federal Funds Rate



10 year Treasury Rate

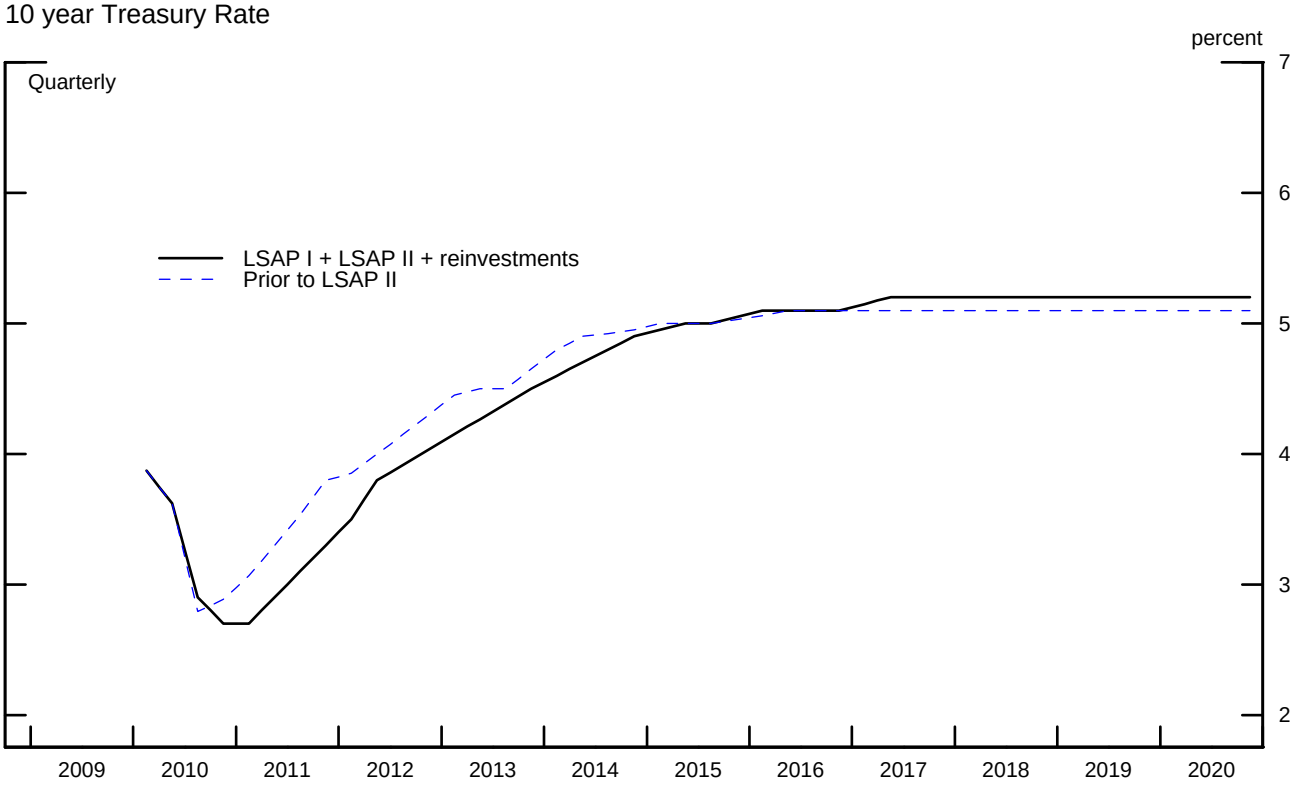


Figure 9 - LSAP II
Term Premium Effects

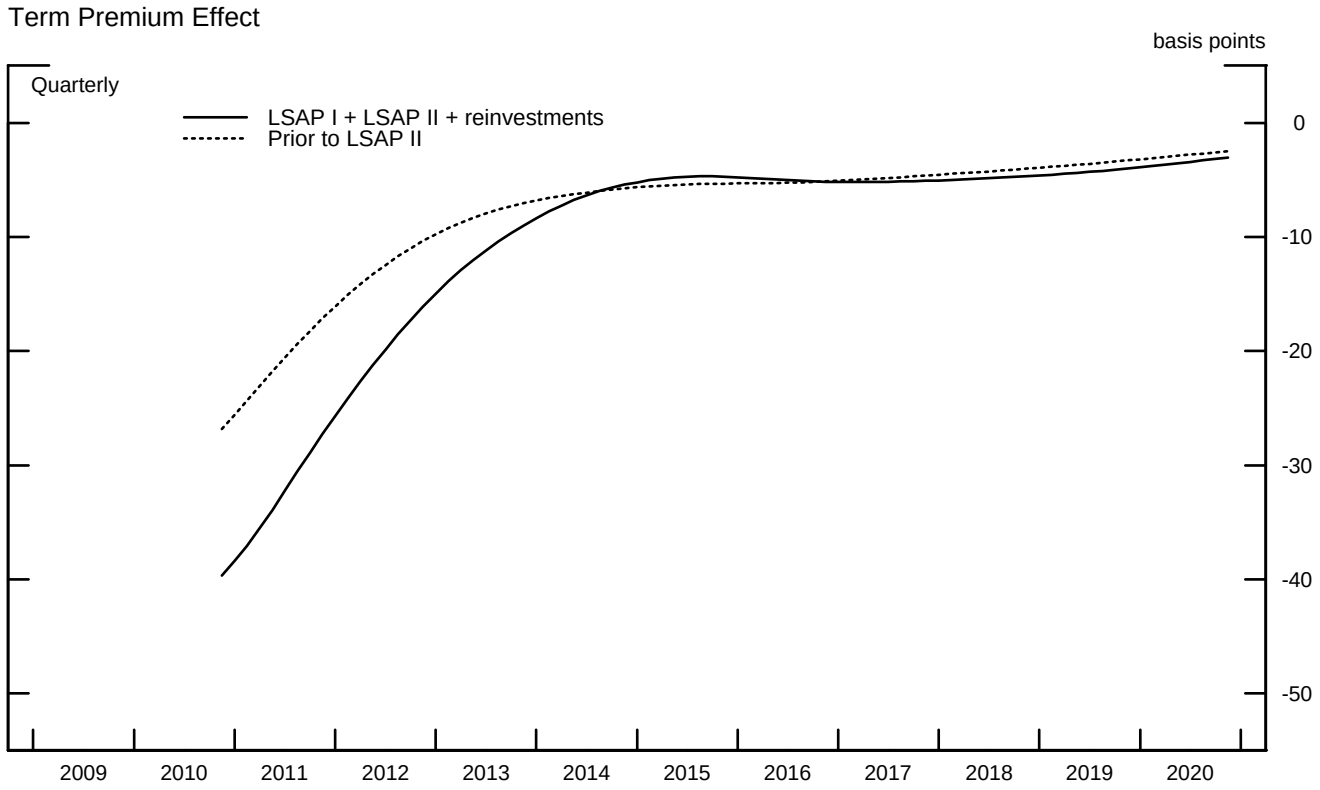


Figure 10 - MEP & MBS Reinvestments

Select Assets of the Balance Sheet

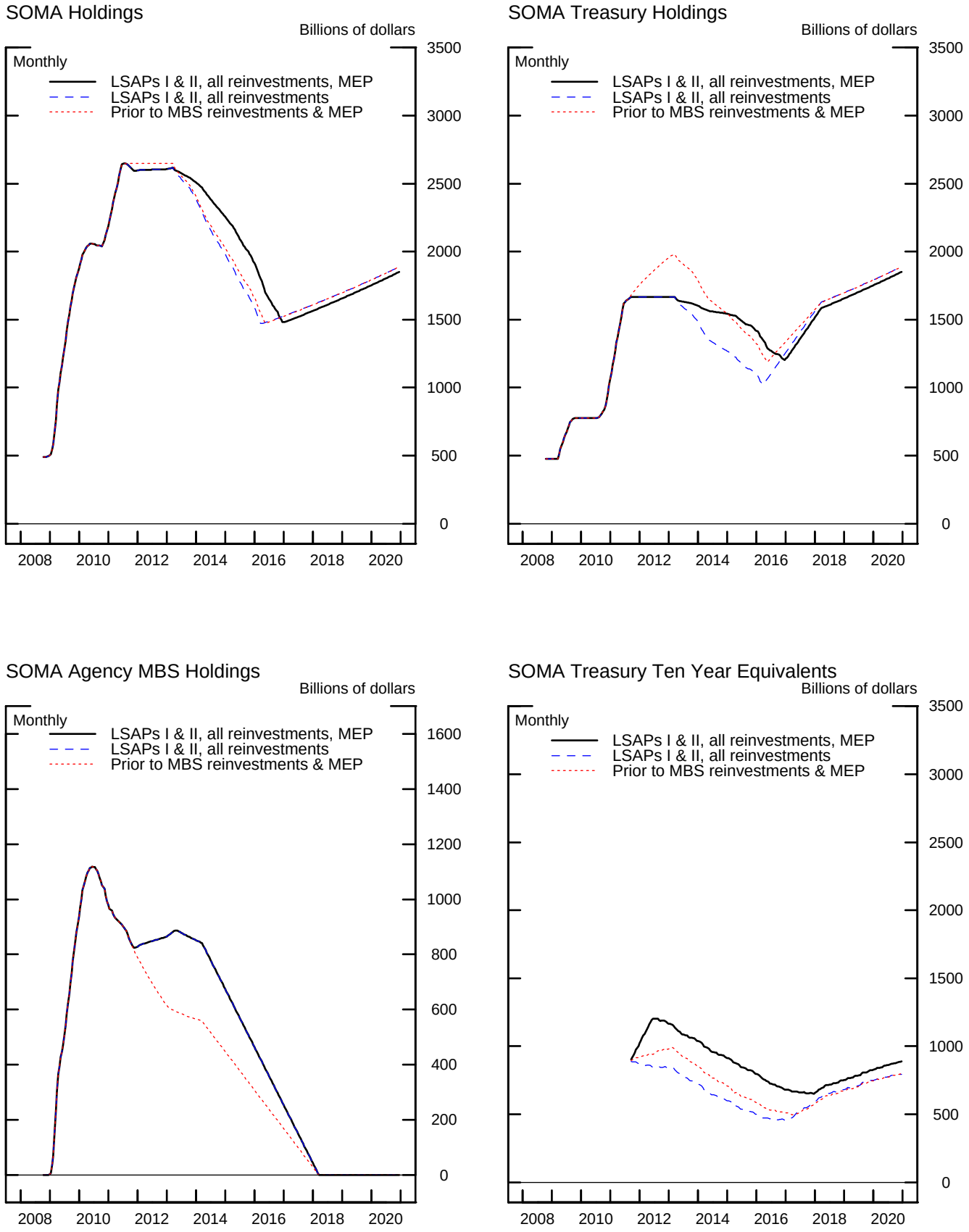
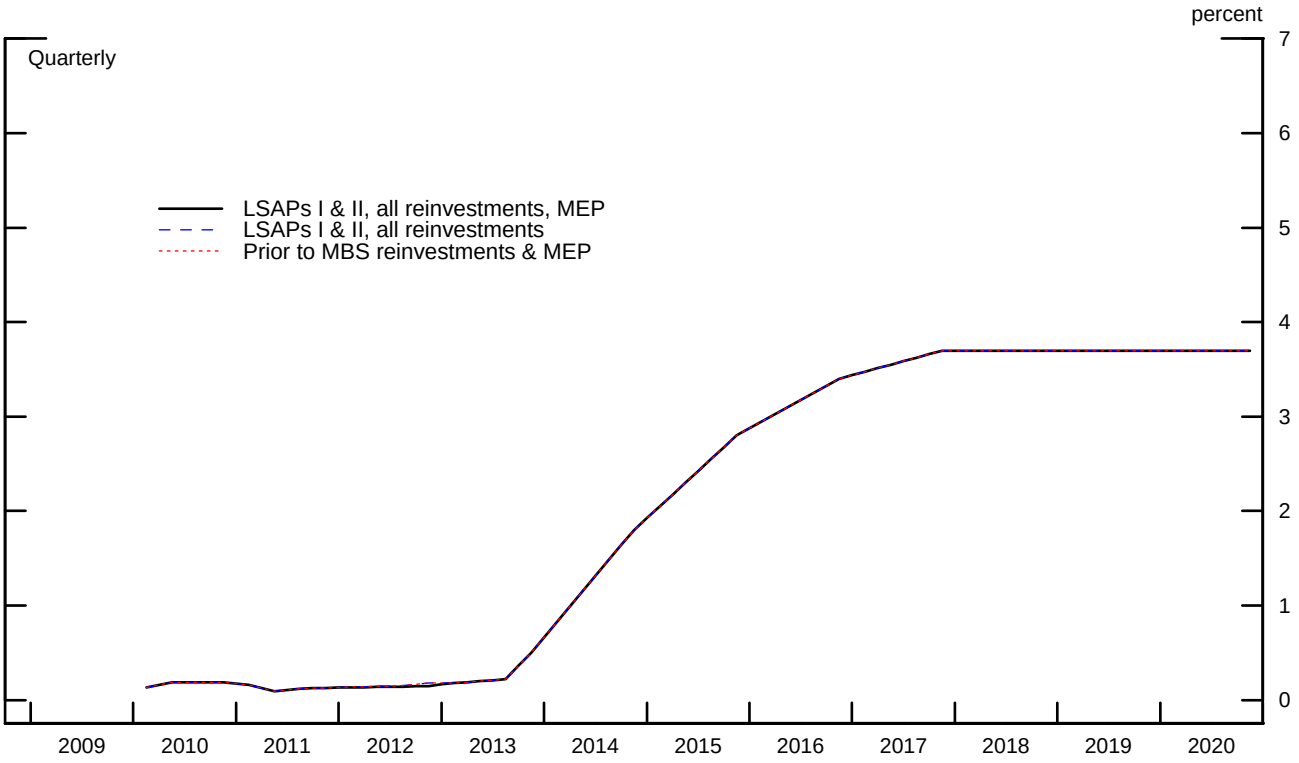
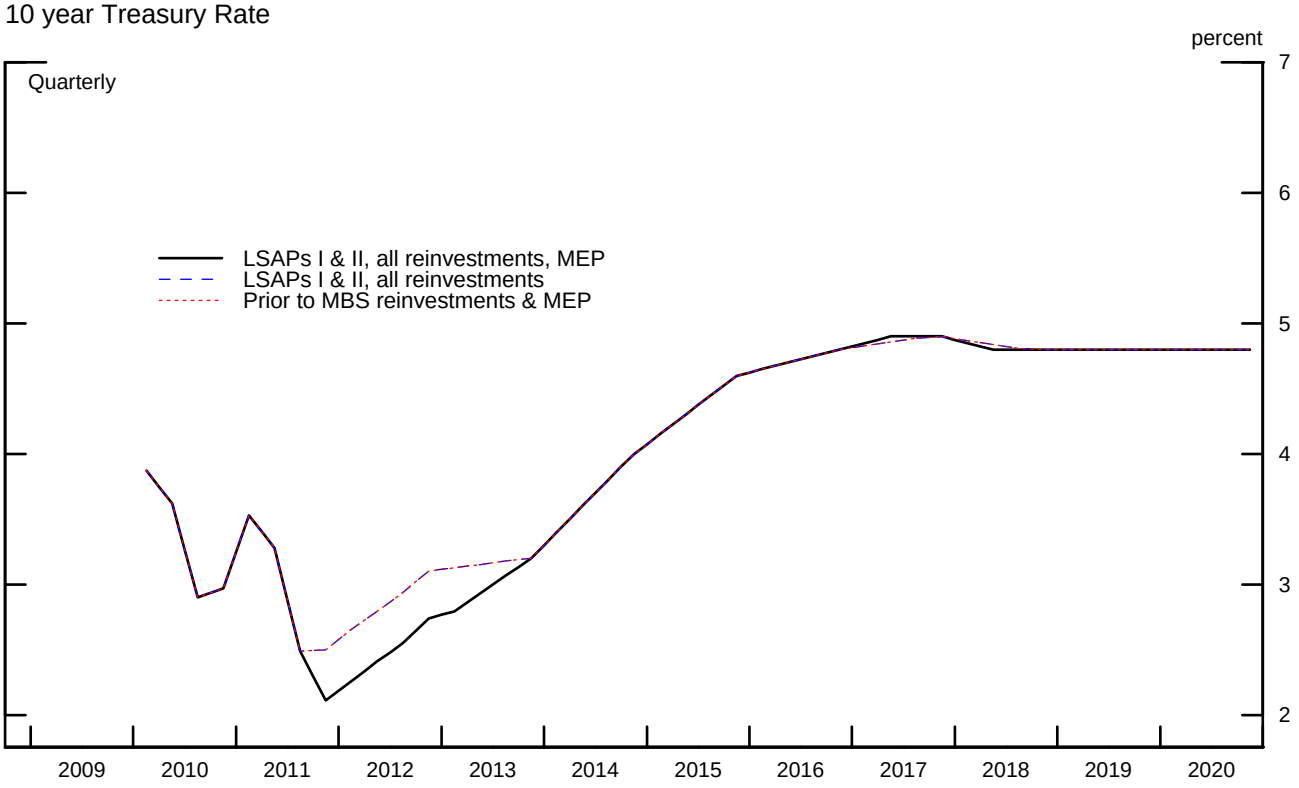


Figure 11 - MEP & MBS Reinvestments
Interest Rates

Federal Funds Rate



10 year Treasury Rate



May 18 2012

Figure 12 - MEP & MBS Reinvestments
Term Premium Effects

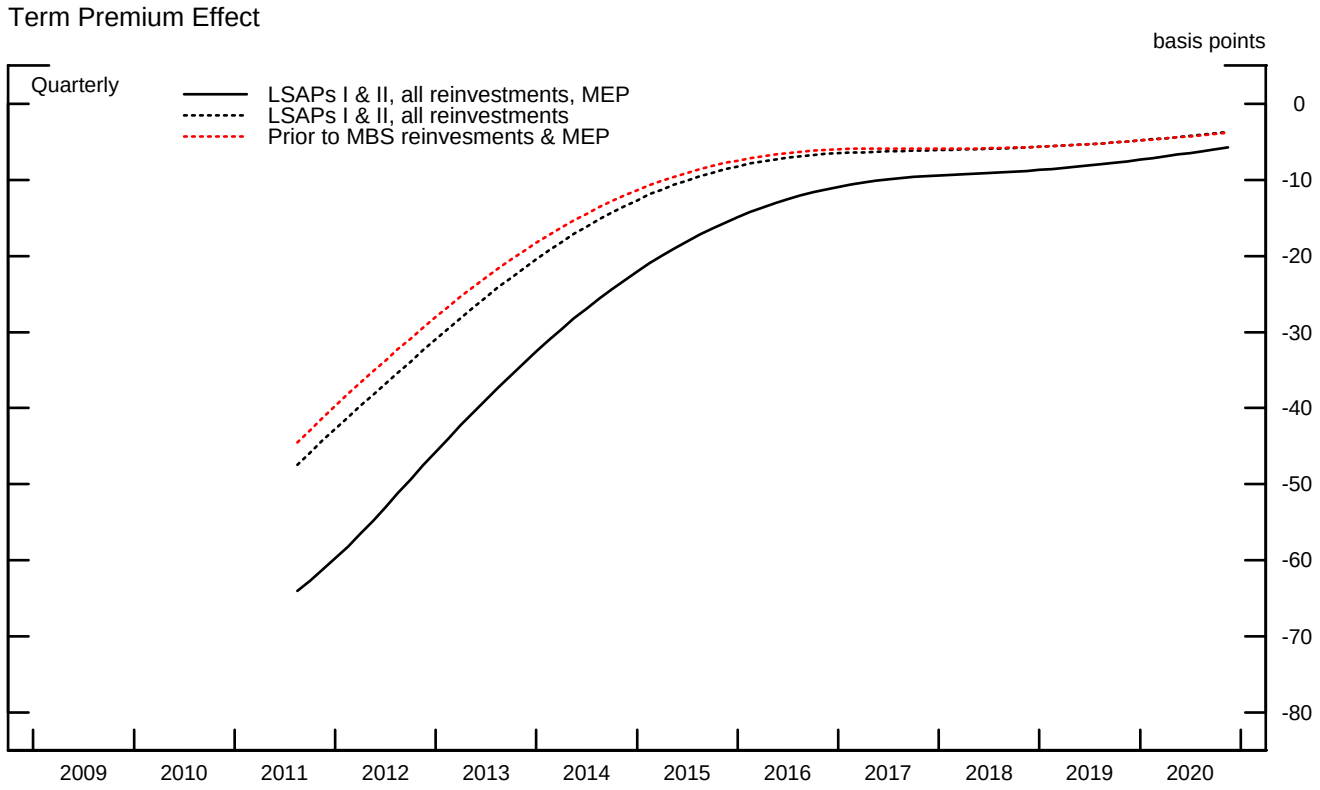


Figure 13 - Current Projections
Select Assets of the Balance Sheet

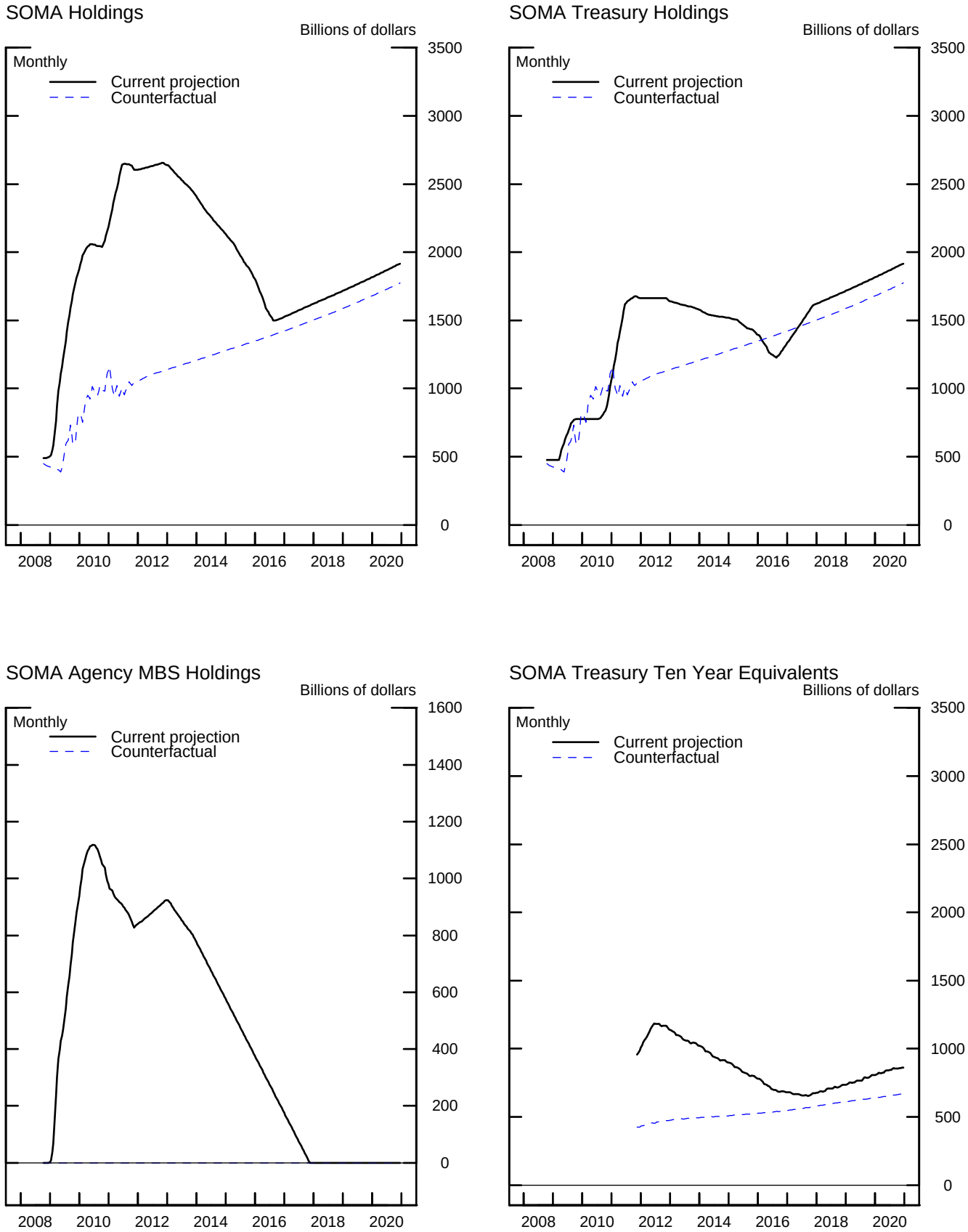
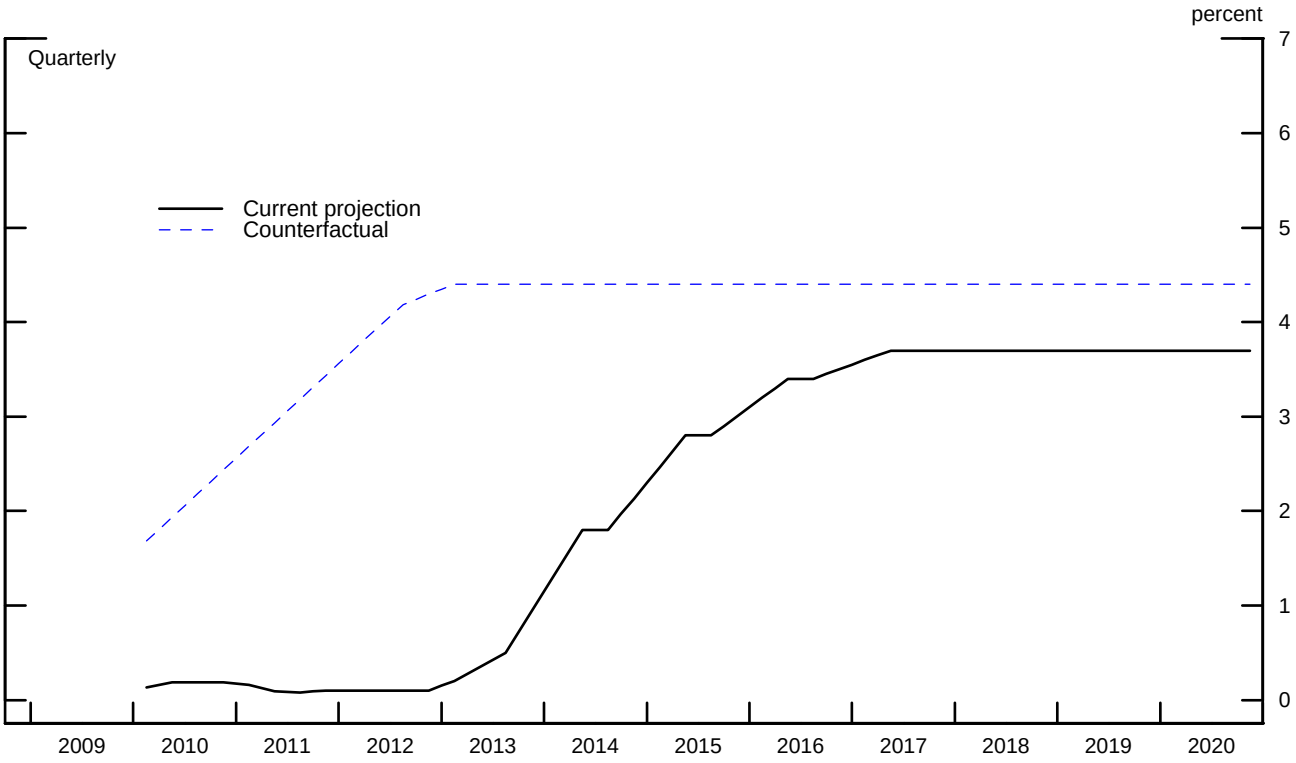
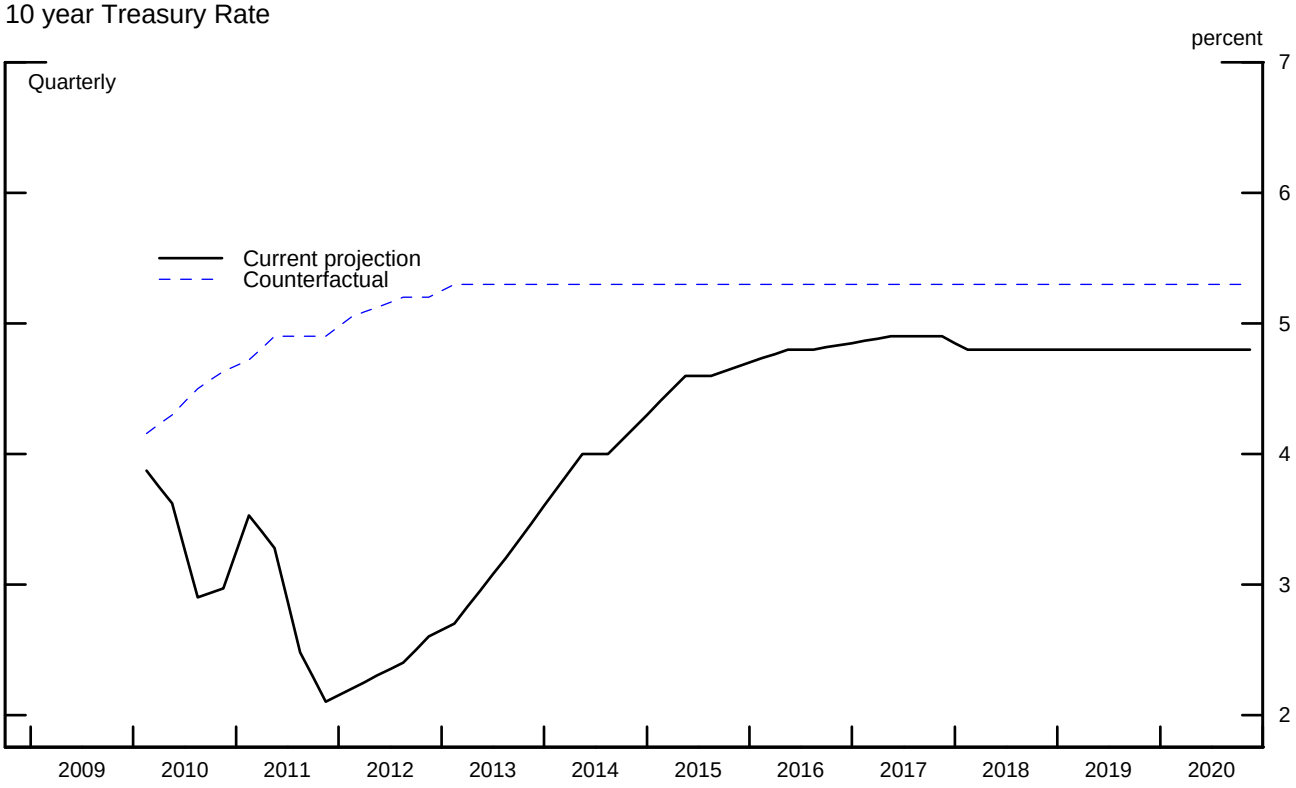


Figure 14 - Current Projections
Interest Rates

Federal Funds Rate



10 year Treasury Rate



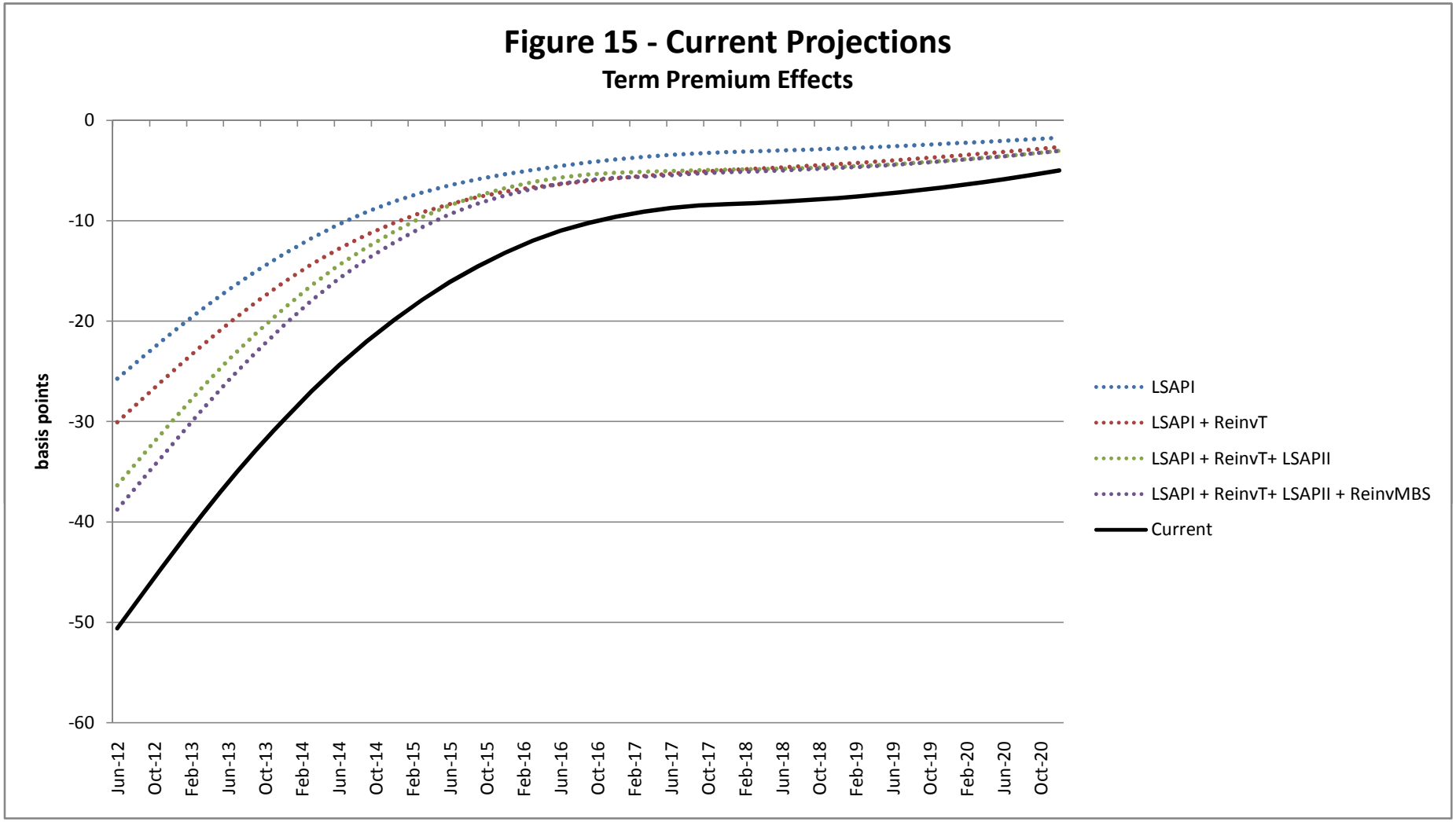


Figure 15 - Current Projections
Term Premium Effects
basis points
0
-10
-20
-30
-40
-50
-60
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
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Jun-19
Oct-19
Feb-20
Jun-20
Oct-20
LSAPI
LSAPI + ReinvT
LSAPI + ReinvT+ LSAPII
LSAPI + ReinvT+ LSAPII + ReinvMBS
Current

Appendix - Growth Rates of Nominal GDP

Scenario	Immediately prior to LSAP 1	Annoucement of extension of LSAP 1	Immediately prior to reinvestments into Treasuries	Annoucement of reinvestments into Treasuries	Annoucement of LSAP 2	Immediately prior to reinvestments into MBS	Annoucement of Reinvestments into MBS	Annoucement of MEP	Current
Short-term Blue Chip Forecast	Nov-08	Apr-09	Jun-10	Sep-10	Dec-10	Sep-11	Sep-11	Oct-11	Novemeber 2011
Long-term Blue Chip Forecast	Jun-08	Jun-09	Jun-10	Dec-10	Dec-10	Dec-11	Dec-11	Dec-11	Dec-11
Date	**Annualized Percentage Rates**								
Dec-08	-0.44	-8.71	-8.71	-8.71	-8.71	-8.71	-8.71	-8.71	-8.71
Mar-09	0.69	-5.34	-5.34	-5.34	-5.34	-5.34	-5.34	-5.34	-5.34
Jun-09	2.14	1.69	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14
Sep-09	3.35	3.07	1.92	1.92	1.92	1.92	1.92	1.92	1.92
Dec-09	3.90	3.76	4.80	4.80	4.80	4.80	4.80	4.80	4.80
Mar-10	4.50	4.16	5.41	5.41	5.41	5.41	5.41	5.41	5.41
Jun-10	5.00	4.10	4.25	5.32	5.32	5.32	5.32	5.32	5.32
Sep-10	5.00	4.40	4.42	3.11	3.81	3.81	3.81	3.81	3.81
Dec-10	5.00	4.60	4.48	3.56	3.60	4.10	4.10	4.10	4.10
Mar-11	5.20	5.00	4.67	4.08	4.00	3.06	3.06	3.06	3.06
Jun-11	5.20	5.00	4.73	4.20	4.08	3.90	3.90	3.90	3.90
Sep-11	5.20	5.00	4.93	4.54	4.52	3.75	3.75	3.75	4.35
Dec-11	5.20	5.00	4.90	4.74	4.70	3.91	3.91	3.76	4.50
Mar-12	5.10	5.20	5.20	5.00	5.00	4.07	4.07	3.96	3.90
Jun-12	5.10	5.20	5.20	5.00	5.00	4.35	4.35	4.21	4.00
Sep-12	5.10	5.20	5.20	5.00	5.00	4.68	4.68	4.53	4.40
Dec-12	5.10	5.20	5.20	5.00	5.00	4.90	4.90	4.68	4.70
Mar-13	5.10	5.10	5.10	5.20	5.20	5.20	5.20	4.92	4.70
Jun-13	5.10	5.10	5.10	5.20	5.20	5.20	5.20	5.20	4.80
Sep-13	5.10	5.10	5.10	5.20	5.20	5.20	5.20	5.20	4.90
Dec-13	5.10	5.10	5.10	5.20	5.20	5.20	5.20	5.20	4.93
Mar-14	5.10	5.10	5.00	5.10	5.10	5.10	5.10	5.10	4.97
Jun-14	5.10	5.10	5.00	5.10	5.10	5.10	5.10	5.10	5.00
Sep-14	5.10	5.10	5.00	5.10	5.10	5.10	5.10	5.10	5.00
Dec-14	5.10	5.10	5.00	5.10	5.10	5.10	5.10	5.10	5.03
Mar-15	5.10	5.30	5.00	5.00	5.00	5.00	5.00	5.00	5.07
Jun-15	5.10	5.30	5.00	5.00	5.00	5.00	5.00	5.00	5.10
Sep-15	5.10	5.30	5.00	5.00	5.00	5.00	5.00	5.00	5.10
Dec-15	5.10	5.30	5.00	5.00	5.00	5.00	5.00	5.00	5.10
Mar-16	5.10	5.00	4.90	4.90	4.90	4.90	4.90	4.90	5.10
Jun-16	5.10	5.00	4.90	4.90	4.90	4.90	4.90	4.90	5.10
Sep-16	5.10	5.00	4.90	4.90	4.90	4.90	4.90	4.90	5.10
Dec-16	5.10	5.00	4.90	4.90	4.90	4.90	4.90	4.90	5.07
Mar-17	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	5.03
Jun-17	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	5.00
Sep-17	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	5.00
Dec-17	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	5.00
Mar-18	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Jun-18	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Sep-18	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Dec-18	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Mar-19	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Jun-19	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Sep-19	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Dec-19	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Mar-20	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Jun-20	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Sep-20	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70
Dec-20	5.10	5.00	4.80	4.70	4.70	4.70	4.70	4.70	4.70