Measuring the Effects of Unconventional Monetary Policy on Asset Prices

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On 16 December 2008, the U.S. Federal Reserve's Federal Open Market Committee (FOMC) lowered the federal funds rate—its traditional monetary policy instrument—to essentially zero in response to the most severe U.S. financial crisis since the Great Depression. Because U.S. currency carries an interest rate of zero, it is essentially impossible for the FOMC to target a value for the federal funds rate that is substantially less than zero. Faced with this zero lower bound (ZLB) constraint, the FOMC subsequently began to pursue alternative, "unconventional" monetary policies, with particular emphasis on forward guidance and large-scale asset purchases (defined below). In this paper, I propose a new method to identify and estimate the effects of these two main types of unconventional monetary policy.

Understanding the effects of unconventional monetary policy is an important topic for both policymakers and researchers. Many central banks around the world have found themselves constrained by the zero lower bound on short-term nominal interest rates. Central banks faced with this constraint must pursue unconventional monetary policy if they wish to affect financial markets and/or the economy. Understanding the effects of different types of unconventional monetary policy, then, allows policymakers and researchers to better understand the efficacy, strengths, and weaknesses of the various alternatives.

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The effectiveness of unconventional monetary policy is also an important determinant of the costs of the zero lower bound constraint. If unconventional monetary policy is relatively ineffective, then the ZLB constraint is more costly, and policymakers should go to greater lengths to prevent hitting the ZLB in the first place—such as by choosing a higher target rate of inflation, as advocated by several authors.[1] On the other hand, if unconventional monetary policy is very effective, then the ZLB constraint is much less costly and policymakers do not need to take such drastic action to avoid hitting it in the future.

In the present paper, I focus on measuring the effects of forward guidance and large-scale asset purchases in particular, since those were the two types of unconventional monetary policy used most extensively by the Federal Reserve during the recent U.S. ZLB period. The term forward guidance refers to communication by the FOMC about the likely future path of the federal funds rate over the next several quarters or years. Large-scale asset purchases (or LSAPs) refers to purchases by the Federal Reserve of hundreds of billions of dollars' worth of longer-term assets, such as long-term U.S. Treasury securities and mortgage-backed securities. The goals of both policies was to lower longer-term U.S. interest rates using methods other than changes in the current federal funds rate. Both types of unconventional monetary policy were used extensively by the Federal Reserve, as can be seen in table 1. In addition to the major unconventional monetary policy announcements listed in table 1, there was incremental news about these policies that was released to financial markets at almost every FOMC meeting, such as updates that a policy was ongoing, was likely to be continued, or might be adjusted.

A major challenge in identifying and estimating the effects of the unconventional monetary policy announcements by the FOMC is determining the size and type of each announcement. For example, many of the statements in table 1 were at least partially anticipated by financial markets prior to their official release. Because financial markets are forward-looking, the anticipated component of each announcement should not have any effect on asset prices; only the unanticipated component should be news to financial markets and have an effect. But determining the size of the unexpected component

1. For example, Summers (1991); Blanchard, Dell'Ariccia, and Mauro (2010); Ball (2014). See also Blanchard, as quoted by Bob Davis, "Q&A: IMF's Blanchard Thinks the Unthinkable," *Wall Street Journal*, 11 February 2010, Real Time Economics blog.

of each announcement in table 1 is very difficult, because there are no good data on what financial markets expected the outcome of each FOMC announcement to be.[2]

Table 1. Major Unconventional Monetary Policy Announcements by the Federal Reserve, 2009–2015

March 18, 2009	FOMC announces it expects to keep the federal funds rate between 0 and 25 basis points (bp) for "an extended period", and that it will purchase $750B of mortgage-backed securities, $300B of longer-term Treasuries, and $100B of agency debt (a.k.a. "QE1")
November 3, 2010	FOMC announces it will purchase an additional $600B of longer-term Treasuries (a.k.a. "QE2")
August 9, 2011	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through mid-2013"
September 21, 2011	FOMC announces it will sell $400B of short-term Treasuries and use the proceeds to buy $400B of long-term Treasuries (a.k.a. "Operation Twist")
January 25, 2012	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through late 2014"
September 13, 2012	FOMC announces it expects to keep the federal funds rate between 0 and 25 bp "at least through mid-2015", and that it will purchase $40B of mortgage-backed securities per month for the indefinite future
December 12, 2012	FOMC announces it will purchase $45B of longer-term Treasuries per month for the indefinite future, and that it expects to keep the federal funds rate between 0 and 25 bp at least as long as the unemployment rate remains above 6.5 percent and inflation expectations remain subdued
December 18, 2013	FOMC announces it will start to taper its purchases of longer-term Treasuries and mortgage-backed securities to paces of $40B and $35B per month, respectively
December 17, 2014	FOMC announces that "it can be patient in beginning to normalize the stance of monetary policy"

2. In contrast, for conventional monetary policy—changes in the federal funds rate—federal funds futures and other short-term financial market instruments provide very good measures of market expectations leading up to each announcement. See Kuttner (2001) and Gürkaynak, Sack, and Swanson (2005, 2007).

A closely related issue is that the FOMC can sometimes surprise markets through its inaction rather than its actions. For example, on 18 September 2013, financial markets widely expected the FOMC to begin tapering its LSAPs, but the FOMC decided not to do so, surprising markets and leading to a large effect on asset prices despite the fact that no action was announced.[3] This implies that even dates not listed in table 1 could have produced a significant surprise in financial markets and led to large effects on asset prices and the economy.

Determining the type of any given announcement—forward guidance versus LSAP—can also be very difficult. For example, many announcements in table 1 clearly contain significant news about both types of policies, which makes disentangling the news on those dates challenging. Even in the case of a seemingly clear-cut announcement, both types of policies may be at work: in particular, several authors argue that LSAPs affect the economy by changing financial market expectations about the future path of the federal funds rate (for example, Woodford, 2012; Bauer and Rudebusch, 2014). To the extent that this channel is operative, even a pure LSAP announcement would have important forward guidance implications. This makes disentangling the two types of policies even more difficult than it might at first seem.

In this paper, I address these problems by adapting the methods of Gürkaynak, Sack, and Swanson (2005, henceforth GSS) to the zero lower bound period in the United States, from 2009 to 2015. The problem GSS faced was similar to the problem I face here, in that they were interested in separately identifying the effects of two dimensions of monetary policy: changes in the current federal funds rate versus changes in FOMC forward guidance. In the zero lower bound environment I consider here, there are also two dimensions of monetary policy: changes in forward guidance and LSAPs. Changes in the current federal funds rate are not a significant component of monetary policy during this period because of the zero lower bound constraint on the funds rate.

Following GSS, I look at how financial markets responded in a thirty-minute window bracketing each FOMC announcement between 2009 and 2015, and compute the first two principal components of those

3. For example, in an article entitled “No Taper Shocks Wall Street,” the *Wall Street Journal* reported that “Bernanke had a free pass to begin that tapering process and chose not to follow [through]. . . The Fed had the market precisely where it needed to be. The delay today has the effect of raising the benchmark to tapering” (Steven Rusolillo, “No Taper Shocks Wall Street: Fed ‘Running Scared’,” *Wall Street Journal*, 18 September 2013, MoneyBeat).

asset price responses. The idea is that forward guidance and LSAPs were by far the two most important components of FOMC announcements for financial markets, so their effects should be well captured by the first two principal components of the asset price responses. I then search over all possible rotations of these two principal components to find the specification in which one of the two factors has the clearest interpretation as a forward guidance factor, using the estimated effect of forward guidance from the pre-ZLB period (computed exactly as in GSS) as the benchmark for what the effects of forward guidance should look like. The remaining, orthogonal factor can then be interpreted as the second main dimension of monetary policy during this period. I interpret this second factor as measuring the FOMC LSAP announcements and present evidence that supports this interpretation. For example, I plot both of these factors—forward guidance and LSAPs—over time and show that they fit identifiable features of major FOMC announcements over the period quite well. In this way, I separately identify the size of the forward guidance and LSAP component of every FOMC announcement between January 2009 and June 2015.

Once the FOMC forward guidance and LSAP announcements are identified, it is then straightforward to estimate the effects of each type of announcement on the high-frequency response of different types of asset prices around those announcements.

The remainder of the paper proceeds as follows. Section 1 reviews the analytical methods of GSS, shows how to adapt them to the recent ZLB period, and describes the data. In section 2, I perform the principal component analysis and rotate the factors as described above. I plot the estimated factors over time and discuss their relationship to identifiable features of major announcements by the FOMC over the ZLB period, showing that my estimates of forward guidance and LSAP announcements seem to be well identified and informative. In section 3, I estimate the effects of these announcements on Treasury yields, stock prices, exchange rates, and corporate bond yields and spreads. In section 5, I discuss the implications of my findings for monetary policy going forward.

1. Methods and Data

My methods in the present paper consist of two main steps. First, I extend the analysis of Gürkaynak, Sack, and Swanson (2005) through 16 December 2008, which was the last time the FOMC announced a change in the federal funds rate target. (After that date, the federal funds rate was essentially at a level of zero, and the FOMC was unable or unwilling to lower it any further.) This allows me to identify and estimate the effects of changes in the federal funds rate and changes in forward guidance in normal times, before the ZLB began to bind.[4] Second, I adapt the methods of GSS to the ZLB period from January 2009 through June 2015, during which the FOMC never changed the current federal funds rate target but made multiple unconventional monetary policy announcements involving forward guidance and large-scale asset purchases, as noted in table 1. I thus use the GSS methods, applied to the ZLB sample, to identify and estimate the effects of forward guidance and LSAPs during this later period.

I extend the GSS dataset through June 2015 using data obtained from staff at the Federal Reserve Board. The combined dataset includes the date of each FOMC announcement from July 1991 through June 2015, together with the change in a number of asset prices in a thirty-minute window bracketing each announcement.[5] The asset prices include federal funds futures rates (contracts with expiration at the end of the current month and each of the next five months), Eurodollar futures rates (contracts with expiration near the end of the current quarter and each of the next seven quarters), Treasury bond yields (for the three-month, six-month, and two-, five-, ten-, and thirty- year maturities), the stock market (as measured by the S&P 500), and the U.S. dollar-yen and dollar-euro exchange rates.

To replicate the GSS analysis over the pre-ZLB period, I focus on the responses of the first and third federal funds futures contracts, the second, third, and fourth Eurodollar futures contracts, and the two-, five-, and ten-year Treasury yields to each FOMC announcement from July 1991 through December 2008. The two federal funds futures contracts can be scaled so as to provide good estimates of the market

4. My results are very similar if I end the sample in December 2004, as GSS did, or in December 2007.

5. The window begins 10 minutes before the FOMC announcement and ends 20 minutes after the FOMC announcement. The data set also includes the dates and times of FOMC announcements and some intraday asset price responses going back to January 1990, but the data for Treasury yield responses begin in July 1991, and those data are an important part of my analysis. Also, as is standard in the literature, I exclude the FOMC announcement on 17 September 2001, which took place after financial markets had been closed for several days following the 11 September terrorist attacks. I also include the Federal Reserve Board's announcement on 25 November 2008 that it would begin purchasing mortgage-backed securities and GSE debt (the beginning of "QE1")—although this announcement was not made by the FOMC itself, all subsequent asset purchase announcements were made by the FOMC, so I include it with those others. However, including or excluding this announcement does not noticeably affect any of my results.

expectation of what the federal funds rate will be after the current and next FOMC meetings (see GSS, 2005, for details). The second through fourth Eurodollar futures contracts provide information about the market expectation of the path of the federal funds rate over the horizon from about four months to one year ahead.[6] The two-, five-, and ten-year Treasury yields provide information about interest rate expectations and risk premiums over longer horizons, about one to ten years.

These asset price responses to FOMC announcements can be written as a matrix **X**, with rows of *X* corresponding to FOMC announcements and columns of *X* corresponding to different futures rates and Treasury yields. Since there are 159 FOMC announcements from July 1991 through December 2008, and I focus on eight asset price responses, the matrix **X** has dimensions 159 × 8.

As in GSS, I use principal component analysis to estimate the two factors that make the most important contribution to the variation in **X**. The idea is that the asset price responses in **X** are well described by a factor model,

$$\mathbf{X} = \mathbf{F}\boldsymbol{\Lambda} + \boldsymbol{\varepsilon}, \tag{1}$$

where **F** is a 159 × 2 matrix containing two factors, $\boldsymbol{\Lambda}$ is a 2 × 8 matrix of loadings of the asset price responses on the two factors, and $\boldsymbol{\varepsilon}$ is a 159 × 8 matrix of white noise residuals. Letting **F** denote the first two principal components of **X**, the two columns of **F** represent the two components of the FOMC announcements that have had the greatest impact on the assets in **X** over the period from July 1991 to December 2008.

6. The reason for focusing on some rather than all of the possible futures contract rates in the data set is to avoid overlapping contracts as much as possible, since they are highly correlated for technical rather than policy-related reasons. When I conduct the principal components analysis of the data below, futures contracts that are highly correlated will tend to show up as a common factor, which would not be interesting if the correlation was generated by overlapping contracts rather than by the way monetary policy is conducted. For example, FOMC announcements are generally spaced six to eight weeks apart, so there is essentially no gain to including the second federal funds futures contract in addition to the first—the second contract is very highly correlated with the first federal funds futures contract, once the latter contract has been scaled to represent the outcome of the current FOMC meeting. Similarly, including the first Eurodollar futures contract would provide essentially no additional information beyond the first and third federal funds futures contracts. I follow GSS and switch from federal funds futures to Eurodollar futures contracts at a horizon of about two quarters because Eurodollar futures were much more liquid over this sample than longer-maturity federal funds futures, and they are thus likely to provide a better measure of financial market expectations at those longer horizons (see Gürkaynak, Sack, and Swanson, 2007).

Although the first two principal components of **X** explain a maximal fraction of the variation in **X**, they are only a statistical decomposition and typically do not have a structural interpretation. To associate one column of **F** with changes in the federal funds rate and the other column with changes in forward guidance—which is a structural interpretation—it is necessary to transform the factor matrix **F** so that it fits this interpretation.

Given this goal, if **F** and **Λ** characterize the data **X** in equation (1), and **U** is any 2 × 2 orthogonal matrix, then the matrix $\tilde{\mathbf{F}} \equiv \mathbf{FU}$ and loadings $\tilde{\mathbf{\Lambda}} \equiv \mathbf{U}'\mathbf{\Lambda}$ represent an alternative factor model that fits the data **X** exactly as well as **F** and **U**, in the sense that it produces exactly the same residuals **ε** in equation (1).[7] Ideally, the two columns of **F** would correspond to changes in the federal funds rate and changes in the FOMC forward guidance, as mentioned above. Although the first two principal components of **X** do not in general have this interpretation, it is possible to choose a rotation matrix **U** such that the rotated factors $\tilde{\mathbf{F}}$ do have such an interpretation. In particular, it is possible to choose **U** such that if $\tilde{f}_1$ and $\tilde{f}_2$ are the two columns of $\tilde{\mathbf{F}}$, then $\tilde{f}_2$ has no effect on the current federal funds rate.[8] This implies that all of the variation in the current federal funds rate (up to the white noise residuals **ε**) in response to FOMC announcements is due to changes in the first factor, $\tilde{f}_1$. The factor $\tilde{f}_1$ can thus be interpreted as the surprise component of the FOMC change in the federal funds rate target. The second factor, $\tilde{f}_2$, then corresponds to all of the other information in the FOMC announcements, above and beyond the surprise change in the funds rate, that changed financial market expectations about the future path of the funds rate. Thus, $\tilde{f}_2$ can be thought of as forward guidance by the FOMC.[9] As GSS show, the second factor $\tilde{f}_2$, identified in this way, corresponds closely to important changes in the FOMC statements about the outlook for the future path of monetary policy, supporting the interpretation of $\tilde{f}_2$ as the change in the FOMC forward guidance.

I next adapt this methodology to the zero lower bound period in the United States, from January 2009 to June 2015. As in GSS and

7. The scale of **F** and **Λ** are also indeterminate: if k is any scalar, then $k\mathbf{F}$ and $\mathbf{\Lambda}/k$ also fit the data **X** exactly as well as **F** and **Λ**. Traditionally, the scale of **F** is normalized so that each column has unit variance.

8. In other words, $\tilde{\lambda}_{21} = 0$, where $\tilde{\lambda}_{ij}$ denotes the (i, j)th element of $\tilde{\mathbf{\Lambda}}$, so the current-month federal funds futures contract is not affected by changes in the second factor.

9. GSS called $\tilde{f}_1$ the target factor and $\tilde{f}_2$ the path factor, because it relates to the future path of the federal funds rate, but the latter is now typically referred to as forward guidance.

discussed above, I create a data matrix $\mathbf{X}$ with rows corresponding to FOMC announcements between January 2009 and June 2015 and columns corresponding to the responses of different futures rates and bond yields in a narrow, thirty-minute window bracketing each announcement. However, I exclude the first and third federal funds futures contracts and the second Eurodollar futures contract from the analysis, because those contracts have such short maturities that they essentially do not respond to news in the ZLB period.[10] The matrix $\mathbf{X}$ that I construct for the ZLB sample thus has dimensions 52×5, corresponding to the 52 FOMC announcements over this period, and five different asset price responses: the third and fourth Eurodollar futures contracts and the two-, five-, and ten-year Treasury yields.

As in GSS and discussed above, I extract the first two principal components from the matrix $\mathbf{X}$. These are the two features of FOMC announcements between 2009 and mid-2015 that moved the five yields listed above the most. As before, these two principal components do not have a structural interpretation in general. Let $\mathbf{F}^{zlb}$ denote the 52×2 matrix of principal components, let $\mathbf{U}$ be a 2×2 orthogonal matrix, let $\tilde{\mathbf{F}}^{zlb} \equiv \mathbf{F}^{zlb}\mathbf{U}$, and let $\tilde{f}_1^{zlb}$ and $\tilde{f}_2^{zlb}$ denote the first and second columns of $\tilde{\mathbf{F}}^{zlb}$. I search over all possible rotation matrices $\mathbf{U}$ to find the one where the first rotated factor $\tilde{f}_1^{zlb}$ is as close as possible (in terms of its asset price effects) to the forward guidance factor $\tilde{f}_2$ estimated previously (over the 1991–2008 sample).[11] The identifying assumption is thus that the effect of forward guidance on medium- and longer-term interest rates during the ZLB period is about the same as it was during the pre-ZLB period from 1991–2008. The remaining factor, $\tilde{f}_2^{zlb}$, then corresponds to the component of FOMC announcements, above and beyond changes in forward guidance, that have the biggest effect on medium- and longer-term interest rates. It is natural to interpret this second factor as corresponding to FOMC large-scale asset purchases.

The crucial assumption underlying this identification is that forward guidance has essentially the same effects on medium- and

10. The first and third federal funds futures contracts correspond to federal funds rate expectations over the next one and three months, respectively, and the second Eurodollar futures contract corresponds to funds rate expectations from about three to six months ahead. As shown by Swanson and Williams (2014), interest rates at these short maturities essentially stopped responding systematically to news from 2009 to 2012 (the end of their sample), and this remains true through about mid-2015.

11. In other words, I choose the rotation matrix $\mathbf{U}$ that matches the factor loadings $\tilde{\lambda}_{11}^{zlb}$, $\tilde{\lambda}_{12}^{zlb}$, $\tilde{\lambda}_{13}^{zlb}$, $\tilde{\lambda}_{14}^{zlb}$, and $\tilde{\lambda}_{15}$ to $\tilde{\lambda}_{24}$, $\tilde{\lambda}_{25}$, $\tilde{\lambda}_{26}$, $\tilde{\lambda}_{27}$, and $\tilde{\lambda}_{28}$ as closely as possible, in the sense of minimum Euclidean distance.

longer-term interest rates before and after the ZLB. This assumption is subject to debate, but it provides a natural starting point for my analysis and in fact seems to work very well, as I show below. Thus, for every FOMC announcement from January 2009 through June 2015, I can separately identify the forward guidance component and the LSAP component of that announcement. Once I have separately identified the two components, it is straightforward to estimate the effects of each component on asset prices using ordinary least squares regressions.

2. The FOMC Forward Guidance and LSAP Announcements

I now report the results of these methods applied to the pre-ZLB and ZLB periods.

2.1 Federal Funds Rate and Forward Guidance Factors before the ZLB

Table 2 reports the rotated loading matrices $\tilde{\mathbf{\Lambda}}$ from the estimation procedure described above. The first two rows report results for the pre-ZLB period, July 1991 to December 2008. Each factor, $\tilde{f}_1$ and $\tilde{f}_2$, is normalized to have a unit standard deviation over this sample, so the coefficients in the table are in units of basis points per standard-deviation change in the monetary policy instrument. A one-standard-deviation increase in the federal funds rate over this period is estimated to cause the current federal funds rate to rise by about 8.6 basis points, the expected federal funds rate at the next FOMC meeting to rise about 6.2 basis points, the second through fourth Eurodollar futures rates to rise by 5.9, 5.6, and 4.8 basis points, respectively, and the two-, five-, and ten-year Treasury yields to increase by 3.8, 1.9, and 0.7 basis points, respectively. The effects of a surprise change in the federal funds rate are thus largest at the short end of the yield curve and die off monotonically as the maturity of the interest rate increases.

Table 2. Estimated Effects of Conventional and Unconventional Monetary Policy Announcements on Interest Rates before and after Dec. 2008

	MP1	*MP2*	*ED2*	*ED3*	*ED4*	*2y Tr.*	*5y Tr.*	*10y Tr.*
July 1991–Dec. 2008:								
(1) change in federal funds rate	8.55	6.23	5.88	5.59	4.81	3.79	1.91	0.68
(2) change in forward guidance	0	1.18	4.23	5.42	6.12	5.08	5.2	4.02
Jan. 2009–June 2015:								
(3) change in forward guidance	-	-	-	3.18	4.15	3.33	4.24	2.35
(4) change in LSAPs	-	-	-	−0.73	−0.99	−1.27	−4.9	−7.46
memo:								
(5) row 3, rescaled	-	-	-	4.68	6.11	4.89	6.24	3.45

Coefficients in the table correspond to elements of the loading matrix Λ from equation (1), in basis points per standard deviation change in the monetary policy instrument (except for row 5, which is rescaled).MP1 and MP2 denote scaled changes in the first and third federal funds futures contracts, respectively; ED2, ED3, and ED4 denote changes in the second through fourth Eurodollar futures contracts; and 2y, 5y, and10y Tr. denote changes in 2-, 5-, and 10-year Treasury yields. See text for details.

The effects of forward guidance, in the second row, are quite different. By construction, a shock to the forward guidance factor has no effect on the current federal funds rate. At longer maturities, however, the forward guidance factor's effects increase, peaking at a horizon of about one year, and then dying off slightly for longer maturities. Thus, changes in forward guidance have a roughly hump-shaped effect on the yield curve. For longer-term yields, such as the five- and ten-year yields, changes in forward guidance are a far more important source of variation than are changes in the federal funds rate, as originally emphasized by GSS.

2.2 Forward Guidance and LSAP Factors during the ZLB Period

The third and fourth rows of table 2 report the rotated loadings $\tilde{\mathbf{\Lambda}}$ for the ZLB period from January 2009 through June 2015. The third row reports the effects of a one-standard-deviation change in forward guidance on the third and fourth Eurodollar futures contract and the two-, five-, and ten-year Treasury yields, respectively. By construction, these coefficients match those in the second row as closely as possible, up to a constant scale factor, so the effect of forward guidance is hump-shaped with a peak at intermediate horizons of about one year. For reference, the fifth row of table 2 rescales the coefficients in row 3 so that their correspondence to the second row can be seen more easily.

The fourth row reports the effects of a one-standard-deviation increase in FOMC asset purchases. I normalize the sign of this factor so that an increase in purchases causes interest rates to fall. The effect on yields is relatively small at short and medium horizons, but increases steadily with maturity—exactly the opposite of changes in the current federal funds rate. At a horizon of one year, the effect of LSAPs is only about 1.0 basis point, but for the ten-year Treasury yield, the effect is more than seven times larger, about 7.5 basis points.

2.3 Correspondence of Factors to Notable FOMC Announcements

In the figure, I plot the time series of estimated values of the forward guidance and LSAP factors for each FOMC announcement from January 2009 to June 2015. The dashed line depicts the forward guidance factor, and the solid line the LSAP factor. To make the interpretation of the LSAP factor more intuitive, I scale it by −1 in the figure, so that an increase in LSAPs appears as a negative value; this sign convention implies that positive values in the figure correspond to monetary policy tightenings and negative values to monetary policy easings. The figure also contains brief annotations that help to explain some of the larger observations in the figure.

The largest and most striking observation in the figure is the negative 5.5-standard-deviation LSAP announcement on 18 March 2009, near the beginning of the ZLB sample. This observation corresponds to the announcement of the first LSAP program, often referred to as QE1 in the press.[12] The key elements of this program are listed in table 1, and the announcement seems to have been a major surprise to financial markets, given the huge estimated size of the factor on that date. My identification procedure for forward guidance versus LSAP announcements described above attributes the effects of this announcement to the LSAP factor.

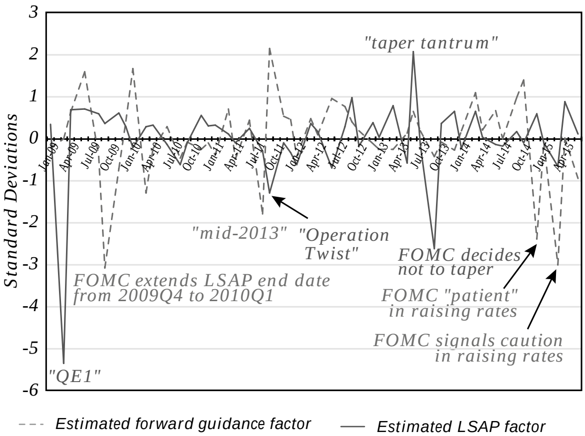
12. The QE1 program began on 25 November 2008, when the Federal Reserve Board announced that it would purchase $600 billion of mortgage-backed securities and $100 billion of debt issued by the mortgage-related government-sponsored enterprises. The term QE1 typically refers to both this earlier program and the huge expansion of that program announced on 18 March 2009.

Given that this FOMC announcement placed such a large emphasis on asset purchases, my identification seems to be working well so far.

The subsequent QE2 program, described in table 1, does not show up as a major event in the figure, perhaps because it was anticipated by financial markets in advance. Looking at the figure around 3 November 2010, the announcement date of the program, there is essentially no estimated effect, because the interest rates included in the estimation responded very little to the announcement. Thus, even though the QE2 announcement was roughly half as large as the earlier QE1 announcement in terms of the quantity of purchases, the surprise component of that announcement appears to have been dramatically smaller.

The next major event in the figure is the negative three-standard-deviation forward guidance announcement on 23 September 2009. On this date, the FOMC stated that it would extend its asset purchase program for an additional three months, through the first quarter of 2010 rather than the fourth quarter of 2009. From the text of the FOMC statement alone, it is unclear whether the announcement should be regarded as forward guidance or LSAPs, or both. However, my identification characterizes this announcement as forward guidance, based on the way financial markets responded (that is, shorter-term interest rates responded more than longer-term interest rates).

Figure. Estimated Forward Guidance and LSAPF Actors, 2009–2015



Plot of estimated forward guidance (dashed line) and LSAP (solid line) factors, $\tilde{f}_1^{zlb}$ and $\tilde{f}_2^{zlb}$, overtime. Notable FOMC announcements are labeled in the figure for reference. The LSAP factor is multiplied by −1 in the figure so that positive values in the figure correspond to interest rate increases. See text for details.

By late 2009, the U.S. economy was beginning to recover, and financial markets expected the FOMC to begin raising the federal funds rate in just a few quarters (Swanson and Williams, 2014), but not until a few meetings after completing its asset purchase program. Thus, an extension of the end date of the LSAP program was taken by markets to imply a correspondingly later liftoff date for the federal funds rate.

Another interesting date in the figure is 9 August 2011. That announcement marked the first time the FOMC gave explicit (rather than implicit) forward guidance about the likely path of the federal funds rate over the next several quarters. In that announcement, described in table 1, the FOMC stated that it expected the current (essentially zero) level of the federal funds rate to be appropriate "at least through mid-2013," a date almost two years in the future. Reassuringly, I estimate the announcement on this date as a negative two-standard-deviation surprise in forward guidance, with essentially no LSAP component.

The next FOMC announcement, on 21 September 2011, corresponds to Operation Twist, a program in which the FOMC sold about $400 billion of short-term Treasury securities in its portfolio and used the proceeds to purchase a like quantity of long-term Treasuries. As shown in the figure, this announcement is estimated to have both LSAP and forward guidance components: a negative 1.3-standard-deviation LSAP effect (which is intuitive), and a positive two-standard-deviation forward guidance effect, which is perhaps surprising. This latter effect is due to the fact that shorter-maturity interest rates rose in response to the FOMC announcement—presumably due to a change in risk premiums on those securities resulting from the large increase in expected sales by the Federal Reserve. Although this is probably not an example of forward guidance by the FOMC per se, it nevertheless looks like forward guidance in the data because of the unusual implication of the announcement for short-term Treasury yields. Thus, even though my identification is arguably missing this subtle distinction on this particular date, the estimates coming out of the identification are intuitive and sensible.

For 19 June 2013, I estimate a substantial, two-standard-deviation decrease in the LSAP factor (which is positive in the figure because it represents a monetary policy tightening). There is little change in the FOMC statement on that date, but as reported by the *Wall Street Journal*, the FOMC released economic projections along with the statement that showed a substantial increase in the FOMC economic outlook. Given earlier remarks by then-Chairman Ben Bernanke that the FOMC could begin tapering its asset purchases soon, markets interpreted this as a signal that a tapering was imminent: for example, "Bond prices slumped, sending the yield on the ten-year Treasury note to its highest level in 15 months, as the Federal Reserve upgraded its growth projections for the U.S. economy.... Stronger U.S. growth is widely perceived in the market as heralding an earlier end to the Fed's program of purchasing $85 billion in bonds each month."[13] Thus, this episode fits into the so-called taper tantrum period during the summer of 2013, and it appears to be correctly identified by my procedure as an increase in interest rates due to the LSAP factor.

The flip side of this announcement occurred on 18 September 2013, when the FOMC was widely expected to begin tapering its asset purchases but opted not to do so. The *Wall Street Journal* reported that "The move, coming after Fed officials spent months alerting the public that they might begin to pare their $85 billion-a-month bond-buying program at the September policy meeting, marks the latest in a string of striking turnabouts from Washington policymakers that have whipsawed markets in recent days."[14] The surprise decision by the FOMC not to taper its asset purchases seems to be correctly identified in my estimates as an increase in LSAPs (depicted as a negative value in figure 1 since it is a monetary policy easing).

Near the end of my sample, on 17 December 2014, markets expected the FOMC to remove its statement that it would keep the federal funds rate at essentially zero "for a considerable time." Not only did the FOMC leave that phrase intact, it announced that "the Committee judges it can be patient in beginning to normalize the stance of monetary policy," which was substantially more dovish than financial markets had expected.[15] This announcement thus appears to be correctly identified by my estimation as a large, 2.5-standard deviation decrease in forward guidance by the FOMC.

13. Katy Burne and Mike Chernev, "Bond Markets Sell Off," *Wall Street Journal*, 19 June 2013, Credit Markets.

14. In an article entitled "No Taper Shocks Wall Street," the *Wall Street Journal* reported that "Bernanke had a free pass to begin that tapering process and chose not to follow [through]. . . The Fed had the market precisely where it needed to be. The delay today has the effect of raising the benchmark to tapering" (Steven Rusolillo, "No Taper Shocks Wall Street: Fed 'Running Scared'," *Wall Street Journal*, 18 September 2013, MoneyBeat).

15. For example, "U.S. stocks surged… after the Federal Reserve issued an especially dovish policy statement at the conclusion of the FOMC meetings" (Paul Vigna, "U.S. Stocks Surge after Fed Gets Dovish on Policy," *Wall Street Journal*, 17 December 2014, MoneyBeat).

Finally, on 18 March 2015, the FOMC revised its projections for U.S. output, inflation, and the federal funds rate substantially downward, significantly below what markets had expected. The revised forecast was read by financial markets "as a sign that the central bank would take its time in raising borrowing costs for the economy."[16] Again, my estimation appears to correctly identify this announcement as a substantial, negative three-standard-deviation change in forward guidance.

2.4 Scale of Forward Guidance and LSAP Factors

The forward guidance and LSAP factors estimated above and plotted in the figure are normalized to have a unit standard deviation over the sample. Similarly, the loadings in table 2 are for these normalized factors and thus represent an effect measured in basis points per standard deviation. For practical policy applications, however, it is more useful to convert these factors to a scale that is less abstract and more tangible.

For forward guidance, it is natural to think of the factor in terms of a 25 basis points effect on the Eurodollar future rate one year ahead, ED4. A forward guidance announcement of this size would be very large by historical standards, equal to about a six-standard-deviation surprise during the ZLB period or a four-standard-deviation surprise in the pre-ZLB period.[17] To estimate the effects of a forward guidance announcement of this magnitude, the coefficients in the third row of table 2 can be multiplied by a factor of about six, which implies that the effects on the five- and ten-year Treasury yields would be about 25.5 and 14.2 basis points, respectively. The interpretation is that if the FOMC gave forward guidance for the federal funds rate that was about 25 basis points lower one year ahead than financial markets expected, then the five- and ten-year Treasury yields would decline by about 25.5 and 14.2 basis points, on average.

16. Min Zeng, "U.S. Government Bonds Rally after Fed Statement," *Wall Street Journal*, 18 March 2015, Credit Markets. See also *Wall Street Journal*, "U.S. Stocks Surge as Fed Seen Taking Time on Rates," 18 March 2015, Money Beat blog.

17. I estimate that the FOMC forward guidance announcements were larger, on average, before the ZLB than during the ZLB, as presented in table 2. One explanation for why this may be is that, once the FOMC issued its "mid-2013" forward guidance, there were essentially no updates or news about that guidance for many meetings. Similarly, after the FOMC revised the guidance to "late 2014, there were again no updates or news about that guidance for many more meetings, and so on.

For LSAPs, the units would ideally be in billions of dollars of purchases, which is a more difficult transformation than a simple renormalization of the coefficients in table 2. Nevertheless, a number of estimates in the literature suggest that a $600 billion LSAP operation in the United States, distributed across medium- and longer-term Treasury securities, leads to a roughly 15-basis-point decline in the ten-year Treasury yield (see, for example, Swanson, 2011; Williams, 2013, table 1). Using this estimate as a benchmark implies that the coefficients in the fourth row of table 2 correspond to a roughly $300 billion surprise LSAP announcement. Thus, it seems reasonable to interpret the coefficients in that row of table 2 as corresponding to a $300 billion change in purchases. The interpretation is thus that if the FOMC announced a new LSAP program that was about $300 billion larger than markets expected, the effects would be about as large those provided in the fourth row of table 2.

3. The Effects of Forward Guidance and LSAPs on Asset Prices

Once the forward guidance and LSAP components of the FOMC announcements from 2009 through 2015 have been identified, it is relatively straightforward to estimate the effects of those announcements on asset prices, using ordinary least squares (OLS) regressions, as follows.

3.1 Treasury Yields

Table 3 reports the responses of six-month and two-, five-, ten-, and thirty-year Treasury yields to the forward guidance and LSAP components of the FOMC announcements. As in previous tables and figures, the coefficients here are in units of basis points per standard deviation surprise in the announcement. Each column of the table reports estimates from an OLS regressions of the form

$$\Delta y_t = \alpha + \beta \tilde{\mathbf{F}}_t^{zlb} + \varepsilon_t , \tag{2}$$

where t indices FOMC announcements between January 2009 and June 2015, y denotes the corresponding Treasury yield, Δ denotes the change in a thirty-minute window bracketing each FOMC announcement, $\tilde{\mathbf{F}}^{zlb}$ denotes the forward guidance and LSAP factors as estimated above, ε is a regression residual, and α and β are parameters.

The point estimates for the two-, five-, and ten-year Treasury yields in table 3 are the same as those in table 2. However, table 3 also reports Huber-White heteroskedasticity-consistent standard errors and *t* statistics for each coefficient, which indicate that the responses of these yields to both forward guidance and LSAPs are extraordinarily statistically significant, with *t* statistics ranging from 8.8 to almost 17.0. The regression R^2 values are also quite high, over 93 percent, so these two factors explain a very large share of the variation in those yields around FOMC announcements.

Table 3 also reports results for the six-month and thirty-year Treasury yields, which were not included in the estimation of the factors themselves.[18] LSAPs do not have a statistically significant effect on the six-month Treasury yield, and the effect of forward guidance on this yield is statistically significant but small, amounting to only about 0.5 basis points per standard deviation surprise, less than one-sixth the size of the two-year Treasury yield response. This is likely due to the fact that the six-month Treasury yield was very close to zero and largely unresponsive to news over much of this period (Swanson and Williams, 2014). To the extent that the six-month Treasury yield was pinned to zero for a significant part of the sample, I would not expect to see much of a response to any type of announcement.

The effect of forward guidance on the thirty-year Treasury yield is also quantitatively small and, in this case, statistically insignificant. In contrast to the six-month Treasury, the thirty-year Treasury yield was not pinned to zero for any length of time during this period, so the small coefficient reflects the fact that forward guidance apparently had little effect on the longest-maturity Treasuries during the ZLB period. The effect of LSAPs on the thirty-year Treasury yield, however, are large and extraordinarily statistically significant, with a *t*-statistic of almost 12. Interestingly, the effects of LSAPs on the thirty-year yield were not quite as large as their effects on the ten-year yield, presumably because the FOMC LSAP operations were typically concentrated around maturities closer to ten years.

18. Results for the three-month Treasury yield are not reported, since the three-month Treasury yield generally did not respond to news over this period, as shown by Swanson and Williams (2014).

Table 3. Estimated Effects of Forward Guidance and LSAPs on U.S. Treasury Yields, 2009–2015

	6-month	*2-year*	*5-year*	*10-year*	*30-year*
Change in forward guidance	0.53***	3.33***	4.24***	2.35***	0.30
(std. err.)	(0.092)	(0.217)	(0.252)	(0.263)	(0.737)
[t-stat.]	[5.75]	[15.33]	[16.82]	[8.91]	[0.40]
Change in LSAPs	−0.08	−1.27***	−4.90***	−7.46***	−5.78***
(std. err.)	(0.08)	(0.077)	(0.556)	(0.453)	(0.493)
[t-stat.]	[−0.99]	[−16.48]	[−8.82]	[−16.47]	[−11.71]
Regression R^2	0.47	0.93	0.94	0.97	0.77
# Observations	52	52	52	52	52

Coefficients β from regressions $\Delta yt = \alpha + \beta\tilde{F}_t^{zlb} + \varepsilon_t$, where *t* indices FOMC announcements between Jan. 2009 and June 2015, *y* denotes a given Treasury yield, $\tilde{F}$ denotes the forward guidance and LSAP factors estimated previously, and Δ is the intraday change in a 30-minute window bracketing each FOMC announcement.Coefficients are in units of basis points per standard deviation change in the monetary policy instrument. Huber-White heteroskedasticity-consistent standard errors in parentheses; *t*-statistics in square brackets; *** denotes statistical significance at the 1% level. See text for details.

3.2 Stock Prices and Exchange Rates

Table 4 reports analogous regression results for the S&P 500 stock index and the dollar-euro and dollar-yen exchange rates. The form of the regressions is the same as in equation (2), except the dependent variable in each regression is now 100 times the log change in the asset price in each column.

As shown in table 4, both forward guidance and LSAPs have statistically significant effects on stock prices and exchange rates. For stocks, a one-standard-deviation increase in forward guidance caused prices to fall by about 0.2 percent, while a one-standard-deviation increase in LSAPs caused stock prices to rise by a similar amount. Both of these coefficients are highly statistically significant, with *t* statistics of about 2.7 and 3.7, respectively. Both effects are also in the direction one would expect from a standard dividend-discount model, given the interest rate responses reported in the previous table; that is, an increase in interest rates reduces the present value of a stock's dividends (and may reduce the size of the dividends themselves, if the economy contracts), which will tend to cause stock prices to fall. Finally, the R^2 for this regression is much lower than those for Treasury yields, due to the high and idiosyncratic volatility of stock prices around FOMC announcements.

The effects of forward guidance and LSAPs on the dollar are more precisely estimated. Both the dollar-euro and dollar-yen exchange rates are expressed as the dollar price per unit of foreign currency.

Table 4. Estimated Effects of Forward Guidance and LSAPs on Stock Prices and Exchange Rates, 2009–2015

	S&P500	*\$/euro*	*\$/yen*
Change in forward guidance	−0.19***	−0.25***	−0.20***
(std. err.)	(0.07)	(0.037)	(0.04)
[t-stat.]	[−2.68]	[−6.66]	[−5.04]
Change in LSAPs	0.20***	0.33***	0.37***
(std. err.)	(0.053)	(0.049)	(0.05)
[t-stat.]	[3.66]	[6.65]	[7.32]
Regression R^2	0.27	0.67	0.8
# Observations	52	52	52

Coefficients β from regressions $\Delta \log xt = \alpha + \beta \tilde{F}_t^{zlb} + \varepsilon_t$, where t indices FOMC announcements between Jan. 2009 and June 2015, x is the asset price, $\tilde{F}$ denotes the forward guidance and LSAP factors estimated previously, and Δ is the intraday change in a 30-minute window bracketing each FOMC announcement.Coefficients are in units of percentage points per standard deviation change in the monetary policy instrument. Huber-White heteroskedasticity-consistent standard errors in parentheses; t-statistics in square brackets; *** denotes statistical significance at the 1% level. See text for details.

In response to a one-standard-deviation increase in forward guidance, the dollar appreciated by about 0.20 to 0.25 percent, and the effect is highly statistically significant, with t statistics of about 6.7 for the euro and 5.0 for the yen. A one-standard-deviation increase in LSAPs causes the dollar to depreciate about 0.35 percent, and the effect is again highly statistically significant with t statistics of 6.6 and 7.3. These effects have the signs one would expect from uncovered interest parity, given the response of interest rates reported in table 3. That is, an increase in U.S. interest rates makes U.S. dollar investments more attractive relative to foreign investments, which tends to drive the value of the dollar up.

3.3 Corporate Bond Yields and Spreads

Table 5 reports results for corporate bond yields and spreads. Corporate bonds are less frequently traded than U.S. Treasuries, stocks, and foreign exchange, so only daily-frequency corporate bond yield data are available. Thus, the regressions in table 5 use the one-day change in corporate bond yields or spreads around each FOMC announcement as the dependent variable. To measure corporate yields, I consider both the Aaa and Baa indices of long-term seasoned corporate bond yields from Moody's.

As shown in the first row of the table, I estimate that changes in FOMC forward guidance had essentially no effect on corporate bond yields during the ZLB period. The point estimates for both Aaa and Baa yields are small (less than one-half of one basis point per standard deviation change in forward guidance) and statistically insignificant. Because ten-year Treasury yields rise modestly in response to a change in forward guidance, the effect on the corporate-Treasury yield spread is thus modestly negative, falling about one to two basis points in response to an increase in guidance, and this effect is moderately statistically significant, with t statistics of 2.2 and 2.5.

The effect of LSAPs on corporate bond yields was much larger and more significant. A one-standard-deviation increase in LSAPs caused both the Aaa and Baa yields to fall about five basis points, and the effect was extraordinarily statistically significant. However, the effect of LSAPs on the ten-year Treasury yield was larger than the effect on corporate bond yields, so the spread between corporate bonds and Treasuries actually increased in response to the LSAP program.[19] This result echoes findings by earlier authors, such as Krishnamurthy and Vissing-Jorgensen (2012) and Swanson (2011), that the Federal Reserve's LSAP programs—which tend to be concentrated in U.S. Treasury securities—push down Treasury yields more than they do private-sector yields. Nevertheless, the effect on corporate bond yields that I estimate here is a bit bigger than those authors find in their studies. For example, Swanson (2011) estimated that corporate bond yields fall by about 4–5 basis points in response to a $600 billion Treasury LSAP, while the estimates in table 5 are closer to 9–10 basis points for the same size operation (assuming this is a roughly two-standard-deviation announcement, as discussed earlier). One reason for the larger estimates here may be that the recent LSAP programs often included a substantial quantity of mortgage-backed securities (MBS) as well as Treasury securities. Those MBS are likely to be closer substitutes for corporate bonds than are Treasuries, so MBS purchases can be expected to have a relatively larger effect on corporate bond yields than purchases of Treasuries alone. The earlier estimates in Krishnamurthy and Vissing-Jorgensen (2012) and Swanson (2011) are for the case of a

19. The ten-year yield response in table 2 is estimated to be about −7.5 basis points, while the effect implied in table 5 is a bit larger, about −8.9 basis points. There are two reasons for this difference. First, the responses in table 2 are thirty-minute responses, while those in table 5 are one-day responses. Second, table 2 uses the on-the-run coupon-bearing ten-year Treasury bond, while table 5 uses the ten-year zero-coupon yield estimate by Gürkaynak, Sack, and Wright (2007). The latter yield has a longer duration than the coupon-bearing ten-year security, which should be a better match to the long-term corporate bonds in the Moody's indices.

Treasury-only LSAP, and they thus could be expected to have smaller effects on private yields than the MBS-and-Treasury LSAPs conducted by the FOMC between 2009 and 2015.

Table 5. Estimated Effects of Forward Guidance and LSAPs on Corporate Bond Yields and Spreads, 2009–2015

	Corporate yields		*Spreads*	
	Aaa	*Baa*	*Aaa−10-yr.*	*Baa−10-yr.*
Change in forward guidance	0.28	−0.33	−1.23**	−1.85**
(std. err.)	(0.58)	(0.755)	(0.558)	(0.743)
[*t*-stat.]	[0.49]	[−0.44]	[−2.21]	[−2.49]
Change in LSAPs	−4.65***	−5.17***	4.25***	3.74***
(std. err.)	(0.373)	(0.577)	(0.546)	(0.911)
[*t*-stat.]	[−12.48]	[−8.96]	[7.79]	[4.11]
Regression R^2	0.44	0.49	0.56	0.55
# Observations	52	52	52	52

Coefficients β from regressions $\Delta yt = \alpha + \beta\tilde{F}_t^{zlb} + \varepsilon_t$, where *t* indexes FOMC announcements between Jan. 2009 and June 2015, *y* denotes the corporate bond yield or spread, $\tilde{F}$ denotes the forward guidance and LSAP factors estimated previously, and Δ is the change in a one-day window bracketing each FOMC announcement. Coefficients are in units of basis points per standard deviation change in the monetary policy instrument. Huber-White heteroskedasticity-consistent standard errors in parentheses; *t*-statistics in square brackets; ** and *** denote statistical significance at the 5% and 1% levels, respectively. See text for details.

4. Conclusions

In this paper, I show how to identify and estimate the forward guidance and large-scale asset purchase component of every FOMC announcement between 2009 and 2015, the U.S. zero lower bound period. Building on earlier work by Gürkaynak, Sack, and Swanson (2005), I estimate a time series for each type of unconventional monetary policy announcement and show that these series correspond to identifiable characteristics of important FOMC statements during this period.

I use these identified forward guidance and LSAP announcements to estimate the effects of each type of policy on Treasury yields, stock prices, exchange rates, and corporate bond yields and spreads. I find that forward guidance affected Treasury yields at all but the very longest maturities, with a peak effect at a maturity of about one to five years. In contrast, I find that the effects of LSAPs increased with maturity, with LSAPs having their peak effect on the longest maturities (ten and thirty years). LSAPs had essentially no effect on the shortest-maturity Treasuries.

I estimate that forward guidance had no effect on corporate bond yields during the ZLB period. In contrast, LSAPs had substantial and highly significant effects on those yields. Nevertheless, the effects of LSAPs on corporate debt was smaller than their effects on Treasuries, so corporate bond spreads actually increased after an increase in FOMC asset purchases. This finding is consistent with others in the literature and probably reflects the fact that the Federal Reserve's LSAP programs focused largely on purchases of Treasury securities.

Stock prices responded about equally to changes in forward guidance and LSAPs over the zero lower bound period. This is perhaps surprising, given that forward guidance seems to have been relatively unimportant for other long-duration assets, such as the thirty-year Treasury and corporate bonds. Forward guidance certainly had much smaller effects than LSAPs on these other long-duration assets.

Finally, I estimate that forward guidance and LSAPs both had significant effects on exchange rates, with LSAPs being moderately more important. An increase in U.S. interest rates due to either forward guidance or LSAPs caused the U.S. dollar to appreciate, consistent with a standard uncovered interest parity channel.

Looking forward, it is natural to ask which policy is more effective. The answer is that it depends. First, it is difficult to compare the scale of the two different types of policies—for example, is a $100 billion

LSAP operation large or small, and is it larger or smaller than a 25 basis points change in forward guidance about the federal funds rate one year ahead? One natural way of comparing magnitudes across the two types of policies is in terms of their historical importance: over the 2009–2015 period, a one-standard-deviation change in forward guidance by the FOMC corresponded to a change of about six basis points in federal funds rate expectations one year ahead, while a one-standard deviation change in LSAPs corresponded to a roughly $300 billion change in bond purchases. Using these estimates as a basis for comparison, a one-standard-deviation change (six basis points) in forward guidance appears to have been about as effective at changing medium-term Treasury yields, stock prices, and exchange rates as a one-standard-deviation ($300 billion) change in LSAPs. However, LSAPs were much more effective at changing long-term Treasury yields and corporate bond yields, while forward guidance was more effective at moving shorter-maturity Treasury yields.

Finally, the analysis in this paper suggests at least three important avenues for future research. First, it is important to investigate the persistence of the effects estimated above. Wright (2012) does not distinguish between forward guidance and LSAPs, but finds that unconventional monetary policy as a whole had effects that died out with a half-life of just two to three months between November 2008 and September 2011. In ongoing research, I am studying the persistence of the effects of forward guidance and LSAPs on financial markets between 2009 and 2015. Second, the time series of forward guidance and LSAP announcements estimated above can be used to investigate the effects of these announcements on macroeconomic as well as financial variables, which I am also pursuing in ongoing work. Third, the analysis above sheds no light on the relative costs of forward guidance versus LSAPs. Obviously, whether one type of policy should be preferred to the other in practice depends on its costs as well as its effects, which makes this another important avenue for future research.

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