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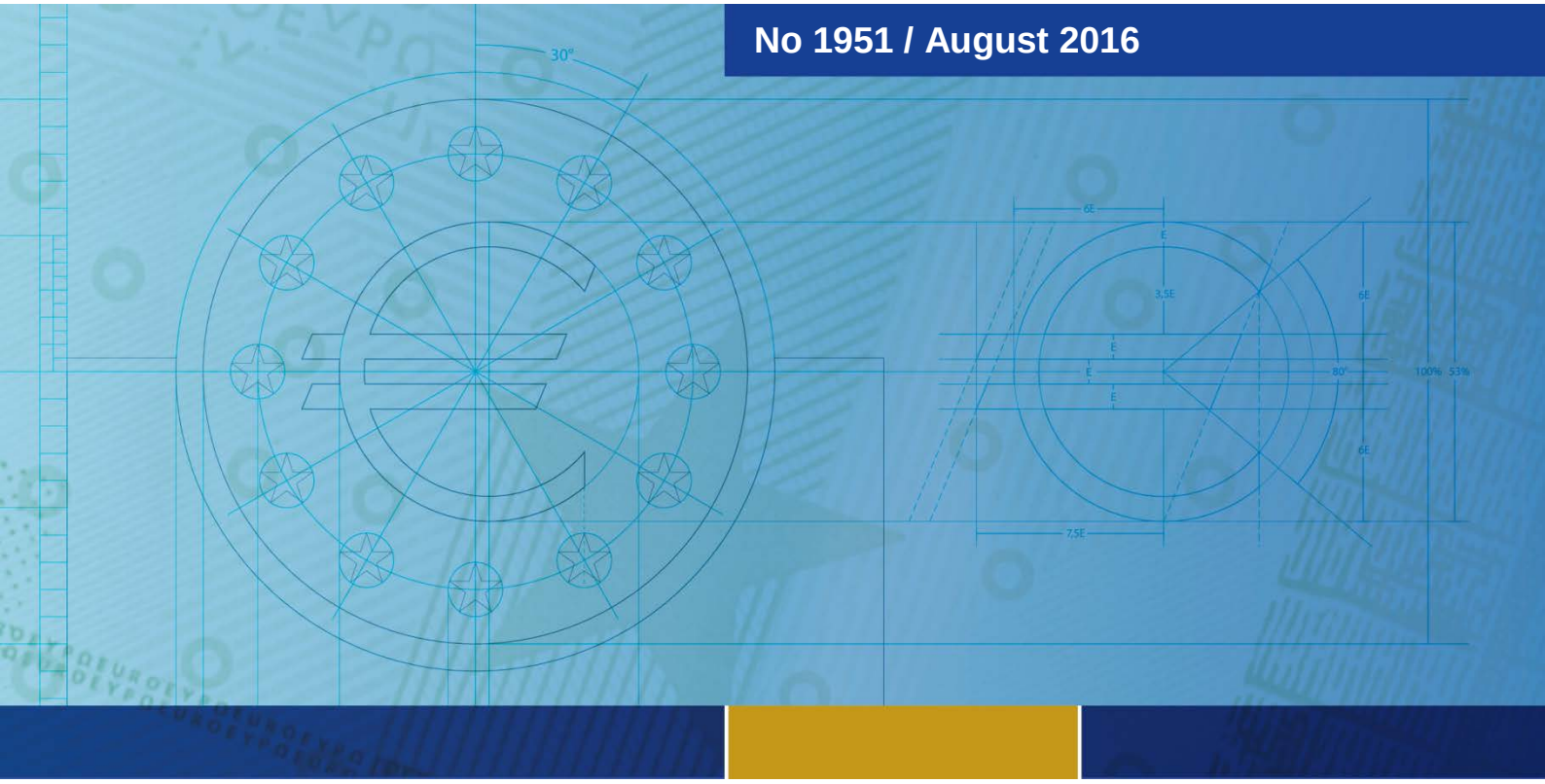
The effectiveness of non-standard monetary policy measures: evidence from survey data



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Abstract

We assess professional forecasters' perceptions of the effects of the unconventional monetary policy measures announced by the US Federal Reserve after the collapse of Lehman Brothers. Using survey data, collected at individual level, we analyze the change in the forecasts for Treasury and corporate bond yields around the announcement dates of the non-standard measures. We find that forecasters expected bond yields to drop significantly for at least one year after the announcement of accommodative policies.

JEL: E58, E65

Keywords: Survey of Professional Forecasters, Large Scale Asset Purchases, Quantitative Easing, Operation Twist, Forward Guidance, Tapering

Non-technical summary

Before the collapse of Lehman Brothers, monetary policy was typically implemented by setting the short-term interest rate. The aggressive policy response to the collapse drove the short-term interest rate down to its zero lower bound (ZLB), eliminating all possibility of additional economic stimulus through conventional operating instruments. Since then, the Federal Reserve's Federal Open Market Committee (FOMC) has engaged systematically in alternative strategies to support consumption and investment by making financial conditions more accommodative and exerting downward pressure on bond yields. In general, these policies have involved large-scale asset purchases – i.e. Quantitative Easing and the Maturity Extension Program – and communication of the Fed's intended degree of future policy accommodation – i.e. forward guidance.

This paper analyses the way in which agents updated their expectations for the yields of Treasury and corporate securities embedding different degrees of credit risk in response to announcements of non-standard measures. By analyzing market expectations over different forecasting horizons, we assess not only the immediate effects of the policies but also their expected persistence.

According to our results, the non-standard measures influenced market expectations effectively and persistently: the forecasters expected bond yields to fall significantly in response to the accommodative actions undertaken by the FOMC in response to the financial crisis. They also projected the decline to be persistent, lasting for at least one year. The size of the downward revisions coincided broadly with the observed change in bond yields around the days of the policy announcements, as documented in the event study. This result indicates, in confirmation of the efficient-market hypothesis, that market participants immediately incorporated the bulk of the information on the monetary policy stance into bond prices.

Interestingly, the compression of yields on Treasury securities and corporate bonds with different credit ratings in concomitance with the announcements of accommodative policies suggests that the effects of the measures extended beyond the financial instruments actually purchased by the central bank to other assets and helped create a favorable environment for long-term funding.

1. Introduction

Before the collapse of Lehman Brothers, monetary policy was typically implemented by setting the short-term interest rate. The aggressive policy response to the collapse drove the short-term interest rate down to its zero lower bound (ZLB), eliminating all possibility of additional economic stimulus through conventional operating instruments. Since then, the Federal Reserve's Federal Open Market Committee (FOMC) has engaged systematically in alternative strategies to support consumption and investment by making financial conditions more accommodative and exerting downward pressure on bond yields. In general, these policies have involved large-scale asset purchases – i.e. Quantitative Easing and the Maturity Extension Program – and communication of the Fed's intended degree of future policy accommodation – i.e. forward guidance.

The effects of the unconventional policies on the yields of different financial assets have been assessed in a substantial empirical literature employing event study methodology. The general finding is that both Treasury and corporate bond yields dropped significantly in concomitance with the announcement and the implementation of such policy measures. See, for instance, Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Swanson (2011), Campbell et al. (2012), and Kool and Thornton (2012), Hamilton and Wu (2012), Del Negro et al. (2013). Event study methodology is a powerful tool for quantifying the immediate effects of policy communication and realization but not for assessing their persistence. The working hypothesis of event studies is that new information is incorporated into the prices of financial assets immediately and permanently (for a comprehensive recent discussion of event study methodology see Gurkaynak and Wright, 2013).

We complement event studies by analyzing the way in which agents updated their expectations for the yields of Treasury and corporate securities embedding different degrees of credit risk in response to announcements of non-standard measures. By analyzing market expectations over different forecasting horizons, we assess not only the immediate effects of the policies but also their expected persistence.

We measure market expectations using the Survey of Professional Forecasters (SPF) conducted by the Federal Reserve Bank of Philadelphia (see Croushore, 1993). Near the middle of every quarter, the survey participants give their forecasts of several variables over various horizons. We quantify the effects of policy announcements on forecasters' expectations by examining how individual forecasters revised their bond yield projections. The focus on revisions of expectations serves to isolate the unexpected component of bond rate changes. However, given the relatively wide time window between surveys – one quarter – the changes could be due to many concurrent factors. We tackle this issue by controlling for the perceived changes in the current macroeconomic environment. Our empirical methodology is based on two identifying assumptions: that

professional forecasters believe policy interventions are transmitted to bond yields immediately but affect expectations for growth and inflation only after one quarter; and that policy makers do not respond contemporaneously to changes in forecasters' beliefs about bond yields in the current quarter. Similar assumptions have been used commonly in time series econometrics to identify exogenous changes in standard monetary policy actions (Sims, 1982; Bernanke and Mihov, 1998; Christiano, Eichenbaum and Evans, 1999).

The paper is structured as follows. Section 2 summarizes the main policy actions taken by the Federal Reserve in response to the financial crises and evaluates their effectiveness through event studies. Section 3 quantifies agents' beliefs concerning the impact on bond yields of the unconventional policy measures. Section 4 concludes.

2. Non-standard measures at zero lower bound

The events that we consider are the Federal Reserve's announcements of non-standard monetary policy measures after the collapse of Lehman Brothers. Starting late in 2008, the Fed announced a series of unconventional policies, including three rounds of quantitative easing and the Maturity Extension Program, also known as "Operation Twist". In addition to large-scale asset purchases, following the crisis the FOMC also relied increasingly on communication, i.e. forward guidance. Monetary policy did not become less accommodative until 2013, when the economic outlook improved. The change in the degree of intended monetary policy accommodation began with the announcements of tapering-off and portfolio downsizing by the Fed. The amount of monthly purchases was decreased steadily until late 2014, when the Fed announced that it would terminate its large-scale asset purchases (LSAP).[1]

We identify a total of twenty-three policy events corresponding to the announcements of the various unconventional measures (summarized in the first two columns of Table 1). For the first round of Quantitative Easing (QE1), we consider the eight events identified in Gagnon et al. (2011): the initial announcement, the Chairman's speech of December 1, 2010, and selected subsequent FOMC meetings. For the second round (QE2), we take the five events analyzed by Wright (2012), namely FOMC meetings and selected speeches by the Chairman. For the Maturity Extension Program (MEP), we identify four events: the official policy announcement (September 21, 2011) and three subsequent meetings at which the FOMC reiterated its intention of continuing the Program.[2] For the third round of Quantitative Easing (QE3) we identify two events, namely the release on August 22, 2012, of the FOMC's July minutes, where the Federal Reserve first signaled

[1] Appendix 1 provides a more detailed chronology of the policy announcements.
[2] We have not included the videoconference meeting of November 28, 2011, since it related to international developments: the Committee discussed a proposal to increase the Federal Reserve's temporary liquidity swap arrangements with foreign central banks in response to pressures in global financial markets.

that it was considering an additional round of Quantitative Easing, and the official announcement of the new round on September 13, 2012. Finally, we analyze three events related to the tapering-off (TAP): the actual announcement (December 18, 2013), and two previous official communications anticipating a possible reduction in the pace of asset purchases (May 22 and June 19, 2013).

In addition to large-scale asset purchases, the FOMC's communications after the crisis increasingly relied on forward guidance. After the onset of the financial crisis, almost every FOMC statement makes explicit reference to the expected macroeconomic outlook, the future policy measures, and the likely path of the short-term rate (see Campbell et al. 2012). Forward guidance has likely empowered the other non-standard policy packages, possibly strengthening some of their channels of accommodation.

INSERT TABLE 1 OVER HERE

We measure the effect of non-standard monetary policies by event study analysis (Gurkaynak and Wright, 2013) around the dates of our selected announcement dates. Specifically, we quantify the changes in the 10-year Treasury bond yields (constant-maturity), and the Moody's indexes of AAA and BAA corporate bond yields over a 2-day event window.[3] The thesis is that gauging the impact of the measures on the yields of both Treasury and corporate bonds featuring different credit quality can help us determine whether the policies affected financial instruments other than those directly purchased.

In practice, the estimates are made by regressing the daily changes in selected bond yields on a set of event dummies. To control for other potential confounding factors, we include in the regression the surprise component of a broad set of market-moving macroeconomic releases, including both hard data (such as non-farm payroll, retail sales and GDP) and soft data (consumer and manufacturing surveys). "Surprises" are defined as the difference between the data released during the event-window days and the consensus forecasts collected immediately beforehand. More specifically, the regression takes the following form:

$$\Delta y_t = \sum_{j=1}^{k} \lambda_j D_{j,t} + \sum_{j=1}^{k} \vartheta_j D_{j,t-1} + \sum_{s=1}^{m} \delta_s News_{s,t} + \varepsilon_t \qquad (1)$$

where *t* indexes days and the dependent variable (Δy_t) is the daily change in bond yields (10-year Treasury bonds and AAA and BAA corporate bonds). $D_{j,t}$ denotes a set of event-dummy variables,

[3] Sovereign yields are Treasury Constant Maturity Rate. Data on corporate bonds are from Moody's.

each taking value 1 at the date of the policy announcement selected and 0 otherwise. For each of the m macroeconomic indicators, $News_{s,t}$ is equal to the surprise component of the variable s. Specifically, if the macroeconomic indicator s is not released on day t the variable is set equal to 0. Otherwise, it is defined as the difference between the data released on day t and the consensus forecasts collected before the release.[4]

The effect of the policy announcement for each of the $k = 23$ events over a 2-day window is measured by the sum $\lambda_j + \vartheta_j$.[5] For the most part, past event studies have not controlled for macroeconomic surprises, a procedure corresponding, in our case, to setting the δ coefficients to 0. In this case, the effect of the announcement corresponds to the change in bond yields between the (end of the) day before the announcement and (the end of) the day after it.

Our estimates are by Ordinary Least Squares, and statistical significance is assessed by heteroskedasticity-robust standard errors. The sample period is from the start of January 2007 to the end of March 2014.

Columns 3, 6, and 8 of Table 1 report the results of the event study "controlling" for macroeconomic news. The estimates not controlling for it are given in Columns 2, 5, and 7; we call these estimates "classical" because previous event studies have omitted these controls.

The results indicate that non-conventional policies had statistically significant and economically important effects on US Treasury and corporate bonds. The first round of policy actions in the wake of the Lehman Brothers collapse had the strongest impact: the cumulative effect of QE1 reduced the yields on 10-year Treasury bonds by about one percentage point and those on corporate bonds by three-fourths of a point. The next two rounds of asset purchases had somewhat less pronounced but still substantial effects: yields on Treasury bonds declined by a total of one-third and one-half of a percentage point around the announcement dates of QE2 and MEP, respectively. And interestingly, although these two programs were for Treasury paper only, their announcements were associated with an appreciable decline of a quarter of a point in corporate bond yields as well. The last round of QE produced less of an impact on yields, while the announcements on the tapering-off of the purchase programs were associated with substantial increases in both Treasury and corporate bond yields. Overall, these findings suggest that the unconventional measures had a considerable impact on the prices of financial assets, substantially lowering the cost of market financing for the government and for firms.

[4] We also control for the ECB Main Refinancing Rate, in order to allow for possible spillovers from announcements of euro-area unconventional measures. Data on the selected variables and the corresponding forecasts are from Bloomberg.

[5] When we limit the effects to one day, measured by λ_j, the results stand qualitatively confirmed.

The inclusion of macroeconomic surprises affects the results only marginally. This suggests that when our selected events occurred, the bond markets were dominated by monetary policy announcements and not by macroeconomic surprises.

3. Non-standard measures and forecasters' beliefs

In the foregoing we used high-frequency event study methodology to quantify the immediate effect of policy announcements. Now we complement that study by assessing the impact of our policy events on the predictions of professional forecasters for Treasury and corporate bond yields, at different horizons.

The data are collected by the Federal Reserve Bank of Philadelphia in its Survey of Professional Forecasters (SPF), which offers comprehensive information on the expectations of each forecaster surveyed for many macroeconomic indicators, including bond yields, at different horizons.[6] It is quarterly, with panelists submitting their predictions around the middle of every quarter. Following the convention of the SPF, we date survey rounds according to the quarter of the submission.

In order to quantify the perceived effect of the unconventional policies, we analyze the way in which individual forecasters revise their predictions for bond yields between consecutive rounds of the survey. We match each round of policy measures to exactly one inter-SPF period, namely the period between two consecutive survey response deadlines. The inter-SPF periods are shown in the last column of Table 1, and the match with policy measures is shown as shaded. It is evident that the policy events associated with any given policy round mostly fall within one inter-SPF period. A notable exception is QE1, whose policy events went on for an entire year; some events associated with the MEP and Tapering also fall outside one period. This might possibly create a distortion, especially as regards QE1, since we omit the FOMC announcement of March 18, 2009, which nevertheless did contribute to the cumulative impact of QE1, as is observed in Section 2 (Table 1).[7]

The reliability of these matches is confirmed by Google trends data. We take the number of Google queries as an indication of the general interest in each non-standard measure stemming from media discussions, economic releases, and official communications. Figure 1 reports a normalized index of internet search queries from the United States for the terms "quantitative easing", "operation twist",[8] and "tapering" from January 2009 to March 2015. For each non-

[6] The survey began in the fourth quarter of 1968 and was originally conducted by the American Statistical Association and the National Bureau of Economic Research. The Federal Reserve Bank of Philadelphia took it over in the second quarter of 1990 (for details, see Croushore, 1993).

[7] One way to address this problem would be to lengthen the inter-SPF periods. For QE1, in fact, we also included the period ending in mid-May 2009. This did not change the results significantly, so we elected to maintain the one-on-one match of one policy measure with one inter-SPF round.

[8] We searched for "operation twist" instead of the official name of the policy because the media used it extensively. "Maturity extension program" did not yield enough search volume to produce a report.

standard measure, the shaded area represents the corresponding inter-SPF evaluation period. It is evident that the relevant search intensity peaks during the period taken for analysis, offering evidence for our identification of the survey rounds.

INSERT FIGURE 1 OVER HERE

In order to measure changes in agents' beliefs, we define forecast revisions as the difference between the forecasts for calendar quarter $t+h$ reported in the survey round of quarter $\mathrm{v}=\mathrm{t}$ and the forecast for the same period ($t+h$) taken from the previous quarter's survey, $\mathrm{v}=\mathrm{t}-1$.

$$Rz_{i,t}^{(h)} = z_{i,t+h|v=t} - z_{i,t+h|v=t-1} \quad h = 0, \dots 3 \tag{2}$$

In other words, the forecast revision made by forecaster i is defined as the difference between the forecast h quarters ahead reported in the survey of quarter $\mathrm{v}=\mathrm{t}$ and the forecast $h+1$ quarters ahead made in the previous survey, conducted in quarter $\mathrm{v}=\mathrm{t}-1$. That is, the calendar quarter to which the forecast refers is fixed; what changes is the reporting period, hence the professional forecasters' information set. In the absence of news during the inter-SPF period, individual forecasters' revisions should be zero.

Figure 2 plots the consensus (the median of individual forecasters) and the cross-sectional dispersions (summarized by selected quantiles) of the revisions of the 10-year Treasury bond yield forecasts at different horizons (h). The vertical gridlines correspond to the inter-SPF periods matched with the non-standard policies. The figure shows clearly that despite significant divergence of opinion, collectively the forecasters revised their long-term interest rate expectations in correspondence with the announcement and the implementation of the unconventional monetary policy measures. The revision was largest in the relevant period for QE1: between November 2008 and February 2009 the median decline in the expectations for government bond yields ranged from 50 to 100 basis points. Interestingly, the revisions are similar for all forecasting horizons beyond the nowcast. Revisions of similar magnitude at all horizons are also observed in correspondence with QE2, MEP and QE3. Around the announcement of the tapering-off of QE purchases we observe an upward revision of about 50 basis points.

INSERT FIGURE 2 OVER HERE

Simply examining forecasters' expectations for bond yields before and after policy announcements is not sufficient for correct assessment of the effects of the measures. During the inter-SPF periods corresponding to the announcements, forecasters also receive other information that presumably influences their predictions. That is, the revisions might be incorporating not only

the effects of the non-standard policies but also those of other, contemporary confounding factors. For example, downward revisions might reflect any news that could be expected to reduce inflation or economic growth. To deal with this problem of endogeneity, we control for current-quarter revisions in the forecasts of inflation and growth.

Specifically, we estimate this equation:

$$Ry_{i,t}^{(h)} = \sum_{j=1}^{k} \gamma_{i,j}^{(h)} Q_t^j + \boldsymbol{\beta}^{(h)\prime} Z_{i,t} + \varepsilon_{i,t}^{(h)} \qquad (3)$$

where the dependent variable $\mathrm{Ry}_{\mathrm{i,t}}^{(\mathrm{h})}$ is the revision of the forecast for yields on different bonds: 10-year Treasury, AAA and BAA corporate bonds. The superscript h ($h = 0,\ldots,3$) indicates the forecast horizons; the subscript i (i$= 1,\ldots,n$) denotes individual forecasters, the subscript j (j=2009q1, 2010q4 and 2011q4, 2012q4, 2013q3) denotes the end of the inter-SPF period that has been matched with the various policy rounds. The regressors $\mathrm{Q}_{\mathrm{t}}^{\mathrm{j}}$ are dummies taking the value 1 in the quarter corresponding to the j-th unconventional monetary policy announcement and 0 in all others. The coefficients $\gamma_{\mathrm{i,j}}^{(\mathrm{h})}$ measure the h-quarters-ahead effect expected by the individual forecaster i of the j-th round of non-standard policy on different bond yields.

The vector $\mathrm{Z}_{\mathrm{i,t}} = (\mathrm{Rg}_{\mathrm{i,t}}^{(0)}, \mathrm{R}\pi_{\mathrm{i,t}}^{(0)}, \mathrm{Rr}_{\mathrm{i,t}}^{(0)})$ contains the revision of current-quarter forecasts for real GDP growth (g), CPI inflation (π), and the 3-month T-bill rate (r). As stated above, the inclusion of revisions to inflation and growth forecasts is intended to net out the effects of other factors, unrelated to unconventional policy, that simultaneously affect both bond yield expectations and the macroeconomic outlook. By including the short-term interest rate, we net out the effects of standard monetary policy. The constant term is not included in the regression, since forecasters are assumed not to revise their predictions persistently in the same direction. The error term $\varepsilon_{i,t}^{(h)}$ represents the change in the expectations for bond yields that is not accounted for by current-quarter developments in prices, output, and the short-term interest rate.

Inference is based on the expectations reported by each professional forecaster during the sample period from the first quarter of 1996 to the first quarter of 2015. The panel is unbalanced, with entries and exits of forecasters. The expectations for all the relevant variables are available over the entire sample, with the sole exception of BAA-rated corporate bond yields, which were not included in the survey until 2010Q1. The model is estimated by Ordinary Least Squares (OLS),[9]

[9] We performed alternative estimates to allow for parameter heterogeneity. We estimated equation (3) by mean-group, with fixed effects. We also consider an alternative set of controls. The results are broadly unchanged (see Appendix 2).

separately for each horizon h.[10]

The estimates of $\gamma_{i,j}^{(h)}$ for the expected effects of non-standard measures are not biased if the regression error $\varepsilon_{i,t}^{(h)}$ is uncorrelated with both $Z_{i,t}$ and Q_t^j, that is if $E\left(\varepsilon_{i,t}^{(h)}\middle|Q_t^j, Z_{i,t}\right) = 0$. This condition is satisfied if: i) the unconventional policies are exogenous, i.e. if in deciding the policies the authorities do not react to current-quarter changes in forecaster's beliefs about bond yields; and ii) the controls $Z_{i,t}$ are not affected by the unconventional policies – that is, if current-quarter expectations for GDP growth, inflation and the short-term interest rate can change in response to confounding factors, but not in response to the announcement of non-standard policy. Assuming that the effect of policy on the real economy is delayed and that policy decisions are not affected by current-quarter variations in long-term bond yields is tantamount to the recursive identification scheme used in Structural Vector Autoregressions to identify standard policy (among others, see Bernanke et al., 2005; Giannone, et al., 2015). Notice that only current-quarter macro forecasts are included as independent variables; we do not control for macro forecasts at longer horizons in order to avoid the problems stemming from the simultaneity of expected bond yields and expected longer-run GDP growth and inflation.

Our methodology is designed in such a way as to quantify the effects of announcements on yield expectations as reflected in surveys. This contrasts with a number of papers that examine the effects of announcements on actual yields (see Wright, 2012). The advantage of taking expectations rather than actual outcomes is the possibility of measuring the dynamic effects of each policy event separately. The countervailing drawback is that expectations as revealed in surveys could theoretically be distorted by herd behavior, strategic considerations, or forecasters' limited ability to process information (see Marinovic, 2013). Additional distortions could derive from informational rigidities (see Coibion and Gorodnichenko, 2012). In practice, however, the predictions of professional forecasters are fairly accurate and compare well with institutional forecasts, such as those of the Federal Reserve staff (see D'Agostino and Whelan, 2008) and with those generated by state-of-the-art econometric models (Del Negro and Schorfheide, 2012; Giannone et al., 2008).

Figure 3 reports the estimates of the distribution across individuals of the perceived effects on Treasury and corporate bond yields of each non-standard policy j at each forecasting horizon h.

Table 2 reports the effects averaged across individuals, in columns (2), (4), and (6); for symmetry with the event study reported earlier, we also report the estimates without controls, in columns (1), (3), and (5). In the latter case, equation (3) is estimated with only the five policy-related dummies as independent variables and corresponds to the revisions to bond yield forecasts during the relevant inter-SPF quarter.

[10] We do not conduct inference on all horizons simultaneously, as this would make the estimation procedure more cumbersome.

Insert Table 2 over Here

Insert Figure 3 over Here

Our results indicate that the unconventional monetary policies did effectively influence market expectations. Their implementation led professional forecasters to revise their expectations for government and corporate bond yields significantly, at all horizons. On average, the announcements of QE1, QE2, MEP and QE3 made them lower their expectations for government bond yields immediately by 55, 66, 84 and 58 basis points, respectively, and the tapering-off event was associated with an upward revision of 56 basis points in the expected yield. The magnitude of the revisions of current-quarter expected yields is of about the same order of magnitude as the effects on actual yields estimated in Section 2 using high-frequency event studies. The only exception is the MEP, for which our estimated drop is larger than the decline estimated with the event-study.[11] Interestingly, the forecasts for longer horizons are revised by a similar amount, indicating that in most cases the effect of the policy is expected to last for one year. This result concords with the efficient market hypothesis, which predicts that new information is transposed immediately into prices with no lagged effects or reversals.[12]

The accommodative monetary policies were also expected to exert significant downward pressure on corporate bonds. The magnitude of the change in the expectations for AAA-rated bond yields is comparable with that for government bond yields. For BAA-rated bonds, forecasters expected a more muted effect. This indicates that the non-standard measures not only reduced the yields on the assets directly purchased by the Fed but spilled over to the yields on other financial assets.

Comparing the results with and without controls for revisions to current-quarter forecasts of growth, inflation, and the short-term interest rate, it is evident that the bias due to this omission is sizeable for the first round of Quantitative Easing, but not for the subsequent rounds of unconventional policy. This suggests that the policy announcements were important events, whose effects were large and dominated the macroeconomic news within our selected inter-SPF periods.[13]

Figure 3 also highlights the substantial heterogeneity of forecasters' beliefs concerning the size of the expected policy effect. The dispersion of beliefs increases as the horizon lengthens, indicating

[11] A possible explanation could be the influence on professional forecasters' expectations for bond yields exerted by the government debt-ceiling crisis of early August 2011.

[12] The evidence that the unconventional monetary policies had persistent effects on bond yields is in contrast with Wright (2012), who finds that they were short-lived. It is difficult to explain the differences in these results. In Wright (2012) the analysis is implicitly based on the revisions of model-based, rather than judgmental, forecasts. Moreover, Wright does not quantify the effects of each single round of policy separately but their average effects.

[13] Not surprisingly, the results remain qualitatively unchanged when we include, as an additional control, the surprise component of all the market-moving macroeconomic data released during the inter-SPF quarter. See Appendix 2 for details.

that there is greater disagreement over the effects of policy at longer horizons. There is also some (weak) evidence that disagreement tended to decrease as more unconventional policies were adopted. This is probably associated with market participants' learning of the impact of the policies and the Fed's resoluteness in pursuing them.

In addition, the moderation of disagreement is associated with the more intensive use of forward guidance. In particular, forecasters tended to concur more on the effects and the persistence of the policy event we label QE3, when the FOMC also announced more aggressive forward guidance by postponing the likely timing of the lift-off and by moving over to state-contingent forward guidance. A similar pattern of decreased disagreement was found for short maturities by Engen et al. (2014) and Andrade et al. (2015).

Overall, our results suggest that the non-standard measures affected market expectations substantially and persistently. Significantly, they also affected professional forecasters' predictions for financial assets not directly purchased by the central bank.

4. Conclusions

We have estimated the effects that professional forecasters expected unconventional monetary policy measures to have on long-term yields of Treasury bonds and corporate bonds, by analyzing the forecasters' revisions to their forecasts, at various horizons, around the announcement of policy decisions. According to our results, the measures influenced market expectations effectively and persistently: the forecasters expected bond yields to fall significantly in response to the accommodative actions undertaken by the FOMC in response to the financial crisis. They also projected the decline to be persistent, lasting for at least one year. The size of the downward revisions coincided broadly with the observed change in bond yields around the days of the policy announcements, as documented in the event study. This result indicates, in confirmation of the efficient-market hypothesis, that market participants immediately incorporated the bulk of the information on the monetary policy stance into bond prices.

Interestingly, the compression of yields on Treasury securities and corporate bonds with different credit ratings in concomitance with the announcements of accommodative policies suggests that the effects of the measures extended beyond the financial instruments actually purchased by the central bank to other assets and helped create a favorable environment for long-term funding.

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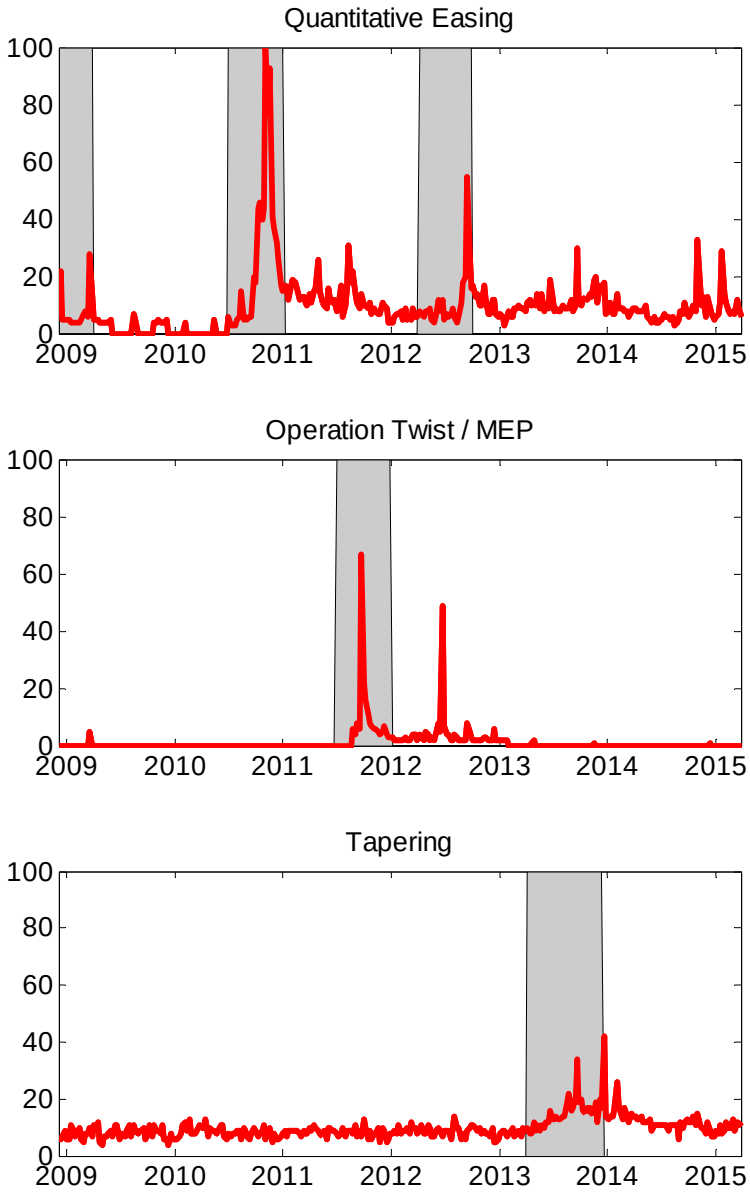
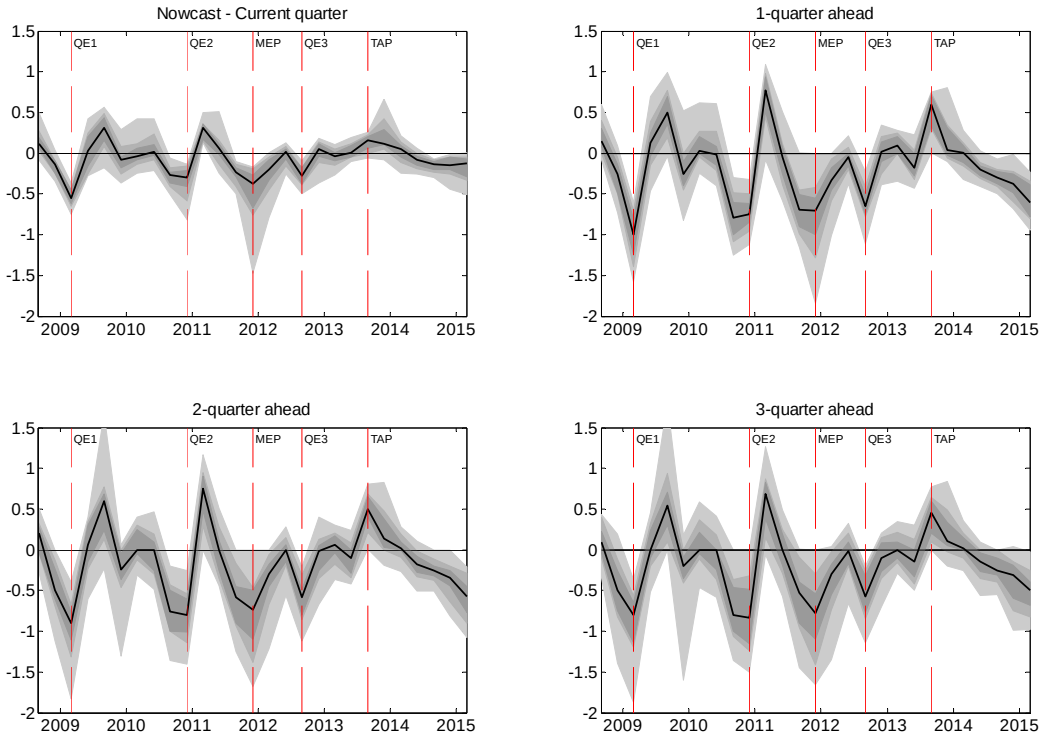
Figure 1: Google Trends search volume index – weekly data



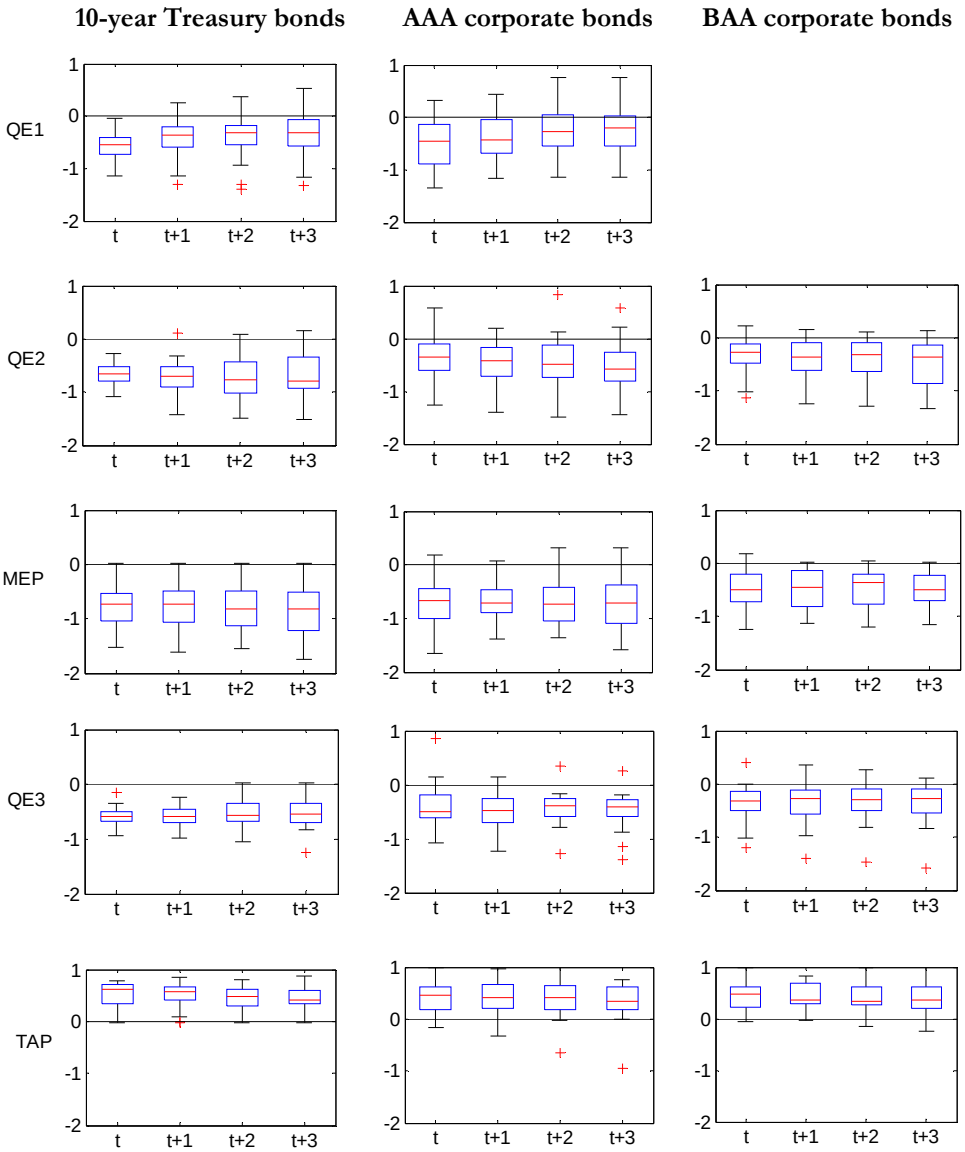
Note: The figure reports the Google Trends count of Internet search queries on the terms "quantitative easing", "operation twist", and "tapering" from the United States from January 2009 to March 2015. Data are scaled to the maximum search traffic for the specific array of terms (represented as 100) during the period from January 2009 to March 2015 in the United States. The shaded areas represent the evaluation periods for the five inter-SPF survey periods considered (i.e., 2009:1, 2010:4, 2011:4, 2012:3, and 2013:3).

Figure 2: Change in the 10-year Treasury bond forecasts



Note: For each quarter from 2008:1 to 2015:1, the figure reports the distribution of forecast revisions across panelists. The solid black line that goes through the areas is the median of the forecasters' distribution for each quarter. The shaded areas comprise 50%, 68% and 90% of the distribution. The vertical gridlines represent the policy rounds and the quarters in which these policies were introduced (i.e., 2009:1, 2010:4, 2011:4, 2012:3, and 2013:3).

Figure 3: Cross-sectional distribution of the effect of non-standard measures on bond yield forecasts



Note: The figure reports the distribution of individual-specific coefficients of the expected effect of the specified non-standard monetary policy measure. QE1=quantitative easing 1; QE2=quantitative easing 2; MEP=maturity extension program; QE3=quantitative easing 3; TAP=tapering. These graphs visualize the interquartile ranges (the box), the averages (the line inside the box), the maximum and the minimum values (the whisker), and the outliers (given a maximum whisker length "w", points are detected as outliers if they are higher than $q_3+w*(q_3-q_1)$ or lower than $q_1-w*(q_3-q_1)$, where q_1 and q_3 are the 25th and 75th percentiles, respectively).

Table 1: Changes in Treasury and Corporate yields around policy event dates

Date	Policy Event	10-year Treasury Bond		AAA Corporate Bond		BAA Corporate Bond		Deadline for SPF
		Classical	Controlled	Classical	Controlled	Classical	Controlled	
Quantitative Easing 1								
Nov. 25 2008	LSAP announcement	-34	-30	-18	-17	-17	-15	
Dec. 1 2008	Chairman Speech	-27	-24	-19	-18	-10	-9	2008:4 (Nov. 18)
Dec. 16 2008	FOMC meeting	-33	-25	-25	-23	-23	-20	2009:1 (Feb. 10)
Jan. 28 2009	FOMC meeting	30	33	26	29	5	7	
Mar. 18 2009	FOMC meeting	-40	-42	-34	-35	-27	-27	
Aug. 12 2009	FOMC meeting	-11	-8	-10	-6	-8	-6	
Sep. 23 2009	FOMC meeting	-7	-7	-8	-9	-7	-7	
Nov. 4 2009	FOMC meeting	6	6	2	2	0	0	
		-116***	-97***	-86***	-76***	-87***	-76***	
Quantitative Easing 2								
Aug. 10 2010	FOMC meeting	-15	-13	-8	-7	-6	-6	
Aug. 27 2010	Chairman speech	5	3	2	1	3	2	2010:3 (Aug. 10)
Sep. 21 2010	FOMC meeting	-14	-15	-8	-9	-10	-11	2010:4 (Nov. 09)
Oct. 15 2010	Chairman speech	0	1	-2	-3	-2	-2	
Nov. 3 2010	FOMC meeting	-13	-13	-8	-8	-10	-11	
		-36**	-38**	-24**	-25**	-25**	-27**	
Maturity Extension Program								
Aug. 9 2011	FOMC meeting	-20	-20	-16	-16	-6	-6	2011:3 (Aug. 08)
Sep. 21 2011	FOMC meeting	-23	-25	-9	-11	0	-2	2011:4 (Nov. 08)
Nov. 2 2011	FOMC meeting	7	15	6	11	2	6	
Dec. 13 2011	FOMC meeting	-11	-10	-6	-5	-6	-4	
Jan. 25 2012	FOMC meeting	-13	-14	-9	-9	-14	-15	
		-60***	-54***	-35***	-29***	-24***	-22***	
Quantitative Easing 3								
Aug. 22 2012	FOMC meeting	-14	-13	-9	-8	-10	-9	2012:3 (Aug. 07)
Sep. 13 2012	FOMC meeting	11	14	2	5	-1	0	2012:4 (Nov. 06)
		-4*	0.3**	-7*	-2**	-11*	-9**	
Tapering								
May 22 2013	Chairman Speech	8	7	4	3	5	5	2013:2 (May 07)
Jun 19 2013	FOMC meeting	24	23	20	19	27	27	2013:3 (Aug. 12)
Dec 18 2013	FOMC meeting	8	8	3	5	3	5	
		40**	38**	27**	28**	36**	37**	

Note: the controlled event study refers to a regression model where the daily changes in bond yields are regressed on a set of event dummies and the surprise component of a large set of market-moving macroeconomic variables. The variables included in the estimation are: ECB main refinancing rate, ADP employment change, change in nonfarm payrolls, Chicago purchasing manager consumer confidence index, continuing claims, CPI net of food and energy, CPI, current account balance, durable goods orders, durables net of transport equipment, existing home sales, factory orders, FOMC rate decision, GDP annualized, GDP price index, housing starts, import price index, industrial production, initial jobless claims, ISM manufacturing, ISM non-manuf. composite, Markit US manufacturing PMI, monthly budget statement, new home sales, PCE core, pending home sales, personal income, personal spending, Philadelphia FED business outlook, PPI ex food and energy, PPI final demand, retail sales advance, retail sales net of auto, Richmond FED manufact. index, S&P/caseshiller 20-city index, trade balance, U. of Michigan sentiment, unemployment rate, and wholesale inventories. Results of the event study are based on a 2-day event window. Newey-West standard errors are used in the estimation. *, **, and *** denote F-test significance of abnormal returns at 10%, 5%, and 1%, respectively.

Table 2: Effect of non-standard measures on bond yields

	10-year Treasury Bond		AAA Corporate Bond Yield		BAA Corporate Bond Yield	
	(1)	(2)	(3)	(4)	(5)	(6)
current-quarter						
Quantitative Easing 1	-1.02***	-0.55***	-0.68***	-0.45***	-	-
Quantitative Easing 2	-0.72***	-0.66***	-0.39***	-0.37***	-0.41**	-0.34***
Maturity Extension Program	-0.85***	-0.84***	-0.70***	-0.69***	-0.52***	-0.49***
Quantitative Easing 3	-0.64***	-0.58***	-0.42***	-0.40***	-0.42***	-0.36***
Tapering	0.56***	0.56***	0.42***	0.42***	0.42***	0.43***
1-quarter-ahead						
Quantitative Easing 1	-0.97***	-0.41***	-0.63***	-0.31**	-	-
Quantitative Easing 2	-0.78***	-0.72***	-0.51***	-0.48***	-0.48***	-0.41***
Maturity Extension Program	-0.85***	-0.84***	-0.67***	-0.66***	-0.51***	-0.47***
Quantitative Easing 3	-0.64***	-0.58***	-0.45***	-0.42***	-0.43***	-0.37***
Tapering	0.54***	0.55***	0.40***	0.41***	0.40***	0.41***
2-quarter-ahead						
Quantitative Easing 1	-0.92***	-0.35***	-0.57***	-0.22**	-	-
Quantitative Easing 2	-0.78***	-0.71***	-0.51***	-0.48***	-0.47***	-0.39***
Maturity Extension Program	-0.88***	-0.87***	-0.69***	-0.68***	-0.54***	-0.49***
Quantitative Easing 3	-0.61***	-0.54***	-0.42***	-0.38***	-0.42***	-0.35***
Tapering	0.48***	0.49***	0.40***	0.40***	0.39***	0.40***
3-quarter-ahead						
Quantitative Easing 1	-0.87***	-0.32***	-0.54***	-0.19*	0	0
Quantitative Easing 2	-0.76***	-0.70***	-0.54***	-0.51***	-0.53***	-0.44***
Maturity Extension Program	-0.93***	-0.92***	-0.71***	-0.70***	-0.59***	-0.54***
Quantitative Easing 3	-0.60***	-0.53***	-0.45***	-0.41***	-0.45***	-0.38***
Tapering	0.45***	0.46***	0.35***	0.35***	0.36***	0.38***
Controls	NO	YES	NO	YES	NO	YES

The table reports estimates of the average effect of different policy measures on 10-year Treasury bond and AAA and BAA corporate bond yields. The results in Columns (1), (3), and (5) are obtained by estimating a regression model where the only explanatory variables are the policy event dummies. Columns (2), (4), and (6) are obtained by estimating the model with the event dummies augmented with the additional control variables. Newey-West standard errors are used in the estimation. Sample: 1996q1-2015q1for the Treasury yields and the AAA corporate yields. Sample: 2010q1 – 2015q1 for the BAA corporate bond yields. The asterisks indicate the level of statistical significance: * p<0.1, ** p<0.05, *** p<0.01

Appendix 1

This appendix gives the chronology of the policy announcements used in the empirical part of the paper.

On November 25, 2008, the FOMC announced its first quantitative easing program (QE1). On December 1, 2008, Chairman Bernanke stated that "Although conventional interest rate policy is constrained by the fact that nominal interest rates cannot fall below zero […] the Fed could influence financial conditions [by purchasing] longer-term Treasury or agency securities on the open market in substantial quantities". By the termination of this program in March 2010, the Fed had purchased $1.25 trillion of mortgage-backed securities, $200 billion of debt directly issued by the housing-related government-sponsored enterprises, and $300 billion of longer-term Treasury securities.

In the second half of 2010, the FOMC announced a second program of quantitative easing (QE2), with projected purchases of a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, at a pace of approximately $75 billion per month.

On September 21, 2011, the FOMC announced a further round of unconventional measures. This program, officially called the Maturity Extension Program (MEP), was also known as "Operation Twist" due to its similarities with a policy implemented in the early 1960s.[14] The Federal Reserve committed to purchase, by the end of June 2012, $400 billion of Treasury securities with residual maturities of 6 to 30 years and sell an equal amount of Treasury securities with residual maturities of 3 years or less. On June 20, 2012, this program was extended to the end of 2012.

On September 13, 2012, the FOMC announced a third round of quantitative easing (QE3) consisting of "purchasing additional agency mortgage-backed securities at a pace of $40 billion per month."[15] Finally, on December 12, 2012, the FOMC announced additional purchases of longer-term Treasury securities initially at a pace of $45 billion per month.

Almost every FOMC statement we analyze makes explicit reference to the expected macroeconomic outlook, the future policy measures, and the likely path of the short-term rate. In its statement of August 2011, for example, the FOMC said that the "Committee currently anticipates that economic conditions [....] are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013." In its January and September 2012 statements, the FOMC revised its outlook for the federal funds rate by extending its expectations of the exceptionally low level at least through "late 2014" and "mid-2015", respectively. On December 12,

[14] See Modigliani and Sutch (1966, and 1967), and Swanson (2011)
[15] Note that in the FOMC statement there was no indication of when QE3 would have ended.

2012, the FOMC indicated that a federal funds rate close to zero would remain appropriate at least as long as the unemployment rate remained above 6½ percent and inflation expectations continued to be well anchored. We have also included policy announcements related to a change in the approach to forward guidance on policy rates. For example, the FOMC statement of August 9, 2011, which made the major change from open-ended to calendar-based forward guidance and thus implicitly altered the form of monetary policy commitment going forward.

Monetary policy became less accommodative during 2013 in response to a more positive economic outlook. The change in the degree of intended accommodation began with the announcements on tapering-off and downsizing of the Fed's portfolio. On May 22, 2013, in his testimony to Congress, Chairman Bernanke hinted at a possible reduction in asset purchases in the next two FOMC meetings. On June 19, 2013, during his press conference, he stated that "if the incoming data are broadly consistent with this forecast, the Committee currently anticipates that it would be appropriate to moderate the monthly pace of purchases later this year." On December 18, 2013, the FOMC "decided to modestly reduce the pace of its asset purchases". More precisely, the monthly purchases of agency mortgage-backed securities and longer-term Treasury securities would be decreased from $40 and $45 billion to $35 and $40 billion, respectively. The reduction in the size of purchases continued until October 29, 2014, when the Fed announced that it would cease large-scale asset purchases at the end of the month.

Appendix 2

This appendix details checks for robustness to the use of alternative estimation methods and model specifications. The results are reported in Table A.1. There are three deviations from the benchmark model that is specified in equation (3) in the main text.

First, the model is estimated with the highest degree of cross-sectional heterogeneity: that is, separately for each individual (columns 1, 3, and 7). The results are then aggregated via mean-group (see Pesaran and Smith, 1995).

Second, the benchmark model is augmented with individual fixed effects (columns 2, 5, and 8) controlling for all possible time-invariant characteristics of the forecasters (observable and not), in order to account for the fact that some forecasters might be present only during a short period that could be marked by movement of the yields always in the same direction. Fixed effects account for persistent biases that might arise from non-rationality, distorted incentives or specificities of the loss functions of individual forecasters. We have not used this specification as our benchmark model, because it implies that the forecasts could have a trend. And in any case, the fixed effects are not statistically significant and the results hold when they are removed from the model.

Third, the model is estimated by adding as additional controls the surprise component of a large set of market-moving macroeconomic data that are released during the inter-SPF quarter (see Section 2). Since these data releases are more frequent than the survey, for each macroeconomic indicator the news is aggregated by cumulating all the news associated with each release between consecutive surveys.

Overall, the results obtained using the alternative specifications do not differ substantially from those with the benchmark procedure presented in the main text. In short, the findings reported in the paper are highly robust to different estimation methods and model specifications.

Table A.1: Robustness analysis on the effect of non-standard measures on bond yields

	10-year Treasury Bond			AAA Corporate Bond Yield			BAA Corporate Bond Yield		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
current-quarter									
Quantitative Easing 1	-0.32***	-0.51**	-0.57**	-0.44***	-0.40***	-0.43***	-	-	-
Quantitative Easing 2	-0.60***	-0.60***	-0.69***	-0.25***	-0.30***	-0.31***	-0.19***	-0.20***	-0.33***
Maturity Extension Program	-0.86***	-0.78***	-1.05***	-0.70***	-0.62***	-0.95***	-0.20***	-0.35***	-0.28**
Quantitative Easing 3	-0.66***	-0.51***	-0.56***	-0.62***	-0.32***	-0.43***	-0.51**	-0.21**	-0.45*
Tapering	0.61***	0.65**	0.43**	0.44***	0.54***	0.27***	0.43***	0.63***	0.19*
1-quarter-ahead									
Quantitative Easing 1	-0.20***	-0.38***	-0.46***	-0.28***	-0.28*	-0.31*	-	-	-
Quantitative Easing 2	-0.66***	-0.65***	-0.78***	-0.36***	-0.40***	-0.46***	-0.17***	-0.28***	-0.42***
Maturity Extension Program	-0.87***	-0.79***	-0.98***	-0.71***	-0.59***	-0.81***	-0.18***	-0.35***	-0.47**
Quantitative Easing 3	-0.70***	-0.50***	-0.56***	-0.65***	-0.35***	-0.45***	-0.55***	-0.25***	-0.26*
Tapering	0.59***	0.63***	0.42***	0.43***	0.49***	0.27***	0.39***	0.58***	0.38*
2-quarter-ahead									
Quantitative Easing 1	-0.18***	-0.32**	-0.39**	-0.28***	-0.18*	-0.18*	-	-	-
Quantitative Easing 2	-0.66***	-0.65***	-0.81***	-0.45***	-0.40***	-0.52***	0.01	-0.26***	-0.40***
Maturity Extension Program	-0.94***	-0.82***	-0.97***	-0.78***	-0.62***	-0.85***	-0.22***	-0.37***	-0.68**
Quantitative Easing 3	-0.64***	-0.46***	-0.50***	-0.62***	-0.31***	-0.37***	-0.47***	-0.22***	-0.13*
Tapering	0.52***	0.56***	0.39***	0.37***	0.48***	0.31***	0.38***	0.57***	0.38*
3-quarter-ahead									
Quantitative Easing 1	-0.18***	-0.30***	-0.38***	-0.27***	-0.14*	-0.16*	-	-	-
Quantitative Easing 2	-0.62***	-0.64***	-0.81***	-0.51***	-0.43***	-0.58***	-0.16***	-0.32***	-0.42***
Maturity Extension Program	-1.00***	-0.87***	-1.05***	-0.85***	-0.64***	-0.90***	-0.36***	-0.41***	-0.83**
Quantitative Easing 3	-0.54***	-0.46***	-0.50***	-0.60***	-0.34***	-0.41***	-0.48***	-0.25***	0.06*
Tapering	0.48***	0.53***	0.40***	0.28***	0.43***	0.31***	0.36***	0.55***	0.49*
SPF Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bloomberg News	NO	NO	YES	NO	NO	YES	NO	NO	YES
Fixed Effects	NO	YES	NO	NO	YES	NO	NO	YES	NO
Mean-group	YES	NO	NO	YES	NO	NO	YES	NO	NO

The table reports the estimation results for 10-year Treasury, AAA and BAA bonds, according to different estimation procedures. The results in Columns 1, 3, and 5 are obtained by estimating a regression model for each forecaster and then aggregating the results via mean-group. Those in columns 2, 4, and 6 are obtained by estimating the model with the fixed effects. Finally, the figures in columns 3, 6, and 9 are obtained by augmenting the benchmark model with the surprise component of a large set of macroeconomic releases (Bloomberg News). Newey-West standard errors are used in the estimation. Sample: 1996q1-2015q1. The asterisks indicate the level of statistical significance: * p<0.1, ** p<0.05, *** p<0.01.

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