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ABSTRACT

The Effectiveness of Non-Standard Monetary Policy Measures: Evidence from Survey Data*

We assess the perception of professional forecasters regarding the effectiveness of unconventional monetary policy measures undertaken by the U.S. Federal Reserve after the collapse of Lehman Brothers. Using individual survey data, we analyse the changes in forecasting of bond yields around the announcement and implementation dates of non-standard monetary policies. The results indicate that bond yields are expected to drop significantly for at least one year after the announcement and the implementation of accommodative policies.

JEL Classification: E58 and E65
Keywords: forward guidance, large scale asset purchases, operation twist, quantitative easing, survey of professional forecasters and tapering

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Submitted 21 May 2014

1 Introduction

Before the collapse of Lehman Brothers, monetary policy was typically implemented by setting the short-term interest rate. After the aggressive policy response that followed the collapse of Lehman Brothers, the short-term interest rate reached its zero lower bound (ZLB), hence preventing any possibility of the Federal Reserve providing additional stimulus to the economy through conventional operating instruments. Since then, the Federal Reserve's Federal Open Market Committee (FOMC) has systematically engaged in alternative strategies with the aim of making financial conditions more accommodative and exerting downward pressure on the long-term interest rate. In general, these policies have involved the use of communication of future policies (Forward Guidance) and Large Scale Asset Purchases (Quantitative Easing and Operation Twists).

There has been a growing empirical literature aimed at assessing the effects of unconventional policies on bond yields using event studies. The general finding is that bond yields dropped significantly in correspondence to the announcement and the implementation of such policy measures, e.g., 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 effect of policy communication and implementation. It is difficult, however, to assess the persistence of those effects because the new information might not be immediately and permanently incorporated into the asset prices (see for example Reichlin, 2011; Gurkaynak and Wright, 2013).

We complement event studies by assessing how agents and markets update their expectations in response to the announcement and implementation of the non-standard policy measures. By analysing market expectations for different forecasting horizons, we are able to assess not only the immediate effects of the non-standard policy events but also the expected persistence of these effects. We measure market expectations for different forecasting horizons by using the Survey of Professional forecasts (SPF) conducted by the Federal Reserve Bank of Philadelphia (see Croushore, 1993). Near the middle of every quarter, the survey participants provide their forecasts of several variables for different forecasting horizons. As the announcement and implementation events are concentrated between consecutive surveys, we can quantify their effects on forecasters' beliefs by examining the changes in the individual forecasts of bond yields. Changes in the term structure of the individuals' forecasts are used to separate expected from unexpected bond rate changes. As the time window between two consecutive surveys is relatively wide, i.e., one quarter, many concurrent events could pollute the estimates. We take this issue into account by controlling for the perceived changes in the current macroeconomic environment. Our identifying assumption to separate exogenous policy actions from the systematic response of policy to changes in the

economic outlook is that policy interventions can transmit immediately to bond yields, while they take some time to affect the real economy. These ideas have been used for a long time in time series econometrics to identify exogenous changes of standard monetary policy actions (Sims, 1982; Christiano, Eichembaum and Evans, 1999).

The paper is structured as follows. Section 2 summarises the main policy actions undertaken by the Fed in response to the financial crises. Moreover, the section relates these policy events with the dates of the survey used in the analysis and presents an event-study analysis. Section 3 presents the methodology used in the paper to assess the effectiveness of the non-standard measures. Section 4 analyses the market participants' perceptions regarding the effectiveness of unconventional monetary policy measures and quantifies the agents' beliefs regarding the impact of these policy measures on Treasury yields. Section 5 presents the conclusions.

2 Event Study

The events of interest involve the announcement and implementation of non-standard monetary policy measures undertaken by the Federal Reserve System after the collapse of Lehman Brothers.

On November 25, 2008, the FOMC announced its first quantitative easing program (QE1). By the end 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 late 2010, the FOMC announced a second program of quantitative easing (QE2), which consisted of purchasing 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 third round of unconventional measures, called Operation Twist (OT) due to its similarities with a policy implemented in the early 1960s. The Federal Reserve committed to purchase, by the end of June 2012, $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and sell an equal amount of Treasury securities with remaining 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."[1]

In addition to large-scale asset purchases, the FOMC's communications after the crisis have increasingly relied on forward guidance. Almost every FOMC statement makes explicit reference to the expected macroeconomic outlook, the future policy measures, as well as the likely future path of the short-term rate. The FOMC Statement of August 2011, for example, stated that "Committee currently anticipates that economic conditions [....] are likely to warrant exceptionally low levels for

[1] Note that in the FOMC statement there was no indication of when QE3 would end.

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, 2012, the FOMC indicated that a federal funds rate close to zero would remain appropriate at least as long as the unemployment rate remains above 6-1/2 per cent and inflation expectations continue to be well anchored.

During 2013, monetary policy became less accommodative in response to a more positive economic outlook. The new cycle of a less accommodative monetary policy stance began with the announcements on the tapering-off and downsizing of the Fed portfolio. On May 22, 2013, in his Testimony to the U.S. Congress, Chairman Bernanke hinted to a possible reduction in asset purchases in the next two FOMC meetings. On June 19, 2013, during his Press Conference, Chairman Bernanke 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." Finally, 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 decreased from $40 and $45 billion to $35 and $40 billion, respectively.[2]

2.1 Policy events

We identify a set of twenty-four policy events summarised in Table 1. The first two columns of Table 1 report the significant dates for the empirical analysis that are classified into different event sets. For the first round of Quantitative Easing (QE1) and Forward Guidance (FG), we consider the eight events identified in Gagnon et al. (2011). For the second round of Quantitative Easing (QE2) and FG, we use the five events analysed by Wright (2012). For Operation Twist (OT) and FG, we identify five events that include the 09/08/2011 policy announcement and the four following FOMC meetings, when the Fed announced Operation Twist (in September) and its intent to continue it.[3] For QE3, we identify two dates: the first (i.e., August 22, 2012) relates to the release of the FOMC minutes from the July/August meeting that provided the first signal that the Federal Reserve was considering QE3, and the second (i.e., September 13, 2012) is the official announcement date of QE3.

[2] When analysing the tapering, there is substantial difficulty in isolating the effects of the unwinding of the QE portfolio from the effects related to the timing and pace of Fed funds rate lift-off. In fact, the tapering has strong signalling effects with regard to the state of the economy as perceived by the FED and could change market expectations regarding the starting period of policy rate hikes.

[3] We have not included the videoconference meeting of November 28, 2011. In that unscheduled meeting, the Committee met to discuss a proposal to increase the Federal Reserve's temporary liquidity swap arrangements with foreign central banks in response to pressures in global financial markets.

We label one event as providing only forward guidance with no other communication or action. This was the case on December 2012, when the FOMC switched to outcome-based forward guidance by referring to explicit quantitative "thresholds" for unemployment and inflation expectations.

Finally, to analyse the bond market reaction during the announcements of the tapering, we select three episodes: the final announcement (December 18, 2013) and two previous episodes that anticipated the possibility of reducing the pace of asset purchases (May 22, and June 19, 2013).

INSERT TABLE 1 OVER HERE

Columns 3 to 7 report the mix of policy measures and announcements associated with each date. For example, the FOMC announcement of 12/16/2008 is associated with three different policy actions. On that occasion, the FOMC simultaneously announced the new target range for the federal funds rate (Target), indicated that this low level of the fed funds was likely to persist "for some times" (forward guidance), and stated that "over the next few quarters the Federal Reserve will purchase large quantities of agency debt and mortgage-backed securities" (QE1).[4] It is evident that all announcements have simultaneously involved both large scale asset purchases and forward guidance. As a consequence, the effects of the two policy measures cannot be separated.

We measure the effect of non-standard monetary policies by using event-study analysis (Gurkaynak and Wright, 2013) based on these announcement dates. Specifically, we quantify the changes in the 10-year Treasury yields in a 2-day event window.[5] Estimates are obtained by regressing the daily changes in the Treasury yields on a set of event-dummies. The sample period ranges from the beginning of January 2007 to the end of March 2014. Estimates are obtained by Ordinary Least Squares and statistical significance is assessed by using heteroskedasticity robust standard errors. We control for other factors that might have influenced the dynamic of the bond rates by including in the regression the macroeconomic news, defined as the difference between the data released during the days of the event and the consensus forecasts collected immediately before the official data release.[6]

Column 9 of Table 1 reports the results of the event study "controlled" for macroeconomic news. Estimates obtained without controlling for the macroeconomic news are reported in Column 8; we call those estimates "classical" because existing event studies have omitted those controls. The results indicate that the effects of non-conventional policy have been statistically significant and economically important, confirming the findings of previous studies. The first round of policies

[4] In the same statement, the FOMC also announced that it "was evaluating the potential benefit of purchasing longer-term Treasury securities".
[5] Using a 1-day event window gives similar results.
[6] Data on macroeconomic news are retrieved from Bloomberg. See Appendix 1 for more details.

implemented immediately after the collapse of Lehman Brothers has been very effective in reducing the Treasury bond rates. Subsequent accommodative policies have been less effective. The announcements of the start of a tightening cycle have been associated with increased bond rates.

As discussed in the introduction, we complement these event studies by studying the changes in expectations regarding the future dynamics of bond yields. We use individual data collected in the Survey of Professional Forecaster (SPF) conducted by the Federal Reserve Bank of Philadelphia.[7] For each quarter, the SPF provides point forecasts up to one year ahead for many macroeconomic variables, including long-term government bond yields. The effects of monetary policy announcements are quantified by analysing how individuals revise their forecasts between two different rounds of the survey in relation to the announcement and implementation of unconventional policy. The last column of table 1 reports the time periods that we analyse based on the exact date at which the forecasters participating in the SPF had to send back their questionnaire. More specifically, the time period for which we evaluate the effect of the different measures spans from November 10, 2008 to February 10, 2009 for the QE1 (and FG), from August 10, 2010 to November 9, 2010 for QE2 (and FG), from August 8, 2011 to November 8, 2011 for OT (and FG), from August 7, 2012 to November 6, 2012 for QE3 (and FG), from November 6, 2012 to February 11, 2013 for FG (i.e., the announcement of the outcome-based forward guidance), and from May 7, 2013 to August 12, 2013 for the Tapering. The policy announcements that fall into these periods are shaded.

The announcements and implementations of specific unconventional policies are concentrated between consecutive surveys. This feature allows us to match various policy actions with the revision of expectations between specific consecutive rounds of the survey. The reliability of the match we use is confirmed by examining Google data. We use Google trends data on internet search queries for the words Quantitative Easing, Operation Twist, Forward Guidance, and Tapering. Figure 2 reports these data. For each non-standard measure, the shaded area represents the corresponding evaluation period between the two selected surveys. It is evident that, with the exception of the forward guidance, search intensity for the selected words peaks during the period considered in the analysis, i.e., the period corresponding to the shaded area. This evidence further corroborates our choice of the selected survey rounds.

INSERT FIGURE 1 OVER HERE

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

3 Using SPF for Policy Analysis

The event study performed above only evaluates the immediate high-frequency effect of the policy announcements and implementations. We complement that study by examining the impact of these policy events on the forecasts of bond yields at different horizons. This allows us to assess whether the effects are perceived to be transitory or persistent.

The identification strategy consists of two steps. First, we isolate the unexpected component of the policy action by focusing on revisions of forecasters' expectations of the yield on 10 year government bonds between two consecutive survey rounds. Second, we isolate the perceived effects of non-standard policy by controlling for changes in the perceived macroeconomic environment (proxied by real GDP and CPI inflation) and for expected conventional policy (proxied by the yields on the three month Treasury bill). The identifying assumption is that it takes at least one quarter for unconventional policy to affect the macroeconomic environment.

Forecast revisions are defined as the difference between the forecasts of a given variable y at time horizon h up to 4-quarters ahead (i.e., from t to $t+3$) made by a professional forecaster i at time t and at time $t-1$.

$$\Delta y_{i,t}(h) = y_{i,t}^{t+h} - y_{i,t-1}^{t+h} \quad , \quad h=0,\ldots,3 \text{ and } i=1,\ldots,n \tag{1}$$

Figure 2 reports the consensus (i.e., the median) and the cross-sectional dispersions (i.e., the disagreement) of the forecasts for the current quarter and of the corresponding forecast changes made by the panellists from 2009Q1 to 2014Q1.[8] The vertical gridlines represent the quarter of interest for which we measure the effects of non-standard policies. For convenience, selected survey rounds will be denoted by the specific associated policy action: QE1 for 2009Q1, QE2 for 2010Q4, OT for 2011Q4, QE3 for 2012Q3, FG for 2013Q1and TAP for 2013Q3. In correspondence to the first four events (the ones characterised by accommodative policy), there was a substantial drop in the forecasts of the Treasury bond rate as well as a downward revision of the predictions for the current quarter. The reverse is true for the last event, which is instead associated with a tightening of policy. It is also evident that the perceived macroeconomic outlook has also been revised, especially in the quarter labelled QE1. Forecasts and forecast changes for real GDP growth and CPI inflation exhibited a sizeable downward movement during late 2008 and early 2009 that might reflect the unexpected turmoil that followed the collapse of Lehman Brothers. It is evident that during the quarter associated with QE1, there was a substantial revision of the expectations of the Treasury bill. This can be attributed to the drop in the federal fund target rate in

[8] The forecasts for 1-quarter and 4-quarters ahead are reported in Figure A1 for all variables for a longer time period (1992:1-2012:1).

late 2008. As stressed above, there might be a reverse causality issue at work here because the changes in economic activity and prices might have influenced the dynamic of Treasury bond yields.

INSERT FIGURE 2 OVER HERE

The figure also highlights the close-to-zero expectations for the level of the short-term interest rate (T-bill) over the last part of the sample. Consistent with the zero lower bound constraint on the interest rate, forecast changes have not exhibited any pattern since the beginning of the 2009. This evidence also reflects the ability of the Fed to anchor the market's expectations of the future path of the short-term interest rate close to its target. In fact because the end of 2008, the target level for the federal funds rate has been set in a range from 0 to 0.25. Finally, in line with Lahiri and Sheng (2010), the figure suggests that there exists a high degree of disagreement among forecasters.

Figure 3 describes the change in expectations of the Treasury bonds rate after the announcement of the unconventional policies at different forecasting horizons. The vertical gridlines highlight the selected quarters of interest. It is evident that forecasters revised downward their predictions for the long-term interest rate in correspondence to the implementation and announcement of unconventional monetary policy measures. The revision was largest in correspondence to QE1 between 2008Q4 and 2009Q1, measuring -1.04 on average for the current period. Interestingly, the magnitude of forecast revisions remains large for longer horizon forecasts. Revisions of similar magnitude at all horizons are also observed in correspondence to QE2, OT and QE3.

In correspondence to the announcement of the forward guidance in 2012Q4, we observe a milder revision of bond yields, while the announcements of the tapering-off of QE purchases are associated with an upward revision of the forecasts (approximately 50bps).

Changes in the term structure of individuals' forecasts are used to separate expected from unexpected bond rate changes as drivers of macroeconomic variables. However, as already mentioned, these changes cannot be interpreted as being only due to the policy measures because the window of the event is large (one quarter) and therefore other factors might have caused the changes in expectation. In the next section, we will correct for these issues by controlling for factors summarising economic developments that might have influenced forecasters' beliefs. An important feature of the surveys is that the forecasts are reported for different horizons. This will allow us to study the beliefs of forecasters regarding how long the eventual effects of policy would last.

INSERT FUGURE 3 OVER HERE

4 The Effects of Policy Announcements on Expected Long-Term Rate

The descriptive analysis in the previous section does not allow for assessing the expected reaction of bond markets to unconventional monetary policy actions due to potential endogeneity problems. Forecast revisions observed in correspondence to the implementation of non-standard monetary measures might reflect a change in the expected macroeconomic outlook and in the stance of monetary policy. If markets revise their expectations for inflation downward, it is likely that they will also revise downward their forecasts of long-term interest rates due to the Fisher effect. Similar dynamics are expected during economic slowdowns due to the link between growth, the natural rate and the long-term rates. At the same time, if the central bank tends to ease monetary policy when there are signals of lower inflation or slower growth, we will also observe a downward revision of long-term interest rate forecasts. As a consequence, by simply examining the change in forecasters' expectations before and after policy announcements, we cannot correctly isolate the effect of the policy measures.

To solve the endogeneity problem, we control for the perceived changes in the current macroeconomic environment. Precisely, we estimate the following equation:

$$\Delta Tbond_{i,t}(h) = \alpha_i^h + \sum_{j=1}^{k} \gamma_{i,j}^h Q_j + \sum_{j=1}^{p} \beta_{i,j}^h \Delta X_{i,t}(0) + \varepsilon_{i,t}^h \qquad (2)$$

The independent variable is the change in Treasury bond forecasts ($\Delta Tbond$). The subscripts h (h=0,….,3) and i (i=1,…,n) indicate the forecast horizons and individual forecasters, respectively. The regressors Q_j (k=1,…,6) are dummy variables that take value 1 at the quarters of interest (i.e., 2009Q1, 2010Q4 and 2011Q4, 2012Q4, 2013Q1, 2013Q3), and zero otherwise. The effects on individual expectations at different horizons during these quarters are measured by the coefficients $\gamma_{i,j}^h$.

The vector ΔX includes the variables aimed at controlling for perceived changes in the current macroeconomic environment. Specifically, the change in current quarter forecasts of real GDP growth and CPI inflation are added as additional explanatory variables. We also control for the news regarding the interest rate on the 3-month Treasury bill in order net out the changes in forecasts of the long-term rate due to standard monetary policy. To take into account possible changes in the reaction of the Treasury bond during the ZLB period, we interact real GDP growth and CPI inflation with a dummy variable that takes value one after 2008:4, and zero otherwise.

The coefficients associated with those control variables are supposed to be the same across individuals.[9] The fixed effects variable (α_i) controls for all possible time-invariant (both observable and non-observable) characteristics of the forecasters.

The error term $\varepsilon_{i,t}^{h}$ represents the change in the expectations of Treasury bond interest rates that not accounted for by current quarter developments in prices, output and the short-term interest rate. These errors are assumed to be exogenous with respect to the policy events and to the perceived changes in the macroeconomic environment. Again, the identifying assumption is that it takes at least one quarter for non-standard policies to affect the economy.

The identification and estimation of this class of models have been recently studied by Arellano and Bonhomme (2011) under the general assumption that the individual specific effects of non-standard policy on Treasury bonds are random variable draws from an unspecified population distribution. The distribution conditional on the regressors is left unspecified. Details on the estimation procedure are provided in Appendix 3. Broadly speaking, in our context the individual specific estimates of the effects of the non-standard policies correspond to the residuals at the time of each policy event, where the residuals are estimated by excluding the policy event quarters from the sample.

Table 2 presents the estimation results for the common component, which represents the first step of the Arellano and Bonhomme (2011) estimation procedure.

INSERT TABLE 2 OVER HERE

Almost all coefficients are significant at the 1% level and have the expected sign. Expected increases of CPI inflation, real GDP growth and the Treasury bill interest rate are associated with an expected rise of long-term bond yields. The results also show that the reaction of the long-term rate to economic activity and inflation changed after the ZLB became binding. Interestingly, the increased reaction is compensating for the indirect effects that in normal times, when the ZLB was not binding, were induced by the systematic reaction of conventional monetary policy, in the form of changes to the short-term interest rate, to macroeconomic conditions.

Table 4 shows the mean and variance of the distribution of individual forecasters' expectations of policy effects. Precisely, for each policy event and forecasting horizon, the table captures the expected change in the Treasury bond's interest rate at the time of the various policy announcements. It is clear that after each non-standard policy announcement, professional forecasters revised their expectations downward regarding the future path of the long-term interest rate. This evidence suggests that unconventional monetary policies implemented in the US have

[9] Qualitative results are unaffected when the coefficients on the control variables are allowed to be individual specific. Results are available upon request.

effectively influenced market expectations. More precisely, the expected decrease in the nominal interest rate following the 2009Q1 and 2010Q4 policy announcements is 65 basis points, , and 87 basis points following the 2011Q4 announcement. The increasing effect of the three policy dummies over time also indicates that in general, markets increasingly believe that these non-standard policies might be effective in reducing the long-term bond rate.

By analysing the different forecasting horizons, it is possible to judge the pace at which forecasters expect the policy effects to die out. Interestingly, the policy effect on interest rate is expected to last at least one year in most cases. This means that non-standard policies are able to persistently revise market expectations.

Figure 4 describes the expected effect of the unconventional policies on Treasury yields at various forecasting horizons. This figure summarises the distribution of forecaster beliefs by using box-plots (also known as a box-and-whisker diagram). Following the announcement of accommodative non-standard policies (the first five events), markets expected a substantial decrease in the long-term interest rate. The expected effect of 2009Q1 is smaller than that of 2010Q4. The expected reduction in the bond rates during the last quarter analysed is also substantial. More interestingly, the time profile of these shocks suggests that the effects of these policies have been perceived as being very persistent. Moving across forecasting horizons, the effects of the policies do not die out. This result is in line with the efficient market hypothesis. In fact, as also suggested in Neely (2011), this hypothesis implies that markets formed the best forecast on future treasury yields based on the initial reaction to policy measures. This evidence is in contrast to the findings in Wright (2011) that the effects of these policies are short-lived, with the half-life of the effect dying out after approximately two months. The amplitude of the interquartile range indicates that there is a high heterogeneity of beliefs among forecasters regarding the size of the expected policy effect.

INSER FIGURE 4 OVER HERE

To compare our results with those of a simpler model that does not take into account current economic developments, we also estimate an event-style regression where only the three event dummies are left as explanatory variables in equation (4). This enables us to measure how the effects would have been perceived without controlling for endogenous reactions of bond rates. Specifically, we compare the density of estimated shocks from our benchmark model with that from the event-style regression for announcement quarters. We use a Gaussian approximation of these densities.

Figure 6 compares for each forecasting horizon the density of the change in expectation of Treasury yields due to policy measures as estimated in the benchmark model (black lines) with that

as estimated in the event-style regression (blue lines). The difference between these densities might be interpreted as the size of correction for endogeneity implied by our model.

The differences between event-style regression and our benchmark model with additional control variables are sizable for 2009Q1 at all forecasting horizons. For the other policy events, the correction is smaller: the expected reduction in Treasury bond rates in the two models (with and without additional variables) is similar.[10] This might be because during the implementation of the 2009Q1 program, the US economy was still in recession. For the second period, although US was not in recession, the correction is still sizable.

For the third period, the correction is very small. This might also be due to the program implemented during that period having a nature different from that of prior programs (as the third period program was a qualitative easing, it is possible that forecasters did not perceive it as inflationary). Additionally, the correction is relatively mild for the fourth and fifth quarters (related to QE3 and the forward guidance announcement of December 2013).

The size of the correction is sizeable for the last selected quarter (related to the tapering). Taking into account the developments in the current macroeconomic environment when estimating the impact of the tapering reduces the size of the effects by 25 basis points on average across the forecasting horizon.

INSERT FIGURE 5 OVER HERE

5 Conclusions

We estimated the perceived effects of unconventional monetary policy measures on long-term bond yields by analysing the revisions of predictions of professional forecasters around the announcement and implementation of policy decisions. The results indicate that professional forecasters expect the long-term rate to drop significantly in response to the accommodative actions undertaken by the FOMC in the aftermath of the financial crisis. The drop is also estimated to be persistent, lasting for at least one year. The magnitude of the drop broadly coincides with the observed change in bond yields in the few days surrounding the most important announcements. These results indicate that, in line with the predictions of the Efficient Market Hypothesis, the bulk of the information regarding the stance of monetary policy has been priced into bond markets immediately by market participants.

[10] Note that the coefficients of the event-style regression are not to be interpreted as the average of the cross-sectional dispersion of the change in forecasters' expectations in the three events. In fact, the event-dummies in our fixed effects setup capture the cross-sectional means in the announcement periods after subtracting to each individual their over-time average.

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Appendix 1 Event study analysis

The regression model used in the event study analysis is the following:

$$\Delta y_t = \sum_{i=1}^{k} \lambda_i D_{i,t} + \sum_{i=1}^{k} \vartheta_i D_{i,t-1} + \varepsilon_t \tag{A.1}$$

The dependent variable (Δy) is the daily change in 10-year Treasury Constant Maturity Rates from the FRED dataset. We construct a set of event-dummy variables (D) that take the value of one for the day of each announcement and the day after the announcement, and zero elsewhere.

For each variable included in table A.1, we can construct a time series of (standardised) daily news as the difference between the first-released (real-time) data and its expected value.[11]

The selected variables are then used in an augmented event-style regression where the explanatory variables now include not only the event-dummies but also all macroeconomic news. This procedure allows us to control for possible movements in the Treasury yields that are due to unexpected changes in macroeconomic variables. We also include the daily change in the federal funds future rate to account for market expectations of the policy rate.[12] The augmented model is the following:

$$\Delta y_t = \sum_{i=1}^{k} \lambda_i D_{i,t} + \sum_{i=1}^{k} \vartheta_i D_{i,t-1} + \sum_{i=1}^{s} \omega_i News_{i,t} + \varepsilon_t \tag{A.2}$$

Table A.1 reports all variables included in the augmented-event-analysis. For each variable, the table reports the corresponding coefficient (in basis points) and T-statistic. Standard errors used in the estimation are corrected for heteroskedasticity and autocorrelation.

The coefficients have the expected sign. An increase in unemployment and initial jobless claims decreases the 10-year bond yields. On the contrary, changes in non-farm payroll and PMI exert an upward pressure on bond yields

INSERT TABLE A.1

[11] Table A.1 in Appendix 1 also reports for each variable the estimated coefficient in a regression where the dependent variable is the change in 10-year Treasury bond yields. Table A.2, A.3 and A.4 show all macroeconomic releases that have been announced during the selected event windows.

[12] The Chicago Board of Trade (CBOT) began offering federal funds futures contracts in October 1988. More specifically, his contract is for the simple average of the daily effective federal funds rate during the month of the contract. See Gürkaynak et al. (2007) for a detailed analysis on different market indicators for monetary policy. Data are from Datastream.

Appendix 2 Estimation of the Heterogeneous Panel Model

To estimate equation (2), we use the methodology proposed in Arellano and Bonhomme (2011). In fact, because in our model the individual-specific variables are the policy-event dummies, and the common components are all other explanatory variables contained in $\mathbf{\Delta X}^{SPF}$, our model can be viewed as a special variant of the model presented in Arellano and Bonhomme (2011).

For each forecasting horizon, the model can be written as follows[13]:

$$\Delta Tbond_{i,t} = \alpha_i + \sum_{j=1}^{k} \gamma_{i,j} Q_{j,t} + \mathbf{Z_i \beta} + \varepsilon_{i,t} \tag{A.3}$$

where the vector **Z** collects the control variables. To obtain individual-specific distributions of the policy effects (i.e., $\gamma_{i,j}$), we can use the two step procedure proposed in Arellano and Bonhomme (2011). Specifically, in the first step we regress the dependent variable and each control variable on a constant and the policy dummies. We can then save the residuals of each regression as follows:

$$\Delta \tilde{\text{Tbond}}_{\text{i,t}} = \Delta \text{Tbond}_{\text{i,t}} - \hat{\phi}_0 + \sum_{j=1}^{k} \hat{\phi}_{i,j} Q_{j,t} \tag{A.4}$$

$$\tilde{Z}_{i,t} = Z_{\text{i,t}} - \hat{\theta}_0 + \sum_{j=1}^{k} \hat{\theta}_{i,j} Q_{j,t} \tag{A.5}$$

Then, we can obtain $\hat{\beta}$ by regressing $\Delta \tilde{Tbond}_{it}$ on $\tilde{Z}_{it}$.

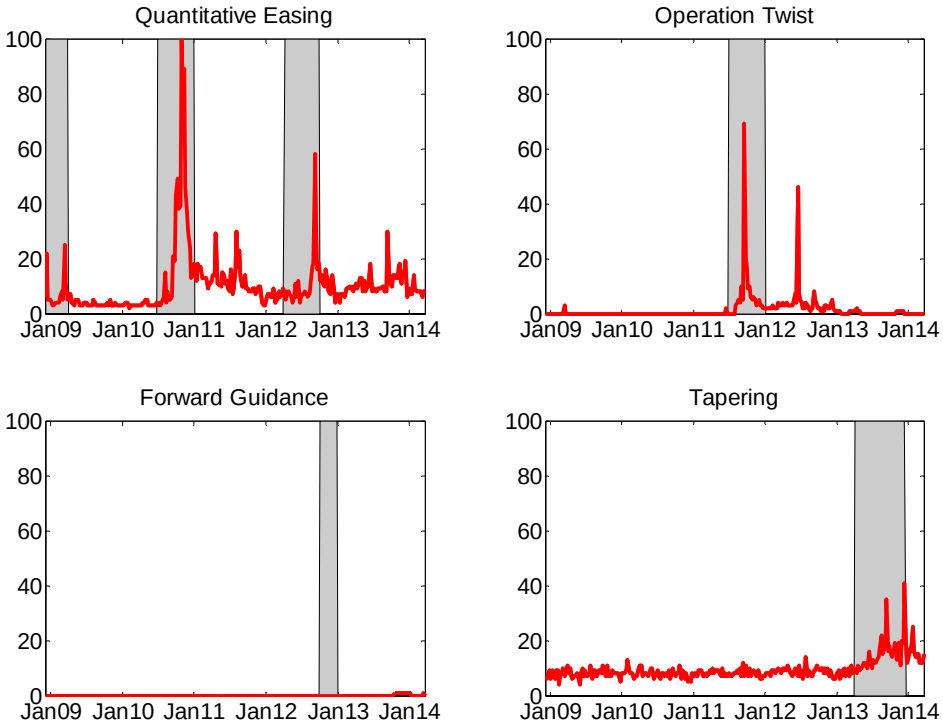
Once we have obtained the vector $\hat{\beta}$, we move to the second step, which consists of computing the mean and variance of the individual-specific effect (γ's) by applying the Mean Group estimator to the following random coefficient model:

$$\left(\Delta \text{Tbond}_{\text{i,t}} - \hat{\beta} Z_{i,t}\right) = \alpha_{\text{i,t}} + \sum_{j=1}^{k} \gamma_{i,j} Q_{j,t} + \varepsilon_{i,t} \tag{A.6}$$

Because T is large in our case, the problem arising when calculating the standard errors obtained with the generated regressor is very minor.

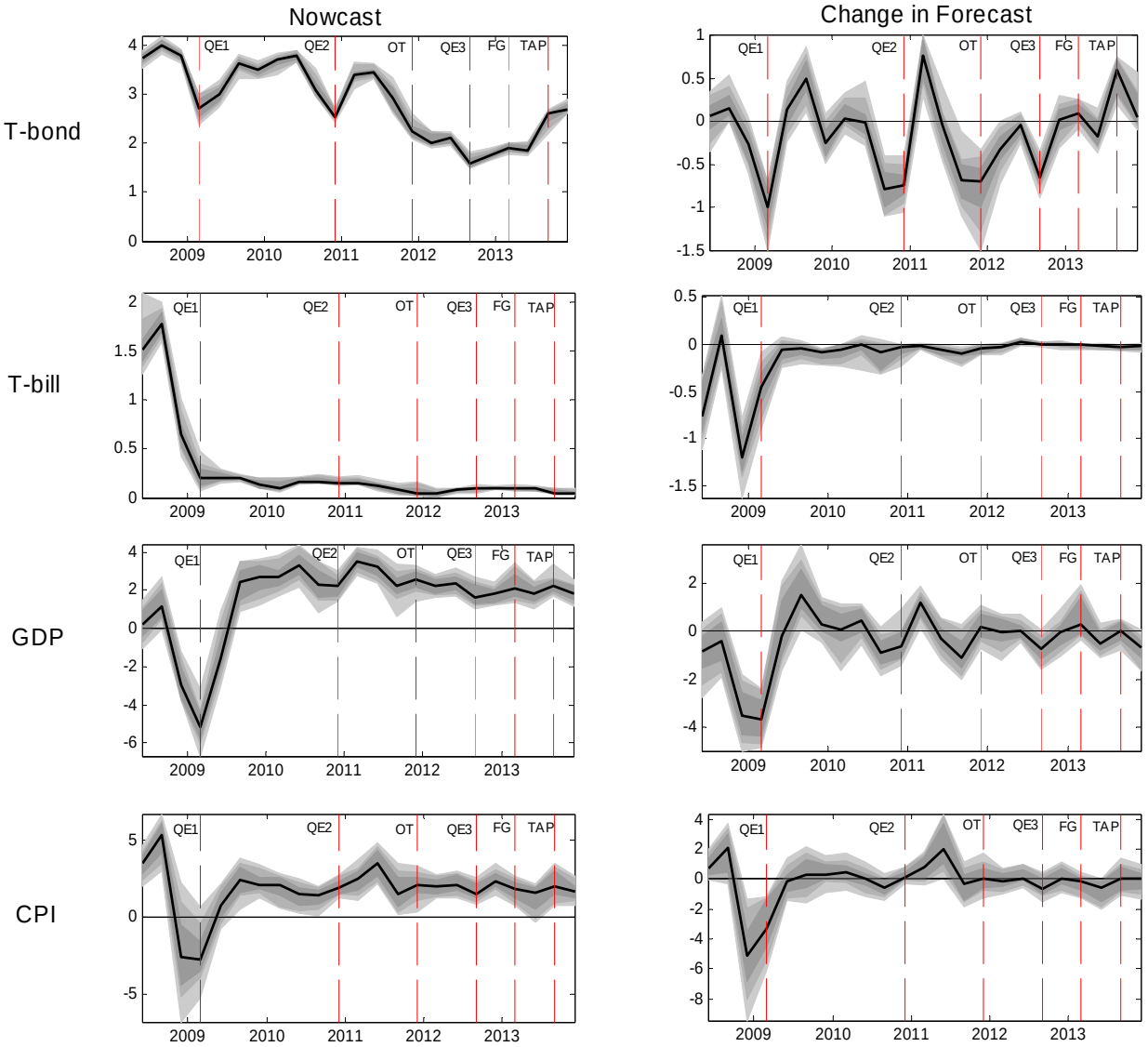
[13] Figure A.1 reports the cross-sectional distribution of forecasts for 1 quarter (left column) and four quarters (right column) ahead of the 10 years government bond yields (T-Bond), the 3-month Treasury bill yields (T-Bill), GDP growth and CPI inflation.

Figure 1: Google Trends search volume index – weekly data



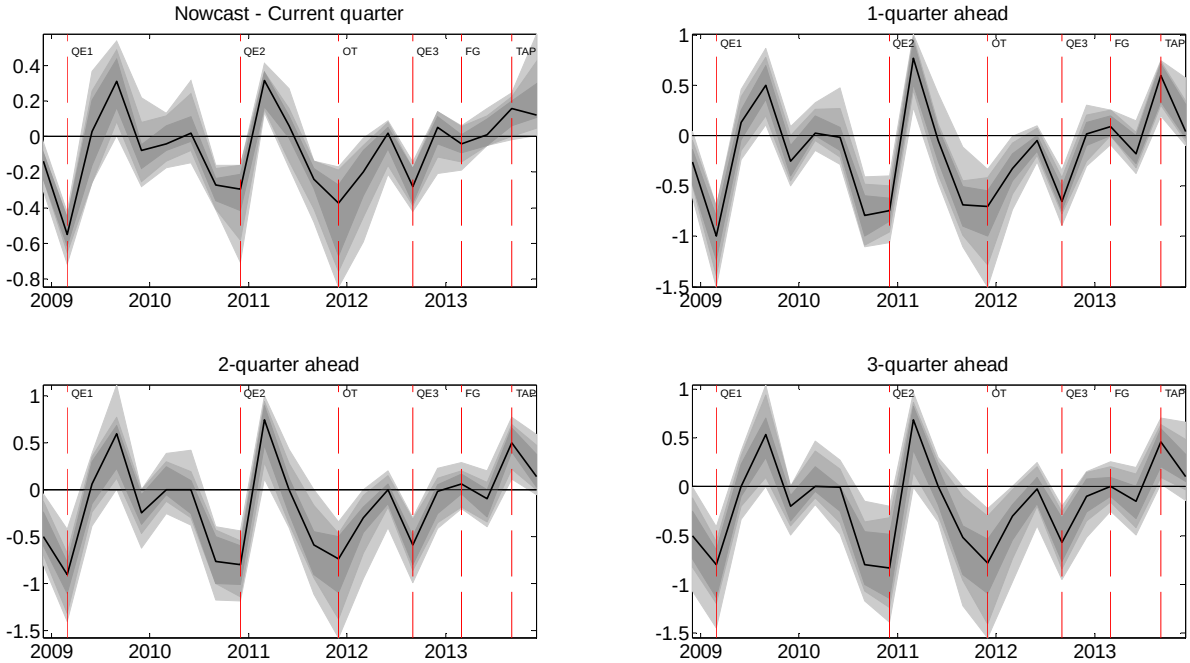
Note: The figure reports the Google Trends count of Internet search queries of the terms "quantitative easing", "operation twist", "forward guidance", and "tapering" from the United States from January 2009 to March 2014. Data are scaled to the maximum search traffic for the specific term (represented as 100) during the time period from January 2009 to March 2014 in the United States. The shaded areas represent the evaluation periods for the six quarters of interest (i.e., 2009:1, 2010:4, 2011:4, 2012:3, 2013:1, and 2013:3).

Figure 2: Nowcast and Change in Forecast



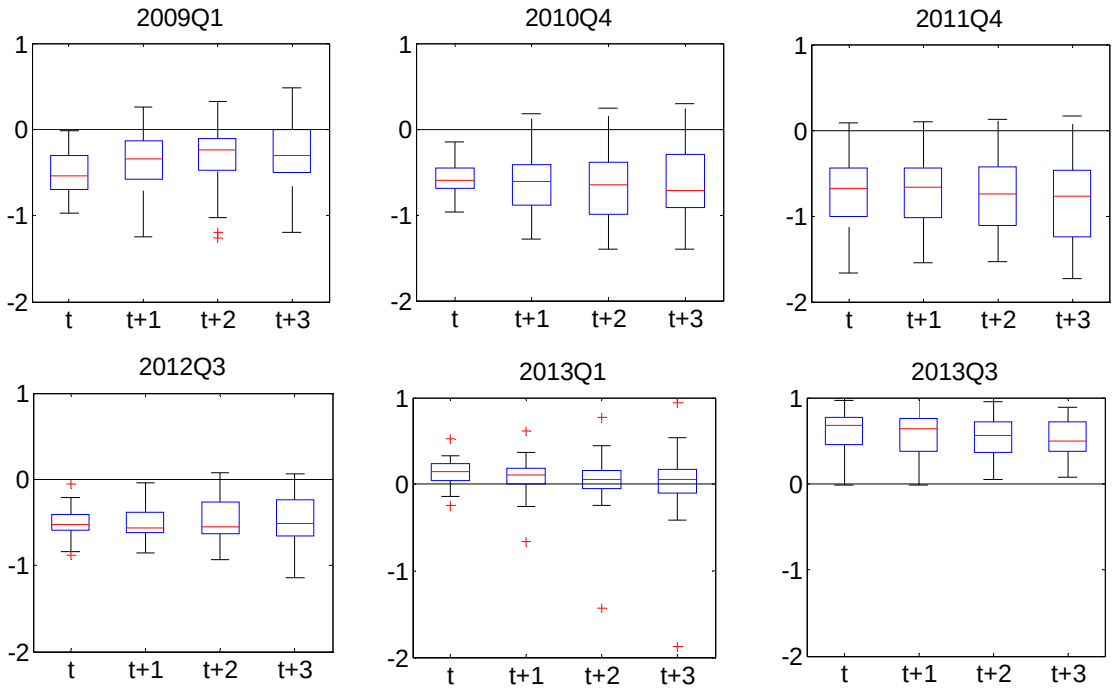
Note: For each quarter from 2008:1 to 2012:1, the figure reports the distribution of forecasts across panelists (left column) and the change in forecasts (right column) of the 10 year government bond yield (T-Bond), the 3 monthTreasury bill yield (T-Bill), GDP growth and CPI inflation. The solid black line that goes through the areas is the median. The shaded areas comprise 50%, 68% and 90% of the distribution. The vertical gridlines represent the quarters of interest, i.e., 2009:1, 2010:4, 2011:4, 2012:3, 2013:1, and 2013:3.

Figure 3: Change in Treasury bond Forecasts



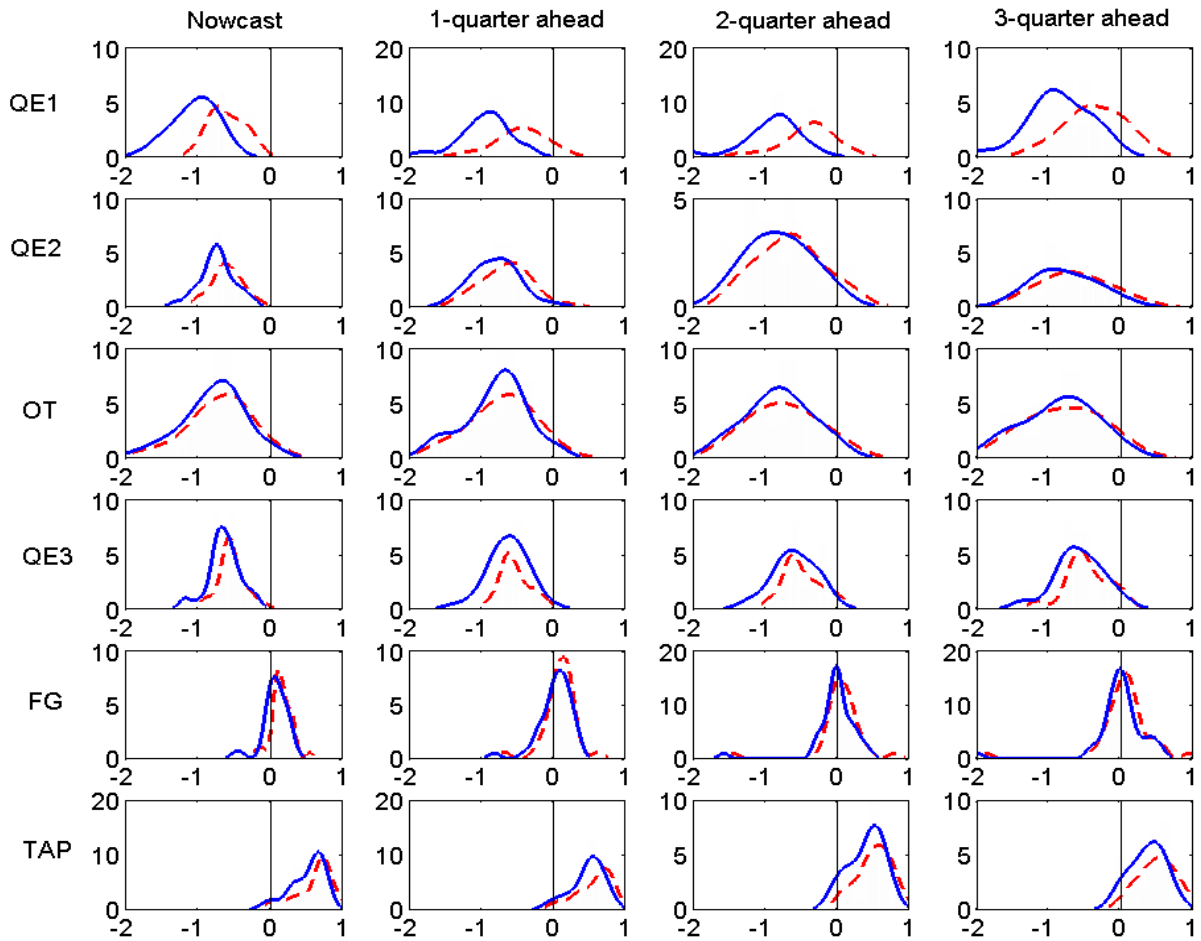
Note: For each quarter from 2008:1 to 2012:1, the figure reports the distribution of forecast revisions across panelists. The solid black line that goes through the areas is the median of the forecasters' distribution for each quarter. The shaded areas comprise 50%, 68% and 90% of the distribution. The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

Figure 4: Cross-sectional distribution of the effect of non-standard measures on T-Bond



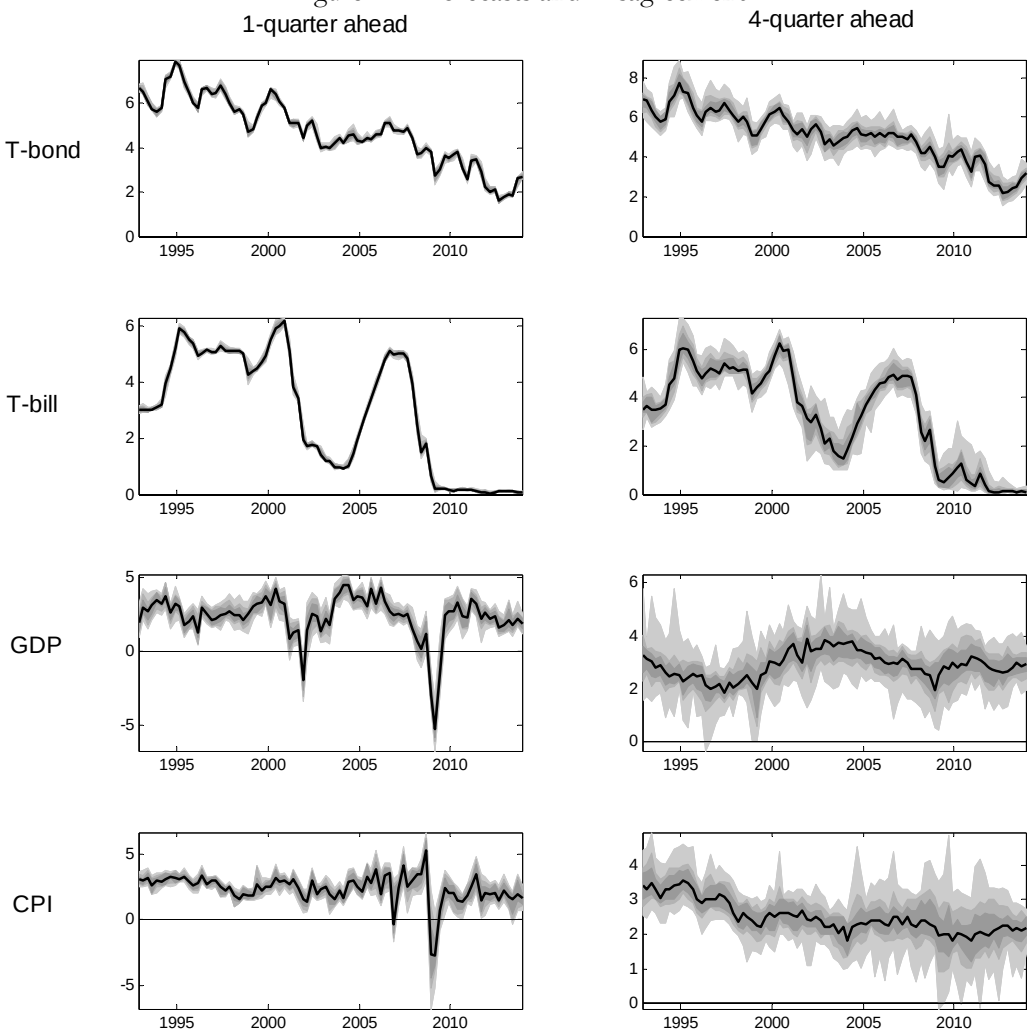
Note: The figure reports the distribution of the individual-specific coefficients of the expected effect of the non-standard monetary policy, which was retrieved from the second step of the estimation procedure. These graphs visualise the interquartile ranges (the box), the averages (the line inside 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 larger than $q_3+w*(q_3-q_1)$ or smaller than $q_1-w*(q_3-q_1)$, where q_1 and q_3 are the 25th and 75th percentiles, respectively).

Figure 5: Actual and Estimated Densities of the effect of non-standard measures on T-Bond



Note: The figure compares for each forecasting horizon the approximation of the individual-specific distribution of the expected effect of the non-standard policy monetary measures estimated by employing the benchmark model (red lines) and the same density estimated by employing an event-style regression (blue lines).

Figure A.1: Forecasts and Disagreement



Note: The figure reports the distribution across panelists of forecasts of the 10 year government bond yields (T-Bond), the 3 month Treasury bill yield (T-Bill), GDP growth and CPI inflation for one quarter (left column) and four quarters (right column) ahead. The solid black line that goes through the areas is the median. The shaded areas comprise 50%, 68% and 90% of the distribution

Table 1: Dates of Non-standard Monetary policy Actions

Date	Policy Event	Target	QE	OT	FG	TAP	Event-study		Deadline date for SPF
							Classical	Controlled	
Quantitative Easing 1 and Forward Guidance									
Nov. 25 2008	LSAP announcement		X		X		-0.36	-0.31	
Dec. 1 2008	Chairman Speech		X				-0.25	-0.22	2008:4 (Nov. 18)
Dec. 16 2008	FOMC meeting	X	X		X		-0.33	-0.264	2009:1 (Feb. 10)
Jan. 28 2009	FOMC meeting		X		X		0.28	0.31	
Mar. 18 2009	FOMC meeting		X		X		-0.41	-0.42	
Aug. 12 2009	FOMC meeting		X		X		-0.12	-0.08	
Sep. 23 2009	FOMC meeting		X		X		-0.06	-0.06	
Nov. 4 2009	FOMC meeting		X		X		0.07	0.07	
							-1.18***	-0.98***	
Quantitative Easing 2 and Forward Guidance									
Aug. 10 2010	FOMC meeting		X		X		-0.14	-0.12	
Aug. 27 2010	Chairman speech		X				0.04	0.02	2010:3 (Aug. 10)
Sep. 21 2010	FOMC meeting		X		X		-0.16	-0.17	2010:4 (Nov. 09)
Oct. 15 2010	Chairman speech		X				0.0	-0.01	
Nov. 3 2010	FOMC meeting		X		X		-0.1	-0.11	
							-0.36**	-0.38**	
Operation Twist and Forward Guidance									
Aug. 9 2011	FOMC meeting				X		-0.23	-0.23	2011:3 (Aug. 08)
Sep. 21 2011	FOMC meeting			X	X		-0.23	-0.26	2011:4 (Nov. 08)
Nov. 2 2011	FOMC meeting			X	X		0.08	0.08	
Dec. 13 2011	FOMC meeting			X	X		-0.11	-0.09	
Jan. 25 2012	FOMC meeting			X	X		-0.12	-0.12	
							-0.61***	-0.62***	
Quantitative Easing 3 and Forward Guidance									
Aug. 22 2012	FOMC meeting		X	X			-0.12	-0.11	2012:3 (Aug. 07)
Sep. 13 2012	FOMC meeting		X	X			0.11	0.10	2012:4 (Nov. 06)
							-0.01*	-0.01**	
Forward Guidance									
Dec 12 2012	FOMC meeting				X		0.08	0.07	2012:4 (Nov. 06) 2013:1 (Feb. 11)
							0.08	0.07	
Tapering and Forward Guidance									
May 22 2013	Chairman Speech					X	0.08	0.07	2013:2 (May 07)
Jun 19 2013	FOMC meeting				X	X	0.21	0.19	2013:3 (Aug. 12)
Dec 18 2013	FOMC meeting				X	X	0.09	0.10	
							0.38**	0.37**	

Note: QE= Quantitative Easing; OT= Operation Twist; FG= Forward Guidance; TAP = Tapering; LSAP = Large-scale-asset-purchase; and FOMC = Federal Open Market Committee. 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 Announcements on Treasury bond

	Real GDP	CPI	T-Bill	D_{ZLB} x Real GDP	D_{ZLB} x CPI
Current-quarter	0.03	0.01	0.48	0.07	0.06
	[3.522]	*[1.238]*	*[19.694]*	*[2.916]*	*[3.575]*
1-quarter ahead	0.05	0.01	0.51	0.06	0.06
	[5.104]	*[1.385]*	*[19.066]*	*[2.273]*	*[3.351]*
2-quarter ahead	0.05	0.02	0.48	0.06	0.05
	[5.177]	*[2.270]*	*[16.617]*	*[2.359]*	*[2.509]*
3-quarter ahead	0.05	0.02	0.45	0.06	0.04
	[4.505]	*[2.775]*	*[15.846]*	*[2.398]*	*[1.972]*

The table reports the estimation results for the common components, which represents the first step of the Arellano and Bonhomme (2011) estimation procedure. Newey-West standard errors are used in the estimation. For each forecasting horizon, the change in forecasts of the Treasury bond is regressed on a set of control variables after filtering out the effects of the event dummies. The table reports the estimated parameters and the corresponding T statistics (in square brackets).

Table 3: Estimated Mean and Variance of individual-specific dummy variables

	Current-quarter	1-quarter ahead	2-quarter ahead	3-quarter ahead
2009Q1				
Mean	-0,49	-0,36	-0,31	-0,29
	[0,08]	[0,09]	[0,10]	[0,10]
Standard Deviation	*0,24*	*0,36*	*0,38*	*0,42*
2010Q4				
Mean	-0,59	-0,65	-0,65	-0,63
	[0,09]	[0,09]	[0,09]	[0,09]
Standard Deviation	*0,20*	*0,34*	*0,46*	*0,46*
2011Q4				
Mean	-0,77	-0,79	-0,81	-0,86
	[0,09]	[0,09]	[0,09]	[0,10]
Standard Deviation	*0,54*	*0,56*	*0,58*	*0,62*
2012Q3				
Mean	-0,51	-0,51	-0,46	-0,46
	[0,08]	[0,09]	[0,09]	[0,09]
Standard Deviation	*0,18*	*0,20*	*0,26*	*0,30*
2013Q1				
Mean	0,13	0,08	0,04	0,04
	[0,08]	[0,08]	[0,08]	[0,08]
Standard Deviation	*0,15*	*0,22*	*0,34*	*0,44*
2013Q3				
Mean	0,65	0,62	0,56	0,53
	[0,10]	[0,10]	[0,10]	[0,10]
Standard Deviation	*0,38*	*0,37*	*0,34*	*0,33*

Note: For each quarter of interest, the table reports three rows. The first and second rows report the mean and the standard deviation (in squared brackets) of the parameter estimates obtained with the random coefficient model. Newey-West standard errors are used in the estimation. The third row reports the standard deviation of the individual-specific distributions.

Table A.1: News variables included in the analysis

	Variable	Coefficient	T stat.
1	ADP Employment Change	1.94	3.47
2	Building Permits	1.24	2.27
3	Capacity Utilization	0.74	0.95
4	Change in Manufact. Payrolls	-1.74	-2.10
5	Change in Nonfarm Payrolls	6.05	5.69
6	Chicago Fed Nat Activity Index	2.17	3.77
7	Chicago Purchasing Manager	1.77	3.64
8	Construction Spending MoM	1.03	1.50
9	Consumer Confidence Index	0.67	1.21
10	Continuing Claims	-0.31	-1.07
11	Core PCE QoQ	0.43	0.63
12	CPI Ex Food and Energy MoM	0.78	1.63
13	CPI MoM	0.13	0.25
14	Current Account Balance	-0.64	-0.97
15	Durable Goods Orders	0.18	0.37
16	Durables Ex Transportation	1.45	2.57
17	Empire Manufacturing	1.03	1.75
18	Employment Cost Index	-0.09	-0.13
19	Existing Home Sales	1.23	2.07
20	Factory Orders	0.10	0.19
21	FOMC Rate Decision	-0.02	-0.07
22	GDP Annualized QoQ	0.83	1.63
23	GDP Price Index	0.53	0.88
24	House Price Index MoM	-0.10	-0.13
25	Housing Starts	-0.18	-0.35
26	Import Price Index MoM	0.18	0.41
27	Industrial Production MoM	0.10	0.18
28	Initial Jobless Claims	-1.19	-4.61
29	ISM Manufacturing	2.45	4.26
30	ISM Non-Manf. Composite	1.49	3.37
31	ISM Prices Paid	0.68	1.23
32	Leading Index	0.70	1.54
33	Monthly Budget Statement	-0.41	-1.40
34	New Home Sales	0.65	1.65
35	PCE Core MoM	0.60	1.12
36	Pending Home Sales MoM	0.68	1.00
37	Personal Consumption	1.12	1.83
38	Personal Income	-0.57	-1.48
39	Personal Spending	0.50	0.87
40	Philadelphia Fed Business Outlook	1.32	2.57
41	PPI Ex Food and Energy MoM	0.17	0.28
42	PPI Ex Food and Energy YoY	1.63	1.92
43	PPI MoM	0.31	0.41
44	PPI YoY	-0.02	-0.02
45	Retail Sales Advance MoM	0.86	0.83
46	Retail Sales Ex Auto and Gas	0.68	0.99
47	Retail Sales Ex Auto MoM	1.79	2.09
48	S&P/CaseShiller Home Price Index NS	0.61	0.36
49	Trade Balance	0.75	1.75
50	Unemployment Rate	-1.18	-2.09
51	Univ. of Michigan Confidence	0.78	2.26
52	Wholesale Inventories MoM	-0.15	-0.30

Note: the table reports the results of a regression where the dependent variable is the 10-year Treasury bond rate while the explicative variables are all macroeconomic news used in the analysis. The columns "Coefficient" report the estimated coefficients for each variable with the correspondent t-statistics in the column "T stat". The shaded areas highlight statistically significant parameters.