The Effectiveness of Unconventional Monetary Policy Announcements in the Euro Area: An Event and Econometric Study

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Abstract

We use daily data on government bond yields and market-based inflation expectations (from inflation-linked swaps) to measure the effects of unconventional monetary policy (UMP) announcements in the euro area. We focus on the effects of policy announcements on ex-ante real interest rates, since the main transmission mechanism of monetary policy is through real interest rates and their effect on aggregate demand. We find evidence of statistically significant effects of UMP announcements of the ECB on real interest rates at maturities of five and ten years that operate by raising inflation expectations. When distinguishing among UMP announcements that exceeded or disappointed market expectations, we find that the former significantly reduced nominal and real interest rates and increased inflation expectations while the latter had the opposite effect.

Non-technical summary

Many central banks in industrialized countries resorted to different types of unconventional monetary policy (UMP) after they had lowered their policy rates to the effective lower bound in response to the financial crisis of 2007-2008. These measures included forward guidance concerning the future path of their policy rates, large scale asset purchases designed to affect the yield curve of interest rates and to increase liquidity in targeted financial markets, and quantitative easing, which entails expanding the size of the central bank's balance sheet. Our empirical focus in this study is on the European case as the ECB (and the Eurosystem) have implemented a rich set of different UMP measures since the beginning of the financial crisis.

The empirical literature on the effectiveness of UMP measures has mostly focused on finding evidence that central bank policy announcements affect the slope of the yield curve of nominal interest rates. However, given that the transmission mechanism of monetary policy involves affecting aggregate demand by changing the real rate of return, the ex-ante real interest rate is the relevant measure of monetary policy effectiveness. Therefore, our investigation of the effectiveness of UMP in this paper also includes an analysis of the impact on inflation expectations and on ex-ante real interest rates at different maturities.

We use high-frequency data on market-based inflation expectations and a country-weighted index of government bond yields to construct a measure of euro area ex-ante real interest rates at maturities of one, five and ten years. We identify 13 major UMP announcements by the ECB between July 2008 and March 2016. As a first step, we investigate whether the impact responses of nominal interest rates, inflation expectations, real interest rates and the dollar/euro exchange rate are significantly stronger on the days (and the following day) of these announcements. Then we conduct an econometric analysis where we control for other events which took place on the same day as the UMP announcements, such as policy rate changes, releases of economic forecasts and analyses by the ECB and important macro data releases.

We find that some of the UMP announcements, in particular the announcements of the Securities Markets Programme, the Outright Monetary Transactions and the first announcement of the Asset Purchase Programme, had a significant negative impact on ex-ante real interest rates at different horizons. The significant effect of these programmes on real interest rates in most cases is due to both a negative effect on nominal interest rates and a significant increase in inflation expectations. This is not very surprising since the Asset Purchase Programme (and to some extent also the SMP and the OMT) are the only programmes that focused explicitly on increasing inflation expectations. The other programmes were primarily designed to provide liquidity to targeted market segments (e.g. the Covered Bonds Purchase Programme) or to the banking system as a whole (e.g. the Longer-Term Refinancing Operations) so that their expected effect on inflation expectations is less clear-cut.

For the 13 UMP announcements together, we find a significant negative effect on medium-term real interest rates which comes mostly from an increase in inflation expectations. When the UMP announcements are grouped into those that exceeded and disappointed market expectations we find that the former were highly effective in lowering nominal and real interest rates at all horizons while the latter had a significant positive impact on nominal and real interest rates.

1 Introduction

In order to boost aggregate demand and inflation, central banks have resorted to several different types of unconventional monetary policy (UMP) measures since the financial crisis of 2007-2008, during which many of them lowered their policy rates to their effective lower bound. These measures have included forward guidance concerning the future path of their policy rates, large scale asset purchases designed to affect the yield curve of interest rates and to increase liquidity in targeted financial markets, and quantitative easing (QE), which entails expanding the size of the central bank's balance sheet. QE provides liquidity to financial markets and also increases the size of the monetary base.

The empirical literature evaluating the effects of UMP has focused on detecting evidence that changes in central banks' policy announcement and/or balance sheets have significant effects on the yield curve of nominal interest rates: reductions in longer-term yields are interpreted as expansionary.

To the extent that the transmission mechanism of monetary policy involves affecting aggregate demand by changing real interest rates, the ex-ante real interest rate is the most relevant measure of monetary policy effectiveness.[1] The availability of high-frequency data on inflation-linked swaps (ILS) for euro area inflation allows us to go beyond looking at the impact of UMP announcements on the yield

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[1] The canonical New Keynesian IS curve depends, as in Woodford (2003), on the ex-ante real interest rate. It is at least theoretically possible for declines in long-term nominal yields to be associated with higher ex-ante real rates: Ambler (2016) shows in a New Keynesian model that if monetary policy is expected to be tight in the future, this can drive down nominal interest rates while driving down inflation expectations even more.

curve of nominal interest rates and to construct ex-ante real interest rates at horizons of one to ten years. We use data on ILS and a country-weighted index of government bond yields of the euro area. We focus on the yields of government bonds rather than private sector bonds or bank loan rates because they usually contain smaller risk premia and they are commonly used to measure the general interest rate level in an economy. The details of the data are described below.

We perform two different types of analysis using this data. First, we look at the distribution of daily nominal yields, daily inflation expectations, daily ex-ante real yields (for different maturities), and exchange rates and investigate whether there is a significantly greater impact response of these variables on days when there were important UMP announcements between July 2008 and March 2016. We measure the impact response as the change in the relevant variable between its value at the end of the trading day previous to the announcement and either the end of the trading day on which the announcement is made or the end of the following trading day.[2] This is an event-study approach similar to the methodology used by several other researchers looking at UMP in the US, Europe, the UK and elsewhere.[3]

Second, we supplement the event study with an econometric analysis designed to control for events other than UMP announcements on the same day. In addition to a dummy variable for days with UMP announcements, we include dummy

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[2]We only look at the immediate effects of UMP announcements and not at the cumulative effect of the announcements plus their implementation.

[3]See the references in Martin and Milas (2012) for the US and the UK and Briciu and Lisi (2015) for the euro area.

variables for days on which there was a change in the ECB's policy rate (three increases and fifteen decreases) and a dummy variable for all ECB meeting dates without major UMP announcements or rate changes. In addition, we control for the effects of surprises in the releases of inflation, real GDP, industrial production and unemployment data in the four largest euro area economies and the euro area itself, and also for the effects of major policy speeches by ECB officials. Finally, we extend the analysis to distinguish between announcements that exceeded, met, or disappointed market expectations as they might potentially affect real interest rates in different directions.

We find that some of the UMP announcements of the Eurosystem since 2008, in particular the announcements of the Securities Markets Programme, the Outright Monetary Transactions and the first announcement of the Asset Purchase Programme, had a significant negative impact on ex-ante real interest rates at different horizons. In most cases where we find significant effects of single UMP announcements on real interest rates this effect is due to both a negative effect on nominal interest rates and to a significant increase in inflation expectations. For all UMP announcements together, we find a significant negative effect on the medium-term real interest rates which comes mostly from an increase in inflation expectations. When the UMP announcements are divided into those that exceeded and disappointed market expectations we find that the former were highly effective in lowering nominal and real interest rates at all horizons while the latter had a significant positive impact on nominal and real interest rates.

The rest of the paper is structured as follows. The second section briefly re-

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views some of the previous empirical evidence on the effectiveness of UMP since the financial crisis. The third section discusses our data and methodology. The fourth section presents the results. First we present visual evidence on the impact of various UMP announcements on nominal yields, inflation expectations, and ex-ante real interest rates. Second, we discuss the results of statistical tests of the effectiveness of individual UMP announcements. Then, we present the econometric evidence of the effectiveness of UMP announcements using announcement-date dummy variables and controlling for other important policy news. The fifth section concludes.

2   Previous Studies

Krishnamurthy and Vissing-Jorgensen (2011) discuss the different transmission channels of UMP. They highlight the following channels: signalling channel, duration risk channel, liquidity channel, safety channel, prepayment risk premium channel, default risk channel and inflation channel. They define the risky ex-ante long-term real interest rate r as a function of the average expected short-term risk-free interest rates up to maturity $\bar{i}$, a composite premium PR (including the default risk premium, duration risk premium, liquidity premium, etc.) and inflation expectations over the same period π^e:

$$r = \bar{i} + PR - \pi^e \tag{1}$$

In this setting UMP can reduce r by reducing $\bar{i}$ (signalling channel), reducing PR (various risk channels) or by increasing π^e (inflation channel). This classification is quite exhaustive. It focuses on how UMP can affect nominal yields at different horizons, but also considers whether the inflation channel can reinforce a reduction in nominal yields by an increase in inflation expectations. They use an event study methodology and find that increases in inflation expectations helped push down real interest rates during the first two phases of QE in the US.[4]

Our methodology is similar to Swanson (2011) and Thornton (2013). Swanson notes (page 159), "A high-frequency event-study analysis uses changes in financial markets within narrow windows of time around major, discrete announcements to measure the effects of those announcements." This methodology is applied to Operation Twist in the US in the 1960s. He does not look at the impact of announcements on inflation expectations, but as the name implies the goal of Operation Twist was to affect the yield curve by swapping long- and short-term debt on the Fed's balance sheet while not changing its total size.

Thornton (2013) discusses identification issues related to the event study methodology. He notes that event studies avoid endogeneity problems associated with the use of lower frequency data. On the other hand, the announcement effects must be due only to the announcement itself which is difficult to ascertain in the case of monetary policy announcements. For the US, Thornton concludes that official UMP announcements by the Fed were by and large not well identified and that

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[4]Their use of a rich set of public and private assets of different maturities allows them to estimate the different elements of PR, but this is beyond the scope of this paper.

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the event study provides only weak evidence that QE reduced long-term nominal yields.

Moessner (2014) looks at inflation expectations but from the standpoint of testing whether they become unanchored in an upward direction as a result of UMP. Speck (2016) also looks at the anchoring of inflation expectations in the euro area. Briciu and Lisi (2015) look at nominal and real two and ten year yields for individual euro area countries (Germany, Italy, Spain). Their approach, like ours, is based on an event study. They do not perform statistical tests to analyze the significance of the changes in real yields. Altavilla, Carboni and Motto (2015) look at the impact of the ECB's Asset Purchase Programme on "other asset classes" which include the exchange rate, the stock market, and inflation expectations. However, they do not calculate ex-ante real interest rates.[5] Pereira (2016) uses an event study methodology to test the significance of 22 different unconventional monetary policy announcements on long-term government and corporate bond yields of individual euro area countries as well as 5y5y ILS forward rates[6] for the euro area. She finds that, overall, the UMP announcements by the ECB had significant effects on long-term interest rates and inflation expectations but the direction of the effects is often opposite to what was expected.

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[5]For broad surveys of UMP measures, see Martin and Milas (2012) and Williams (2011).

[6]The 5y5y ILS forward rate measures expected inflation over five years starting in five years, which is implicit in the 10-year and the 5-year ILS. With this measure, however, Pereira cannot directly back out the real interest rate and test the effects of UMP measures on real rates.

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3 Data and Methodology

3.1 Data

The data set we use consists of daily observations on government bond yields, market-based inflation expectations of different maturities, market-based overnight interest rate expectations and the US-dollar/euro exchange rate.[7] Nominal yields are a weighted average of all euro area countries and inflation expectations are derived from inflation-linked swap (ILS) rates for euro area inflation.[8] Data are available for maturities from 1 to 10 years, but we conduct our analysis only for two-, five- and ten-year maturities because trading volumes are highest (and thus volatilities are lowest) for these maturities.[9] In addition, for the one-year maturity there is no euro area aggregate series for bond yields due to the lack of comparable one-year treasury bills across euro area countries. In order to be able to evaluate the announcement effects of UMP measures on real interest rates, we calculate daily implicit ex-ante real bond returns from the nominal yields and the ILS rates with corresponding maturities.

Overnight interest rate expectations are derived from overnight index swaps (OIS) for the euro area which follow a similar concept as the ILS. They are used

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[7]The exchange rate is defined as the amount of US-dollars required for one euro, such that an increase denotes an appreciation of the euro and a decrease a depreciation.

[8]Inflation-linked swaps are bilateral agreements which allow counterparties to exchange fixed interest rate payments on a nominal for floating-rate payments linked to inflation. The fixed rate is thus a measure of the market's expectation of inflation over the relevant period. See Hurd and Relleen (2006) and ECB (2011) for a detailed explanation. The swaps may incorporate inflation risk premia and possibly other premia related to institutional factors. As is standard in the literature, we ignore these premia.

[9]Speck (2016) also excludes one-year ILS because of high volatility and seasonality.

to assess to which degree the UMP announcements surprised financial markets (for a detailed description see Appendix B).

Daily observations are available for weekdays and are end-of-business-day values. They are downloaded with Datastream from the Thomson Reuters Financial Data database. Our sample period spans from 01/07/2008 to 11/03/2016 (roughly 2,000 observations) as daily ILS are available only from July 2008 onwards.

We are interested in analyzing whether ECB announcements can affect aggregate demand at the level of the euro area. For this reason, we focus on a measure of aggregate yield. There may be substitution effects of policy announcement across different national government bonds (flight to safety effects, etc.). Neglecting term premia, the five- and ten-year maturities should be an average of expected short-term yields over the relevant horizons. Even if inflation and the short-term riskless rate are expected to be at their steady-state levels in five or ten years, the components of the five-year and ten-year yields that are closer to the present can still be affected by monetary policy announcements.

For the control variables in our regressions we additionally use macroeconomic release data of the major four euro area economies (Germany, France, Italy and Spain) and of the euro area itself. The release data are retrieved from Bloomberg along with survey-based expectations of the releases which are then used to construct a surprise measure of the data releases.

3.2 Announcement Dates and Control Variables

In the period July 2008 to March 2016, we have identified 13 announcement dates of important UMP measures. They are summarized in Table 1 in Appendix A. The announcement dates are identified by scrutinizing the press releases and press conferences following all ECB Governing Council meetings that fall into our sample period and choosing those dates when either new UMP programmes have been announced or existing ones have been re-defined/extended/modified. We are aware that his approach entails a certain degree of subjectivity. For instance, we have left out the date when actual purchases under the Asset Purchase Programme started – on 05/03/2015 – as we are interested only in the announcement but not the implementation effects of the UMP measures.[10]

Based on these considerations, we identified the following major UMP announcement dates between July 2008 and March 2016 (see also Table 1):

1. On 07/05/2009 the Governing Council announced the first liquidity providing Longer-Term Refinancing Operation (LTRO1). Three one-year fixed rate tender procedures with full allotment were announced to be conducted in June, September and December 2009.

2. On 04/06/2009 the first Covered Bond Purchase Programme (CBPP1) was announced which consisted of an intended purchase of 60 billion EUR of euro-denominated covered bonds starting in July 2009.

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[10]For an exhaustive list of UMP announcements by the ECB, see Lamers, Mergaerts, Meuleman and Van der Vennet (2016).

3. In the light of severe tensions on the sovereign bond markets in some euro area countries, on 10/05/2010 the Governing Council announced a first set of market interventions to bring down yields in these countries. In the first phase of this programme, which was called Securities Markets Programme (SMP1), the Eurosystem purchased a large amount of Irish, Portuguese and Greek government bonds. The effects of these purchases on the monetary base were fully sterilized.

4. In the second phase of the Securities Markets Programme (SMP2), which was announced on 07/08/2011,[11] the Eurosystem purchased large amounts of Italian and Spanish government bonds.

5. On 06/10/2011 the Governing Council announced a second Covered Bond Purchase Programme (CBPP2) under which an amount of 40 billion EUR of covered bonds was intended to be purchased starting in November 2011.

6. On 08/12/2011 a second set of Longer-Term Refinancing Operations (LTRO2) was announced. The operations consisted of two tenders with a maturity of three years and full allotment where banks had the option of early repayment.

7. On 02/08/2012 the Governing Council announced its readiness to intervene in secondary sovereign bond markets to reduce excessive risk premia and safeguard monetary policy transmission (OMT1).

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[11]The press release was actually published on a Sunday but in our analysis we consider the following business day, Monday 08/08/2011, as the announcement date.

8. On 06/09/2012 the technical features of this programme, which was called Outright Monetary Transactions (OMT), were announced (OMT2). Any transaction under this programme was conditional on a country's participation in the European Financial Stability Facility/European Stability Mechanism (EFSF/ESM). The liquidity created through OMT was announced to be fully sterilized and the OMT was intended to replace the SMP. So far, the OMT was actually never activated but it nevertheless had a sizeable impact on bond yields at the time, as shown below.

9. On 05/06/2014 the Governing Council announced a first series of Targeted Longer-Term Refinancing Operations (TLTRO1) which were set up as four-year tenders conducted quarterly until June 2016. Under this arrangement, banks were allowed to borrow from the Eurosystem up to 7% of the amount of their loans to the private sector (excluding household loans for house purchases).

10. On 04/09/2014 the ECB announced its intended purchase of a significant amount of Asset-Backed Securities (ABSPP) to support credit creation in the non-financial corporate sector. ABS purchases were intended for at least two years and started in the fourth quarter of 2014. In the same meeting, the Governing Council also decided on a third Covered Bond Purchase Programme (CBPP3) which started in October 2014.

11. On 22/01/2015 the Governing Council announced a large-scale Asset Purchase Programme (APP1). This programme expands the purchases under

the ABSPP and CBPP3 to include also bonds issued by euro area central governments, agencies and European institutions, the so called Public Sector Purchase Programme (PSPP). Combined monthly purchases under the APP were announced to amount to 60 billion EUR and to be conducted up to September 2016.

12. On 03/12/2015 the Governing Council announced an extension of the APP to at least March 2017 and that principal payments of maturing bonds will be reinvested in order to prevent a decline in the size of the central bank's balance sheet (APP2).

13. On 10/03/2016 the ECB announced further refinements of the APP (APP3): combined monthly purchases were increased to 80 billion EUR and investment-grade euro-denominated bonds issued by non-financial corporations were added to the purchases under a new Corporate Sector Purchase Programme (CSPP). On the same day, the ECB also announced a second series of Targeted Longer-Term Refinancing Operations (TLTRO2) which consists of four consecutive quarterly four-year tenders starting in June 2016. Under this arrangement, banks are allowed to borrow up to 30% of their outstanding loans to the private sector (excluding household loans for house purchases).

Apart from these major UMP announcements, during the sample period the ECB Governing Council has also made decisions on interest rates and released important information that might have had an effect on nominal and real inter-

est rates and on inflation expectations. In order to control for these events, we consider the 18 meetings in which the ECB changed its key interest rates (three increases and fifteen decreases)[12] and all 66 remaining meetings without interest rate changes and important UMP announcements as control variables in our regressions.

It is conceivable that the reaction of bond yields and inflation expectations to UMP announcements is driven primarily by the surprise content of the announcements rather than by the announcements themselves.[13] With the help of expectations of short-term money market rates we identify announcements that exceeded the expectations of financial markets, announcements that were were broadly in line with market expectations and announcements that disappointed markets. A detailed description of this process is given in Appendix B.

Changes in monetary policy are not only announced following ECB Governing Council meetings. Major speeches by ECB officials can also contain hints to markets about important upcoming policy changes.[14] We use a text-based search among more than 900 policy-oriented speeches of ECB board members and identified ten important speeches that were used to create an additional dummy variable for our regression analysis. Details are described in Appendix C.

We also control for the impact of the releases of inflation, real GDP, industrial

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[12]In 6 cases the dates of interest rate changes overlap with UMP announcement dates: 07/05/2009, 08/12/2011, 05/06/2014, 04/09/2014, 03/12/2015, 10/03/2016.

[13]A similar argument is made in Martin and Milas (2012).

[14]For instance, the statement of President Draghi that "the ECB is ready to do whatever it takes to preserve the Euro" in his speech on 26/07/2012 is widely known as having moved financial markets at the time.

production and unemployment data in the four largest euro area economies and the euro area itself. We use the methodology of Speck (2016) to construct a surprise measure of the data releases by subtracting the market expectations from the actual releases normalized by the standard deviation of the expected values. This yields a total of 20 dummy variables which contain non-zero values on release dates when the median expectation did not coincide with the actual release and 0 on all other dates. We describe the details of the construction of these series in Appendix D.

3.3 Methodology

In order to estimate the effects of UMP announcements on nominal and real interest rates and on inflation expectations we conduct a high-frequency data event study. Our econometric analysis consists of regressing the time series of daily changes in returns and inflation expectations on a number of event dummies and control variables.

Event studies have recently been widely employed in the literature to evaluate announcement effects of policy measures (e.g. Swanson (2011), Thornton (2013), Speck (2016), Briciu and Lisi (2015)). They have a number of advantages and one disadvantage over VAR analysis which is a common alternative (e.g. Baumeister and Benati (2013)) to assess the effectiveness of UMP measures. The main advantage of high-frequency event studies is the absence of problems of reverse causality and endogeneity from the regressions as policy makers normally do not react to macroeconomic news on the same day. Furthermore, under perfect information, financial markets should incorporate news into asset prices very quickly

after the announcement. This allows announcement effects to be estimated consistently from the same-day changes in returns. Another advantage of event studies is that the concentration on announcement days abstracts from economic news on non-announcement days that might affect bond returns and inflation expectations, such that the resulting estimates are not contaminated by factors other than UMP announcements.

On the other hand, the major disadvantage of event studies is that identification of the pure effect of UMP announcements is often difficult. Typically, when central banks announce UMP programmes they also release other relevant information for financial markets, such as economic analyses and forecasts. With all this information being released on the same day, it is hard to disentangle the separate effects of different pieces of information on bond returns and inflation expectations.[15] Even when controlling for rate cuts and macro data releases which happen on the same day as the UMP announcements, our estimated coefficients are only imprecise estimates of the true announcement effects. Nevertheless, we feel safe to assume that the major part of the reaction of financial variables on announcement days is actually due to the UMP announcement.

3.4 Empirical Setup

As a first step, we provide descriptive evidence of possible announcement effects. In Table 4 we show the daily changes in nominal and real returns and inflation expectations for two-, five- and ten-year maturities on the 13 announcement

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[15]See Thornton (2013).

days as well as the change in the dollar/euro exchange rate. Statistical significance (depicted by asterisks) is assessed relative to the standard deviation of daily changes in the respective variables on non-announcement days.[16] To capture possible lagged effects of UMP announcements, we also consider changes in yields by the end of the day following the UMP announcements, i.e. two-day changes (shown in Table 5).[17]

For a more formal evaluation of the effect of UMP announcements we then regress the time series of daily changes in nominal and real returns and inflation expectations as well as the dollar/euro exchange rate on event dummies. Our baseline specification is the following regression equation: (We discuss extensions and sensitivity analysis in the section on results below.)

$$\Delta y_t = \alpha + \beta_1 D_t^{ump} + \beta_2 D_t^{rc} + \beta_3 D_t^{meeting} + \varepsilon_t \tag{2}$$

where Δy_t can be one-day and two-day changes in nominal government bond yields, inflation expectations, real returns, or the dollar/euro exchange rate, D_t^{ump} is a dummy for the 13 UMP announcement dates (taking the value 1 on announce-

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[16]Specifically, we perform a t-test to assess whether the observed changes in yields and inflation expectations on each announcement day are significantly different from the mean of these variables on non-announcement days. The asterisks reflect the significance of these t-tests using standard critical values. The presence of sizeable outliers in our data (such as the fall in bond yields in response to the second Greek bailout in March 2012) inflates the estimates of the standard deviation of yields, so that significance errs rather on the conservative side.

[17]This is the change in yields between the closing value on the day before the announcement and the closing value on the day after the announcement. The ECB normally announces rate changes and UMP measures in a press conference starting at 2:30pm on the day of Governing Council meetings, which gives European markets less than two and a half hours to react within the same day.

ment dates and 0 otherwise), D_t^{rc} the dummy for the 15 rate cuts and $D_t^{meeting}$ for the 66 Governing Council meetings without interest rate and UMP decisions. The rate cut dummy is included to control for the effects of the interest rate cuts of the ECB during our sample period on government bond yields and inflation expectations and the latter dummy to control for possible effects of the remaining Governing Council meetings without UMP announcements.[18] All estimations are performed for two-, five- and ten-year maturities and with robust standard errors with respect to conditional heteroskedasticity of unknown form.

4 Results

4.1 Visual Evidence

Figure 1 below presents evidence on the evolution of the two-year yield on a weighted index of government bonds of euro area countries, a market measure of two-year inflation expectations based on inflation-linked swaps and the two-year ex-ante real interest rate obtained by subtracting inflation expectations from the two-year nominal yield. To obtain smoother series, the plots are five-day moving averages. The vertical bars on the graph represent the 13 announcement dates of major UMP measures by the ECB since the beginning of our sample. Figure 2 shows three similar curves, but for five-year nominal and real returns and Figure

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[18]On the dates when UMP announcements overlap with rate cuts, our setup implicitly assumes that part of the effect on returns and inflation expectations comes from the UMP announcement and part from the rate cut. In our sample, there were no announcement dates when UMP announcements coincided with interest rate hikes.

3 shows the curves for ten-year nominal and real yields. The graphs illustrate at least three stylized facts.

1. The huge drop in yields coinciding with the Greek government debt bailout in March 2012 (between LTRO2 and OMT1 on the graphs) is striking. After tensions had been built up in the course of fall 2011, a debt-restructuring agreement was implemented on 09/03/2012 according to which all outstanding short-term Greek government bonds were converted into longer-term bonds which made short-term Greek bonds disappear from the markets causing a sudden drop in the euro area aggregate of two- and five-year bond yields. This change is by far the largest outlier in our data set. The graph for two-year yields has been vertically truncated, and the histograms in Figures 4 and 5 have also been truncated to exclude this observation.

2. Most UMP announcements have little or no visible effect on nominal yields at all maturities. Exceptions are SMP1 and SMP2, OMT1 and OMT2 and APP1 which seem to have lowered nominal yields at medium and long maturities. Indeed, the SMP and the OMT were particularly designed to bring down nominal yields in some countries which obviously also affects the euro area aggregate.

3. Some of the asset purchase programmes seem to have had discernable effects on inflation expectations. The strongest upward spikes in inflation expectations coincide with SMP1, SMP2, CBPP2 and OMT1, depending on the maturity.

The histograms in Figures 4 and 5 show that the distribution of one-day and two-day changes in nominal yields look approximately normal (neglecting the effects of the 2012 Greek bond bailout) but for inflation expectations we can see a spike near 0 indicating that there are many days with only very small changes in ILS rates.

4.2   Descriptive Announcement Effects

Table 4 and 5 in the Appendix show the changes in nominal yields, inflation expectations, real interest rates and the dollar/euro exchange rate on individual announcement dates and present the results of statistical tests of the significance of these effects. One asterisk next to a date indicates significance at a marginal level of 10%, two asterisks indicate significance at 5% and three asterisks indicate significance at 1%. All tests are two-sided.

We consider the impact of announcements by the end of the same trading day (Table 4) and also by the end of the day after the policy announcement (Table 5). A number of findings emerge form the tables.

There are more significant coefficients for two-day impacts than for end-of-day impacts. There are only six cases where the end-of-day impacts are significant while the two-day impacts are not, and three of these are at the 10% marginal significance level.

Considering one-day changes first, SMP1 and SMP2 have the strongest effects. SMP1 has significant effects on nominal yields, inflation expectations and ex-ante real interest rates at all maturities considered. SMP2 has significant ef-

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fects on nominal yields and ex-ante real interest rates at horizons of five and ten years, on inflation expectations only at a horizon of ten years.[19]

LTRO1 and CBPP1 were not effective. They even had counterintuitive effects on nominal yields for the ten-year horizon. However, it has to be taken into account that these measures have been taken in the middle of the financial crisis (in mid-2009), a time of general financial turmoil. LTRO2 also had counterintuitive effects on nominal bond yields at maturities of five and ten years.

CBPP2 had a significant effect only on inflation expectations at horizons of five and ten years. The announcement of the second intervention under the OMT had a significant effect only on two-day changes for some maturities. The effect operated through both, nominal yields and inflation expectations. Also the TL-TRO1 had only significant effects on two-day changes, specifically on nominal and real yields at a horizon of ten years.

The first announcement of the Asset Purchase Programme (APP1) on 22/01/2015 had a significantly negative impact on ten-year nominal and real government bond yields but no significant effect on inflation expectations. APP2, the extension and modification of the Asset Purchase Programme announced on 03/12/2015, had a significantly positive impact on nominal yields at horizons of five and ten years. Its effects on inflation expectations were small (and insignificant) so that it resulted in a significant positive impact on ex-ante real interest rates at horizons of five and ten years. This seems surprising at first sight, but it is likely that the size

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[19]The standard deviations of changes in two-year nominal yields are higher than those at five and ten year horizons. This means that a larger change in the two-year nominal yields on announcement dates is needed in order for it to be statistically significant.

of the programme announced by the ECB did not live up to the expectations of market participants. This explanation is reinforced by an appreciation of the euro following APP2 and our own classification of APP2 as "disappointing market expectations" (see Table 2).

The last (at the time of writing) modification of the APP on 10/03/2016 (APP3) had no significant effects on neither nominal yields nor on inflation expectations and therefore also not on ex-ante real interest rates.

The impact on the dollar/euro exchange rate is broadly consistent with the other results. The increase in nominal yields, decrease in inflation expectations, and euro appreciation following APP2 are all consistent with a policy announcement that disappointed markets by not going far enough. The significant euro depreciation on the day following APP1 is consistent with the significant decrease in nominal yields. Concerning ABSPP, neither the effects on nominal and real yields nor on the exchange rate are significant but they go in the right direction. The reaction to SMP1 seems puzzling at first blush. It reduced nominal yields, increased inflation expectations, and reduced real interest rates, but appreciated the exchange rate significantly by the end of the first day (the sign reverses itself by the end of the second day and becomes insignificant). The SMP1 purchases were sterilized, and were aimed at shoring up specific national bond markets. A fall in the default risk premia on Irish, Portuguese and Greek debt could explain the exchange rate appreciation, but we cannot directly test this hypothesis with our data.

4.3 Regression Results

4.3.1 Baseline Specification

Table 6 below presents the results of regressions that group together all thirteen announcement dates in one dummy variable that takes a value of 1 on announcement dates and 0 on all other dates.

We find that all announcements together have a significantly negative impact on real returns only for the five-year horizon. This is the case for both, one-day and two-day changes. The effects of announcements on real returns work primarily through their impact on inflation expectations which are positively affected by the announcements at five- and ten-year maturities. At a horizon of ten years, this does not translate into a significant effect on the ex-ante real interest rate. This can possibly be explained by the weak response of the nominal ten-year yields to announcements. Also at other maturities, announcements have no significant impact on nominal yields.

The dummy variable that controls for important information released on other meeting dates without major UMP announcements and rate cuts shows a significant negative effect on nominal and real government bond yields at the five year horizon and a positive effect on inflation expectations at the ten year horizon, while the rate cuts did not on average have the expected negative impact on nominal and real bond yields in our sample.

The regression results are quite different than the results of the previous section, where we found significant impacts of individual announcements also on

nominal yields. The regressions seem to indicate a stronger impact on inflation expectations. This is probably because some announcements (LTRO1, CBPP1, LTRO2 and APP2) have positive impacts on nominal yields at five- and ten-year horizons which likely washes out the significant negative effects on other announcement dates.[20]

In order to evaluate the effects of the distinct UMP programmes which were announced in different stages, we grouped the announcement dates for the different programmes into six dummies: CBPP (CBPP1-CBPP3), LTRO (LTRO1, LTRO2), SMP (SMP1, SMP2), OMT (OMT1, OMT2), TLTRO (TLTRO1, TLTRO2) and APP (APP1-APP3). Regression results for the grouped announcement dates are shown in Table 7.

The programmes which were explicitly designed to reduce default risk premia and thereby bring down nominal bond yields, the SMP and the OMT, were obviously successful in doing so. The SMP has a highly significant negative impact on nominal yields at all horizons, as did the OMT at the two-year (and in the case of the two-day changes also at the five-year) horizon. The SMP (and for two-day changes also the OMT) also had a significant positive effect on inflation expectations which, together with the effect on nominal yields, implies a highly significant negative impact on real interest rates. Interestingly, the announcements of the SMP and of the OMT were both followed by a significant appreciation of the dollar/euro exchange rate on the same day. The reasons for this are unclear, but – as

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[20]Excluding LTRO1, LTRO2, CBPP1 and APP2 from the UMP dummy increases the significance of the effects on real yields at the five- and ten-year horizons (not shown).

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already mentioned in the previous section – the fact that the announcements successfully stabilized bond yields in the targeted countries could have contributed to a better macroeconomic outlook in these countries and thereby to an appreciation of the euro.

As could be expected from the individual results on LTRO1 and LTRO2, both LTROs together had a significantly positive (counterintuitive) effect on ten-year nominal and real bond yields. In contrast, the TLTROs had a joint negative effect on nominal and real bond yields which is significant at the five-year horizon for 1-day changes and additionally at other horizons for 2-day changes. The TLTRO announcements were also followed by a significant depreciation of the euro on the same day.

The latest UMP programme, the APP, has only a small and insignificant positive announcement effect on nominal and real bond yields as well as on inflation expectations. The insignificance of the overall effect is most likely the result of the negative effect of APP1 and the positive effect of APP2 which compensate each other when combined.

4.3.2 Sensitivity Analysis

To investigate if the UMP announcements had different effects on yields and inflation expectations depending on whether they were expected by markets or surprised them, we estimate regressions where the UMP announcements are decomposed into three dummy variables according to whether they exceeded, broadly met or disappointed market expectations. The estimated equation is the following:

$$\Delta y_t = \alpha + \beta_1 D_t^{exceed} + \beta_2 D_t^{met} + \beta_3 D_t^{disapp} + \beta_4 D_t^{rc} + \beta_5 D_t^{meeting} + \varepsilon_t \quad (3)$$

Here, D^{exceed}, D^{met} and D^{disapp} are dummy variables that take the value 1 when a UMP announcement is classified as having exceeded, broadly met or disappointed market expectations, respectively – according to the definition in Appendix B; D^{rc} and $D^{meeting}$ are the rate cut and meeting dummies as before.

The estimation results are found in Table 8. The significance of the UMP announcements is considerably enhanced by decomposing them according to the degree to which they were expected by the markets.

UMP announcements that exceeded market expectations had large and significant negative effects (based on one-day and two-day changes) on nominal bond yields at all horizons. They drove up inflation expectations, with a strongly significant effect on five-year ILS (for both one-day and two-day changes) and on ten-year ILS for one-day changes. The net result on real interest rates is a strongly negative and significant impact at all three horizons.

For the UMP announcements that fell short of market expectations we would expect the reverse effect, i.e. a positive impact on yields and a negative one on inflation expectations. Indeed, the disappointing announcements had significant positive impacts on two-, five- and ten-year nominal yields for both one- and two-day changes. Their effect on inflation expectations, however, was not significant. The resulting impact on real yields is still positive, significant for two-year real

yields based on one-day changes and for two-year and ten-year yields based on two-day changes.

In contrast, UMP announcements which are in line with expectations should not produce any strong market reactions. Indeed, the set of announcements that broadly met market expectations generally had little impact on nominal yields. The sign is consistently negative and insignificant, with the only exception of five-year yields in the case of two-day changes. Interestingly, the impact of the expected announcements on inflation expectations is positive and significant at all horizons, except for ten-year ILS based on one-day changes. This translates into a consistently negative impact on real yields, but which is significant in only two cases (for two-year yields based on one-day changes and five-year yields based on two-day changes).

Concerning the exchange rate, we only find a significant appreciation of the euro following the disappointing announcements in the case of two-day changes, which is most likely driven by the appreciation induced by APP2 (cf. Table 5).

In our final specification, we control for the effects of important macroeconomic data releases and of major policy speeches by ECB officials which potentially affect government bond yields and inflation expectations and could therefore contaminate our estimates of the announcement effects. To do so, we additionally include measures of macroeconomic data release surprises and a dummy to cap-

ture the effect of important policy speeches in our regression:

$$\Delta y_t = \alpha + \beta_1 D_t^{exceed} + \beta_2 D_t^{met} + \beta_3 D_t^{disapp} + \beta_4 D_t^{rc} + \beta_5 D_t^{meeting} + \\ \beta_6 D_t^{speech} + \beta_7 Z_t + \varepsilon_t \tag{4}$$

where D^{speech} is a dummy variable that takes the value 1 on dates with impor-
tant policy speeches and Z is a vector of 20 macroeconomic data release surprise
variables (as defined in Appendix D).

The results for one-day changes are shown in Table 9 and for two-day changes
in Table 10. The speech dummy and the macro data surprise variables generally do
not contribute strongly significant effects. The speech dummy is only significant
in two of the 20 regressions (for ten-year real yields based on one-day changes and
for ten-year inflation expectations based on two-day changes). Across 20 regres-
sions and 19 macro data surprise series[21] (a total of 380 estimated coefficients),
15 coefficients are significant at the 10%, 12 at the 5%, and 10 at the 1% level.
Positive inflation surprises in the euro area and in Germany significantly drove
up inflation expectations at the two- and five-year horizons and positive unem-
ployment surprises in France significantly reduced nominal yields at the five- and
ten-year horizons.

Overall, dividing up UMP announcements into those that exceeded, were in
line with, and disappointed market expectations is useful for bringing out their
significance. The control variables do not by themselves have strong effects, but

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[21]The GDP release surprise variable for the euro area is always zero during our sample period
and therefore drops out of the regressions.

controlling for other potential impacts on yields and inflation expectations should reinforce confidence that the UMP announcement dummies are picking up the pure announcement effects.

5   Summary and Conclusions

Some of the UMP announcements identified in this study, most strikingly the SMP and the OMT, had the intended effects of significantly lowering real bond yields at different horizons. These significant effects came through both their negative effect on nominal yields and their positive effect on inflation expectations. In addition, the first announcement of the APP also had a negative significant impact on nominal as well as real yields at the ten-year horizon.

However, some of the UMP announcements (LTRO, CBPP1 and APP2) had a significant positive rather than negative impact on the nominal yields of government bonds and little or no impact on inflation expectations.

The APP, and to some degree also the SMP and the OMT, have been the only programmes to focus explicitly on increasing inflation expectations. The other programmes were designed to provide liquidity to targeted market segments (CBPP, ABSPP) or to the banking system as a whole (LTRO and TLTRO) and therefore are not be expected to have clear-cut effects on inflation expectations.

When we grouped UMP announcements according to whether they exceeded, met, or disappointed market expectations, we found that announcements that exceeded expectations had significant negative effects on real yields while those that

disappointed expectations had strong and significant positive effects on real yields.

Overall, our regression results support the main hypothesis of this paper that significant impacts of announcements on real interest rates work partly through inflation expectations.

Although we can confirm the statistical significance of some UMP announcements, the estimated regression coefficients do not measure the overall impact of UMP announcements on yields and inflation expectations as only the effects on announcement dates and the following day are considered.

Indeed, except for a brief period in 2011-2012, euro area inflation has been persistently and at times considerably below 2% after the financial crisis. This suggests that while UMP can affect inflation expectations and real rates of return, the ECB could go further. Given that its announced intention is to boost inflation to a level "close to, but below 2%", it could announce its intention to reach a target for a price level path in order to create an even stronger impact on inflation and aggregate demand. This would mean that inflation would have to temporarily overshoot 2% in order for the price level to catch up which would imply a permanently higher path for the ECB's balance sheet and monetary base.[22]

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[22]A permanent expansion of the money supply is precisely what theory suggests is required for QE to have stronger real effects. See Ambler (2016), Beckworth (2014, 2015), Hanke (2015), Hetzel (2015), Reichlin, Turner and Woodford (2013) and Rowe (2009) for detailed discussions of this point.

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Appendix A: UMP Announcements

Table 1: Key UMP Announcements of the Eurosystem

Date	Programme	Description
07/05/2009	LTRO1	First LTRO: three 1-year tenders, full allotment
04/06/2009	CBPP1	First CBPP: purchase of 60 bn. EUR as of July 2009
10/05/2010	SMP1	First phase of SMP: purchase of IE, PT and GR bonds
08/08/2011	SMP2	Second phase of SMP: purchase of IT and ES bonds
06/10/2011	CBPP2	Second CBPP: purchase of 40 bn. EUR as of Nov 2011
08/12/2011	LTRO2	Second LTRO: two 3-year tenders, full allotment
02/08/2012	OMT1	Conditional on EFSF/ESM programme
06/09/2012	OMT2	Details of OMT: full sterilization, terminates SMP
05/06/2014	TLTRO1	Series of 4-year tenders, up to 7% of private sector loans
04/09/2014	ABSPP	Intended for at least 2 years, starting in Q4 2014
	CBPP3	Third CBPP: purchases starting in Oct 2014
22/01/2015	APP1	ABSPP+CBPP+PSPP: 60 bn. EUR/m up to Sept 2016
03/12/2015	APP2	Extension of APP to March 2017, reinvestment policy
10/03/2016	APP3	Expansion to 80 bn. EUR/m and corporate bonds (CSPP)
	TLTRO2	Series of 4-year tenders, up to 30% of private sector loans

Notes: Abbreviations and details of the programmes are explained in section 3.2 in the text.

Appendix B: Decomposition of the Announcements

To examine whether the UMP announcements had different effects depending on the degree to which they surprised financial market participants, we divided the 13 announcements into three groups: announcements that were more comprehensive than markets had expected (exceeding expectations), another set of announcements that fell short of expectations (disappointing expectations) and a third group that were broadly in line with market expectations. Unlike for key interest rate changes, data on expectations about the scale, volume and duration

of UMP measures are not directly available. Thus, we had to construct a measure of the surprise content of UMP announcements indirectly from other data. We use the daily (and two-day) changes in overnight interest rate expectations on announcement dates based on overnight index swaps (OIS). OIS are risk-free interest rate expectations at the very short end of the money market and are therefore mainly determined by monetary policy (expectations). They are available for different contract lengths (one week up to three years). We use OIS with a maturity of one month because, on the one hand, they should be as short as possible to be uncorrelated with the dependent variables of our regressions[23] and, at the same time, they are more liquid and thus less volatile than the very short OIS.[24]

Our working hypothesis is that significant movements in one-month OIS on announcement days can only be caused by the announced policy measures and are therefore a measure of the surprise content of the announcement.[25] We classified announcement dates on which one-month OIS decreased by more than one standard deviation of daily OIS changes as exceeding expectations, announcement dates with more than one standard deviation increases in OIS as disappointing expectations, and dates with OIS changes of less than one standard deviation as broadly in line with expectations. Table 2 shows the result of this classification. SMP2, TLTRO1, and ABSPP/CBPP3 exceeded expectations for both

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[23]The correlation coefficient between one-day and two-day changes in two-year, five-year and ten-year nominal bond yields and the changes in one-month OIS varies between 0.004 and 0.07 for the whole sample. Considering only Governing Council meeting dates, the correlation between changes in OIS and bond yields of different maturities is somewhat higher but never exceeds 0.16 (and is never significant at the 10% level). This documents that the joint-response bias of market-based monetary policy measures and interest rates as discussed in Thornton (2014) is not an issue in our data.

[24]One-month OIS denote the average expected overnight interest rate over the following 30 days. Before 2015 the ECB Governing Council meetings took place at 4-week intervals, after that at 6-week intervals. As a result, before the change in the meeting schedule the daily changes on meeting dates might not only reflect the news from the current meeting but also any change in expectations about the following meeting. As the following meeting will only be at the very end of the 30 day period, we assume that its effect on the average – if any – can be neglected.

[25]This idea has similarities with the seminal contribution of Kuttner (2001) who uses the federal funds futures rate to derive the unexpected component of (conventional) monetary policy decisions.

one-day and two-day changes. CBPP1, CBPP2, and APP2 disappointed expectations for both one-day and two-day changes. LTRO1, LTRO2, OMT2, APP1, and APP3/TLTRO2 broadly met expectations for both one-day and two-day changes. The only ambiguities concern SMP1 (which can be classified as exceeding expectations only on the basis of one-day changes) and OMT1 (which disappointed expectations only on the basis of one-day changes).

Table 2: Decomposition of UMP Announcements into Exceeding, Meeting and Disappointing Market Expectations

Date	1-day changes			2-day changes		
	Exceeding	Meeting	Disappointing	Exceeding	Meeting	Disappointing
07/05/2009		LTRO1			LTRO1	
04/06/2009			CBPP1			CBPP1
10/05/2010	SMP1				SMP1	
08/08/2011	SMP2			SMP2		
06/10/2011			CBPP2			CBPP2
08/12/2011		LTRO2			LTRO2	
02/08/2012			OMT1		OMT1	
06/09/2012		OMT2			OMT2	
05/06/2014	TLTRO1			TLTRO1		
04/09/2014	ABSPP			ABSPP		
	CBPP3			CBPP3		
22/01/2015		APP1			APP1	
03/12/2015			APP2			APP2
10/03/2016		APP3			APP3	
		TLTRO2			TLTRO2	

Notes: Abbreviations are explained in section 3.2.

Appendix C: Speeches

To control for the effects of important policy speeches we employed a text-based search among more than 900 speeches held by ECB board members between mid-2008 and March 2016 which potentially contain important information and hints on future unconventional monetary policy. We only searched for speeches that contain information about future accommodative measures such that the expected effect on bond yields is negative (and positive on inflation expectations).

For a speech to be relevant it has to fulfil two criteria. It needs to be forward looking and it should contain information on intended UMP measures. Thus, we search for keywords of future tense or future intentions (e.g. 'will', 'going to', 'plan to', 'intend to', 'willing to', 'ready to', etc.) and for keywords associated with expansionary unconventional monetary policy (e.g. 'accommodate', 'ease', 'expand', 'loose', 'stimulate' in all possible variations). Specifically, our procedure counts the occurrences of the future/intention keywords followed by any of the stimulus keywords at the paragraph level in each speech. In a first round, we select all speeches with a count number grater than three which narrows down the number of relevant speeches from more than 900 to 62. In a second round, we scrutinize these 62 speeches manually and further narrow them down to a total of ten speeches which we deem relevant and informative about future UMP measures.[26] Table 3 lists the selected speeches. Seven of the ten speeches were held by the president of the ECB, two by the vice president and one by an other member of the Executive Board. Half of them fall into the second half of 2014 which was the time when die ECB started preparing the markets for their large-scale asset purchase programmes.[27]

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[26]We noticed that some of the potentially relevant speeches are very close to each other in terms of date or look very much alike. In this case, we only kept the first speech of a series of similar speeches and discarded the later ones.

[27]In some cases when speeches were held after 5pm in Europe or in the afternoon in North America, we considered the relevant speech date for the markets to be the following business day.

Table 3: Major Monetary Policy Speeches by ECB Board Members

Date	Description
12/02/2009	V.Pres. Papademos about policies for stability and recovery (London)
26/07/2012	Pres. Draghi Remarks at the Global Investment Conference (London)
24/04/2014	Pres. Draghi about monetary policy communication (De Nederlandsche Bank)
15/07/2014	Pres. Draghi Hearing at the EU Parliament Committee (Strasbourg)
10/10/2014	Pres. Draghi about recovery and reform in the euro area (Washington)
21/11/2014	Pres. Draghi about monetary policy in the euro area (European Banking Congress)
26/11/2014	V.Pres. Constancio about the banking union (FT Banking Summit, London)
10/12/2014	Board Member Praet about current issues in monetary policy (Washington)
20/04/2015	Pres. Draghi about ECB's monetary policy and current challenges (IMF)
20/11/2015	Pres. Draghi about past, present and future monetary policy (Frankfurt)

Notes: The given dates mark the first business day when the speeches became known to financial markets in Europe which could be different from the date when the speeches were actually held.

Appendix D: Macro Data Surprises

Major macroeconomic data releases, among other factors, are known to have a – sometimes considerable – effect on government bond yields and ILS rates. However, they affect asset prices only to the degree they are not anticipated by market participants. Some of the data releases even occur on the same day as the UMP announcements.[28] Therefore, it is important to control for the macro data releases when estimating the UMP announcement effects.

We consider inflation, real GDP, industrial production and the unemployment rate to be the most important macroeconomic indicators that market participants, in particular on public bond and ILS markets, look at. Since the weighted euro area index of government bond yields contains bonds of all euro area countries, we do not only consider data releases for the euro area aggregate but also for the

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[28]7 of the 13 announcement dates coincide with the release of at least one of the considered macroeconomic data. For instance, on the day when the SMP1 was announced, i.e. 10/05/2010, new data on industrial production in France and Italy were released.

big four economies in the euro area, i.e. Germany, France, Italy and Spain (which make up for roughly 75% of total euro area GDP).

Similar as in Speck (2016), we construct a surprise measure for each data release by subtracting the median of the expected values by market participants from the actual release value divided by the standard deviation of all expected values. Thus, for a higher than expected outturn (underestimation) the surprise measure has a positive sign and for a lower than expected outturn (overestimation) it has a negative sign. Data on market expectations of data releases are obtained from Bloomberg where registered users (mostly financial market observers and traders) can post their expectations of upcoming data releases.[29] For each data release-country combination, we then create a time series with non-zero surprise measures on release dates when market expectations diverged from the actual release and 0 otherwise, i.e. also on dates when the release value was perfectly anticipated by market participants. This yields a total of 20 macro surprise data release series which are then included in our regressions (see Tables 9 and 10).

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[29]Actually, the surprise measure is also directly available on Bloomberg.

Table 4: 1-day changes in nominal yields, inflation expectations, real yields and the exchange rate on announcement dates

Programme	Date	nominal bond yields			inflation expectations			real bond yields			$/€
		2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
LTRO1, rate cut	07/05/2009	0.03	0.08	0.11**	-0.01	0.04	0.05	0.04	0.04	0.05	0.004
CBPP1	04/06/2009	0.12	0.13	0.08**	-0.03	-0.01	-0.01	0.15	0.14	0.09	-0.011
SMP1	10/05/2010	-1.21***	-0.58***	-0.16***	0.14*	0.13**	0.10*	-1.35***	-0.71***	-0.26***	0.022**
SMP2	08/08/2011	-0.37	-0.37***	-0.31***	-0.05	0.08	0.12**	-0.33	-0.45***	-0.43***	0.007
CBPP2	06/10/2011	0.05	0.01	0.03	-0.12	0.14**	0.13**	0.16	-0.12	-0.09	-0.007
LTRO2, rate cut	08/12/2011	0.05	0.17*	0.13***	0.00	0.00	0.00	0.05	0.17	0.13**	0.003
OMT1	02/08/2012	-0.01	0.03	0.04	0.00	0.02	0.01	-0.01	0.01	0.03	0.005
OMT2	06/09/2012	-0.05	-0.06	-0.05	0.10	0.00	0.00	-0.15	-0.06	-0.05	0.006
TLTRO1, rate cut	05/06/2014	-0.06	-0.07	-0.04	0.02	0.02	0.03	-0.08	-0.09	-0.07	-0.006
ABSPP, CBPP3, rc	04/09/2014	-0.07	-0.07	-0.04	0.00	0.00	0.00	-0.07	-0.07	-0.04	-0.014
APP1	22/01/2015	-0.04	-0.06	-0.10**	0.05	0.09	0.08	-0.09	-0.15	-0.18***	0.003
APP2, rate cut	03/12/2015	0.14	0.20**	0.22***	-0.03	-0.03	-0.02	0.16	0.23**	0.24***	0.006
APP3, TLTRO2, rc	10/03/2016	0.05	0.05	0.04	-0.01	0.00	0.03	0.06	0.05	0.01	-0.012

Notes: Numbers show changes in the respective variables on announcements days in percentage points (absolute changes in case of the exchange rate). Significance is assessed with a two-sided t-test where the observed changes on announcements days are compared with the corresponding means on non-announcements days. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Table 5: 2-day changes in nominal yields, inflation expectations, real yields and the exchange rate on announcement dates

Programme	Date	nominal bond yields			inflation expectations			real bond yields			$/€
		2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
LTRO1, rate cut	07/05/2009	-0.07	0.03	0.12**	-0.08	0.04	0.04	0.01	-0.01	0.09	0.010
CBPP1	04/06/2009	0.28	0.27*	0.16***	0.06	0.03	0.03	0.22	0.24	0.13	-0.003
SMP1	10/05/2010	-1.33**	-0.63***	-0.20***	0.12	0.12	0.08	-1.45***	-0.75***	-0.29***	-0.005
SMP2	08/08/2011	-0.44	-0.35**	-0.29***	0.03	0.13*	0.18***	-0.47	-0.48***	-0.46***	0.011
CBPP2	06/10/2011	0.31	0.07	0.09	-0.12	0.12	0.12*	0.42	-0.05	-0.02	0.010
LTRO2, rate cut	08/12/2011	0.92*	0.05	0.12**	0.00	0.00	0.00	0.92*	0.05	0.12	0.001
OMT1	02/08/2012	-0.17	-0.06	0.07	0.31***	0.03	0.02	-0.49	-0.09	0.05	-0.005
OMT2	06/09/2012	-0.10	-0.17	-0.17**	0.08	0.13*	0.02	-0.17	-0.30*	-0.19**	0.013
TLTRO1, rate cut	05/06/2014	-0.10	-0.22	-0.14**	0.02	0.02	0.03	-0.12	-0.24	-0.17*	0.002
ABSPP, CBPP3, rc	04/09/2014	-0.08	-0.11	-0.10	0.00	0.00	0.00	-0.08	-0.11	-0.10	-0.020
APP1	22/01/2015	-0.02	-0.07	-0.17***	0.05	0.09	0.08	-0.08	-0.16	-0.25***	-0.040***
APP2, rate cut	03/12/2015	0.12	0.19	0.22***	-0.06	-0.07	-0.06	0.18	0.26*	0.28***	0.029**
APP3, TLTRO2, rc	10/03/2016	0.04	-0.00	-0.03	0.00	0.01	0.01	0.04	-0.01	-0.04	0.012

Notes: Numbers show changes in the respective variables on announcements days and the day after in percentage points (absolute changes in case of the exchange rate). Significance is assessed with a two-sided t-test where the observed changes on announcements days are compared with the corresponding means on non-announcements days. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Table 6: Regression results for 1-day and 2-day changes in nominal yields, inflation expectations, implicit real yields and the exchange rate

1-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
unconventional measures	-0.137	-0.072	-0.021	0.016	0.053***	0.036*	-0.154	-0.125*	-0.057	0.001
rate cut	0.075	0.073**	0.041	-0.021	-0.034*	0.010	0.096*	0.107***	0.031	-0.002
other meetings	0.013	-0.014*	-0.002	-0.006	-0.001	0.017*	0.019	-0.013	-0.019*	0.000
constant	-0.003	-0.002	-0.002**	-0.001	-0.001	-0.002	-0.002	-0.001	-0.000	-0.000

2-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
unconventional measures	-0.102	-0.098	-0.036	0.052	0.072***	0.040*	-0.153	-0.170**	-0.077	-0.057
rate cut	0.126	0.055	0.034	-0.037	-0.047**	0.007	0.163*	0.101**	0.028	0.055
other meetings	0.028	-0.015	-0.008	0.001	0.013	0.016**	0.027	-0.028**	-0.024**	-0.006
constant	-0.006	-0.004	-0.004**	-0.002	-0.003	-0.002	-0.004	-0.001	-0.001	-0.003

Notes: Coefficients of OLS regressions of changes in the respective variables on announcement and control dummy variables (see equation (2)). All standard errors are estimated robustly. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Table 7: Regression results with grouped UMP programmes

1-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
CBPP (CBPP1-3)	0.032	0.018	0.021	-0.042	0.053	0.034	0.073	-0.035	-0.013	-0.010***
LTRO (LTRO1,2)	0.036	0.100**	0.105***	0.013	0.053**	0.011	0.022	0.047	0.094**	0.004
SMP (SMP1,2)	-0.790***	-0.474***	-0.236***	0.048	0.104***	0.109***	-0.839**	-0.578***	-0.346***	0.015***
OMT (OMT1,2)	-0.030*	-0.010	-0.001	0.048	0.011	0.007*	-0.078*	-0.021	-0.008	0.006***
TLTRO (TLTRO1,2)	-0.043	-0.074*	-0.038	0.018	0.029	0.005	-0.060	-0.103*	-0.043	-0.010***
APP (APP1-3)	0.060	0.068	0.058	0.014	0.030	0.016	0.047	0.037	0.042	0.002
rate cut	0.011	0.030	0.014	-0.017	-0.032	0.018	0.028	0.062**	-0.003	0.000
other meetings	0.012	-0.014*	-0.003	-0.006	-0.001	0.017*	0.019	-0.013	-0.019*	0.000
constant	-0.002	-0.002	-0.002**	-0.001	-0.001	-0.002	-0.001	-0.001	-0.000	-0.000

2-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
CBPP (CBPP1-3)	0.169	0.075	0.052	-0.010	0.065***	0.043	0.179	0.009	0.010	-0.005
LTRO (LTRO1,2)	0.410	0.030	0.114***	-0.021	0.061**	-0.000	0.431	-0.032	0.114***	0.002
SMP (SMP1,2)	-0.880***	-0.488***	-0.241***	0.076**	0.123***	0.132***	-0.956***	-0.611***	-0.373***	0.004
OMT (OMT1,2)	-0.131***	-0.110***	-0.043	0.197**	0.080**	0.022***	-0.328***	-0.190**	-0.066	0.004
TLTRO (TLTRO1,2)	-0.078	-0.166***	-0.115*	0.027	0.046*	0.003	-0.106*	-0.212***	-0.119	0.005
APP (APP1-3)	0.063	0.087	0.039	0.004	0.021	-0.002	0.059	0.066	0.041	-0.003
rate cut	0.021	0.017	0.011	-0.017	-0.039	0.020	0.037	0.056	-0.009	0.004
other meetings	0.028	-0.015	-0.008	0.001	0.013	0.016**	0.027	-0.028**	-0.024**	-0.003
constant	-0.006	-0.004	-0.004**	-0.002	-0.003	-0.002*	-0.003	-0.001	-0.001	-0.000

Notes: Coefficients of OLS regressions of changes in the respective variables on grouped announcement and control dummy variables.
All standard errors are estimated robustly. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Table 8: Regression results with announcements grouped as exceeding, meeting and disappointing market expectations

1-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
exceeding	-0.470**	-0.312***	-0.161***	0.043	0.075***	0.058*	-0.512**	-0.387***	-0.219***	0.004
expected	-0.039	-0.010	-0.001	0.043**	0.048**	0.028	-0.082**	-0.058	-0.030	0.002
disappointing	0.055**	0.075***	0.083***	-0.035	0.038	0.025	0.090**	0.037	0.058	-0.001
rate cut	0.087*	0.083***	0.049**	-0.026	-0.035**	0.009	0.113**	0.118***	0.040	-0.002
other meetings	0.013	-0.014*	-0.002	-0.006	-0.001	0.017*	0.019	-0.013	-0.019*	0.000
constant	-0.003	-0.002	-0.002**	-0.001	-0.001	-0.002	-0.002	-0.001	-0.000	-0.000

2-day changes Variables	nominal bond yields			inflation expectations			real bond yields			$/€
	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
exceeding	-0.296***	-0.271***	-0.205***	0.043	0.083***	0.067	-0.339***	-0.354***	-0.272***	-0.005
expected	-0.161	-0.147*	-0.054	0.088**	0.081***	0.036**	-0.249	-0.228**	-0.089	-0.004
disappointing	0.195**	0.159***	0.146***	-0.022	0.044	0.028	0.217**	0.114	0.117*	0.011*
rate cut	0.144*	0.071**	0.048	-0.038	-0.048**	0.005	0.182**	0.119***	0.043	0.004
other meetings	0.028	-0.015	-0.008	0.001	0.013	0.016**	0.028	-0.028**	-0.024**	-0.003
constant	-0.006	-0.004	-0.004***	-0.002	-0.003	-0.002	-0.004	-0.001	-0.001	-0.000

Notes: Coefficients of OLS regressions of changes in the respective variables on grouped announcement and control dummy variables. All standard errors are estimated robustly. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Table 9: Regression results with announcements grouped as exceeding, meeting and disappointing market expectations including speech and macro release dummies

| 1-day changes	nominal bond yields			inflation expectations			real bond yields			$/€
Variables	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
exceeding	-0.472**	-0.328***	-0.172***	0.035	0.067***	0.053	-0.507**	-0.395***	-0.225***	0.004
expected	-0.039	-0.009	-0.002	0.042**	0.048**	0.030	-0.081**	-0.057	-0.032	0.002
disappointing	0.059*	0.091***	0.093***	-0.029	0.042	0.033	0.089**	0.049	0.061	-0.001
rate cut	0.086*	0.081***	0.048**	-0.027	-0.036**	0.009	0.113**	0.117***	0.039	-0.002
other meetings	0.011	-0.017**	-0.005	-0.008	-0.004	0.016	0.019	-0.014	-0.021*	0.000
speeches	-0.036	-0.026	-0.020	-0.012	0.014	0.006	-0.024	-0.040	-0.026*	-0.002
hicp euro	0.006	-0.004	-0.001	0.016***	0.012**	0.003	-0.011	-0.016**	-0.004	0.001
hicp de	-0.018	0.004	0.002	0.013**	0.010*	0.001	-0.031	-0.006	0.001	0.000
hicp es	-0.003	0.003	0.001	-0.004	-0.005	-0.002	0.002	0.008	0.003	0.000
hicp fr	0.013	-0.000	0.001	-0.000	0.001	-0.001	0.013	-0.001	0.002	-0.001
hicp it	-0.004	0.002	0.001	-0.001	-0.006	0.004	-0.003	0.009*	-0.003	0.000
gdp de	0.006	0.004	0.001	-0.003	0.005	0.004	0.009*	-0.002	-0.003	0.001**
gdp es	0.002	0.002	0.004	-0.007	-0.008	0.006	0.010	0.010	-0.002	-0.000
gdp fr	0.005	-0.000	-0.001	-0.004	0.004	-0.002	0.008	-0.004	0.001	-0.000
gdp it	-0.002	-0.002	0.000	-0.001	-0.006	0.005	-0.001	0.004	-0.005	0.001
ip euro	-0.000	0.004*	0.004*	-0.000	0.008*	0.003	-0.000	-0.004	0.001	0.001*
ip de	0.001	0.003	0.001	-0.000	0.001	-0.002	0.001	0.002	0.003	0.000
ip es	0.002	-0.001	-0.001	-0.000	0.000	-0.002	0.002	-0.002	0.000	0.000
ip fr	-0.003	0.001	0.002	0.003	0.002	-0.002	-0.007	-0.001	0.004	-0.000
ip it	0.005	-0.003*	-0.002	0.001	-0.004*	-0.001	0.003	0.001	-0.001	0.001**
un euro	-0.002	-0.006	-0.001	-0.007	-0.004	-0.004	0.006	-0.003	0.002	-0.001***
un de	0.020	0.005	0.000	0.002	0.002	-0.000	0.018	0.002	0.000	0.000
un es	0.007	-0.002	-0.003	-0.008	-0.007	-0.003	0.014	0.004	-0.001	0.001*
un fr	-0.005	-0.012***	-0.007***	-0.005	-0.004	-0.005	-0.001	-0.008*	-0.002	0.000
un it	0.000	0.000	-0.004	0.002	-0.006	0.001	-0.002	0.006	-0.005	-0.002
constant	-0.002	-0.002	-0.002**	-0.000	-0.001	-0.002	-0.001	-0.001	-0.000	-0.000

Notes: Coefficients of OLS regressions of changes in the respective variables on grouped announcement and control dummy variables. *hicp*, *gdp*, *ip* and *un* denote data release surprises of HICP inflation, real quarter-on-quarter GDP growth, year-on-year growth of industrial production and the unemployment rate, respectively (followed by the country abbreviations). All standard errors are estimated robustly. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

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Table 10: Regression results with announcements grouped as exceeding, meeting and disappointing market expectations including speech and macro release dummies

2-day changes	nominal bond yields			inflation expectations			real bond yields			$/€
Variables	2-year	5-year	10-year	2-year	5-year	10-year	2-year	5-year	10-year	
exceeding	-0.297***	-0.285***	-0.217***	0.031	0.074***	0.058	-0.328***	-0.359***	-0.275***	-0.006
expected	-0.154	-0.148*	-0.056	0.093**	0.083***	0.037**	-0.247	-0.231**	-0.093	-0.003
disappointing	0.193**	0.173***	0.160***	-0.007	0.054*	0.040	0.200*	0.119	0.121*	0.011*
rate cut	0.141*	0.070**	0.048	-0.040	-0.049**	0.004	0.181**	0.119***	0.043	0.004
other meetings	0.029	-0.017	-0.010	-0.002	0.010	0.014*	0.032	-0.027**	-0.024**	-0.003
speeches	-0.040	-0.028	-0.020	-0.028	-0.025	-0.036**	-0.011	-0.003	0.016	-0.002
hicp euro	0.006	-0.003	-0.002	0.022**	0.010*	0.004	-0.016	-0.013	-0.007	0.001
hicp de	0.011	0.010	0.005	0.024***	0.015***	0.011**	-0.013	-0.004	-0.006	0.001
hicp es	-0.002	-0.001	-0.001	0.009	0.003	0.000	-0.010	-0.004	-0.001	0.001
hicp fr	0.004	0.002	0.005	-0.000	0.005	0.003	0.005	-0.003	0.002	-0.000
hicp it	0.001	0.008	0.003	0.007	0.004	0.008	-0.007	0.003	-0.005	-0.000
gdp de	0.011	0.008	0.002	-0.017***	-0.003	0.007	0.028***	0.011	-0.004	-0.001
gdp es	-0.003	0.007	0.006	0.009	0.007	0.002	-0.012	0.000	0.004	-0.001
gdp fr	0.033	0.005	0.002	0.016*	0.016**	0.009**	0.017	-0.011	-0.007	0.001
gdp it	-0.009	-0.004	-0.000	0.003	-0.002	0.001	-0.012	-0.001	-0.001	0.002*
ip euro	-0.005	0.003	0.004	0.002	0.007	0.006	-0.007	-0.005	-0.002	0.000
ip de	-0.001	-0.000	0.001	0.000	-0.000	-0.001	-0.002	-0.000	0.001	-0.000
ip es	0.002	-0.000	-0.001	-0.002	-0.001	-0.002	0.004	-0.000	-0.000	0.000
ip fr	0.001	0.003	0.002	-0.000	0.000	-0.001	0.002	0.003	0.003	-0.000
ip it	0.042	0.006	-0.001	0.007**	-0.001	-0.001	0.035	0.007	-0.000	0.001*
un euro	-0.007	-0.009	-0.006**	-0.010	-0.006	-0.003	0.003	-0.003	-0.004	-0.002***
un de	0.017	0.006	0.005	-0.001	0.001	0.004	0.018	0.005	0.001	-0.000
un es	0.017	0.000	-0.001	-0.016	-0.014	-0.005	0.034	0.014	0.005	0.001
un fr	-0.001	-0.008***	-0.008**	-0.008	-0.005	-0.006	0.007	-0.003	-0.002	-0.001
un it	0.003	0.001	-0.003	-0.001	-0.005	-0.000	0.004	0.006	-0.003	-0.001
constant	-0.004	-0.004	-0.004**	-0.002	-0.002	-0.002	-0.003	-0.001	-0.002	-0.000

Notes: Coefficients of OLS regressions of changes in the respective variables on grouped announcement and control dummy variables. *hicp*, *gdp*, *ip* and *un* denote data release surprises of HICP inflation, real quarter-on-quarter GDP growth, year-on-year growth of industrial production and the unemployment rate, respectively (followed by the country abbreviations). All standard errors are estimated robustly.
* denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

Figure 1

2 years nominal interest rate, inflation expectations and implied real interest rate

in % ; 5 day moving average
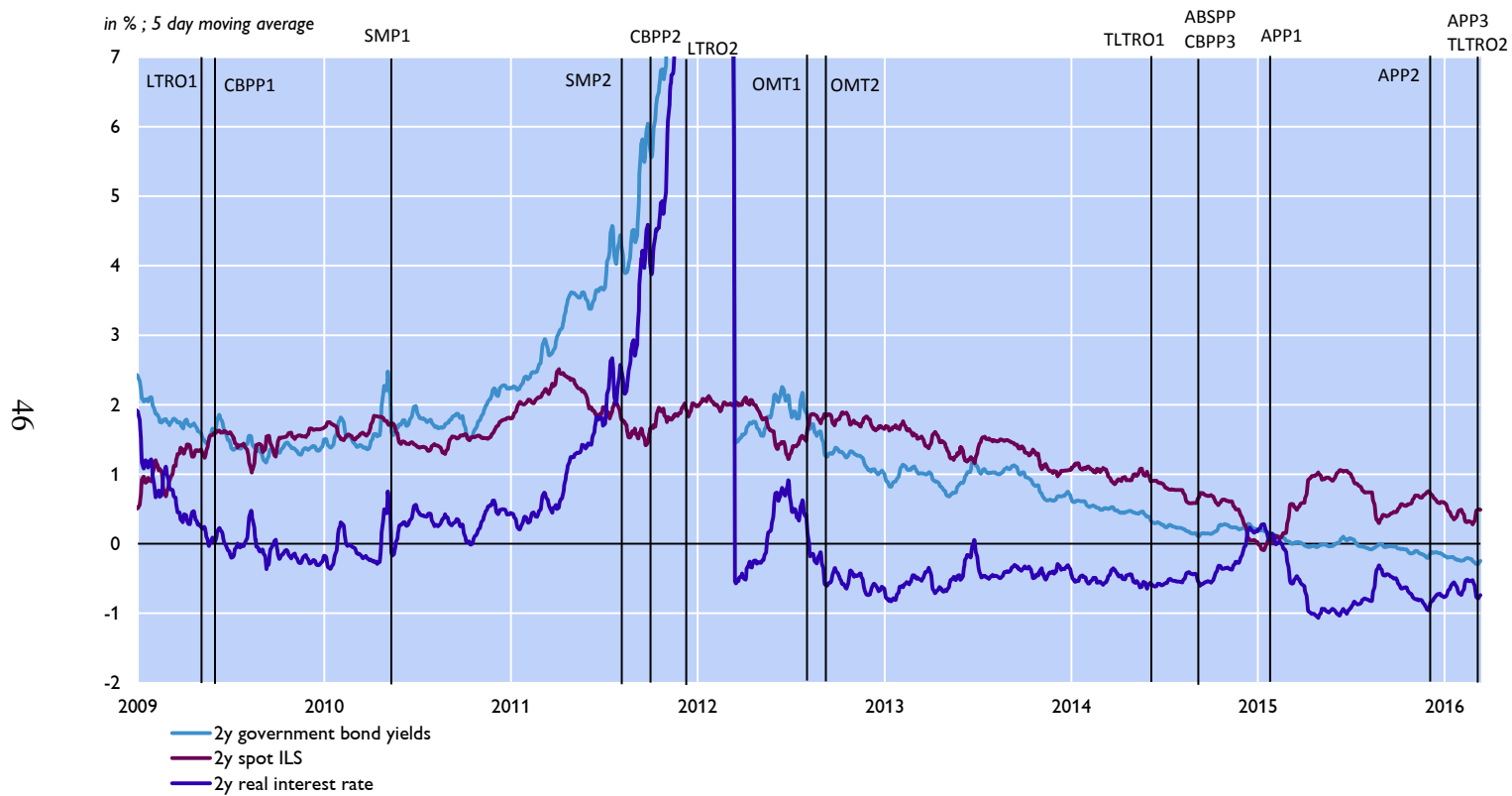
Source: Thomson Reuters.

Figure 1: Two-Year Returns

Figure 2

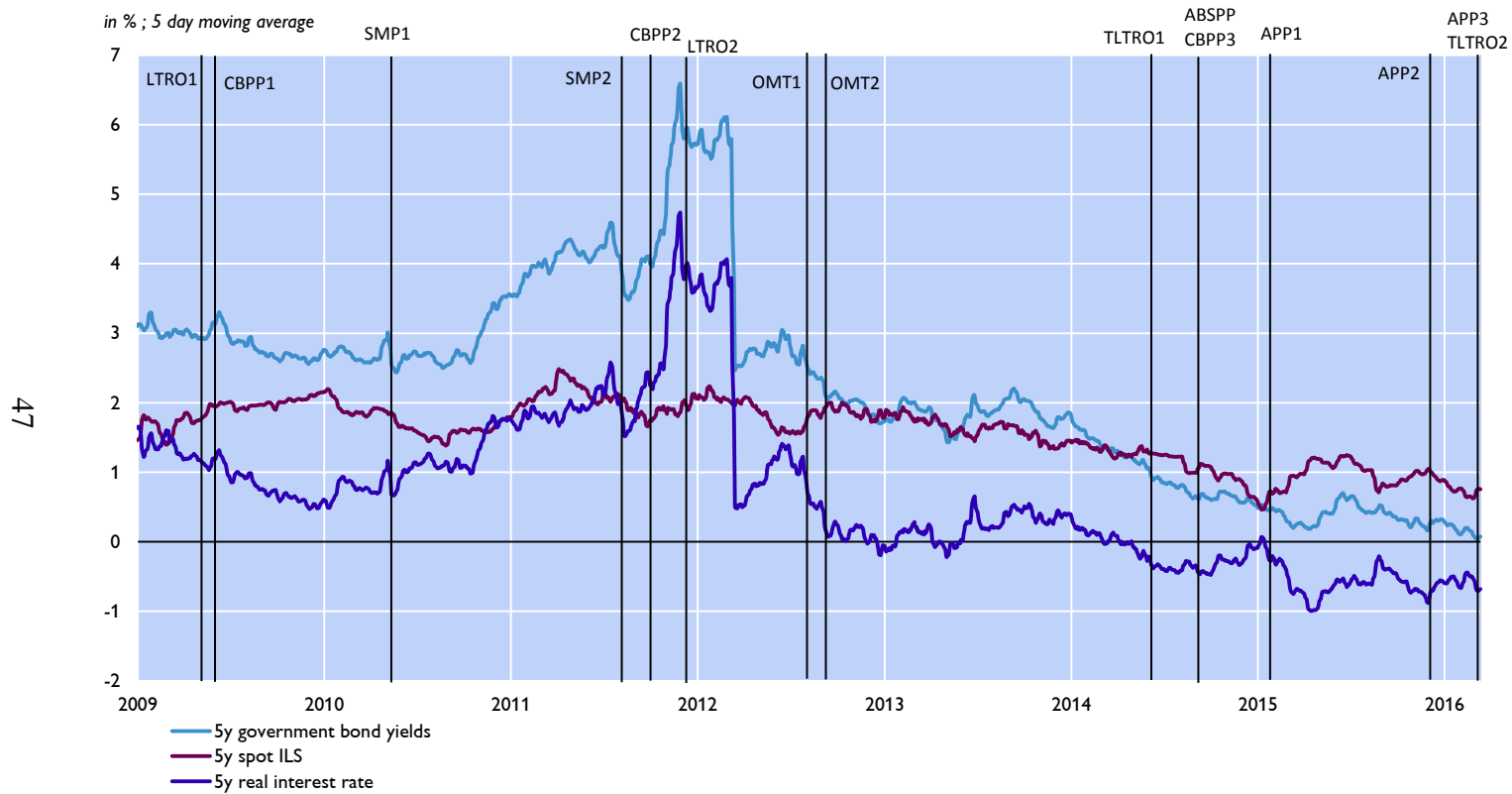**5 years nominal interest rate, inflation expectations and implied real interest rate**

in % ; 5 day moving average

SMP1 CBPP2 LTRO2 ABSPP APP1 APP3
CBPP3 TLTRO2
LTRO1 CBPP1 SMP2 OMT1 OMT2 TLTRO1 APP2

7

6

5

4

3

2

1

0

-1

-2

2009   2010   2011   2012   2013   2014   2015   2016

47

—— 5y government bond yields
—— 5y spot ILS
—— 5y real interest rate

Source: Thomson Reuters.

Figure 2: Five-Year Returns

Figure 3

10 years nominal interest rate, inflation expectations and implied real interest rate
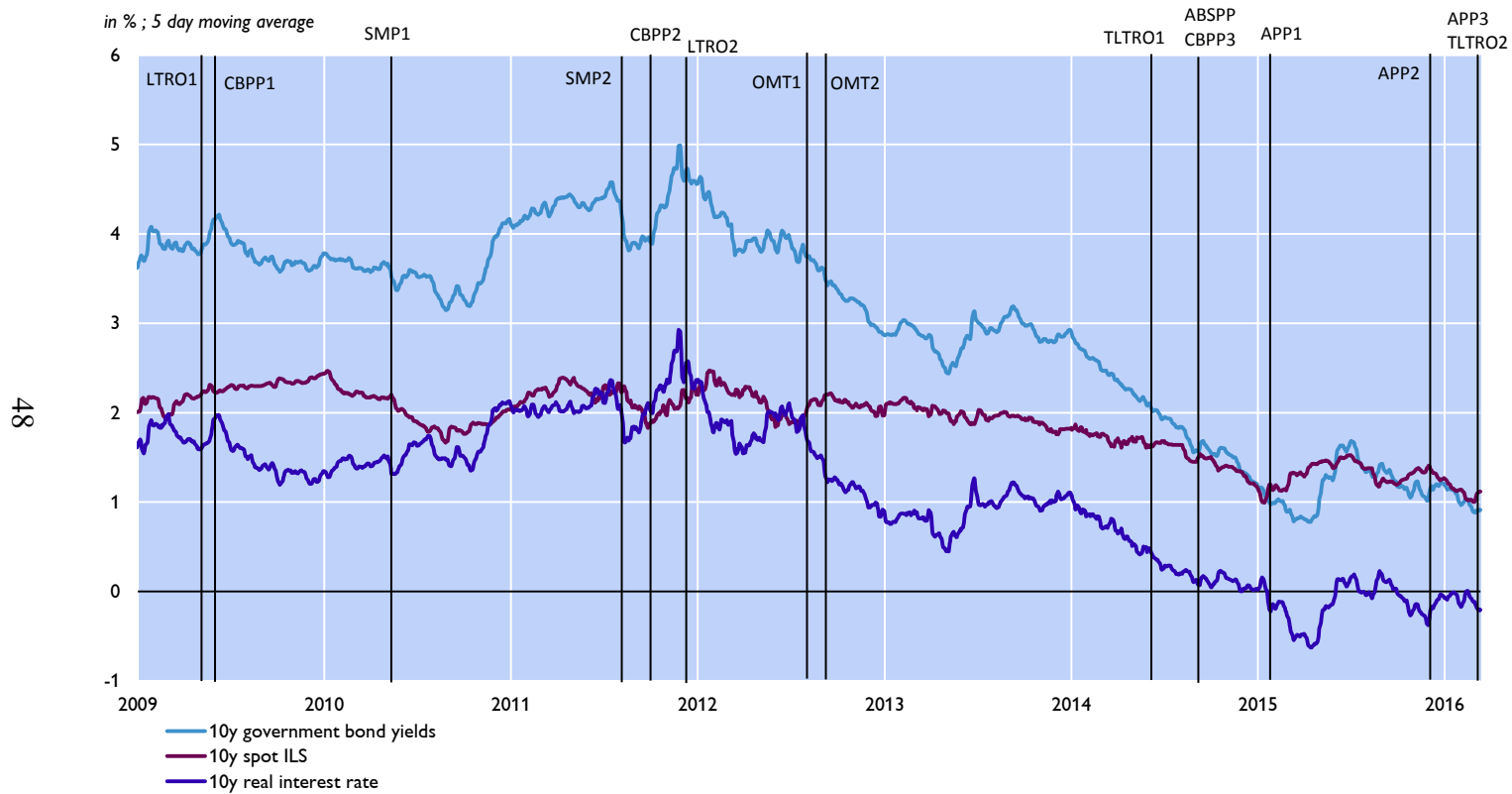
Figure 3: Ten-Year Returns
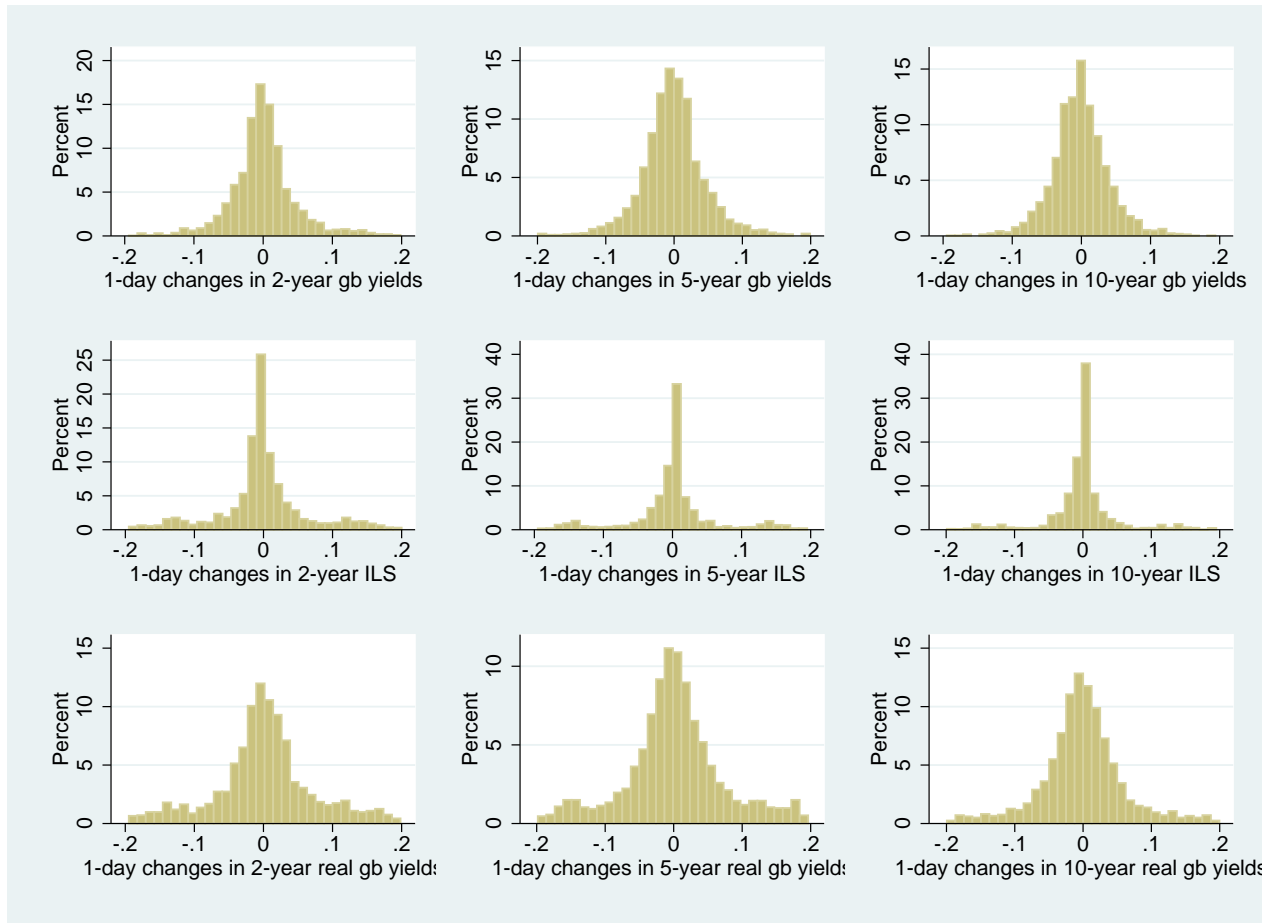
Figure 4: Histograms of 1-day changes in nominal yields, inflation expectations and implicit real yields
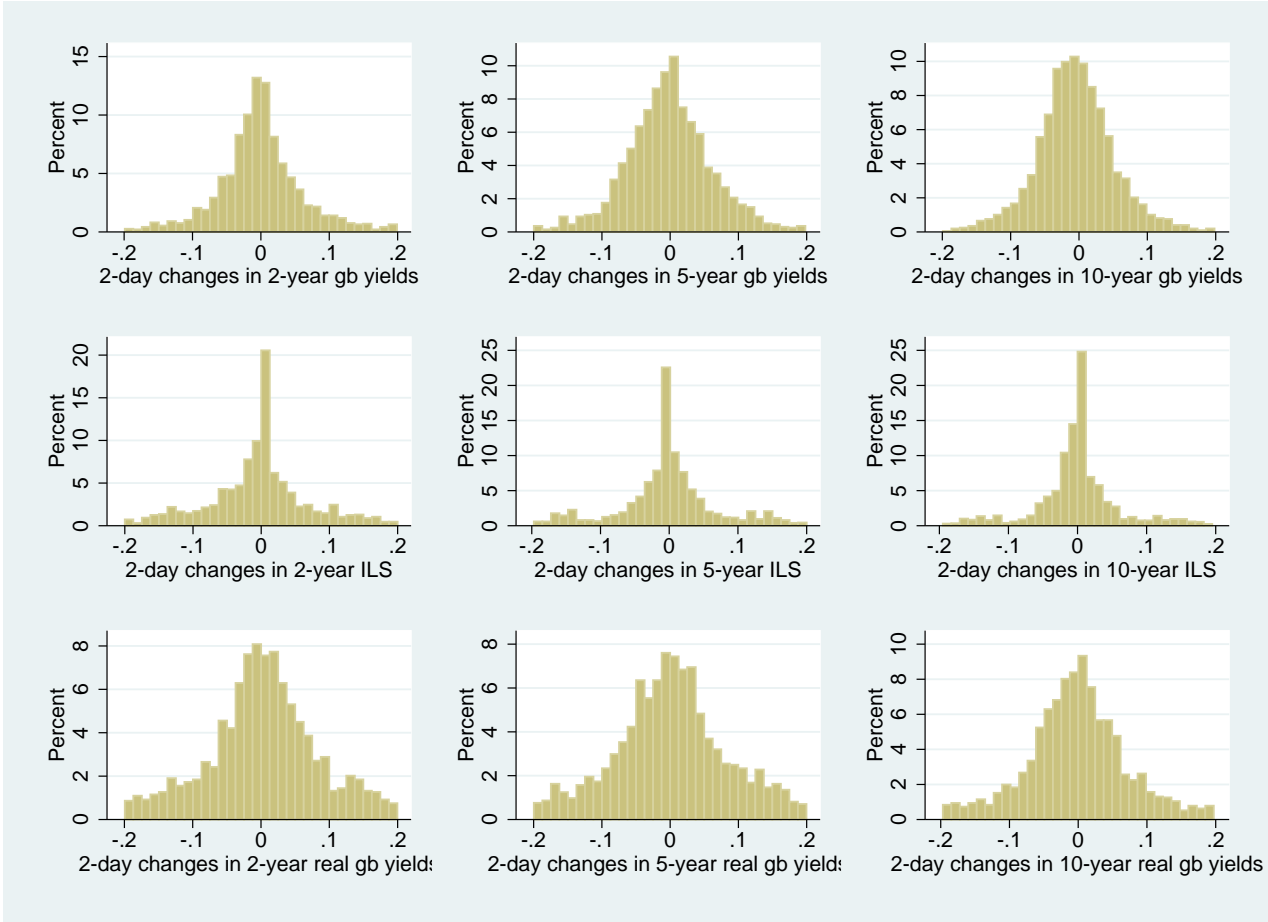
Figure 5: Histograms of 2-day changes in nominal yields, inflation expectations and implicit real yields

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