# The Impact of the ECB's QE Programme: Core versus Periphery

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**Abstract**

We estimate the extent to which unconventional ECB policies have depressed sovereign bond yields in the euro area. We decompose yields into a component that captures risk-neutral expectations about monetary policy and a risk premium, which allows us to distinguish different channels of policy transmission. Using the two components, we conduct an event study to gauge the impact of the various unconventional policy measures, as well as announcements by other major central banks. As a novel feature, our paper also controls for the adjustment of yields to the state of the economy. We find differences in the yield response along four dimensions: 1) across the euro area core versus the periphery; 2) for announcements of quantitative easing relative to SMP and OMT; 3) for ECB policies compared to announcements by the Bank of England and the Federal Reserve; and 4) across monetary transmission channels, especially the signalling, credit risk and portfolio rebalancing channel.

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# 1 Introduction

In October 2017, the European Central Bank announced to substantially reduce the pace at which it buys government debt under its Asset Purchase Programme. Calls are increasingly made for it to signal an end to continued purchases and an eventual reduction of its balance sheet. A fundamental question is how long-term interest rates in different euro area member states will be affected by such a quantitative tightening. This paper therefore analyses heterogeneities in the degree to which unconventional monetary policy announcements depressed yields in recent years. We find differences in the interest rate response along four dimensions: 1) across euro area countries, in particular in the core versus the periphery, 2) for announcements of quantitative easing by the ECB relative to other unconventional monetary policy measures, 3) for ECB policies compared to announcements by other major central banks, 4) across monetary transmission channels, especially the signalling, credit risk and portfolio rebalancing channel.

A number of studies conclude that announcements by the Federal Reserve to conduct large-scale asset purchases had a significant impact on long-term Treasury yields through a portfolio rebalancing channel (D'Amico and King, 2013]) and a signalling channel (Bauer and Rudebusch, 2014). Similar effects have been estimated for the Bank of England's QE programmes on gilt yields, although with varying intensity of activated transmission channels Joyce et al., 2012, Chadha and Waters, 2014). For the euro area, Falagiarda and Reitz (2015) show that unconventional measures taken by the ECB to fight market distress during the sovereign debt crisis substantially reduced bond yield spreads of the periphery but the impact varied across vulnerable countries and was stronger for the Securities Markets Programme than for the Outright Monetary Transactions programme. With respect to the Asset Purchase Programme, i.e. QE, De Santis (2016) finds that vulnerable countries also benefitted more. Altavilla et al. (2015) identify a credit risk channel through which the APP lowered periphery yields, alongside portfolio rebalancing effects, which, according to Lemke and Werner (2017), played a bigger role for German yields. Our study extends the work on the euro area by analysing in a uniform framework the impact of the ECB's QE programme relative to other unconventional monetary policy announcements. We also disentangle the transmission channels at work for different countries. Large-scale asset purchase programmes tend to have spillover effects to the rest of the world, especially from the US. A particular emphasis has been put on portfolio flows in and out of emerging markets, e.g. by Fratzscher et al. (2013). We estimate the impact of QE in the US and the United Kingdom on euro area yields and compare it to estimates of ECB effects.

The methodological approach we take consists of two steps. First, we decompose euro area sovereign bond yields into a risk premium and a component that captures expectations of the risk-free rate. This allows us to disentangle the transmission channels of unconventional monetary policy. We build on the regression approach by Adrian et al. (2013) and apply it to the German yield curve to extract the euro area risk-free rate. The residual component between observed yields and the estimate of the risk-free rate captures the premium investors require for uncertainty about future monetary policy, for potential risks of a euro area break-

up as well as for bond market liquidity risks. Compared to a simple spread between euro area bond yields and the German benchmark, our premium component remains unaffected by safe haven effects that tend to depress German yields. Using our set of country-specific risk premia, we filter out common components which allow us to identify in more detail transmission effects through a euro area credit risk channel.

As a second step, we conduct an event study of different policy announcement effects separately for each bond yield component and 11 euro area countries. A common challenge is to isolate the response to monetary policy announcements from macroeconomic trends and other news. We therefore estimate a model of daily movements in yield components, allowing for convergence over time to a long-term yield level determined by macroeconomic and fiscal fundamentals (the so-called fair value). Our model also controls for short-term changes in international market sentiment and information releases that may affect euro area financial markets. We then use this model to identify the yield response to different types of monetary policy announcements by the European Central Bank as well as the Federal Reserve and the Bank of England.

Our findings suggest that the announcement of ECB quantitative easing benefitted the euro area periphery more than the core. This is because it helped reduce uncertainty about the future stance of monetary policy and confirmed the commitment of the ECB to support a recovery in the euro area as a whole. However, estimates are small compared to those obtained for the ECB programmes that aimed at reducing euro area break-up risk, namely the SMP and OMT programme. Core countries benefitted from the APP mainly through a small but statistically significant signalling effect on the risk-free rate. The impact on euro area yields of QE announcements by the central banks in the United States and the United Kingdom has been at least as large as the impact of ECB QE. This may be because these announcements were made during a time of elevated financial market distress, in contrast to QE announcements by the ECB.

The paper proceeds as follows. Section 2 explains how we estimate the term premium component of euro area sovereign bond yields. Our event study methodology is set out in section 3. Results are discussed in section 4. Section 5 concludes.

# 2 Decomposing sovereign bond yields

## 2.1 Estimating the term premium

Yields of bonds of a given maturity can be decomposed into a part that reflects expectations about future short-term risk-free interest rates and a risk premium, often referred to as 'term premium'. The term premium an be thought of as the compensation a holder of a bond requires for a number of risks. For holders of sovereign bonds, risks include the uncertainty about future monetary policy, i.e. uncertainty about future risk-free rates. Investors may further require compensation for the risk of default, or in the euro area a break-up of the currency union, which would imply that sovereign issuers return none of the principal, or only parts of it, to the investor. The term premium also reflects risks associated with expectations

about the liquidity of bonds. The prospect of relatively illiquid markets, for example due to central bank interventions on markets for sovereign debt, implies that it will be harder for investors to sell their sovereign bond portfolio and risk premia rise.

To decompose the yields of euro area sovereign bonds, we apply the three-step estimation proposed by Adrian et al. (2013) to the German 10-year Bund. The Adrian et al. (2013) estimation approach is computationally fast and does not require observations of zero-coupon yields. We obtain an estimate of the German term premium, which can be used to infer expectations about future short-term euro area interest rates. Making use of the fact that risk-free rates are identical across members of the euro area, we subtract inferred short-term rate expectations from constant maturity average yields of the main member states to calculate country-specific term premium estimates. Unlike spreads relative to the German benchmark, country-specific premia obtained in that way remain unaffected by movements in the German term premium. In particular a flight to safety may have depressed German yields during the European government debt crisis, biasing upwards conventional spread measures.

**Excess return model** Adrian et al. (2013) assume that pricing factors follow a dynamic specification

$$X_{t+1} = \mu + \Phi X_t + v_{t+1} \tag{1}$$

where $X_{t+1}$ is a matrix of observable pricing factors. $\mu$ is a constant term and $\Phi$ is the autoregressive parameter, which predict the pricing factors. $v_{t+1}$ are innovations, which are assumed to follow a Gaussian distribution, conditional on the history of $X_t$. Adrian et al. (2013) also assume an exponentially affine pricing kernel $M_{t+1}$ for the evolution of zero coupon bond prices with maturity $n$, $P_t^n = \mathrm{E}_t[M_{t+1}P_{t+1}^{(n-1)}]$. With affine market prices of risk $\lambda_t = \Sigma^{-\frac{1}{2}}(\lambda_0 + \lambda_1 X_t)$, $M_{t+1}$ is defined as

$$M_{t+1} = \exp(-r_t - \frac{1}{2}\lambda_t{}'\lambda_t - \lambda_t{}'^{-\frac{1}{2}}v_{t+1}). \tag{2}$$

$r_t$ is the continuously compounded risk-free rate, which can be used to obtain log excess holding returns

$$rx_{t+1}^{(n-1)} = \ln P_{t+1}^{(n-1)} - \ln P_t^{(n)} - r_t. \tag{3}$$

Adrian et al. (2013) show that with additional assumptions, excess returns can be written as

$$rx_{t+1}^{(n-1)} = \beta^{(n-1)'}(\lambda_0 + \lambda_1 X_t) - \frac{1}{2}(\beta^{(n-1)'(n-1)} + \sigma^2) + \beta^{(n-1)'}v_{t+1} + e_{t+1}^{(n-1)} \tag{4}$$

where $e_{t+1}^{(n-1)}$ are return pricing errors that are orthogonal to factor innovations $v_{t+1}$ and conditionally independently and identically distributed with variance $\sigma^2$. The first component captures the excess return that can be expected from the contemporaneous level of pricing factors. The second term of equation (4) allows for a convexity adjustment and the third

term is the effect of factor innovations on excess returns.

**Estimation** Following Adrian et al. (2013), we estimate the parameters of equation (4) in three steps. First, equation (1) is estimated by ordinary least squares. We obtain measures of observable pricing factors $X_{t+1}$ in the form of linear combinations of log yields. To do so, we construct yields at different maturities using parameters of fitted Svensson yield curves, which we obtain from the Bundesbank. We then conduct a principal components analysis and use the first five principal components as our proxies for $X_{t+1}$.

Second, excess returns are regressed a constant term, lagged pricing factors and factor innovations stacked into a matrix $\hat{V}_t$

$$rx_{t+1}^{(n-1)} = aI_T' + \beta'\hat{V}_t + cX_t + E_{t+1}. \tag{5}$$

This yields estimates of parameter $\beta$ of equation (4). Residuals from equation (5), $\hat{E}_{t+1}$, are employed to obtain an estimate of $\sigma^2$.

Third, price of risk parameters $\lambda_0$ and $\lambda_1$ are estimated by cross-sectional regression across yields at different maturities.

Parameter estimates can be used to construct zero coupon yield curves. Expectations of risk-free short-term rates are calculated by setting price of risk parameters $\lambda_0$ and $\lambda_1$ to zero. In what follows, we work with model-implied 10-year yields $\hat{y}_{it}^{10}$ for Germany and estimates of the compounded euro area risk-free rate 10 years out, which we refer to as $\hat{r}_t^{10}$. Constant maturity yield indices, provided by Datastream, are used as measures for 10-year yields of all other countries $j \neq i$. The country-specific term premium is then calculated as the difference between model-implied fitted yields and the estimated risk-free yield:

$$\hat{rx}_{it}^{10} = \hat{y}_{it}^{10} - \hat{r}_t^{10}. \tag{6}$$

## 2.2 Sovereign yield components and descriptive statistics

We estimate term premia for Germany and 10 other euro area member states, listed in table 1. The estimation sample stretches from 8 August 1997 to 1 August 2017. Table 1 provides a summary of descriptive statistics for a sub-period that starts on 1 January 2008 and is used for our event study analysis. The table shows that average term premia vary widely across countries. We estimate an average of 127 basis points for Germany, and 996 basis points for Greece. By contrast, the estimated risk-free rate component has on average been 72 basis points during the period of interest.

The share of the variance of the term premium component relative to the variance of the overall yield lies between around 23 percent in the core countries Germany, Netherlands and Finland and above 100 percent in crisis-hit countries of the periphery. A variance of the term premium component above the variance of the overall yield implies that the term premium and the model-implied risk-free rate component are negatively correlated. This is the case in Greece and Portugal. The final column of Table 1 shows the fraction of the variation in the overall yield explained by the term premium for a sub-period covering the height of the

Table 1: Sovereign yields data, risk-free rate and term premium estimates

| | | Yield | Risk-free rate | Term premium | Variance due to premium[a] | |
|---|---|---|---|---|---|---|
| | N | Mean | Mean | Mean | Overall | 2010-2014 |
| Germany | 2436 | 199.3 | 72.2 | 127.1 | 24% | 22% |
| France | 2436 | 199.3 | 72.2 | 161.9 | 27% | 33% |
| Austria | 2436 | 228.1 | 72.2 | 155.9 | 28% | 31% |
| Belgium | 2436 | 259.5 | 72.2 | 187.3 | 39% | 52% |
| Finland | 2436 | 212.6 | 72.2 | 140.4 | 23% | 21% |
| Netherlands | 2436 | 214.5 | 72.2 | 142.4 | 23% | 20% |
| Italy | 2436 | 368.3 | 72.2 | 296.1 | 76% | 107% |
| Spain | 2436 | 369.1 | 72.2 | 296.9 | 82% | 100% |
| Greece | 2436 | 1068.6 | 72.2 | 996.4 | 107% | 101% |
| Ireland | 2436 | 409.6 | 72.2 | 337.4 | 80% | 79% |
| Portugal | 2436 | 547.2 | 72.2 | 475.0 | 105% | 99% |

*Source:* Authors' calculation based on data from Bundesbank, Datastream.
*Note:* Sample period 2008-2017. [a] Calculated as the ratio of the variance of the term premium over the variance of the yield.

European government debt crisis between 2010 and 2014. Compared to the overall sample, the fraction of the yield variance explained by the variation in term premia is higher, or very similar, but not substantially lower. This suggests that the variation in yields during the crisis increased mainly due to larger movements in term premia.

Figure 1 plots term premia estimates for the Big 4 countries of the euro area, Germany, France, Italy, and Spain. It illustrates that there has been a substantial divergence between premia of core and periphery countries during the sovereign debt crisis, starting in 2010. By contrast, expectations about future monetary policy, reflected in risk-free rate estimates, loosened substantially over the course of the sample, in line with announcements by major central banks. Three main announcements by the ECB are depicted as vertical lines: the initial announcement of the SMP, Draghi's London speech of 2012 hinting at the OMT programme, and the official announcement of the PSPP. Following each of those announcements, term premia, in particular in Italy and Spain, appear to decrease. This suggests that unconventional monetary policy announcements had a substantial effect on premia by reducing the uncertainty about future monetary policy and decreasing default risk. The rest of this paper provides a formal test of this hypothesis.

# 3 Event study set-up

## 3.1 'Fair value' specification

We employ an event study approach to gauge the announcement effect of unconventional monetary policies on sovereign bond yields and their components. Such an approach builds on the assumption that prices on financial markets immediately reflect new information about the future, provided that markets are sufficiently efficient in the sense described by Fama (1970). We therefore aim at capturing the stock effect of monetary policy announcements (D'Amico and King, 2013), i.e. the one-off adjustment by markets. A common challenge

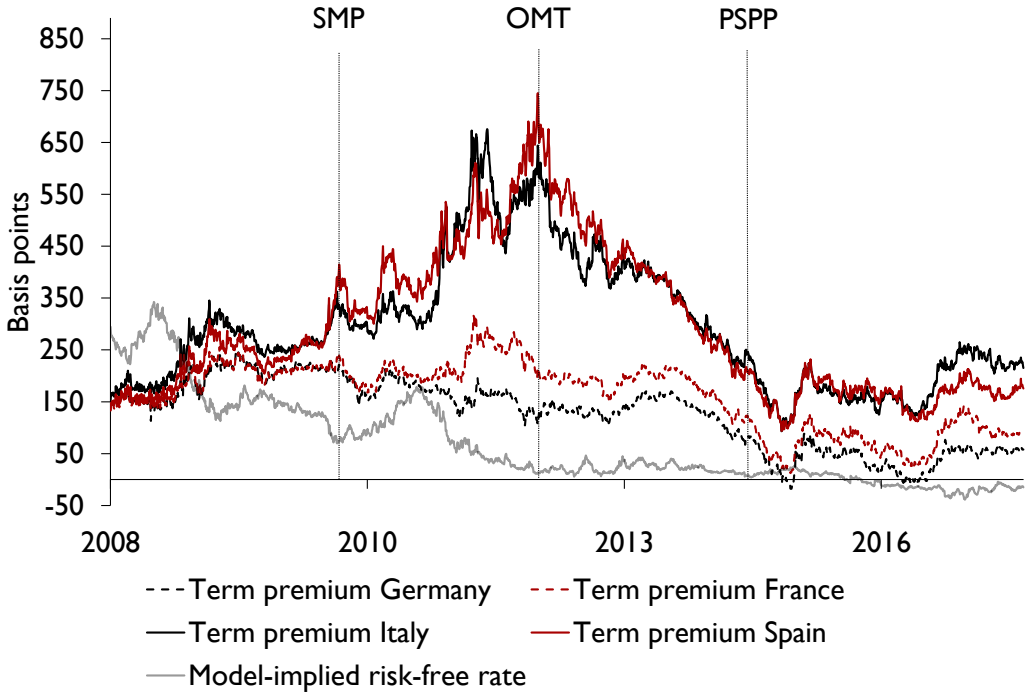


Figure 1: Euro area bond yield components

one faces when estimating the effect of policy changes on financial market outcomes, is to identify the price movement that is due to the announcement, and disentangle it from the price movement that would have taken place, had the announcement not been made. In firm-level analyses, it is comparatively easy to distinguish between price movements due to a firm-specific event and the general market movement: it is given by the difference between firm-specific prices and prices specific to a portfolio of other firms that are unaffected by the event, whereby the link between the 'treated' firm's prices and the other firms' prices is established for an uncontaminated period before the event (the so-called 'estimation window'). In the context of prices related to sovereign debt, a sample of an 'untreated' benchmark is hard to find given strong spillovers across sovereign debt markets. A solution is often found by defining a relatively short window of time around the event. We work with a two-day event window (and compare results to those obtained for a one-day window). However, even daily changes in sovereign yields may partly reflect anticipated market movements. In particular during periods when yields no longer reflect macroeconomic and fiscal fundamentals, market participants often expect a correction to what is referred to as 'fair value'.

We therefore estimate a model of daily movements in yields and their components, allowing for an error correction to a long-run relationship between yields and fundamentals.

$$\Delta y_{it} = A_t'\beta_1 - \delta[y_{it-1} - X_{it-1}{}'b_1] + \Delta N_t'\beta_2 + \epsilon_{it} \tag{7}$$

$y_{it}$ is the sovereign bond yield of country $i$ on day $t$; the difference operator $\Delta$ specifies the daily movement. Matrix $A_t$ contains a set of dummy variables for each unconventional

monetary policy announcement by the ECB as well as the Federal Reserve and the Bank of England. We define dummy indicators to take the value of one on the day the announcement is made, as all as the day thereafter, to estimate responses within a two-day window. To gauge the cumulative effect of a specific monetary policy programme $p$, we sum the coefficients for the subset of dummy indicators related to such a programme and conduct a Wald test of aggregate significance

$$\hat{\beta}_1^p = \sum_{s=1}^{S} A_t^{s\prime} \hat{\beta}_1 \text{ for all } A^s \in A^p \tag{8}$$

In equation (7), the term in squared brackets is the error correction term, or the deviation of lagged yield levels from fair value. The fair value relationship is given by ${X_{it-1}}' b_1$. Matrix $X_{it-1}$ contains macroeconomic and fiscal fundamentals that determine the level of yields in the long term, each with a specific weight that vector $b_1$ collects. As potential determinants of fair value yields, we first of all consider the annual rate of consumer price inflation, which gives some indication about the future stance of monetary policy, and hence on expectations about future short-term interest rates. To control for expectations about the state of the macroeconomy, which also feed into expectations about future monetary policy, we account for economic sentiment. Sovereign credit risk has been an important driver of bond yields during the European sovereign debt crisis. We therefore consider a measure of rollover risk as a component of fair value yields, which is approximated with the amount of debt to be redeemed over the course of a year, relative to all debt outstanding.

Other news may affect yields at a daily frequency. In particular economic data releases are often observed and immediately priced on financial markets. Given that most of these releases are made at fixed intervals, we capture their effects using dummy indicators for the day of the week and the day of the month in matrix $N_t$. Finally, international market sentiment may spill over into European fixed income markets. We therefore also control for US option-implied volatility in $N_t$.

$\epsilon_{it}$ is the error term. Given that daily changes in bond yields are serially correlated, robust Newey-West standard errors are calculated for inference.

We estimate equation 7 separately for each country's 10-year sovereign yield. To analyse monetary transmission channels, we replace $y_{it}$ with bond yield components and a measure of euro area break-up risk. All regressors are kept. If the short-term rate expectations component serves as dependent variable, the model is augmented with the first difference of US short-term rate expectations to account for shifts in expectation about the global monetary cycle.

### 3.2 Unconventional monetary policy announcements

At their press conference on 22 January 2015, the ECB announced its version of quantitative easing – the expanded asset purchase programme. In particular, purchases of sovereign bonds were added to private sector purchases of asset-backed securities and covered bonds. Purchases under the Public Sector Purchase Programme contributed around 85 per cent to

the €60 billion of assets to be purchased every month. The announcement implied that by September 2016, the ECB would hold around €1 trillion of sovereign bonds on its balance sheet due to the PSPP. It came after euro area inflation fell below 0.5 per cent over the course of 2014, substantially below the central bank's target of below but close to 2 per cent. By the beginning of 2015, some form of quantitative easing was widely anticipated by markets. President Draghi had hinted at several press conferences at the end of 2014 that further monetary accommodation would be provided. We therefore estimate not only the announcement effect for the January 2015 press conference but consider a wider set of dates, over which we accumulate market reactions, listed in table 2. These include the press conferences between September and December 2014 and an interview by Draghi on 14 January, as well as the events at which PSPP modalities were published and adjusted, and asset purchases started.[1]

Announcements related to the PSPP were made at a time when financial markets had been relatively calm. This is in stark contrast to announcements related to the Federal Reserve's QE programmes. The first part of QE 1 was announced on 25 November 2008, only two months after the collapse of Lehman Brothers. QE 1 was extended to longer-term Treasuries in March 2009 and followed by two additional QE programmes to move the US economy out of the recession. The Bank of England followed the Federal Reserve in March 2009, when it announced its first QE programme while market distress was still severe. As the economy remained weak, a follow-up programme was announced in October 2011, with two extensions thereafter. The third QE package was launched following the UK Brexit referendum in August 2016, in order to reduce uncertainty in markets.

We compare the impact of the ECB's QE programme not only with comparable programmes by the Federal Reserve and Bank of England but also to unconventional monetary measures related to sovereign bond purchases adopted at the height of the European sovereign debt crisis – the Securities Markets Programme and the Outright Monetary Transactions programme. Unlike QE, the objective of the SMP and its successor OMT was not directly related to the inflation target but to improve monetary transmission by lifting the risk of a euro area break-up. Under the SMP, the ECB intervened on bond markets of countries, for which risk premia on government debt had surged to unsustainable levels. The programme was extended once but faced the criticism of going beyond the central bank's mandate. As a replacement, OMT was designed, under which sovereign bond purchases would be tied to conditions to prevent them from causing fiscal effects. While the programme has as of yet not been activated, President Draghi's speech in London on 26 July 2012, which set the scene for OMT, immediately calmed down markets after he promised to "do whatever it takes to preserve the euro. And believe me, it will be enough." (Draghi, 2012). The legitimacy of OMT as a monetary policy instrument was questioned on several occasions, including by the German Consitutional Court. Given that this may have affected the credibility of the programme, we include a set of dates at which such criticism was raised by market-relevant actors.

[1] Altavilla et al. (2015) employ a somewhat larger set of events related to the announcement of PSPP. We experimented with further dates but found that these do not add substantial information to our analysis.

If event dates fall on a Sunday, we evaluate the market response over the course of the following Monday. We had to omit some events if their dates coincided with other important announcements, to avoid contamination of news.

Table 2: Monetary policy announcements

| | |
|---|---|
| *SMP* | |
| 10/05/2010 | Security Markets Programme (SMP) announced |
| 08/08/2011 | SMP extended |
| | |
| *OMT* | |
| 26/07/2012 | Draghi "whatever it takes speech" |
| 02/08/2012 | Outright Monetary Transactions (OMT) programme announced |
| 06/09/2012 | OMT modalities |
| 12/09/2012 | German constitutional court to review OMT |
| 25/04/2013 | Bundesbank expresses strong opposition to OMT leaked in letter |
| 11/06/2013 | German Constitutional Court holds hearings on OMT |
| 14/01/2015 | ECJ first opinion on OMT. OMT in principle compatible with EU law. |
| | |
| *PSPP* | |
| 04/09/2014 | ECB press conference |
| 02/10/2014 | ECB press conference |
| 06/11/2014 | ECB press conference: Draghi hints at further stimulus |
| 04/12/2014 | ECB press conference: Draghi hints at QE |
| 14/01/2015 | Interview with Die Zeit, published on 15 January 2015 |
| 22/01/2015 | ECB QE announced (Public Sector Purchase Programme) |
| 05/02/2015 | ECB publishes PSPP modalities |
| 09/03/2015 | ECB begins PSPP asset purchases |
| 03/09/2015 | ECB raises asset purchase programme issue limit from 25% to 33% |
| | |
| *Fed QE* | |
| 25/11/2008 | QE1 (part 1) - USD 100bn GSE direct obligations / USD 500bn in MBS |
| 01/12/2008 | Evaluating benefits of expanding QE into treasuries - Bernanke speech |
| 16/12/2008 | Evaluating benefits of expanding QE into treasuries - FOMC statement |
| 28/01/2009 | FOMC stands ready to expand the programme |
| 18/03/2009 | QE1 (part 2) - MBS programme expanded, buy-up of longer-term Treasuries |
| 27/08/2010 | Bernanke hints at QE2 in Jackson hole |
| 21/09/2010 | Fed hints at QE2 FOMC Statement |
| 03/11/2010 | QE2 - FOMC statement / USD 600bn announced |
| 22/06/2011 | QE2 completed |
| 31/08/2012 | Bernanke hints at QE3 in Jackson Hole |
| | |
| *BoE QE* | |
| 11/02/2009 | BoE hints at QE in Inflation Report |
| 05/03/2009 | QE1 announced and rates cut to 0.5%. |
| 06/08/2009 | QE1 extended |
| 05/11/2009 | QE1 extended by 25bn to 200bn |
| 09/02/2012 | QE2 extended by GBP50bn to GBP 325bn |
| 05/07/2012 | QE2 extended by 50bn to 375bn |
| 04/08/2016 | Start of QE3 |

### 3.3 Control variables

To control for market expectations of the state of the macroeconomy, we employ an indicator of economic sentiment provided by the Centre for European Economic research (ZEW). It is based on a monthly survey of market participants at banks, insurance companies and financial departments at large corporations, which report their reading of recent financial

market data and economic forecasts. We use the index version for the eurozone given that monetary policy targets the currency union as a whole. We allocate monthly observations across the days of each month. Table 3 provides summary statistics. For our sample period (2008 to 2017), the index stood at 15 points on average, with wide variation around that mean.

Our measure of inflation is the annual rate of growth in the eurozone consumer price index. The measure is available at a monthly frequency and observations are spread over the days per month. On average, inflation has been 1.4 per cent over the course of our sample and dropped below zero twice: briefly during the Great Recession of 2009, and again in the early months of 2015. The data series has been obtained from Eurostat.

To measure the vulnerability of countries to debt rollover risk, we construct a monthly indicator of redemptions. Using data from Bloomberg on the maturity of sovereign bonds, we sum the nominal amount of all bonds that mature between a given month and 12 months ahead. This yields a measure of upcoming redemptions the sovereign has to roll over. We scale the measure by dividing it by the total amount of outstanding bonds at the time. Table 3 reports summary statistics by euro area member state. We find that rollover risk varies substantially across countries, and, for our sample period, is highest in the Netherlands and lowest in Ireland.

Finally, we use the CBOE VIX index of option-implied volatility as a measure of global market sentiment. The index is often referred to as 'fear gauge' and increased to a historical high of 80 points during the financial crisis.

Table 3: Control variables

| | Mean | Std dev | Min | Max |
|---|---|---|---|---|
| ZEW sentiment index | 14.8 | 35.1 | -63.7 | 73.3 |
| CPI inflation (%) | 1.4 | 1.2 | -0.7 | 4.1 |
| Redemptions/bonds outstanding (%) | | | | |
| Germany | 11.3 | 2.5 | 7.5 | 17.2 |
| France | 25.2 | 4.4 | 14.2 | 35.2 |
| Austria | 10.7 | 2.9 | 3.1 | 16.9 |
| Belgium | 22.0 | 5.1 | 14.3 | 33.6 |
| Finland | 20.3 | 10.8 | 6.4 | 51.8 |
| Netherlands | 31.7 | 15.2 | 17.2 | 74.4 |
| Italy | 20.2 | 3.1 | 15.3 | 28.1 |
| Spain | 18.1 | 2.7 | 13.9 | 25.9 |
| Greece | 19.5 | 5.8 | 10.1 | 37.5 |
| Ireland | 8.4 | 7.8 | 0.5 | 31.8 |
| Portugal | 14.6 | 3.8 | 7.8 | 22.4 |
| VIX | 20.5 | 10.0 | 9.4 | 80.9 |

*Source:* Authors' calculation based on data from Bloomberg, Datastream.
*Note:* Sample period 2008-2017.

# 4 Results

## 4.1 'Fair value' results

We summarise our results by first confirming the validity of our 'fair value' specification. Table 4 reports the drivers of yields and yield components in the long run for our set of core and periphery countries. In order for an error correction specification to apply, the dependent variable is required to follow a stochastic trend. Column I of table 4 reports the $p$-value of Dickey-Fuller unit root tests. These show that the hypothesis, that daily yield, term premia and risk-free rate series follow a unit root process, cannot be rejected. That yield components generally tend to converge to a long-run level, here referred to as 'fair value', is further confirmed in column II, which reports the coefficient for the lagged level of the dependent variable, corresponding to parameter $\delta$ in equation (4). The coefficient has the expected negative sign throughout and is statistically significant in a number of specifications. Its size varies across bond yield components and countries, reflecting a different speed of adjustment to fair value.

The fair value (error correction) relationship is in most cases further determined by macroeconomic and fiscal variables reported in columns III to V. Stronger economic sentiment (column III) raises the prospect of higher short-term interest rates in the future and affects yields through the risk-free rate component, for which the coefficient is statistically significant (panel C). Higher levels of inflation (column IV) have a positive, albeit insignificant effect on the risk-free rate component, but are associated positively with the fair value of yields through the term premium, possibly reflecting the effect of higher levels of uncertainty about future monetary policy. The amount of sovereign debt to be redeemed (column V) also affects the fair value of yields through term premia: the higher upcoming redemptions, the larger the compensation investors require for the risk of refinancing difficulties.

We conclude that not accounting for the convergence of yields to a long-run 'fair value' relationship determined by macroeconomic and fiscal fundamentals in a specification of bond yield changes may bias results. Our 'fair value' specification therefore provides the basis for our analysis of monetary policy effects.

Column VI of table 4 further reports coefficients for the change in the global volatility index VIX, which we consider as short-run control. Results show a large divide between countries considered by financial markets to be part of the euro area core – Germany, France, Austria, Belgium, Finland, Netherlands –, and periphery member states – Italy, Spain, Greece, Ireland and Portugal. Risk premia in the former group, and thereby yields, exhibit a negative sensitivity to global market sentiment: as risk aversion rises, a flight to safety sets in, increases the demand for core country bonds and reduces term premia. The opposite holds for countries of the periphery, which pay higher risk premia if sentiment is downbeat. The sensitivity of periphery risk premia to sentiment is a theme we return to in more detail in section 4.3.

Table 4: 'Fair value' determinants

| | I<br>Unit root test[a] | II<br>Lagged level | III<br>Sentiment | IV<br>Inflation | V<br>Redemptions | VI<br>ΔVIX |
|---|---|---|---|---|---|---|
| *Panel A:* sovereign yields | | | | | | |
| Germany | 0.561 | -0.004 | 0.002 | 0.185 | 0.154 | -0.420*** |
| | | (0.00) | (0.00) | (0.17) | (0.10) | (0.07) |
| France | 0.678 | -0.011*** | 0.010* | 0.774*** | 0.243*** | -0.442*** |
| | | (0.00) | (0.01) | (0.21) | (0.06) | (0.06) |
| Austria | 0.699 | -0.001 | -0.000 | 0.107 | -0.001 | -0.453*** |
| | | (0.00) | (0.00) | (0.14) | (0.04) | (0.06) |
| Belgium | 0.798 | -0.005 | 0.009 | 0.248 | 0.134 | -0.281*** |
| | | (0.00) | (0.01) | (0.18) | (0.13) | (0.06) |
| Finland | 0.647 | -0.004** | 0.006 | 0.248* | 0.042** | -0.570*** |
| | | (0.00) | (0.01) | (0.15) | (0.02) | (0.07) |
| Netherlands | 0.630 | -0.008*** | 0.016*** | 0.573*** | 0.065*** | -0.561*** |
| | | (0.00) | (0.01) | (0.20) | (0.02) | (0.07) |
| Italy | 0.735 | -0.005 | 0.007 | 0.612** | 0.051 | 0.329** |
| | | (0.00) | (0.01) | (0.28) | (0.11) | (0.13) |
| Spain | 0.834 | -0.007** | 0.015* | 1.119*** | 0.222*** | 0.151 |
| | | (0.00) | (0.01) | (0.38) | (0.08) | (0.11) |
| Greece | 0.172 | -0.007 | -0.044 | 0.623 | 0.191 | 2.053*** |
| | | (0.01) | (0.06) | (0.83) | (0.47) | (0.73) |
| Ireland | 0.921 | -0.001 | 0.015 | 0.622 | 0.039 | -0.112 |
| | | (0.00) | (0.01) | (0.46) | (0.04) | (0.10) |
| Portugal | 0.769 | -0.003 | 0.001 | 0.377 | 0.222** | 0.319** |
| | | (0.00) | (0.02) | (0.56) | (0.11) | (0.15) |
| *Panel B:* term premium | | | | | | |
| Germany | 0.626 | -0.014*** | 0.007 | 0.384** | 0.325*** | -0.228*** |
| | | (0.00) | (0.01) | (0.16) | (0.09) | (0.07) |
| France | 0.460 | -0.011*** | 0.007 | 0.448*** | 0.114*** | -0.253*** |
| | | (0.00) | (0.01) | (0.17) | (0.04) | (0.08) |
| Austria | 0.548 | -0.005** | -0.003 | 0.209 | 0.052 | -0.262*** |
| | | (0.00) | (0.00) | (0.15) | (0.04) | (0.08) |
| Belgium | 0.605 | -0.004 | 0.003 | 0.226 | 0.055 | -0.089 |
| | | (0.00) | (0.01) | (0.17) | (0.06) | (0.09) |
| Finland | 0.501 | -0.005** | 0.002 | 0.191 | 0.022** | -0.377*** |
| | | (0.00) | (0.00) | (0.13) | (0.01) | (0.08) |
| Netherlands | 0.505 | -0.008*** | 0.008* | 0.329** | 0.028*** | -0.371*** |
| | | (0.00) | (0.01) | (0.15) | (0.01) | (0.08) |
| Italy | 0.440 | -0.003 | 0.001 | 0.429** | -0.016 | 0.523*** |
| | | (0.00) | (0.01) | (0.20) | (0.05) | (0.15) |
| Spain | 0.565 | -0.004* | 0.008 | 0.599** | 0.123** | 0.348*** |
| | | (0.00) | (0.01) | (0.23) | (0.05) | (0.13) |
| Greece | 0.169 | -0.007 | -0.046 | 0.281 | 0.210 | 2.250*** |
| | | (0.01) | (0.06) | (0.99) | (0.50) | (0.74) |
| Ireland | 0.808 | -0.002 | 0.013 | 0.629* | 0.039 | 0.080 |
| | | (0.00) | (0.01) | (0.35) | (0.03) | (0.13) |
| Portugal | 0.627 | -0.002 | -0.002 | 0.259 | 0.188* | 0.516*** |
| | | (0.00) | (0.02) | (0.51) | (0.11) | (0.17) |
| *Panel C:* risk-free rate | | | | | | |
| Eurozone | 0.106 | -0.003** | 0.006* | 0.076 | | -0.199*** |
| | | (0.00) | (0.00) | (0.09) | | (0.06) |

*Note:* Dependent variable in basis points. Newey-West standard errors in parentheses. Significance level given by *** p<0.01, ** p<0.05, * p<0.1. [a] Dickey-Fuller test of null hypothesis that series contain a unit root, $p$-value reported.

### 4.2 Monetary policy transmission channels

We next turn to the impact of unconventional monetary policies by the ECB on yields across the euro area. The fact that bond yields and their components follow stochastic trends implies that announcements have the potential to cause long-lasting deviations from fair value. Table 5 reports our findings for all events associated with the SMP, OMT and PSPP programmes. Decomposing the effect on premia into effects through the term premium and the risk-free rate allows us to gauge the channels of monetary transmission at work.

Table 5: Monetary policy transmission channels

| | SMP | | OMT | | PSPP | |
|---|---|---|---|---|---|---|
| | Yield | Term premium | Yield | Term premium | Yield | Term premium |
| Germany | 10.25*** | 9.883*** | 28.51*** | 13.77*** | -19.77*** | -17.26*** |
| France | 3.982*** | 4.713*** | -11.78*** | -22.38*** | -55.83*** | -55.46*** |
| Austria | -4.337*** | -4.266** | -2.649 | -18.64*** | -52.61*** | -50.80*** |
| Finland | -0.780 | -0.836 | 14.01*** | -2.937 | -47.69*** | -47.22*** |
| Netherlands | -0.890 | -0.960 | 7.577** | -8.567*** | -53.78*** | -54.06*** |
| Belgium | -39.13*** | -39.41*** | -18.37*** | -33.36*** | -60.75*** | -57.50*** |
| Italy | -124.4*** | -124.8*** | -71.80*** | -88.99*** | -62.23*** | -59.27*** |
| Spain | -148*** | -148.1*** | -111.6*** | -131.4*** | -42.10*** | -38.76*** |
| Portugal | -221.4*** | -221.8*** | -61.58*** | -81.89*** | -79.68*** | -77.67*** |
| Ireland | -169.6*** | -169.8*** | -27.57*** | -43.90*** | -40.13*** | -37.45*** |
| Greece | -443.5*** | -443.8*** | -45.82 | -63.41 | -77.89 | -75.22 |
| Risk-free rate | 0.886 | | 16.51*** | | -3.005 | |

*Note:* Dependent variable in basis points. Cumulative coefficients reported, significance level of Wald test given by *** p<0.01, ** p<0.05, * p<0.1.

The first two columns show that the announcement of the SMP significantly lowered yields of periphery countries, by just above 120 basis points for Italy and Portugal and more than 400 basis points for Greece. The impact can almost entirely be explained by a reduction in risk premia, as expectations of the risk-free rate did not respond. This, together with the finding of much smaller effects for core countries, confirms that the SMP worked mainly through a reduction in euro area break-up risk, in line with the programme's objective. In fact, German and French term premia increased following the announcement as the flight to safety abated.

Confirming results in Falagiarda and Reitz (2015), we find that the OMT had similar effects on periphery countries, although with smaller magnitude. In particular the response of the Greek term premium is much smaller and not statistically significant. This can be explained by the fact that Greek bonds were not eligible for OMT. Interestingly, we find a sizeable positive and statistically significant effect on risk-free rate expectations. This may suggest that markets interpreted the reduction in risk premia as a development that would allow a faster than previously expected normalisation of monetary policy.

The last two columns of table 5 show results for the PSPP. Quantitative easing decreased bond yields in all countries. We find that this is only to a small extent driven by a direct signalling effect: the risk-free rate component of yields fell only by 3 basis points as the PSPP was announced, and the effect is not significant at statistical levels. By contrast, the PSPP

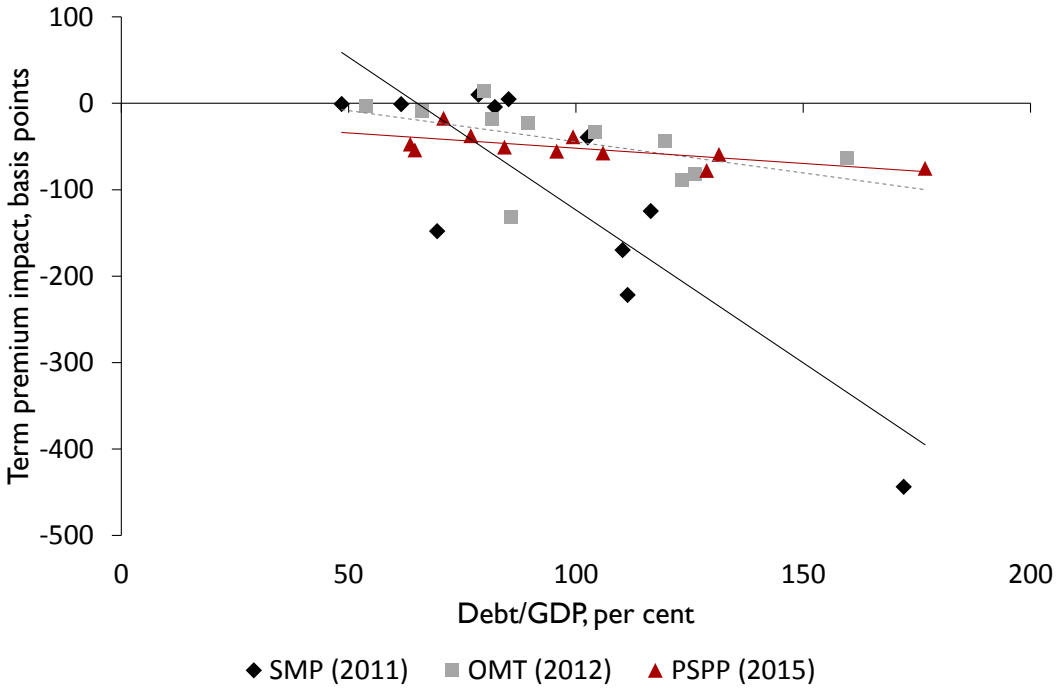


Figure 2: Risk channel of monetary policy

reduced term premia significantly. The fact that both core and periphery countries benefitted, suggests that QE served as a commitment to keep monetary policy accommodative for longer, reducing uncertainty-related premia. Nevertheless, the response of term premia was not uniform. This confirms findings in De Santis (2016) for a wider set of core and periphery countries. German premia decreased by around 17 basis points, whereas for most other member states the impact lies closer to 50 basis points. It is highest for Italy and Portugal (as well as Greece[2]), which implies that countries' fiscal position increases the sensitivity to QE. The euro break-up, or credit risk channel appears to have been important also for the transmission of QE (see also Altavilla et al., 2015).

This is further illustrated by figure 2, which in a stylised manner plots the responsiveness of term premia to the announcements of SMP, OMT, and PSPP by country in relation to the level of government debt-to-GDP in 2011, 2012, and 2015 respectively. There is a clear negative relationship for the SMP but a simple regression line retains a negative slope also for the PSPP.

### 4.3 Euro area risk channel

To explore further the role of a euro area risk channel in transmitting unconventional monetary policy announcements to bond markets, we use our term premium estimates to extract a common component and an euro area risk component. To do so, we conduct a principal components analysis. We filter out the first two components that together explain 95 percent

[2]The results for Greece are not statistically significant and more uncertain.

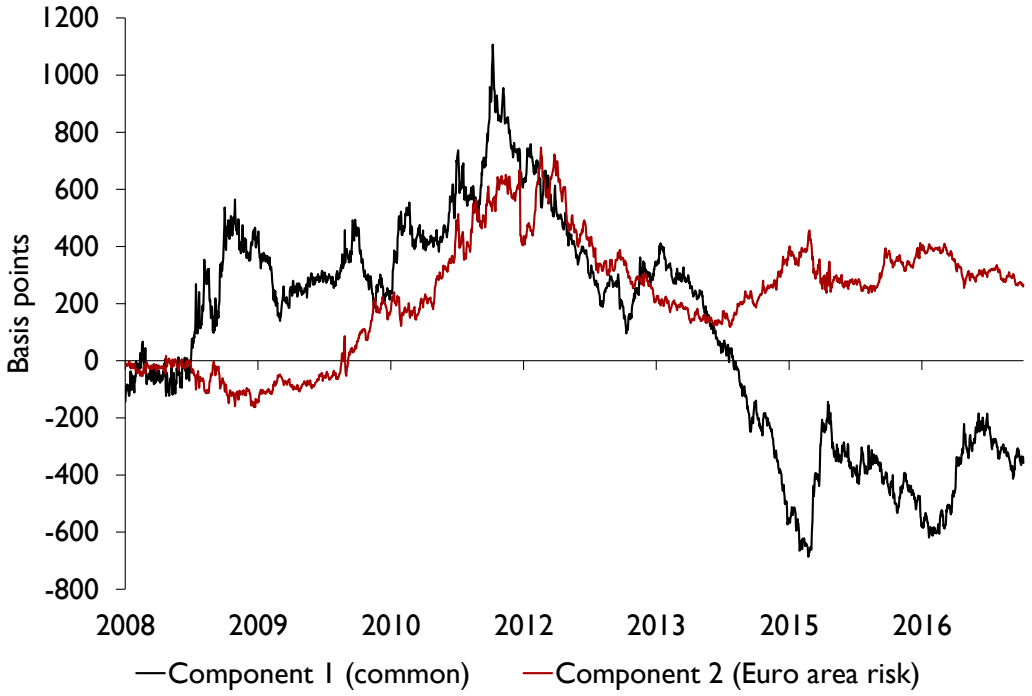


Figure 3: Common components in term premia

of the overall variation in term premia. We then transform both series to adopt a mean and standard deviation that correspond to the moments of our sample of term premia. Figure 3 plots both series. The first component tracks closely the overall movement in term premia (see also figure 1). It increases during the financial crisis and at the height of the European sovereign debt crisis and declines thereafter. By contrast, the second component increases substantially only during the euro area crisis, which marks a structural break and the series has remained elevated since. We therefore interpret the first component as a common market component and the second component as a measure of euro area risk.

Table 6: Principal components analysis: country weights

| | Component 1 | Component 2 |
|---|---|---|
| Germany | 0.270 | -0.370 |
| France | 0.357 | -0.143 |
| Austria | 0.338 | -0.221 |
| Finland | 0.308 | -0.306 |
| Netherlands | 0.310 | -0.302 |
| Belgium | 0.369 | -0.033 |
| | | |
| Italy | 0.300 | 0.301 |
| Spain | 0.292 | 0.306 |
| Portugal | 0.242 | 0.405 |
| Ireland | 0.308 | 0.225 |
| Greece | 0.172 | 0.457 |

Such an interpretation seems to be justified by the weights with which country-specific term premia enter each component, summarised in table 6. Every country's term premium

Table 7: Euro area risk channel

| | SMP | OMT | PSPP |
|---|---|---|---|
| Component 1 (Common) | -166.3*** | -144.6*** | -236.7*** |
| Component 2 (Euro area risk) | -183.5*** | -82.33*** | 61.33*** |

*Note:* Dependent variables are transformed principal components and comparable to results in basis points. Cumulative coefficients reported, significance level of Wald test given by *** p<0.01, ** p<0.05, * p<0.1.

is linked positively to the first principal component with a factor of close to 0.3, with the exception of Greece. The difference for the second principal component is striking. Term premia of member states generally classified as core countries negatively enter the second component. German term premia are associated with the most negative weight and French with the smallest weight in absolute terms. On the other hand, term premia of periphery countries enter the second component with positive weights, which are largest for Portugal and Greece.

Table 7 shows the impact of PSPP and the other two ECB programmes on both components. The PSPP has a large negative effect on the common component. This confirms that bond markets mainly reacted to the reduction in uncertainty about future monetary policy, which all euro area member states benefitted from. By contrast, the SMP hit the euro area risk component more strongly, as the programme lifted the risk of a euro area break-up. Responses to OMT are placed in between.

### 4.4 International spillovers

We next turn to the question to what extent euro area yields are subject to spillovers from monetary policy announcements abroad. Table 8 reports the cumulative impact announcements related to QE programmes by the Federal Reserve and Bank of England had on euro area yields. We obtain almost a mirror image of the results we estimate for unconventional monetary policy announcements by the ECB: effects on yields of the euro area periphery vary in magnitude and statistical significance, whereas for core countries we find a substantial reduction in yields of between 70 and 110 basis points for US QE and an impact of half that size for UK QE. This is partly explained by a reduction in the risk-free rate component of 20 and 9 basis points, respectively (bottom of table 8). Euro area yields benefitted from the turn in global monetary policy that the main foreign central banks embarked upon after the global financial crisis.

Most of the reduction in core countries' yields can be explained by a reduction in their term premia. We interpret this as the result of international portfolio rebalancing. As US and UK Treasury debt was bought up by the central banks in both countries, investors turned to similarly safe assets abroad. This raised demand for core country bonds and term premia decreased. By contrast, vulnerable periphery countries benefitted less (apart from Greece), partly because their debt may have been considered a less attractive substitute.

Table 8: Monetary policy spillovers

| | Fed QE | | BoE QE | |
|---|---|---|---|---|
| | Yield | Term premium | Yield | Term premium |
| Germany | -69.38*** | -41.68*** | -51.55*** | -38.82*** |
| France | -97.01*** | -65.63*** | -37.88*** | -25.25*** |
| Austria | -81.08*** | -53.91*** | -38.04*** | -26.12*** |
| Finland | -109.8*** | -82.30*** | -48.42*** | -37.90*** |
| Netherlands | -108.3*** | -78.01*** | -47.34*** | -37.63*** |
| Belgium | -107.1*** | -77.82*** | -32.93*** | -21.89 |
| Italy | -62.34*** | -37.03*** | 13.87 | 22.65** |
| Spain | -4.285 | 19.53** | 31.48*** | 39.82*** |
| Portugal | -77.70*** | -50.81*** | -70.14*** | -63.14*** |
| Ireland | -23.83* | 2.253 | 3.829 | 13.95 |
| Greece | -213.6*** | -188.5*** | 145.4** | 150.5** |
| Risk-free rate | -19.72*** | | -8.954** | |

*Note:* Dependent variable in basis points. Cumulative coefficients reported, significance level of Wald test given by *** p<0.01, ** p<0.05, * p<0.1.

### 4.5 Robustness checks

**One-day responses** Results for the impact of monetary policy announcements so far have been reported for an event window of two days, i.e. accumulated over the announcement response and the movement in yield components the day after. In line with the literature, a two-day window was chosen to minimise contamination from other news but allow some time for the digestion of new information by market participants. Nevertheless, a two-day window may be too large if the day after the announcement is characterised by other events that impact yields. In particular during the European sovereign debt crisis, events often unfolded right after another. We therefore re-estimate our main results using a one-day event window, i.e. only consider changes in yield components that take place on the announcement day. Results are reported in table A1 in the Appendix. Overall, it is confirmed that SMP and OMT mainly reduced risk premia of the periphery while PSPP affected all euro area countries significantly. An exception is Germany, for which a positive term premium effect from PSPP is estimated. This may have to do with the fact that portfolio rebalancing effects take somewhat longer to materialise compared to a reduction in credit risk premia, which is immediately priced. Interestingly, the response of the risk-free rate component is more negative and statistically significant, compared to our baseline result. Signalling effects of PSPP may therefore have been somewhat stronger than implied by two-day responses.

**Alternative risk premium measures** We justify our decomposition of bond yields by arguing that conventional financial market measures of risk premia and risk-free rates cannot clearly distinguish between expectations of future monetary policy and various sources of risk. However, the estimation approach we adopted may not be free of error. We therefore compare our results to two alternative measures of risk premia: the conventional spread between euro area yields and the German benchmark, and a risk premium derived from using the OIS 10-year forward rate as a proxy for expectations about future short-term rates. We report

results in table A2 in the Appendix. We find that spreads yield qualitatively similar results but show that the response to monetary policy announcements may be biased. This is because movements in risk-free rate expectations are not sufficiently captured. In addition, a lessening in the flight to safety provided by the German Bund, which increases German term premia, leads to an underestimation of euro area yield responses.

Similarly, OIS-derived premia move in a similar direction compared to our term premia estimates, at least for periphery countries, but understate the overall response of the premium component. This is because OIS-implied interest rate expectations are arguably not completely free of risk priced by financial markets, compared to our estimates of risk-free rates. This may also explain why the estimate of the OIS forward rate response to PSPP, although still negative, is much larger in absolute terms.

# 5 Conclusion

Motivated by the imminent tapering of QE in the euro area, this paper sets out to estimate the extent to which unconventional policies taken by the ECB have depressed yields across the currency union. For 11 euro area member states, we decompose daily yields into a component that captures expectations about future short-term rates, and a risk premium. The latter captures the compensation investors require for uncertainty about monetary policy, liquidity risk and sovereign credit risk. The decomposition allows us to gauge the transmission channels at work for different types of monetary policy announcements. Compared to conventional spread measures relative to a benchmark bond, term premia estimates are free from liquidity effects the benchmark itself may be affected by. We then make use of an event study approach to gauge the stock effect of announcements on bond yield components. We employ a fair value specification that controls for the fact that yields tend to converge over time to a long-run level defined by macroeconomic and fiscal fundamentals. We find that yields of countries of the euro area periphery are not only more sensitive to monetary policy measures targeted at reducing euro area break-up risk, but also to QE. The ECB's QE programme PSPP is found to have only a small signalling effect, as expectations about future risk-free rates move only marginally. The PSPP, however, confirmed the commitment by the central bank to stabilise the currency union as whole. This may be the reason why we also do not find substantial portfolio rebalancing effects from the PSPP, which should have benefitted core countries more. By contrast, QE programmes adopted by the Federal Reserve and Bank of England depressed core country yields at least as much as ECB policies, likely because these measures were taken in a period of elevated market distress.

For the process of quantitative tightening in the euro area, our findings imply that announcements should be made gradually so as not to trigger a renewed divergence of yields. For the future evolution of long-term interest rates, however, the credibility of OMT and institutional reforms, that help stabilise the euro area, appear to be more important than the pace at which the ECB reduces its balance sheet.

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# Appendix

Table A1: Robustness check: one-day response

| | SMP | | OMT | | PSPP | |
|---|---|---|---|---|---|---|
| | Yield | Term premium | Yield | Term premium | Yield | Term premium |
| Germany | 33.24*** | 16.66*** | 24.72*** | 10.46*** | 2.594 | 9.990*** |
| France | 6.098*** | -9.808*** | -10.07*** | -22.13*** | -32.89*** | -26.69*** |
| Austria | 2.052** | -14.15*** | -3.693* | -18.34*** | -27.90*** | -20.81*** |
| Finland | 3.351*** | -12.91*** | 1.475 | -13.79*** | -30.56*** | -24.31*** |
| Netherlands | 4.488*** | -11.77*** | -2.143 | -16.97*** | -29.40*** | -23.32*** |
| Belgium | -25.43*** | -41.72*** | -10.70*** | -24.95*** | -33.17*** | -25.83*** |
| Italy | -112.3*** | -128.9*** | -21.72*** | -36.90*** | -31.09*** | -23.58*** |
| Spain | -134.7*** | -151.3*** | -52.05*** | -68.67*** | -25.73*** | -17.98*** |
| Portugal | -167.4*** | -184*** | -12.23 | -29.21*** | -41.60*** | -34.07*** |
| Ireland | -107.7*** | -124*** | -7.937* | -22.96*** | -18.77*** | -11.38*** |
| Greece | -434.3*** | -450.8*** | 25.92 | 10.42 | -53.30** | -45.89** |
| Risk-free rate | 16.83*** | | 15.10*** | | -7.668*** | |

*Note:* Dependent variable in basis points. Cumulative coefficients reported, significance level of Wald test given by *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Robustness check: alternative risk premia measures

| | SMP | | OMT | | PSPP | |
|---|---|---|---|---|---|---|
| | Spread | OIS-derived premium | Spread | OIS-derived premium | Spread | OIS-derived premium |
| Germany | | 13.38*** | | 8.904*** | | 34.61*** |
| France | -5.789*** | 12.49*** | -33.52*** | -33.17*** | -35.97*** | -20.75*** |
| Austria | -14.68*** | 3.352*** | -30.49*** | -28.18*** | -36.55*** | -18.27*** |
| Finland | -10.24*** | 6.822*** | -36.06*** | -13.54*** | -56.88*** | -14.88*** |
| Netherlands | -12.39*** | 6.482*** | -16.42*** | -18.78*** | -45.94*** | -20.51*** |
| Belgium | -49.27*** | -31.73*** | -45.37*** | -43.13*** | -37.27*** | -23.48*** |
| Italy | -135.1*** | -116.8*** | -100.2*** | -99.32*** | -40.78*** | -27.06*** |
| Spain | -158.5*** | -140.1*** | -146.4*** | -144.5*** | -19.16** | -5.987 |
| Portugal | -232.4*** | -213.8*** | -97.75*** | -94.74*** | -58.60*** | -46.05*** |
| Ireland | -180.3*** | -161.9*** | -56.91*** | -53.72*** | -19.96** | -6.106 |
| Greece | -454.3*** | -436.2*** | -77.03 | -74.07 | -53.27 | -40.38 |
| OIS rate | -7.443*** | | 26.50*** | | -35.96*** | |

*Note:* Dependent variable in basis points. Cumulative coefficients reported, significance level of Wald test given by *** p<0.01, ** p<0.05, * p<0.1.