The Effects of ECB's Asset Purchase Announcements on Euro Area Government Bond Yields

Frederik Neugebauer*

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Abstract

This paper employs event study methods to evaluate the effects of ECB's unconventional monetary policy program announcements on 10-year government bond yields of euro area member states. It covers data from 11 euro area countries from January 1, 2007 to August 31, 2017 and distinguishes between the more solvent countries (Austria, Belgium, Finland, France, Germany, the Netherlands) and the less solvent ones (Greece, Ireland, Italy, Portugal, Spain). The paper makes two contributions to the literature. First, it is the first paper to reveal that measurable effects of announcements arise with a one-day delay meaning that government bond markets take some time to react to ECB announcements. Second, it quantifies the country-specific extent of yield reduction which seems inversely related to the solvency rating of the corresponding countries. The reduction of the spread between both groups in response to an event is due to a stronger decrease in the less solvent group. By employing different data as control variables, it turns out that the results are robust for a given event set.

JEL classification: E44, E52, E58, G14

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*WHU – Otto Beisheim School of Management, Department of Economics, Burgplatz 2, 56179 Vallendar, Germany. frederik.neugebauer@whu.edu. The author would like to thank participants at the 11^{th} RGS Doctoral Conference in Economics, and the 1^{st} CESifo EconPol Europe PhD Workshop: Economic and Fiscal Policy in Europe.

1 Introduction

National government bond yields include the risk premium of a specific country. That is why the sole announcement of an asset purchase by a central bank can already reduce the yields through amended expectations of investors. Event studies by Joyce et al. (2011) and Gagnon et al. (2011) find evidence for short-term yield reductions to quantitative easing announcements in the UK and in the US, respectively. Previous research, however, indicates that announcement effects are somewhat specific to the respective country.[1] This study aims at quantifying ECB announcement effects for the euro area. In particular, the study examines whether there is a similar or varying impact on 10-year government bond yields of different euro area members. Such evidence is of high relevance for ECB's policy making and communication strategy. Before making an announcement the ECB might want to assess its consequences on individual euro area members because it matters whether an announcement is perceived differently within the euro area.

In general, massive asset purchases by any central bank provide more liquidity. The present study, however, focuses on the sole announcements of such liquidity provision while the actual amount of asset purchases is not considered.[2] A credible asset purchase announcement directly affects investors' expectations on the (future) attractiveness of particular assets (or asset classes). As a potential consequence the demand for these assets rises and increases asset prices. In case of government bonds, this, in turn, directly reduces the government bond yields in question. For this short-term mechanism to work, it is irrelevant whether the future quantitative easing measures have the expected effects or whether they merely work as a placebo. More specifically, it is expected that ECB's asset purchase program announcements have a stronger effect on the government bonds of stressed countries since the programs intend to foster primarily the euro area economies under stress. In contrast, the yields of more solvent countries are expected to be less sensitive to such announcements. Although at the announcement day it is yet not clear what sort of assets the ECB exactly will buy, that is to which economy the purchased assets belong, the possibility that also assets from the countries under stress might be bought, substantially smooths market expectations.

[1] For the case of Japan with its long history at the zero lower bound and quantitative easing measures, no evidence of yield reactions to central bank announcements exists. In contrast, in an event study Bernanke et al. (2004) state that communications by the Federal Reserve change market expectations and thus long-term yields in the US while statements by the Bank of Japan do not affect Japanese yields.

[2] For a study that implements actual purchases to assess the impact on sovereign bond yields, see for instance Eser and Schwaab (2016).

Most existing literature only investigates the announcement effects on the aggregate euro area as a whole. For instance, Ambler and Rumler (2017) use weighted average real yields of all euro area countries to search for announcement effects. Their research indicates that announcements lead to significantly lower real bond yields. The few existing disaggregated studies compare only a few countries, however. For instance, Altavilla et al. (2016) analyze the effects of outright monetary transactions announcements on the government bond yields of Germany, France, Italy and Spain while Briciu and Lisi (2015) look exclusively at the yields of only Germany, Italy, and Spain in response to ECB's announcements. Both studies find yield reducing effects in response to ECB's unconventional monetary policy announcements.

Many studies consider the effects on yields' spreads rather than levels. For instance, Falagiarda and Reitz (2015) state that the inter-European spreads on government bond yields decrease in response to ECB's asset purchase announcements. They find a reduction of long-term yield spreads of Ireland, Italy, Portugal and Spain. Similarly, Szczerbowicz (2015) evaluates the impact of ECB's unconventional monetary policies on 10-year sovereign bond yield spreads of France, Greece, Ireland, Italy, Portugal and Spain with respect to the German sovereign yield. She also confirms spread reducing effects. Recently, Bulligan and Monache (2018) quantify the spread reduction of Italy, France and Spain (vis-à-vis Germany) for asset purchase announcements between September 2014 and July 2017. Nevertheless, the question remains which (relative) level effects of the respective spread-defining yields exactly underlie these spread reductions.

Therefore, this study covers a large number of euro area members and focusses on the level effects. For policy making, it is essential to see the absolute (level) impact of an announcement to evaluate its costs or benefits. The relative (spread) position to another economy is less important. Furthermore, this study covers a long time span of over ten years. So far, studies in this field of research are typically constrained to a shorter period. For instance, Christensen and Krogstrup (2018) only consider events during one month, Altavilla et al. (2016) during three months and Gagnon et al. (2011) during two years.

Hence, this study extends the existing literature in three directions. First, the separate consideration of individual euro area members allows a comparison of national effects. A euro area average impact seems not entirely helpful for policy analysis. A study of differences between countries gives important insights on economic conditions of the respective countries instead. Second, the focus on the level is more useful than spread analysis. A reduction in

spread does not explain the inherent direction of yield changes, that is whether both yields are increasing/decreasing to a different extent or whether they are moving into opposite directions. Third, the long time span guarantees that announcements are considered at different states of the financial crisis. Unlike Bulligan and Monache (2018) who divide their three year observation period into subsamples this study aims at a (time-invariant) generalization of the findings. Given that some programs and their announcements last for a long time and are continuously prolonged, it would be inappropriate to include only a part of its announcement history. Moreover, a long sample period increases the validity and reliability of findings, by improving statistical properties with additional observations.

By covering data from 11 euro area countries from January 1, 2007 to August 31, 2017 and searching for country-specific level effects on 10-year government bonds yields of ECB announcements the paper adds two significant findings to the existing literature. First, to the best of my knowledge this event study is the first one to reveal that the effects of announcements arise with a one-day delay meaning that government bond markets take some time to react to ECB announcements. Second, it shows that the country-specific quantitative extent of yield reduction is inversely related to the solvency rating of the corresponding euro area country: The worse the rating is, the bigger the yield reduction is. This also implies that the observed reduction of the yield spread between core/solvent and periphery/less solvent countries in response to an announcement event is due to a stronger decrease in the yield of the latter. A group-wise panel analysis confirms these findings. By employing different data as control variables, it is demonstrated that these findings are robust for a given event set.

The remainder of the paper proceeds as follows. Section 2 describes the methodology and the data. Section 3 presents the empirical results. Section 4 provides robustness checks, while the final section 5 concludes.

2 Methodology and Data

In order to investigate the short-term impact of ECB's asset purchase announcements on the 10-year benchmark bond yield to redemption of individual euro area members,[3] an event study methodology as in Moessner (2015) is applied. The dataset consists of daily yields (per bank working day) of Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Nether-

[3]The results hold taking 10-year zero coupon government yields as dependent variable instead of yields to redemption.

lands, Portugal and Spain from January 1, 2007 to August 31, 2017. These are the founding members of the euro area except Luxembourg while Greece (which joined in 2001) is additionally included. While a small country like Luxembourg might bias the results it is essential to include Greece as an economy heavily hit during the sovereign debt crisis. The study is limited to long-term yields only to overcome the zero lower bound problematic or even negative yields that are partly present for short-term yields.

The identical regression is carried out for each government bond yield y_t to test whether there are different reactions among the euro area countries. The baseline specification uses first-differences and is

$$\Delta y_t = \alpha + \beta_1 \Delta y_{t-1} + \beta_2 \Delta stock_t + \beta_3 \Delta CESI_t + \beta_4 \Delta exch_t + \gamma APA_t + \varepsilon_t, \tag{1}$$

with $t = 1, ..., T = 2784$ observations per country denoting the daily observations for each variable and the error term $\varepsilon_t \sim (0, \sigma^2)$, while α is a constant.

It is assumed that the present day's yield change is dependent on that of the previous day as common in financial time series. Therefore, a one lag estimator y_{t-1} is included in the regression as in Urbschat and Watzka (2017).[4] The choice of additional control variables is motivated as follows. The country-specific stock market indices $stock_t$ intend to represent the investors' perception of an economy. A rising index ceteris paribus reduces the default risk of sovereign debt. Thus, it decreases government bond yields. The Citigroup Economic Surprise Index for the Eurozone $CESI_t$ is defined as weighted historical standard deviations of macroeconomic data surprises and controls for general events taking place all over Europe. A positive development of this index increases perceived risks of investors, which, in turn, increases bond yields. The influence of the US-\$/€ spot exchange rate (in price notation) is captured by $exch_t$.[5] It intends to control for the link between exchange rate movements and interest rates due to international arbitrage considerations. All variables are obtained from Datastream and are end-of-business-day values ('close prices').

[4] The application of the model with an additional two-day lag estimator y_{t-2} shows an insignificant estimator for all bonds under consideration. One might argue that a lagged dependent variable might cause endogeneity problems. Although it is common in related literature to apply such lags (Szczerbowicz (2015), Jäger and Grigoriadis (2017), Urbschat and Watzka (2017)), the model is also applied without a lagged dependent variable to overcome endogeneity concerns as a robustness check. The results (available upon request) persist highlighting that endogeneity is negligible in this kind of models.

[5] Of course, one could also implement an effective exchange rate such as the rate vis-à-vis the EER-19 trading partners. However, due to gaps in the data availability (overall 52 missing observations) the spot exchange rate is convenient. Note that independent of the chosen exchange rate variable the results remain almost identical.

The timing is important to consider. An announcement event usually takes place in the middle of the day. For instance, one would expect different reactions in case of start-of-business-day values ('open prices') or daily averages. It would be interesting to include market sentiment measures such as the index of economic policy uncertainty by Baker et al. (2016) or the consumer confidence indicator by the European Commission. However, these indices are not available at a daily frequency and a transformation of monthly survey data to a daily basis would bias the results.

APA_t is the variable of our main interest. It is a dummy variable taking the value of 1 on the day of a specific ECB asset purchase program announcement, and 0 otherwise. In contrast to Falagiarda and Reitz (2015) who add a dummy variable for each single event, all announcement events are represented by one common dummy variable in order to detect a generalized effect of an ECB announcement. An overall effect is more suitable for policy making because the ECB is interested in gauging the average effect of similar future announcements. If each announcement is considered individually, the result is only valid for an identical announcement in the future. The coefficient γ measures the general announcement effect and it is expected to have a negative sign ($\gamma < 0$).

An integral element in the analysis is the identification of asset purchase announcements. Press releases and statements by ECB's officials are therefore carefully scrutinized according to their content. This approach of deliberately determining events is common in related literature and 'entails a certain degree of subjectivity' (Ambler and Rumler (2017), p. 10). Table A1 in the Appendix shows an extended list of potentially relevant events that might affect the European government bond market. Out of this list, 23 events are chosen and denoted in bold. Furthermore, the keywords why a certain event is included are denoted in italics. That means, APA_t is equal to 1 on these days, and 0 otherwise.

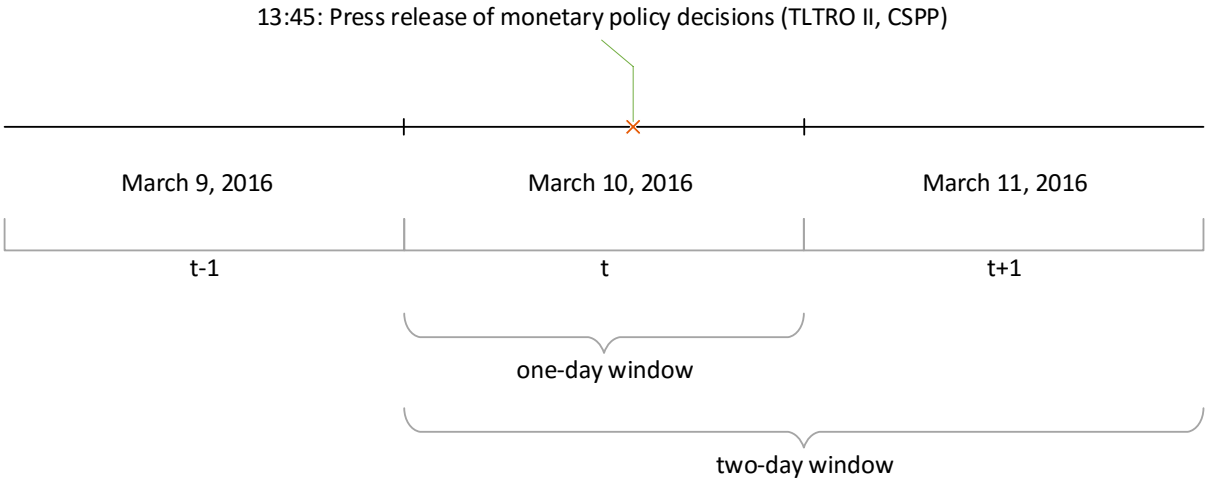
All events refer to specific asset purchase programs. For this reason the famous 'whatever it takes' statement by Mario Draghi on July 26, 2012 is not chosen as it is not referring to a specific program. Other monetary policy statements, for example press releases regarding conventional monetary policy tools or forward guidance statements[6] are also omitted because the study focuses merely on unconventional quantitative easing measures. Announcements on purely technical details of asset purchase programs are not considered as they do not provide

[6]Since forward guidance was recently implemented in the euro area, studies that look explicitly at forward guidance are limited to the Federal Reserve that implemented it earlier (Moessner (2015), Neugebauer et al. (2017)).

new information to the market. One might argue that confirming announcements such as the press releases by the ECB on January 19, 2017 or July 20, 2017 are not effective. However, they are included for the following reason. Since investors believe that there might be an end of the extreme expansive monetary policy a repeated announcement that contradicts this expectation can lead to surprise effects. Some studies rely on news from other sources than ECB officials, for example Altavilla et al. (2015) use a news database to screen articles for keywords in order to detect relevant events. However, this approach is less helpful to work out policy implications because media is out of control of the ECB and can only be indirectly influenced by its policy statements.

The choice of the correct event window width is another debatable element in any event study. While a too long window width induces the risk of contamination of news not related to monetary policy, a too short window width might neglect delayed effects of monetary policy announcements. Recent literature typically uses either one-day windows (e.g. Glick and Leduc (2012), Haitsma et al. (2016), Georgiadis and Gräb (2016)) or two-day windows (e.g. Altavilla et al. (2015), Szczerbowicz (2015), Christensen and Krogstrup (2018)). Figure 1 exemplifies the event window for the announcement made on March 10, 2016: the dummy variable either is set to 1 on March 10 only (one-day window) or on both March 10 and March 11 (two-day window).

Figure 1: Event window



This study sets the window width to just one day as the risk of including effects from other events is evaluated higher than the possibility of excluding delayed effects. Furthermore, fre-

quent trading on financial markets supports this choice.[7] To capture potential delayed reactions to the announcement we will lag the one-day to the March 11 rather than expanding the window width.

Table A2 in the Appendix presents the descriptive statistics. It shows that the stock indices vary considerably across countries. Their standard deviations range from 83 points (the Netherlands) to 7,367 points (Italy). The yields differ substantially in their level. They range from a minimum of -0.22% in case of Germany to a maximum of 48.6% in case of Greece. This underpins the choice of applying first-differences instead of absolute values.

The data set motivates to distinguish two country groups: The first group consists of Austria, Belgium, Finland, France, Germany and the Netherlands. Their bonds show moderate yields over time with an average smaller than 3% and a maximum smaller than 6%. In contrast, the second group consisting of Greece, Ireland, Italy, Portugal and Spain possesses high bond yields with an average higher than 3% and a maximum up to 48%. The former groups is labeled 'Core countries' and the latter group is referred to as 'Periphery countries' in the following. These expressions are synonyms for the more solvent and the less solvent countries, respectively. The grouping corresponds to the common distinction of PIIGS countries and other euro area members.[8]

Plotting the dependent variable over time gives additional insights. Figure A1 in the Appendix shows that the divergence in yields emerged from 2010 on and it clearly demonstrates the varying levels across countries. Since the middle of 2014, all yields except for Greece persist at a lower level than in 2007. To detect possible differences within both groups, Figure A2 and Figure A3 in the Appendix plot the yields of Core countries and Periphery countries, respectively. While the yields of Core countries are similar and follow the same (negative) trend, the yields of Periphery countries do not. The high peaks of Ireland, Greece and Portugal explain its high standard deviations of more than 2 percentage points (cf. Table A2). In contrast, Italy and Spain only exceed the 6%-threshold marginally in 2012. The figures indicate that the data seems to be non-stationary. An augmented Dickey-Fuller test shows that all variables are inte-

[7] The website https://www.investing.com/rates-bonds/european-government-bonds provides an illustrative overview of European bonds with different maturities. The live data demonstrate frequently changing yields where bonds with a larger maturity typically have a larger volume and are more frequently traded. Note that applying a two-day event window does not change the results but the coefficients become smaller, most probably due to the contamination with other news. This further underpins the use of a one-day event window.

[8] Belgium with values close to the threshold lies somewhere between these groups and could also belong to Periphery countries, for example if one decides for a maximum of 5% for Core countries.

grated of order 1.[9] Taking first-differences makes them stationary. Furthermore, it guarantees comparability of various bond yields and control variables. Robust standard errors according to the Newey-West methodology are applied to treat heteroscedasticity and autocorrelation.[10]

3 Results

This section presents the results of (i) the baseline specification, (ii) an extended case of program-specific effects and (iii) a panel analysis. For each of these specifications, the immediate effects, that is the effects on the announcement day itself, are investigated first. In turn, all specifications are analyzed with a delay of one day. The delay is motivated by the argument that investors might take some time to digest the new information and react accordingly. Another reason might be transactional frictions.

3.1 Baseline specification

Table 1 shows the results of the baseline specification defined in Equation (1) assuming immediate (same-day) effects. The announcements do not seem to influence the yields (negatively) at all. Counterintuitively, even a significantly positive effect for the German and French bonds shows up. Two possible explanations emerge. Either government bond markets do not respond at all to such announcements or, which seems more plausible, there is a delayed reaction to be tested and discussed below.

The yield changes of the previous day are determining those of the actual day for all bonds as the positive significant estimators of the lagged yield change show. There is also a significantly positive effect of the CESI on most yields.

Surprisingly, the national stock market influences the yields of Core countries positively while it affects the yields of Periphery countries negatively, though the absolute size of the effect is rather small. A positive development in a national stock market implies a higher trust level of the investors in the respective economy. This should reduce a country's risk-premium, which, in turn, reduces its government bond yield. Hence, the analysis confirms the expected reducing effect merely for Periphery countries. As a result, the mechanism that rising stock

[9] One might argue that interest rate time series have to be stationary by definition since they do not have a long-term growth trend such as GDP or debts. However, the time span of ten years might be too short as it reveals a negative trend.

[10] More specifically, the Bartled Kernel with $T^{\frac{1}{3}}$ as number of maximum lags is used. Applying the regressions using normal standard errors is not appropriate. The Breusch-Godfrey test indicates autocorrelation while the White test signals heteroscedastic error terms for all countries under consideration.

Table 1: Immediate effects of ECB announcements on 10-year government bond yields

	Δy_{t-1}	$\Delta stock_t$	$\Delta CESI_t$	$\Delta exch_t$	APA_t
Δy_{DE}	0.0828***	0.000161***	0.000441***	0.667***	0.0306**
Δy_{FR}	0.0642***	0.000209***	0.000574***	0.167	0.0291**
Δy_{NL}	0.0791***	0.00297***	0.000497***	0.457***	0.0219
Δy_{AU}	0.0829***	0.000287***	0.000600***	0.112	0.0154
Δy_{FI}	0.0644***	0.000139***	0.000484***	0.502***	0.0156
Δy_{BE}	0.191***	0.000185***	0.000511***	-0.176	0.00891
Δy_{ES}	0.205***	-5.23e-05***	0.000625***	-0.900***	-0.0446
Δy_{IT}	0.102***	-3.38e-05***	0.000520***	-0.723***	-0.0298
Δy_{IR}	0.232***	1.10E-05	0.000644**	-0.932***	-0.0347
Δy_{GR}	0.0960**	-0.00121***	0.00137	-2.459*	-0.167
Δy_{PT}	0.242***	-0.000212***	0.000429	-0.992***	-0.0543

Note: 2,782 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Constant omitted. The horizontal middle line separates Core countries (above) and Periphery countries (below). Sample period: January 1, 2007 to August 31, 2017.

prices reduce government bond yields is not empirically valid for all countries.

Indeed, one observes the opposite of the expected effect for Core countries. The different effects induced by the stock markets might be due to the fact that a positive development of the stock market in a stressed economy is perceived as a signal that also the state will be better off. The demand for those bonds rise so that the government can reduce the offered interest. In contrast, investors already have a positive perception of solvent countries so that a movement in the stock market does not change the trust level. In consequence, the positive effect on the government bond yield can be induced by a portfolio change: Investors switch from Core countries to Periphery countries, which explains the opposing signs during an increase in the stock market. It is likely that European stock indices develop similarly according to a common trend so that the opposing effect is credible. The same logic applies to the reaction to the exchange rate because a stronger euro decreases the yield spread between both country groups.[11]

Table 2 shows the results of the baseline specification defined in Equation (1) but rather assumes a delayed announcement effect, meaning the dummy variable takes the value of 1 if the event took place the day before. The previously discussed results for the control variables persist. However, the coefficients of APA_t change substantially. 9 out of 11 countries display a significantly negative coefficient indicating a reduction of the yield. For instance, an ECB asset purchase program announcement made the previous day reduces the Dutch 10-year government bond

[11] An exception is Belgium with a negative though not significant estimator. As mentioned above, this bond could also adhere to Periphery countries under another threshold.

yield on the actual day by about 2 basis points (bps) on average.

Table 2: One-day delayed effects of ECB announcements on 10-year government bond yields

	Δy_{t-1}	$\Delta stock_t$	$\Delta CESI_t$	$\Delta exch_t$	APA_t
Δy_{DE}	0.0857***	0.000161***	0.000449***	0.664***	-0.0188**
Δy_{FR}	0.0677***	0.000210***	0.000584***	0.164	-0.0252***
Δy_{NL}	0.0815***	0.00298***	0.000504***	0.454***	-0.0195**
Δy_{AU}	0.0846***	0.000288***	0.000606***	0.11	-0.0185**
Δy_{FI}	0.0656***	0.000139***	0.000489***	0.500***	-0.0121
Δy_{BE}	0.193***	0.000186***	0.000521***	-0.177	-0.0333***
Δy_{ES}	0.202***	-5.30e-05***	0.000628***	-0.894***	-0.0243**
Δy_{IT}	0.100***	-3.39e-05***	0.000525***	-0.719***	-0.0306**
Δy_{IR}	0.232***	1.24E-05	0.000651***	-0.930***	-0.0366
Δy_{GR}	0.0954**	-0.00122***	0.00137	-2.443*	-0.0758**
Δy_{PT}	0.241***	-0.000214***	0.000436	-0.983***	-0.0414**

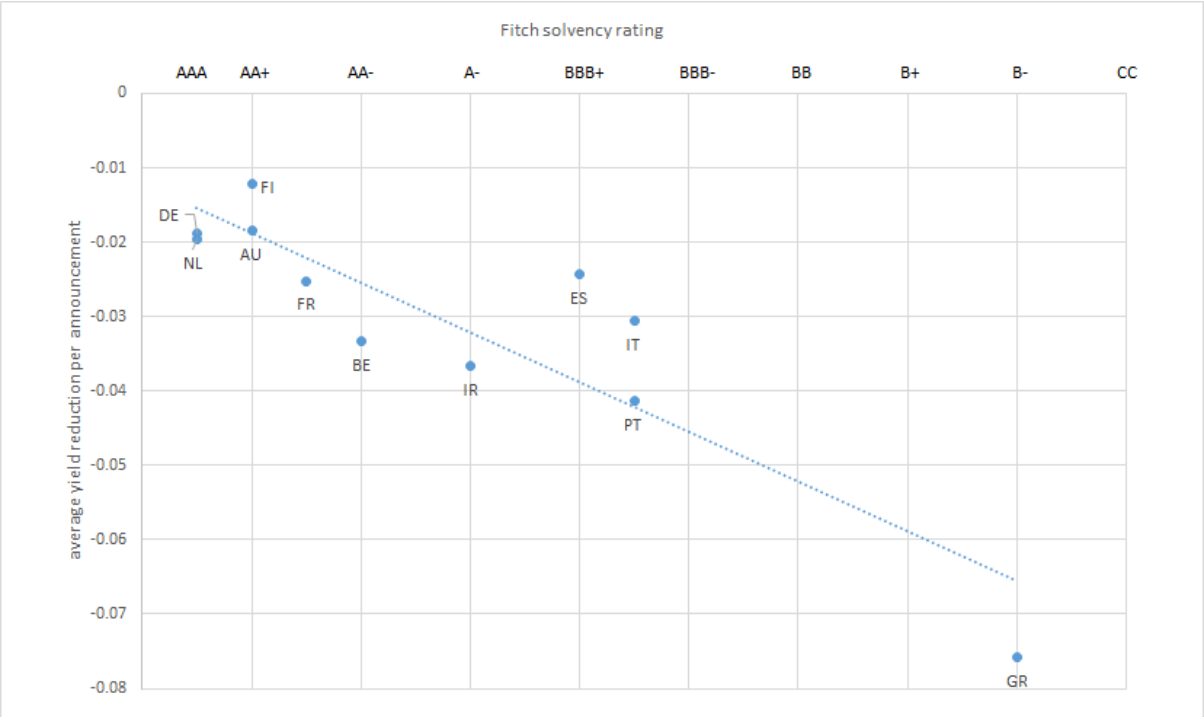
Note: 2,782 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Constant omitted. The horizontal middle line separates Core countries (above) and Periphery countries (below). Sample period: January 1, 2007 to August 31, 2017.

A remarkable difference of 5.7 bps can be observed between the Austrian and Greek coefficient (-0.0185 versus -0.0758). Hence, on average an announcement reduces the yield spread the most between those countries. In general, the extent of yield reduction seems inversely related to the solvency rating of the corresponding countries. In other words, a low rating reinforces the announcement effect. Figure 2 suggests a negative relationship between the announcement impact and the respective country's solvency rating. For instance, Spain with a BBB+ in the Fitch rating reacts stronger to an announcement than Austria that has an AA+ rating (2.4 versus 1.8 bps reduction in bond yields). This has important implications for policy making. While this feature currently leads to a convergence of euro area government bond yields it might cause problems in the future. One day the ECB has to initialize the way back to conventional measures if the price development in Europe approaches the 2% inflation aim. Announcements by the ECB in the opposite direction (for example a higher main refinancing rate, redemption of assets) might result in a divergence in yields and induce refinancing problems for Periphery countries.[12] This, in turn, can lead to a lower solvency rating which reinforces this mechanism.

Overall, the results confirm the expectation that ECB's asset purchase program announcements have a stronger effect on the bonds of Periphery countries. It is worth noting that impacts arise only one day after the announcement was made. This is a surprising finding as one would expect immediate reactions on the frequently trading financial markets. Two arguments might

[12] Although the ECB's mandate is limited to price stability it might also be interested in stable governmental budgets of its member countries. A similar fiscal situation across the euro area makes a common monetary policy more efficient.

Figure 2: Relationship between country's yield reduction and solvency rating



The trend line suggests the following relationship: $yield\ reduction = -0.012 - 0.0033 \cdot ranking$; $R^2 = 0.797$, t-values -3.0 and -5.9, respectively. For details on the ratings, see Table A3 in the Appendix. The Fitch rating is scaled as 1 unit per step, meaning AAA is represented by 1 while D translates to 21. A similar pattern emerges when using the Moody's or S&P rating.

explain the delayed effect.

First, it is helpful to differentiate bonds to other asset classes. While the equity market entails a higher risk and volatility the bond market has a relatively larger volume and it is less volatile. The trade with government bonds is more complex as maturity, coupon and ranking come into play. Government bonds are listed on markets like the Frankfurt stock exchange or the London stock exchange but not on electronic stock markets such as Xetra. They are mainly traded over the counter (OTC) and thus their transactions are less transparent than stocks. Hence, government bonds are less frequently traded than equities leading to a comparatively illiquid bond market.[13]

Second, large institutional investors such as pension funds typically trade government bonds. They have a long-term planning horizon and are unlikely to adjust their portfolio shortly in response to market news. Moreover, regulatory issues prevent them from doing so, for example a bank that holds government bonds as collateral needs to find a substitute before liquidation. Most importantly, the decision process on how to react to market news is likely to take longer

[13]In contrast to the bonds themselves, futures on bonds are more frequently traded, for example through Eurex. These assets should be more responsive to central bank announcements.

inside a large institution compared to a small investment trust or a private individual investor. After the portfolio management department interprets new information on the announcement day, the orders of buying/selling the bonds are likely to be carried out only on the subsequent day by the dealers. This implies predominantly dealers manually trade government bonds OTC on the trading floor – in contrast to automatic transactions on a centralized exchange triggered by computer algorithms. Consequently, government bonds are less quickly traded as opposed to equities which might lead to the observed one-day delayed effect.

A casual inspection of some announcement events in Figure A2 in the Appendix might suggest a reduction in yields taking place immediately before the announcement. One reason might be that market participants anticipate monetary policy decisions and react even before the actual announcement takes place. To test for this, the same regressions are carried out putting the dummy to the value of 1 on the working day before the events outlined in Table A1, and 0 otherwise. Note that the same analysis is carried out with a two-day delay, too, meaning the dummy variables take the value of 1 two days after the corresponding announcements to test for a slower reaction of market participants. The results for both alternative window settings (available upon request) do not indicate any impact on yields. Hence, when investigating announcement effects solely one-day delayed dummy variables produce significant results. Therefore, the focus will subsequently lie on the one-day delayed effects in the subsequent specifications.

One might argue that it is not adequate to treat each announcement event equally. ECB's asset purchase programs vary significantly in instrument, size, conditionality and duration. If the programs have different impacts, an aggregation of them could cancel out opposing effects. Therefore, each announcement is assigned to its corresponding asset purchase program in the following.

3.2 Program-specific effects

In order to test for program-specific effects Equation (1) changes to

$$\Delta y_t = \alpha + \beta_1 \Delta y_{t-1} + \beta_2 \Delta stock_t + \beta_3 \Delta CESI_t + \beta_4 \Delta exch_t + \sum_{j=1}^{6} \gamma_j APP_{j,t} + \varepsilon_t. \qquad (2)$$

The former dummy variable APA_t is replaced by six program-specific dummy variables $\sum_{j=1}^{6} \gamma_j APP_{j,t}$ representing a specific asset purchase program j, each taking the value of 1 in case of an event belonging to the specific program, and 0 otherwise. More specifically,

the model differentiates between (targeted) long term refinancing operations (TLTROs), the securities market programme (SMP), corporate sector purchase programme (CSPP), public sector purchase programme (PSPP), asset-backed securities purchase programme (ABSPP) and covered bond purchase programme (CBPP). They are expected to have a negative influence on yields ($\gamma_j < 0 \; \forall \; j = 1, ..., 6$). It is worth noting that the expanded asset purchase programme (EAPP) subsumes the last four mentioned programs which complicates the differentiation. Yet it is not possible to pool all events and classify them as EAPP because ABSPP and CBPP started before the introduction of EAPP. The classification of the events can be found in the second column of Table A1. In fact, TLTROs are not part of an official asset purchase program but as the emphasized events refer to supplementary purchases they cannot be classified as regular, either. They provide unexpectedly more liquidity to the market like the asset purchase programs and should induce the same announcement effects. Since half of the events overlap, a pure separation of the diverse programs is not feasible. The single effects cannot be distinguished perfectly impairing the program-specific analysis.

In addition, it is questionable whether the programs can be compared because the applied instruments differ. While CSPP refers to bonds of the private sector, PSPP is restricted to securities from states. Figure A4 in the Appendix juxtaposes the programs in terms of starting date, number of announcements and quantity. PSPP is by far the dominating program in size. Together with TLTRO it accounts for three quarters of overall asset purchases. SMP only has 2 events while the largest groups TLTRO, CBPP, ABSPP and PSPP include 10 events. Still these programs might not have sufficient data points considering the long examination period. Accordingly the results should be interpreted with caution.

Table 3 shows the results of the program-specific specification defined in Equation (2) assuming one-day delayed effects. Distinguishing between the different programs reveals a mixed result. Investors indeed seem to be sensible to the type of program announcement.

On the one hand, ABSPP and TLTRO both show significantly negative estimators for most bonds. For instance, an ECB announcement relating to the ABSPP the previous day reduces the Spanish 10-year government bond yield this day by 5.6 bps while an announcement relating to TLTRO decreases that yield by 4.3 bps on average.

On the other hand, CBPP announcements seem to have the opposite effect leading to an increase in yields for most countries, up to 10.3 bps in case of Greece. Moreover, it is astonishing

Table 3: One-day delayed effects of program-specific ECB announcements on 10-year government bond yields

Country	ABSPP	CSPP	CBPP	PSPP	TLTRO	SMP
Δy_{DE}	-0.0401***	-0.00455	0.0515***	-0.0156	-0.0338***	0.0135*
Δy_{FR}	-0.0223	-0.0192	0.0404*	-0.00928	-0.0560***	0.0528***
Δy_{NL}	-0.0383***	-0.0204	0.0489***	-0.00471	-0.0362***	0.0339***
Δy_{AU}	-0.0459***	-0.00736	0.0431***	0.00351	-0.0403***	0.0242**
Δy_{FI}	-0.0490***	0.0103	0.0437***	-0.00999	-0.0303*	0.0371***
Δy_{BE}	-0.0302	0.00969	0.0135	-0.00462	-0.0482***	-0.00274
Δy_{ES}	-0.0563*	0.0333	0.0285	-0.0215	-0.0434**	0.0777***
Δy_{IT}	-0.0584	0.00559	0.0630**	-0.0238	-0.0515***	-0.000282
Δy_{IR}	-0.0607**	0.0431	0.0151	-0.0047	-0.00594	-0.177
Δy_{GR}	-0.150***	0.069	0.103***	-0.023	-0.160***	0.0218
Δy_{PT}	-0.0314	-0.0176	0.0453	-0.0218	-0.039	-0.0918

Note: 2,782 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Δy_{t-1}, $\Delta stock_t$, $\Delta CESI_t$, $\Delta exch_t$ and constant omitted. The horizontal middle line separates Core countries (above) and Periphery countries (below). Sample period: January 1, 2007 to August 31, 2017.

why the yields of Core Countries and Spain are positively affected by SMP announcements. The portfolio change does not seem to apply because countries of both groups are affected.

In contrast, neither of the yields is responsive to CSPP and PSPP announcements. This is a counterintuitive finding because PSPP is by far the program with the largest asset purchase volume. The apparent differences might be caused by EAPP announcements. The EAPP includes programs that have at the same time significantly positive (CBPP) and negative impacts (ABSPP) as well as non-significant impacts (PSPP, CSPP). Hence, as EAPP announcements foster all of those programs it is not clear in which direction such an announcement influences bond yields. This problem will likely persist in the future because recent announcements belong to this program.

Additionally, Table A4 in the Appendix presents the results of the program-specific specification defined in Equation (2) assuming same-day effects. Distinguishing the different programs gives little insights. A noticeable result is the substantial reduction of 63.8 and 53.6 bps in the yields of Spain and Italy by the SMP announcement. This reduction is most probably in response to the justification of the SMP on August 7, 2011. Overall, out of the announcements of six different programs, two programs influence some yields positively, two negatively and two not at all. The different results for programs, especially the opposite signs, question whether it is reasonable to include all events in one dummy as a general ECB's asset purchase program announcement.

Both the baseline specification and the case of program-specific effects indicate a similar

reaction of the countries' yields to asset purchase announcements, albeit there is a difference in the extent between Core countries and Periphery countries. Next, the analysis is enhanced by pooling the countries in a panel framework.

3.3 Panel analysis

When evaluating monetary policy measures it is helpful to analyze the effects on solvent versus less solvent countries separately. Therefore, three panel regressions are carried out: one for the aggregate case of all 11 euro area countries under consideration (labeled 'Euro countries' in the following) and one for Core countries and Periphery countries as group-wise panels, respectively. The former searches for a Europe-wide effect, while the latter analyzes group-specific effects of the asset purchase announcements. Equation (1) changes to

$$\Delta y_{i,t} = \alpha + \beta_1 \Delta y_{i,t-1} + \beta_2 \Delta stock_{i,t} + \beta_3 \Delta CESI_t + \beta_4 \Delta exch_t + \gamma APA_t + \mu_i + \varepsilon_{i,t} \quad (3)$$

while Equation (2) accordingly becomes

$$\Delta y_{i,t} = \alpha + \beta_1 \Delta y_{i,t-1} + \beta_2 \Delta stock_{i,t} + \beta_3 \Delta CESI_t + \beta_4 \Delta exch_t + \sum_{j=1}^{6} \gamma_j APP_{j,t} + \mu_i + \varepsilon_{i,t}, \quad (4)$$

where $i = 1, ..., 11$ denotes a specific country and μ_i describes the country-specific fixed effect in the panel regressions. A fixed effects instead of random effects model is chosen because this specification does not need to assume conditional mean independence between country-specific effects and dependent variables across all periods. In any case the difference between both estimators is asymptotically equivalent for large T. Note that time-specific effects are not applicable since the dummy variables already control for events taking place at a certain point of time. Employing the test proposed by Levin et al. (2002) indicates that the panel time series are integrated of order 1 justifying first-difference transformation for the panel specification, too. One might argue that the lagged dependent variable $\Delta y_{i,t-1}$ causes an endogeneity problem. However, Nickell (1981) shows that the bias is of order $\frac{1}{T}$, which is negligible for the present long panel with 2784 observations for each of the 11 yields.[14]

Table 4 shows the results of the panel specifications defined in Equation (3) and Equation (4) for each of the three groupings assuming one-day delayed effects. The results for the control

[14]Note that the results remain robust when omitting $\Delta y_{i,t-1}$ underscoring the slim extent of the Nickell bias. Similarly, a GMM estimator produces identical results.

variables remain the same. As above, the lagged dependent variable and CESI both show highly significant and positive estimators. Also, Core countries and Periphery Countries possess opposite stock market and exchange rate effects. Similarly, both the general and the program-specific announcement effects are similar in all panel groups.

Table 4: Panel Regression one-day delayed effects

	11 Euro countries		6 Core countries		5 Periphery countries	
specification	(3)	(4)	(3)	(4)	(3)	(4)
Δy_{t-1}	0.104***	0.104***	0.101***	0.100***	0.104***	0.104***
$\Delta stock_t$	-2.30E-05	-2.31E-05	0.000171***	0.000170***	-5.18e-05*	-5.20e-05*
$\Delta exch_t$	-0.374	-0.391	0.336*	0.328*	-1.384**	-1.413**
$\Delta CESI_t$	0.000642***	0.000631***	0.000523***	0.000515***	0.000764***	0.000751***
ABSPP		-0.0576***		-0.0381***		-0.0788**
CSPP		0.0159		-0.00375		0.0355
CBPP		0.0442***		0.0399***		0.0515**
PSPP		-0.0113**		-0.00617*		-0.0221**
TLTRO		-0.0497***		-0.0409***		-0.0607*
SMP		-0.0164		0.0247**		-0.0723
APA_t	-0.0309***		-0.0210***		-0.0448***	
R^2	0.012	0.012	0.096	0.099	0.014	0.014

Note: 30,602 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Constant omitted. Sample period: January 1, 2007 to August 31, 2017.

An announcement taking place this day reduces next day's yield significantly for all country groups. The average general reducing effect is 3.1 bps for Euro countries while it is only 2.1 points for Core countries in contrast to Periphery countries with 4.5 bps. Accordingly, the extent is higher in Periphery countries for each program. For instance, an ABSPP announcement reduces the yield of Core countries by 3.8 bps whereas it reduces that of Periphery countries by 7.9 bps on average. Hence, stressed countries are more sensible to announcements than countries that are more solvent. The only difference to the previous findings is that in the panel specifications PSPP produces significantly negative estimators while SMP is not significant anymore. The latter is most likely because SMP was designed for Italy and Spain. Pooling with other economies dilutes the country-specific effects.

Table A5 in the Appendix shows the results of the panel specifications of Equation (3) and Equation (4) assuming same-day effects. While the aggregate effect of announcements is not significant in Euro countries, a significant and positive one appears for Core countries and a significant and negative one for Periphery countries. Hence, the panel analyses suggest an immediate spread reducing effect: An ECB's announcement increases Core countries' yields while it decreases Periphery countries' yields at the same time. More precisely, it increases the yields of Core countries by 2.1 bps and decreases those of Periphery countries by 6.9 bps on

average.

The results justify the separation of euro area economies into two groups. The surprising increase of Core countries' yields can potentially be explained by investors who demand a higher risk premium for the yields of those countries that mainly have to finance and guarantee for the asset purchase programs. Hence, while Euro countries confirm the previous findings, the other groups reveal immediate effects in the panel framework. Regarding the specific program announcements only Core Countries are affected by CSPP, CBPP, PSPP and TLTRO. In contrast, the negative influence by SMP is induced by Periphery countries confirming the findings in Table A4. A striking observation are the highly significant and negative estimators of ABSPP which are not significant for any country in the baseline specification (cf. Table A4).

In sum, the results reveal a one-day delay of the government bond yield market in its reaction to ECB's asset purchase program announcements. This is astonishing because one would expect an immediate effect in the frequently trading financial markets, notably in the light of close price data used in the analysis. The observed delayed effect challenges event studies like Falagiarda and Reitz (2015) who neither detect anticipated nor delayed effects, and recent ones like Urbschat and Watzka (2017) that find significant effects for the euro area bond market only on the announcement day itself. In contrast to their findings, this paper does not suggest any immediate impacts.

The varying extent of the reducing yield effect among Core countries and Periphery countries is in line with the literature. The analysis suggests a general reducing effect on yields by an ECB's asset purchase announcement. It contributes to the literature by quantifying the reducing effect for each individual country. Additionally, one observes a rating: The better the solvency rating for a country, the lower is the reducing effect on the corresponding bond yield. It is not possible to claim consistent program-specific effects. This is most likely because of announcement days addressing several programs at the same time. The panel analysis justifies the separation of both country groups.[15] Nevertheless, the country-by-country analysis is more suitable because it allows to measure the impact on a particular economy.

[15]Note that the results are robust to assigning Belgium to Periphery Countries.

4 Robustness checks

Several robustness checks are considered to challenge the previous findings. First, the choice of events is modified in different ways. Second, alternative variables are implemented. The results of the subsequent robustness checks are not explicitly displayed for the sake of parsimony but available upon request.

4.1 Choice of events

Excluding TLTRO: One might argue that the TLTROs are part of conventional monetary policy because they are very close to the conventional LTRO. Therefore, the regression is carried out without the announcements denoted with TLTRO in Table A1. Hence, 18 events remain and the time span starts from 2009 as there are not other types of events before.

In fact, while dropping these 5 (pure) TLTRO events in question the results for the immediate case persist. In contrast, a striking difference can be found in the delayed case where only the yields of Core countries have significantly negative estimators. This is contrary to the argument of shrinking spreads in response to announcements. This implies that TLTRO announcements are crucial for the reducing effect in stressed economies. Hence, it is reasonable to keep TLTRO events in the analysis. The panel analysis is not responsive to this modification for both same-day and delayed effects.

Considering each event separately: Several studies consider each event separately by using one dummy for every single announcement (e.g. Falagiarda and Reitz (2015), Ambler and Rumler (2017)). Therefore, this methodology is adopted as a robustness check. The results for the separate and panel case are similar. All event dates' coefficients are highly significant but the results are not interpretable. This is due to the utilization of Newey-West standard errors. Fomby and Murfin (2005) explain this issue with econometric terms. Arbitrarily selected event dates all seem to be highly significant even without any specific event happening at the chosen event because heteroscedastic and autocorrelation robust standard errors' t-statistics are spuriously identified. Ford et al. (2010) demonstrate this problem in a financial event study.

Initial events only: The alternative choice of only the 6 initial events of each program tests for the hypothesis of diminishing effects. These pivotal events should show the strongest effects. This approach assumes that repeating announcements do not provide new information. In consequence, investors do not amend their choices because there is not any surprise in these

announcements. An advantage of this approach is that every program is weighed equally using its first announcement only. By construction a distinction between the programs cannot be made as an analysis considering each event separately is not feasible as discussed in the previous paragraph.

Only the yields of Germany, the Netherlands and Finland are positively affected by announcements in the immediate case. This is supported by the panel regression showing a positive impact for Core countries. Therefore, the initial effects are the main drivers for the result obtained for the panel regressions assuming immediate effects.

For the delayed case, the negative impact is only significant for Core countries while Periphery countries are not affected by initial announcements. The issue that Periphery countries do not react to the announcement events is puzzling, especially considering a negative impact on yields for both groups in the panel regressions. One explanation could be that investors need additional confirmation to change their perception on Periphery countries. On the initial announcement day they are still skeptical about future development. After a confirming announcement they trust the policy change and adopt their expectations accordingly. Consequently, the results highlight that repeated announcements do matter.

Including events of technical details: Technical details of the asset purchase programs are announced by the ECB regularly. Investors should not react to these announcements as they do not change the situation on financial markets substantially. To test for this hypothesis, events regarding details of the programs are added. Table A1 lists all relevant 69 events; TLTRO is the dominating program.

For the immediate case, the yields of Germany and the Netherlands have positive and significant estimators while for the delayed case there are significantly negative estimators for countries mainly adhering to Periphery countries (Austria, Belgium, Spain, Italy, Ireland, Portugal). This is in line with the previous findings stating little immediate but substantial delayed negative effects. Regarding the program-specific effects, the results are almost identical, only in the immediate case CSPP is now significant instead of TLTRO.

Overall, adding events that provide technical details does not change the results. Put differently, they are not relevant and can be omitted. The persisting panel results support this hypothesis. However, it is worth noting that when considering all 69 events, Core countries do not seem to be impacted any more.

Random selection: One might argue that the significant impact of the 23 chosen events is just a statistical coincidence. Therefore, iteratively 23 events are randomly drawn from the data sample and employed in the analysis. Even after 30 iterations the results clearly indicate that there is no impact of any randomly chosen event set on government bond yields. Similarly, to control for reactions to monetary policy announcements independent of its content, 23 dates are randomly drawn from the 132 monetary policy press releases made by the ECB during the observation period and from the 69 ECB announcements listed in Table A1, respectively. They do not produce any significant results, either. Hence, a monetary press release per se does not affect government bond yields. This underlines the appropriateness of the chosen events.

The previous robustness checks demonstrate that the number of events is crucial to the results. In general, a trade-off exists: Taking few events (initial events, no TLTRO) makes the estimators of Core countries significant while those of Periphery countries become insignificant. In contrast, employing lots of events (technical details) makes the estimators of Periphery countries significant while those of Core countries become insignificant. One should bear in mind this sensitivity when comparing the findings with other studies. After all the best way is to find economic arguments why to include the events ignoring the total number of chosen events. It has been decided to keep the baseline scenario of 23 events outlined in Section 2 as a middle way. It generates an economically meaningful result showing that both country groups are impacted by asset purchase program announcements – just the extent differs.

4.2 Choice of variables

Effect on stock markets: One might argue that monetary policy announcements directly affect the stock market.[16] If this is true, the application of both APA_t and $\Delta stock_t$ as independent variables is not feasible. To test for it, the country-specific stock market indices are taken as dependent variable. Hence, Δy_t is replaced by $\Delta stock_t$ in Equations (1) and (2). Likewise, $\Delta y_{i,t}$ is replaced by $\Delta stock_{i,t}$ in Equations (3) and (4).

The results demonstrate that ECB's announcements neither have an immediate nor a delayed direct effect on none of the stock market indices. Hence, the choice of $\Delta stock_{i,t}$ as independent variable is appropriate. The announcements only have an indirect effect on the stock markets in the medium-term as higher liquidity induces rising asset prices.

[16] Lyócsa et al. (2017) find that quantitative easing announcements increase stock market volatility in the US, Canada, Japan and euro area while Lee et al. (2016) analyze the effects of monetary policy announcements of the Bank of Korea on stock market liquidity.

Yield spreads as dependent variable: Following Jäger and Grigoriadis (2017) the spread is calculated with the help of the euro swap rate in order to be able to keep the German government bond yields. Using the spread as dependent variable instead of the level the results and hence the conclusions remain the same. Put differently, the study confirms the spread reducing effects worked out in related literature.

Variables in growth rates: Growth rates might be better suitable to compare yield dynamics of the various countries. First-differences only take the absolute differences into account independent of the level in the respective country. For instance, Periphery countries typically state higher absolute changes in yields than Core countries due to its higher yield level. In contrast, if one considers growth rates instead one corrects for this shortcoming by dividing by the absolute level. This might weaken the observed differences among the countries.

When using growth rates variables the results assuming immediate effects only change in the way that the control variables get insignificant. For the one-day delayed effects, however, the estimators of APA_t for Germany, the Netherland and Finland become insignificant. In consequence, the estimator of APA_t becomes insignificant for Core countries in the panel specification. In addition, the coefficients of APA_t for Periphery countries are lower than those of France, Austria, and Belgium. Hence, the utilization of growth rates instead of first-differences relativizes the previously found differences between both country groups. Nevertheless, the first-difference analysis is more suitable for policy analysis because it provides the absolute changes in yields. These are more relevant for the countries because they correspond to the overall short-term costs/benefits of a euro area government's refinancing conditions in response to an ECB's asset purchase announcement. Moreover, investors are more interested in the absolute yield changes that represent actual profits/losses than in an abstract growth number.

Choice of control variables: If one uses the MSCI Europe Index instead of CESI the results persist. The results do not change, either, when adding the iTraxx Europe index to depict the investors' preference for risk. Similarly, the results hold employing the surprise and uncertainty indices developed by Scotti (2016).

In sum, when employing different data as control variables, the results remain unchanged for a given event set. Thus, we are quite confident with the results.

5 Conclusion

This study evaluates short-term effects of ECB's asset purchase program announcements on 10-year government bond yields from January 1, 2007 to August 31, 2017. It distinguishes between more solvent countries (Austria, Belgium, Finland, France, Germany, the Netherlands) and less solvent ones (Greece, Ireland, Italy, Portugal, Spain). The general and program-specific effects are evaluated by considering key announcement events.

The contribution to the literature is twofold. First, this event study is the first to find that the effects of ECB's asset purchase announcements on government bond yields arise with a one-day delay. This means the government bond market takes some time to react to central bank announcements. This is astonishing because one would expect an immediate effect in the frequently trading financial markets, notably in the light of close price data used in the analysis. A reason for the delay might be the locus of transactions and agents who trade: institutional investors trade government bonds OTC on trading floors. In the light of this delay working with daily data seems appropriate to assess announcement effects on the bond markets. The use of more frequent data such as hours or minutes intervals is not likely to give additional insights in future research.

Second, the study quantifies different degrees of investors' reaction across the countries under consideration. The same announcement triggers varying expectations according to a specific economy. In this way, the ECB can observe the perception of its announcements in different markets. This is an important aspect for the ECB when deciding on a common monetary policy. More specifically, the extent of yield reduction seems inversely related to the solvency rating of the corresponding country. This implies that those countries suffering most from investors' skepticism profited most in terms of yield reductions. The varying extent of the reducing yield effect among Core countries and Periphery countries is in line with recent literature (e.g. Urbschat and Watzka (2017), Bulligan and Monache (2018)) but gives additional insights. The reduction of the spread is due to a stronger fall in the yields of the less solvent countries compared to the more solvent countries' bond yields in reaction to an ECB's asset purchase announcement. It underlines that the risk premium is higher for Periphery countries while there is not much leeway in risk premium reduction for Core countries. This means all yields react the same way and only the extent differs. Hence, the announcements lead to a convergence of government bond yields that is in the interest of a central bank responsible for

several economies. The panel analysis confirms the separation of both country groups.

Mixed results for program-specific announcements lead to an ambiguous conclusion. The analysis suggests a general reducing effect on yields by an ECB's asset purchase program announcement. However, it is not possible to claim consistent program-specific effects. Only ABSPP and TLTRO work in the expected direction. Counterintuitively, SMP and CBPP announcements even show positive effects on some countries' yields while PSPP and CSPP announcements have no influence. Hence, investors seem to be sensible to the type of program announcement. The panel analysis results confirm the findings. However, several programs are mentioned concomitantly on half of the event dates which impairs the program-specific analysis.

The study proves that the quantitative effect of asset purchase announcements depends on the number of chosen events. Employing different data as control variables, the results are robust for a given event set. Overall, the study provides evidence that one has to differentiate the effects of asset purchase program announcements by the ECB on its member countries. Although the ECB's aim is to target an aggregate European market, subsequent studies should keep in mind that its actions potentially have differing effects in national markets. Finally, it would be interesting to see if the reverse effect can be detected in the hypothetic case of asset redemption announcements in the future or the exit from the unconventional monetary policy in general.

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Appendix

Table A1: Overview of ECB's program announcements

Announcement date	**Program**	**measure/statement**
July 20, 2017	EAPP	*Repetition*/confirmation of decided measures.
June 8, 2017	EAPP	*Repetition*/confirmation of decided measures.
April 27, 2017	EAPP	*Repetition*/confirmation of decided measures.
January 19, 2017	EAPP details	ECB provides further details on EAPP purchases of assets with yields below the deposit facility rate; GovC confirms that it will continue to make purchases under the asset purchase programme (EAPP) at the current monthly pace of €80 billion until the end of March 2017 and that, *from April 2017, the net asset purchases are intended to continue at a monthly pace of €60 billion until the end of December 2017, or beyond*, if necessary, and in any case until the GovC sees a sustained adjustment in the path of inflation consistent with its inflation aim.
December 15, 2016	ABSPP	Eurosystem to *take up all asset management tasks in the ABSPP from 1 April 2017.*
December 8, 2016	PSPP, EAPP, TLTRO	Eurosystem introduces *cash collateral for PSPP securities* lending facilities; ECB adjusts parameters of its asset purchase programme; *GovC decided to continue its purchases under the asset purchase programme (EAPP) at the current monthly pace* of €80 billion until the end of March 2017. From April 2017, the net asset purchases are intended to *continue at a monthly pace of €60 billion until the end of December 2017.*
June 2, 2016	CSPP	ECB announces remaining details of the corporate sector purchase programme (CSPP)
June 1, 2016	CSPP	ECB decision about CSPP
May 3, 2016	TLTRO II	ECB publishes legal acts relating to the second series of targeted longer-term refinancing operations (TLTRO II)
April 21, 2016	CSPP	ECB announces details of the corporate sector purchase programme (CSPP)
March 10, 2016	TLTRO II, CSPP	ECB announces new series of targeted longer-term refinancing operations (TLTRO II); ECB adds corporate sector purchase programme (CSPP) to the asset purchase programme (EAPP) and announces changes to EAPP.
December 3, 2015	EAPP	*Extension EAPP* at least *until March 2017.*
September 10, 2015	ABSPP	Details implementation of ABSPP.
January 22, 2015	EAPP, ABSPP, CBPP3, TLTRO II	*ECB announces expanded asset purchase programme* (EAPP) including governments, agencies and European institutions, ABSPP and CBPP3: 'add the purchase of sovereign bonds to its existing private sector asset purchase programmes'
December 11, 2014	TLTRO	Amount allotted in the second TLTRO €129.84 billion
December 4, 2014	PSPP	Evidently we are convinced that a *QE programme* which could *include sovereign bonds* falls within our mandate. (M. Draghi)
November 26, 2014	PSPP	'we will have to consider buying other assets, including sovereign bonds in the secondary market' (V. Constâncio)
November 19, 2014	ABSPP	ECB's legal decision on ABSPP
November 17, 2014	PSPP	'The Governing Councel is unanimous in its commitment to using additional unconventional instruments [...] *Unconventional measures might entail* the purchase of a variety of assets, one of which is *sovereign bonds.*'
November 7, 2014	TLTRO	ECB suspends early repayments of the three-year TLTROs during the year-end period
October 15, 2014	CBPP3	ECB's legal decision on CBPP3
October 2, 2014	CBPP3, ABSPP	The ECB announces operational details of asset-backed securities and covered bond purchase programmes
September 18, 2014	TLTRO	ECB allots €82.6 billion in first targeted longer-term refinancing operation
September 4, 2014	CBPP3, ABSPP	*ABS purchase programme (ABSPP) announced, CBPP3 announced.*
July 29, 2014	TLRTO	ECB publishes legal act relating to targeted longer-term refinancing operations
July 3, 2014	TLTRO	details on TLTRO
June 5, 2014	TLTRO, ABSPP	ECB announces monetary policy measures to enhance the functioning of the monetary policy transmission mechanism: *targeted LTROs* (TLTORs) and *asset backet securites* (ABS)
November 22, 2013	TLTRO	ECB suspends early repayments of the three-year TLTROs during the year-end period
November 8, 2013	TLTRO	The GovC decided to continue to conduct its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
May 2, 2013	TLTRO	The GovC has decided to conduct the three-month longer-term refinancing operations (TLTROs) as fixed rate tender procedures with full allotment.
February 21, 2013	SMP	The GovC decided to publish the Eurosystem's holdings of securities acquired under the Securities Markets Programme (SMP)
December 6, 2012	TLTRO	The GovC decided to continue conducting its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
October 31, 2012	CBPP2	Termination of CBBP2
September 6, 2012	SMP	Termination of SMP
June 6, 2012	TLTRO	The GovC decided to continue to conduct its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
February 29, 2012	TLTRO	Amount allotted in the second three-year TLTRO €529.53bn
December 21, 2011	TLTRO	Amount allotted in the first three-year TLTROs €489.19bn
December 8, 2011	TLTRO	ECB announces measures to support bank lending and money market activity: expansion of eligible collateral and *3-year TLTROs*
December 1, 2011	TLTRO	Rumours on 3-year TLTRO come up due to Draghis words
November 3, 2011	CBPPs	Details on CBPP2 and legal implementation
October 25, 2011	TLTRO	First allotment of 36-month TLTRO

Table A1: Overview of ECB's program announcements (continued)

Announcement date	Program	measure/statement
October 6, 2011	CBPP2, TLTRO	Details of refinancing operations, ECB announces *new covered bond purchase programme* (CBPP2) and two *12-month TLTROs*
August 7, 2011	SMP	*Securities Markets Programme*: Statement by the ECB president to *justify the program* (Italy and Spain)
August 4, 2011	TLTRO	The GovC decided to continue to conduct its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
June 9, 2011	TLTRO	The GovC decided to continue to conduct its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
March 3, 2011	TLTRO	Fixed Rate Full Allotment Refinancing Operations details
December 2, 2010	TLTRO	The GovC decided to continue to conduct its MROs as FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
September 2, 2010	TLTRO	The GovC decided to continue to conduct its MROs as full rate tenders with full allotment) FRTPFA for as long as necessary, and to conduct 3-month TLTROs as FRTPFA
June 30, 2010	CBPP1	CBPP1 terminated
May 14, 2010	SMP	legal declaration of SMP
May 10, 2010	SMP, TLTRO	ECB decides on measures to address severe tensions in financial markets: continue TLTROs and *start of securities market programme* (SMP)
March 4, 2010	TLTRO	Details and enhancement of TLTRO provisions
December 15, 2009	TLTRO	Amount allotted in third one year TLTRO € 96.93bn
December 3, 2009	TLTRO	details and enhancement of TLTRO provisions
September 29, 2009	TLTRO	Amount allotted in second one year TLTRO € 75.24bn
July 2, 2009	CBPP1	Details CBPP1: legal declaration
June 23, 2009	TLTRO	Amount allotted in first one year TLTRO 442.24bn
June 4, 2009	CBPP1	Details CBPP1: amount of 60 billion €
May 7, 2009	CBPP1/TLTRO	Announcement of 3 *supplementary liquidity-providing longer-term refinancing operations* (TLTROs) with a maturity of one year, purchase of *euro-denominated covered bonds* issued in the euro area and prolongation until the end of 2010 the temporary expansion of the list of eligible assets, announced on 15 October 2008.
March 5, 2009	TLTRO	decided to continue the fixed rate tender procedure with full allotment for all [...] supplementary and regular longer-term refinancing operations for as long as needed, and in any case beyond the end of 2009.
October 15, 2008	TLTRO	Renewal and *adding of TLTROs, STRO, STLTRO*
October 7, 2008	TLTRO	Increase of the allotment amount in the six-month supplementary longer-term refinancing operation that was pre-announced in the press release of 4 September 2008 from EUR 25 billion to EUR 50 billion.
September 4, 2008	TLTRO	Renewal of the outstanding six-month supplementary longer-term refinancing operation (TLTRO) of € 25 billion that was allotted on 2 April, and that will mature on 9 October 2008. Renewal of the two threemonth supplementary TLTROs (€ 50 billion each).
July 31, 2008	TLTRO	renewal of the two three month supplementary TLTROs carried out through variable rate tenders, each with a preset amount of EUR 60 billion
March 28, 2008	TLTRO	2 *supplementary* six-month longer-term refinancing operations (each 25 billion €) and continuation of the 2 supplementary three-month longer-term refinancing operations (each 50 billion €)
February 7, 2008	TLTRO	renewal of the two supplementary TLTROs carried out through variable rate tenders, each with a preset amount of € 60 billion.
November 8, 2007	TLTRO	renewal of the two supplementary TLTROs carried out through variable rate tenders, each with a preset amount of € 60 billion.
September 6, 2007	TLTRO	*supplementary* liquidity-providing longer-term refinancing operation with a maturity of three months (no preset allotment amount)
August 22, 2007	TLTRO	*supplementary* liquidity-providing longer-term refinancing operation with a maturity of three months for an amount of € 40 billion

Source: https://www.ecb.europa.eu/press/pr/date/2017/html/index.en.html. The 23 baseline events are denoted in **bold** and its key statements are denoted in *italics*.

Table A2: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Datastream mnemonic
y_{DE}	2.077094	1.401357	-0.2158	4.6709	BDBRYLD
y_{ES}	3.724737	1.511228	0.9506	7.59	ESBRYLD
y_{IT}	3.737538	1.387554	1.0488	7.288	ITBRYLD
y_{IR}	4.07029	2.608185	0.3262	13.895	IRBRYLD
y_{GR}	10.03045	7.105	4.0855	48.602	GRBRYLD
y_{PT}	5.33587	2.787902	1.3682	16.211	PTBRYLD
y_{FR}	2.507666	1.32649	0.0967	4.8391	FRBRYLD
y_{BE}	2.73687	1.4667	0.1027	5.843	BGBRYLD
y_{NL}	2.330448	1.407129	-0.028	4.8434	NLBRYLD
y_{AU}	2.45217	1.427796	0.0517	4.868	OEBRYLD
y_{FI}	2.309453	1.410364	-0.0149	4.8512	FNBRYLD
$stock_{DE}$	8013.626	2173.922	3666.41	12888.95	DAXINDX
$stock_{ES}$	10284.56	2062.054	5956.3	15945.7	IBEX35I
$stock_{IT}$	22089.05	7367.602	12362.51	44364.41	FTSEMIB
$stock_{IR}$	4781.496	1953.51	1916.38	9981.08	ISEQUIT
$stock_{GR}$	1686.286	1346.435	440.88	5334.5	GRAGENL
$stock_{PT}$	7001.23	2320.455	4260.13	13702	POPSI20
$stock_{FR}$	4222.391	781.9079	2519.29	6168.15	FRCAC40
$stock_{BE}$	3032.488	733.1538	1527.27	4756.82	BGBEL20
$stock_{NL}$	393.0323	83.52945	199.25	561.9	AMSTEOE
$stock_{AU}$	2699.998	789.9755	1411.95	4981.87	ATXINDX
$stock_{FI}$	7600.459	1765.335	4110.31	12656.77	HEXINDX
$CESI$	2.225647	54.81031	-188.6	149.4	EKCESIR
$exch$	1.298318	0.1317633	1.0364	1.599	USECBSP
Euro Swap	2.439488	1.400558	0.241	5.107	ICEIB10
iTraxx Europe	117.9609	33.63895	39.5	219.75	DIXETMC
MSCI Europe	1542.793	271.3635	794.232	2235.356	MSEROP$
surprise	-0.0510734	0.3513932	-1.439006	0.9654292	from Scotti (2016)
uncertainty	0.986725	0.32734	0.3628792	2.165764	from Scotti (2016)

Note: 2,784 daily observations per variable. Yields are benchmark return indices and displayed in per cent.

Table A3: Euro area member solvency ratings

Country	Coefficient	Fitch	S&P	Moody's
FI	-0.0121	AA+	AA+	Aa1
AU	-0.0185**	AAA	AAA	Aa1
DE	-0.0188**	AA+	AA+	Aaa
NL	-0.0195**	AAA	AAA	Aaa
ES	-0.0243**	BBB+	BBB+	Baa2
FR	-0.0252***	AA	AA	Aa2
IT	-0.0306**	BBB	BBB	Baa2
BE	-0.0333***	AA-	AA	Aa3
IR	-0.0366	A	A+	A2
PT	-0.0414**	BBB	BB+	Ba1
GR	-0.0758**	B-	B-	Caa2

Note: Rating according to Börsen-Zeitung (2018). Effective January 2018.

Table A4: Immediate effects of program-specific ECB announcements on 10-year government bond yields

Country	ABSPP	CSPP	CBPP	PSPP	TLTRO	SMP
Δy_{DE}	0.0322	0.0205	0.0493*	-0.0114	0.0243	0.0415
Δy_{FR}	-0.0464	0.04	0.0386	-0.0106	0.0303	-0.00551
Δy_{NL}	-0.0401	0.0318	0.0502*	-0.015	0.0122	-0.0155
Δy_{AU}	-0.0179	0.0262	0.0289	-0.0202	0.00533	-0.00985
Δy_{FI}	-0.0378	0.0104	0.0501*	-0.00604	0.0104	-0.022
Δy_{BE}	-0.0318	0.0348	0.0145	0.000462	0.0234	-0.161***
Δy_{ES}	-0.0475	0.0158	-0.0145	0.0343	0.0488	-0.638***
Δy_{IT}	-0.01	0.0287	-0.044	0.0141	0.0581	-0.536***
Δy_{IR}	-0.043	0.0633*	0.0159	-0.00848	-0.0702	-0.45
Δy_{GR}	0.0246	-0.13	-0.0146	0.097	-0.201	-2.071
Δy_{PT}	-0.0271	0.0351	0.0506	-0.0124	-0.0871	-0.711*

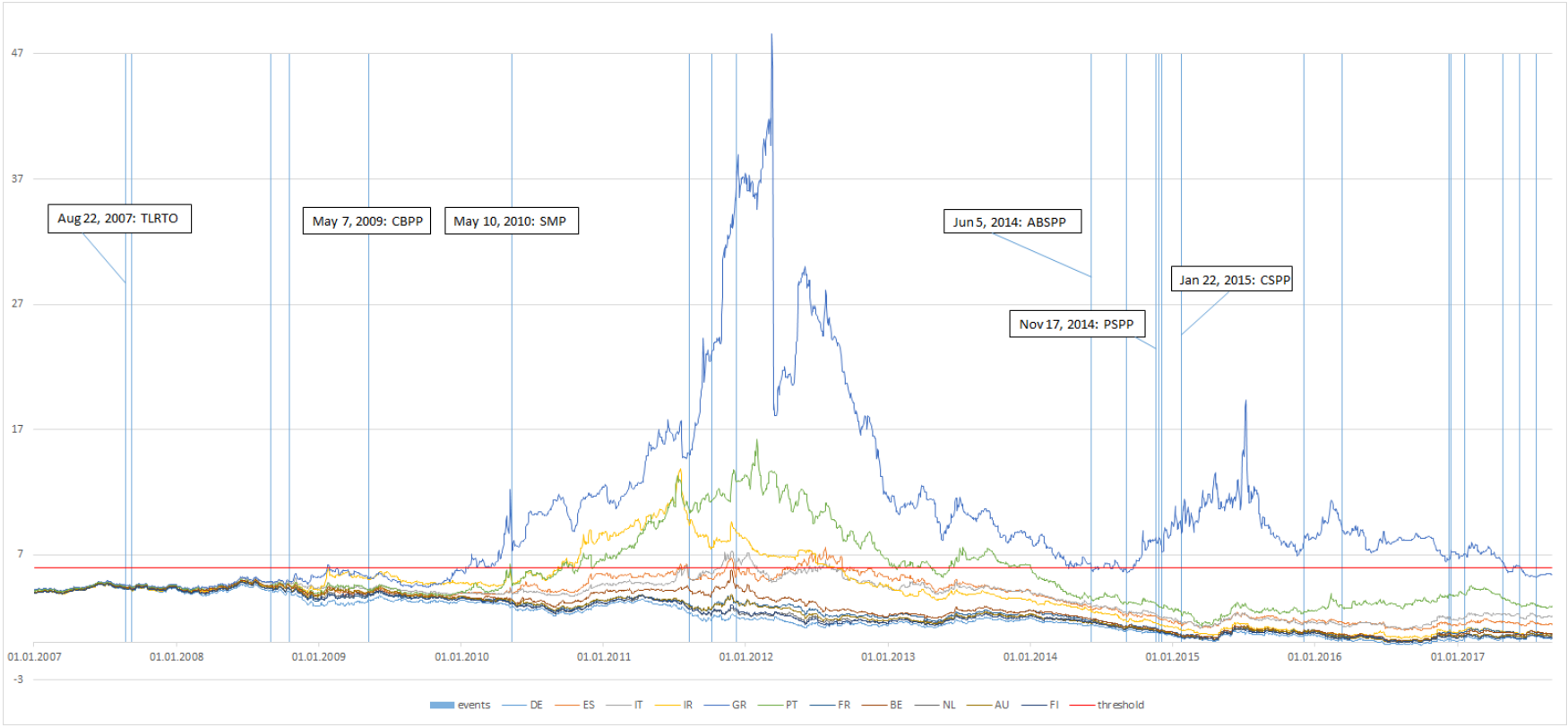
Note: 2,782 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Δy_{t-1}, $\Delta stock_t$, $\Delta CESI_t$, $\Delta exch_t$ and constant omitted. The horizontal middle line separates Core countries (above) and Periphery countries (below). Sample period: January 1, 2007 to August 31, 2017.

Table A5: Panel Regression immediate effects

	11 Euro countries		6 Core countries		5 Periphery countries	
specification	(3)	(4)	(3)	(4)	(3)	(4)
Δy_{t-1}	0.104***	0.105***	0.0987***	0.0973***	0.105***	0.106***
$\Delta stock_t$	-2.30E-05	-2.01E-05	0.000170***	0.000170***	-5.13e-05*	-4.49e-05*
$\Delta exch_t$	-0.376	-0.318	0.338*	0.337*	-1.391**	-1.269**
$\Delta CESI_t$	0.000635***	0.000619***	0.000516***	0.000516***	0.000758***	0.000726***
ABSPP		-0.0265***		-0.0325***		-0.0256**
CSPP		0.00814		0.0231***		0.00381
CBPP		0.0247**		0.0409***		-0.000186
PSPP		0.00568		-0.0112**		0.0264
TLTRO		-0.013		0.0188***		-0.0529
SMP		-0.422**		-0.0261		-0.897**
APA_t	-0.0204		0.0206***		-0.0690*	
R^2	0.012	0.015	0.096	0.097	0.014	0.021

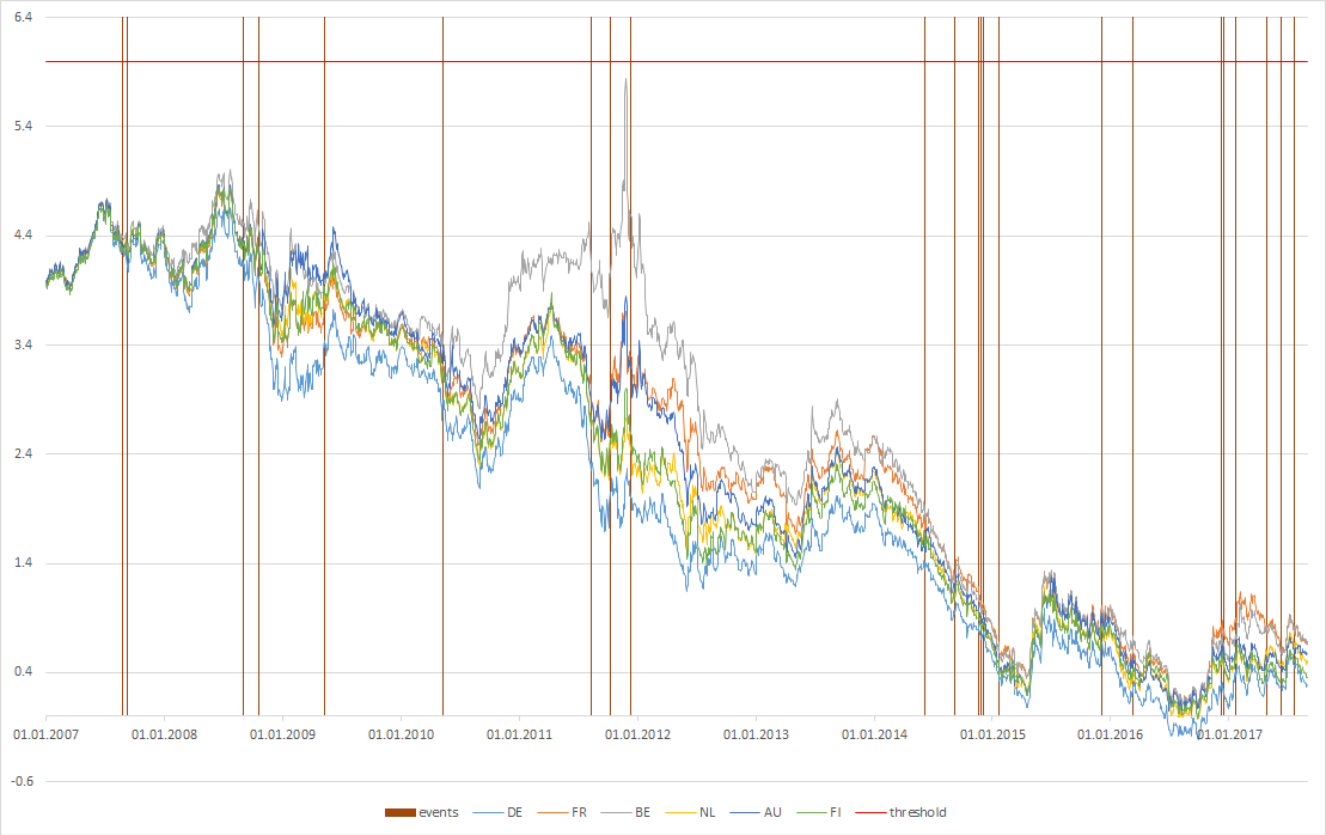
Note: 30,602 Observations. ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Newey-West-adjusted standard errors. Constant omitted. Sample period: January 1, 2007 to August 31, 2017.

Figure A1: 10-year Euro area government bond yields



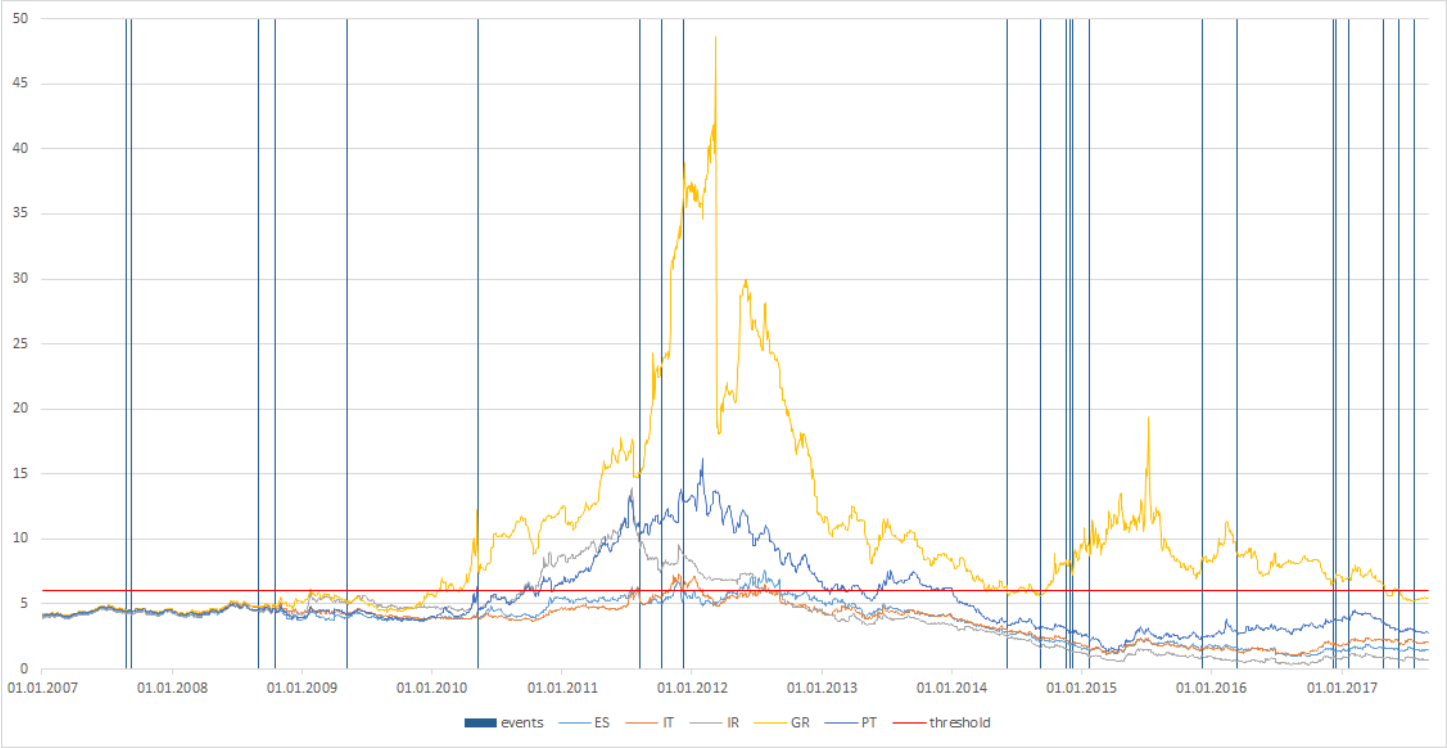
Source: Datastream. Time span: January 1, 2007 to August 31, 2017. Vertical lines indicate the 23 baseline announcement dates while the horizontal line represents the 6% threshold. The six indicated dates represent the first announcement of the respective program.

Figure A2: 10-year Euro area government bond yields: Core countries



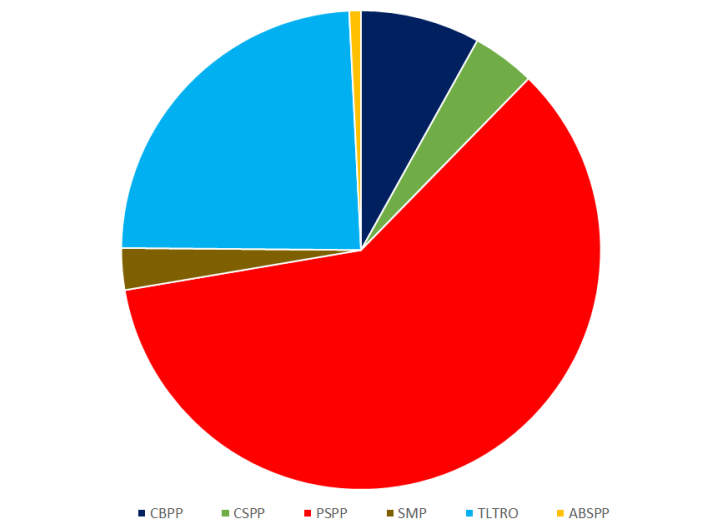
Source: Datastream. Time span: January 1, 2007 to August 31, 2017. Vertical lines indicate the 23 baseline announcement dates while the horizontal line represents the 6% threshold.

Figure A3: 10-year Euro area government bond yields: Periphery countries



Source: Datastream. Time span: January 1, 2007 to August 31, 2017. Vertical lines indicate the 23 baseline announcement dates while the horizontal line represents the 6% threshold.

Figure A4: ECB's asset purchase programs characteristics



name	# announcements	starting date	million €
TLTRO: (targeted) long term refinancing operation	10	August 2007	760,639
CBPP: covered bond purchase programme	10	July 2, 2009	255,627
SMP: securities market programme	2	May 10, 2010	89,134
ABSPP: asset-backed securities purchase programme	10	November 21, 2014	25,032
PSPP: public sector purchase programme	10	March 9, 2015	1,902,213
CSPP: corporate sector purchase programme	8	June 8, 2016	134,622

Note: Effective January 19, 2018. The pie diagram juxtaposes the outstanding amount in million euro.