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# The Impact of the ECB's Asset Purchase Programmes on Sovereign Bond Spreads in the Euro Area

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## Abstract

This paper estimates the immediate impact of the European Central Bank's asset purchase programmes on sovereign bond spreads in the euro area between 2008 and 2015 using a country-by-country GARCH model. The baseline estimates are rigorously diagnosed for misspecification and subjected to a wide range of sensitivity tests. Among others, changes in the dependent variable, the independent variables and the number of (G)ARCH terms are tested. Moreover, the model is applied to subsamples and dynamic conditional correlations are analyzed to estimate the effects of the asset purchases on the contagion of spread movements. Generally, it is found that the asset purchase programmes triggered an reduction of sovereign bond spreads. More specifically, the Securities Markets Programme (SMP) had the most significant immediate effects on sovereign bond spreads across the euro area. The announcements related to the Outright Monetary Transactions (OMT) programme also yielded substantial spread compression in the periphery. In contrast to that, the most recent Public Sector Purchase Programme (PSPP) announced in January 2015 and implemented since March 2015 had no significant immediate effects on sovereign bond spreads, except for Irish spreads. Hence, immediate effects seem to be dependent upon the size of the programme, the extent to which it targets distressed sovereigns and the way in which it is communicated.

**Keywords:** European Central Bank, asset purchase programmes, sovereign bond yield spreads, event study, GARCH model

**JEL classification:** E52, E58, E44, G12

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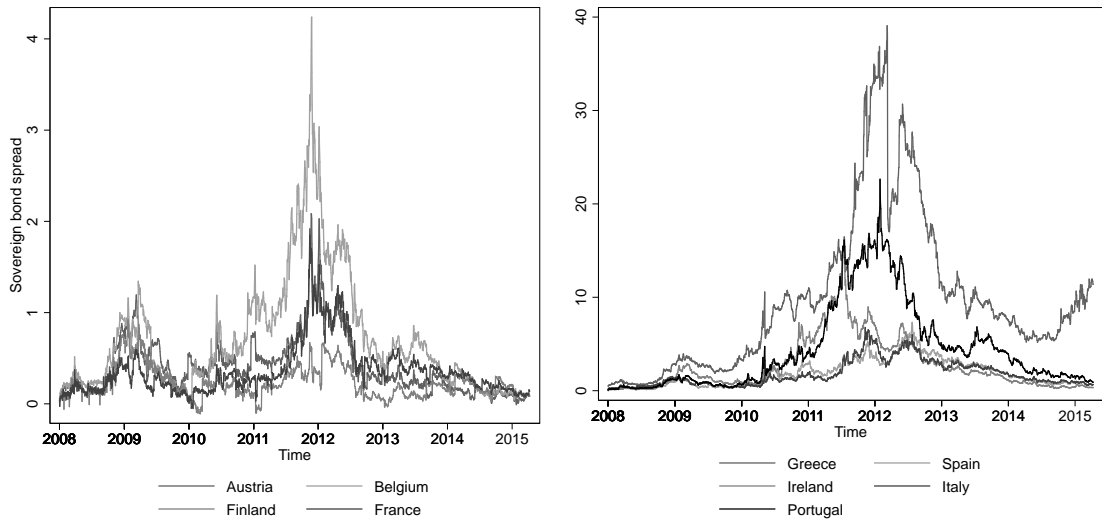
# 1 Introduction

On January 22, the European Central Bank (ECB) announced a EUR 1.1 trillion sovereign bond purchase programme in order to contain deflationary trends and restore increasingly fragmented financial markets. This continues a series of asset purchase programmes adopted by the ECB in recent years. Since the onset of the global financial crisis in 2008, spreads in euro area bond markets increased to an extent that had not been seen during the era of Economic and Monetary Union (EMU) so far (see Figure 1). These developments combined with the fact that interest rates had reached the zero lower bound relatively soon after the start of the crisis, caused the ECB to use unconventional monetary policy measures.

At the core of these measures were several asset purchase programmes. The Covered Bond Purchase Programme (CBPP) was launched already in 2009, and was since reactivated twice. The Securities Markets Programme (SMP) launched in 2010 aimed at purchasing bonds from public and private bond markets and led to a balance sheet increase of the ECB of more than EUR 200 billion. Finally, in 2012, the Outright Monetary Transactions (OMT) programme was announced, which allows the ECB to buy an unlimited amount of sovereign bonds in the secondary market. However, this instrument has so far not been used. Interestingly enough, the announcement of the OMT alone is said to have been effective in driving down bond spreads closer to pre-crisis levels (Wolf, 2014, p. 128).

Taken together, the main goal of these asset purchase programmes was the compression of spreads in order to repair the dysfunctional monetary policy transmission mechanism by removing market fragmentation (Coeure, 2013). Given the most recent announcement by the ECB to purchase bonds worth at least EUR 1.1 trillion in the period between March 2015 and September 2016, it is ever more important to assess the effects of the past ECB programmes. Moreover, the literature on the functioning of unconventional monetary policy measures is naturally relatively undeveloped. Therefore, this paper aims at assessing the impact of the ECB's asset purchase programmes on the change of sovereign bond spreads.

In theory, the consumption-based asset pricing model developed by Cochrane (2001) implies that the change of sovereign bond spreads is determined by three main components (Manganelli and Wolswijk, 2009). Firstly, the change of spreads over time is determined by the change of differences between two countries' quality of fundamentals such as absolute and relative government debt, growth, interest rates and inflation (Poghosyan, 2014). Secondly, the change of spreads critically depend on the evolution of differences in default risk and liquidity risk between two countries. This means that if one of the two countries



**Figure 1:** Daily 5-year sovereign bond spreads in core (left) and periphery (right) euro area countries (2008-2015). Source: Own calculations, Thomson Reuters.

becomes relatively more risky than the other, spreads will increase.<sup>1</sup> Finally, the impact of changes in fundamental and risk differentials is amplified by general market uncertainty.

In theory, determinants of sovereign bond spreads include the differences of countries' macroeconomic fundamentals, the differences in default and liquidity risk and general market uncertainty (see Manganelli and Wolswijk (2009)). By using the instrument of direct asset purchases, central banks can in principle influence all of these factors through the monetary policy transmission mechanism. When announcing an asset purchase programme clearly in advance, central banks can use the signalling channel to influence the expectations of market participants about countries' fundamentals and their risk. Moreover, a well-functioning portfolio balance channel will allow the central bank to directly exert influence over countries' fundamentals, such as the interest rates, and their relative risk. Finally, the liquidity channel and the confidence channel enable the central bank to influence liquidity risk and credit risk, respectively, while potentially calming markets (see Hausken and Ncube (2013)).

Previous empirical literature has found that the ECB's asset purchase programmes were

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<sup>1</sup>This holds in case the spread is measured as the yield of the riskier country less the yield of the less risky country, which is usually the case.

successful in lowering sovereign bond spreads. Being targeted specifically at distressed periphery euro area sovereigns, the SMP had a large impact in terms of spread compression. In this case, the effects exerted through the signalling channel (Szczerbowicz, 2014) were arguably larger than the effects induced by the portfolio balance channel (Ghysels et al., 2014). This is confirmed by the literature looking at both channels at the same time (Fratzschler et al., 2014). Moreover, the OMT announcement including Mario Draghi’s famous words “whatever it takes” also had significant immediate effects (Krishnamurthy et al., 2014). For many, this case constitutes the best example of the effectiveness of the signalling channel, if not for central banks as a whole.

This paper will contribute to the literature by assessing the immediate effect of the ECB’s asset purchase programmes on the change of sovereign bond spreads in the euro area. For this purpose, an event study approach will be used. Using a generalized autoregressive conditional heteroskedasticity (GARCH) model, the change in sovereign bond spreads at certain announcement dates will be scrutinized. This specification is deemed particularly useful in the context of this paper as the observed volatility clustering in changes of spreads can be modelled explicitly. Moreover, the effect of the purchases themselves will be estimated. The dataset to be used includes daily data of 5-year sovereign bond yields of 10 euro area countries and a series of dummy variables indicating certain types of announcements by the ECB relating to asset purchases and data on purchase volumes. Thereby, this paper is the first to analyze the most recent announcements of an extended asset purchase programme by the ECB on 22 January and 9 March 2015.

The main result of this paper is that the ECB was able to lower sovereign bond spreads significantly by way of its asset purchase programmes. In terms of announcement effects, the SMP has been the most effective programme so far, lowering yields in the magnitude of 27 to 188 basis points (bp) in the periphery.<sup>2</sup> The immediate effect of the OMT announcement was smaller (35 to 40 bp), however, the weeks and months that followed saw a strong convergence of sovereign bond yields across the board.<sup>3</sup> Finally, the announcement effect of the PSPP was negligible (except for Greece and Ireland), mostly due to the fact that market participants anticipated the a large-scale bond purchasing programme long before the announcement was made.

In order to assess the impact of the ECB’s asset purchases on sovereign bond spreads, a description of the asset purchase programmes of the ECB since the beginning of the financial crisis will be given first. Second, a short literature review of the empirical evidence

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<sup>2</sup>The estimates ranged from -27 bp (Spain), -30 bp (Portugal), -35 bp (Italy) to -188 bp (Greece).

<sup>3</sup>Given the event studies approach of this paper, the conclusions are confined to immediate effects.

for the ECB's impact on sovereign bond spreads will be described. Finally, a unique empirical assessment will be conducted and tested extensively for its robustness when changing the assumptions of the underlying model.



## 2 The ECB's asset purchase programmes

Since 2009, the ECB has made regular use of large scale asset purchase programmes as part of its non-standard monetary policy toolkit. On a fundamental level, there are two different aims that were to be achieved by using large scale asset purchases. In most instances, the asset purchase programmes of the ECB were directly targeting markets that were essential for commercial banks' funding. The drying up of certain markets was a direct consequence of the financial crisis starting with the collapse of Lehman Brothers in September 2008. In other instances, the ECB used asset purchases to contain risks in the euro area. Ultimately, these broad aims can more or less be proxied by one single benchmark: spread compression. As of April 2015, three different markets have been directly targeted, including the covered bond market, the market for asset-backed securities and the sovereign bond market.

The first market to be targeted was the covered bond market. In 2009, the first covered bond purchase programme (CBPP) was launched, followed by a second programme (CBPP2) in 2011 and a third programme (CBPP3) in 2014. The covered bond market constitutes an important source of funding for commercial banks and had been severely affected by the financial crisis starting in 2008 (Trichet, 2009). Directly purchasing covered bonds was supposed to increase liquidity in this almost completely dried up market. Also, the spread between covered bonds in the periphery and the core of the euro area was intended to be decreased (*ibid.*). Most recently, on 4 September 2014, two asset purchase programmes were announced (Draghi, 2014). The first was a continuation of the CBPP as CBPP3. The second targeted the market for asset-backed securities (ABS). Within the ABSPP, "senior and guaranteed mezzanine tranches of ABSs" were to be bought in both primary and secondary markets (*ibid.*).

Looking at potential effects on the sovereign spreads, the programmes targeting the covered bond market or the market for asset-backed securities were not large when compared to the sovereign bond market. At most, their effect on sovereign spreads could have been indirect through portfolio balancing effects. However, given the degree of market uncertainty and illiquidity in the respective markets in 2009 and 2011, there is a potential to find impacts of the CBPP's and the ABSPP on the change of sovereign spreads.

Next to asset purchase programmes mainly aiming at increasing the liquidity of commercial banks, there was a second line of programmes adopted by the ECB targeted more towards risk containment. In May 2010, the sovereign debt crisis was imminent. During a weekend of hectic negotiations between the ECB, the European Commission and representatives of the Member States, the ECB drew up a plan to purchase sovereign bonds in secondary markets.

In this context, the Securities Markets Programme (SMP) was announced on 10 May 2010, together with other measures taken by euro area governments (ECB, 2010). The aim of the SMP was to reduce market uncertainty in general, and more specifically, in terms of perceived credit and liquidity risks. The ECB wanted "to address the malfunctioning of securities markets and restore an appropriate monetary policy transmission mechanism" (ECB, 2010). In terms of implementation, therefore, this programme aimed specifically at spread compression between peripheral and core euro area sovereign bonds.

The SMP was special in the sense that the purchases were conducted on a very discretionary and ad-hoc basis according to daily market conditions. Thereby, the ECB had wide-ranging discretion in order to reduce high spreads in the markets (Fratzscher et al., 2014, p. 6). From a theoretical point of view, the SMP should have had a large influence on sovereign bond spreads. It was targeted in particular at those sovereigns that were highly risky in terms of both default risk and liquidity risk. Moreover, as there was no *ex ante* limit on the amount of purchases, the SMP could be considered to be large enough to move the market.

In mid-2012, the sovereign debt crisis in the euro area was more imminent than ever before. Speculations about a break-up of the euro area became more and more prominent. On 26 July 2012, the newly appointed president of the ECB, Mario Draghi, announced that the ECB was ready to do "whatever it takes" to preserve the euro (Draghi, 2012b). This paved the way for the announcement of the Outright Monetary Transactions (OMT) programme on 6 September 2012 (Draghi, 2012a). Under this programme, the ECB can purchase an unlimited amount of relatively short-term sovereign bonds.<sup>4</sup> However, it allows the ECB to purchase only sovereign bonds from those countries that are under an EFSF or ESM adjustment programme (conditionality element).

The OMT was designed to contain default risk, or more specifically, the risk that one country will leave the euro area and adopt a national currency (*ibid.*).<sup>5</sup> This risk is commonly called redenomination risk. As of April 2015, no single purchase has been conducted under the OMT and still, the programme is considered to have contained redenomination risk to a large extent (Plickert, 2014). Thereby, Draghi's announcement to do "whatever it takes" to preserve the euro used the signalling channel to correct the expectation of the markets that a redenomination of Greece, and potentially other periphery countries, was imminent.

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<sup>4</sup>Short-term refers to a maturity of up to three years.

<sup>5</sup>"OMTs will enable us to address severe distortions in government bond markets which originate from, in particular, unfounded fears on the part of investors of the reversibility of the [...] the euro is irreversible" (Draghi, 2012b)

Looking at the OMT's theoretical effect on sovereign bond spreads, the OMT did indeed have a strong potential to influence this measure. It targeted specifically the highly risky sovereigns under the condition of participation in an adjustment programme. Moreover, given the emphasis on the fact that purchases would be unlimited *ex ante*, the programme was definitely large enough to move the sovereign bond market. However, the initial speech by Mario Draghi did not contain any details to how the OMT would look like.<sup>6</sup> In two subsequent announcements, the ECB clarified the details of the OMT, some of which are not even clear in 2015. Therefore, the announcement are not be expected to have had strong immediate effects on spreads.

The most recent asset purchase programme of the ECB is by far the largest. On 22 January 2015 an extended asset purchase programme was officially announced containing a broad public sector purchase programme (PSPP) and the previously launched ABSPP and CBPP. The whole programme would have a target volume of EUR 60 billion per month lasting at least until September 2016 for purchases of sovereign and supranational bonds in the secondary market. In contrast to all previous programmes it was specified that purchases were to be conducted by national central banks according to their shares in the ECB's capital key. This means that, for the first time, the ECB does not have discretion to decide from which sovereign it wants to buy bonds. Hence, it is not to be expected that the PSPP significantly lowers spreads. Instead, it might lower yields across all sovereigns of the euro area.

Overall, when comparing the impact of the different asset purchase programmes, it is expected that the SMP had the largest effects on sovereign bond spreads. As the OMT was initially relatively vaguely defined, but large and targeted enough to move markets, it is expected that the OMT did influence spreads between the periphery and the core significantly. As it does not target risky sovereigns specifically, the PSPP is not expected to have a significant impact on the spreads. Similarly, the CBPP's and the ABSPP are not expected to have influenced sovereign bond spreads.

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<sup>6</sup>The announcement did not contain any details due its ad-hoc nature (Plickert, 2014).

### 3 Literature review

This subsection will look at the empirical literature related to the impact of the ECB's asset purchase programmes on sovereign bond spreads. Generally, the literature finds that the effects are limited to the periphery countries: Greece, Ireland, Portugal, Spain and Italy. On average, the SMP had the largest impact in terms of spread compression with large variations between the periphery countries. While the OMT announcement has had a more limited immediate effect on sovereign bond spreads, the CBPP's showed no significant influence. Thereby, these findings confirm the expectations about the impact of the different asset purchase programmes. The most recent ABSPP/CBPP3 as well as the PSPP have not yet been covered by the literature.

The amount of literature on the effects of the asset purchase programmes on sovereign bond spreads is very limited. Szczerbowicz (2014) and Falagiarda and Reitz (2015) both employ an event study framework to look at the impact of major asset purchase announcements on spreads. With regard to the SMP, Greek spreads saw the largest decrease, between 170 and 485 bp. However, both studies acknowledge that their estimates of the impact on Greek spreads are unstable. The announcement impact on Irish and Portuguese spreads was also considerable with a reduction of between 78 and 121 bp for Ireland and between 54 and 102 bp for Portugal. Finally, the studies find a reduction in Spanish spreads of between 59 to 81 bp and for Italian spreads between 31 and 70 bp.

Instead of looking at the impact of the SMP on sovereign bond spreads, the largest part of the empirical literature assesses the impact on yields. While Kilponen et al. (2012), Eser et al. (2013) and Krishnamurthy et al. (2014) look at the impact of the ECB's announcements only, Ghysels et al. (2014) looks at the impact of the actual purchases. Fratzscher et al. (2014) look at both announcement and operational effects within the same methodological framework.

Due to the SMP announcements, yields decreased mostly in Portugal (-228 bp), Ireland (-176 bp), Spain (-149 bp) and Italy (-123 bp), according to Krishnamurthy et al. (2014). Fratzscher et al. (2014) confirm the finding for Italy and Spain with a combined impact of -121 bp. The operational effects were significantly smaller: Italian and Spanish yields decreased by 70 bp (*ibid.*), whereas Irish yields decreased by 21 bp and Portuguese yields decreased by 20 bp (Ghysels et al., 2014). The finding that operational effects are generally smaller than announcement effects could either stem from the strength of the signalling channel or from methodological issues (i.e. endogeneity of daily asset purchases). On a different note, De Pooter et al. (2014) find that the SMP announcements significantly decreased sovereign liquidity risk premia in magnitude of 23 bp for each percent of debt outstanding purchased.

According to the literature of the effects of the ECB's asset purchases on spreads, the immediate announcement effects of the OMT were more subdued than those of the SMP. Szczerbowicz (2014) finds the largest impact on spreads for Spanish (-59 bp) and Portuguese (-54 bp) spreads. For Italy, she finds a reduction of 31 bp as a response to the OMT announcements. In terms of yields, Fratzscher et al. (2014) find a reduction for Italian and Spanish bonds of 70 bp, whereas Altavilla et al. (2014) find a reduction of up to 200 bp using high frequency data. Krishnamurthy et al. (2014) find reductions of -129 bp (Spain), -118 bp (Portugal) and -83 bp (Italy). However, these values are considerably smaller than the effects these studies find for the SMP.

Generally, there are several methodological deficiencies in the empirical literature. Most importantly, there is a lack of robustness testing when modelling sovereign bond yields and spreads. In what follows, this paper will therefore present a unique empirical assessment of the ECB's asset purchase programmes combining different elements from the previous empirical literature. It will look at the impact on sovereign bond spreads employing an event study framework following the recent popularity of this approach (see, for instance, Szczerbowicz (2014), Krishnamurthy et al. (2014) and Hausken and Ncube (2013)). Thereby, a GARCH specification for modelling daily changes in sovereign bond spreads similar to Falagiarda and Reitz (2013) will be used. In order to tackle a familiar problem when taking into account operational effects, the endogeneity contained in daily SMP purchases will be eliminated following the methodology proposed by Fratzscher et al. (2014).

## 4 Methodology

### 4.1 Model

The aim of this paper is to assess the impact of the ECB's asset purchases on sovereign bond spreads. Due to the I(1) character of the time series of bond spreads, changes in spreads will be modelled. With regard to the event window, there is a trade-off that is common in the related literature. The smaller the event window (i.e. the time period over which the change is calculated), the less of the effect of monetary policy is captured. However, the larger the window, the less precise, or the more noisy, the estimate will be (see also Hausken and Ncube (2013, p. 25)). This paper will use the two-day change in sovereign bond spreads as the dependent variable that is to be modelled. The choice represents a compromise often used in the relevant empirical literature.<sup>7</sup>

The type of model that is most appropriate for the statistical properties of the time series of changes of spreads is the GARCH model originally developed by Bollerslev (1987).<sup>8</sup> The GARCH model assumes that the residuals are conditionally homoskedastic and unconditionally heteroskedastic. In addition to a specification for the mean, the GARCH model allows to model the variance of the time series explicitly. It can also account for volatility clustering, as the variance is modelled as a function of its past values and past disturbances. Therefore, the baseline specification for modelling two-day changes in sovereign bond spreads is a GARCH specification.

$$\Delta s_{i,t} = \alpha_i + \beta_i AN_t + \phi_i OP_{i,t} + \rho \Delta s_{i,t-1} + \gamma_i X_{i,t} + \epsilon_{i,t} \quad (1)$$

Equation 1 allows for an estimation of the immediate effects of asset purchase announcements and implementations. It models the mean of the two-day change in sovereign bond spreads, represented by  $\Delta s$  in time  $t$  for each country  $i$ . The control vector  $X$  contains the most important determinants of the change of sovereign bond spreads (see Manganello and

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<sup>7</sup>See, for example, Szczerbowicz (2014), Falagiarda and Reitz (2013), Hausken and Ncube (2013) and Joyce et al. (2011).

<sup>8</sup>The time series of the change in spreads is stationary, and thus the unconditional mean is constant, i.e. the conditional mean is zero. Moreover, the positive autocorrelation in changes in spreads justifies the use of one lag of the dependent variable when modelling the mean. Furthermore, the positive autocorrelation in the variance of changes of spreads justifies the explicit modelling of the variance of change of spreads. Also, the volatility clustering means that the variance should be a function of past disturbances. Finally, the positive autocorrelation up until a very high lag order suggests that the variance should also be a function of its own lags.

Wolswijk (2009)). This includes macroeconomic fundamentals, general market uncertainty, credit risk and liquidity risk. Moreover, other possibly important factors for the change in sovereign bond spreads have been added. This includes inflationary expectations (a more specific element of macroeconomic fundamentals), redenomination risk (a specific form of credit risk that was particularly important in the euro area sovereign debt crisis) and equity market returns. Seasonal effects are eliminated by including dummy variables for each weekday (Falagiarda and Gregori, 2015, p. 10).<sup>9</sup>

The central bank is assumed to affect the change of sovereign bond spreads through announcements of asset purchases, represented by the vector  $AN$ <sup>10</sup> and through the purchases of assets itself,  $OP$ <sup>11</sup>. The vector  $AN$  contains the “impulse dummies” listed in Table 1 (Fratzscher et al., 2014). However, the dummies relating to the CBPP and the ABSPP are left out from the baseline specification as these programmes did not target sovereign debt markets directly. Accordingly, the vector  $OP$  contains the following variables:  $OP\_SMP_{i,t}$  and  $OP\_PSPP_{i,t}$ .<sup>12</sup> Incorporating both of these types of variables within a single equation has first been advocated by Fratzscher et al. (2014) and Ghysels et al. (2014).

On a fundamental level, the GARCH model allows the error term to be zero mean and its variance to be unconditionally heteroskedastic.

$$\epsilon_{i,t} \sim N(0, \sigma_{i,t}^2) \quad (2)$$

The variance itself is modelled as an ARMA process. In the baseline model, one AR component and one MA component are included. This specification is usually referred to as GARCH(1,1) and represents the simplest GARCH specification.<sup>13</sup>

$$\sigma_{i,t}^2 = \omega_i + \eta_i \epsilon_{i,t-1}^2 + \pi_i \sigma_{i,t-1}^2 \quad (3)$$

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<sup>9</sup>In the baseline specification, the control vector  $X$  contains:  $\Delta CESI_t$ ,  $\Delta FS5y5y_t$ ,  $\Delta VSTOXX_t$ ,  $\Delta CDS_{i,t}$ ,  $\Delta QCDS_{i,t}$ ,  $\Delta BA_{i,t}$  and  $\Delta Emkt_{i,t}$ . The variables are explained in the data section.

<sup>10</sup>This variable represents the signalling channel.

<sup>11</sup>This variable represents the portfolio balance channel.

<sup>12</sup>Note that both the operational variable of the SMP and the PSPP contain per-country data as signified by the subscript  $i$ .

<sup>13</sup> $\sigma_{i,t}$  is the conditional variance of  $\epsilon$ ,  $\eta_i$  is the ARCH coefficient and  $\pi_i$  is the GARCH coefficient.

Equations 1 and 3 thus describe the complete empirical specification to be used as a baseline specification in this paper. The estimates from the GARCH model are obtained via maximum likelihood estimation using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) and the Berndt-Hall-Hausman (BHHH) algorithms. The model is estimated for each sample country separately in order to analyze heterogeneity across countries.

## 4.2 Data

The dataset used for this paper contains daily data covering the period from January 1, 2008 to April 13, 2015. It is comprised of data on 10 euro area countries, each categorized either as core or as periphery country.<sup>14</sup> Daily data for 5-year sovereign bond yields<sup>15</sup> was collected from Datastream and originates from Thomson Reuters. Subsequently, the 5-year sovereign bond yields have been transformed into 5-year sovereign bond spreads with respect to German sovereign bond yields. The eventual dependent variable was then obtained by taking the two-day change of 5-year sovereign bond spreads.<sup>16</sup>

The key announcement dates of the ECB’s policies as listed in Table 1 were taken from the relevant literature (Krishnamurthy et al. (2014), Szczerbowicz (2014) and Fratzscher et al. (2014)). The significance of the selected dates was double-checked by looking up the exact content of the announcement on the ECB’s website. Subsequently, each announcement was transformed into an impulse dummy variable equal to one on the date of the announcement and zero otherwise.

The data concerning the volume of the ECB’s asset purchases was obtained from the ECB’s website.<sup>17</sup> However, parts of the data on the ECB’s purchases is only available on a weekly basis. As it is crucial for the analysis in this paper to be based on daily data, the weekly data has been interpolated by assuming that the purchase volume during a week was equally distributed over the five weekdays. Thereby, this paper follows Fratzscher et al. (2014). Another data-related issue is the endogeneity of daily SMP purchases with respect to sovereign bond yields and spreads. As Fratzscher et al. (2014) argue, this stems

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<sup>14</sup>Core countries: Austria, Belgium, Finland, France, Germany. Periphery countries: Greece, Ireland, Italy, Portugal, Spain.

<sup>15</sup>The 5-year maturity has been chosen because it is in the middle between the 2-year and 10-year maturity bonds that were targeted by the ECB (Eser et al., 2013, p. 10).

<sup>16</sup>In the baseline specification, a two-day change refers to the change between the closing price at  $t - 2$  and the closing price at  $t$ . Different definitions will be applied in the section on robustness tests.

<sup>17</sup>More specifically, the data originates from the website’s section on liquidity analysis as well as the numbers on the “securities held for monetary policy purposes” from the weekly financial statements.



Date	Programme	Impulse Dummy	Description
07 May 2009	CBPP1	an_cbppi_1	The Governing Council of the ECB announces its decision to purchase covered bonds.
04 June 2009	CBPP1	an_cbppi_2	The ECB publishes detailed modalities for the CBPP1, including information on volume and eligibility.
10 May 2010	SMP	an_smp_1	The Governing Council announces the SMP as part of a package with other measures to address increased tensions of euro area financial markets.
07 August 2011	SMP	an_smp_2	Draghi announces the reactivation of the SMP, targeting Italian and Spanish bonds in particular.
06 October 2011	CBPP2	an_cbppii_1	The Governing Council announces the launch of the CBPP2, including details on volume and length.
03 November 2011	CBPP2	an_cbppii_2	The ECB announces detailed modalities for the CBPP2.
26 July 2012	OMT	an_omt_1	Draghi announces that the ECB is "ready to do whatever it takes to preserve the euro".
02 August 2012	OMT	an_omt_2	The Governing Council announces its consideration of outright open market operations.
06 September 2012	OMT	an_omt_3	The Governing Council announces the OMT programme, including detailed modalities.
04 September 2014	ABSPP / CBPP3	an_abspp_1	The Governing Council announces its decision to launch the ABSPP and the CBPP3.
02 October 2014	ABSPP / CBPP3	an_abspp_2	The ECB publishes detailed modalities for the ABSPP and the CBPP3.
22 January 2015	PSPP	an_pspp_1	The Governing Council announces an expanded asset purchase programme, encompassing the new PSPP as well as the formerly launched ABSPP and the CBPP3.
09 March 2015	PSPP	an_pspp_2	The PSPP is implemented.

**Table 1:** Overview of the ECB's asset purchase programme announcements.

from the fact that the ECB conducted its purchases according to prevailing market conditions. This issue has been tackled by modelling an SMP-specific reaction function of the ECB following the approach of Fratzscher et al. (2014).

In order to control for countries' macroeconomics fundamentals at a daily frequency, the Citigroup Economic Surprise Indicator (CESI) for the euro area is used as a control variable. It measures the surprise content of the release of macroeconomic news. A positive value indicates that economic news have come as a positive surprise, whereas a negative value points to news that did not meet market expectations (Mackintosh, 2011). The data comes from Citigroup and has been obtained through Datastream. A positive change in the CESI is expected to be related to a negative change of sovereign spreads. Thus, the coefficient of this variable is expected to be negative.

A particularly important macroeconomic fundamental is inflation and, more specifically,

inflationary expectations. Shocks to inflationary expectations could potentially affect the change of sovereign bond spreads (Cantor and Packer, 1996). The ECB and thus the market commonly uses the 5-year-5-year forward interest swap rate as a proxy for medium-term inflationary expectations (Blackstone, 2014). Thus, this paper will utilize this measure in the baseline specification. The data has been obtained through Datastream and originates from Thomson Reuters. A positive change in inflationary expectations is expected to be related to a negative change of sovereign spreads.<sup>18</sup> Thus, the coefficient of this variable is expected to be negative.

A country's default risk is proxied by its credit default swap (CDS) premium (see, for instance, Aizenman et al. (2013)). In this case, the 5-year CDS premia have been chosen as the appropriate variable, as it corresponds to the maturity of the sovereign bond spreads used as a dependent variable.<sup>19</sup> This data has also been obtained from Datastream. As argued in section two, a higher default risk is supposed to increase spreads. Thus, a positive coefficient for this variable is expected.

As described above, a form of default risk that was very important during the euro sovereign debt crisis is redenomination risk. In the context of the euro area, this risk describes "the risk that a euro asset will be redenominated into a devalued legacy currency" (De Santis, 2015, p. 1). It stands for the fears of a breakup of the euro area and has arguably been a major driver in the spreads that caused Draghi to assert that the ECB would do "whatever it takes" to preserve the euro (Draghi, 2012b). According to De Santis (2015, p. 35), redenomination risk can be computed with the help of quanto CDS premia. The latter is the difference between a CDS denominated in US Dollar and the analogue CDS denominated in EUR. Taking the difference between a country's quanto CDS and the benchmark quanto CDS<sup>20</sup> yields the measure for redenomination risk. A higher redenomination risk should theoretically increase sovereign bond spreads. Thus, this variable is expected to have a positive coefficient.

Another potentially important control variable is the development of equity markets, as equities constitute, to a certain extent, an alternative to bonds (Falagiarda and Reitz, 2015). Therefore, equity market indices for each country in the sample have been obtained from Datastream. Further possible controls include dummy variables for other important policy

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<sup>18</sup>This expectation stems from the fact that, if there is an increase in expected inflation, this is seen to come mainly from periphery countries.

<sup>19</sup>Moreover, the CDS premia used here are those denominated in US Dollar, as the market for euro area CDS in USD is substantially more liquid than the market for euro area CDS in euro (De Santis, 2015, p. 8).

<sup>20</sup>Again, Germany is chosen as a benchmark.

announcements from the US Federal Reserve and those related to the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM). Moreover, control vector  $X$  also contains weekday dummies in order to eliminate seasonal effects and a dummy variable equal to one during the euro sovereign debt crisis and zero elsewhere (following Falagiarda and Reitz (2015)).

## 5 Empirical results

This section will present the results of estimating the baseline specification. Subsequently, the validity of the assumptions underlying the baseline model will be tested.

### 5.1 Baseline estimates

The results of the estimation of the baseline specification are reported in Table 2. In line with the empirical literature, the SMP is identified as the asset purchase programme with the largest impact on sovereign bond spreads in the euro area. The strongest impact was achieved by the announcement on 7 August 2011 to reactivate the SMP programme by purchasing Italian and Spanish bonds. Indeed, their spreads were reduced by 35 and 27 bp, respectively. Greek spreads were reduced by 48 and Portuguese spreads by 30 bp.<sup>21</sup> These estimates are smaller than the average estimates from previous empirical studies. Moreover, this announcement had an impact beyond peripheral spreads, with spread compression in Belgium (-11 bp), Finland (-10 bp) and Austria (-7 bp).<sup>22</sup> The initial announcement of the SMP on 10 May 2010 affected only Greek spreads, but with a larger magnitude of -140 bp.<sup>23</sup> In terms of operational effects, the estimation did not yield significant impacts for the SMP.<sup>24</sup>

According to the baseline estimates and again in line with the empirical literature, the OMT did not immediately impact spreads as much as the SMP did. However, the effects of the OMT were still sizeable. For the Italian spread, a 41 bp reduction was estimated for all OMT-related announcements taken together, while the estimate for Ireland (-35 bp) is only weakly significant. Again, Greek spreads behaved very differently from those of the rest of the euro area. In fact, the OMT announcement increased Greek spreads by 42 to 73 bp.<sup>25</sup> This points to the inherent weakness of the event study framework. The effect of the OMT announcement did not abruptly translate into lower spreads, but did so only over weeks and months. These lagged effects arguably were due to the vagueness of the announcements and cannot be captured with the event study framework used in this paper.

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<sup>21</sup>The coefficient for Portugal is only weakly significant. Whenever significance is referred to as “weak”, a significance at the 10% level is meant.

<sup>22</sup>The coefficient for Austria is only weakly significant.

<sup>23</sup>Again, this result is only weakly statistically significant.

<sup>24</sup>Somewhat counterintuitively, the implementation of the SMP was estimated to have increased Greek spreads by 8 bp.

<sup>25</sup>The latter estimate incorporates the coefficient for the first OMT announcement and the weakly significant coefficient for the third OMT announcement.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	IE.BL	EL.BL	PT.BL	ES.BL	IT.BL	AT.BL	BE.BL	FI.BL	FR.BL
Sov. Spread, 1st diff.									
AN_SMP_1	-1.204	-1.404*	-0.359	-0.261	-0.182	0.058	-0.097	-0.071	0.021
AN_SMP_2	-0.106	-0.479***	-0.298*	-0.267**	-0.347***	-0.071*	-0.111***	-0.099***	0.064
AN_OMT_1	0.141	0.421***	0.232	-0.314	-0.409***	-0.029	-0.042	-0.044	-0.017
AN_OMT_2	-0.014	0.192	-0.276	0.044	-0.136	0.042	-0.045	-0.019	0.029
AN_OMT_3	-0.348*	0.309*	0.058	0.119	-0.013	-0.068	-0.068*	-0.064	-0.061
AN_PSP_1	-0.004	0.301**	0.010	-0.041	-0.031	-0.022	-0.059	-0.024	-0.008
AN_PSP_2	0.053	-0.012	0.038	0.016	0.036	-0.010	-0.002	-0.035	0.028
OP_SMP	0.024	0.081*	0.050	-0.010	-0.023				
OP_PSPP	-0.997*		-0.010	0.065	-0.031	-0.005	-0.164	0.048	-0.015
CESI	-0.000	-0.001***	-0.000**	-0.000	-0.000*	-0.000	-0.000**	0.000	-0.000
Forward swap 5y5y	-0.215***	-0.042	-0.072**	-0.047*	-0.091***	-0.075***	-0.033**	0.004	-0.020
VSTOXX	0.002*	0.008***	0.002**	-0.000	0.001	0.002***	0.002***	0.001*	0.001
CDS	0.004***	0.001***	0.006***	0.007***	0.007***	0.003***	0.005***	0.003***	0.003***
QCDS spread	-0.004***	-0.001***	-0.003***	-0.006***	-0.006***	-0.001**	-0.001		-0.001*
Bid-ask spread	0.126	-0.952***	0.584***	0.197	0.237	0.046	-0.099	0.203	-0.036
Equity market	-0.000***	-0.000***	-0.000	-0.000***	-0.000***	-0.000	0.000	-0.000*	-0.000*
Constant	-0.011**	0.001	-0.011**	-0.006	-0.007*	-0.001	-0.003*	-0.002	-0.003*
ARMA									
L.ar	0.473***	0.454***	0.461***	0.440***	0.437***	0.390***	0.458***	0.312***	0.377***
ARCH									
L.arch	0.216***	0.484***	0.308***	0.156***	0.161***	0.440***	0.330***	0.627***	0.314***
L.garch	0.822***	0.661***	0.772***	0.851***	0.845***	0.644***	0.734***	0.535***	0.736***
Constant	0.000*	0.001***	0.000*	0.000**	0.000**	0.000***	0.000***	0.000***	0.000***
Observations	1678	1879	1849	1735	1879	1534	1879	1824	1735
AIC	-2773.019	-1180.110	-2385.387	-3963.977	-4572.197	-5796.023	-6435.465	-7572.010	-6684.061
BIC	-2631.960	-1041.648	-2241.805	-3822.049	-4428.196	-5662.632	-6297.003	-7439.799	-6547.592

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**Table 2:** Results of the estimation of the baseline specification. Dependent variables: Two-day change of sovereign bond spreads.

In line with the expectations described above, the baseline estimates for the impact of the most recently announced PSPP are mostly insignificant. Again, Greece is an exception. The announcement of the PSPP lead to a 30 bp increase of spreads. This might stem from the fact that Greek bonds are not included in the PSPP, while the bonds of all other sovereigns in the sample are included. Due to the actual purchase of assets, Irish spreads have contracted by -100 bp since the start of the PSPP purchases on 9 March 2015.<sup>26</sup> The finding that the PSPP did not have an impact on other spreads possibly comes from the fact that the PSPP purchases are conducted very broadly, in line with the ECB's capital key. That implies that, in contrast to the SMP, bonds from all countries in the sample are bought. Hence, instead of immediate spread compression an immediate reduction in bond yields can be expected from the implementation of the PSPP. Beyond immediate effects the PSPP could however very well have second-order effects on sovereign bond spreads due to investors' search for yield.

The controlling components of the baseline model are largely appropriate. The AR coefficient in the mean equation is highly significant in all countries. Thereby, this term partially eliminates the serial correlation in the dependent variable. Moreover, the ARCH and GARCH terms are both highly significant in all countries. Throughout, the sum of the two is close to one, indicating that the variance of two-day changes in spreads is a long memory process.<sup>27</sup> More broadly, this also confirms the choice of a GARCH model as the baseline specification for modelling the two-day change in sovereign bond spreads.

Furthermore, the coefficients of the control variables mostly have the expected signs. The negative coefficients for the CESI in most countries confirm that better-than-expected macroeconomic fundamentals decrease sovereign bond spreads. The positive coefficients for the VSTOXX in all countries show that indeed higher market uncertainty leads to higher sovereign bond spreads. Looking at the influence of default risk, the positive coefficients for the CDS premia in almost all countries confirm that higher default risk implies a higher spread. The mostly insignificant coefficients related to the bid-ask spreads, however, do not confirm the theoretical impact of liquidity risk on sovereign bond spreads. Either liquidity risk was not a determining factor for sovereign bond spreads in the sample period, or there is a measurement problem as the bid-ask spread does not capture liquidity risk in its entirety.<sup>28</sup> Also, the coefficients for the quanto CDS spreads are mostly negative, which is not in line with the empirical findings of De Santis (2015).

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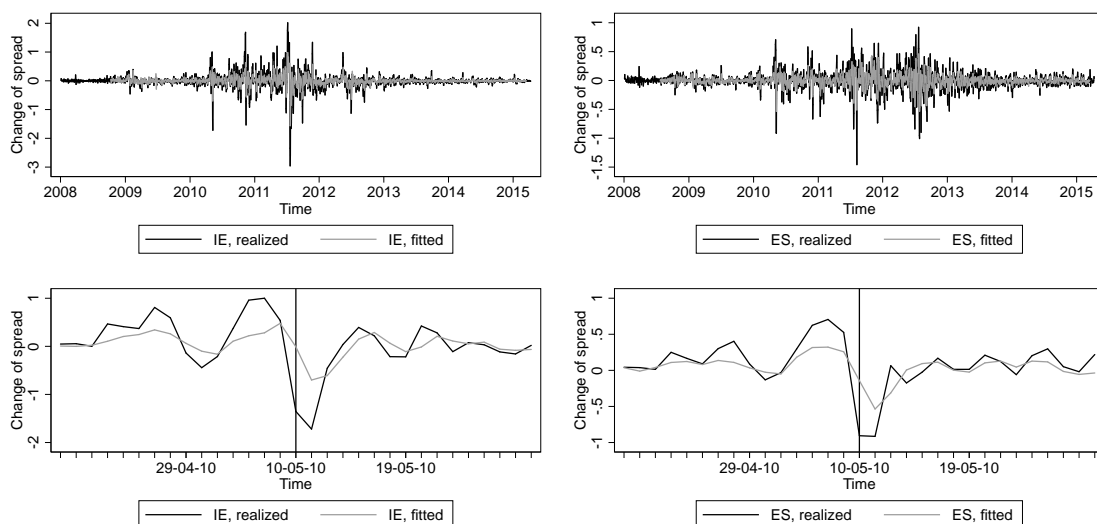
<sup>26</sup>This coefficient is only weakly significant.

<sup>27</sup>This would require another robustness test involving long-memory models such as IGARCH or FI-GARCH.

<sup>28</sup>Note that the bid-ask spread is only one proxy for liquidity. There are more indicators, for which data was not available.

## 5.2 Baseline diagnostics

This subsection will gauge the degree to which the baseline specification is an appropriate representation of the realized change in sovereign bond spreads. This will give an indication of how reliable the results from the baseline estimation are. For this purpose, the fit of the model will firstly be assessed graphically. Secondly, it will be checked both graphically and quantitatively whether or not there is serial correlation in the fitted residuals. Thirdly, it will be tested for residual ARCH effects contained in the fitted variance of residuals. Finally, it will be checked whether the distribution of the fitted residuals is in line with the assumed distribution in the baseline specification.



**Figure 2:** Fit of the baseline specification. The top panels show the fitted and realized values for the whole sample (in percentage points) in Ireland (left) and Spain (right). The bottom panels show the fitted and realized values around the second SMP announcement in Ireland (left) and Spain (right).

Regarding the in-sample fit, as shown in Figure 2, the baseline model fits the realized changes in sovereign bond spreads quite well. The SMP announcement effect, shown in Figure 2, is well captured by the baseline model. Hence, from this rough graphical analysis, the model indeed seems to be a good representation of real-world changes of sovereign bond spreads including the effect of the ECB's announcement of an asset purchase programme.

Furthermore, in order for the model to be correctly specified, it should have eliminated serial correlation in the standardized fitted residuals (Bollerslev, 1987). The ACFs and PACFs did not confirm this. In fact, serial correlation is present in all time series except the one for Greece. In particular, the combination of the autocorrelation functions and the partial autocorrelation functions reveal a moving average (MA) signature.<sup>29</sup> As a result, the baseline model seems to be somewhat misspecified in this respect.

Turning to another indicator for misspecification, the model was checked for residual ARCH effects in the squared standardized residuals (*ibid.*). As shown in Figure ??, the result is mixed in this respect. In some of the estimated variances (such as Ireland, Greece and Italy), there seem to be residual ARCH effects pointing at a lack of ARCH/GARCH terms in the baseline specification. In theory, this could be circumvented by increasing the number of ARCH/GARCH terms. However, this presents a trade-off between estimation precision and misspecification. Still, the model seems to be misspecified for some countries in terms of residual ARCH effects.

Finally, it was checked whether the assumption that the standardized residuals that were fitted with the baseline specification indeed follow a Student's t distribution with the appropriate degrees of freedom.<sup>30</sup> As shown in Figure ?? and Table ??, the t-distribution seems to be an appropriate assumption in all cases except for Greece and Spain. Therefore, the model seems to be largely correctly specified in terms of distributional match.

Having presented the results of the baseline estimation and having pointed out the deficiencies of the model in representing realized changes in sovereign bond spreads, the next section will stress test the baseline specification. Changing the various assumptions of the underlying baseline model will allow for a thorough assessment of the reliability of the baseline estimates.

### 5.3 Robustness tests

In order to assess the sensitivity of the empirical results to changes in the underlying assumptions, seven different types of robustness tests were conducted. Besides changes in the dependent variable, in the variables of interest and the control variables in both the mean and the variance equation, the estimation strategy has been changed. Moreover, a

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<sup>29</sup>This stems from the fact that the autocorrelation functions cut off after one, two or three lags and the partial autocorrelation functions decay over time.

<sup>30</sup>Note that there was no *ex ante* assumption about the degrees of freedom of the Student's t distribution. Instead, the degrees of freedom were estimated along with the parameters of the model.



subsample analysis has been conducted and dynamic conditional correlations have been analyzed. The latter is useful to assess potential effects on the contagion between euro area sovereign spreads.

Firstly, the dependent variable has been changed from two-day changes in sovereign bond spreads to one-day changes.<sup>31</sup> This change of assumptions renders the impact of the asset purchases insignificant. However, the estimates with respect to the control variables remain very stable. From this, it could be inferred that the very immediate effects of asset purchase programmes are small and insignificant compared to other drivers of sovereign spreads. Less significant estimates are obtained also when changing the definition of the dependent variable to capture some of the anticipatory effects of the announcements (Falagarda and Reitz, 2013). Overall, however, the magnitudes are similar.

Secondly, announcement and implementation variables of the CBPP and the ABSPP have been added to the baseline specification. All variables related to the CBPP and the ABSPP do not yield significant effects on changes in sovereign bond spreads. The estimates for the other programmes change if at all only marginally.

Following Szczerbowicz (2014), another sensitivity test includes three further control variables to the baseline specification: a dummy for important QE-related announcements of the US Federal Reserve, a dummy for important announcements relating to the EFSF and the ESM and a dummy for acute periods of sovereign debt crisis in the euro area. When including the new control variables, the estimates do not change at all compared to the baseline estimates. Also, the newly included control variables are, at best, weakly significant.

A reason for the residual ARCH effects in some of the fitted standardized residuals could be the lack of explanatory variables in the baseline equation for the variance. Two variables that could potentially have a direct impact on the variance of changes in spreads could be market uncertainty and redenomination risk. However, when including the VSTOXX and the quanto CDS spreads in the variance equation, the estimates from the baseline model do not change significantly.

The baseline diagnostics have also pointed to the deficiency of the baseline model of not entirely capturing ARCH effects in the squared standardized residuals. Thus, it is sensible to include additional ARCH and GARCH terms into the baseline specification. By changing this, some of the estimates indeed deviate substantially from the baseline estimates.

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<sup>31</sup>In this specification, the changes of the control variables was also reduced from two-day to one-day.

The highly significant impact of the SMP on Spanish spreads (-27 bp) found with the baseline specification turns insignificant and halves in magnitude when including an additional ARCH term. However, Irish and Belgian coefficients do not deviate substantially. Furthermore, a GJR-GARCH specification was tested. The magnitude of the coefficients is largely the same, but their significance is higher across variables and countries. Thus, even when taking into account asymmetries in the distribution, the estimates do not differ from the baseline estimates.

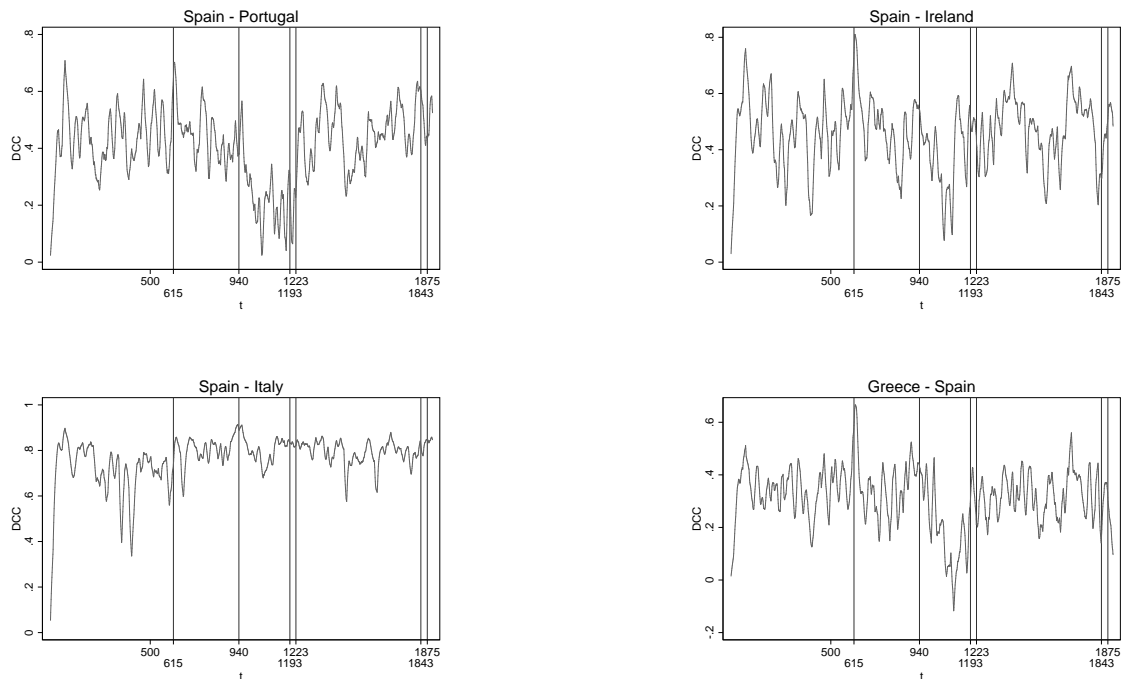
Another sensitivity test to be used in order to test the robustness of the baseline estimates is subsample analysis. It could be argued that market conditions between the three main sovereign bond market targeting programmes SMP, OMT and PSPP were fundamentally different and thus requires separate estimations. For this purpose, the sample was divided into three: a period of the start of the euro area sovereign debt crisis including the SMP (January 2008 until June 2012), a period of heightened market tensions that gradually decreased, including the OMT announcements (July 2012 until February 2013) and, finally, a period of a relatively calm sovereign debt market with increasingly lower inflationary expectations leading up to the PSPP (March 2013 until April 2015).

When estimating the baseline specification for the three subsamples, the impact of the asset purchase programmes generally increases to some extent. This deviation from the whole sample estimates is particularly strong for the SMP. The impact of the second SMP announcement on the Spanish spread increases from -27 bp to -48 bp. Moreover, the impact of the first SMP announcement on Spanish spreads also increases from -26 bp to -37 bp and becomes highly significant. The corresponding estimate for the Belgian spread increases from -11 bp to -14 bp.

There is a similar effect for the OMT when looking at the results of the subsample analysis. Compared to the baseline estimate, the impact of the OMT on Irish spreads increases in absolute terms by 4 bp to -38 bp. The other coefficients for the OMT remain unchanged. The estimates for the PSPP change somewhat with Belgian spreads now showing a reaction of -6 bp to the first PSPP announcement on 22 January 2015. The large effect of the PSPP purchases on Irish spreads turn from weakly significant to insignificant. On another note, as expected from the hypothesis of differing market conditions between the subsamples, the coefficients for some of the control variables vary considerably across subsample periods. The impact of inflationary expectations on Irish spreads, for instance, varies between -15 bp in the first subsample, -88 bp in the second subsample and -22 bp in the third subsample.

Viewed from a different perspective, in the particular crisis situation that led to the adop-

tion of the SMP and the OMT programmes it was not only important for the ECB to have an effect on the spreads themselves, but also on the correlations of spreads between euro area sovereigns. The correlation of spreads is an indicator for contagion. Following the approach of Missio and Watzka (2011), a Dynamic Conditional Correlations (DCC) model was estimated. The variances were subsequently standardized to obtain correlations. In many cases, the correlations show a downward trend after the second announcement related to the SMP on 7 August 2011, as shown in Figures 3. This is especially the case for Greek and Portuguese spreads. Thus, the SMP did not only reduce spreads, but also limited contagion between distressed euro area sovereigns.



**Figure 3:** Dynamic conditional correlations of Spanish spreads with spreads from other periphery euro area sovereigns. The vertical lines represent the asset purchase announcements (SMP1, SMP2, OMT1, OMT3, PSPP1, PSPP2).

Overall, the only change of assumptions that made a substantial difference to the baseline estimates was the inclusion of an additional ARCH term. However, the baseline model as a whole is still superior to a specification with more than one ARCH term. This has been tested by looking at various ARCH/GARCH specifications to explain the change in sovereign bond spreads. Also, the deviation when including an additional ARCH term is less pronounced in countries other than Spain. All in all, the sensitivity tests described in

this section show the high degree of robustness of the baseline estimates. In other words, the fact that the relaxation of all the different assumptions underlying the baseline do not substantially change the estimates, makes the baseline estimates particularly reliable.

## 6 Policy implications

What can euro area central bankers learn from this? Based on the results of this paper, an asset purchase programme intended to reduce sovereign bond market fragmentation in the short run has maximum impact if the ECB optimizes across the following three dimensions.

Firstly, the allocation of sovereign bond purchases should be based on three kinds of risks: default risk, redenomination risk and liquidity risk. This paper has supported the view of the theoretical literature that the size of sovereign bond spreads is determined by differences in default risk, redenomination risk and liquidity risk across countries. Hence, there is a justification for purchasing the bonds of those sovereigns with the largest risks in these three dimensions. These sovereigns should be targeted first and with most of the available firepower to achieve maximum immediate spread compression. The purchases of the ECB would thereby signal to investors that the events of default, redenomination and illiquidity in the concerned countries are more unlikely than before. As this information is priced in by investors, sovereign bond spreads will contract.

Secondly, the size of the asset purchase programme needs to be sufficient to move markets. The SMP contained no *ex ante* limit. It worked well in terms of spread compression because markets knew that the pockets of the ECB were deep enough to ultimately achieve a reduction of market fragmentation. When announcing the OMT programme, the ECB explicitly mentioned that purchases would be of unlimited size. The emphasis on the potential magnitude of the programme was an important factor for its effectiveness in moving the sovereign bond market. In contrast, the case of the CBPPs shows that programmes that are small relative to the market do not result in significant immediate spread compression.<sup>32</sup> Finally, the PSPP announcement in January 2015 surprised market participants as the amount of purchases was larger than what was commonly expected. This fact alone was likely to trigger portfolio rebalancing.<sup>33</sup> Hence, the ECB could either announce no target with respect to programme size, relying on its theoretically unlimited potential to purchase bonds. Or alternatively, the ECB could observe market expectations and announce a size that is above those expectations.

Thirdly, a clear communication of which assets are to be purchased facilitates a more pronounced immediate impact. If the primary target of an asset purchase programme is immediate spread reduction, the ECB would act optimally if the sovereign bonds to be purchased are announced explicitly *ex ante*. The bonds of these sovereigns would then be

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<sup>32</sup>Although in this case the programme was aimed at targeting the covered bond market, for which it was relatively large.

<sup>33</sup>This effect was limited by the fact that distressed sovereigns were not explicitly targeted.

the most likely to have their spreads reduced. This was done to a certain extent when announcing the SMP. However, in practice an asset purchase programme will most likely not exclusively aim at reducing sovereign bond spreads. In these cases, it might often be optimal to leave unclear which sovereigns will be targeted to what extent.

## 7 Conclusion

This paper confirmed and strengthened previous findings that the ECB's asset purchase programmes generally lowered sovereign bond spreads. A closer look into the differences across programmes yields substantially differing results. The SMP had the strongest immediate effects on sovereign bond spreads across the euro area, including some of the core countries. The effect of the SMP has also been shown to have limited the contagion between euro area sovereigns. The OMT announcements had a smaller immediate impact in some of the periphery countries. In this case, the effects propagated to sovereign spreads through a longer time period due to the relatively vague nature of the announcements. As had been expected, the most recent PSPP adopted by the ECB had no significant immediate impacts on sovereign bond spreads in the euro area. However, there might be a second-order effect from the PSPP on the spreads due to investors' search for yield. Finally, the CBPP's and the ABSPP were targeted at other markets and were not found to have immediately affected sovereign bond spreads.

The differences in the magnitude of the effects on spreads were due to the very different features of the programmes. The SMP was a large programme in the sense that no *ex ante* commitments on purchase volumes were made. Moreover, it was very clearly communicated to be implemented straight away<sup>34</sup> and in a way that targeted particularly sovereign bonds of distressed euro area countries. The OMT programme was large as well as it was set up with the potential to purchase unlimited amounts of sovereign bonds. Furthermore, given the conditionality element of the OMT, purchases were clearly targeted towards sovereign bonds of distressed euro area countries. As effective as this communication eventually turned out to be, immediate effects on spreads were smaller than through the SMP, due to a lack of clear commitments. As the PSPP is not targeted particularly at distressed euro area sovereigns, it was already expected that it would not immediately impact spreads. These findings are thus in line with the theory-based expectations.

On a methodological note, the increasingly popular event study approach to the evaluation of central banks' asset purchases proved to be useful. In this respect, the contribution of this paper was to carefully select a GARCH model specification that has been shown to be robust to sensitivity tests from a variety of different angles. However, several shortcomings of this approach have been identified. On the one hand, the event study framework does not allow to reliably extract effects that go beyond a 1 to 3-day event window. On the other hand, the GARCH specification was not very robust to changes in the number

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<sup>34</sup>For both SMP announcements on 10 May 2010 and on 7 August 2011, the implementation followed within one day after the announcement.

of ARCH terms. The effects of the asset purchases of the ECB found in this paper are smaller in magnitude than in the empirical literature. Moreover, the effects vanish when including the additional ARCH term. Therefore, immediate effects found in the previous literature might, on average, be overstated. Finally, with a dataset that covers a large time period with market regime changes, subsample analysis might yield more reliable results. However, this analysis is methodologically difficult as the regime changes might in fact be triggered by the asset purchase programmes themselves.

Apart from these general limitations of the methodological approach used in this paper, there are some specific limitations that should be taken into account by future research. The endogeneity of the daily purchases during the SMP programme could not be eliminated to a large extent. This was due to the fact that the necessary data was unavailable. Thus, the finding that there were no significant effects from the daily purchases of the SMP on sovereign spreads has to be taken with caution. Moreover, the use of more granular data (i.e. country-by-country data on both the controls and the asset purchases) could yield even more robust results. Finally, the approach of this paper could well be used for a counterfactual analysis.

Overall, the findings of this paper have policy implications for central banks and the ECB, in particular. When designing an asset purchase programme to combat increasing sovereign bond spreads, three criteria should be met to maximize the impact of the programme. Firstly, risky sovereigns should be targeted specifically in line with their relative default, redenomination and liquidity risks. Secondly, the programme should be large enough to move the market. In practice, no *ex ante* commitment on purchase volumes might be most effective in this respect. Finally, the programme should be clearly communicated to allow market participants to price in the decrease in the relative risk of the distressed sovereigns. Considering what is at stake in financial market crisis situations, having a clear recipe such as this might very well prevent a breakup of the euro area.



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