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Sovereign Risk, European Crisis Resolution Policies and Bond Yields

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Abstract

We study the effects of the ECB monetary policy and the European crises resolution policies on the 10 year sovereign bond yields of seven European countries. We find that some of the decisions have had significant impact on sovereign bond yields and have succeeded in reducing stress in the financial markets. However, the impact of the same policy decision might have been positive for some countries while negative for others, suggesting that contagion effects may be important. The economically most significant effects on the bond yields have been due to the announcement of ECB's Securities Market Programme.

JEL: F34, E42, G15

Key words: bond markets, policy effects, liquidity, European sovereign debt crisis, monetary policy

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1 Introduction

Following the creation of the monetary union in 1999, yields on euro area sovereign bonds began to converge rapidly, reflecting the elimination of inflation and exchange rate risks from bonds of individual countries. The convergence in sovereign bond yields was supported also by the zero risk weights assigned to government bonds in capital adequacy regulation and the European Central Bank's practice of valuing all euro area countries' bonds on the same terms as collateral for central bank credit to banks. The period of convergence was followed by a few-year phase when sovereign bond yields remained stable and low despite divergent macroeconomic and fiscal developments in euro area countries.

Investors' focus turned back to sovereign debt risks soon after the collapse of Lehman Brothers in September 2008. As the financial crisis intensified and spread to the real economy, European governments had to provide support to their banking sectors and use fiscal stimulus measures to support their economies. Macroeconomic fundamentals deteriorated faster in some countries than others. Deficits accumulated during the apparently tranquil phase prior to the crisis rapidly became a problem for those countries which had a limited room to manoeuvre their fiscal policy.

Sovereign bond yields began to increase rapidly in countries with a weakened macroeconomic situation and fiscal position or otherwise had the banking sector that was particularly vulnerable to international financial crises (Greece, Ireland and Portugal). In contrast, in countries with stronger economic fundamentals (eg Germany, the Netherlands and Finland), long-term interest rates declined as a result of flight-to-quality. In mid-May 2010 the Greek sovereign debt markets fell into severe stress and the crisis began to spread to other European countries. Market-based funding dried up for Greece, Ireland and Portugal, forcing these countries, one after another, to seek financial support in the European crisis mechanisms and the International Monetary Fund.

Euro area sovereign crises have led to a number of policy initiatives by the European fiscal authorities, including the decision to establish the European Stability Mechanism (ESM) as a follow up to the European Financial Stability Facility (ESFS) and the European Financial Stability Mechanism. A number of important policy initiatives have also been directed to improve the fiscal discipline within the euro area. At the same time, the European Central Bank has used a series of non-standard policy measures to contain pressure to the financial system by providing both short-term and long-term liquidity support

and lowered its main policy rate to historically low levels. Enhanced liquidity support have included lengthening of the maximum maturity of refinancing operations, extension of the eligible collateral list, provision of liquidity in foreign currencies, and provision of unlimited liquidity at a fixed rate. In addition, the ECB has set up the Covered Bond Purchase Program (CBPP) and Securities Market Program (SMP) to purchases private and public bonds.

In this paper, we study the impact of these eurowide policy decisions on the long term sovereign bond yields of seven euro area countries: Germany, France, Spain, Italy, Portugal, Greece and Ireland. We study the policy effects with an empirical model, where the explanatory variable is the change in the spread between the 10-year government bond yield and the 10 year euro swap rate. Our daily data runs from 1 Jan 2007 to 21 March 2012. We control for the effect of credit risk, liquidity risk and the general risk appetite, as they have been found[1] to be the main risk factors determining the yields of the European sovereign bonds.

Our results suggest that in general many policy decisions have had significant short term effects in the European bond market. The announcement of ECB's securities market program (SMP) have had a significant negative effect on yield changes in all the seven euro area countries considered in this study. At the same time, we do not find lasting impact of the liquidity support decision on sovereign bond yields and the same applies for the ECB's covered bond purchase program (CBPP). The latter is understandable, given that the CBPP was directed to support banking system at the early phase of the crises.

The ECB interest rate decisions have mainly been anticipated in the markets, but we find that in some cases lowering of the policy rate has led to a decline in the long term rate. News on financial support package requests and decisions have had some mixed impacts. The decisions on support packages have decreased yields in Greece, Ireland and Portugal, but increased the yields in Spain and Italy, suggesting possible policy contagion effects. On the one hand, the decisions related to European Stability Mechanism (ESM) have caused an increase in the yields in Germany, Ireland and Greece but no effects in other countries. On the other hand, the decisions regarding the European Financial Stability Facility (EFSF) seem to have decreased the yield changes significantly in most of the countries. The decision on the European economic recovery plan (EERP) had a

[1] E.g. Arghyrou and Kontonikas (2011), Barbosa and Costa (2010), Barrios et al. (2009), Favero et al. (2010), Fontana and Scheicher (2010), Manganelli and Wolswijk (2009), Pozzi and Woslwijk, (2008), Sgrerri and Zoli (2009)

significant increasing effect on the yields of most of the countries, but significantly negative effect on the yield changes in Portugal and Ireland. Other policy decisions, mainly related to strengthening of the growth and stability pack and improving of fiscal discipline have not had lasting impact on bond yields.

The paper is organized as follows. The second section summarizes the findings of the literature related to our paper. Our empirical model is presented in the third section, and the estimation results of the empirical model are presented in section four. The fifth section finally concludes our findings.

2 Determinants of the sovereign bond yields

There exists a vast literature studying the factors that determine the yields of the euro area sovereign bonds. The earlier literature focused on understanding the convergence in the euro area sovereign bond yields after introducing the EMU. The more recent literature on the other hand has been trying to explain the fast divergence of the yields in the same set of sovereign bonds.

In this section we first take a closer look at the evolution of the euro area government bond yields. We then provide some theoretical background for the empirical studies explaining the determinants of the sovereign bond yields and finally summarize the main results of the empirical literature.

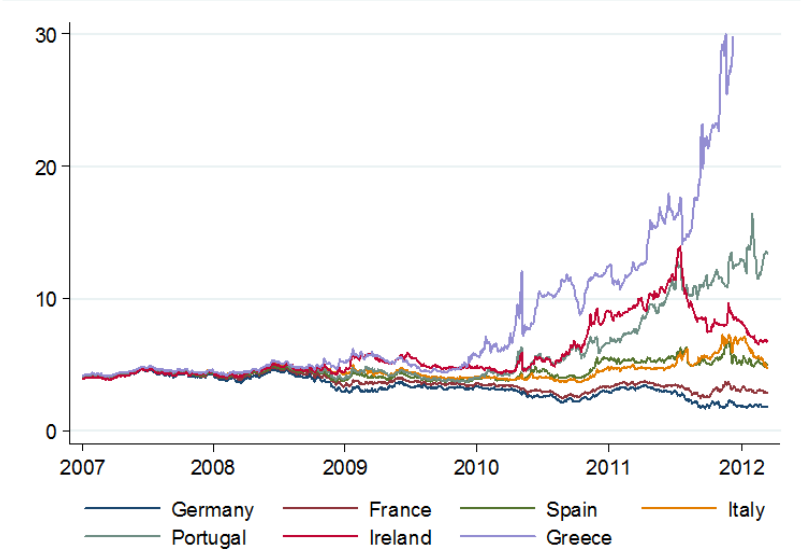
2.1 Evolution of euro area government bond yields

After the introduction of euro the yields of the euro area sovereign bonds converged rapidly. At that time this development was believed to be fairly natural. Given that there was no longer exchange rate and inflation risk, it was quite understandable that the yields were decreasing. At the same time with the decreased price for debt, the liquidity and credit risks decreased as well. The phase of convergence was followed by few years of apparent harmony, and the credit market focused more on corporate bonds and other 'more exciting' debt instruments.

The markets turned their focus to the euro area sovereign debt market again after the collapse of the Lehman Brothers in September 2008. Figure 1 presents the evolution of sovereign bond yields for selected euro area countries. It can be seen that the development during the past five years has been dramatic. It is easy to see that there has been a regime

shift in the pricing of the European sovereign bonds.

Figure 1. Yields of the 10-year government bonds for selected euro area countries



When the financial crisis intensified and spread to the real economy, the euro area governments provided support for the banking sector and used stimulus measures for supporting their economies. However, the strength of the spillovers from financial markets to the real economy was surprisingly strong and the macroeconomic fundamentals deteriorated in many euro area countries dramatically, leading to significant widening of the euro area bond yields.

Long term interest rates started to rise especially in those countries that had accumulated deficits during apparently tranquil times or otherwise had the banking sector that was particularly vulnerable to international financial crises. The crisis hit especially hard Greece, where debt markets have been under severe stress since the mid 2010, but later on the debt crisis started to spread also to other financially vulnerable euro area countries with well known consequences. Greece, Ireland and most recently Portugal have been driven out from the markets and are now primarily financed by the European crises resolution mechanisms and the IMF. Lastly, also the large euro area countries Spain and Italy have suffered from deteriorating market sentiment driving up the yields and hampering their ability to roll-over debt and finance their deficits at sustainable rates.

Euro area sovereign crises have led to a number of policy actions and initiatives by the European fiscal authorities, including the decision to establish the European Stability Mechanism as a follow up to the European Financial Stability Facility and the European

Financial Stability Mechanism. A number of important policy initiatives have also been directed to improve the fiscal discipline within the euro area. At the same time, the European Central Bank has used a series of non-standard policy measures to contain pressure to the financial system by providing both short-term and long- term liquidity support and lowered its main policy rate to historically low levels. Enhanced credit support measures have included lengthening of the maximum maturity of refinancing operations, extension of the eligible collateral list, provision of liquidity in foreign currencies, and provision of unlimited liquidity at a fixed rate. The ECB has also acquired private and public bonds within its Covered Bond Purchases Program and Securities Market Program, which were tailored to support the market liquidity and transmission of monetary policy.

2.2 Theoretical background

The empirical studies explaining the determinants of the sovereign bond yields often rely (loosely) on the structural model of Merton (1974). The key idea behind the Merton model is that a risky zero-coupon bond has the same payoff structure as a risk-free bond plus a put option on the firm's value, with a strike price equal to the face value of the firm's debt. Therefore, the value of the put option is the cost of eliminating the credit risk and the default-risky bonds can hence be priced by using standard option pricing theory such as Black-Scholes equation.

The model is relying on an assumption that the firms default is triggered when the firm value falls below some threshold and that this threshold is a function of the amount of debt that the firm has. This relates the corporate credit risk to its fundamentals such as leverage ratio and the volatility of the firm value. The third factor that determines the price of a default risky bond in the Merton model is the risk-free interest rate.

The original Merton model has been extended in various ways. The extension that is the most relevant to us is the one by Gapen et al (2005). While the original Merton model considers the corporate bonds, Gapen et al (2005) extend the model for the default-risky sovereign bonds. Gapen et al. (2005) state, that the main factors of the sovereign credit risk are the volatility of sovereign assets and a country's leverage.

Even though the Merton model has had an influence on some of the empirical studies of yield determination, most of the papers are purely empirical[2]. There exists strong

[2]In their recent paper, Arghyrou and Tsoukalas (2011) find the lack of theoretical background troublesome and propose a new theoretical framework for the European debt crisis. The key idea in their model is that in the currency union the systemic macroeconomic risks cannot be solved by currency adjustments,

empirical evidence, discussed in more detail in section 2.3, suggesting that besides the credit risk, the sovereign yields are affected by liquidity risk, general risk appetite and perhaps the interaction terms of these three factors.

2.3 Empirical evidence on yield determination

The empirical evidence on the determinants of the European sovereign bond yields is extensive, yet mixed. Different factors have been found to be relevant depending on the used set of countries, time period, data frequency, estimation methodology or proxies for the different risk factors. One thing that almost all studies seem to agree upon, however, is that there exists a common risk factor that reflects investors' changing attitudes towards risk (Arghyrou and Kontonikas, 2011; Barrios et al.. 2009; Favero et al., 2010; Manganelli and Wolswijk, 2009; Pozzi and Woslwijk, 2008; Sgrerri and Zoli, 2009). The rationale behind these findings is that higher uncertainty increases investors' risk aversion and this causes them to restructure their portfolios. Typically this is done in favor of bonds with safe-heaven status, and hence the yields of the bonds with higher default risk increase.

Even though it is widely agreed that such a factor of general risk attitude or appetite exists, there is still an ongoing debate on how to measure this factor, and what are the underlying causes of the changes in investors' risk aversion. Manganelli and Wolswijk (2009) suggest that the ECB policy rate is the key issue driving the aggregate risk perception. Others concentrate less on the causes of uncertainty and settle for measuring the risk attitude with some financial market variables that describe the uncertainty in the global financial markets, such as the S&P 500 implied volatility index, i.e. VIX-index[3] (Arghyrou and Kontonikas, 2011; Beber et al., 2009; Borgy et al., 2011; Gerlach et al., 2010) or the spread between the yields of US corporate bonds against US treasury bills (Attinasi et al., 2009; Favero et al., 2010; Haugh et al., 2009).

Besides the common market risk factors, the models of yield determination also include country-specific risk factors. The most important of those is the sovereign credit risk. Credit risk premium is the part of the yield that an investor demands as a compensation for tolerating the non-zero probability that a government defaults totally or partially and

but are instead diverted to the sovereign debt market and hence cause increasing default risk.

[3]The Chicago Board Options Exchange Volatility Index, i.e. VIX-index is constructed by using the implied volatility of the S&P 500 index options with different strikes. It reflects the expected movement in the S&P 500 index over the next 30-day period and is hence typically used as an index of market sentiment or fear. Bekaert et al. (2010) proposed a decomposition of VIX index to risk appetite and uncertainty factors.

the investor does not regain his full investment or interest.

Most of the existing studies have used data sets with low frequency (monthly or quarterly). This has some advantages, such as being able to use the macroeconomic statistics (e.g. debt-to-GDP, budget deficit-to-GDP, debt service ratio and current account balance or expected fiscal positions by using forecasts on those same variables) that are released only rarely to describe the fiscal position and hence credit risk of the country (Arghyrou and Kontonikas, 2011; Aßmann and Boysen-Hogrefe, 2011; Attinasi et al., 2009; Barrios et al., 2009; Haugh et al., 2009). Some papers have also used a country's credit rating as an indicator for credit risk (e.g. Manganelli and Wolswijk, 2009). The studies that use higher frequency data typically use other measures for credit risk, such as credit default swap (CDS) spreads[4] (Arghyrou and Kontonikas, 2011; Barrios et al., 2009; Beber et al., 2009), because the variables that change as infrequently as once in a month or quarter would probably not have an effect on noisy daily yields.

The empirical evidence on the relevance of the fiscal imbalances is mixed. However, an increasingly common finding in the literature is that expected fiscal deficits have an effect on long-term government bond yields (Arghyrou and Kontonikas, 2011; Attinasi et al. 2009; Sgherri and Zoli, 2009; Barbosa and Costa, 2010; Gerlach et al., 2010). Good summary of findings of this literature is provided by Haugh et al. (2009). The impact of CDS spreads on bond yields has been found to be positive. However, their use is somewhat problematic because of the potential endogeneity problems. As being a tradable instrument in the same markets, the prices of credit default swaps are likely to be determined at least partially by the same factors as the bonds themselves.

Another potential risk factor explaining the yield differentials is the liquidity risk. If the bond markets are large and deep, investors are able to find a counterpart more easily and execute trades when they choose. In the liquid markets it is also less likely that prices will change due to individual transactions. Due to these reasons, investor will require a smaller premium in terms of the yield. Therefore, the liquidity risk premium measures the extra interest rate an investor requires for bearing the liquidity risk.

Liquidity is typically considered hard to measure. The used proxies have been e.g. bid-ask spreads (Aßmann and Boysen-Hogrefe, 2011; Fontana and Scheicher, 2010; Gómez-

[4] A credit default swap (CDS) is an agreement between two parties, in which one can buy an 'insurance' against a potential default of a bond. The buyer of the CDS makes a series of payments (i.e. spread) to the seller, and in case of the default the seller will compensate the buyer for the losses she made in the underlying bond contract.

Puig, 2009) or the size of the government bond markets (Arghyrou and Kontonikas, 2011; Bernoth et al., 2012; Gomez-Puig, 2009; Haugh et al., 2009; Attinasi et al., 2009), or some other measures such as the yield spread between bonds issued by KFW and German government bonds, used by Schwartz (2009).

The findings on the role of the liquidity risk seem to be mixed. Some find liquidity risk to be an important factor for yield determination (Arghyrou and Kontonikas, 2011; Attinasi et al., 2009; Barrios et al., 2009; Favero et al., 2010; Gerlach et al., 2010; Gómez-Puig, 2009; Manganelli and Wolswijk, 2009; Sgherri and Zoli, 2009; Schwartz, 2009), whereas sometimes it has not been found to have significant impact on yields (Bernoth and Erdogan, 2010; von Hagen et al., 2011).

Other variables that have been included in the models of yield determination are e.g. the risk-free interest rate (e.g. Fontana and Scheicher, 2010; Oliveira et al., 2012), local stock market indices (e.g. Oliveira et al., 2012), volatility of the local asset markets (e.g. Barrios et al., 2009; Fontana and Scheicher, 2010, Oliveira et al., 2012), foreign exchange market volatility (e.g. Barrios et al., 2009; Fontana and Scheicher, 2010) and term structure variables (Fontana and Scheicher, 2010; Oliveira et al., 2012). Neither of these variables has gained a status of belonging to the set of "core risk factors" as the three variables mentioned above.

One reason that could explain the mixed empirical findings is that the relevance of the different risk factors changes in time as suggested by e.g. Aßmann and Boysen-Hogrefe (2011), Arghyrou and Kontonikas (2011), Barrios et al. (2009), Oliveira et al. (2012) and many others. It might not be very surprising that the risk factors would have changed between the pre-emu, pre-crisis and crisis periods, but it has been also suggested that there have been two or three regime shifts also during the financial crisis (Barbosa and Costa, 2010; Caceres et al., 2010).

Many studies (e.g. Arghyrou and Kontonikas, 2011; Bernoth et al., 2010) confirm that the markets have been penalizing bad fiscal positions more during the financial crisis. Also the required liquidity risk premium has been found to be higher during the crisis (Aßmann and Boysen-Hogrefe, 2011). The relevance of the global investors' risk aversion has also increased during the crisis (Arghyrou and Kontonikas, 2011; Barrios et al., 2009; Bernoth et al., 2010; Haugh et al., 2009; Sgherri and Zoli, 2009) and the market has also priced the interaction between the risk aversion and the credit and liquidity risks (Manganelli and Wolswijk, 2009; von Hagen et al., 2011).

The contagion in the euro area sovereign markets has been studied e.g. by Arghyrou and Kontonikas (2011), Caceres et al. (2010), Claeys and Vašíček (2012). Arghyrou and Kontonikas (2011) use monthly 10 year bond data for ten euro area countries covering the period from Jan 1999 to Feb 2010 and find that many EMU countries, especially Portugal, Ireland and Spain, have experienced contagion from Greece. Claeys and Vašíček (2012) also find significant spillover effects in these countries. According to Caceres et al. (2010), after September 2008, risk of contagion was also an important factor pricing the euro area sovereign bonds.

From the number of papers examining the yield determination during the financial crisis, the paper that comes closest to ours is that of Attinasi et al. (2009). They study the determinants of the sovereign bond yields in ten euro area countries during the period from 31 July 2007 to 25 March 2009. Besides studying the risk factors, they examine the announcements of the government rescue packages for banks. They find that the announcements of the rescue packages have caused repricing of the sovereign risk, but the actual amount of the package had not have a significant effect on government bond yields. Therefore, the results of Attinasi et al. (2009) suggest that the stress in the national banking sector was transferred to the public sector through government's rescue packages.

Instead of using announcements on banking rescue packages, this paper contributes to the literature by studying the impact of the announcements on various political decisions made in Europe during the financial and debt crises. To the best of our knowledge, the effect of the policy decisions on euro area sovereign yields has not been studied before. Our paper differs from others also by data frequency. In order to be able to capture the policy impact from other factors in the bond markets, we need to use daily data. Other papers typically concentrate on slower dynamics (weekly, monthly or quarterly) of the sovereign bond markets. Our empirical model on yield determination and policy effects is explained more carefully in the next section.

3 Empirical model on yield spreads

This section presents the empirical model used for studying the determinants of the yield spreads on the European sovereign bonds. We first describe the financial market data set, then the policy decisions of interest and finally the econometric model to be estimated.

3.1 Financial market data

Our data set of dependent variables includes daily yield spreads between the benchmark 10-year government bond[5] and the 10-year euro swap rate from 1 January 2007 to 21 March 2012 for the following countries[6]: Germany (DE), France (FR), Spain (ES), Italy (IT), Portugal (PT), Ireland (IE) and Greece (GR). The dependent variable is henceforth denoted as $y_{i,t}$ for the country i, where $i = \{DE, FR, ES, IT, PT, IE, GR\}$ and day t. The group of countries was selected such that it includes both countries in stress and those that are healthier. The selected countries also vary in terms of the size of the economy.

The ten-year bond maturity was chosen because it has been the most common horizon used in the similar literature. The euro swap rate (e.g. Beber et al., 2009) and German government bond yield (e.g. Arghyrou and Kontonikas, 2011; Haugh et al., 2009) have both been used as a measure for the risk-free interest rate in the literature. From these two we chose to use the first one, because the euro swap rate has some advantages compared to use of the German Bund yield. First, it allows for adding Germany in the analysis and second, according to e.g. Beber et al. (2009) it is commonly seen as the measure which the market participants prefer as a risk-free rate.

As discussed in the subsection 2.3, there exists wide empirical evidence that the sovereign bond yields are determined by three main risk factors: credit risk, liquidity risk and general risk appetite. Following the literature, we also try to capture these risk factors by adding proxies for these risk factors in the model as explanatory variables. We measure the country-specific risk factors, i.e. credit risk and liquidity risk by 10-year CDS spreads, henceforth denoted as $CDS_{i,t}$ and bid-ask spreads of the 10-year bond yields, henceforth denoted as $BAS_{i,t}$, respectively.

Typical proxies for country credit risk used in the literature are e.g. ratio of debt to its assets, i.e. leverage ratio, or some measures for the current or expected fiscal imbalances. However, given that our data set frequency is daily, and these macroeconomy based proxies are usually available quarterly or monthly at best, they are unfortunately less suitable for our purposes. CDS price is a market based proxy which has the advantage of being available on daily basis. However, it is very likely that the CDS spreads and the bond spreads share some determinants, one of which could be the international risk appetite. Therefore the use of CDS prices introduces a potential endogeneity problem. We reduce

[5] The data were obtained from Thomson-Reuters.

[6] Due to lack of data on some explanatory variables, the dates are not exactly these for all countries.

the risk of endogeneity problem by using the lagged CDS spread as explanatory variable[7].

Another potential problem with the CDS spreads and bid-ask spreads is their correlation with other explanatory variables, i.e. measures for the risk aversion. Even though the bid-ask spread is widely accepted as a measure for liquidity, it is also recognized that the liquidity risk correlates strongly with the market uncertainty. The same applies for credit risk, although the empirical evidence is less clear. To study the relevance of these effects we do some robustness checks by including interaction terms between the CDS spread/bid ask spread and measures for risk aversion.

As for the general risk aversion, we use VIX-index, henceforth denoted as VIX_t, to describe the risk appetite of the global investors and iTraxx Europe index[8], henceforth denoted as $ITRX_t$, to proxy the general risk atmosphere in the European debt market. We also considered other indicators describing uncertainty in the financial markets, but they all turned out to be insignificant and were hence left out from the final model specification. These indicators were the VSTOXX index[9] to describe the uncertainty in the European stock markets, the one month implied volatility of the EUR/USD exchange rate to represent the stress in the currency markets[10], the squared bond yield changes to measure the uncertainty in a particular sovereign bond market and the weekly CISS index[11] by Hollo et al. (2012) to describe the level of systemic risk at the European financial markets.

Besides the different risk factors, we considered including the 3-month Euribor interest rate to proxy the risk-free short term interest rate in the model, but it turned out to be statistically insignificant and was hence left out from the final model specification.

In order to capture possible direct contagion effects between the countries, we include the lagged bond yield spreads of all the countries as an explanatory variable. We recognize that the contagion effects are not best captured with a noisy daily data, but we include the contagion variables as a first approximation to see if there are any signs of patterns of contagion between the countries.

Besides the risk factors and the contagion variables, our model includes dummy vari-

[7] The lagged values are also used for bid-ask spread and the general risk aversion variables.

[8] The Markit iTraxx Europe index comprises 125 equally weighted credit default swaps on investment grade European corporate entities.

[9] VSTOXX index measures the implied volatility of the EURO STOXX 50 index options and is created jointly by Deutche Borse and Goldman Sachs to measure volatility in the euro-area.

[10] Implied volatility is a measure of the market expected future volatility of a currency exchange rate from now until the maturity date.

[11] CISS index is a composite index using information from the total of 15 individual financial stress measures from financial intermediaries (banks and non-banks), money markets, securities (stocks and bonds) and foreign exchange markets). Linear interpolation is used for changing weekly data frequency to daily.

ables for the policy decisions. These are discussed in more detail in the next subsection.

3.2 Policy decisions

All the European wide policy decisions we are interested are listed in Appendix. To study the impact of these events, we create two dummy variables for each policy decision such that the first dummy variable equals one at the date of the announcement of the policy decision and the second dummy variable equals one on the day following the announcement, and zero otherwise.

Instead of creating just one dummy variable for each decision, we create two of them to make sure we capture the effect of the decision fully. In some cases it might be that the decision is done in the evening when the markets are already closed for that day, and hence the market reacts to the announcement only in the day following the announcement. Also, it might be that the effect of some of the decisions on sovereign risk is difficult to judge, and hence the market is processing the decision longer than one day.

Altogether we have identified more than 50 important policy decisions since January 2007. Because such a large amount of dummy variables would easily lead to multicollinearity problems in estimation, we divide the policy decision to eleven categories, and combine the dummy variables belonging to the same category. The policy categories and the policy decisions belonging to each category are presented in Table 1.

The first five categories include all the policy decisions made by ECB. The decisions to increase and decrease the interest rate are studied separately, and the categories of these dummy variables are denoted as $ECBup_t$ and $ECBdw_t$, respectively. The dummy variable related to ECB's liquidity support decisions is denoted as $ECBls_t$. The policy announcements related to the ECB's covered bond purchase program and securities market program are studied separately, and the dummy variables for these categories are denoted as $ECBcb_t$ and $ECBsmp_t$, respectively[12].

As for the rest of the groups we try to disentangle among the decisions that have implied a launch of the new financial support program (requests for the support packages, denoted as $SPreq_t$, and the announcements related to the decisions of the support packages, denoted as $SPdec_t$, are studied separately), announcements related to the creation of the ESM (denoted as ESM_t, decisions on widening of the EFSF mandate (denoted as

[12] In the earlier version of the model (see Kilponen-Laakkonen-Vilmunen, 2012) the ECB policy decisions were categorised differently. We separated the short term and the long term liquidity policy decisions, whereby the ECB's SMP program was included among the long-term liquidity support decisions.

$EFSF_t$), announcement of the European Economic Recovery Plan (denoted as $EERP_t$) as well as other decisions related to European economic governance (denoted as OD_t). These other decisions are primarily related to strengthening of the stability and growth pact, and improving of fiscal discipline and fiscal coordination in the euro area.

Table 1. Categories of the policy decisions

ECB interest rate decisions
Increases ($ECBup_t$)
8 Mar 2007, 6 Jun 2007, 3 Jul 2007, 7 Apr 2011, 7 Jul 2011
Decreases ($ECBdw_t$)
6 Nov 2008, 8 Oct 2008, 4 Dec 2008, 15 Jan 2009, 5 Mar 2009, 2 Apr 2009, 7 May 2009, 3 Nov 2011
ECB liquidity support ($ECBls_t$)
22 Aug 2007, 6 Sep 2007, 8 Nov 2007, 12 Dec 2007, 7 Feb 2008, 11 Mar 2008, 23 Mar 2008, 2 May 2008, 31 Jul 2008, 4 Sep 2008, 26 Sep 2008, 29 Sep 2008, 7 Oct 2008, 13 Oct 2008, , 4 Jun 2009, 4 Aug 2011, 6 Oct 2011, 8 Dec 2011
ECB Covered Bond Purchases Program ($ECBcb_t$)
7 May 2009, 6 oct 2011
ECB Securities Market Program ($ECBsmp_t$)
10 May 2010
Support Packages
Requests ($SPreq_t$)
23 Apr 2010, 21 Nov 2010, 8 Apr 2011
Decisions ($SPdec_t$)
11 Apr 2010, 10 May 2010, 28 Nov 2010, 16 May 2011, 21 Jul 2011, 20 Feb 2012
Decisions on ESM (ESM_t)
28 Oct 2010, 16 Dec 2010, 21 Mar 2011, 2 Feb 2012
Widening of the Mandate of EFSF/ESM ($EFSF_t$)
20 Jun 2011, 21 Jul 2011, 29 Nov 2011
European economic recovery plan ($EERP_t$)
26 Nov 2008
Other Decisions related to European economic governance (OD_t)
27 May 2009, 29 Sep 2010, 11 Mar 2011, 25 Mar 2011, 8 Nov 2011, 19 Dec 2011

3.3 The model

To study the determinants of the yield spreads of the European sovereign bond markets, and the impact of the fiscal and monetary policy decisions in the Europe during the debt crisis, we estimate a following model (1) with the Ordinary Least Squares estimation method for all the countries ($i = Germany$, $France$, $Spain$, $Italy$, $Portugal$, $Ireland$, $Greece$).

The dependent variable and the explanatory variables are explained in subsections 3.1 and 3.2. As the dependent variable is very likely to be nonstationary, noticed also by many studies using similar data to ours (e.g. Fontana and Scheicher, 2010), the model is estimated in differences. α is a constant, β_i for $i = \{DE, FR, ES, IT, PT, IE, GR\}$ are parameters that describe the potential contagion effects between countries, γ_i for $i = \{CDS, BAS, VIX, ITRX\}$ are parameters for controlling the effects of the different risk factors, ϕ_i for $i = \{ECBup\_n, ECBdw\_n, ECBls\_n, ECBcb\_n, ECBsmp\_n, SPreq\_n, SPdec\_n, ESM\_n, EFSF\_n, EERP\_n, OD\_n\}$ capture the impact of different categories of policy decisions on the day of the decision ($n = 0$) and on the following day ($n = 1$) and $\varepsilon_{i,t}$ is the error term of the model. The Newey-West standard errors (with 30 lags) are used because of the undefined form of autocorrelation and heteroskedasticity in the residuals.

$$
\begin{aligned}
\Delta y_{i,t} \;=\; & \alpha + \sum_{i=1}^{7} \beta_i \Delta y_{i,t-1} + \gamma_{CDS} \Delta CDS_{i,t-1} + \gamma_{BAS} \Delta BAS_{i,t-1} \\
& + \gamma_{VIX} \Delta VIX_{t-1} + \gamma_{ITRX} \Delta ITRX_{t-1} \\
& + \sum_{n=0}^{1} \phi_{ECBup\_n} ECBup_{t-n} + \sum_{n=0}^{1} \phi_{ECBdw\_n} ECBdw_{t-n} \\
& + \sum_{n=0}^{1} \phi_{ECBls\_n} ECBls_{t-n} \\
& + \sum_{n=0}^{1} \phi_{ECBcb\_n} ECBcb_{t-n} + \sum_{n=0}^{1} \phi_{ECBsmp\_n} ECBsmp_{t-n} \\
& + \sum_{n=0}^{1} \phi_{SPreq\_n} SPreq_{t-n} + \sum_{n=0}^{1} \phi_{SPdec\_n} SPdec_{t-n} \\
& + \sum_{n=0}^{1} \phi_{ESM\_n} ESM_{t-n} + \sum_{n=0}^{1} \phi_{EFSF\_n} EFSF_{t-n} \\
& + \sum_{n=0}^{1} \phi_{EERP\_n} EERP_{t-n} + \sum_{n=0}^{1} \phi_{OD\_n} OD_{t-n} + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

4 The results

In this section we present the estimation results of the empirical model (1) proposed in the subsection 3.3. The main results are presented in Tables 2 and 3. We first summarize the findings related to the three risk factors: credit and liquidity risk and the general risk aversion as well as the contagion variables. We then summarize the impact of the policy decisions on the sovereign bond yields. Finally, we present findings of some robustness checks related to the results.

4.1 Risk factors and contagion variables

According to our estimation results (Table 2), the impact of CDS spreads and bid ask spreads, which are used as proxies for credit and liquidity risk, respectively, are typically positive, as expected. Interestingly, the bid ask spread correlates negatively with the yield changes in the case of Ireland and Portugal. The negative parameter coefficient may reflect the ECB's policy interventions in the secondary bond markets when the liquidity has been drying up in the markets and contributed to increasing yields. If this is the case, the supportive participation by the ECB to increase liquidity in the Portugese and Irish sovereign bond market has successfully reduced the liquidity risk in these markets.

Of the proxies for the general risk appetite, the impact of iTraxx index is significant only in the case of Germany. For all the other countries the parameter coefficient for iTraxx index does not differ from zero (in case for Ireland iTraxx is positive and significant at 10% level). The impact of VIX-index is significantly negative for almost all countries. Negative coefficient is perhaps best explained by the fact that VIX index reflects the riskiness of the stock markets rather than the general risk appetite per se[13]. This is supported by the fact that both variables describing the general risk appetite have been at their highest level in the beginning of the financial crisis, especially during the year 2008. Hence, it might be that at that time the uncertainty was reflected more in the other segments of the financial markets such as stock markets (especially banking sector) and corporate bond markets, and the sovereign bonds were seen as a less risky choice. However, it is quite clear that neither of these risk aversion measures does capture the current uncertainty among the European bond market investors very well. Given that we did not find any significant impact by using some alternative measures for risk aversion (described in subsection 3.1), it might be that general risk appetite is less important factor in pricing the European sovereign bonds compared to the credit and liquidity risks. It is also possible that our credit and liquidity riks measures are reflecting the uncertainty in the bond market so strongly, that it its effect is difficult to identify separately.

So far, our results for contagion channels, other than those directly related to the European crises resolution policies, are rather weak. There is some evidence of negative correlation between the yield changes of some countries (e.g. Ireland and Greece) and Germany, which might be explained by the flight-to-safety. There were also some significant

[13] Bekaert et al. (2010) suggested that the VICX-index can be decomposited into separate general risk aversion and uncertainty factors.

parameter coefficients within the countries Spain, Italy and Portugal, but it is difficult to interpret these results as a sign of systematic patterns of contagion.

Table 2. Estimation Results for the risk factors and contagion variables

	Germany	France	Spain	Italy	Portugal	Ireland	Greece
γ_{CDS}	0.020	0.080^{*}	0.106^{*}	0.033	0.124^{*}	0.002	0.100^{***}
γ_{BAS}	0.079^{***}	0.011	0.040	0.080^{***}	-0.157^{***}	-0.149^{***}	0.091^{**}
γ_{VIX}	-0.083^{**}	-0.065^{**}	-0.063^{*}	-0.102^{***}	-0.069^{***}	-0.060^{**}	-0.005
γ_{ITRX}	-0.094^{**}	-0.015	-0.027	0.047	0.038	0.057^{*}	0.005
β_{DE}	-0.300^{***}	-0.088^{**}	-0.026	0.051	-0.034	-0.075^{*}	-0.070^{**}
β_{FR}	0.093^{**}	-0.124^{**}	-0.058	-0.187^{**}	0.023	0.037	0.067
β_{ES}	-0.074	-0.104	0.222^{***}	0.021	-0.079	0.033	0.040
β_{IT}	-0.095^{*}	0.114	-0.114^{**}	0.125^{*}	0.052	-0.003	0.036
β_{PT}	-0.039	-0.113	-0.137^{*}	-0.136	0.148^{**}	-0.057	0.056
β_{IE}	0.052	0.060	0.098^{**}	0.141^{***}	0.045	0.279^{***}	-0.019
β_{GR}	-0.013	0.023	-0.054	-0.027	-0.019	-0.012	0.005

Note: Table presents the estimation results of the model (1) for the risk factors and the contagion variables. The estimation results for the policy decisions are presented in Table 3. The model is estimated in differences and using Newey-West standard errors with 30 lags. *, ** and *** denote the 10%, 5% and 1% significance levels, respectively.

4.2 Policy decisions

The impacts of the policy decisions vary (Table 3). The interest rate decisions of the ECB do not affect the long term sovereign bond yields very strongly. The increases have hardly any effect, while decreases of the interest rate seem to decrease long term interest rates in some countries. The liquidity support and the covered bond program[14] of ECB has not affected the 10-year sovereign bond yields in general while the announcement of the ECB's securities market program have had a significant and rather large impact in all the seven countries. It has to be kept in mind, however, that on the same day with the securities markets program, the decision of 750 billion EUR resque package was made. This decision is included in the support package decision category, but probably explains part of the strong reaction in 10 May 2010.

The decisions related to the government support packages are mixed. The decision to request financial support has typically not affected the markets significantly, maybe

[14]The covered bond program category includes to decisions, the decisions on the first and the second programs. If we study these separeately we find that the announcement of the first program has a very significant negative reaction to the yields on all of the countries. However, the second program does not have an effect and hence the overall effect of these two decisions is negative in most of the cases but statistically insignificant.

Table 3. Estimation Results for the policy decisions

	Germany	France	Spain	Italy	Portugal	Ireland	Greece
ϕ_{ECBup_0}	0.275	−0.013	0.064	0.137	−0.541	−0.352	−0.142
ϕ_{ECBup_1}	−0.592***	−0.039	0.298	0.244	−0.228*	0.982	−0.033
ϕ_{ECBdw_0}	−0.511	−0.870**	−0.239	−0.609**	−0.191	−0.456**	0.229
ϕ_{ECBdw_1}	−0.217	−0.025	0.029	0.350	−0.070	0.077	0.241
ϕ_{ECBls_0}	0.400*	0.760**	0.586	0.648	0.088	−0.068	0.107
ϕ_{ECBls_1}	−0.151	−0.697**	−0.437	−0.291	−0.126	−0.254	−0.159
ϕ_{ECBcb_0}	−0.365	−0.408	−1.205	−1.227	−0.150	0.327***	−0.090
ϕ_{ECBcb_1}	1.059	0.420	0.029	0.529	−0.136	−0.055	0.587
ϕ_{ECBsmp_0}	1.195***	−0.609*	−5.967***	−4.503***	−8.929***	−9.740***	−7.779***
ϕ_{ECBsmp_1}	−2.434***	−2.216***	−0.816	−0.782	1.413*	2.221***	1.208**
ϕ_{SPreq_0}	0.533**	0.058	0.019	−0.236	0.036	−0.792	0.076
ϕ_{SPreq_1}	−0.301***	−0.003	0.950	0.424	0.657***	1.223	0.345
ϕ_{SPdec_0}	0.624***	0.240	−0.318	−0.523	−0.820*	−1.101	−0.336*
ϕ_{SPdec_1}	−0.282**	0.202	0.708**	0.683*	−0.147	0.002	−0.231
ϕ_{ESM_0}	0.472	−0.345	0.297	−0.112	−0.087	0.095	0.350*
ϕ_{ESM_1}	0.233*	0.132	−0.000	0.242	−1.436	0.641***	0.896
ϕ_{EFSF_0}	−0.311**	−0.942	−1.707**	−1.008	0.153	−0.250	0.002
ϕ_{EFSF_1}	−0.149	−0.795	−0.609	−0.458	0.416	−1.454**	−0.988**
ϕ_{EERP_0}	0.753***	−0.021	0.411***	0.326***	−0.179**	−0.134*	0.010
ϕ_{EERP_1}	0.717***	0.493***	0.355***	0.761***	−0.018	0.121	0.027
ϕ_{OD_0}	−0.532***	−0.427*	−0.509***	−0.301	−0.377	−0.105	0.050
ϕ_{OD_1}	0.642	0.927	0.264	0.651	0.126	0.095	−0.216

Note: Table presents the estimation results of the model (1) for the policy decision dummies. The estimation results for the risk factors and the contagion variables are presented in Table 2. The model is estimated in differences and using Newey-West standard errors with 30 lags. *, ** and *** denote the 10%, 5% and 1% significance levels, respectively.

because the decisions have been already anticipated. At the same time, the decisions to grant the package have had significant, yet mixed impacts. The decision has decreased the yields in the receiving countries, but increased the yields in Spain and Italy. The latter may reflect contagion effect, whereby the markets have re-evaluated the riskiness of sovereign bonds in the other euro area countries after the financial support decision has been made. The fact that response of German 10 –year bund yield to financial support has been mostly positive, may well reflect the risks sharing aspects of the financial rescue packages.

The decision on ESM seems to have increased the long term interest rates in some countries, while the decisions related to the EFSF has rather decreased the long term

interest rates. Especially the parameter coefficients of Ireland and Greece, which are statistically significant and rather large, suggest that these policy decisions have been successful at least in the short run.

The parameter coefficient for the European Economic Recovery Plan is positive, as expected, for the most of the countries. Short run economic stabilization will probably increase the uncertainty related to the long run sustainability of the public sector, which dominates the interest rate effect in most of the countries. However, the coefficient is significantly negative for Ireland and Portugal. One possible explanation is that the exports in these two small open economies are gaining from the euro area wide economic fiscal stimulus plans and hence the markets have interpreted this as good news for the sovereign debt in the short run as well. If this is the case, then it is clear that short term stabilization concerns have dominated the sustainability concerns (at the time) in these countries.

Other policy decisions have had statistically significant negative effect on the sovereign yields in Germany, France and Spain on the day of the announcement. However, this negative impact has been overturned by a positive coefficient on the following day. For other countries, the effects have not been statistically significant.

4.3 Robustness checks and non-linearities

There exists strong heteroskedasticity in the error terms, which implies that our empirical model is not completely adequate. At this point we deal the heteroskedasticity by using robust standard errors, but we believe the model could be improved. For example, the considered variables for risk appetite do not seem to work well. Most of them are at the highest during the financial crisis in 2008-2009, but are not capturing the uncertainty at the current debt crisis well enough. We also tried to model the heteroskedasticity, but at least the standard GARCH-models seem not to be adequate for modeling the heteroskedasticity.

It is also likely that there exist some non-linearities in the determinants of the model either with respect to time, themselves, each other or some other variables not included in our model. We have examined the possibility of non-linearities with respect to the regressors by themselves by adding squared regressors as explanatory variables in to the model. With some minor exceptions, they all turned out to be statistically insignificant.

We investigated the potential non-linearities with respect to the regressors for each other by adding some interaction terms between the credit risk and general risk aversion,

and liquidity risk and general risk aversion to the model. We have also studied the possibility that there exist nonlinear relationships with respect to the level of uncertainty by using the linearity tests against the Smooth Transition -type of nonlinearity. By adding the interaction terms we found some significant effects, although not very systematic ones. The linearity test also suggests that there exist nonlinearities with respect to the uncertainty measures such as yield volatility and CISS index.

We also examined the possibility of instabilities in the parameter coefficients, and it seems that there exists (at least one) regime shift that is situated towards the end of the data set. The transition time seemed to vary across countries. The results are so preliminary that we have decided to exclude them at this point. It could be that the instability test is detecting the same nonlinearities discovered by the linearity test suggesting nonlinearity against uncertainty.

The results of the model with nonlinearities are potentially interesting. Most importantly, they did not have significant effects on the policy announcement dummies and hence we believe that the results regarding the policy effects are relatively robust.

5 Conclusions

In this paper we study the impact of the monetary policy and the European crisis resolution policy decisions made during the latest financial crisis on the long term sovereign bond yields of seven European countries. We examine the policy effects with an empirical model where we control the effect of credit and liquidity risks as well as general risk aversion and contagion between the countries.

We find that many decisions made for stabilizing the European debt crisis have had significant effects on the sovereign yields at least in the short run. As expected, the decisions have caused different kind of reactions depending on the country. A decision that eases the pressure in one country may increase the risks in others reflecting contagion, but possibly also the risk sharing nature of the financial support related decisions. In general, however, it seems that the reactions to the policy decisions have been stabilizing i.e. those expected by the policy maker

The ECB's SMP seem to have had the strongest immidiate stabilizing effect on the bond yields, whereas the decisions related to the new European economic governance has not been very successful in reducing the uncertainty in the countries whose sovereign debt

markets have been under stress. The uncertainty related to the fiscal sustainability is probably dominating the impact of those decisions that should improve the European fiscal landscape in the long run. This may also reflect the high political risk associated to these decisions and an unproven commitment of individual Member States to collectively follow the rules.

Finally, it is very important to understand, which part of yield changes is caused by expectations related to the changes in economic fundamentals, and which part is caused by the changes in the risk appetite. If the increases in the yields are caused by the increased credit risk, it is very likely that the yields are going to stay high for a very long time. In this case it is not enough to provide time and liquidity to these markets, but the trust of the markets are gained only by improving the long term sustainability of the government fiscal position and increasing the credibility of public policy making

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Appendix

8 March 2007	ECB decides to increase the interest rate on the main refinancing operations by 25 basis points to 3.75%.
6 June 2007	ECB decides to increase the interest rate on the main refinancing operations by 25 basis points to 4.00%.
3 July 2007	ECB decides to increase the interest rate on the main refinancing operations by 25 basis points to 4.25%.
22 August 2007	ECB decides to conduct a supplementary liquidity-providing longer-term refinancing operation with a maturity of three months.
6 September 2007	ECB decides to conduct a supplementary liquidity-providing longer-term refinancing operation with a maturity of three months
8 November 2007	ECB decides to renew the two supplementary longer-term refinancing operations (LTROs).
12 December 2007	ECB decided to conduct two US dollar liquidity-providing operations.
7 February 2008	ECB decided to renew two supplementary longer-term refinancing operations (LTROs).
11 March 2008	ECB decides on specific measures to address liquidity pressures in funding markets.
28 March 2008	ECB decides on two supplementary six-month longer-term refinancing operations and continuation of the supplementary three-month longer-term refinancing operations.
2 May 2008	ECB decides on measures to address liquidity pressures in some funding markets.
31 July 2008	ECB decides on renewal of the supplementary three-month longer-term refinancing operations.
4 September 2008	ECB decides on continuation of supplementary longer-term refinancing operations.
26 September 2008	ECB decides on measures designed to address elevated pressures in the short-term US dollar funding markets.
29 September 2008	ECB decides to conduct a special term refinancing operation.
7 October 2008	ECB decides to increase from EUR 25 billion to EUR 50 billion the allotment amount in the six-month supplementary longer-term refinancing operation.

8 October 2008	ECB decides to decrease the interest rate on the main refinancing operations by 50 basis points to 3.75%.
13 October 2008	ECB decides on measures designed to address elevated pressures in the short-term US dollar funding markets.
6 November 2008	ECB decides to decrease the interest rate on the main refinancing operations by 50 basis points to 3.25%.
26 November 2008	European economic recovery plan (EERP)
4 December 2008	ECB decides to decrease the interest rate on the main refinancing operations by 75 basis points to 2.50%.
15 January 2009	ECB decides to decrease the interest rate on the main refinancing operations by 50 basis points to 2%.
5 March 2009	ECB decides to decrease the interest rate on the main refinancing operations by 50 basis points to 1.50%.
2 April 2009	ECB decides to decrease the interest rate on the main refinancing operations by 25 basis points to 1.25%.
7 May 2009	ECB decides to decrease the interest rate on the main refinancing operations by 25 basis points to 1.00% and to conduct liquidity-providing longer-term refinancing operations (LTROs) with a maturity of one year.
27 May 2009	New European financial supervisory framework.
4 June 2009	ECB Covered Bond Purchase Programme.
11 April 2010	€110 billion for Greece (€ 80 billion euro-area Member States, € 30 billion IMF).
23 April 2010	Greece requests for support.
10 May 2010	€750 billion for European support package to secure stability within the Euro-area. ECB decides to conduct interventions in the euro-area public and private debt securities markets (Securities Markets Programme).
29 September 2010	New Economic Governance Package.
28 October 2010	The European Council agreed on the need to set up a permanent crisis resolution mechanism (ESM).
21 November 2010	Ireland requests Financial Support.
28 November 2010	Agreement of financial assistance programme for Ireland (€85 billion) Agreement on the key elements of the European Stability Mechanism.
16-17 December 2010	The European Council agreed on limited amendment to the EU Treaty to underpin the permanent mechanism.

11 March 2011	Pact for the Euro was endorsed.
21 March 2011	Eurogroup + agreed on the organisational and financial details of the ESM.
24-25 March 2011	Heads of State finalize comprehensive package.
7 April 2011	ECB decides to increase the interest rate on the main refinancing operations by 25 basis points to 1.25%.
8 April 2011	Ministers acknowledged the Portuguese authorities' request for financial assistance.
16 May 2011	Agreement of financial assistance program to Portugal.
20 June 2011	Agreement to increase effective capacity and widen the mandate of the European Financial Stability Facility (EFSF).
7 July 2011	ECB decides to increase the interest rate on the main refinancing operations by 25 basis points to 1.50%
21 July 2011	Euro Zone Summit, second package for Greece and widening of the scope of EFSF/ESM.
4 August 2011	The Eurosystem will conduct a liquidity-providing supplementary longer-term refinancing operation with a maturity of approximately six months as a fixed rate tender procedure with full allotment.
6 October 2011	ECB decides to conduct two longer-term refinancing operations – one with a maturity of approximately 12 months in October 2011, and another with a maturity of approximately 13 months in December 2011 and to launch a new covered bond purchase programme in November 2011.
3 November 2011	ECB decides to decrease the interest rate on the main refinancing operations by 25 basis points to 1.25%.
08 November 2011	Enforcing budgetary discipline.
29 November 2011	Euro-area Finance Ministers agreed on the terms and conditions to leverage EFSF's capacity.
8 December 2011	ECB announces measures to support bank lending and money market activity: two longer-term refinancing operations (LTROs) with a maturity of 36 months.
19 December 2011	EU Member States support a substantial increase in the IMF's resources.
20 December 2011	Implementation of the ECB decision on 8 Dec 2011.
2 February 2012	Treaty Establishing the European Stability Mechanism (ESM): New legal text of the ESM treaty.
20 February 2012	New Greek Package.

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