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Abstract

Despite the partial realignment of European long-term government bonds after the crisis in 2012, there has been some renewed divergence in yields in the last years. We analyse the sources of these divergences and find that the government bond markets in the Eurozone are highly sensitive to changing market sentiments, both in time and across countries. We analyse the implications of this finding for the QE-programme. Our analysis of the recent developments in the bond markets and in the macroeconomic developments of the euro area suggests that pulling the plug on QE too soon might undo some of the benefits of QE in the countries of the periphery and may lead to increases in the refinancing costs of member states with little or no fiscal space.

1. INTRODUCTION

Low yields on sovereign bonds have characterized the post-crisis scenario with QE interventions preventing a return of bond yields closer to nominal growth rates. However, most recently, capital markets appeared prone to volatility, with long-term rates being on the rise again since the end of the second half of 2016. This trend is in line with the recent increase in the headline inflation. An important factor in explaining inflation dynamics is the contagion from the US bond market due to the expected tightening of the Fed's monetary policy, and a weaker euro. However, this renewed divergence in yields runs contrary to improving or plateauing fundamentals, thus not necessarily signalling a return to a more "neutral" level of bond yields. The observed divergence may be the results of a tug of war between opposing forces – with political risk, lack of structural reforms, meagre growth prospects, and the existence of technical limits regarding QE purchases (Gerba and Macchiarelli, 2016) preventing a lingering of low nominal bond yields, particularly in southern euro area countries. The continuation of such an upward trend could create additional trouble for the still fragile Euro area recovery and the smooth functioning of European capital markets. One cannot exclude the risk that the resumption of bond sell-off from investors could generate a rise in long-term interest rates to levels not in line with fundamentals (see De Grauwe and Ji, 2012; 2013), thereby endangering the smooth functioning of monetary policy and adding pressure to public finances. Against this background, this note assesses recent developments in European long-term bond rates, and discusses the risks of interest rates overshooting in the short term, and the implications for the European Central Bank.

2. DIVERGENCE IN EUROZONE BOND YIELDS

After the record-low level reached in 2015-2016, there has been renewed divergence in long term government bond yields, particularly during the last year. As observed from Figure 1(a), this runs contrary to improving or anyway plateauing fundamentals. In countries such as Portugal, Spain and Italy, while increasing debt/GDP levels partly explained high bond yields during the sovereign debt crisis, debt ratios have stabilized since 2013 (Figure 1(b)).

Figure 1(a): Euro area 10 bond yields
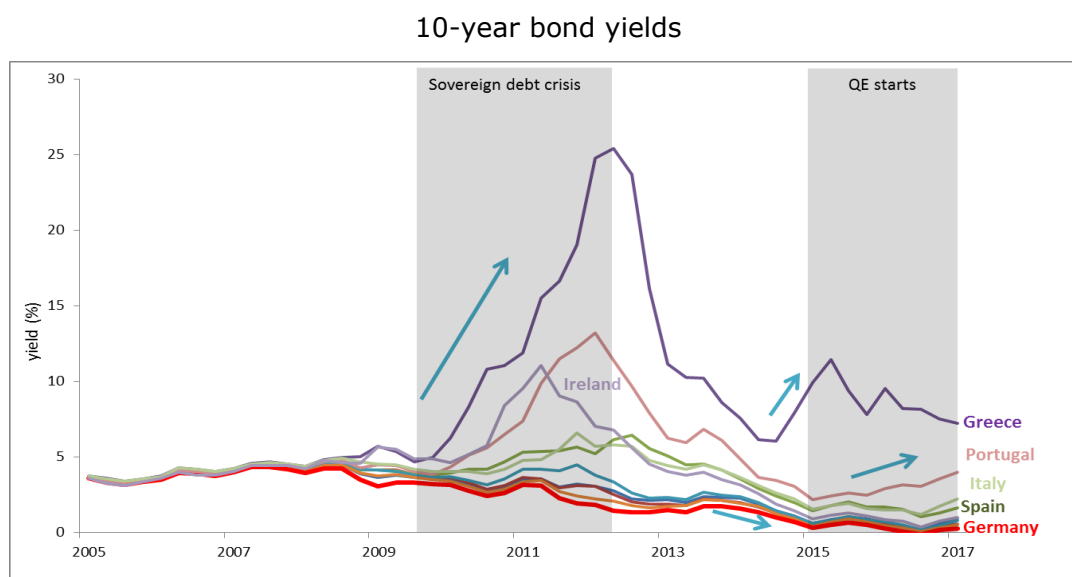
10-year bond yields

Figure 1(b): Debt-to-GDP ratios for selected countries
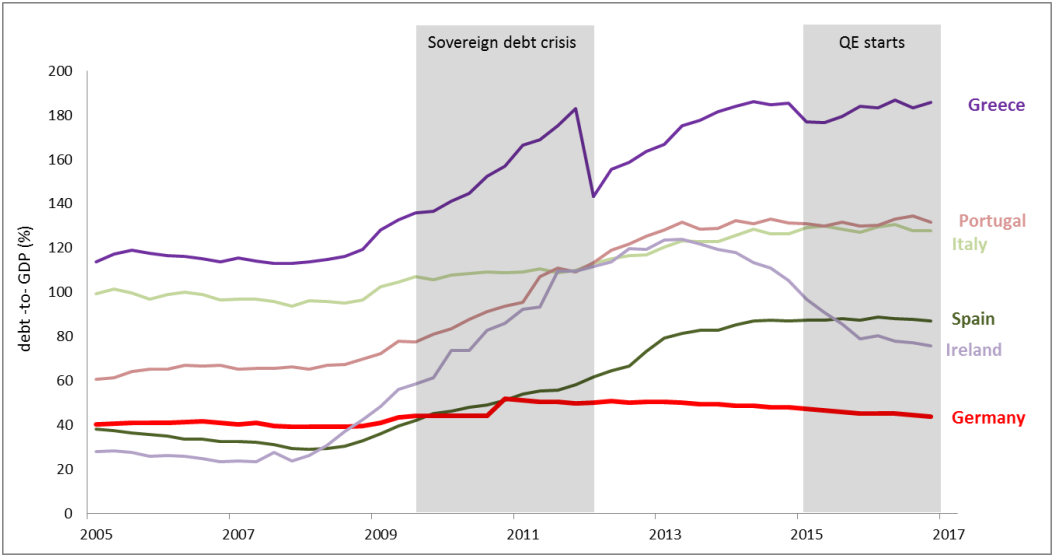
Part of these dynamics is the result of headline inflation and market-based long-term inflation expectations being on the rise again (ECB data, not reported here). An important factor in explaining inflation dynamics is the the ECB's QE that contributed to a weakening of the euro against the dollar. However, those increases in nominal government yields are more apparent in some countries (namely, Portugal, Italy, Spain) rather than in others.

Figure 2(a): Spread and debt to GDP ratios in the Euro area 10

10-year bond yields
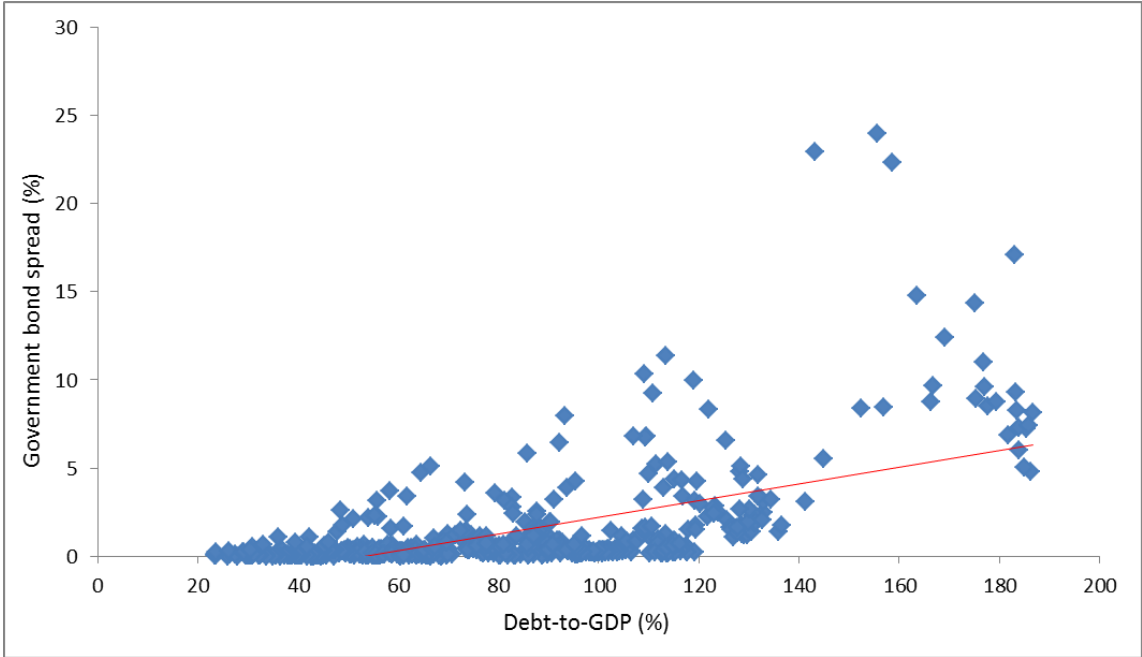
Figure 2(a): Spread and debt to GDP ratios in the Eurozone 10

10-year bond yields

x-axis: debt-to-GDP (%); *y-axis:* government bond spread *vis-à-vis* Germany (%)
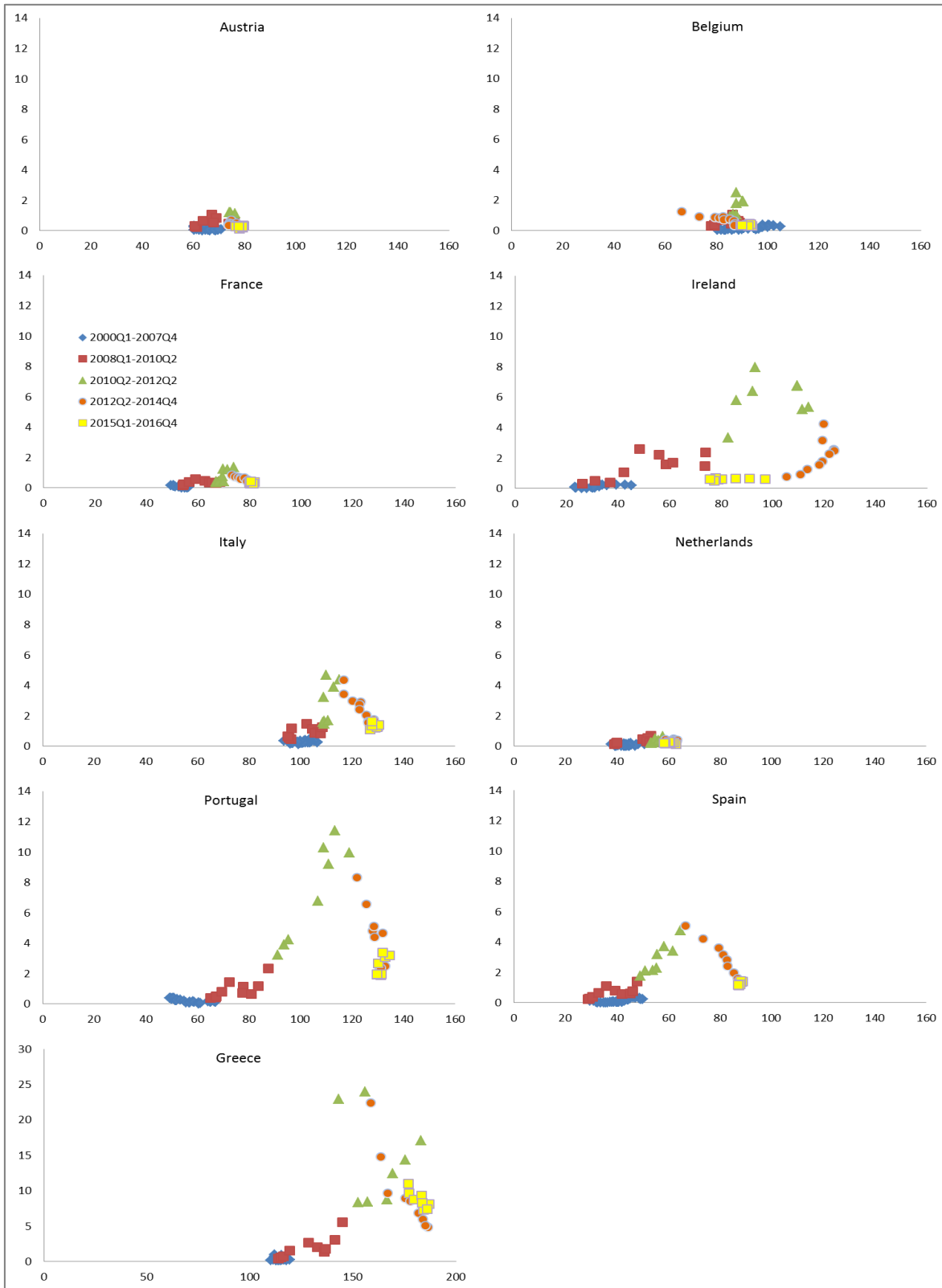
The relationship between debt/GDP and bond yields is not a linear one (Figure 2), particularly in euro area countries, where a systematic mispricing of sovereign risk has been documented at the peak of the sovereign debt crisis (De Grauwe and Ji, 2012; 2013; for a theoretical discussion see De Grauwe, 2011). This implies that, although fundamentals may have stabilised, bond sell-off from investors could still generate a rise in long-term interest rates to levels not in line with the fundamentals risk characteristics of these assets, whenever investors' perception shift.

In Figure 2, we look at the spreads (vertical axis) as a function of the debt-to-GDP ratios (horizontal axis) in selected eurozone countries. Each point is a particular observation of one of the countries in a particular quarter (sample period 2000Q1-2016Q4). De Grauwe and Ji (2012; 2013) observed a positive relation between the spread and the debt-to-GDP ratio. We equally find such a positive relationship by updating the sample with more recent figures (represented by the positively sloped regression line in Figure 2(a)). However, it appears that only a small fraction of the total variation of the spreads can be accounted for by the debt-to-GDP ratio. This seems to be a feature also of more recent observations (post OMT-announcement and QE, i.e. 2012Q3-2016Q4 highlighted in yellow and green respectively in Figure 2(b)) where changes in the observations away from the pre-crisis period seems to show a time dependency pattern.

Figure 2(b) shows nevertheless that the perceived market risk of default and ensuing fire-sale of bonds in Eurozone countries has overall dropped since the crisis (a result well documented by the literature in the light of the OMT-announcement and ensuing rounds of QE in Europe; see Altavilla *et al.* 2014; 2015)[1], with the exception of Greece.

In addition, although debt levels have not changed, the composition of that debt has changed, with almost 40% of the universe of government bonds trading at negative rates currently (Table 1).

Table 1: Market volume of outstanding public debt with negative yields and yields below the ECB's deposit rate for selected countries (in EUR bn)

	Germany	France	Netherlands	Belgium	Austria	Finland	Luxemburg
Less than 0%	66.2%	49.7%	56.5%	34.40%	47.80%	53.00%	37.70%
Less than ECB's deposit facility (- 0.4%)	52.2%	33.8%	33.2%	19.00%	30.40%	30.70%	0.00%
	Italy	*Spain*	*Portugal*	*Ireland*	*Cyprus*	*Malta*	***Euro area***
Less than 0%	16.4%	32.5%	11.10%	35.60%	5.50%	17.60%	39.90%
Less than ECB's deposit facility (- 0.4%)	2.3%	4.3%	0.00%	10.50%	1.10%	13.70%	22.60%

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[1] Still, a high level of fragmentation remains and recent data confirm that, in most countries, the ECB's purchases have not completely reversed the home bias in banks' holdings of government debt (Hüttl and Goncalves Raposo, 2017; see also Koutroumpis and Macchiarelli, 2016).

While the story about bad debt dynamics is thus not too compelling, it should be understood that investors' price sensitivity when interest rates are very low or negative is higher. As a result, losses for those investors highly exposed to low-yielding bonds with long maturities can be large even for relatively limited movements in underlying interest rates (ECB, 2016). This could partially explain markets' nervousness.

Figure 3: Dispersion of government bond yields and evolution of the average yield – euro area 10
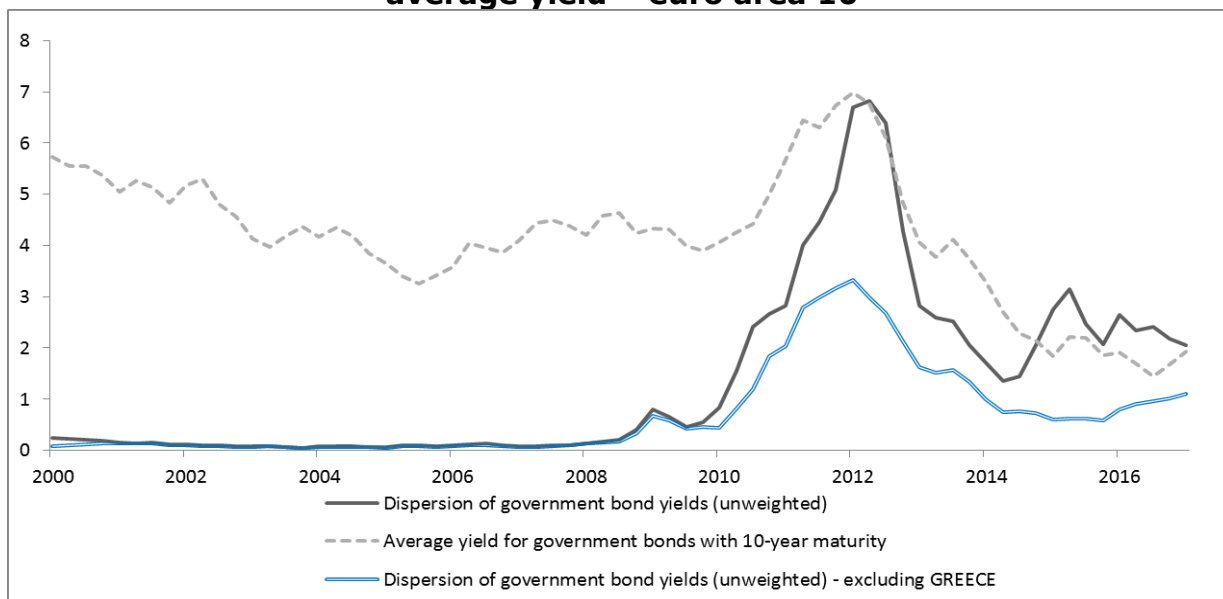
*Source***:** Own calculations based on Datastream data. *Source***:** The euro area 10 excludes Luxemburg and includes Greece.

Table 2: Percentage of variance explained by the first principal component across yields for different groups of countries

		Euro area 10	Euro area 10 minus Ireland, Italy, Portugal, Spain	Ireland, Italy, Portugal, Spain	Ireland, Italy, Portugal, Spain + Greece
	Full-period	76.0%	88.2%	84.5%	72.8%
Pre-crisis	2000Q1-2007Q4	99.8%	99.8%	99.7%	99.4%
Crisis I	2008Q1-2010Q2	72.3%	83.7%	56.4%	45.3%
Crisis II (sovereign debt)	2010Q3-2012Q2	51.1%	72.9%	**72.9%**	**73.3%**
Post OMT-announcement	2012Q3-2014Q4	84.4%	88.5%	**97.8%**	**95.4%**
QE announcement and implementation	2015Q1-2017Q1	85.9%	97%	65%	52.7%

*Source***:** Own calculations based on Datastream data. *Source***:** The euro area 10 excludes Luxemburg.

In order to analyze the determinants of bond spreads, we preliminary look at the cross-country standard deviation of government bond yields for securities with long-maturity (10 years) over the period 2001Q1-2017Q1 (Figure 3). The lower the dispersion in yields, the more integrated the market for government bonds. Focusing on the last couple of years,

the measure suggests a renewed divergence of government bond yields in the euro area which – as discussed- cannot primarily be attributed primarily to the divergence in underlying fundamentals or a fundamental deterioration of the fiscal situation in several euro area countries. Besides the dispersion in yields, an alternative measure might be provided by a principal component analysis (Table 2). We run the analysis on the bond yields at the 10-year maturity for countries which were under financial distress during the sovereign debt crisis (Portugal, Italy, Spain, Ireland, plus Greece) and the rest of the Euro area 10. Consistent with our previous discussion, we can account for as much as 76% of the original variability of the yields across the euro area 10. This number jumps up to 88% when Portugal, Italy, Spain, Ireland are excluded. For Portugal, Italy, Spain, Ireland alone the principal component accounts for 85% of the yields' variance. When adding Greece, this number drops down to 72%, confirming that Greece was very much an outlier. For the sovereign debt crisis and the post-OMT announcement, for Portugal, Italy, Spain, Ireland (and Greece) the variance accounted for altogether is higher than what the principal component can explain for the euro area 10. This suggests that the bond yield dynamics in those countries (Portugal, Italy, Spain, Ireland, plus Greece) possibly reflected factors of common nature, such as risk aversion. Common factors in those countries have weakened for the most recent period. In the next Section, we explore this idea more formally.

3. HOW MUCH OF THESE CHANGES ARE FUNDAMENTALS?

As always, it is critical to differentiate between change in investors' sentiment and genuine changes in the economy's fundamentals. In the next two sections, we present a survey of the literature on the determinants of sovereign bond yields. In Section 3.3, we propose an analysis of the determinants of the yield spreads based on an update of the reduced-form model proposed in De Grauwe and Ji (2012; 2013).

3.1. The determinants of sovereign bond yields during the crisis

Previous studies have suggested that the developments in sovereign bond spreads in euro area countries can be broadly explained by a set of determinants relating to credit and liquidity risk as well by the interaction of these risks with investors' assessment of each country's creditworthiness, or their aversion to risk, more generally. While credit and liquidity risks are mostly country-specific, the degree of risk aversion tends to reflect common or global factors and is typically regarded as one of the most relevant driver of fluctuations of bond yield spreads *vis-à-vis* the German Bund (ECB, 2014). The relevance of these determinants is likely to vary over time (see, e.g., D'Agostino and Ehrmann, 2014). In particular, during times of financial uncertainty – i.e. periods in which risk aversion is high – investors will rebalance their portfolio and will likely increase their holding of less risky securities. Sovereign bonds will thus become more sensitive to credit and liquidity risks. This is a recurring finding in the empirical literature since the start of the financial crisis (see Bernoth and Erdogan, 2012).

The determinants of **credit risk premia** are typically associated with default risk (or the probability of government default), credit spread risk (the probability that the market value of bonds will decline relative to other comparable assets) and downgrade risk (the probability of a government downgrade). As such, credit risk is typically proxied by variables describing a country's fiscal position (debt and deficit-to-GDP ratios, structure of debt maturity, interest expenditure-to-GDP etc.; see Barrios et al., 2009) and country ratings. Given that investors may be more interested in evaluating the fiscal outlook rather than current and past fiscal situations in order to assess the solvency of a country, several papers use the expected – rather than observed – fiscal fundamentals as explanatory

variables in sovereign bond spreads. D'Agostino and Ehrmann (2014), for instance, extend the range of variables used in order to capture credit risk to the consensus forecasts of macroeconomic variables (current account balance-to-GDP ratio, real GDP growth, unemployment and consumer price inflation). Others, e.g., Maltritz (2012), have considered related variables such as openness and the terms of trade, or the countries' financial sector soundness and price competitiveness as expressed by country ratings (Dötz and Fischer, 2010). Since the crisis, and to a larger extent, the sovereign debt crisis, the observed heightened importance for credit risk variables may be linked to the deterioration of fiscal positions in several euro area countries. For example, De Sanctis (2012), claims that fiscal developments are being taken into consideration by investors while assessing growth prospects and the government ability to debt-repayment, whereas Attinasi *et al.* (2010) suggest that the announcement of bank rescue packages, shifting risk from private to public sector, has led to a reassessment of sovereign credit risk (ECB, 2014). Other related variables include the existence of fiscal rules. Iara and Woldd (2010) suggest, for instance, how using a compilation of mix sources (statutory base, rule's enforcement, media visibility etc.) their constructed index for fiscal rules is highly explanatory when investors became risk adverse. To a similar token, studies such as Eichler (2011) and Di Cesare *et al.* (2012) and Klose and Weigert (2014) explicitly explored the role for the risk of a EMU break-up.[2] Similarly, analysing data up to June 2011, Favero and Missale (2012), concluded that the "non-default components [of sovereign bond spreads] are unlikely to reflect expectations of depreciation".

As a second factor, the **liquidity** of the various government bonds will most likely influence the yield spread. Liquidity is frequently measured by the overall outstanding amount of public debt, bid-ask spreads and trading volumes (Beber *et al.*, 2009; Bernoth and Erdogan, 2012). Beber et al. (2009) find, for instance, that credit premia tend to be generally more relevant than liquidity premia for euro area sovereign bonds but liquidity factors may well prevail during periods of increased uncertainty.

Finally, the degree of **investors' risk perception** is normally proxied by the European (EuroSTOXX 50) or US stock market implied volatility or the corporate bond spreads (see Fontana and Scheicher, 2016; Bernoth *et al.*, 2012; Favero *et al.*, 2010; von Hagen et al., 2010). While global and common factors are important, since the financial crisis, more and more studies have highlighted how risk perception has recently been affected by idiosyncratic factors, rather than international factors (see e.g., Barrios et al., 2009).

3.2. Contagion and multiple equilibria in the sovereign bond market

Multiple equilibria are generally understood in a sovereign bond yield context as the result of self-fulfilling default crises which are often triggered by deep recessions. In fact, uncertainty regarding an economy's future fundamentals, the government's inability to commit *ex ante* to its debt-repayment and the investors' risk aversion generate all together the possibility of a "bad" equilibrium whereby the government is forced to default even in the case of solvency or anyway non-negative developments in fundamentals. A formal model has been proposed, among the others, by Azariadis (1981), De Grauwe (2011), Corsetti and Dedola (2011; 2012). Multiple equilibria and the idea of contagion suggest a potential role for the central bank to coordinate market participants' expectations away from the "bad" equilibrium. However, the central bank cannot remove the underlying

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[2] Eichler (2011), for instance, using data from American depositary receipt (ADR) of underlying stocks from Spain, Italy, Greece, Ireland and Portugal for the period of Jan-2007 -Mar-2009, finds evidence that investors priced-in the risk of a EMU withdrawal but concludes that the perceived risk over this period was small.

causes of fragility in sovereign bond markets related to weak or the lack of economic fundamentals (ECB, 2014). A broader discussion has been proposed recently also by De Grauwe and Ji (2016).

3.3.   Explaining euro area sovereign bond yield spreads

To analyze the determinants of the yield spreads in the EMS and the Eurozone, we update the reduced form model proposed in De Grauwe and Ji (2012; 2013). Particularly, we specify the following fixed-effect econometric model:

$$S_{it} = a + bF_{it} + a_i + u_{it} \qquad\qquad (1)$$

where S_{it} is the yield spread of country i in period t. The spread is defined as the difference between country i's 10-year government bond rate and the German 10-year government bond rate. a is the constant term and a_i is country i's fixed effect. The latter variable measures the idiosyncrasies of a country that affect its spread and that are not time dependent. For example, the efficiency of the tax system, the quality of the governance, the population structure and many other variables that are country-specific are captured by the fixed effect. F_{it} is a set of fundamental variables. A fixed effect model helps to control for unobserved time-invariant variables and produces unbiased estimates of the "interested variables".

In the second step, following De Grauwe and Ji (2013), we introduce time dummies into the basic model and the specification is as follows:

$$S_{it} = a + bF_{it} + a_i + e_t + u_{it} \qquad\qquad (2)$$

where e_t is a set of time dummy variables. This measures the common time effects that are unrelated to the fundamentals of the model or (by definition) to the fixed effects. If significant, it shows that the spreads move in time unrelated to the fundamental forces driving the yields. It will allow us to evaluate the importance of fundamental economic factors and time effects. The latter can be interpreted as market sentiments unrelated to fundamentals. To deal with possible differences in time effects between the core and periphery country groups, as suggested in the literature, we also introduce different time dummies. ce_t represents the common time effects for the core Eurozone group and pe_t for the periphery Eurozone group.

$$S_{it} = a + bF_{it} + a_i + ce_t + pe_t + u_{it} \qquad\qquad (3)$$

The set of economic and monetary variables F_{it} include the most common fundamental variables found in the literature on the determinants of *sovereign bond spreads.*[3] They are variables measuring the sustainability of government debt. We will use the debt to GDP ratio, the fiscal space of the government, the budget deficit, the current account position,

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[3] See e.g., Attinasi et *al.* (2010), Gerlach, et al.(2010), von Hagen *et al.* (2010), De Grauwe and Ji (2012), Aizenman and Hutchinson (2012), Beirne and Fratzscher (2012). As discussed in the previous section, there is of course a vast literature on the spreads in the government bond markets in general.

the real effective exchange rate and the rate of economic growth as fundamental variables affecting the spreads. The effects of these fundamental variables on the spreads can be described as follows.

- When the government debt to GDP ratio increases the burden of the debt service increases leading to an increasing probability of default. This then in turn leads to an increase in the spread, which is a risk premium investors demand to compensate them for the increased default risk. We also add debt to GDP ratio squared. The reason of focusing on the non-linear relationship comes from the fact that every decision to default is a discontinuous one, and leads to high potential losses. Thus, as the debt to GDP ratio increases, investors realize that they come closer to the default decision, making them more sensitive to a given increase in the debt to GDP ratio (Giavazzi and Pagano, 1990).

  As an alternative measure of fiscal sustainability, we will also use the fiscal space of the government. This is defined as the ratio of GDP to tax revenues. It has been used by Aizenman and Hutchinson (2013). It measures the capacity of governments to raise the taxes necessary to service the debt. An increase of the fiscal space variable raises the spreads.

  The debt-to-GDP ratio and the fiscal space variables are stock variables. As a robustness test it will also be useful to use the government budget deficit (a flow variable). This has the same expected effects on the spreads as the government debt to GDP ratio.

- The current account has a similar effect on the spreads. Current account deficits should be interpreted as increases in the net foreign debt of the country as a whole (private and official residents). This is also likely to increase the default risk of the government for the following reason. If the increase in net foreign debt arises from the private sector's overspending it will lead to default risk of the private sector. However, the government is likely to be affected because such defaults lead to a negative effect on economic activity, inducing a decline in government revenues and an increase in government budget deficits. If the increase in net foreign indebtedness arises from government overspending, it directly increases the government's debt service, and thus the default risk. To capture net foreign debt position of a country, we use the accumulated current account GDP ratio of that country. It is computed as the current account accumulated since 2000Q1 divided by GDP.

- The real effective exchange rate as a measure of competitiveness can be considered as an early warning variable indicating that a country that experiences a real appreciation will run into problems of competitiveness which in turn will lead to future current account deficits, and future debt problems. Investors may then demand an additional risk premium.

- Economic growth affects the ease with which a government is capable of servicing its debt. The lower the growth rate the more difficult it is to raise tax revenues. As a result a decline of economic growth will increase the incentive of the government to default, raising the default risk and the spread.

The fundamental variables can be seen as "early warning" variables. They would be in the list of variables that agents trying to forecast the future sustainability of the government debt would use to make these forecasts. Thus, our model can be interpreted to use the current debt to GDP ratio (alternatively the current fiscal space) and the other fundamental variables to obtain forecasts of the future sustainability of the government debt.

We could also have used the forecasts about the future sustainability of the government debt that were made in each period t. The IMF, for example, makes such forecasts. However, it appears that these forecasts are very unreliable producing large errors. In addition, there is the risk that these forecasts are not exogenous, i.e. that they depend on the spreads. Put differently, when the spreads increase, say on the Greek government bonds, forecasters typically react by adjusting their forecasts of the future sustainability of the Greek government debt. As a result of this endogeneity of the forecasts our estimates will be biased. For these reasons, we have not pursued this approach.

From the preceding it follows that we can interpret the set of fundamental variables as signaling present and future solvency problems of governments issuing debt. Changes in these variables create spreads reflecting solvency risk. In contrast the time dummies that, as will be remembered, are independent from the fundamental variables and therefore are not associated with solvency risk, create spreads that by default should be associated with liquidity risks that arise from self-fulfilling fears that sovereigns may not be able to rollover their debt.

There is a potential issue of omitted variables here. Our previous conclusion holds provided the model incorporates all relevant fundamental variables. If we fail to incorporate some relevant fundamental variables this conclusion will not hold anymore. We have used here the prevailing economic literature that has identified the fundamentals that matter. There is one exception, though. Some of the econometric studies of the spreads have used measures of risk such as the CDS-spreads as exogenous variables explaining the spreads in the government bond markets (see Aizenman and Hutchinson, 2012; Aizeman *et al.*, 2013; Beirne and Fratzscher, 2012). We have criticized this approach in De Grauwe and Ji (2013) on the ground that these measures of risk are not exogenous variables. During moments of crisis risk perception increases and the sovereign debt and CDS spreads increase simultaneously. In no way can it be concluded that the CDS-spreads are exogenous variables causing the sovereign debt spreads to increase. Adding the CDS-spreads into the regression may improve the statistical fitness without however adding explanatory power.

We run regressions on equation (1), (2) and (3) using a sample of the ten original Eurozone countries (without Luxembourg) during 2000-2015 (quarterly data). We did not select the countries that joined the Eurozone after the sovereign debt crisis. It would not be appropriate to include these countries as they experienced a very different monetary regime during most of the sample period. Note also that Germany is included as the benchmark country.

After having established by a Hausman test that the random effect model is inappropriate, we used a fixed effect model to analyze the long-term bond spreads in the Eurozone. Table 3 presents regressions of the Eurozone countries using the proposed fixed effect models. The standard errors (in brackets) correct for the existence of heteroscedasticity in the error terms and for contemporaneous correlation across panels.

Regressions shown in columns (1) to (3) use the model with the debt to GDP ratio as a measure of debt sustainability. Regression (1) does not have time dummies; regression (2) adds common time dummies for all countries and regression (3) has separate time dummies for the periphery countries. Regression (4) adds the budget deficit to GDP ratio and regression (5) used fiscal space as the alternative measure of fiscal sustainability.

We find that fundamental variables have a significant effect on the spreads in these regressions, except for the real exchange rate and the budget deficit variable. The fiscal space variable provides similar significant results as the debt-to-GDP ratio. Adding time dummies in regressions (2) and (3) has improved the R^2 (goodness of the fit of the model). We conduct two F tests on the time dummies and both tests reject the null hypothesis that

the coefficients are jointly equal to zero. The first F test suggests that time fixed effects are needed and the regression with time dummies is shown in column (2) of Table 3. Moreover, the second F test suggests that different time fixed effects are needed for core and periphery country groups and the regression is shown column (3).

Table 3 Estimation Results on Spread (%)

Sample period: 2000Q1-2015Q2

	(1)	(2)	(3)	(4)	(5)
Debt GDP ratio	-0.0292*	-0.0416***	-0.0745***	-0.0716***	
	[0.0153]	[0.0150]	[0.0166]	[0.0184]	
Debt GDP ratio squared	0.0004***	0.0004***	0.0005***	0.0005***	
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	
Real effective exchange rate	-0.0318	-0.3985	-0.7420	-0.7502	-0.8786
	[0.8769]	[1.0396]	[0.9237]	[0.9234]	[0.9092]
Accumulated current account GDP ratio	-0.6134***	-0.4849***	-0.4856***	-0.4830***	-0.8155***
(%)	[0.1379]	[0.1215]	[0.1081]	[0.1081]	[0.1129]
Growth rate of GDP	-0.2301***	-0.3404***	-0.2259***	-0.2322***	-0.2596***
(%)	[0.0393]	[0.0531]	[0.0457]	[0.0524]	[0.0510]
Deficit GDP ratio				0.0160	0.0146
(%)				[0.0317]	[0.0307]
Fiscal space					-3.5953***
					[1.0034]
Fiscal space squared					0.7246***
					[0.2316]
Time fixed effects (quarterly)	No	Yes	Yes	Yes	Yes
Time fixed effects periphery countries	No	No	Yes	Yes	Yes
F test on main economic variables	Yes	Yes	Yes	Yes	Yes
F test on time dummies		Yes[1]	Yes[3]	Yes	Yes
F test on periphery time dummies			Yes[2,3]	Yes	Yes
Number of countries	10	10	10	10	10
Observations	620	620	620	620	620
R^2	0.660	0.784	0.866	0.866	0.857

Note:

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Breusch-Pagan LM test is used confirm cross-sectional correlation in the disturbances.
Standard errors are in brackets assuming that the disturbances are heteroskedastic and contemporaneously correlated across panels.
Data sources: the government debt to GDP ratio, the fiscal space, the real effective exchange rate (defined as the relative unit labour costs and expressed as an index with base year 2005), the current accounts and the growth rate of GDP are all obtained from Eurostat.
[1]F test on time dummies: $F(61, 544) = 5.10$. F test rejects the null that the coefficients for all quarters are jointly equal to zero, therefore time fixed effects are needed.
[2]F test on periphery time dummies: $F(61, 483) = 4.88$. F test rejects the null that the coefficients for all quarters are jointly equal to zero, therefore different time fixed effects are needed for core and periphery country groups.
[3]The time dummies in regression (3) are shown in Figure 4.

Regression (3) gives the best R^2 after allowing for two different time dummies on the periphery and core countries. The estimated coefficients can be interpreted as follows. Increasing government debt ratios lead in a non-linear way to higher spreads. From the estimated coefficients of the linear and quadratic terms we find that the two terms together start being positive when the debt ratio reaches 149. However, to find the effect of changes

in the spread we have to take the derivative of -0.0745x + 0.0005x2 (where x = debt/GDP). This yields -0.0745 + 0.001x. Solving for x we find x = 74.5, i.e. when the debt ratio exceeds 74.5% increases in the debt ratio start increasing the spread. We show the estimated non-linear relationship between spreads and the debt to GDP ratio in figure A1 in appendix.

The real exchange rate has the expected negative sign but the estimated coefficients are not statistically different from zero. The the economic growth variable has the expected negative and significant effect on the spreads, i.e. a decline in economic growth raises the spreads as it reduces the capacity of governments to generate tax revenues necessary to service the debt. This is a result that is often found in the literature (see Aizenman and Hutchinson, 2012, Beirne and Fratzscher, 2012).

We also find a significant effect of accumulated current accounts on the spreads, however, the coefficient has the wrong (negative) sign. In De Grauwe and Ji (2013) several robustness tests were produced. First, it was found that in the pre-crisis period (1999-2007) the coefficient of the accumulated current accounts is zero. The negative sign is obtained only for the post-crisis period. Second, when estimating the model for the core and the periphery countries separately, it is found that the negative coefficient only applies to the core countries. The periphery countries exhibit a coefficient equal to zero. Our interpretation is the following. The negative coefficient on the accumulated current account appears after the crisis and only in the subsample of core countries. The reason may be that core countries that had accumulated large current account surpluses (Belgium, Netherlands) also saw their spreads increase (*vis-à-vis* Germany) after the crisis. We conclude that the current account variable does not provide for a reliable estimate of future sustainability of the government debt.

Statistical significance is one thing; economic significance is another one. We also want to know what the economic significance is of the fundamental variables. Put differently, we want to measure the quantitative importance of the fundamental variables in explaining the movements in the spreads.

In order to obtain information on the economic significance of the fundamentals we have to compare these with the effect of the time dummy variable. We use regression (3) in Table 3 with different time components for the core (Austria, Belgium, France, Finland, the Netherlands and Italy) and the periphery (Spain, Ireland, Portugal and Greece) Eurozone groups. We show the estimated time components (associated with regression (3)) in Figure 4. The shaded areas indicate the time dummies that are significantly different from zero. This confirms the existence of significant time components that led to deviations of the spreads from the underlying fundamentals and thus were signaling risks unrelated to solvency.

This time effect is especially pronounced in the periphery countries. In particular we find that in the periphery countries, there was a surge of the spreads during the sovereign debt crisis from 2010 to 2012 that was independent of the movements in the fundamentals. In 2012 there was the OMT-announcement, and we observe that the spreads decline forcefully, again independently of the movements of the fundamentals.

Thus, it appears that the announcement of OMT, by itself, triggered a large decline in the spreads that could not be associated with improvements in the fundamentals.

The period prior to the crisis is also interesting. We find that prior to the crisis the time dummy becomes increasingly negative. This suggests that the financial markets were increasingly disregarding the fundamentals (some of which were deteriorating in the periphery) and kept the spreads close to zero. Put differently, investors appear to have disregarded the risks of holding sovereign debt from the periphery despite the warnings

given by deteriorating fundamentals. The emergence of the crisis can be seen as a wake-up call, which then led investors to overreact and even to panic, producing spreads that (again) were out of line with the underlying fundamentals. The OMT announced by the ECB allowed the fear factor to disappear. This then led to a steep decline in the spreads, that again cannot be explained by the fundamentals in the model. All this seems to suggest that financial markets can easily switch from modes of risk-denial to excessive risk perception.

Figure 4: Time dummies of spread (%)
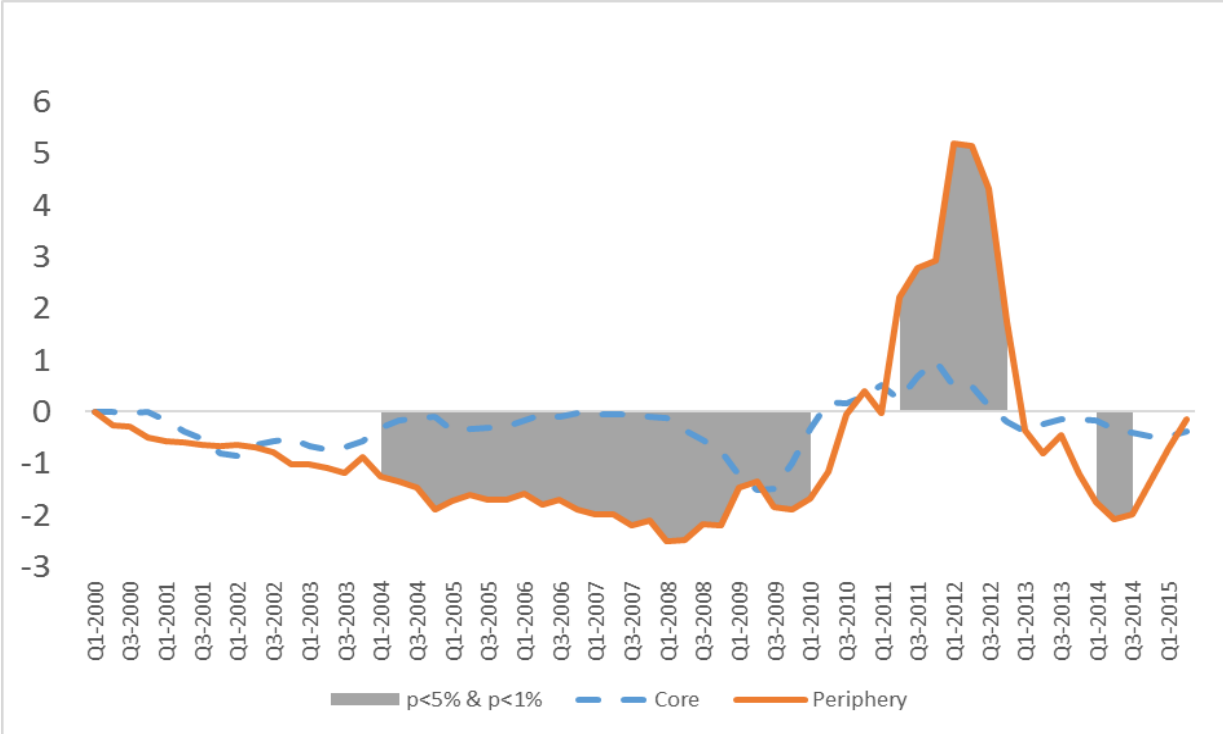
Source: Own calculations.

Note: The vertical axis shows the coefficient of the time dummies using regression (3). It is to be interpreted as percentage points of the spreads. Thus when the coefficient of the time dummy is 5%, as it was in 2012, this means that the spreads were 5 percentage points higher than the spread as determined by the fundamentals.

The next step in the analysis consists in estimating the contribution of the fundamentals and the time dummy in explaining the movements in the spreads. We perform this exercise during two periods. The first one is the crisis period, starting from 2008Q1 until 2012Q2 (just before the OMT-announcement). The second (post-OMT) period runs from 2012Q3 to 2015Q2. We show the results in Figures 2 and 3.

We find that during the crisis period, the time dummy is by far the largest explanatory factor in explaining the surge of the spreads for Ireland, Portugal and Spain. In the case of Greece, fundamentals have a somewhat higher importance: they explain 44% of the surge in the Greek spread.

The post OMT-period shows a similar pattern. The time variable explains by far the largest part of the decline in the spreads observed since 2012, suggesting that the decline in the spreads was made possible mostly by the OMT-announcement. Changes in the fundamentals do not seem to have contributed much in explaining this decline.

Since we are interested in the influence of the government debt to GDP ratio, it will be useful to repeat the previous exercise and to isolate the separate effect of the debt to GDP

ratio on the spreads during the two periods. We show the results of this exercise in Figures 7 and 8. Figure 7 shows the decomposition during the crisis period 2008-12. We find that the changes in the government debt to GDP ratio observed during that period contributed very little to the surge of the spreads. This surge is mainly explained by the time dummy, measuring market sentiments, and to a lesser degree by the deterioration of the other fundamentals (economic growth). This suggests that the surge of the spreads during the crisis was unrelated to the movements of the most important fundamental variable, i.e. de government debt to GDP ratio.
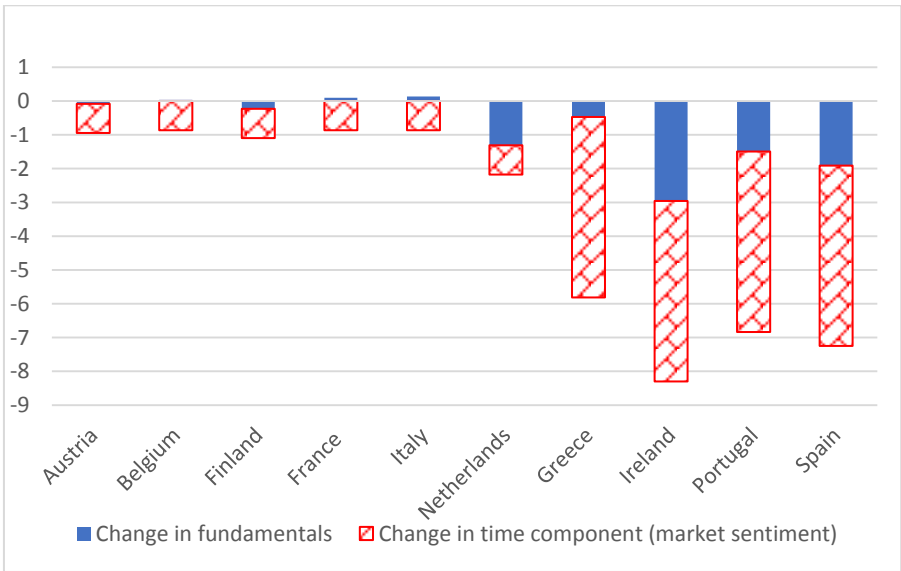
Figure 5: Contribution of fundamentals and time dummies to predicted changes in spread (%, 2008Q1-2012Q2)
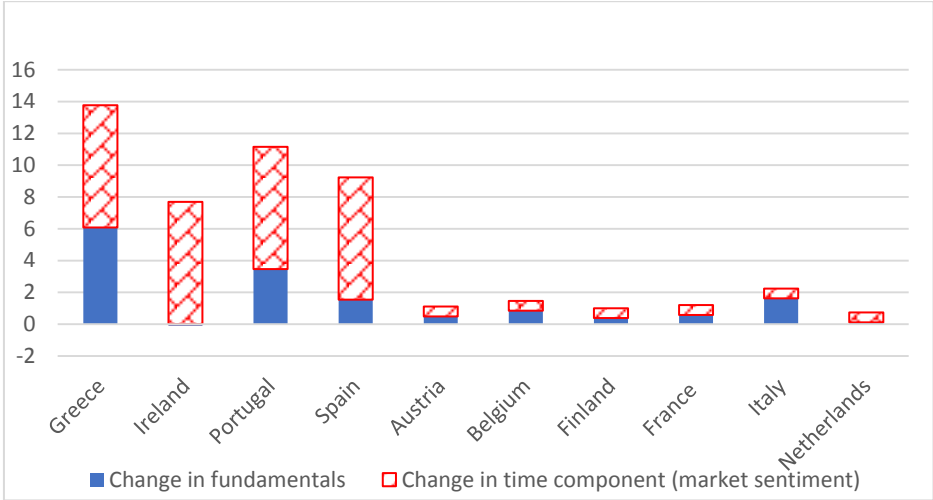
Source: Own calculations

Note: With "predicted" we mean the value of the spreads as estimated by the model.

Figure 6: Contribution of fundamentals and time dummies to predicted changes in spread (%, 2012Q2-2015Q2)
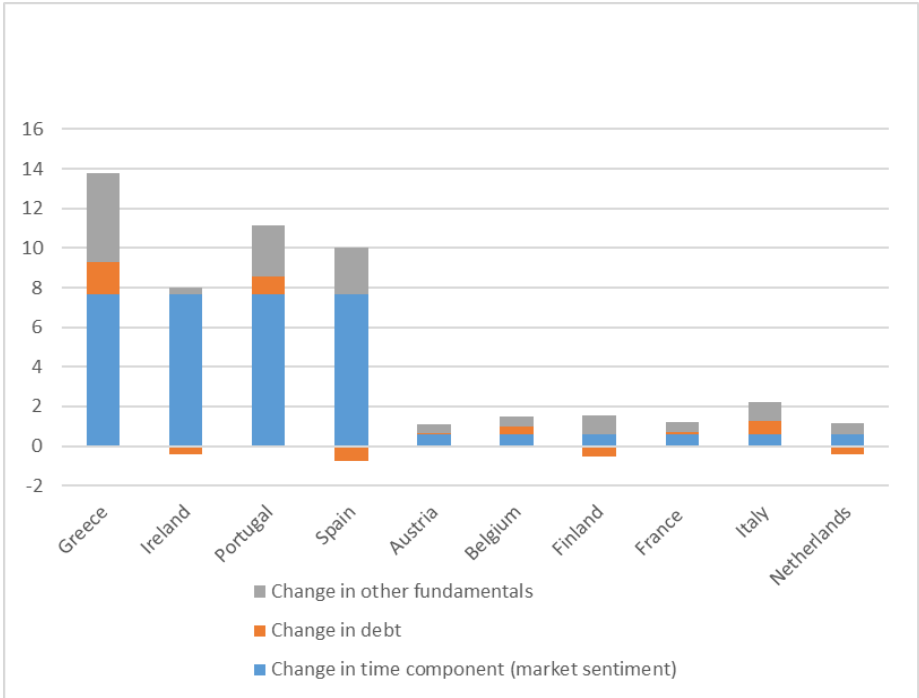

Source: Own calculations

Figure 8 shows the same decomposition during the post-OMT period (2012-15). Again, we find that the changes in the government debt ratio explain only a small fraction of the decline in the spreads. This decline is mainly driven by the market sentiment variable and by the other fundamental variables. As the latter improved somewhat they tended to reinforce the effect of market sentiments.

In this empirical section, we have provided evidence showing that during the sovereign debt crisis the surge of the spreads was determined mostly by market sentiments, which we measured by time dummies that are independent from underlying economic fundamentals. In addition, we found that the changes in the debt to GDP ratios observed during this period had practically no influence on the increase in the spreads. Other fundamentals, in particular, the decline in economic growth had some, but relatively small influence.

Figure 7: Contribution of debt, other fundamentals and time dummy in changes in spread (%, 2008-2012)

Source: Own calculations

Figure 8: Contribution of debt, other fundamentals and time dummy in changes in spread (%, 2012-2015)
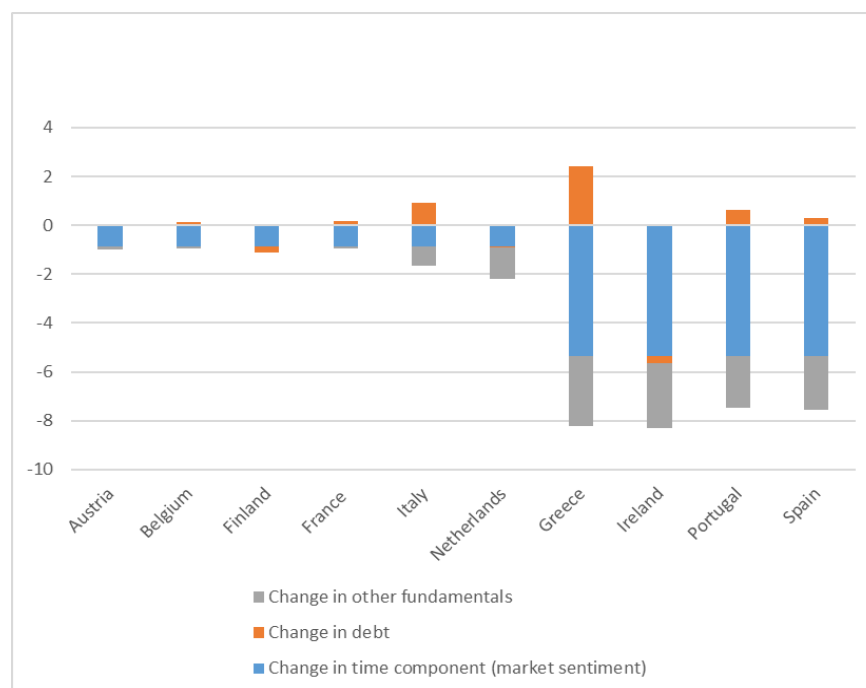
Source: Own calculations

The conclusions from the empirical analysis of the post-OMT period are similar. The rapid decline in the spreads during 2012-15 was triggered mainly by positive market sentiments, which are likely to have been the result of the OMT-announcement. The changes in the fundamentals, and, in particular, the changes in the debt to GDP ratios, had very little impact on the spreads.

These empirical results suggest that the sovereign debt crisis that erupted in 2010 and that led to spectacular increases in the sovereign bond rates of a number of countries was not the result of deteriorating government debt positions, but from market sentiments of panic and fear, and to lesser degree a decline in growth. Put differently, the surge of the spreads during 2010-12 was reflecting market sentiments in which panic and fear led investors to massively sell government bonds. These then in a self-fulfilling way triggered a liquidity squeeze making it increasingly difficult for the governments concerned to rollover their debt.

4. POLICY IMPLICATIONS

The above analysis shows that both fundamental factors (such as debt to GDP ratio, growth rate, current account balance) and market sentiment play significant role in the euro area sovereign bond yield spreads. Since late 2012, the announcement of the OMT certainly has removed the market sentiment factors leading to dramatic reductions in the spreads of the periphery sovereign bond markets. Following the ECB's QE intervention in 2015, we observe three positive developments in the periphery countries and the euro are in general. First, as shown in Figure 9, the positive real GDP growth in the euro area has been gradually restored. Second, the current account balances have turned to surpluses in some euro member states as shown in Figure 10. Third, the debt to GDP ratios, though still high, have been stabilized as shown in Figure 1(b). These improvements of the fundamentals have certainly played a role in reducing the sovereign bond spreads. However, the

improvements in the economic fundamentals as mentioned above remain insufficient. The real GDP levels in some Eurozone countries are still below their levels prior to the financial crisis. Therefore, we believe that QE could still play a positive role in supporting and restoring the economic fundamentals in the euro area. Our analysis of the recent developments in the bond markets suggest that pulling the plug on QE too soon might increase the refinancing costs of member states with little or no fiscal space.

Our analysis also suggests that the government bond markets in the Eurozone are highly sensitive to changing market sentiments, both in time and across countries. Government bond markets can easily switch from modes of risk-denial to excessive risk perception. In addition these changing risk perceptions can affect countries very differently. Thus, it is key for the ECB to avoid creating perceptions that the (inevitable) future unwinding of QE will lead to different implications for the sovereign bond markets. Such divergences could trigger self-fulfilling crises and destabilizing capital flows between the member countries when investors pull their money out of the bond markets perceived to have become risky and into bond markets perceived to be safe.

The recent ECB's Council Decision (8 December 2016) to broaden the maturity range of public sector purchases by decreasing the minimum residual maturity for eligible assets from 2 to 1 years, and – "to the extent necessary" – removing the deposit facility flooring, imply that the problem of scarcity of bonds discussed in a previous note might not be binding in the medium-term. However, the 33% issuer limit implies that any extensions of QE purchases should be followed by a broadening of the universe of eligible assets – the latter being quite politically controversial (see Gerba and Macchiarelli, 2016).

To avoid the risk of "QE infinity", the Governing Council has an important role in the management of expectations in the euro area. Managing expectations in a monetary union with many different member countries is more difficult than in standalone countries. The challenge for the ECB when it will unwind its QE-program in the future is vastly greater than for the US-Fed. It will be important for the ECB to reassure the markets that if the unwinding of QE leads to liquidity crises in some of the sovereign debt markets it stands ready to use its OMT-program to support these markets. The announcement by itself will be sufficient to avoid volatile market sentiments from destabilizing the system during the process of unwinding QE.

A return to stability at the European level can be achieved through supporting a full transition to a Capital Market and Banking Union, through the provision of federal guarantees for a smooth financial markets' functioning. Steps in those directions have proved to considerably weaken the link between banks and public debt levels (for a discussion on the European Banking Union see Macchiarelli 2016; see also ECB 2014).

Figure 9. Real GDP in Euro area (2010=100)
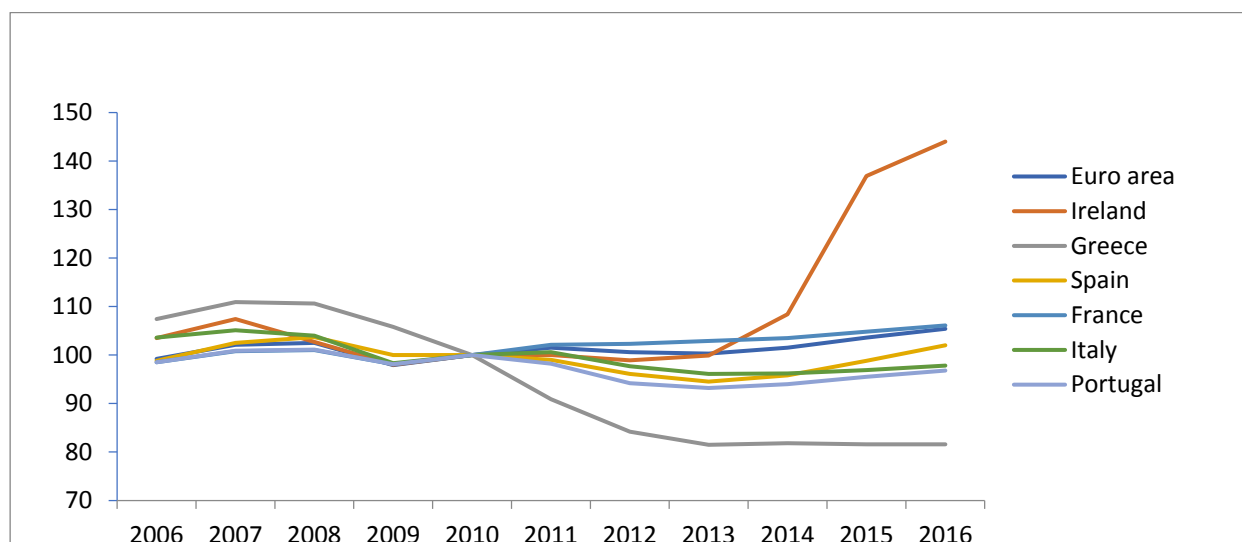
Source: Eurostat

Figure 10. Current account balances (2002-2016)
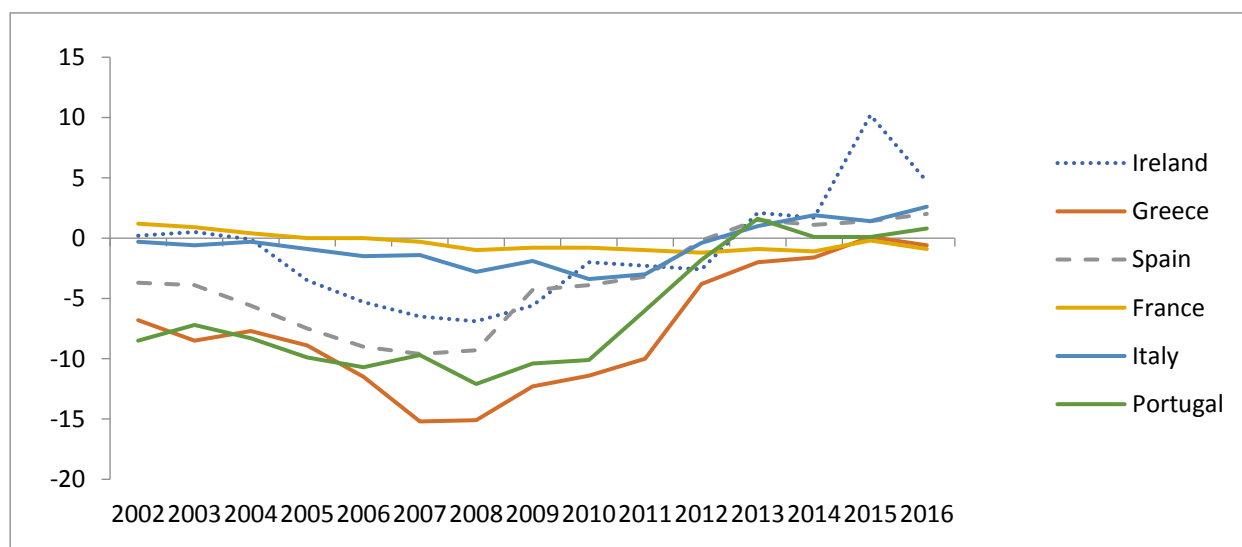
Source: Eurostat

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