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Abstract

We propose a common European bond which would yield a common European Monetary Union risk free rate. We present a tentative estimate of this common risk free for the European Monetary Union countries from January 2004 to December 2010 using variables motivated by a theoretical portfolio selection model. First, we analyze the determinants of EMU sovereign yield spreads and find significant effects of the credit quality, macro, correlation, liquidity and interaction variables. Robustness tests with different data frequencies, benchmarks, liquidity and risk variables, cross section regressions, balanced panels and maturities confirm the initial results. Then, we estimate a common risk free rate and show that this common rate would imply, in most cases, average savings in borrowing costs for all the countries involved although under some extreme market circumstances, some countries may suffer increased borrowing costs.

Keywords: Euro government bonds; Credit quality; Liquidity; Macro factors

JEL classification: F33, G12, H63

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1 Introduction

We present a tentative estimate of a new financial variable: the common risk free rate of interest for the European Monetary Union (EMU) members. We show how to estimate it for a given set of countries and discuss its uses for monetary policy management and its implication for financial markets' integration. The results suggest that this common rate, in most cases, could imply savings in borrowing costs for all the countries involved

The possibility of a common European bond has attracted the interest of the financial press and is receiving increased attention from policy makers.[1] There are potential wider benefits for the Eurozone as well as specific benefits for market agents such as issuers, dealers, and investors. A large common bond issue could have benefits even for countries with low credit risk (Germany, France), as it could rival American's treasuries market for liquidity. Moreover a single issuer would make EMU bonds more attractive to investors in large foreign-exchange reserves (China, Japan) and enhance the euro's standing as a reserve currency, as well as lowering borrowing costs for all countries that took part in it.[2] We also think that this common bond should not imply the disappearance of the individual sovereign bonds. Quite the opposite our framework implies that both kind of bonds (common European and individual country) should go hand in hand because they play complementary roles as exemplified by the state-issued and Federal bonds in the case of the USA. On the other hand, some arguments against it have been raised focusing on the possible increase in moral hazard as well as the technical and institutional difficulties of managing a common bond issuance. Governments in the Euro zone would have a limit for borrowing using Eurobonds (a certain percentage of country's GDP) and so, they would need to use the domestic debt markets for financing above this limit. Whenever the interest rate paid in the domestic market is higher than the common risk-free rate, there would be an incentive for governments to reduce the debt and deficit levels to pay lower interest rates on their domestic debt. As far as we know, there is no published quantification of a common risk free rate and nor a detailed comparison with other possible alternatives is available. This paper addresses both questions.

A common risk free rate could be used as a benchmark for measuring the benefits from financial market integration in the EMU. We conjecture and provide some evidence that our estimate of this rate would be close to what a common EMU-based single bond would yield for a specified maturity. We can then compare actual rates offered by the different EMU countries with sovereign bonds with this common

1 EPDA(2008,2009)

2 Additional technical advantages such as minimizing the possibilities of "squeezes" are discussed in Pagano and Von Thadden (2004)

rate. This allows us to compute the savings in terms of financing costs per year for the different EMU members. Given the common risk free rate measure we construct, our results suggest that, in most cases, there would be savings in borrowing costs for all EMU countries involved. Of course, there are many institutional design features that must be resolved (seniority, amount relative to total debt issues, guarantee fund, etc.) before such a common bond can be launched. But our paper provides a first insight into one central issue, namely, what should be the required compensation a given country X should pay to the actual issuer (let's assume that the issuer is the ECB or other EMU-wide agency) to be allowed to share a given issue of EMU-based single bonds. We argue that this compensation should be the Credit Default Swap (CDS) spread on X's sovereign bonds. The benefits for country X in using the common bond (instead of the sovereign bond) will be the enhanced rating and liquidity the common bond would provide plus additional premiums for country X's macro fundamentals. The fee charged to the issuers of the common bond could also be related to other fiscal or deficit related variables to limit the dependence on CDS market which in periods of financial distress could reflect other risks than credit risk. However, the use of the CDS spread could be considered as an upper and conservative bound for the issuance fee such that if these alternative leads to savings in borrowing costs, these savings would be higher with the other alternatives.

Motivated by a simple theoretical portfolio selection model, we first analyze the determinants of EMU sovereign yield spreads and find significant effects of the credit quality, macro, correlation, and liquidity variables. Robustness tests with different data frequencies, benchmarks, liquidity and risk variables, cross section regressions, balanced panels and maturities confirm the initial results.

We define the 'Hedged Yield' of the sovereign debt of a country as the difference of actual yield and the corresponding CDS spread. Based on these hedged yields we build one estimate of the common risk free rate and show that this common rate would imply savings in borrowing costs for all the countries involved in most cases, although higher borrowing costs may also occur for specific countries under extreme market conditions.

The remainder of the paper is organized as follows: Section 1 reviews some current literature on the subject; Section 2 introduces a theoretical model that allows us to determine the main components of the sovereign bond yields. Section 3 describes the data. Section 4 discusses the empirical results and presents some robustness tests. Section 5 introduces the construction of the common risk free rate. Section 6 discusses some policy implications and Section 7 offers some concluding remarks and proposes future lines of research.

2 Related Literature on EMU Sovereign Bond Spreads

Since the formation of the European Monetary Union (EMU henceforth) the topic of the determinants of the sovereign bonds' yield spreads within the EMU has been the subject of intense and increasing research. Researchers have tried to find out which are the factors that explain the differences between sovereign yields in the EMU countries, but so far no clear consensus has emerged. Codogno, Favero and Misale (2003) find that for most EMU countries only international risk factors have explanatory power while liquidity factors play a smaller role. Amira (2004) finds that sovereign yields increase with maturity, issue size and gross fees and decrease with credit rating. Geyer, Kossmeier and Pichler (2004) report that EMU government bond spreads are related to common factors whereas they do not find evidence for a significant impact of macroeconomic or liquidity related variables. Bernoth, von Hagen and Schuknecht (2006) report that global risk factors as well as idiosyncratic macroeconomic factors affect yield spreads, whereas liquidity plays a marginal role. Gomez-Puig (2008) finds that idiosyncratic factors (credit risk and liquidity) mostly drive yield differentials but systemic risk factors play only a marginal role. Favero, Pagano and Von Thadden (2008) find that one aggregate risk factor is consistently priced, that liquidity differentials are priced for a subset of countries, and that the interaction of liquidity differentials with the risk factor is consistently priced. In all these papers the benchmark for comparing the yield spreads is based on the German 10-year bund or German zero coupon curves. Beber, Brandt and Kavajecz (2009), however, use as benchmark the Euro-swap curve and show that the bulk of yield spread is explained by differences in credit quality as measured by the CDS, whereas liquidity plays a nontrivial role especially for low credit risk countries and in times of high market uncertainty. In summary, most papers suggest that credit quality-related factors, common business cycle factors (international or EMU), and, to a lower extent, liquidity-related factors are critical drivers of sovereign yield differentials.

The selection of the appropriate benchmark reference, however, has not received extensive attention in the literature. The most common view associates the benchmark bond with the lowest yield. If that were all that mattered for benchmark status, then the German market would provide, on average, the benchmark at all maturities. Analysts who take this view accept that the appropriate criterion for benchmark status is that this is the security against which others are priced, and they simply assume that the security with lowest yield takes that role. A plausible alternative, however, is to interpret benchmark to mean the most liquid security, which is therefore most capable of providing a reference point for the market. But the Italian market, not the German, is easily the most liquid for short-dated bonds;[3] and per-

3 Most of the trading for 10-year German bonds occurs on the futures market; this market is then more liquid and deeper than the cash market.

haps the French is most liquid at medium maturities.[4] Dunne, Moore and Portes (2002) consider in detail the meaning of the term "benchmark" bond. They investigate two possible criteria, using Granger-causality and cointegration tests. They find rather different results with the two methods, reflecting their different temporal focus. But with neither of them do they find the unambiguous benchmark status for German securities that would come from a simple focus on the securities with the lowest yield at a given maturity. They suggest looking for benchmark portfolios rather than a single benchmark security. This may be particularly appropriate in this partially integrated market and it is the approach we take in this paper. We take the benchmark to be a weighted average of the total gross debt at nominal value issued by the general governments of the different EMU members.

4 Favero, et al. (2008) set the French bond as the benchmark for the five-year maturity. This choice is supported by the evidence in Dunne, Moore and Portes (2002) and by the fact that traders view the French bond as the most liquid for that maturity.

3 Theoretical Model

The model we use to motivate the explanatory variables employed in the empirical part of the paper is an extension of the portfolio model of bond yield differentials developed in Bernoth et al (2006). Consider a domestic (benchmark) investor allocating a fraction θ_t (θ^*_t) of his real wealth w_t (w^*_t) to a domestic *D* (benchmark *F*) security and a fraction $1\text{-}\theta_t$ ($1\text{-}\theta^*_t$) to a benchmark (domestic) security. Assume that both the domestic and benchmark securities are subject to default risk. The default process is assumed to follow a correlated bivariate Bernoulli process (x_t , x^*_t), with domestic (benchmark) default probability $1\text{-}P_t$ ($1\text{-}P^*_t$). In the event of default the investor receives a fraction τ_t (τ^*_t) of his gross domestic (benchmark) payment, $\tau_t \, \varepsilon \, [0,1+r)$ ($\tau^*_t \, \varepsilon \, [0,1+r^*)$) where r (r^*) is the interest rate on the domestic (benchmark) bond. There are proportional transaction costs l_t (l^*_t) decreasing with domestic (benchmark) market liquidity. To simplify the presentation the coefficient of risk aversion ρ is assumed to be the same for both investors. Let S_t be the total supply of bond issued by the domestic government and assuming that the market clears, market equilibrium requires that

$$S_t = \hat{\theta}_t w_t + \hat{\theta}^*_t w^*_t \tag{1}$$

where the first term in the right hand side denotes the optimal amount of domestic bonds held by the domestic investor and the second term denotes the optimal amount of domestic bonds held by the benchmark investor. Assuming that the investors maximize a one period mean-variance utility function it is possible to solve for the interest rate differential between the two economies (details of the model can be found in Appendix I):

$$\begin{aligned} r_t - r^*_t = {} & (l_t - l^*_t) + S_t \frac{\rho}{2} Var\left[(1+r_t-\tau_t)x_t - (1+r^*_t-\tau^*_t)x^*_t\right] \\ & - \frac{\rho}{2}(w_t + w^*_t)\left[(1+r^*_t-\tau^*_t)^2 P^*_t (1-P^*_t)\right] \\ & + \frac{\rho(w_t + w^*_t)}{2}\left[(1+r_t-\tau_t)(1+r^*_t-\tau^*_t) Cov(x_t, x^*_t)\right] \\ & + (1+r_t-\tau_t)(1-P_t) - (1+r^*_t-\tau^*_t)(1-P^*_t) \end{aligned} \tag{2}$$

Defining $\quad k = (1+r_t-\tau_t) \qquad k^* = (1+r^*_t-\tau^*_t)$

The model can then be written:

$$\begin{aligned} r_t - r^*_t = {} & kE\left[1-x_t\right] - k^* E\left[1-x^*_t\right] + (l_t - l^*_t) + A_1 S_t Var\left[kx_t - k^* x^*_t\right] \\ & + A_2 (kk^* Cov\left[x_t, x^*_t\right] - (k^*)^2 Var\left[x^*_t\right]) \end{aligned} \tag{3}$$

where $\quad A_1 = \frac{\rho}{2} \qquad A_2 = A_1\left[w_t + w^*_t\right]$

Equation (3) decomposes the yield spread into four components. The first two terms are the *default risk premium* which is related with individual (country-specific) default probabilities. The higher is the domestic (benchmark) country-specific default probability the higher (lower) is the spread. Also, the riskier the domestic bond is in comparison with the benchmark, the greater will be the premium. Overall the effect of increases in the default risk premium will tend to increase yield spreads.[5] The third term on the right hand side is the *liquidity premium*. The less liquid the domestic bond is in comparison with the benchmark' liquidity, the greater will be this premium. The fourth term depends on the total debt S_t (which we later proxy with macro factors like budget and trade balances), the volatility of the differences in the default processes, and their interaction. The last term in the equation is a measure of *covariance risk* in excess of the volatility of the benchmark's default risk.

To test this model empirically we need to specify proxies for the components in equation (3). We use the CDS spreads as a proxy of the default risk premium as suggested in Beber et al. (2009).[6] As a measure of liquidity we use the bond's daily turnover volume; the difference between the domestic and benchmark economy serves to estimate the liquidity premium.[7] We also include two macro measures directly related with the total supply of bond issued by the domestic government and the health of the trade sector: total debt over GDP and net trade balance over GDP, both of them in deviations from the benchmark. Also, we use the interaction between the total debt over GDP and the volatility of the differences between the domestic and benchmark yields as a measure of both the total supply of debt and its relative risk.[8] Since the overall investor's risk attitude is not observable we proxy the global risk aversion with the Chicago Board Options Exchange Volatility Index VIX.[9]

Finally, the correlation between the domestic bond yield and the benchmark bond yield is used as a proxy for country-specific covariance risk.[10] Additionally, we include two crisis dummy variables to take into account possible changes in the intercept before and during crisis. The two crisis dummies correspond to two different crisis periods, the first related to the subprime crisis and the second with the European sovereign credit crisis, and are equal to one after August 2007 and November 2009, respectively, and zero otherwise.

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5 In the domestic (benchmark) cases the default risk premium decreases (increases) with an increase in the recovery rates in case of default τ_t (τ_t^*).

6 To deal with possible endogeneity problems we use the one day-lagged CDS spread

7 We realize that there is no generally held definition of liquidity. Many other measures have been suggested in the literature. In fact there is a close relationship between many of the measures and actual transactions costs, and the assumption that liquidity proxies measure liquidity seems to be granted, see Goyenko, Holden and Trzcinka (2008). Moreover, volume and other liquidity measures are usually employed in policy analysis, see European Central Bank (2009). In Section 4.2.4 we perform some robustness tests with respect to different specifications of the liquidity variable.

8 The volatility of the differences between the domestic and benchmark yields accounts for the differences in the default processes.

9 The VIX is often used as a proxy for investor's attitude toward risk and appears to explain movements of the bond spreads in recent years, see Hartelius et al. (2008) and Pan and Singleton (2007).

10 This approximation is consistent with assuming that the volatility of both rates are similar and then the last term in (3) reduces to $(k^*)^2 Var(x^*)[(k/k^*)Corr(x,x^*) - 1]$ and the expected sign for our proxy is negative. The intuition is that, assuming the ratio k/k^* to be close to 1, the correlation term is usually positive and lower than 1 and therefore the whole term above is usually negative. The higher the country-specific covariance risk (the lower the correlation), the higher the spread.

4 Data

The data consists of daily sovereign yields with maturities of 3, 5, 7, and 10 years for eleven EMU countries from January, 1 2004 to December 31, 2010. From August 9, 2007 to the end of the sample, the period during the ongoing financial crisis, a crisis dummy is added to some of the estimations. Another dummy variable is added to take into account the European sovereign debt crisis, starting in November 2009. Appendix II provides additional details about the definition, sources, and timing of the data used in the study.[11] Table 1 reports the total gross government debt outstanding at the end of the year for the eleven EMU members for the period 2003-2010. Summarizing the most salient features in Table 1, the three largest EMU bond issuers are Germany (26%), Italy (23%) and France (20%) and the smallest are Portugal (2.06%), Ireland (1.9%) and Finland (1.1%).

General Government Gross Debt TABLE 1

		2003	2004	2005	2006	2007	2008	2009	2010
Austria	Amount outs.	**146.3**	**150.7**	**155.8**	**159.4**	**165.0**	**180.5**	**191.0**	**205.2**
	% of the total	2.82%	2.78%	2.74%	2.74%	2.78%	2.81%	2.70%	2.63%
Belgium	Amount outs.	**271.6**	**273.9**	**279.1**	**280.4**	**282.1**	**309.2**	**326.4**	**341.0**
	% of the total	5.24%	5.05%	4.92%	4.81%	4.75%	4.81%	4.62%	4.38%
Finland	Amount outs.	**64.8**	**67.6**	**65.7**	**65.7**	**63.2**	**63.0**	**75.0**	**87.2**
	% of the total	1.25%	1.25%	1.16%	1.13%	1.06%	0.98%	1.06%	1.12%
France	Amount outs.	**1003.4**	**1076.9**	**1145.4**	**1149.9**	**1211.6**	**1318.6**	**1492.7**	**1591.2**
	% of the total	19.35%	19.84%	20.17%	19.73%	20.38%	20.51%	21.14%	20.42%
Germany	Amount outs.	**1383.5**	**1453.8**	**1524.4**	**1571.6**	**1578.8**	**1644.1**	**1760.8**	**2079.6**
	% of the total	26.68%	26.78%	26.85%	26.97%	26.56%	25.58%	24.93%	26.68%
Greece	Amount outs.	**168.0**	**183.2**	**195.4**	**224.2**	**239.4**	**262.3**	**298.7**	**328.6**
	% of the total	3.24%	3.37%	3.44%	3.85%	4.03%	4.08%	4.23%	4.22%
Ireland	Amount outs.	**43.3**	**44.3**	**44.4**	**44.0**	**47.4**	**79.8**	**104.8**	**148.1**
	% of the total	0.84%	0.82%	0.78%	0.76%	0.80%	1.24%	1.48%	1.90%
Italy	Amount outs.	**1394.3**	**1445.8**	**1514.4**	**1584.1**	**1602.1**	**1666.6**	**1763.9**	**1843.0**
	% of the total	26.89%	26.63%	26.67%	27.19%	26.95%	25.93%	24.98%	23.65%
Netherlands	Amount outs.	**248.0**	**257.6**	**266.1**	**255.9**	**259.0**	**347.1**	**347.6**	**371.0**
	% of the total	4.78%	4.75%	4.69%	4.39%	4.36%	5.40%	4.92%	4.76%
Portugal	Amount outs.	**79.9**	**85.8**	**96.5**	**102.4**	**115.6**	**123.1**	**139.9**	**160.5**
	% of the total	1.54%	1.58%	1.70%	1.76%	1.94%	1.92%	1.98%	2.06%
Spain	Amount outs.	**381.6**	**388.7**	**391.1**	**389.5**	**380.7**	**433.6**	**561.3**	**638.8**
	% of the total	7.36%	7.16%	6.89%	6.68%	6.40%	6.75%	7.95%	8.20%
Total	Amount outs.	**5184.7**	**5428.3**	**5678.3**	**5827.1**	**5944.9**	**6427.9**	**7062.1**	**7794.2**
	% of the total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Ameco Database. Economic and Financial Affairs, European Commission.

This table reports the total gross government debt outstanding at the end of the year for eleven EMU members for the period 2003-2010 in billions (milliards) of Euros. It also reports the proportion of the total debt outstanding by each of the EMU members.

11 Detailed descriptive statistics for all the variables and countries are available on request. We report some of the important descriptive statistics below.

In all cases the yields increase and the volatilities decrease with maturity. In general, average trading volume decreased during the crisis[12] suggesting that transaction costs increased across the board in the crisis period as well as CDS spreads and yield volatilities.[13] There is also evidence of an overall worsening of the trade balance across countries after the crisis started as well as an increase of the ratio of debt to GDP.

For the 3, 5, 7, and 10 year sovereign yields the lowest averages are 2.82, 3.15, 3.42 and 3.72 respectively for Germany; the highest averages are 4.37, 4.70, 4.79, and 5.18 for Greece. Both the standard deviations and the minimum and maximum values indicate that there can be significant time-series variation in the sovereign yields. For example, 3-year yield for Greece ranges from 2.28 to 14.25 during the sample period.

Average daily trading volume (in millions of Euros) also presents wide variation ranging from the high volumes for Germany (15,804) and Italy (9,916) to the low volumes for Finland (247) and Ireland (202).

Average CDS rates vary substantially across countries. The lowest average in the whole sample is 14.79 basis points for Germany; the highest average is 139.30 basis points for Greece.[14] The macro factors also vary widely across countries. For instance using 2010 data, the countries with highest average Debt/GDP ratio are Greece (144%) and Italy (118%) and the lowest Finland (48%) and the country with worse average trade balance is Greece (-1.42%) and the best one is Ireland (+1.65%). Regarding the average interaction debt factor, which measures not only the total debt outstanding but also its risk with respect to the benchmark, varies between 19 for Greece and 3 for Finland, increasing markedly once the crisis starts to 65 and 20 respectively.[15] Finally, the average correlation between the domestic 10-year government yield and the benchmark for the whole sample is highest for France (0.91) and lowest for Austria (0.75) decreasing in all countries after summer 2007 with France being the highest (0.85) and Spain the lowest (0.56). However the decrease is even stronger after the beginning of the European sovereign debt crisis with France being the highest (0.66) and Spain the lowest (0.22). This decrease in the correlations could reflect a decrease in the degree of integration in the sovereign bond market of the EMU area in time periods of financial distress.[16]

12 There are slight increases in Belgium, Ireland, Finland, France and the Netherlands.

13 It is interesting to note that some countries viewed by the market as having very little average sovereign risk (CDS spread around 2 basis points) before the summer of 2007, like Germany, Austria, Belgium, Finland, France, or The Netherlands, were penalized in different ways once the European sovereign debt crisis unfolds, being Finland (28 b.p.), Germany (38 b.p.), and The Netherlands (43 b.p.), viewed as the safest, then France (64 b.p.) and finally Austria (78 b.p.) and Belgium (100 b.p.). All countries experienced, in specific days, very high CDS premium, for instance Germany (92 b.p.), Finland (94 b.p.), France (110 b.p.), The Netherlands (131 b.p.), Belgium (254 b.p.) or Austria (272 b.p.).

14 Both the standard deviations and the minimum and maximum values indicate that there can also be significant time-series variation in the sovereign CDS premium. For example, the cost of credit protection for Greece ranges from 4.40 to 1125.81 basis points during the sample period.

15 Similar increases are also observed in all other countries.

16 Analyses of financial integration in the Euro Area sovereign bond market can be found in Adam et al. (2002), Adjaouté and Danthine (2003) Baele et al. (2004) and Schulz and Wolff (2008) among others. They conclude that despite the great convergence between yields, yield differentials have not disappeared completely under EMU and so, European sovereign bonds are still not perfect substitutes.

5 Empirical Results

Having established the factors to be used as explanatory variables for the sovereign yields spreads (as suggested by the theoretical model), we now turn our attention to examine the economic and statistical significance of the variables in explaining both the cross-section as well as the time series of yields spreads. We group the data by country (11 countries) and maturity (3, 5, 7 and 10 years) totaling 44 groups which form an unbalanced panel.[17]

Correlation between Explanatory Variables TABLE 2

Observations = 66718	Gov. Yield	CDS(-1)	Liquidity	Debt/ GDP	Inter. (Debt)	Trade Bal./GDP	Global Risk	Corr (dom & bchmk)	Yield - CDS	Crisis (Aug 07)	Crisis (Nov 09)
Gov. Yield											
CDS(-1)	0.976										
Liquidity	-0.171	-0.167									
Debt/GDP	0.258	0.252	0.486								
Inter. (Debt)	0.703	0.689	-0.071	0.230							
Trade Bal./GDP	-0.132	-0.108	-0.160	-0.437	-0.138						
Global Risk: log(VIX)	0.089	0.078	0.020	-0.041	0.172	-0.005					
Corr(dom. & bnchmk y.)	-0.198	-0.186	0.098	0.060	-0.280	-0.058	-0.226				
Yield - CDS	0.369	0.278	-0.082	0.189	0.171	-0.055	-0.220	0.065			
Crisis Dummy (August 07)	0.134	0.124	0.024	-0.049	0.264	0.004	0.778	-0.369	-0.360		
Crisis Dummy (November 09)	0.204	0.194	0.012	0.007	0.413	0.050	0.139	-0.552	-0.105	0.444	

This table reports the correlation between the dependent and explanatory variables employed in equations (4), (5) and (6). Gov. Yield refers to the difference between the domestic Government yield and the benchmark yield. CDS(-1) refers to the difference between the domestic and benchmark CDS spreads (in percentage) lagged one day. Liquidity represents the deviation of the logarithm of the domestic total bond daily turnover volume, in millions of Euros, from the log of the benchmark total bond daily turnover volume. Debt/GDP refers to the difference between the domestic and benchmark total gross debt outstanding at the end of the year divided by the corresponding GDP at that moment. Inter. (Debt) is an interaction term that represents the product of Debt/GDP and the standard deviation of the domestic yield minus the benchmark yield. Trade Balance/GDP refers to the deviation of the domestic net trade balance at the end of every month divided by the GDP from the benchmark equivalent measure. Global Risk is a measure of the overall risk which is obtained from the Chicago Board Options Exchange Volatility Index (VIX) and it is a measure of the implied volatility of S&P 500 index options. Corr(dom. & bnchmk y.) is the monthly correlation between the domestic Government bond yield and the EMU benchmark bond yield. Yield - CDS refers to the deviation of the domestic Government yield minus the CDS spread for the same maturity from the benchmark equivalent measure. Crisis Dummy (August 07) represents a variable which is equal to one after August 2007 and zero otherwise. Crisis Dummy (November 09) represents a variable which is equal to one after November 2009 and zero otherwise. Gov. Yield is employed as dependent variable in equations (4) and (5). The dependent variable in equation (6) is the Government yield minus the CDS spread for the same maturity but this variable is not in deviations from the benchmark as the Yield - CDS variable that appears in this table.

17 The panel is unbalanced because we do not have information on some variables from the beginning of the sample. However, there are no missing values once we include the first realization of the series.

Average correlations among dependent and explanatory variables are presented[18] in Table 2. As expected, sovereign yields spreads are highly and positively related to CDSs lagged by one day. This is consistent with our theoretical model's prediction that increases in default risk premiums are associated with increases in yield spreads. The negative correlation between yield spreads and the liquidity variable is in agreement with the theoretical prediction that the less liquid the domestic bond market is in comparison with the benchmark' liquidity, the greater will be the yield spread. The positive correlations for the Debt/GDP, Interaction Debt variable and global risk suggest that as they each increase, sovereign yield spreads increase. The negative correlation for the Trade balance variable suggests that trade deficit increase government yield spreads. Overall, the signs are in agreement with the ones suggested by the theoretical model. Both crisis dummy variables are positively correlated with the spread as expected, being the sovereign debt crisis dummy the one presenting stronger impact. Our main objective, however, is to examine the joint effect of these explanatory variables on the yield spreads.

4.1 Unbalanced Panel Regression

We regress the difference between the sovereign yield in EMU country *i* and the benchmark portfolio yield onto differences in country *i*'s credit quality, liquidity and macro measures from their respective cross-sectional weighted averages (or benchmark values) and onto global risk and interaction measures. We employ a Prais-Winsten regression with correlated panels, corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common[19] to all the panels.[20] Our panel regression model is described by the equation:

$$r_{it} - r_{it}^{*} = \alpha + \sum_{k=1}^{K} \beta_k (X_{k,i,t} - X_{k,BNCH,t}) + \sum_{j=1}^{M} \gamma_j D_{j,t} + \chi\, Y_{i,t} + \delta\, Z_t + \psi\, C_{i,t} + \varepsilon_{i,t} \qquad (4)$$

where the dependent variable is the spread between the government bond's yield of country *i*, r_{it} at four different maturities (3, 5, 7, and 10 years) and the benchmark yield r^{*}_{it}, at the same maturities. The benchmark yields are obtained as the weighted average of the Government yields of the EMU countries in the sample for the corresponding maturity (3, 5, 7, and 10 years). The weights are proportional to the portion of debt outstanding by each country with respect to the total amount outstanding by all these countries[21] and change annually. The $X_{k,i,t}$ are credit risk, liquidity and macro explanatory variables (CDS_{t-1}, Volume, Total debt/GDP, Net Trade Balance/GDP) and $X_{BNCH,t}$ are their respective weighted averages over the eleven countries, obtained using the same procedure employed to build the benchmark

18 All the variables, with the exception of the measure of global risk, the correlation between the domestic Government and benchmark yields, and the crisis dummy are in deviations from the benchmark.

19 Better fit, as measured by the Schwarz Information Criteria, is obtained using an AR(1) autocorrelation structure common to all panels instead of a panel-specific AR(1) autocorrelation structure.

20 Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance.

21 To gain a better perspective of the dependent variable, it is worth mentioning that its maximum (minimum) average value is equal to 21.5 (-8.9) basis points for Greece (Germany).

yield.[22] Notice that we specify the credit, liquidity and macro variables as differences from their cross-sectional weighted averages (or benchmark value). This approach stresses the fact that credit risk; liquidity and macro variables are relative concepts. The $D_{j,t}$ are dummy variables to take into account the maturity effect in bond yields (3, 5, and 7 years) as well as the two crisis dummies, the first is equal to zero before August 9, 2007 and one afterwards and the second is equal to zero before November 2009 and one afterwards. The $Y_{i,\ t}$ is the interaction term of total debt/GDP of country i times the volatility of the difference between domestic yield and benchmark yield. Finally, the Z_t is the global risk factor measured as the log of the VIX index and $C_{i,t}$ is the correlation between the country i yield (for its corresponding maturity) and the benchmark's yield.

The results of the panel regressions are reported in Table 3. Column 1 gives the results without the crisis dummies Column 2 with the first crisis dummy and Column 3 with the second crisis dummy. The explanatory power of the regressions, reflected in their adjusted R^2, is 39.5%, 39.6% and 39.8%, respectively. Consistent with intuition as well as with our theoretical model and the previous literature, the CDS lagged one period has a strong positive impact on sovereign yield spread which indicates that a lower credit quality increases the yield spread. The liquidity differential is also significant. The negative coefficient suggests that higher than average liquidity is associated with lower yield spreads. The total debt over GDP) and the global risk factor have also a positive and significant impact in the sovereign yield spread. However the impact of the relative health of the trade sector, albeit negative as expected, is not significant. The effect of the term measuring the interaction of total debt relative to GDP and the standard deviation of the domestic yield minus the benchmark yield is positive and significant. Recall that this variable measures both the total supply of debt and its relative risk against the benchmark. Therefore the economic meaning of this variable is that, for a given debt level, an increase in the volatility of the difference of the domestic yield and benchmark yield increases yield spreads. The more the two rates grow apart the higher the effect on yield spreads. This could be the case in a situation where a given country's spreads tends to diverge from the benchmark behavior and then the market penalizes this divergence demanding higher yield spreads. If two countries present the same divergence from the benchmark yield behavior, the penalization is higher for the country with the higher level of debt relative to GDP. The correlation between the domestic bond yield and the benchmark bond yield has a negative effect possibly reflecting a lower "integration" in crisis periods and also the fact that the correlations are lower for peripheral countries (see footnote 10).

Both crisis dummies are positive and significant as it also the case with the maturity dummy variables coefficients.[23] Overall, these results provide strong support for the theoretical model and for all the proxy explanatory variables chosen. The inclusion of the two crisis dummies, though significantly positive in both cases, does not affect materially the size and significance of the other explanatory variables.

22 Notice that the CDS variable is different for different maturities, whereas the other variables are the same for all maturities.

23 We repeated the regression in Table 3 using weights proportional to the debt outstanding by each EMU member in the Prais-Winsten regression and results do not change significantly. These results are available upon request.

Determinants of the Deviations between the Government Yield and the Benchmark Yield

TABLE 3

		(1)	(2)	(3)
CDS(-1)		0.599***	0.596***	0.594***
		(0.012)	(0.012)	(0.012)
Log (Total bond daily turnover volume)		-0.077***	-0.078***	-0.078***
		(-0.005)	(-0.005)	(-0.005)
Total debt issued divided by GDP		0.712***	0.725***	0.715***
		(0,037)	(0,037)	(0,037)
Interaction of total debt divided by GDP and the standard deviation of		0.346***	0.338***	0.329***
the domestic yield minus the benchmark yield		(0,045)	(0,044)	(0,044)
Net Trade Balance divided by GDP		-1,014	-0,979	-1,230
		(-0.842)	(-0.842)	(-0.840)
Global risk measure: log(VIX index)		0.036***	0.025***	0.036***
		(0,005)	(0,005)	(0,005)
Correlation between domestic Government yield and EMU benchmark		-0.026***	-0.024***	-0.020**
Government Yield		(-0.008)	(-0.008)	(-0.009)
Dummy for the 3-year yield		0.016***	0.016***	0.016***
		(0.006)	(0.006)	(0.006)
Dummy for the 5-year yield		0.024***	0.024***	0.024***
		(0.005)	(0.005)	(0.005)
Dummy for the 7-year yield		0.010**	0.010**	0.010**
		(0.004)	(0.004)	(0.004)
Crisis dummy (August 2007)			0.077***	
			(0.010)	
Crisis dummy (November 2009)				0.118***
				(0.009)
Constant		-0.078***	-0.089***	-0.105***
		(-0.018)	(-0.018)	(-0.018)
Autorregressive (AR(1)) coefficient		0.941	0.941	0.941
R-squared		0.395	0.396	0.398
Observations		70780	70780	70780
Number of groups		44	44	44
Observations per group	Minimum	687	687	687
	Average	1609	1609	1609
	Maximum	1826	1826	1826
Wald chi2 (10 df)		3350	3432	3740
Prob. > chi2		0	0	0
Condition Index		7.730	11.980	8.950

This table reports the results of the unbalanced panel regressions. The dependent variable is the deviations between the Government yields and the Benchmark yields which are obtained as the weighted average of the Governments yields of the different European Monetary Union countries in the sample. The weights are proportional to the portion of debt outstanding by each of the EMU countries with respect to the total amount outstanding by all these countries. Our database is formed by eleven EMU countries and spans from January 2004 to December 2010. All the variables (dependent and explanatory) except the measure of global risk, the measure of correlation between the domestic Government and benchmark yields and the crisis dummy are presented in deviations from the value of the same variable for the benchmark. We group the panels by country and maturity (3, 5, 7 and 10 years) such that we have, at most, 44 groups which form an overall unbalanced panel. We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. Column (1) reports the results for the whole sample without using the crisis dummy as an explanatory variable and Column (2) reports the results using the crisis dummy which is equal to one after August 2007 as explanatory variable. Column (3) reports the results using the crisis dummy which is equal to one after November 2009. The results presented correspond to the estimated coefficient and the standard errors (between brackets). The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

Determinants of the Deviations between the Government Yield and the Benchmark Yield using Different Specifications for the Credit Risk Proxy TABLE 4

		(1)	(2)	(3)	(4)
CDS(-1)		0.594***	0.595***	0.621***	0.562***
		(0.012)	(0.015)	(0.018)	(0.023)
Log (Total bond daily turnover volume)		-0.078***	-0.075***	-0.049***	-0.058***
		(-0.005)	(-0.005)	(-0.006)	(-0.006)
Total debt issued divided by GDP		0.715***	0.712***	0.590***	0.795***
		(0.037)	(0.038)	(0.042)	(0.051)
Interaction of total debt divided by GDP and the standard		0.329***	0.402***	0.552***	0.434***
de viation of the domestic yield minus the benchmark yield		(0.044)	(0.047)	(0.044)	(0.045)
Net Trade Balance divided by GDP		-1.230	-1.135	-2.383**	1.463
		(-0.840)	(-0.894)	(-0.937)	(1.036)
Global risk measure: log(VIX index)		0.036***	0.037***	0.038***	0.041***
		(0.005)	(0.006)	(0.005)	(0.006)
Correlation between domestic Government yield and EMU		-0.020**	-0.013	-0.004	-0.027***
benchmark Government Yield		(-0.009)	(-0.010)	(-0.009)	(-0.009)
Dummy for the 3-year yield		0.016***	0.015**	0.014*	0.015*
		(0.006)	(0.006)	(0.007)	(0.009)
Dummy for the 5-year yield		0.024***	0.024***	0.023***	0.024***
		(0.005)	(0.005)	(0.006)	(0.007)
Dummy for the 7-year yield		0.010**	0.010**	0.010*	0.010
		(0.004)	(0.004)	(0.005)	(0.006)
Crisis dummy (November 2009)		0.118***	0.114***	0.100***	0.109***
		(0.009)	(0.010)	(0.010)	(0.011)
Constant		-0.105***	-0.112***	-0.099***	-0.056**
		(-0.018)	(-0.021)	(-0.021)	(-0.022)
Autorregressive (AR(1)) coefficient		0.941	0.943	0.952	0.959
R-squared		0.398	0.324	0.267	0.177
Observations		70780	70672	70208	68656
Number of groups		44	44	44	44
Observations per group	Minimum	687	684	675	654
	Average	1609	1606	1596	1560
	Maximum	1826	1822	1805	1762
Wald chi2 (10 df)		3741	2482	1904	1219
Prob. > chi2		0	0	0	0
Condition Index		8.950	8.950	8.930	8.840

This table reports the results of the unbalanced panel regression using different specifications for the credit risk proxy. Column (1) corresponds to the baseline regression in which credit risk is proxied by CDS spread lagged one day, similar to Column (3) of Table 3. Columns (2) (3 and 4) reports the results obtained when the credit risk proxies correspond to the average CDS spreads in the week previous (month and quarter) to the current week (month and quarter, respectively). All the variables (dependent and explanatory) except the measure of global risk, the measure of correlation between the domestic Government and benchmark yields and the crisis dummy are presented in deviations from the value of the same variable for the benchmark. We group the panels by country and maturity (3, 5, 7 and 10 years) such that we have, at most, 44 groups which form an overall unbalanced panel. We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance mat(** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively rix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. The results presented correspond to the estimated coefficient and the standard errors (between brackets). The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%)

Since there is a potential endogeneity between a country's sovereign yields and its CDS rates, in the panel regression results reported in Table 3 we have used a one period (day) lag in the CDS explanatory variable. This is a standard procedure to deal with potential endogeneity. To further address this issue, we have run an identical panel regression but omitting the deviation of the domestic CDS spread from the benchmark and the deviation of the domestic interaction between the CDS and bid-ask spreads from the benchmark corresponding interaction. The results (not reported but available on request) are qualitatively very similar to those in Table 3, confirming the significance of most other explanatory variables and suggesting that endogeneity is not a serious issue in our case. A methodological point should also be mentioned here. The CDS prices present certain degree of persistence and so one may argue that lagging by one-day would not solve entirely potential endogeneity problems. To deal with this criticism we construct new variables from CDS spreads which reflect credit risk but have a lower degree of persistence. Thus, we calculate the average CDS every week (month and quarter) for every country and use as an alternative explanatory variable the average level of the CDS spread the week (month and quarter) previous to the current week (month and quarter, respectively). That is, we use the average CDS spread in the last week of January for the days corresponding to the first week of February and the same is done for the equivalent monthly and quarterly averages. Results are shown in Table 4. As expected, when the time period considered to calculating the average CDS spread increases, the R-squared decreases given that it is less informative of the current credit risk. Nevertheless, the effect of the credit risk proxy is always significant at 1% significance level. Moreover, the signs, levels of significance, and coefficients for the remaining explanatory variables do not change noticeably across the four columns of Table 4.

Finally, we analyze the effect of the cross-sectional dispersion between countries in the explanatory variables on the dependent variable. For this aim, we first calculate the standard deviation of each explanatory variable across countries at each date *t*. Then, we compute the average of these standard deviations for all dates and finally multiply this average by the corresponding coefficient (see Table 3). In Table 5 we report the results of this sensitivity analysis of the determinants of the yield spreads. Specifically, we report the magnitude of the change, in basis points, of the dependent variable given a change equal to the average of the standard deviations across countries of a given explanatory variable over all dates.[24] We focus on the cross-sectional dimension of the panel and employ the time-series dimension to calculate the average effect across time. [25] This allows us to evaluate how the different macro or risk factors of the countries under study affect the yield spreads.

The largest effect on yield spreads is caused by deviations between the countries' CDSs spreads (24.6 b.p.). The variable with the second strongest effect is the total

24 The standard deviation of the following variables: CDS spread (lagged one day); interaction of total debt divided by GDP and the standard deviation of the difference between domestic and benchmark yields; and correlation between domestic Government yield and benchmark yield are calculated for the five year's maturity.

25 We repeat the sensitivity analysis focused on the time-series dimension of the panel. By means of this analysis, we estimate the change in the dependent variable after a change of one standard deviation in a given explanatory variable across time and countries. Results are in line with the ones in Table 5 but are not reported in this paper given that our aim is to focus on how the differences between countries affect the deviations in the yield spreads and so, we focus in the cross-section dimension.

Sensitivity Analysis of the Determinants of the Deviations between the Government Yield and the Benchmark Yield TABLE 5

	(1)	(2)	(3)
CDS (lagged one period) spread	24.60	24.47	24.39
Total bond daily turnover volume	-11.53	-11.67	-11.67
Total debt issued divided by GDP	18.03	18.36	18.11
Interaction of total debt divided by GDP and the yield S.D.	1.40	1.36	1.33
Net Trade Balance divided by GDP	-0.84	-0.81	-1.02
Correlation between Gov. yield and benchmark yield	-0.29	-0.27	-0.22

This table provides the sensitivity analysis of the determinants of the deviations between the Government yields and the Benchmark yields. All the variables (dependent and explanatory) except the correlation between the domestic and benchmark yields are presented in deviations from the value of the variable for the benchmark. Column (1) reports the results for the whole sample without using the crisis dummy as an explanatory variable and Column (2) reports the results using the crisis dummy which is equal to one after August 2007 as explanatory variable. Column (3) reports the results using the crisis dummy which is equal to one after November 2009. Each column reports the response, in basis points, of the dependent variable (deviation of the domestic Government yield from the benchmark yield) to a change equal to the average of the standard deviations of a given explanatory variable across countries over all dates. For this aim, we first calculate the standard deviation of each explanatory variable across countries at each date t. Then, we compute the average of these standard deviations for all the dates t and finally, we multiply this average by the corresponding coefficient (see Table 3). The standard deviation of variables: CDS spread (lagged one period); interaction of total debt divided by GDP and yield S.D.; and correlation between Gov. yield and benchmark yield are presented for a maturity of five years.

debt issued relative to GDP (18.03 b.p.) The next most influential variable is liquidity (-11.53 b.p.) whereas the other variables have lower effects. Note that the sensitivities are practically unaffected by the inclusion of the crisis dummies.

5.2 Robustness Tests

In this section, we report the results of several checks on the basic results. The robustness tests consider cross-section regressions, changes in the benchmark, using balance panel regressions and alternative liquidity measures, employing alternative data frequencies and analysing maturity by maturity. In all cases the results are robust to the alternative specifications.

5.2.1 Cross Section Regressions

As a first robustness test we run a cross-section regression every day and then we test for the significance of the time series of coefficients, see Fama and Macbeth (1973). Equation (5) details our cross-section regression model:

$$r_{it} - r_{it}^{*} = \alpha_t + \sum_{k=1}^{K} \beta_{k,t} (X_{k,i,t} - X_{k,BNCH,t}) + \sum_{j=1}^{M} \gamma_{j,t} D_{j,t} + \chi_t Y_{i,t} + \varepsilon_{i,t} \qquad i = 1,\ldots 44 \quad t = 1,\ldots,1294 \tag{5}$$

where the dependent variable is the spread between the government bond's yield of country i (i=1,...,11) r_{it} at four different maturities (3,5,7,and 10 years) and the benchmark yield r^*_{it}, at the same maturities. The benchmark yields are obtained as the weighted average of the Government yields of the EMU countries in the sample for the corresponding maturity (3, 5, 7, and 10 years). The weights are proportional to the portion of debt outstanding by each country with respect to the total amount outstanding by all these countries. The $X_{k,i,t}$ are credit risk, liquidity and macro explanatory variables (CDS_{t-1}, Volume, Total debt/GDP, Trade Balance/GDP) and $X_{k,BNCH,t}$ are their respective weighted averages over the eleven countries. Notice that we specify the credit, liquidity and macro variables as differences from their cross-sectional weighted averages. This approach stresses that credit risk, liquidity, and macro stance are relative concepts. The $D_{j,t}$ are dummy variables to take into account the maturity effect in bond yields (3, 5, and 7 years). Finally, the $Y_{i,t}$ is the interaction term of total debt relative to GDP times the volatility of the difference between domestic yield and benchmark yield.[26]

In order to estimate the cross-sectional effects of the above variables, we run a cross-sectional regression by OLS for every date in the sample (1294 in total) and compute the average coefficient for the whole sample. Petersen (2009) states that the Fama-MacBeth standard errors are biased in exactly the same way as the OLS estimates and the magnitude of the bias is a function of the serial correlation of both the independent variable and the residual within a cluster and the number of time periods per firm (or cluster). Thus, we must adjust the standard errors for the autocorrelation of the estimated slope coefficients.[27] We employ the Fama-MacBeth methodology with Newey-West standard errors.[28]

The results of the cross section regressions are reported in Table 6. Column 1 gives the estimated coefficients, Column 2 the corrected t-statistics, Column 3 the proportion of coefficients with the right sign, and Column 4 the change in the dependent variable given a change of one standard deviation in the explanatory variable. The average R^2 of the cross-sectional regression is 73%. The magnitude of the regression coefficient suggests that a one standard deviation increase in the CDS above the weighted average is associated with an average increase in the following day's sovereign yield spread of 35.1 b.p.[29] This is the most economically significant effect found for the explanatory variables. The total debt relative to GDP has a lower impact in the sovereign yield spread of 8.8 b.p. One standard deviation increase in the total debt above the weighted average is associated with an average increase in the sovereign yield spread of 2.3 b.p. The economic impact of this variable is the lowest of all the explanatory variables in the analysis.

26 Note that in equation (5) we do not employ the VIX index, the crisis dummy and the correlation between the domestic and the benchmark yields. The reason is because both the VIX index and the crisis dummy are the same for all the countries and maturities. We exclude the correlation variable because it causes multicollinearity problems.

27 As Petersen (2009) states, when there is only a time effect, the correlation of the estimated slope coefficients across years is zero and the standard errors estimated by the Fama-MacBeth are unbiased.

28 In order to find an unbiased *t*-statistic, we regress the estimated coefficients on a constant using the Newey-West adjustment to control for serial correlation. This methodology is also employed in Davydenko and Strebulaev (2007).

29 To gain a better understanding of the effects of the explanatory variables on the dependent variable, it is worth noting that the maximum (minimum) average value by country for the deviation between the Government yield and the benchmark yield for the five years maturity is equal to 121 (-22) basis points for Greece (Germany).

Determinants of the Deviations between the Government Yield and the Benchmark Yield (Cross Section Analysis)

TABLE 6

	Coefficient	Corrected t-stat	Right Sign (%)	1 S.D. change
CDS spread lagged one period	1.072	25.15	98.9	0.351
Log (Total bond daily bond turnover volume)	-0.023	-6.75	66.0	-0.031
Total debt issued divided by GDP	0.091	5.39	68.0	0.023
Interaction of total debt divided by GDP and the standard deviation of the domestic yield minus the benchmark yield	1.647	9.92	74.6	0.077
Net Trade Balance divided by GDP	0.453	1.06	48.2	0.004
Dummy for the 3-year yield	0.009	2.23	62.8	0.004
Dummy for the 5-year yield	0.019	5.49	66.9	0.008
Dummy for the 7-year yield	0.013	5.09	64.5	0.006
Constant	-0.064	-8.40	78.3	
Average R-squared	0.775			
Cross-Sections with Condition Matrix Above 30	0			

This table reports the results of the cross-sectional regressions. All the variables (dependent and explanatory) are presented in deviations from the value of the variable for the benchmark. We run a cross-sectional regression by OLS for every date (1808) in the sample and calculate the average coefficient for the 1808 regressions which is reported in the first column. We find that the estimated slope coefficients present autocorrelation and for this reason, in the second column we report the t-statistic obtained from the Newey-West adjusted standard errors. These errors are obtained after regressing with Newey-West standard errors adjustment the loadings on each factor, which are shown in the first column, on a constant. Intercept that was included at the first stage is not reported. The third column reports the portion of cross-sectional regressions where the sign of the coefficient is the same as the expected sign. The fourth column shows the change in the dependent variable after a change in the explanatory variable equal to the standard deviation of this variable. We report the results obtained using all the explanatory variables in Table 3 but the global risk, the crisis dummy and the correlation between domestic and EMU benchmark Government yields.

The effect of the term measuring the interaction of total debt and the standard deviation of the domestic yield minus the benchmark yield is positive and significant. One standard deviation increase in this variable is associated with an average increase in the sovereign yield spread of 7.7 b.p.

With respect to the liquidity differential variable the negative coefficient suggests that higher than weighted average liquidity is associated with lower yield spreads. One standard deviation increase in liquidity above the average is associated with an average change in the sovereign yield spread of -3.1 basis points. The sign of the net trade balance relative to GDP variable is not negative as expected but is not significant at any standard level of significance.

Overall the results of the cross sectional regressions are consistent with the ones given by the unbalanced panel regression reported in Section 4.1 indicating that the main results of the analysis are robust to different specifications of the regressions. The sensitivity analysis' results for the cross-sectional regression are also similar to those reported in Table 5 for the panel regressions.

5.2.2 Changing the Benchmark

We next address the issue of how robust are our results to the choice of benchmark. In particular, as is common in the literature, we use the German bond as a benchmark.

Table 7 presents the results of estimating the panel regression equation (4) using two different benchmarks. Besides the benchmark used in this study, which is obtained from the relative weights calculated from the total debt outstanding by each country over the total amount in the EMU, we present the results obtained using the German bond as the benchmark. As can be seen from Table 7, our main results are not very sensitive to the choice of benchmark.[30]

5.2.3 Balanced Panel

To be able to use as much of the data as possible and deal with missing observations the panel regressions estimated in this paper have been unbalanced. In this section we look at the robustness of our results to the use of a balanced panel.

Table 8 presents the results of fitting equation (4) to a balanced panel data formed by ten of the eleven countries, and ranging from March 2006 to December 2010.[31] The estimation is done by means of Generalized Least Squares (GLS). The GLS procedure allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels. Even though the data used in this regression is somewhat different, the results obtained are similar to those obtained for the unbalanced panel. In fact, the magnitude and significance of the explanatory variables provides stronger support for the specification used.

30 As a potential benchmark we have also analyzed the Euro Swap rate. In fact, Beber, Brandt and Kavajecz (2009) use the Euro swap curve. When we use the Euro Swap rate as the benchmark we find similar results with the exception of the coefficient obtained for the trade balance variable which now becomes positive but is not significant.

31 We exclude Finland and the observations before the 7th of September, 2005 in order to have a balanced panel. The reason is that for some countries, the CDSs series present missing values before that date. In the case of Finland there are only 682 observations on CDSs.

Determinants of the Deviations between the Government Yield and the Benchmark Yield for Different Benchmarks

TABLE 7

		(1)	(2)
CDS(-1)		0.594***	0.650***
		(0.012)	(0.011)
Log (Total bond daily turnover volume)		-0.078***	-0.089***
		(-0.005)	(-0.006)
Total debt issued divided by GDP		0.715***	0.688***
		(0.037)	(0.033)
Interaction of total debt divided by GDP and the standard deviation of the domestic yield minus the benchmark yield		0.329***	0.391***
		(0.044)	(0.051)
Net Trade Balance divided by GDP		-1.230	-0.630
		(-0.840)	(-0.895)
Global risk measure: log(VIX index)		0.036***	0.123***
		(0.005)	(0.014)
Correlation between domestic Government yield and EMU benchmark Government Yield		-0.020**	-0.037***
		(-0.009)	(-0.012)
Dummy for the 3-year yield		0.016***	-0.028***
		(0.006)	(-0.009)
Dummy for the 5-year yield		0.024***	0.004
		(0.005)	(0.007)
Dummy for the 7-year yield		0.010**	-0.008
		(0.004)	(-0.006)
Crisis dummy (November 2009)		0.118***	0.259***
		(0.009)	(0.027)
Constant		-0.105***	-0.464***
		(-0.018)	(-0.049)
Autorregressive (AR(1)) coefficient		0.941	0.923
R-squared		0.398	0.524
Observations		70780	63468
Number of groups		44	40
Observations per group	Minimum	687	687
	Average	1609	1587
	Maximum	1826	1822
Wald chi2 (10 df)		3740	5293
Prob. > chi2		0	0
Condition Index		8.950	9.000

This table reports the results of the unbalanced panel regressions using an alternative benchmark: German bond yield. All the variables (dependent and explanatory) except the measure of global risk, the measure of correlation between the domestic Government and benchmark yields and the crisis dummy are presented in deviations from the value of the variable for the benchmark. We group the panels by country and maturity (3, 5, 7 and 10 years) such that we have, at most, 44 groups which form an overall unbalanced panel. We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. Column (1) reports the results for the benchmark employed in Table 3 and it is equivalent to the third column of that table. The results in Column (2) are obtained by using the values of Germany as the benchmark. The results presented correspond to the estimated coefficient and the standard errors (between brackets). The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

Determinants of the Deviations between the Government Yield and the Benchmark Yield Using a Balanced Panel

TABLE 8

	(1)	(2)	(3)
CDS(-1)	0.340***	0.340***	0.341***
	(0.007)	(0.007)	(0.007)
Log (Total bond daily turnover volume)	-0.042***	-0.042***	-0.042***
	(-0.003)	(-0.003)	(-0.003)
Total debt issued divided by GDP	0.419***	0.420***	0.418***
	(0.024)	(0.024)	(0.024)
Interaction of total debt divided by GDP and the standard deviation of	0.032***	0.031***	0.029***
the domestic yield minus the benchmark yield	(0.006)	(0.006)	(0.006)
Net Trade Balance divided by GDP	0.187	0.192	0.080
	(0.513)	(0.535)	(0.567)
Global risk measure: log(VIX index)	0.005***	0.004**	0.007***
	(0.001)	(0.002)	(0.002)
Correlation between domestic Government yield and EMU benchmark	-0.001	-0.001	-0.001
Government Yield	(-0.001)	(-0.001)	(-0.001)
Dummy for the 3-year yield	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
Dummy for the 5-year yield	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)
Dummy for the 7-year yield	0.001	0.001	0.001
	(0.001)	(0.001)	(0.000)
Crisis dummy (August 2007)		0.009***	
		(0.003)	
Crisis dummy (November 2009)			0.033***
			(0.004)
Constant	-0.001	-0.002	-0.004
	(-0.004)	(-0.005)	(-0.007)
Autorregressive (AR(1)) coefficient	0.942	0.942	0.942
Log likelihood	146023	145917	145816
Observations	55480	55480	55480
Number of groups	40.00	40	40
Time periods	1387.00	1387	1387
Wald chi2 (10 df)	2753.260	2776.680	2901.500
Prob. > chi2	0	0	0
Condition Index	7.350	11.850	8.460

This table reports the results of the balanced panel regressions. The data includes only ten of the eleven EMU countries and spans the period from March 2006 to December 2010. In order to have a balanced panel Finland and the observations before the 27th of March are excluded. All the variables (dependent and explanatory) except the measure of global risk, the measure of correlation between the domestic Government and benchmark yields and the crisis dummy are presented in deviations from the value of the variable for the benchmark. We group the panels by country and maturity (3, 5, 7, and 10 years) such that we have, at most 40 groups which form a balanced panel. The estimation is done using Generalized Least Squares. The GLS procedure that we employ allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels. Column (1) reports the results for the whole sample without using the crisis dummy as an explanatory variable and Column (2) reports the results using the crisis dummy which is equal to one after August 2007 as explanatory variable. Column (3) reports the results using the crisis dummy which is equal to one after November 2009. The results presented correspond to the estimated coefficient and the standard errors (between brackets). The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

5.2.4 Liquidity and risk measures

We also analyze the robustness of our results to alternative specifications of the liquidity measure. Table 9 presents the results of fitting model (4) to the full sample using three alternative liquidity measures: total daily turnover volume, bid-ask spreads and average daily turnover volume.[32] In all cases the liquidity coefficients have the expected signs and they are significant. The results for the other variables do not change materially. As the volume and the bid-ask spread are different liquidity measures and they affect yields in the opposite direction, the coefficients' order of magnitude cannot be directly compared. However, looking at a standardized measure such as the t-statistic (which is 15, 5 and 13 in columns 1, 2 and 3) we observe that liquidity measures based on volume (total daily turnover and average daily turnover) have stronger effect than the bid-ask spread.

As the liquidity proxies change with maturity and given that what matters to investors is the liquidity of a particular segment of the yield curve and not the overall liquidity of the sovereign bond market, we repeat the analysis using alternative liquidity measures with the corresponding maturity (3, 5, 7 or 10 years). Additionally, the CDS(-1) variable is also employed with the corresponding maturity (3, 5, 7, or 10 years) such that there is a perfect matching with the maturity of the dependent variable. The results obtained under this modification are shown in Table 10 and they do not change substantially with respect to Table 9.

Finally, besides the logarithm of the VIX Index we try different proxies for the global risk factor due to the great variety of variables that have been traditionally employed to proxy this factor. For instance, we employ: logarithm of the VDAX Index, square of the MSCI returns, iTraxx Europe (European CDS Index), difference between 10-year AAA US corporate yield and 10-year US Government bonds yield, difference between 10-year BBB US corporate yield and 10-year US Government bonds yield, difference between 10-year BBB US corporate yield and 10-year AAA US corporate yield. We find that their effects are positive in all cases and the standardizations of the coefficients from the t-statistics are very similar among them. Moreover, the coefficients of the remaining variables remain unchanged.[33]

32 This average volume is calculated as the ratio between the total daily turnover volume and the number of bonds issued by the corresponding country.

33 These results are available upon request.

Determinants of the Deviations between the Government Yield and the Benchmark Yield Using Different Liquidity Measures TABLE 9

		(1)	(2)	(3)
CDS(-1)		0.594***	0.619***	0.595***
		(0.012)	(0.012)	(0.012)
Liquidity		-0.078***	0.109***	-0.083***
		(-0.005)	(-0.021)	(-0.006)
Total debt issued divided by GDP		0.715***	0.450***	0.627***
		(0.037)	(0.030)	(0.034)
Interaction of total debt divided by GDP and the standard		0.329***	0.330***	0.332***
deviation of the domestic yield minus the benchmark yield		(0.044)	(0.046)	(0.044)
Net Trade Balance divided by GDP		-1.230	-1.622*	-1.296
		(-0.849)	(-0.831)	(-0.847)
Global risk measure: log(VIX index)		0.036***	0.033***	0.036***
		(0.005)	(0.005)	(0.005)
Correlation between domestic Government yield and EMU		-0.020**	-0.023***	-0.021**
benchmark Government Yield		-(0.01)	-(0.01)	-(0.01)
Dummy for the 3-year yield		0.016***	0.016***	0.016***
		(0.006)	(0.005)	(0.006)
Dummy for the 5-year yield		0.024***	0.024***	0.024***
		(0.005)	(0.005)	(0.005)
Dummy for the 7-year yield		0.010**	0.010**	0.010**
		(0.00)	(0.00)	(0.00)
Crisis dummy (November 2009)		0.118***	0.108***	0.116***
		(0.009)	(0.008)	(0.009)
Constant		-0.105***	-0.029	-0.079***
		(-0.018)	(-0.018)	(-0.018)
Autorregressive (AR(1)) coefficient		0.941	0.938	0.942
R-squared		0.398	0.418	0.392
Observations		70780	70344	70780
Number of groups		44	44	44
Observations per group	Minimum	687	687	687
	Average	1609	1599	1609
	Maximum	1826	1804	1826
Wald chi2 (10 df)		3740.970	3830.160	3621.320
Prob. > chi2		0	0	0
Condition Index		8.95	8.65	8.89

This table reports the results of the unbalanced panel regression using alternative liquidity measures. Column (1) reports the results for the whole sample using as liquidity proxy the total daily turnover volume, Column (2) reports the results obtained after using the bid-ask spread (b.p.) as the liquidity measure and Column (3) shows the results obtained if we employ as a proxy for liquidity the average daily turnover volume. This average volume is calculated as the ratio between the total daily turnover volume and the number of bonds issued by the corresponding country. The results presented correspond to the estimated coefficient and the standard errors (between brackets). We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order auto-correlation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

Determinants of the Deviations between the Government Yield and the Benchmark Yield Using Different Liquidity Measures and CDS Spreads with the Corresponding maturity

TABLE 10

		(1)	(2)	(3)
CDS(-1)		0.561***	0.586***	0.657***
		(0.011)	(0.013)	(0.012)
Liquidity		-0.096***	-0.044***	0.092***
		(-0.005)	(-0.003)	(-0.009)
Total debt issued divided by GDP		0.840***	0.642***	0.936***
		(0.038)	(0.034)	(0.049)
Interaction of total debt divided by GDP and the standard		0.375***	0.379***	0.352***
deviation of the domestic yield minus the benchmark yield		(0.046)	(0.053)	(0.046)
Net Trade Balance divided by GDP		-0.807	-1.216	1.708
		(-0.870)	(-0.925)	(1.294)
Global risk measure: log(VIX index)		0.038***	0.038***	0.033***
		(0.005)	(0.006)	(0.007)
Correlation between domestic Government yield and EMU		-0.027***	-0.030***	-0.018*
benchmark Government Yield		(-0.009)	(-0.010)	(-0.010)
Dummy for the 3-year yield		0.002	0.005	0.033***
		(0.006)	(0.008)	(0.010)
Dummy for the 5-year yield		0.010**	-0.002	0.042***
		(0.005)	(-0.005)	(0.008)
Dummy for the 7-year yield		0.006	-0.005	0.025***
		(0.004)	(-0.004)	(0.006)
Crisis dummy (November 2009)		0.132***	0.125***	0.159***
		(0.009)	(0.010)	(0.012)
Constant		-0.106***	-0.028	0.030
		(-0.019)	(-0.021)	(-0.025)
Autorregressive (AR(1)) coefficient		0.936	0.936	0.939
R-squared		0.398	0.400	0.520
Observations		66706	62620	62334
Number of groups		44	44	44
Observations per group	Minimum	687	651	764
	Average	1516	1423	1417
	Maximum	1826	1826	1609
Wald chi2 (10 df)		3866.950	3240.790	4309.540
Prob. > chi2		0	0	0
Condition Index		8.79	8.50	7.57

This table reports the results of the unbalanced panel regression using alternative liquidity measures with the corresponding maturity (3, 5, 7, or 10 years). Additionally, CDS(-1) variable is also employed with the corresponding maturity (3, 5, 7, or 10 years) such that there is a perfect matching with the maturity of the dependent variable. Column (1) reports the results for the whole sample using as liquidity proxy the total daily turnover volume, Column (2) reports the results obtained after using the bid-ask spread as the liquidity measure and Column (3) shows the results obtained if we employ as a proxy for liquidity the average daily turnover volume. This average volume is calculated as the ratio between the total daily turnover volume and the number of bonds issued by the corresponding country. The results presented correspond to the estimated coefficient and the standard errors (between brackets). We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

5.2.5 Data frequency

Some macro series (Gross Debt outstanding) have annual frequency; other series (GDP) have quarterly frequency while others (Net Trade Balance) have monthly frequency. In fact these are the data frequencies employed in Curto et al. (2008) or Codogno et al. (2003) among others. As an additional robustness test we analyze the regression in equation (4) using data with a monthly and quarterly frequency. In both cases the number of observations decreases substantially with respect to the case where we use daily frequency. However, results are in line with the ones obtained using a daily data and are available on request. Overall the above outcomes suggest that our main findings are not sensitive to the data's time frequency.[34]

5.2.6 Maturity Analysis

The effect of credit or macro risk is likely to have a differential effect on bonds with a different maturity. In equations (4) and (5) we only incorporate a level effect by means of the dummies for the different maturities. As an additional robustness test, we include the effect of the different maturities by regressing the yield spread on the explanatory variables for individual maturities. Results are shown in Table 11.

We observe that the total debt divided by GDP has a stronger effect on the shortest maturity. The liquidity has a stronger effect on the 5-year maturity, widely considered as the most liquid market segment. The global risk measure has a decreasing effect with maturity. The effect of the crisis dummy is significant in all cases. Finally, the domestic CDS lagged one period, the interaction term and the correlation do not follow a clear pattern across the different maturities but the correlation seems to has a more significant effect on the 5 and 7 year maturities. Overall, however, these results are in line with the results presented in Table 3.

34 Gomez-Puig (2007) transforms the macro variables employed in her analysis into variables with a daily frequency. For this transformation, she extrapolates the corresponding variable assuming a daily constant rate of increase. We find that the results obtained after extrapolating the macro variables, assuming a constant rate of increase between two different values of the corresponding variable, are equivalent to the ones obtained in Table 3. These results and the ones commented in Subsection 4.2.5 are available upon request.

Determinants of the Deviations between the Government Yield and the Benchmark Yield by Maturity TABLE 11

		(1)	(2)	(3)	(4)
CDS(-1)		0.570***	0.611***	0.573***	0.609***
		(0.015)	(0.013)	(0.011)	(0.012)
Log (Total bond daily turnover volume)		-0.075***	-0.082***	-0.076***	-0.075***
		(-0.007)	(-0.005)	(-0.004)	(-0.005)
Total debt issued divided by GDP		0.787***	0.731***	0.645***	0.705***
		(0.056)	(0.042)	(0.033)	(0.036)
Interaction of total debt divided by GDP and the standard deviation of the domestic yield minus the benchmark yield		0.211***	0.358***	0.391***	0.371***
		(0.046)	(0.051)	(0.052)	(0.055)
Net Trade Balance divided by GDP		-1.886	-1.171	-0.299	-1.251
		(-1.181)	(-0.972)	(-0.777)	(-0.826)
Global risk measure: log(VIX index)		0.039***	0.037***	0.035***	0.032***
		(0.006)	(0.005)	(0.005)	(0.005)
Correlation between domestic Government yield and EMU benchmark Government Yield		-0.007	-0.013	-0.032***	-0.028***
		-(0.01)	-(0.01)	-(0.01)	-0.009
Crisis dummy (November 2009)		0.103***	0.120***	0.128***	0.118***
		(0.011)	(0.010)	(0.009)	(0.009)
Constant		-0.089***	-0.099***	-0.086***	-0.087***
		-0.023	-0.021	-0.019	-0.019
Autorregressive (AR(1)) coefficient		0.954	0.944	0.935	0.932
R-squared		0.299	0.396	0.454	0.455
Observations		17695	17695	17695	17695
Number of groups		11	11	11	11
Observations per group	Minimum	687	687	687	687
	Average	1608	1608	1608	1608
	Maximum	1826	1826	1826	1826
Wald chi2 (10 df)		2032	3250	4288	3962
Prob. > chi2		0	0	0	0
Condition Index		8.260	8.390	8.700	7.340

This table reports the results of the unbalanced panel regressions. The dependent variable is the deviations between the Government yields and the Benchmark yields which are obtained as the weighted average of the Governments yields of the different European Monetary Union countries in the sample. The weights are proportional to the portion of debt outstanding by each of the EMU countries with respect to the total amount outstanding by all these countries. Our database is formed by eleven EMU countries and spans from January 2004 to December 2010. All the variables (dependent and explanatory) except the measure of global risk, the measure of correlation between the domestic Government and benchmark yields and the crisis dummy are presented in deviations from the value of the same variable for the benchmark. We group the panels by country such that we have, at most, 11 groups for each maturity which form an overall unbalanced panel. We estimate the coefficients of the determinants of deviations between yields by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process common to all the panels. Each element in the covariance matrix of the disturbances is computed with all available observations that are common to the two panels contributing to the covariance. Columns (1), (2), (3) and (4) report the results for the 3, 5, 7 and 10 years maturities, respectively. The results presented correspond to the estimated coefficient and the standard errors (between brackets). The symbol * (** and ***) denotes that the variable is significant at 10% (5% and 1%, respectively).

6 Computing Common Risk Free Rates

The results in the previous section motivate the following question. What should be the yield of a common eurozone bond, free, at least to some extent, from the effect of the risk factors (credit, liquidity, macro, correlation) that influence the yield of individual sovereign bonds? The existence of such a common European bond would imply the existence of a common European interest rate.[35] In this section, we attempt to provide a measure for this rate and discuss the hypothetical benefits that it would yield. A common risk free rate could produce benefits for every EMU country because of the enhanced rating and liquidity of the common bond and from the reduction of the effects associated with macro fundamentals.

It seems reasonable to suggest that to be allowed to profit from the reduction in borrowing costs this common rate would provide, each EMU country interested in participating in an issue of common bonds should compensate the bond issuer for the specific country's credit risk. As a starting point for this analysis we suggest that the CDSs on its sovereign bonds is the best proxy publicly available to measure the country risk and so, the CDS spreads represent the compensation that a given country should pay in order to be allowed to participate in the issuance of common bonds. In what follows we refer to the 'Hedged Yield' of the sovereign debt of a country as the difference of actual yield and the corresponding CDS spread.

Our proposed measure, which we call Common Risk-Free Rate (CRFR), is the Hedged Yield free of liquidity, correlation and macro risk effects.[36] The reasons why we think CRFR would be free to a considerable extent of those effects are as follows. Regarding liquidity our model implies that CRFR will not be affected by individual bond's liquidity variables. One can argue that a specific liquidity factor related with the common bond may appear in due course but our view is that this variable will have small effects. Liquidity is valuable for market participants, and especially in times of market stress, the most liquid bonds have tended to command a considerable price premium. Previous studies of liquidity and liquidity premia in government bond markets, based mainly on data from the U.S. Treasury market and also from European sovereign bonds such as ECB (2010), have identified pronounced liquidity differences across government securities, being the benchmark bonds (and we assume that the common bond will have a fair chance to be the benchmark) the

35 As Galati and Tsatsaronis (2001) remark, the most vivid illustration of the shortcomings of the Government bond market is the absence of a single established reference yield curve for the new currency.

36 The impact of these effects is estimated by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation. The effects are estimated on an annual basis such that we run the previous regression every year from 2004 to 2010. We estimate these effects every year instead of using the whole sample given the noticeable changes in variability and levels observed in all the variables.

most favoured. Regarding the net trade balance over GDP, it should be remembered that about 70% of the total trade of EMU countries is within the European Union and therefore the aggregate value of this variable (due to offsetting positions) is bound to be small. Finally, and with respect to total debt over GDP, our model implies that CRFR will not be affected by individual bond's total debt. It can be argued that the aggregate debt ratio of the EMU countries could have some effect on CRFR.[37] Given that we estimate the CRFR year by year and that the frequency of the Debt/GDP variable is annual, the effect of this variable is included in the constant term.

It is well known that CDS spreads are not immune from the effects of liquidity and global risk factors. Increases in both factors increase CDS spreads irrespective of actual changes in the underlying country's credit risk. Therefore the appropriate insurance premium a given country should pay to be allowed to participate in an issue of the European common bond should take into account these upward biases.

The CRFR is computed using the following steps:

a) We run the following Prais-Winsten regression:

$$r_{it} - CDS_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,i,t} + \sum_{j=1}^{M} \gamma_j D_{j,t} + \chi Y_{i,t} + \delta Z_t + \psi C_{it} + \varepsilon_{i,t} \qquad i = 1,\ldots 44 \qquad (6)$$

where the dependent variable is the Hedged Yield of country i (i=1,...,11) at four different maturities (3, 5, 7 and 10 years). The $X_{k,i,t}$ are liquidity and macro explanatory variables (Volume, Total debt/GDP, Trade Balance/GDP) of country i. The $D_{j,t}$ are dummy variables to take into account the maturity effect in bond yields (3,5, and 7 years). The $Y_{i,t}$ is the interaction term of total debt relative to GDP times the volatility of the difference between domestic yield and benchmark yield. The Z_t is the global risk factor measured as the logarithm of VIX. The C_{it} is the correlation between the country i yield (for its corresponding maturity) and the benchmark's yield.

This regression is similar to the one in equation (4) with the exception that the dependent variable is the hedged yield and the liquidity and macro variables are not deviations from the benchmark. The regression is fitted every year.[38] We do not include the European sovereign debt crisis dummy given that it is only active from the end of 2009 and we aim to be consistent in terms of the variables employed in the different year estimations.

b) We define the Common Risk Free Rate (CRFR) at time t for the corresponding maturity according to:

$$CRFR_t = \hat{\alpha} + \hat{\gamma}_j + \hat{\delta} Z_t + \bar{\hat{\varepsilon}}_t \qquad j = 1,\ 2,\ 3,\ 4. \qquad (7)$$

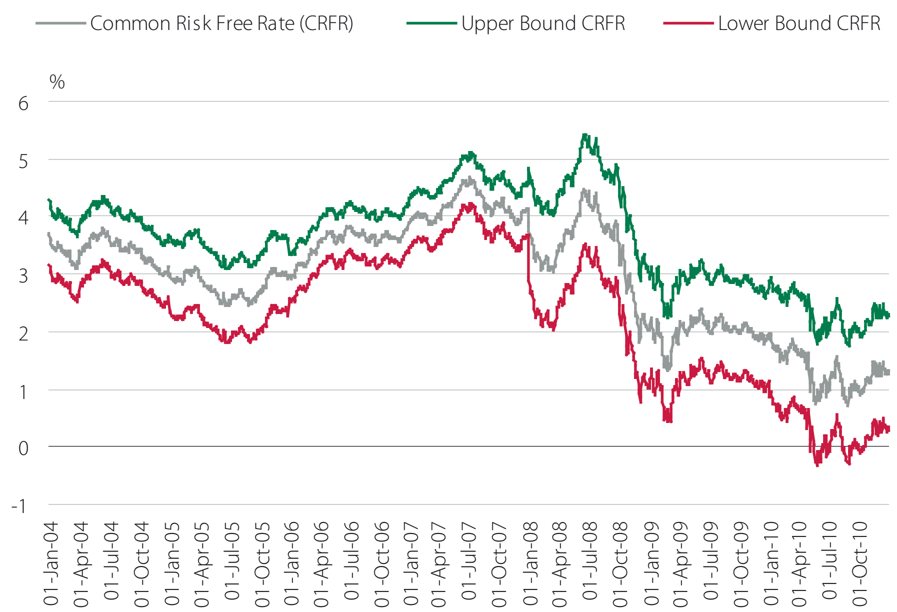
37 Given the evidence in Krishnamurthy, and Vissing-Jørgensen (2007), we should expect that when the stock of total debt over GDP is low, the marginal convenience valuation of sovereign debt is high. Investors bid up the price of Treasuries relative to other securities, such as corporate bonds, causing the yield on Treasuries to fall further below corporate bond rate. The opposite applies when the stock of debt is high.

38 For the sake of brevity we do not report the results corresponding to the annual estimations but they are available upon request.

where the parameter $\hat{\alpha}$ is the estimated constant, $\hat{\gamma}_j$ is the estimate of the dummy parameters for the maturities of 3, 5 and 7 years, respectively, $\hat{\delta}$ is the estimate of the logarithm of VIX parameter, and $\bar{\hat{\varepsilon}}_t$ is the average cross-sectional residual among the eleven EMU countries at time t. The parameter $\hat{\alpha}$ gives the average common hedged risk free rate without the effect of the other variables, $\hat{\gamma}_j$ gives the term structure, $\hat{\delta}$ gives the global risk effect and $\bar{\hat{\varepsilon}}_t$ gives the time series variation in interest rates. The benefits for a given country in using the common bond will be the enhanced rating and liquidity the common bond would provide plus additional premiums for country's macro fundamentals. On the other hand the common risk free rate is not unfettered of the influence of the crisis and global risk factor's influence. Even when the interest rate is free of the issuers' default risk due to the hedging strategy which involves the payment of the CDS spread (although counterparty risk may be an issue in this case), global risk may affect the European monetary policy which at the same time will affect the level of such interest rate.

As the measure proposed here comes from an estimated model, (equation (6) above) the estimate is vulnerable to sampling and model specification error. To address this point we construct 95% confidence bands around the estimates using 95% upper and lower limits of the estimated parameters (i.e 2.5% in each direction).

Common Risk Free Rate and Upper and Lower Bounds FIGURE 1



The figure shows the estimated 5-year common risk free rate in the EMU area (CRFR) and the confidence bands around the CRFR. The common rate measure is obtained as the sum of an intercept on the hedge yields, a maturity adjustment, the effect of the VIX Index on the hedge yields, and a residual after controlling for liquidity and macroeconomic variables using a Prais-Winsten regression. Concretely, we employ a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation which is estimated on an annual basis for ever year from 2004 to 2010. To estimate the lower and upper confidence bands, we employ the estimated lower and upper confidence limits of the 95% confidence interval for each parameter involved in the estimation of the CRFR.

In Figure 1 we show the estimated 5-year common risk free rate in the EMU area (CRFR) and the confidence bands around the CRFR. The CRFR average value is 2.95% while the average values for the upper and the lower bands are 3.65% and 2.25%, respectively.

7 Policy Implications: Savings in Borrowing Costs

The measure previously defined can be used to estimate the possible savings (or lack thereof) in borrowing costs from the issuance of common bonds in the EMU. The procedure is as follows. We obtain the savings for a given country and maturity every day by subtracting from the corresponding yield the CDS spread and the estimate of the common risk free rate for 3-year, 5-year, 7-year, and 10-year maturities in the sample from September, 2005 to December, 2010. The results are reported in Panel A on Table 12. In Panel B we split the average savings reported in Panel A for every year from 2006 to 2010. In Panel C we report the average annual savings using the information on all EMU countries Euro-denominated sovereign bonds issued during the sample period (2004 – 2010) and with a maturity equal or lower than 11 years at the issuance date.[39] Bonds issued by Greece after the rescue are not considered (i.e. two bonds issued the 30th and 31st December 2010). These average annual savings are computed as the bond's coupon minus the CRFR minus the corresponding CDS spread for every bond in our sample. The CRFR and CDS are the ones observed at the moment of bond's issuance. There are interesting differences between Panel A and B. Panel A confirms that the average savings in borrowing costs for the period September 2005 – December 2010 are positive irrespective of the country and maturity. According to Panel A, the country that, on average, gets the biggest decrease in financing costs across the four maturities is Greece while Spanish the one getting the smallest decrease.[40, 41] Countries above (below) the average in Panel A are Finland and Greece (Austria, Germany, Ireland, Italy, and Spain) whereas Belgium, France, The Netherlands, and Portugal are close to the average. However, although we find positive savings, on average, for the whole time period there are also losses in some specific periods and for some specific countries. We find, on average, positive savings for the five years with the exception of 2007 in which there are losses averaging -0.7 basis points. This result reflects that the savings are not always positive by definition but depend on market conditions. The only countries with

39 We have estimated the Common Risk Free Rate for the 3, 5, 7 and 10 years maturities. Thus, in the cases in which we have a bond with a time-to-maturity different to the estimated CRFR maturities, we employ a Piecewise Cubic Hermite Interpolation Polynomial (PCHIP) algorithm to obtain the corresponding term. The same procedure is used whenever we do not have information on a CDS with a given maturity.

40 For the seven years maturity, the savings for Finland are higher than for Greece. However, we have only 688 observations for Finland in comparison with the almost 1,345 observations for Greece. Additionally, the available information for Finland corresponds to the years (2008-2010) with the highest savings in borrowing costs (see Panel B of Table 12).

41 The low decrease in financing costs for Spain can be explained from the definition of the cost of financing. This cost is defined from (i) the CDS spread to be paid to participate in the issuance of common bonds and (ii) the common risk free rate. Thus, the difference between the hedge yield (Yield – CDS) and the CRFR represents the savings in terms of borrowing costs. However, the lowest average hedge yield for the period 2006-2010 is the one corresponding to Spain due to the high CDS spread relative to the bond yield..

Savings in Borrowing Costs derived from a Single EMU Bond

TABLE 12

Panel A

September 2005 - December 2010	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	Average
3y Common Risk-Free Rate	7.5	13.2	35.7	12.9	10.2	45.5	0.7	7.3	12.9	10.4	2.1	14.4
5y Common Risk-Free Rate	6.1	12.4	35.1	10.5	7.5	47.8	7.6	4.4	11.9	11.9	3.1	14.4
7y Common Risk-Free Rate	8.1	15.4	37.1	11.5	8.3	31.2	13.2	7.8	12.4	13.8	0.9	14.5
10y Common Risk-Free Rate	3.6	12.7	23.8	9.6	6.7	42.9	11.9	9.2	11.5	18.1	2.2	13.8
Average	6.3	13.4	32.9	11.1	8.2	41.9	8.4	7.2	12.2	13.6	2.1	14.3

Panel B

Years	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	Average
2006	5.8	6.0	-	4.3	7.4	9.8	6.2	7.6	4.0	7.6	3.5	6.2
2007	-1.6	-1.7	-	-2.1	-4.4	3.9	8.9	1.8	-4.8	-1.8	-4.9	-0.7
2008	20.3	31.8	31.3	27.6	17.1	23.7	13.3	22.4	24.1	21.4	12.5	22.3
2009	-6.7	30.8	39.4	21.8	5.8	45.1	-15.1	-3.4	21.2	35.4	8.0	16.6
2010	13.3	-2.4	33.2	2.3	11.9	169.9	27.7	-7.1	20.9	-1.0	-3.4	24.1

Panel C

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	Average
Average Annual Savings	0.7	3.7	23.6	1.2	2.9	28.0	25.7	1.2	15.8	34.1	4.0	11.7

This table reports the estimated average annual savings by country and the overall EMU average benefits, in basis points, for the maturities of 3, 5, 7 and 10 years derived from the existence of a single EMU bond market. In Panel A, we report the average annual savings for the period that spans from September 7th, 2005 to December 31st, 2010. The beginning of the sample is set in September 2005 in order to facilitate comparisons between countries due to the lack of CDSs data for some maturities before that date. CDSs are necessary to obtain the hedged yield which enables us to estimate the savings in borrowing costs. The Common Risk-Free Rate that we propose is estimated by excluding the effect of country specific risk factors, the liquidity factor and macro factors from the hedged yield. The effect of the previous factors is estimated by means of a Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) and robust to heteroskedasticity, contemporaneous correlation across panels and serial autocorrelation (AR(1)) within panels. The dependent variable in the previous regression is the hedged yield, and the explanatory variables are the same as the ones in Table 3, with the exception of the lagged CDS spread and the crisis dummies, but in absolute terms instead of deviations from the benchmark. Finally, in the last column we show the average profits (in basis points) in terms of yields for the overall EMU derived from the existence of a single EMU bond for the different maturities. Panel B reports the average savings on an annual basis for every year from 2004 to 2010. In Panel C, we report the average annual savings using the information on Euro-denominated sovereign bonds that were issued during our sample period (September 2005 – December 2010) and with a maturity equal or lower than 11 years at the issuance date. These average annual savings are computed as the bond's coupon minus the CRFR minus the corresponding CDS spread. The CRFR and CDS are the ones observed at the moment of bond's issuance.

positive savings irrespectively of the time period considered are Greece and Finland. In the case of Greece, the main benefit would coincide with the beginning of the European sovereign debt crisis up to the point that the savings would reach a magnitude of 169 b.p. in the year of the EU/IMF bailout. Not all the peripheral countries would have obtained savings in 2010 but only Greece and Ireland. This result could be reflecting the pressures suffered by the CDS market relative to the bond market but also the fact that the highest bond yields are the ones referred to Greece and Ireland. France, Germany, and The Netherlands would have suffered losses in 2007 but all of them would have obtained benefits during the European sovereign debt crisis. Notice also that some countries in some years experience non-negligible losses, for instance Spain and the Netherlands in 2007, Ireland and Austria in 2009 or Italy and Belgium in 2010. In Panel C, the country that, on average, gets the biggest decrease in financing costs is Portugal while Austria is the one getting the smallest decrease. An interesting pattern observed in Panel C is that countries with the biggest decrease in financing costs are the three countries which asked for the EU/IMF bailout during the European sovereign debt crisis (Portugal, Greece, and Ireland) followed by Finland and The Netherlands. The average annual savings in borrowing costs for other countries (Austria, Belgium, France, and Germany) as well as for Italy and Spain are lower than 4 basis points. These results are tentative and subject to measurement error (see Figure 1), but they give some idea about the possible savings involved in a common bond.

Adjaouté and Danthine (2003) argue that a unified market is Pareto superior to a fragmented market given that yields will be lower in the former. As Adjaouté and Danthine (2003) point out, the pricing differences between yields reflect a failure of integration and imply costs to the euro-area Treasuries. They estimate that at the debt levels in the euro area in 2000 the annual cost may be as high as €5 billion which could be saved with a common bond.[42] They consider that the integration could occur simply by the establishment of a centralized agency in charge of issuing debt on behalf of the euro area's governments.[43] However, they do not give additional details about how to achieve this integration and how to estimate the common rates derived from the centralized debt issuance. According to our estimations of the common risk free rate, the average savings could be higher than in Adjaouté and Danthine (2003). Our estimations suggest that the average annual savings for the EMU in the period that spans from September 2005 to December 2010 might be around €9.02 billion with the Common Risk Free Rate,[44] assuming that the common bond takes over up to 100% of the overall financing of euro zone countries. Moreover, the average annual savings for the EMU obtained from the Euro-denominated sovereign bonds issued during the sample period (September 2005 – December 2010) and with a maturity equal or lower than 11 years at the issuance date are roughly €2.4 billion. As Favero and Von Thadden (2004) state, the possibility of joint bond issuance by euro-area countries has been repeatedly considered because of its ability to exploit fully the liquidity benefits, among others, of a unified market. They also suggest that this scheme has been discarded because it would generate an implicit debt guarantee by some countries in favour of others. Our tentative evidence, based on hedged yields, suggests that a common bond market with a common yield would reap average benefits for all countries involved although under some extreme market circumstances, some countries may suffer losses.

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42 Adjaouté and Danthine (2003) estimate this amount by multiplying the outstanding debt of the Euro area minus Germany in 2000 (2,470 billion) by the average difference of the yields with respect to German yield which is employed as the benchmark (20 basis points).

43 Such a proposal was made in 1999 with a view of harmonizing the maturity structures, delivering a true and single benchmark curve and helping reduce the cost that some member states have to pay to primary dealers in order to promote their debt outside the country (Favero et al., 2000). Adjaouté and Danthine (2003) proposal was met with considerable skepticism, because such a set-up implies some collective responsibility for national debts, which runs contrary to the Maastricht Treaty but they also argue that the debate on the establishment of a multilateral agency should be reopened.

44 The annual average savings are obtained by multiplying the annual average debt outstanding in the EMU during the period 2005-2010 by the average annual profits in terms of yields for the period 2005-2010. The average yield value is obtained as the average of the four different maturities. Additionally, we calculate the annual average savings obtained when we multiply the average annual debt outstanding for the period 2005-2010 in every country by the average annual profits in terms of yields for the period 2005-2010 and they are around €6.41 billion.

Next, we run some robustness tests to check for the adequacy of the savings obtained under the baseline specification. The results of these tests are reported in Table 13. The first row corresponds to the baseline estimation procedure which is employed to construct Table 12. The savings reported in Table 13 correspond to the average for the four maturities.

Credit risk of European sovereign countries is measured by CDS spreads but as documented in Mayordomo, Peña, and Schwartz (2011), actual CDS prices could differ across data sources. This difference could be even more remarkable at the beginning of the sample, for less standard maturities, and for some European countries. For this reason, we estimate the Euro bond yield and the subsequent savings using an alternative data set for CDS spreads: Markit. Results are reported in the second row of Table 13. Although we do not find exactly the same savings as using CDS spreads obtained from CMA, the overall pattern is very similar pattern and savings are positive for all the countries. It should be also noted that due to the low liquidity in the sovereign CDS market for some countries and maturities at the beginning of the sample, we calculate the savings for the period September 2005 – December 2010.

Following the same argument, and given that there are differences of a few basis points between costs and benefits, we analyze whether different bond yields could be also a source of bias. The baseline results are obtained using a yield curve which is interpolated with cubic splines on the basis of a third order polynomial. Datastream provides an additional yield curve which is based on the same methodology but using a fifth order polynomial. Thus, we use the new yield curve and as shown in the third row of Table 13, and we find that the savings for both types of yield estimations are very similar.

Next, we construct the common risk free rate using each of the four maturities separately. Thus, we estimate Equation (6) for each individual maturity and then calculate the average across the four maturities. As we can observe from the fourth row of Table 13 savings are identical to the ones obtained for the baseline case.

The approach described in Equation (6) implicitly assumes that the common bond yields will be free of liquidity and macro (trade balance and debt) premiums and the only variable (besides the maturity dummies) affecting the common rate is the level of global risk. We next adopt a more conservative approach and consider that the common rate will be free of those effects whose coefficients are not significantly different from zero. Not surprisingly, the most repeated significant coefficient is the one corresponding to the VIX Index (it is significant in 4 years). The coefficients corresponding to the net trade balance over GDP, Debt/GDP ratio, liquidity, and correlation variable are only significant in one of the seven estimations/years which confirm that the CDS could be a fair insurance instrument. Equation (7) will change for every year depending on the significant coefficients and could be changed into the next expression:

$$CRFR_t = \hat{\alpha} + \hat{\gamma}_j + \sum_{i=1}^{N} \hat{\psi}_i S_{i,t} + \overline{\hat{\varepsilon}}_t \qquad j = 1,\ 2,\ 3,\ 4. \tag{8}$$

where $S_{i,t-}$ denotes all the variables which have a significant effect in the year in which Equation (6) is estimated and $\hat{\psi}_i$ represent the coefficients for the i significant variables. Results are shown in the last row of Table 13. This new estimation

Robustness Tests on the Savings in Borrowing Costs Derived from a Single EMU Bond TABLE 13

September 2005 - December 2010	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	Average
Baseline	6.3	13.4	32.9	11.1	8.2	41.9	8.4	7.2	12.2	13.6	2.1	14.3
Alternative CDS spread (Markit)	2.4	10.8	13.3	8.7	3.3	28.2	6.0	5.0	9.4	11.5	1.2	9.1
Alternative yield	6.7	14.0	29.8	11.5	8.5	42.2	8.7	7.6	12.6	13.9	2.5	14.4
Maturity by maturity	5.6	12.9	31.5	10.4	7.4	41.1	7.6	6.4	11.4	12.8	1.3	13.5
Using significant coefficients	0.8	7.0	18.6	5.5	2.6	36.3	2.8	1.6	6.6	8.0	-3.1	7.9

This table reports some robustness tests on the estimated average annual savings by country and the overall EMU. As in Table 12 we report the average savings, in basis points, for the period September 2005 – December 2010 after averaging the savings corresponding to the four maturities. The first row corresponds with the baseline estimation which is employed to construct Table 12 and is equal to the last row of Panel A in Table 12. The savings in the second row (Alternative CDS spread, Markit) are obtained using an alternative dataset, Markit. The savings reported in the third row (Alternative yield) are obtained using an alternative yield which is calculated using a slightly different interpolation methodology to the one employed in the yield of the baseline scenario. The savings of the fourth row (Maturity by maturity) are obtained using a different estimation methodology in which we estimate Equation (6) for each individual maturity and then calculate the average savings. The last row (Using significant coefficients) is constructed using a more conservative approach in which we consider that the common rate will be free of the effects whose coefficients in the estimation of Equation (6) are not significantly different from zero but not from the significant effects.

methodology leads to the lowest savings in borrowing costs but they are again on average positive and the only country with losses is Spain.

An additional question is how the system could work in practice. We suggest that an EMU-wide agency (the European Debt Agency, EDA, or a similar institution) issues the bonds (taking over up to 50% of financing of euro zone countries for instance) and distributes the money to participant countries. Participant members would pay to the agency their (liquidity and global-risk adjusted) CDS spreads, common bond's coupons and repay the principal at maturity. Additionally they would post the corresponding amount on sovereign euro bonds as guaranty,[45] possibly subject to margin calls to minimize moral hazard. In fact it could be argued that the common Euro bond is actually discouraging "moral hazard." Suppose that the EDA lets governments in the Euro zone borrow only up to 50% of their GDP in Eurobonds. If they need to borrow more, they have to issue internal government bonds, which will bear high interest (most likely even higher than what they face now in the market). Thus Greece, Portugal, Ireland and others will have a significant incentive to limit borrowing in the limit permitted by Eurobonds, provided that strict no bail out rules are actually enforced.

45 It may be argued that the common euro bond would be subject to currency risk because, if the ECB is in charge, and given that it cannot tax participant countries, then the ECB may need to print Euros to pay the debt. Therefore our CRFR measure would be a downward biased measure of the "true" risk free rate. However to quantify this specific effect is beyond the scope of this paper and is left for future research.

8 Summary and Conclusions

In this paper we study the determinants of EMU sovereign bonds yields and then present an estimation of the hypothetical risk free rate that a common bond would yield. To model the determinants of yield spreads we first propose a theoretical portfolio selection model to motivate the variable selection. Then for the period 2004 to 2010 we fit an unbalanced panel model, using as a benchmark a weighted average of the total gross debt issued by the governments of the different EMU members. We find that credit quality; macro, correlation, and liquidity variables have significant effects on EMU sovereign yield spreads. Robustness tests with different data frequency, benchmarks, liquidity and risk variables, cross section regressions, balanced panel, and maturities analyses confirm the initial results.

Motivated by these results we try to answer the following question: What should be the yield of a common eurozone bond, free, at least to some extent, from the effect of the risk factors (credit, liquidity, macro, correlation) that influence the yield of individual sovereign bonds? We present an estimation of this hypothetical common risk free rate and show that average savings in borrowing costs for all EMU countries are positive irrespective of the maturity of the common risk free rate measure employed although this common bond has ups and downs, implying that for some countries in some periods losses may occur .

We realize that there are many complex institutional design features that must be resolved before an actual common bond issue for the eurozone could be a reality, but our paper provides a first insight into one central issue. Namely, what should be the required compensation a given country should pay to the formal issuer to be allowed to share a given issue of EMU-based single bonds. We argue that this compensation should be the (adjusted) CDS spread on a given country sovereign bonds. The benefits for a given country in using the common bond will be the enhanced rating and liquidity the common bond would provide plus additional premiums for country macro fundamentals. But we also stress that this common bond is not a replacement to the individual country bonds but an addition to the investment opportunity set.

Our results may be interpreted as tentative evidence in favour of the hypothesis that a common bond and a common risk free rate in the EMU could produce substantial average savings in borrowing costs for all the countries involved in the sample 2005 to 2010 although under some market circumstances, some countries may suffer losses. Looking forward, we expect more conclusive evidence on other common risk free rate measures as well as in other market segments. The procedures of this paper can also be applied to other sovereign bonds and common currency areas as well as rates on state bonds for states in the USA or other federal states.

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Appendix I

We consider a domestic (benchmark) investor allocating a fraction θ_t (θ^*_t) of his real wealth w_t (w^*_t) to a domestic D (benchmark, F) security and a fraction $1\text{-}\theta_t$ ($1\text{-}\theta^*_t$) to a benchmark (domestic) security. We assume that both the domestic and benchmark securities are subject to default risk. The default process is assumed to follow a correlated bivariate Bernoulli process (x_t, x^*_t), with domestic (benchmark) default probability $1\text{-}P_t$ ($1\text{-}P^*_t$). In the event of default the investor receives a fraction τ_t (τ^*_t) of his gross domestic (benchmark) payment, $\tau_t \,\varepsilon\, [0,1+r)$ ($\tau^*_t \,\varepsilon\, [0,1+r^*)$) where r (r^*) is the interest rate on the domestic (benchmark) bond. There are proportional transaction costs l_t (l^*_t) decreasing with domestic (benchmark) market liquidity. The coefficient of risk aversion ρ is the same for both investors. The utility function of both the domestic and foreign investors depends positively on the expected real wealth, $E_t\left[w_{t+1}\right]$ and negatively on its variance $Var_t\left[w_{t+1}\right]$. The domestic investor maximizes the following mean-variance utility function:

$$E_t\left[w_{t+1}\right]-\frac{\rho}{2}Var_t\left[w_{t+1}\right] \tag{A.1}$$

where according to the previous notation, the expected wealth and variance of wealth are, respectively:

$$\begin{aligned}E_t\left[w_{t+1}\right] &= (1+r_t)\theta_t w_t P_t + \tau_t\theta_t w_t(1-P_t) - \theta_t w_t l_t + \\ &\quad + (1+r_t^*)(1-\theta_t)w_t P_t^* + \tau_t^*(1-\theta_t)w_t(1-P_t^*) - (1-\theta_t)w_t l_t^* \\ Var_t\left[w_{t+1}\right] &= (1+r_t-\tau_t)^2\theta_t^2 w_t^2 P_t(1-P_t) + (1+r_t^*-\tau_t^*)^2(1-\theta_t)^2 w_t^2 P_t^*(1-P_t^*) + \\ &\quad + 2w_t^2\theta_t(1-\theta_t)(1+r_t-\tau_t)(1+r_t^*-\tau_t^*)Cov(x_t,x_t^*)\end{aligned} \tag{A.2}$$

The domestic investor maximizes his corresponding utility function to obtain the optimal fraction of his wealth to allocate to the domestic bond, $\hat{\theta}_t$:

$$\hat{\theta}_t = \frac{(1+r_t)P_t + \tau_t(1-P_t) - l_t - (1+r_t^*)P_t^* - \tau^*(1-P_t^*) + l_t^* +}{\rho w_t\Big[\left(1+r_t-\tau_t\right)^2 P_t(1-P_t) + \left(1+r_t^*-\tau_t^*\right)^2 P_t^*(1-P_t^*)} \quad \frac{+\rho w_t(1+r_t^*-\tau_t^*)^2 P_t^*(1-P_t^*) - \rho w_t(1+r_t-\tau_t)(1+r_t^*-\tau_t^*)Cov(x_t,x_t^*)}{-2\left(1+r_t-\tau_t\right)\left(1+r_t^*-\tau_t^*\right)Cov(x_t,x_t^*)\Big]} \tag{A.3}$$

The foreign investor maximizes his corresponding mean-variance utility function:

$$E_t\left[w_{t+1}^*\right]-\frac{\rho}{2}Var_t\left[w_{t+1}^*\right] \tag{A.4}$$

The foreign investor's expected wealth and variance of wealth are the following:

$$E_t\left[w_{t+1}^*\right]=(1+r_t)\theta_t^* w_t^* P_t+\tau_t\theta_t^* w_t^*(1-P_t)-\theta_t^* w_t^* l_t+$$
$$+(1+r_t^*)(1-\theta_t^*)w_t^* P_t^*+\tau_t^*(1-\theta_t^*)w_t^*(1-P_t^*)-(1-\theta_t^*)w_t^* l_t^*$$

(A.5)

$$Var_t\left[w_{t+1}^*\right]=(1+r_t-\tau_t)^2\theta_t^{*2}w_t^{*2}P_t(1-P_t)+(1+r_t^*-\tau_t^*)^2(1-\theta_t^*)^2 w_t^{*2}P_t^*(1-P_t^*)+$$
$$+2w_t^{*2}\theta_t^*(1-\theta_t^*)(1+r_t-\tau_t)(1+r_t^*-\tau_t^*)Cov(x_t,x_t^*)$$

The foreign investor maximizes his utility function to obtain the optimal fraction of his wealth to allocate to the domestic bond, $\hat{\theta}_t^*$:

$$\hat{\theta}_t^*=\frac{(1+r_t)P_t+\tau_t(1-P_t)-l_t-(1+r_t^*)P_t^*-\tau^*(1-P_t^*)+l_t^*+}{\rho w_t^*\left[\left(1+r_t-\tau_t\right)^2 P_t(1-P_t)+\left(1+r_t^*-\tau_t^*\right)^2 P_t^*(1-P_t^*)\right.}$$

(A.6)

$$\frac{+\rho w_t^*(1+r_t^*-\tau_t^*)^2 P_t^*(1-P_t^*)-\rho w_t^*(1+r_t-\tau_t)(1+r_t^*-\tau_t^*)Cov(x_t,x_t^*)}{\left.-2\left(1+r_t-\tau_t\right)\left(1+r_t^*-\tau_t^*\right)Cov(x_t,x_t^*)\right]}$$

After imposing market clearing equation (1) and rearranging terms we get the final expression:

$$r_t-r_t^*=(l_t-l_t^*)+S_t\frac{\rho}{2}Var\left[(1+r_t-\tau_t)x_t-(1+r_t^*-\tau_t^*)x_t^*\right]$$

(A.7)

$$-\frac{\rho}{2}(w_t+w_t^*)\left[(1+r_t^*-\tau_t^*)^2P_t^*(1-P_t^*)\right]+\frac{\rho(w_t+w_t^*)}{2}\left[(1+r_t-\tau_t)(1+r_t^*-\tau_t^*)Cov(x_t,x_t^*)\right]$$
$$+(1+r_t-\tau_t)(1-P_t)-(1+r_t^*-\tau_t^*)(1-P_t^*)$$

Appendix II

This appendix provides additional details about the definition, sources, and timing of the data used in the study:[46]

1. **Sovereign Yields Spreads.** 3, 5, 7 and 10 years daily sovereign yields are obtained from Datastream. These yields are computed using "on the run" (benchmark) 3, 5, 7 and 10-year bonds at every moment of time. The dependent variable in equation (4) is defined as the difference between the domestic sovereign yield and the benchmark yield. The benchmark yield is defined as the weighted average of the EMU Government yields. The weights are proportional to the portion of debt outstanding by each of the EMU countries with respect to the total amount outstanding in the EMU. The general governments gross debt data employed to form the weights are reported in Table 1 and are obtained from the AMECO database.

2. **Liquidity (total bond daily turnover volume).** Liquidity is proxied by the total daily turnover volume reported in Datastream. The total turnover volume is obtained as the sum of the turnover volumes of all the sovereign bonds issued by a given country. This volume is reported in terms of monthly information on the average daily turnover volume per bond during a given month by Datastream. The turnover volume for the total number of bonds issued by a given Government derives from trades entered into TRAX. In equation (4), we employ the deviation of the logarithm of the domestic total bond daily turnover volume, in million of Euros, from the log of the benchmark total bond daily turnover volume, in million of Euros. We also employ the average daily turnover volume which is calculated as the ratio between the total daily turnover volume and the number of bonds issued by the corresponding country.

3. **CDS.** The daily CDS spreads in the study are obtained from the Credit Market Analysis (CMA). These CDS spreads are midmarket indicative prices for three, five, seven and ten year CDS contracts. In all cases, the CDS contract references the sovereign (as opposed to a central bank or some other entity). For all countries CDSs are Euro-denominated. CDSs quotes are given in basis points. In equation (4) the explanatory variable referent to CDSs is obtained as the difference between the domestic and benchmark (weighted average) CDS spreads lagged one day, in percentages. Additionally, we use CDS spreads obtained from Markit. The restructuring clause (Modified Modified Restructuring, MMR), the seniority (Senior), and the currency (Euro) are the same for both CMA and Markit CDS spreads.

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46 For yearly, quarterly and monthly data we use end of previous year (quarter or month) data. For instance, in the case of the Debt/GDP variable which has yearly frequency, we use the value at the end of 2004 for the whole year 2005. Thus, we are assuming that investors at any time in 2005 know the value of Debt/GDP variable at the end of 2004 but do not know its 2005 end-of-year value.

4. **Debt/GDP.** This variable is the ratio between the general Government gross debt at nominal value and the GDP, obtained from Ecowin. The frequencies of both the gross debt and GDP variables are annual and so, the frequency of this ratio is also annual. In equation (4), we employ the difference between the domestic and benchmark Debt/GDP ratios as explanatory variable.

5. **Interact.(Debt).** This variable is an interaction term representing the product of Debt/GDP and the monthly standard deviation of the domestic yield minus the benchmark yield. This variable has monthly frequency.

6. **Trade Balance/GDP.** This variable is the ratio between the net trade balances at the end of every month divided by the annual GDP. The net trade balance data as well as GDP data are obtained from Ecowin. The frequency of this ratio is monthly due to the frequency of the trade balance variable. The explanatory variable of equation (4) is obtained as the deviation of the domestic Trade Balance/GDP ratio from the benchmark equivalent ratio.

7. **VIX (Global risk).** This variable represents the overall global risk and it is proxied by the Chicago Board Options Exchange Volatility Index (VIX) (it is a measure of the implied volatility of S&P 500 index options). VIX is obtained from the Reuters system. We take the logarithm of VIX when we employ it as an explanatory variable. VIX has daily frequency.

8. **Corr (domestic, benchmark).** This variable is the monthly correlation between the domestic Government bond yield and the EMU benchmark bond yield. This correlation is calculated for the 3, 5, 7 and 10 years maturities. The frequency of this variable is monthly.

9. **Yield – CDS.** This variable is the difference between the Government yield minus the CDS spread for the same maturity (3, 5, 7 and 10 years). This variable is employed as the dependent variable in equation (6) and has daily frequency.

10. **Crisis dummy**. This variable is a dummy variable which is equal to zero before August 9, 2007 and one afterwards.

11. **Interaction of liquidity (bid-ask spread) and CDS lagged one period.** This variable represents the difference (in percentage) between two interaction terms referred to the domestic country and the benchmark, respectively. The first interaction term is referred to the domestic country and represents the product of a liquidity premium or trading costs, which are measured by means of the bid-ask spread (in percentage) for the overall maturities, and the CDS spread (in percentage) for the 5-year maturity lagged one day while the second interaction term represents the benchmark equivalent measure. The daily bid-ask spreads are obtained from the Bloomberg system.