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Abstract

We study the sovereign bond market co-movements and spillovers within 10 EMU countries, the so-called "periphery" and "core" countries, during the period 1999:01 to 2016:07. Implementing Generalized Methods of Moments (GMM) within a panel setting and bivariate VAR analysis, we find that an increase in the lagged spreads of Italian and Austrian bonds negatively affect the spreads of the whole sample while the increase in the Irish, Portuguese, Belgian and French lagged yields increased the overall spreads. In the VAR analysis we find that spillover effects within the sample are mostly positive.

JEL: C23, E52, G10
Keywords: sovereign yields spreads, spillovers, euro area, panel data

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1. Introduction

The sovereign debt crisis in 2008 that followed by the Global Financial Crisis (GFC) led to a considerable increase in the spreads of the euro area countries vis-á-vis Germany (see Figures A1 – A12).Due to the strong financial and macroeconomic integration within euro zone, a sequence of bail out programs (followed by the Greece's distressed debt position in late 2009) aimed to limit the crisis fall-out on the affected countries and to control the possible contagion to other countries (Constâncio (2012)). This was mainly due to the high exposure of the European Union banks to Greece and the loss of the investors' confidence due to the adverse macroeconomic developments and fiscal imbalances, which led to the increase in the EMU's sovereign yield spreads compared to German Bunds (Gomez-Puig and Sosvilla-Rivero (2013)). This situation raises question about the existence of possible adverse effects of the changes in the risk of national sovereign bonds on the other sovereign bonds (Confrey and Cronin (2013)).

Several authors have found evidence of contagion from the periphery countries to the so-called core countries. Arghyrou and Kontonikas (2012) report evidence of multiple sources of contagion from Ireland, Greece, Portugal and Spain during the late stages of the crisis (2010-2011) in a sample of 10 euro area countries. Claeys and Vasícek (2014) found evidence of contagion on the time of the assistance request by Greece, Ireland and Portugal during the sovereign debt crisis.

However, Cronin et al. (2016) conclude that contagion transmission is not only associated with the periphery countries but also with the core countries. Broto and Pérez-Quirós (2015) conclude that the country source of contagion cannot be assigned to a single economy because it is sequential and varies over time. They show that in the first years of the crisis, contagion was triggered by Greece but later it was transmitted through Portugal, Spain, Ireland and Italy. They use weekly data on the 10 OECD countries (including 8 euro area countries plus the US and the UK) over the period 1 January 2007 to 12 March 2012. Moreover, authors such as Pragidis et al. (2015) do not confirm the existence of contagion from the Greek 10-year bond to the periphery or core European countries. Therefore, we do not see conclusive empirical evidence on the existence of contagion across euro area.

Bae et al. (2003) mention that the evidence in the difficulty of studying the contagion scientifically is due to the fact that there is little agreement in defining contagion. Therefore, we choose the definitions proposed by Forbes and Rigobon (2002) and Smeets (2016) among various definitions suggested in the literature on measuring contagion. Contagion is defined as "a significant increase in market dependence between normal and crisis period" by Forbes and Rigobon (2002) and as "a significant increase in market linkages" by Smeets (2016).

In this paper, we study how sovereign bond markets have interacted within 10 EMU countries during the period 01.01.1999 to 01.07.2016, conducting GMM regression analysis for a country panel as well as VAR analysis using time series data. Our VAR estimations analyze these effects for the full sample as well as for the two distinct periods: pre-crisis (1999:01 – 2008:12) and post-crisis (2009:01 –2016:07). The results of the panel GMM regressions show that an increase in the lagged spreads of Italian and Austrian bonds negatively affect the spreads of the full sample while the increase in the Irish, Portuguese, Belgian and French lagged yields increased overall spreads.

In addition, to check the co-movements in the yields we estimated 243 different VARs for each pair of countries. Our VAR results show that the spillover effects are not just associated with the periphery countries, and also that most of the spillover effects within the sample are found to be positive. Furthermore, we also have less evidence of spillovers from the Spanish and Greek spreads than from the Portuguese and Irish spreads.

The remainder of the paper is organized as follows. Section two describes the empirical framework section three reports and discusses the main results, and section four is the conclusion.

2. Empirical framework

We used a panel of 10 EMU countries namely, Austria (AUS), Belgium (BEL), Finland (FIN), France (FRA), Greece (GRC), Ireland (IRL), Italy (ITA), the Netherlands (NTH), Portugal (PRT) and Spain (ESP), over the period 1999:01 – 2016:07. Our dependent variable is the sovereign bond yield spreads ($spread_{it}$) which is computed by subtracting the German bund yields (($yield_{DEt}$) commonly accepted benchmark) from the sovereign bond yields of the sample countries ($yield_{it}$), using the following expression:

$$spread_{it} = yield_{it} - yield_{DEt}. \qquad (1)$$

We consider the following specifications for the 10-year sovereign bond yield spreads vis-à-vis Germany:

$$spread_{it} = \alpha + \beta_0 spread_{i,t-1} + \beta_1 vix_{it} + \beta_2 BAS_{it} + \beta_3 REER_{it} + \beta_4 EX\_Debt_{it} + \sum_{j=1}^{N} \beta_{j,t} spread_{j,t-1} + \varepsilon_{it} \quad (2)$$

$$spread_{it} = \alpha + \beta_0 spread_{i,t-1} + \beta_1 vix_{it} + \beta_2 BAS_{it} + \beta_3 REER_{it} + \beta_4 EX\_Debt_{it} + \sum_{j=1}^{N} \beta_{j,t} \Delta yield_{j,t-1} + \varepsilon_{it} \quad (3)$$

where $i \neq j$ (which identify the 10 euro area countries) and the error term is an i.i.d process.

Regarding the additional explanatory variables, vix_{it} is the Chicago board of exchange volatility index and we use it as a proxy for the international risk aversion factor. The higher (lower) values of vix_{it} increase (decrease) bond yield spreads. BAS_{it} is the 10-year bond yield bid-ask spread, which is used as a liquidity measure, and higher (lower) values of BAS_{it} lead to a decrease (increase) in liquidity and consequently increase (decrease) yield spreads.

We also use the real effective exchange rate denoted by $REER_{it}$ where a positive (negative) change in $REER_{it}$ leads to appreciation (depreciation) of the respective currency, and therefore increases (decreases) yield spreads. EX_Debt_{it} is the expected difference of the government debt-to-GDP ratio against Germany, where a higher value of this variable is associated with a higher sovereign risk and therefore an increase in the spreads.

We chose these explanatory variables by following the literature on the determinants of the sovereign yield spreads (see, for example, Aßmann and Boysen-Hogrefe (2012), Afonso et al. (2014), Constantini et al. (2014)). All those studies confirm that sovereign bond spreads in the EMU countries are driven by international financial market conditions, default and liquidity risk and exchange rate premia. Table A1 in the Appendix includes the sources for the collected dataset and Table A2 shows the correlation between each two pairs of sovereign yield spreads.

In order to estimate the abovementioned specifications we used a GMM regression analysis to deal with the potential endogeneity issues that may stem from different sources. Therefore, we chose the first three lags of vix_{it}, BAS_{it}, $REER_{it}$ and EX_Debt_{it} as the instruments of the regression.

In addition we have conducted a set of bivariate VAR estimations for the whole sample period as well as for the pre-crisis and for the post-crisis periods using the following specifications:

$$X_t = \phi_0 + \sum_{l=1}^{p} \Phi_l X_{t-l} + \gamma_1 vix_t + \gamma_2 BAS_{it} + \gamma_3 REER_{it} + \gamma_4 EX\_Debt_{it} + \varepsilon_t \qquad (4)$$

where, $X_t = [spread_{it}\ spread_{jt}]'$, and $i \neq j$, $\varepsilon_t = [\varepsilon_{it}\ \varepsilon_{jt}]'$ is the multivariate white noise, $\phi_0 = [\phi_{i0}\ \phi_{j0}]'$ is the vector of intercepts, and Φ_l is a 2×2 coefficient matrix $\Phi_l = [\Phi_{ij}(l)]$. The variables $vix_t, BAS_{it}, REER_{it}$ and EX_Debt_{it} are considered as exogenous to control for systemic risk.

We used the Schwarz information criterion for choosing the lag length in each estimated VAR. In the cases where the two series were stationary in different levels we applied the VAR in their first or second differences using the following specification:

$$\Delta X_t = \phi_0 + \sum_{l=1}^{p} \Phi_l \, \Delta X_{t-l} + \gamma_1 vix_t + \gamma_2 BAS_{it} + \gamma_3 REER_{it} + \gamma_4 EX\_Debt_{it} + \varepsilon_t \quad (5)$$

where, $\Delta X_t = [\Delta spread_{it} \; \Delta spread_{jt}]'$, and $i \neq j$.

For the cases of cointegrated series, which are stationary in different levels or both are I(2), we applied the below specification where we add an error correction term and estimate a Vector Error Correction model (VECM),

$$\Delta X_t = \phi_0 + \sum_{l=1}^{p} \Phi_l \, \Delta X_{t-l} + \delta_t ECT_{X,t-1} + \varepsilon_t. \quad (6)$$

However, in the cases where the two series were either I(0) or I(1) and cointegrated, we applied a levels VAR framework that is actually valid according to Sims et al. (1990).

3. Results

The GMM results are presented in Tables 1, 2 and 3. As we can see, the lagged yield spreads have a high significant impact on the yield spreads in period t. According to the results, we obtained the expected signs for the vix, the BAS and the $REER$. However, the expected debt vis-á-vis Germany appeared not to have a significant impact on the yield spreads in the country sample (only significant in some specifications as we can see in Table 2 and Table 3).

Moreover, we find that an increase in the lagged spreads of Austria and Italy contributed to reducing the spreads of the overall sample and an increase in the lagged spreads of France and Ireland positively affected the spreads of the sample countries.

[Table 1]

In addition, positive changes in Austria's and Italy's lagged yields contributed to decrease the spreads of the other countries while positive changes in the lagged yields of Belgium and Portugal increased the overall spreads.

In general, we can say that an increase in the lagged yields of Austrian and Italian bonds can be due to the decrease in the demand for these bonds (lower price) in period t-1. This demand might shift to the bonds of the other countries in the sample and contributes to increase the price of the bonds of these countries, therefore lowering their respective yields. This phenomenon can be perceived as "flight-to-quality" for the case of Italy (see also Ehrmann and Fratzscher, 2017).[1]

These results did not change when we estimated the models excluding one country at a time (see Table 2 and Table 3). From Table 2, we can again see that an increase in the lagged spreads of Italy and Austria (and Spain only in one specification) contributes to decreasing the overall panel spreads. While an increase in the lagged spreads of France and Ireland (and Belgium and the Netherlands only in some specifications) increases the spreads of the other countries.

[Table 2]

[Table 3]

As we can see in Table 3, an increase in the lagged yields of Austrian and Italian bonds negatively affects the spread of the whole sample while an increase in the lagged bond yields of Belgium and Portugal increases the spreads of the whole sample.

From these results, we can see that the spillovers effects are not just associated with the periphery countries but also with the core countries (Austria, Belgium and France).

In order to check the co-movements in these bond markets we have implemented 243 different VARs for each pair of countries. The sign and significance level of the first lag of the relevant variable in each VAR is reported in each cell in Table 4 (4a, 4b and 4c). Before estimating each VAR, first, we applied unit root tests (Augmented Dickey-Fuller using Schwarz Info Criterion for the lag length selection) to test for the stationarity of each series. According to the results of these tests all of our series are stationary in their first difference (I(1)) for the full sample period (Table A3). Second, we tested the cointegration of each two series using the Johansen cointegration test (Table A4).

[Table 4]

The results of the VARs for the whole sample period, when considering the yield spreads as the endogenous variables, show mostly positive spillovers within the sample countries bond markets. However, we found that when the spreads of Austria, Finland, France, Italy and the Netherlands increase, Belgian spread decreases. This decrease can be associated with the increase in the demand for the Belgian bonds. We also found that an increase in the

[1] Ehrmann and Fratzscher (2017) define flight-to-quality as "instances where a shock that raises yields in a stressed country would lower yields in the core countries".

spreads of Ireland, Portugal, Spain and Italy decreases the Irish yield spread. There is less evidence of spillovers from Spanish bond markets compared to other periphery countries bond markets.

In order to capture the effects of the sovereign debt crisis on possible spreads spillovers, we divided the sample into two sub-samples of "pre-crisis" (1999:01 –2008:12) and "post-crisis" (2009:01 – 2016:07) and implemented the VARs once again. The results are reported in Tables 4b and 4c.

In the pre-crisis period, we mostly observe positive spillovers. However, we found negative spillovers from the spreads of Finland, Ireland and Portugal on the spread of Belgium. This effect can be explained by the shift of demand from the bonds of Finland, Ireland and Portugal to the Belgian sovereign securities, which leads to an increase in the market price of Belgian bonds, and consequently the yields of Belgian bonds decrease. The impact of an increase in the Portuguese and Irish yields spreads can be perceived as the flight-to-liquidity. For instance, we can formulate the hypothesis that an increase in the spread of Irish bonds negatively affects the spreads of Spain, this can be again considered as the demand shift from the Irish bonds to Spanish bonds.

However, we can also observe from our results that after the crisis the shift of demand from the Irish and Portuguese bonds disappeared. Instead, the spreads of these two countries contributed to increasing the yield spread of Belgium. In that post crisis period, an increase in the spreads of Greece, Portugal, Spain, Italy, France and Belgium decreased the yield spread of Ireland. A remarkable result is that the number of significant coefficients increased in the post crisis period and this can be perceived as the increase in the sovereign bond market interdependence. Looking at the overall results we can conclude that the spillover effects are not just associated with the periphery countries but they also occur the core countries. This result is in line with the results of Cronin et al. (2016).

4. Conclusion

In this paper we have studied the spillovers of the sovereign yield spreads of the 10 EMU countries using monthly data over the period 1999:01 – 2016:07.

In a first step, we conducted GMM regressions for the country panel set. We found that, both lagged spreads and yields of Austrian and Italian bonds contributed to decrease the overall spreads of the sample countries. On the other hand, the lagged spreads of France and Ireland had a positive impact on the overall spreads. We also found that an increase in the lagged

Portuguese and Belgian yields increases the spreads of the overall sample. We didn't find any spillover effects from the Greece yield on the country sample.

In the next step we implemented a bivariate VAR analysis for each pairs of countries using the countries' spreads as endogenous variables. Most of the spillover effects were found to be positive and these effects were associated to both periphery and core countries. However, we found that prior to crisis the Portuguese and Irish spreads contributed to decreasing the spread of Belgium (flight-to-quality) while after the crisis they positively affected the Belgian spread. We also found that an increase in the spreads of Italy, Greece, Portugal and Spain negatively affected the spread of Ireland. The evidence on the spillovers from the Spanish and Greek bond markets were found to be less important than the other periphery countries.

Our analysis has implications for macroeconomic policy-makers because of the relevance of the need to consider the increasing interdependencies across euro area countries and markets. It also has implications for financial markets and investors who are seeking to construct optimal diversified portfolios at an international level.

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Table 1- GMM estimation results (dependent variable: $spread_t$)

specification		1	2
Spread_t_1		0.9416***	0.9256***
vix		0.0032***	0.0035***
BAS		0.8318***	0.9419***
REER		0.0017*	0.0022**
Ex_Debt		0.0012	0.0015
AUS	$spread_{t-1}$	-0.3306**	
	$\Delta yield_{t-1}$		-0.3840*
BEL	$spread_{t-1}$	0.0890	
	$\Delta yield_{t-1}$		0.6187***
FRA	$spread_{t-1}$	0.5010**	
	$\Delta yield_{t-1}$		-0.1706
ITA	$spread_{t-1}$	-0.1711***	
	$\Delta yield_{t-1}$		-0.2415**
NTH	$spread_{t-1}$	0.1708	
	$\Delta yield_{t-1}$		0.1558
FIN	$spread_{t-1}$	-0.0382	
	$\Delta yield_{t-1}$		-0.0992
GRC	$spread_{t-1}$	0.0029	
	$\Delta yield_{t-1}$		0.0136
IRL	$spread_{t-1}$	0.0410**	
	$\Delta yield_{t-1}$		0.0147
PRT	$spread_{t-1}$	0.0104	
	$\Delta yield_{t-1}$		0.0775*
ESP	$spread_{t-1}$	-0.0343	
	$\Delta yield_{t-1}$		0.0074
R-squared		0.9754	0.9747
N observations		1983	1983

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Table 2 - GMM results excluding one country at a time (dependent variable: $spread_t$)

specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Spread_t_1	0.9164***	0.9494***	0.9175***	0.9363***	0.9447***	0.9481***	0.9453***	0.9333***	0.9380***	0.9419***
Vix	0.0033***	0.0034***	0.0024**	0.0035***	0.0033***	0.0032***	0.0031***	0.0026**	0.0031***	0.0030***
BAS	0.9464***	0.7967***	0.9313***	0.8507***	0.8166***	0.8058***	0.8149***	0.8731***	0.8425***	0.8295***
REER	0.0025***	0.0015	0.0025***	0.0015*	0.0017*	0.0015	0.0016*	0.0024**	0.0018*	0.0019**
EX_Debt	0.0022*	0.0009	0.0021*	0.0014	0.0011	0.0010	0.0011	0.0016	0.0013	0.0012
$\boldsymbol{AUS\_spread_{t-1}}$		-0.3044**	-0.2110*	-0.2708**	-0.3123**	-0.3523***	-0.3242**	-0.3060**	-0.3334***	-0.3191**
$\boldsymbol{BEL\_spread_{t-1}}$	-0.0246		0.1471	-0.0182	0.0576	0.0758	0.0743	0.2551***	0.1176	0.1200
$\boldsymbol{FRA\_spread_{t-1}}$	0.3069	0.5636**		0.3198	0.5506**	0.5230**	0.5276**	0.2840	0.4878**	0.5017**
$\boldsymbol{ITA\_spread_{t-1}}$	-0.1458**	-0.1497**	-0.1145**		-0.1560**	-0.1649**	-0.1746***	-0.2507***	-0.1624***	-0.2122***
$\boldsymbol{NTH\_spread_{t-1}}$	0.0802	0.1116	0.3217*	0.0381		0.1378	0.1387	0.3691*	0.1579	0.1664
$\boldsymbol{FIN\_spread_{t-1}}$	-0.1569	-0.0025	-0.0638	0.0359	0.0446		-0.0213	-0.1145	-0.0498	-0.0440
$\boldsymbol{GRC\_spread_{t-1}}$	0.0018	0.0014	0.0075	0.0045	0.0016	0.0025		0.0042	0.0049	0.0018
$\boldsymbol{IRL\_spread_{t-1}}$	0.0428**	0.0473***	0.0316*	0.0605***	0.0447***	0.0417**	0.0403**		0.0411**	0.0347*
$\boldsymbol{PRT\_spread_{t-1}}$	0.0145	0.0154	0.0109	-0.0052	0.0077	0.0119	0.0155	0.0305		0.0124
$\boldsymbol{ESP\_spread_{t-1}}$	-0.0017	-0.0541	-0.0211	-0.1082***	-0.0352	-0.0426	-0.0306	0.0201	-0.0319	
R-squared	0.9754	0.9752	0.9754	0.9753	0.9753	0.9752	0.9753	0.9753	0.9754	0.9754
N observation	1983	1983	1983	1.983	1983	1983	1983	1983	1983	1983

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Table 3 - GMM results excluding one country at a time (dependent variable: $spread_t$)

Specification	1	2	3	4	5	6	7	8	9	10
Spread_t_1	0.9220***	0.9056***	0.9252***	0.9305***	0.9237***	0.9272***	0.9328***	0.9258***	0.9229***	0.9275***
vix	0.0033***	0.0040***	0.0036***	0.0033***	0.0034***	0.0034***	0.0035***	0.0035***	0.0036***	0.0035***
BAS	0.9511***	1.0208***	0.9433***	0.9069***	0.9478***	0.9310***	0.9104***	0.9425***	0.9632***	0.9345***
REER	0.0023**	0.0028***	0.0022**	0.0021**	0.0022**	0.0022**	0.0021**	0.0022**	0.0023**	0.0022**
EX_Debt	0.0016	0.0023*	0.0015	0.0014	0.0016	0.0015	0.0013	0.0015	0.0016	0.0015
$AUS\_\Delta yield_{t-1}$		-0.2406	-0.4220**	-0.4145**	-0.3770*	-0.3651*	-0.4033**	-0.3808*	-0.3443*	-0.3807*
$BEL\_\Delta yield_{t-1}$	0.5577***		0.5662***	0.4815***	0.5943***	0.5988***	0.5995***	0.5981***	0.5542***	0.6200***
$FRA\_\Delta yield_{t-1}$	-0.4031	0.1660		-0.1704	-0.1188	-0.1987	-0.1420	-0.1705	-0.1572	-0.1725
$ITA\_\Delta yield_{t-1}$	-0.2418**	-0.1270	-0.2423**		-0.2441**	-0.2287*	-0.2268**	-0.2309**	-0.1775	-0.2365**
$NTH\_\Delta yield_{t-1}$	0.1140	-0.0326	0.0750	0.1631		0.0753	0.1562	0.1483	0.1374	0.1554
$FIN\_\Delta yield_{t-1}$	-0.1435	0.0726	-0.1014	-0.0054	0.0095		-0.1207	-0.0800	-0.0876	-0.1004
$GRC\_\Delta yield_{t-1}$	0.0138	0.0108	0.0138	0.0107	0.0137	0.0127		0.0136	0.0168	0.0131
$IRL\_\Delta yield_{t-1}$	0.0177	0.0165	0.0147	0.0241	0.0136	0.0107	0.0165		0.0519	0.0163
$PRT\_\Delta yield_{t-1}$	0.0684	0.0509	0.0735*	0.0554	0.0754*	0.0801*	0.0885**	0.0824**		0.0777*
$ESP\_\Delta yield_{t-1}$	0.0125	0.0743	0.0146	-0.1332	0.0223	0.0150	0.0154	0.0174	-0.0055	
R-squared	0.9747	0.9744	0.9747	0.9749	0.9747	0.9747	0.9748	0.9747	0.9746	0.9747
N observation	1983	1983	1983	1983	1983	1983	1983	1983	1983	1983

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Table 4a – VAR estimation results using yield spreads at period t as endogenous variables (full sample period)

Impact on →	S_AUS	S_BEL	S_FRA	S_ITA	S_NTH	S_FIN	S_GRC	S_IRL	S_PRT	S_ESP
S_AUS		-***	-	-**	+*	+	+***	-	+**	+
S_BEL	+***		+***	+**	+***	+**	+***	-**	+***	+**
S_FRA	+***	-***		+	+***	+*	+***	-***	+**	+***
S_ITA	+***	-***	+***		+**	+*	+	-***	+	-
S_NTH	+**	-*	-	+		+**	+*	+	+*	+
S_FIN	+**	-**	-	-	+*		+	+	+**	+
S_GRC	+***	+	+**	+	+***	+*		-***	-	+***
S_IRL	+***	+***	+***	+***	+***	+**	+**		+	+***
S_PRT	+***	+***	+***	+***	+***	+**	+***	-***		+***
S_ESP	+**	-	+	+***	+**	+	+	-***	-	

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Table 4b – VAR estimation results using yield spreads at period t as endogenous variables (pre-crisis)

Impact on →	S_AUS	S_BEL	S_FRA	S_ITA	S_NTH	S_FIN	S_GRC	S_IRL	S_PRT	S_ESP
S_AUS		+	+**	+	+***	+***	+***	+*	+**	+
S_BEL	+***		+***	+	+***	+	-	+	+***	+
S_FRA	+***	-		-	+***	+***	+***	+	+**	+
S_ITA	+***	+	+***		+***	+	+***	+*	+**	+
S_NTH	+	-	-	-		+***	+***	+	-	-
S_FIN	-	-***	-	-	+		+	-	-	-
S_GRC	+	-	+	+**	+**	+		+***		+
S_IRL	-	-**	-	-	+	+	+		-	-*
S_PRT	-	-**	+*	+**	+**	+	-	+	+	-
S_ESP	+	+	+***	+	+	+	-	-	+**	

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Table 4c – VAR estimation results using yield spreads at period t as endogenous variables (post-crisis)

Impact on →	S_AUS	S_BEL	S_FRA	S_ITA	S_NTH	S_FIN	S_GRC	S_IRL	S_PRT	S_ESP
S_AUS		-***	-*	-**	-	+	+*	-	+**	-
S_BEL	+***		+***	+	+*	+***	+*	-*	+***	+
S_FRA	+***	-***		+	+*	+**	+**	-*	+**	+
S_ITA	+***	-**	+*		+	+**	+	-***	+	-
S_NTH	-	-**	-	+		+	+	-	+*	+
S_FIN	+	-**	-	-	+		+	-	+**	-
S_GRC	+***	-	+	+	+	+**		-**	-	+
S_IRL	+**	+***	+**	+**	+*	+**	+		-	+
S_PRT	+***	+***	+***	+***	+***	+***	+*	-**		+***
S_ESP	+	-	+	+**	+	+***	+	-*	-	

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively.

Appendix

Table A1- Data description and Sources

Variable	Description	Source
Yield	10-year bond yield	ECB
spread	10-year bond yield spread against German bond	Own calculations (specification (1))
VIX	Chicago Board of Exchange Volatility Index	Bloomberg
BAS	10-year bond yield bid_ask Spread	Bloomberg and ECB
REER	Real Effective Exchange Rate, CPI based	IFS
EX_Debt	Expected government debt, % of GDP	EC

Table A2 – Spreads correlations

	S_AUS	S_BEL	S_FRA	S_ITA	S_NTH	S_FIN	S_GRC	S_IRL	S_PRT	S_ESP
S_AUS	1									
S_BEL	0.912	1								
S_FRA	0.885	0.935	1							
S_ITA	0.794	0.906	0.964	1						
S_NTH	0.891	0.813	0.846	0.781	1					
S_FIN	0.869	0.741	0.723	0.617	0.899	1				
S_GRC	0.705	0.831	0.889	0.920	0.649	0.511	1			
S_IRL	0.755	0.892	0.785	0.796	0.688	0.580	0.789	1		
S_PRT	0.769	0.923	0.925	0.950	0.700	0.559	0.941	0.882	1	
S_ESP	0.725	0.852	0.919	0.974	0.738	0.559	0.928	0.804	0.934	1

Table A3 – Augmented Dickey Fuller unit root test results

country	1999:01 – 2016:07		1999:01 – 2008:12		2009:01 – 2016:07	
	t.statistic	order	t.statistic	order	t.statistic	order
AUS	-8.65***	I(1)	-5.03***	I(1)	-10.81***	I(1)
BEL	-12.33***	I(1)	-7.47***	I(1)	-8.20***	I(1)
FIN	-13.14***	I(1)	-4.75***	I(1)	-3.63***	I(0)
FRA	-14.37***	I(1)	-8.58***	I(1)	-9.48***	I(1)
GRC	-11.96***	I(1)	-3.32**	I(1)	-8.41***	I(1)
IRL	-11.63***	I(1)	-12.36***	I(2)	-7.82***	I(1)
ITA	-11.63***	I(1)	-5.38***	I(1)	-7.63***	I(1)
NTH	-13.32***	I(1)	-6.72***	I(1)	-2.95**	I(0)
PRT	-4.88***	I(1)	-7.82***	I(1)	-3.10**	I(1)
ESP	-12.25***	I(1)	-8.14***	I(2)	-7.99***	I(1)

Note: the asterisks ***, **, * indicate significance at 1, 5, 10% respectively. Null hypothesis: series have unit root.

Table A4 – Johansen cointegration test results (1999:01 – 2016:07)

	S_AUS	S_BEL	S_FRA	S_ITA	S_NTH	S_FIN	S_GRC	S_IRL	S_PRT	S_ESP
S_AUS										
S_BEL	0.07**									
S_FRA	0.08***	0.14***								
S_ITA	0.10***	0.12***	0.12***							
S_NTH	0.12***	0.06**	0.07**	0.05						
S_FIN	0.07***	0.04	0.05*	0.05*	0.10***					
S_GRC	0.07**	0.10***	0.07**	0.11***	0.04	0.05*				
S_IRL	0.10***	0.11***	0.12***	0.13***	0.04	0.05	0.13***			
S_PRT	0.07**	0.08***	0.04*	0.07***	0.04	0.04	0.08**	0.17***		
S_ESP	0.13***	0.22***	0.13***	0.17***	0.05	0.06*	0.12***	0.10***	0.12***	

Note: values reported are the eigenvalues. The asterisks ***, **, * indicate significance at 1, 5, 10% respectively. Null hypothesis: ther.e is no cointegration.

Figure A1 – Austria's bond yield spread vis-á-vis German Bund

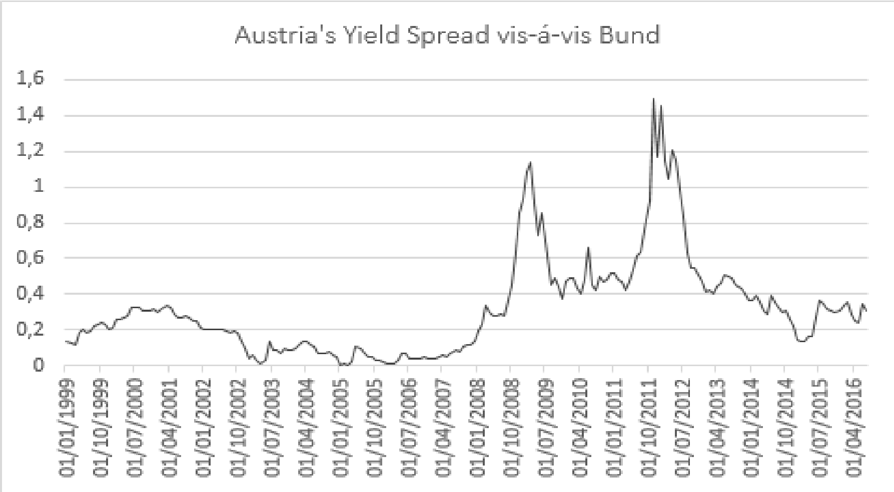

Figure A2 – Belgium's bond yield spread vis-á-vis German Bund

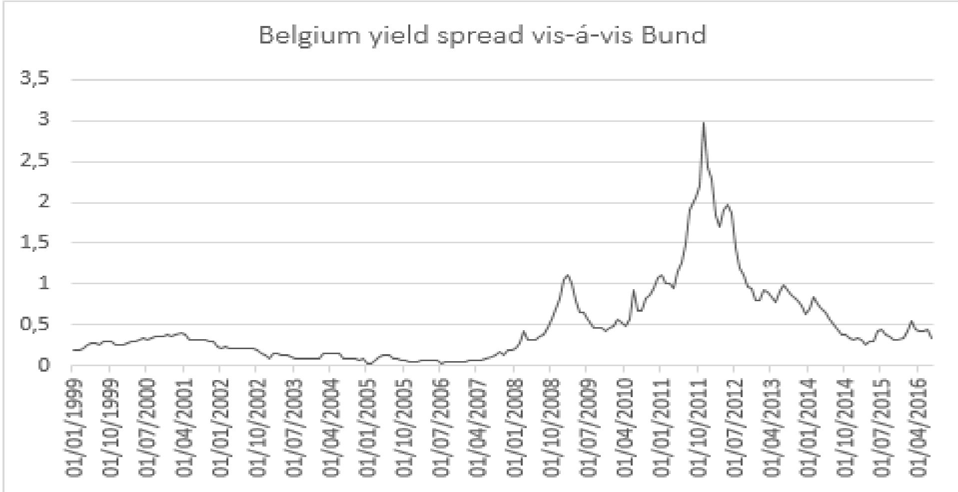

Figure A3 – France's bond yield spread vis-á-vis German Bund

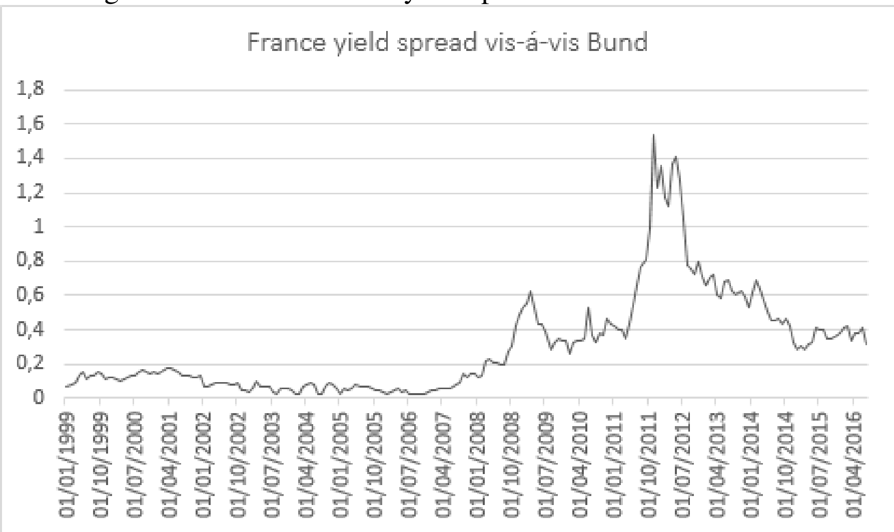

Figure A4 – Italy's bond yield spread vis-á-vis German Bund

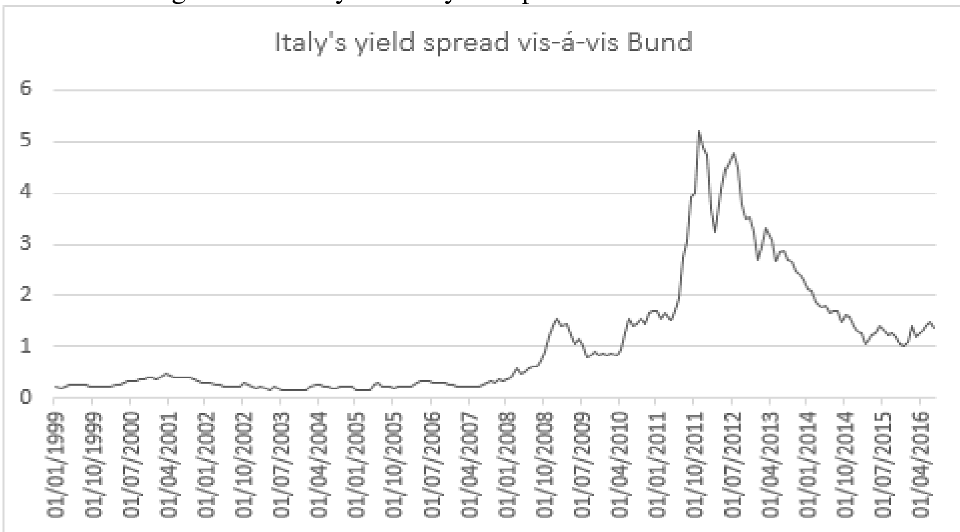

Figure A5 – The Netherland's bond yield spread vis-á-vis German Bund

Figure A6 – Finland's bond yield spread vis-á-vis German Bund

Figure A7 – Greece's bond yield spread vis-á-vis German Bund

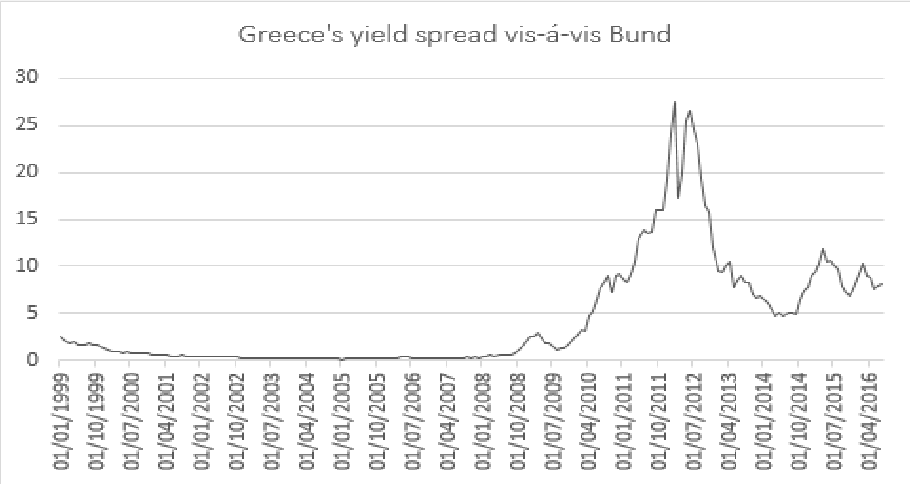

Figure A8 – Ireland's bond yield spread vis-á-vis German Bund

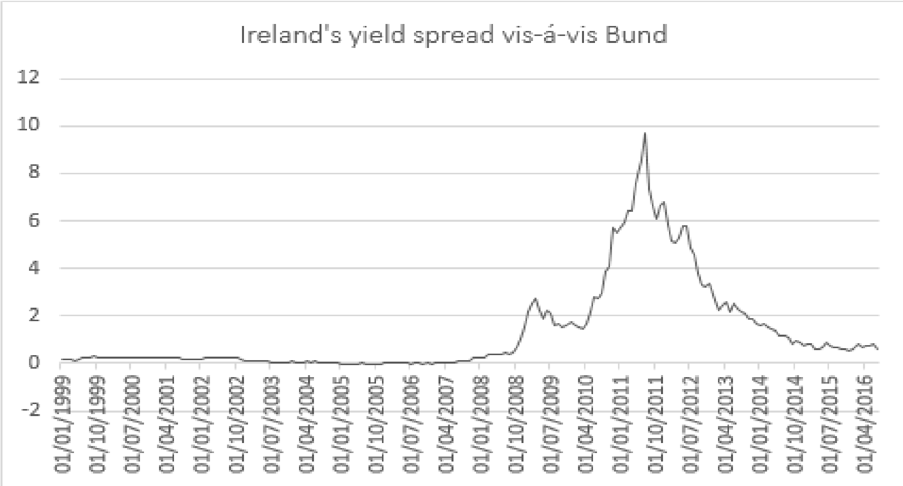

Figure A9 – Portugal's bond yield spread vis-á-vis German Bund

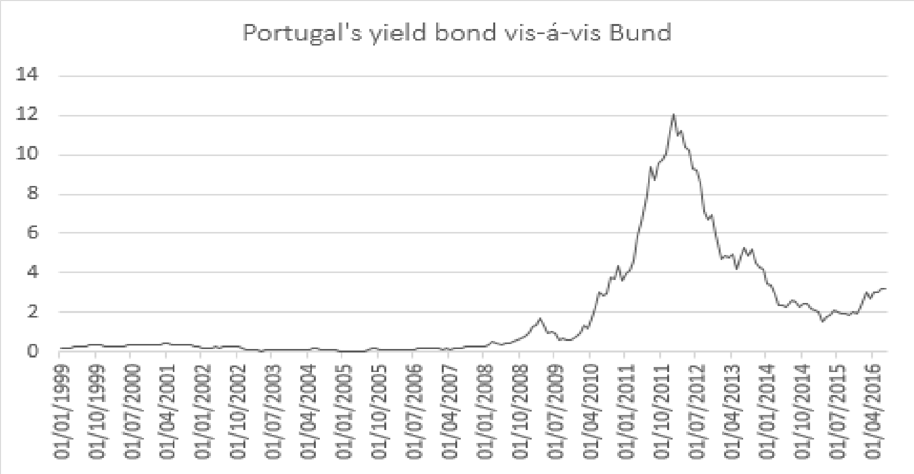

Figure A10 – Spain's bond yield spread vis-á-vis German Bund

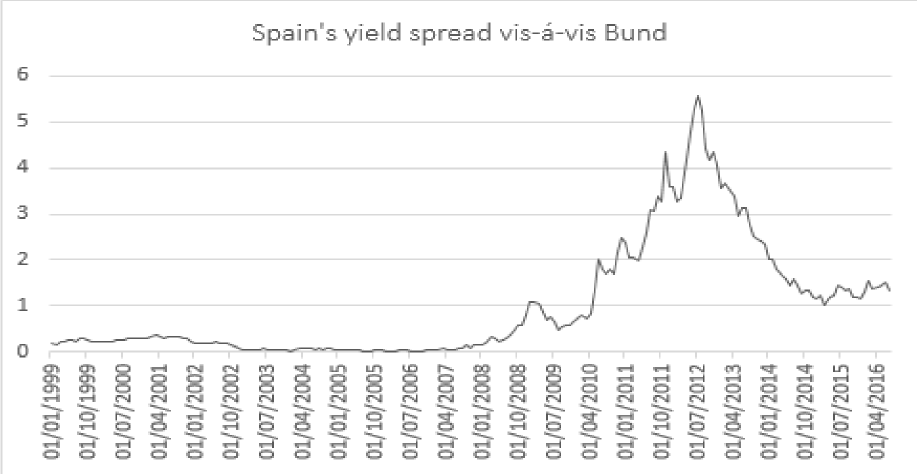

Figure A11 – Core countries yield spreads vis-á-vis German Bund

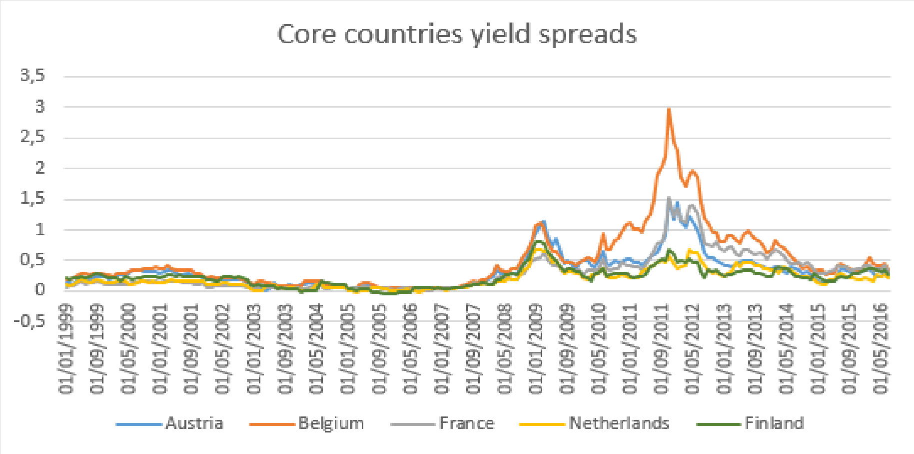

Figure A12 – Periphery countries yield spreads vis-á-vis German Bund