Bocconi

WORKING PAPER SERIES

WORKING PAPER
N. 120
OCTOBER 2019

Time-Varying Price Discovery in Sovereign Credit Markets

By Massimo Guidolin, Manuela Pedio and Alessandra Tosi

Time-Varying Price Discovery in Sovereign Credit Markets

Massimo Guidolin[1]
Bocconi University, Baffi CAREFIN

Manuela Pedio
Bocconi University, Baffi CAREFIN

Alessandra Tosi
Bocconi University

July 2019

Abstract

We analyze the time-varying nature of the price discovery process in the sovereign debt market over the sample period January 2006 – September 2015. In particular, we test whether the cointegration relationship that should tie bond and CDS spreads together holds over the entire sample. In addition, we investigate which (if any) of the two markets leads the price discovery in each of a number of sub-samples. We focus on ten European countries (Portugal, Italy, Ireland, Greece, Spain, Netherland, Germany, France, Austria, and Belgium), the UK, and the US. We find that while for all the peripheral countries but Greece the CDS and bond spreads show a long-run equilibrium relationship over the full sample, this is not the case for core European countries, the UK, and the US. Moreover, when the cointegration relationship fails to hold, none of the two markets appears to lead the price discovery process.

Keywords: Treasury bond spreads, credit default swaps, sovereign credit risk, vector error correction models, price discovery.

JEL code: C32, E52, E43

[1] Corresponding author. Address: Bocconi University, Finance dept., via Roetgen 1, 20136 Milan, Italy. E-mail: massimo.guidolin@unibocconi.it. Tel.: +39-02-5836.5885.

1. Introduction

After the great financial crisis of 2008-2009, the sovereign debt markets in many developed countries, which have always been considered as free of default risk from a practical standpoint, came under unprecedented stress. In Europe, since the end of 2009, several Eurozone member states (namely, Greece, Portugal, Ireland, and Spain) were unable to re-pay or re-finance their government debt or to bail-out their over-indebted banks, forcing the European Central Bank (ECB) to intervene with a set of financial support measures such as the Security Market Program (SMP) and a wave of Outright Monetary Transactions (OTMs).[2] Therefore, as pointed out, for instance, by Fontana and Scheicher (2016), the great financial crisis has dramatically changed the way in which sovereign credit risk is perceived and priced by the market participants. Motivated by this consideration, in this paper we aim at investigating whether the outburst of the European debt crisis and the policy measures that have been put into place to tackle it have altered the mechanisms that lead to the price discovery of credit risk. In particular, we investigate the price discovery process for ten Eurozone countries, both core and peripheral, over a sample period January 6, 2006 – September 11, 2015. To obtain a standard benchmark of comparison, we also study the data for the UK and the US over the same period.

We follow Blanco et al. (2005), who use a cointegration framework to describe the no-arbitrage, equilibrium relationship that in principle should tie together the bond credit spread and the credit default swap (CDS) premium for the same reference entity. In their seminal paper, Blanco and co-authors focus on corporate reference entities and perform a Johansen test to assess whether bond and CDS spreads are cointegrated; when they find evidence of cointegration, i.e., that the two spreads are tied by a long-run relationship, they estimate a vector error correction model (VECM) and use it to compute Gonzalo-Granger

[2] The SMP, launched in May 2010 to tackle the Greek debt crisis and terminated in January 2012, consisted in the purchase of EUR-denominated bonds by the ECB. The largest purchases occurred after its introduction and in August 2011, amid ongoing stress in the Italian and Spanish sovereign bond markets. This program was replaced in August 2012 by OTMs.

measure of price discovery. On the contrary, in the case of reference entities that fail to display a cointegrating relationship, they estimate a vector autoregressive (VAR) model and use Granger causality to investigate the price discovery process.

Motivated by the fact that we are interested in assessing whether the financial crisis and the European debt crisis have changed the price discovery mechanism that characterize the sovereign debt market and differently from Blanco et al. (2005), we perform the Johansen test in a recursive, expanding window fashion. This way, we can distinguish periods when the cointegrating relationship holds from periods in which the long-run equilibrium relationship failed to materialize and conduct appropriate, different analyses over the two sub-periods.

Despite most of the literature that has investigated the price discovery process in credit marketa has focused on corporate bonds (see, e.g., Zhu, 2006; Forte and Pena, 2009; Palladini and Portes, 2011; Avino et al., 2015), there are a few papers that have studied the European sovereign debt market (see, e.g., Delis and Mylonidis, 2011; Arce et al., 2013; Fontana and Scheicher, 2016). In particular, our paper is closely related to Arce et al. (2013). However, Arce et al. (2013) assume that the cointegration relationship holds over the entire sample period and estimate the cointegration coefficients in a recursive manner. On the contrary, we recursively test for cointegration and individuate periods in which the long run equilibrium relationship between the bond and the CDS market does not hold.

We report several interesting findings. First, all the peripheral countries with the exception of Greece display a long-run equilibrium relationship over the entire sample period. However, while in tranquil times the CDS market leads the price discovery process, the reverse is true in times of crisis, in line with similar findings reported, for instance, by Arce et al. (2013). Interestingly, during the sovereign debt crisis the cointegrating relationship between CDS and bond spreads of most of the core countries fails to hold and none of the two markets leads price discovery. Even though this may seem puzzling, we believe this is a result of a flight-to-quality phenomenon that characterized the European debt crisis. Finally, we find that in the case of the US, the cointegrating relationship did not hold between October 2011 and the end of the sample. This result may be a consequence of the prolonged unconventional monetary policy carried out by the US monetary authority. In contrast, the bond purchases carried out by the ECB seem to have restored instead of altering the equilibrium between the bond and the CDS markets.

The rest of this paper is structured as follows. Section 2 describes the data. Section 3 presents the methodology. Section 4 discusses the main results concerning the recursive Johansen test and the price discover analysis and Section 5 concludes.

2. Data

In our analysis, we consider the CDS premia and the bond spreads of five core (Austria, Belgium, Germany, France, and Netherlands) and of five peripheral European countries (Portugal, Italy, Ireland, Greece, and Spain, also known as PIIGS) at a weekly frequency over the sample period January 6, 2006 – September 11, 2015. For comparison purposes, we also include in our analysis data for the US and UK CDS and bond spreads over the same period. We start our analysis in January 2006 because this is the first date on which all the CDS spreads are available (due to lack of sufficiently frequent transaction before 2006, see, e.g., Delis and Mylonidis, 2011, for a discussion). Similar to Blanco et al. (2005) and Ammer and Cai (2011), we focus on 5-year CDSs because they are the most liquid swaps traded; for the same reason, we consider CDSs that are denominated in USD for the European countries (including the UK), while in the case of the US, we consider CDS denominated in Euros.[3] All the data on CDS premia are retrieved from Markit. The bond spreads are computed as the difference between the 5-year constant-maturity

[3] In case of a credit event involving a sovereign entity, a severe depreciation of the currency of the issuing State is likely. Therefore, sovereign CDSs denominated in the currency of the State against the default of which they provide insurance tend to be less traded than those denominated in a different currency (see, e.g., Fontana and Scheicher, 2016). In addition, we use CDSs including a cumulative restructuring (CR) clause, which are the most common in Europe; the CR clause includes ‘‘restructuring’’ as a default event and allows the protection buyer to deliver bonds of any maturity after restructuring of the debt.

rates (converted in the same currency as the corresponding CDS premia) and the risk-free rate. The 5-year constant-maturity rates are retrieved from Thompson Reuters. As a proxy for the risk-free rate, we use the overnight index swap (OIS) rate, in which the floating leg consists of the European Overnight Index Average (EONIA) (for European countries) or the Effective Fed Fund Rate (for the US).

Table 1 provides descriptive statistics for CDS premia, bond spreads, and the CDS-Bond spread basis. For what concerns CDS premia, core countries can be categorized into two sub-groups: Austria, Belgium, and France show similar mean spreads, ranging from 56 to 77 basis points; Germany and the Netherlands display slightly lower mean spreads (30 and 38 basis points, respectively). The volatility of the CDS premia of core countries is typically low, ranging from approximately 27 basis points (Germany) to 79 basis points (Belgium). The CDS premia of peripheral countries display higher means when compared to those of core countries and are considerably more volatile. For instance, Greece has an average CDS spread of approximately 2,031 basis points with a steep volatility of 4,009 basis points. The other four countries are characterized by less extreme statistics, with mean spreads ranging from approximately 150 basis points (in the case of Italy and Spain) to 328 basis points (Portugal). The mean spread of UK sovereign CDS is in line with core European countries (approximately 41 basis points) while the US report the lowest mean spread among all the countries under consideration (27 basis points, with a volatility of 19 basis points only). Bond spreads are typically lower than CDS spreads are, leading to a positive CDS-bond basis. In particular, there are three countries, namely Germany, the UK, and the US, which imply negative mean bond spreads. We find only one case, Portugal, characterized by a negative average basis (approximately -33 basis points). For the remaining the countries, the average basis tends to be approximately in the range 25-30 basis points, with the notable exception of Greece, which implies an exceptionally high mean basis of 1,337 basis points.

Finally, the last column of Table 1 reports the correlation between bond and CDS spreads, while in Figure 1 we present the scatter plot of the two series. Notably, all peripheral countries with the sole exception of Greece are characterized by a high correlation of bond and CDS spreads, in line with the theoretical no-arbitrage relationship that should tie them together (see Duffie, 1999). The estimated correlations are lower for core countries (with the exception of Austria and Belgium, which display correlations of 0.91 and 0.95, respectively) and the US and it is even negative and close to zero for the UK and Germany.

3. Methodology

Our analysis consists of two steps. In the first step, because all the bond and CDS spread series turn out to be I(1), we proceed to test whether a cointegrating relationship exists between each pair of CDS and bond spread time series.[4] We expect such long-run equilibrium relationship to hold because, in absence of frictions and market imperfections, CDS premia and bond spreads should be tied together by a no-arbitrage relationship: indeed, the risk-reward profile of a protection seller is equivalent to a trading strategy that combines a long position in a bond of the same maturity and a short position in the risk-free asset denominatd in the same currency (see Duffie, 1999). However, the literature has pointed out that the nature of this relationship may be highly time-varying (see, e.g., Delis and Mylonidis, 2011; Arce et al., 2013; Avino et al., 2015).[5]

Because we conjecture that the series may be cointegrated over some sub-samples but not in others, we proceed in three steps. In a first stage, we apply Johansen's (1988) trace test in a

[4] To assess whether the bond and CDS spread series contain a unit root, we employ an Augmented Dickey Fuller test under three different specifications: the series do not contain either a constant or a trend; the series include a constant but not a trend; the series contain both a constant and a trend. The number of lags included in the test equations are specified by means of minimization of the Schwarz's information criterion (SIC). For all the series and under all specifications, we cannot reject the null hypothesis of unit root. Complete results are available from the Authors upon requests.

[5] Similarly, Bariviera et al. (2018) show that the information efficiency of the sovereign bond market in European countries is time-varying. Surprisingly though, they find that the recent sovereign debt crisis has enhanced the informational efficiency of the sovereign bond markets instead of decreasing it.

recursive manner, considering an expanding window framework with initial sample January 01, 2006 – January 02, 2009. We follow Forte and Pena (2009) in the specification of the test equation and we consider the presence of constants in the cointegrating relationship and in the level of the data but not of trends. The number of lags is specified according to the Schwarz's information criterion (SIC).

In a second step. when we find evidence of cointegration over the entire sample, i.e., in case the trace statistics is always above the critical value so that we can always reject the null hypothesis of no-cointegration at a 5% level, we proceed to estimate the model:

$$\Delta CDS_t = \mu_1 + \alpha_1(CDS_{t-1} - c - \beta Bond_{t-1}) + \sum_{i=1}^{p} \gamma_{1i}\, \Delta CDS_{t-i} \sum_{i=1}^{p} \delta_{1i}\, \Delta Bond_{t-i} + \varepsilon_{1t} \quad (1)$$

$$\Delta Bond_t = \mu_2 + \alpha_2(CDS_{t-1} - c - \beta Bond_{t-1}) + \sum_{i=1}^{p} \gamma_{2i}\, \Delta CDS_{t-i} \sum_{i=1}^{p} \delta_{2i}\, \Delta Bond_{t-i} + \varepsilon_{2t} \quad (2)$$

where α_1 and α_2 are the coefficients that measure the speed of adjustment to deviations from the long-run equilibrium, $[1 - c - \beta]$ is the cointegrating vector, p is the number of lags included in the model, and ε_{1t} and ε_{2t} are identically and independently distributed error terms such that $\varepsilon_t \equiv [\varepsilon_{1t}\ \varepsilon_{2t}]' \sim N(\mathbf{0}, \mathbf{\Sigma})$. In case we fail to find evidence of cointegration over the full sample, we divide our sample period into subsamples. For the periods in which we are able to reject the null-hypothesis of no-cointegration, we estimate the vector error correction model (VECM) described in (1)-(2). For the periods in which we are not able to reject the null-hypothesis of no-cointegration, we estimate the following vector autoregressive (VAR) model on the differentiated series:

$$\Delta CDS_t = \kappa_1 + \sum_{i=1}^{p} \phi_{1i}\, \Delta CDS_{t-i} \sum_{i=1}^{q} \rho_{1i}\, \Delta Bond_{t-i} + \eta_{1t} \quad (3)$$

$$\Delta Bond_t = \kappa_2 + \sum_{i=1}^{p} \phi_{2i}\, \Delta CDS_{t-i} \sum_{i=1}^{q} \rho_{2i}\, \Delta Bond_{t-i} + \eta_{2t} \quad (4)$$

where q is the number of lags included in the model, and ε_{1t} and ε_{2t} are identically and independently distributed error terms such that $\boldsymbol{\eta}_t \equiv [\eta_{1t}\ \eta_{2t}]' \sim N(\mathbf{0}, \mathbf{\Omega})$.

In the third step of our analysis, we proceed to investigate the price discovery mechanism in the two markets. When a cointegration relationship holds, the two speed of adjustment coefficients, α_1 and α_2, contain information on the way in which the spreads in the two markets adjust to shocks that cause a deviation from the long-run equilibrium. In particular, when α_1 is negative and significant, the CDS premium adjusts to deviations that have originated in the bond market; if α_2 is positive and significant, then the bond spreads move on average to incorporate news originating in the CDS market. To assess which market (if any) is dominant in the price discovery process, we adopt the method in Blanco et al. (2005) and Arce et al. (2013) and compute the Gonzalo-Granger's (1995) measures (henceforth, GG):

$$GG_{Bond} = \frac{-\alpha_1}{-\alpha_1+\alpha_2} \qquad\qquad GG_{CDS} = \frac{\alpha_2}{-\alpha_1+\alpha_2} \tag{6}$$

If GG_{CDS} exceeds 0.5, we consider the CDS market as the one that leads price discovery; on the contrary, if GG_{Bond} exceeds 0.5, we shall infer that the bond market is more informative and hence reactive than the CDS market is. If both measures are instead close to 0.5, we shall conclude that both markets equally contribute to the price discovery process.

Finally, when the cointegration relationship does not hold, we follow Blanco et al. (2005) and apply Granger's causality tests. If changes in the CDS market Granger cause changes in the bond market, we determine the CDS market to maintain a leading position in the price discovery process; the opposite conclusion applies when changes in bond spreader Granger cause changes in CDS premia. In case we find bi-directional Granger causality, we conclude that both markets contribute to the price discovery process.

4. Results

4.1 Results from recursive Johansen tests

Figure 2 shows the results of the recursive Johansen tests. As we suspected, there are many countries that fail to show cointegration over a portion of the sample. Interestingly, in contrast with the idea that the ECB policy interventions may have impaired the long-run equilibrium between bond and CDS spreads, we find that a cointegration relationship holds over the entire sample for all peripheral countries, whose bonds were actively purchased by the ECB between May 2010 and September 2012 under the Securities Market Program, with the sole exception of Greece. Moreover, Greek bond and CDS spreads fail to be cointegrated in the period that precedes ECB's activity and not in the one that follows it. Indeed, Figure 2 shows that we are able to reject the null hypothesis of no-cointegration from May 2010, exactly when the SMP purchases begun. Therefore, the ECB interventions seem to have restored the equilibrium between bond and credit default swap markets, instead of destroying it. In addition to Italy, Ireland, Portugal and Spain, also Austria shows a cointegration relationship between CDS and bonds over the full sample period.

On the contrary, there are three countries for which the cointegration relationship between the two spreads ceased to exist at the onset of the European crisis, in the Summer of 2009: Germany, the UK, and the Netherlands. This finding seems to support the idea that the absence of a long-term relationship between the CDS and the bond premia may be related to the existence of a flight-to-quality phenomenon that shifted the trading activity from the "peripheral" bonds to the "core", safer ones, which in turn caused a decoupling between the two spreads, as pointed out, for example, by Fontana and Scheicher (2016). To this end, it is important to consider that, in contrast to what should be normally expected, in the case of Germany (and to some extent, the UK) bond and CDS spreads display a negative correlation, i.e., the bond spread decreases when the CDS premium increases.

Finally, in the case of Belgium, France, and the US, the sample seems to be naturally split into three periods: from January 2006 to March 2009 and then from October 2011 to the end of the sample, bond and CDS spreads are tied by a cointegrating relationship. However, between March 2009 and September 2011, the two markets fail to be cointegrated. In the case of the two European countries, the explanation may be represented by the presence of flight-to-quality dynamics, that however, at least in case of these two countries, seem to have ceased when the ECB started its purchases of peripheral bonds. Instead, the case of the US is rather peculiar: in the case of this sovereign name, the departure from the equilibrium relation seems to correspond with the announcement of the purchase of up to $600 billion of long-term Treasury bond in March 2009.[6] Therefore, we may conjecture that, while the ECB bond purchases have not impaired the long-term equilibrium between the two markets in which sovereign risk is traded, this seems to have been the case in the US.

4.2 Price discovery analysis

In Table 2, we report the estimates of the adjustment coefficients and of the cointegrating vectors for the five countries that have displayed a cointegration relationship over our entire sample, namely Austria, Italy, Spain, Portugal, and Ireland. We also test whether the no-arbitrage restriction holds exactly between each pair of markets; finally, we present the two estimated GG price-discovery measures. For all the countries under investigation, price-discovery seems to be driven by the CDS market. However, from Figure 3 that plots the recursively estimated adjustment coefficients, it is possible to note that in the case of Italy, Spain, and to some extent Ireland and Portugal, α_1 had turned more negative, while at the α_2 had become negative or insignificant (starting from a positive value) during the period 2011-2012 (in correspondence of the second Greek crisis). As we have explained in Section 3, this indicates that the price discovery shifted from the CDS market to the bond one. This result is not entirely surprising because the fact that the bond market tends to lead the price discovery during times of crisis has been reported, for example, by Blanco et al. (2005) and Arce et al. (2013). Interestingly, in the case of Ireland and Spain (and Italy, if we consider a size of the test of 5% or lower), it is not possible to reject the no-arbitrage restrictions: this means that, on average, the bond and the CDS markets tend to price credit risk homogeneously in the case of these two countries.

[6] The Large-Scale Asset Purchases program was launched in November 2008 and originally consisted of the purchase of $600 billion of long-term securities, mainly agency bonds and mortgage-backed securities. In March 2009, the program was extended to the purchase of an additional $600 billion of Treasury bonds.

In Table 3, we report the results of the price discovery analysis for Belgium, France, and the US. In particular, as discussed in Section 3, in correspondence to the periods in which the two markets fail to be cointegrated, we report the estimates of the adjustment coefficients, the cointegrating vectors, and the GG measures, as in Table 2. With reference to the periods in which the two spreads are not cointegrated, we estimate a VAR model and we determine the leading market using a Granger causality test. Interestingly, over the interval March 2009 – September 2011, when bond and CDS spreads were not cointegrated, none of the markets is estimated to lead the price-discovery process (practically, none of the markets causes the other in a Granger sense). This is in line with the idea that during that period the two markets did price credit risk in significantly different ways. Over the remaining two sub-samples, when the two spreads turn out to be bound by a long-run equilibrium, each of the three countries shows a different behavior. In the case of Belgium, the bond market was driving the price discovery before the debt crisis, while from October 2011 and to the end of the sample the CDS market was the leading one. In the case of France, the CDS was always leading the price discovery when the two markets were cointegrated. Finally, in the US, the CDS was leading the price discovery in the period January 2006 – March 2009, while the opposite held between October 2011 and the end of the sample. This latter, interesting result may be a consequence of the prolonged unconventional monetary policy carried out by the US monetary authorities.

Table 4 reports the price discovery analysis applied to Germany, the Netherlands, and the UK and is similar to Table 3 exception for the fact that in the case of these countries, bond and CDS spreads are cointegrated over the period January 2006 – March 2009, while they fail to show a long-run relationship between April 2009 and the end of our sample. Similarly to what we observed for Belgium, France, and the US, also in the case of the UK and Germany, there is no leading market when the two spreads fail to be cointegrated; on the contrary, in the case of the Netherlands, the CDS market always leads ì price discovery. In addition, in the

UK, there is no clearly leading market over the period January 2006 – March 2009, while the CDS market drives the price discovery in Germany during the same period. Finally, Table 5 presents the results that concern Greece, where cointegration is detected between May 2010 and end of the sample, but not over the January 2006 - April 2010 interval.[7] Interestingly, the bond market appears to lead price discovery over the entire sample.

5. Conclusions

In this paper, we have investigated the time-varying nature of the cointegrating relationship and of the price discovery process of credit risk in the CDS and Treasury bond markets for 10 European countries, the UK, and the US. We report at least three interesting empirical findings. First, from a recursive Johansen test, we have been able to conclude that for seven out of the twelve countries under scrutiny, the cointegrating relationship between bond and CDS spreads fail to hold over our full sample period. Interestingly, and in contrast to what may be expected, four of the PIIGS, i.e., all countries but Greece, display a stable, long-run equilibrium relationship between bond and credit default swap markets. On the contrary, in core countries such as Belgium, France, the UK, the Netherlands, and Germany, the cointegration relationship failed to hold after the outburst of the European debt crisis. These results support the idea that the decoupling of the two markets was caused by a flight-to-quality phenomenon (as discussed, for instance, by Fontana and Scheicher, 2016).

Second, we find that when the cointegrating relationship fails to hold, none of the two credit markets is inferred to be leading the price discovery process, with the sole exception of the Netherlands. This confirms that over these periods, the two markets actually priced credit risk in heterogeneous ways. Third, in the case of the US, the two markets decoupled in the period March 2009-December 2011, when the Federal Reserve started to purchase long-term Treasury bonds under its Quantitative Easing programs. Indeed, in this period, not only

[7] We omit to report the estimated coefficients for all the lags of the VAR model to save space, but the results are available upon request from the Authors.

the long-run relationship between CDS and bond spreads failed to hold, but also none of the two markets was leading the price discovery. Therefore, we conjecture that unconventional monetary policy has altered the credit risk price discovery process in the US.

References

Ammer, J., & Cai, F. (2011). Sovereign CDS and bond pricing dynamics in emerging markets: Does the cheapest-to-deliver option matter? *Journal of International Financial Markets, Institutions and Money*, 21, 3, 369-387.

Arce, O., Mayordomo, S., & Peña, J. I. (2013). Credit-risk valuation in the sovereign CDS and bonds markets: Evidence from the euro area crisis. *Journal of International Money and Finance*, 35, 124-145.

Avino, D., Lazar, E., & Varotto, S., 2015. Time varying price discovery. *Economics Letters*, 126, 18-21.

Bariviera, A. F., Guercio, M. B., & Martinez, L. B., 2012. A comparative analysis of the informational efficiency of the fixed income market in seven European countries. *Economics Letters*, 116, 426-428.

Blanco, R., Brennan, S., & Marsh, I. W., 2005. An empirical analysis of the dynamic relation between investment-grade bonds and credit default swaps. *Journal of Finance*, 60, 2255-2281.

Delis, M. D., & Mylonidis, N., 2011. The chicken or the egg? A note on the dynamic interrelation between government bond spreads and credit default swaps. *Finance Research Letters*, 8, 163-170.

Duffie, D. (1999). Credit swap valuation, *Financial Analysts Journal,* 55, 73-85.

Fontana, A., & Scheicher, M., 2016. An analysis of euro area sovereign CDS and their relation with government bonds. *Journal of Banking and Finance*, 62, 126-140.

Forte, S., and Pena, J. I., 2009. Credit spreads: an empirical analysis on the informational content of stocks, bonds, and CDS". *Journal of Banking and Finance*, 33, 2013-2025.

Johansen, S., 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231–254.

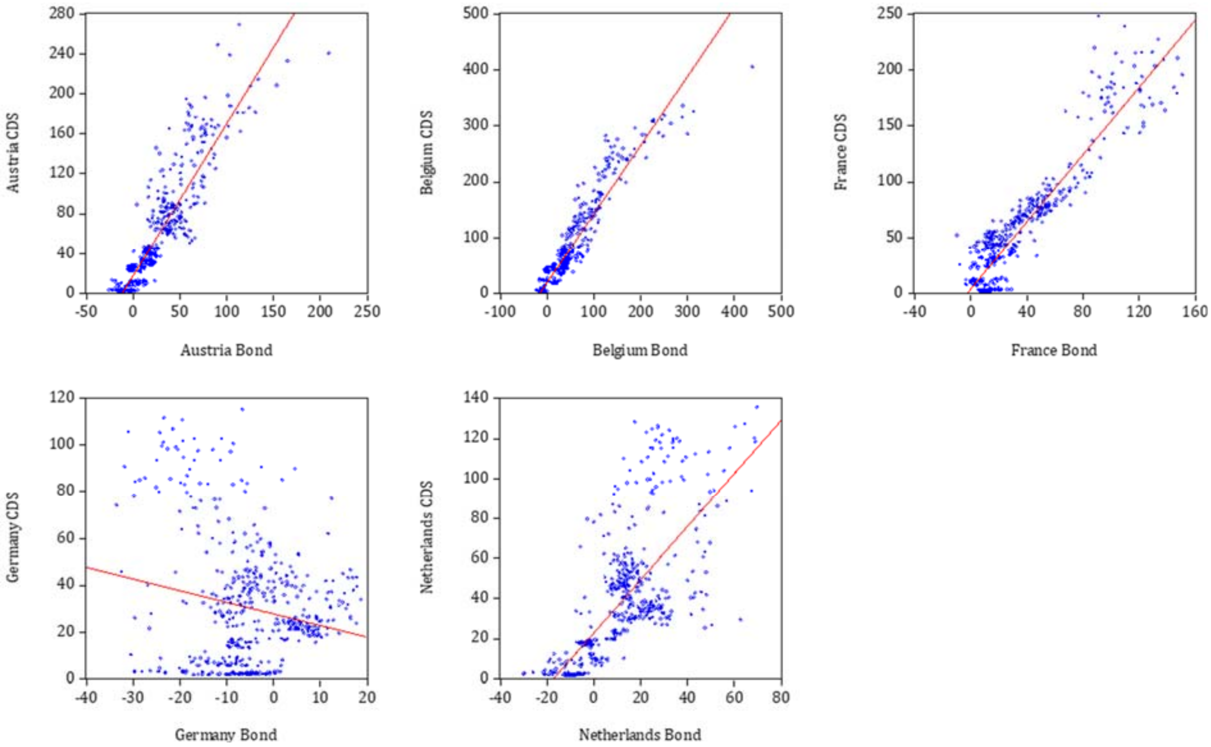
Gonzalo, J., and Granger, C. W. J., 1995. Estimation of common long-memory components in cointegrated systems". *Journal of Business and Economic Statistics*, 13, 27-35.

Palladini, G., & Portes, R., 2011. The information content of Euro-area sovereign CDS spreads. Working Paper, London Business School.

Zhu, H., 2006. "An Empirical Comparison of Credit Spreads Between the Bond Market and the Credit Default Swap Market". *Journal of Financial Services Research*, 29, 211-235.

Figure 1 – Scatter Plot of CDS premia vs. Bond spreads for (a) pheriperal and (b) core European countries.

Panel (a)



Panel (b)

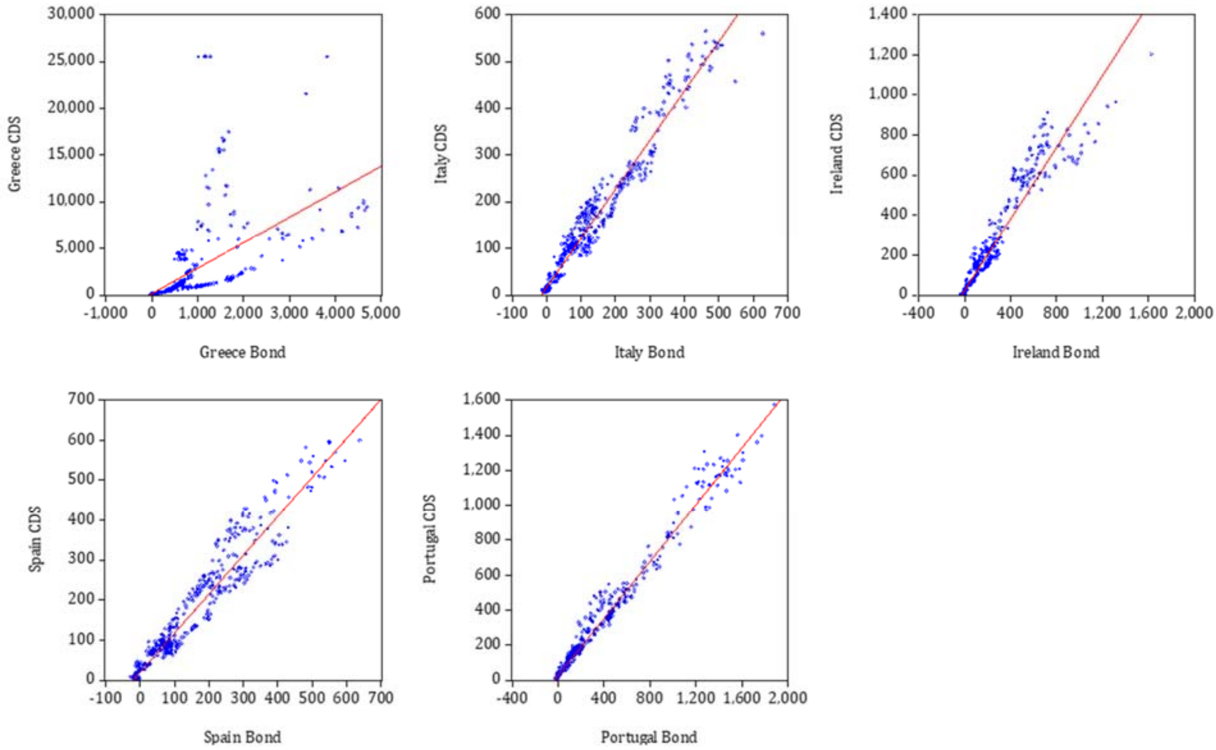
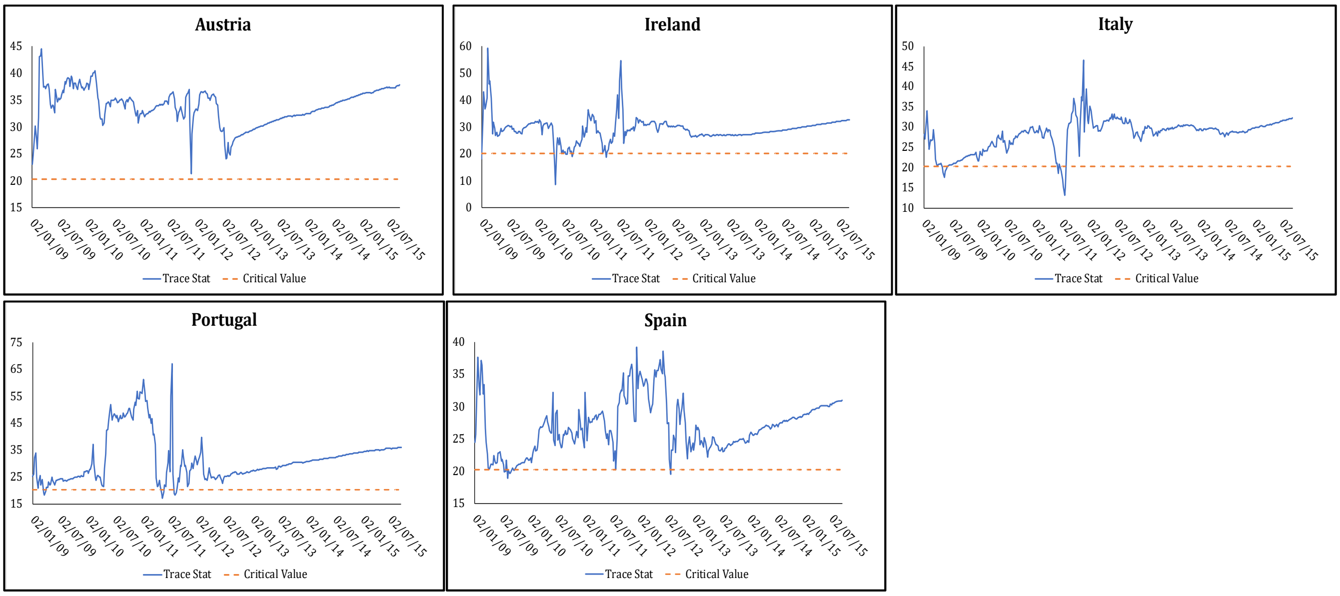
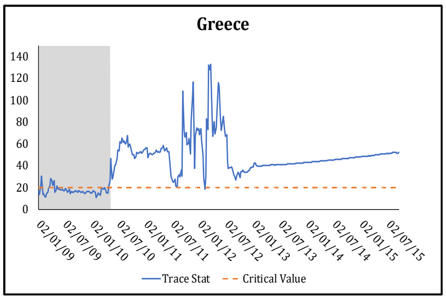


Figure 2 – Plots of Trace Statistics resulting from a Johansen's test for cointegration performed recursively over the sample period January 01, 2006 – September 11, 2015, considering an expanding window with initial sample January 01, 2006 – January 02, 2009.

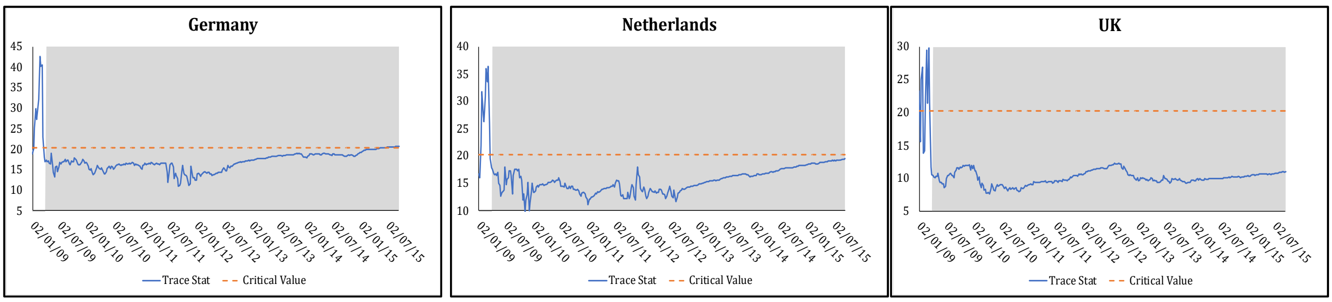
Panel (a)



Panel (b)



Panel (c)



Panel (d)

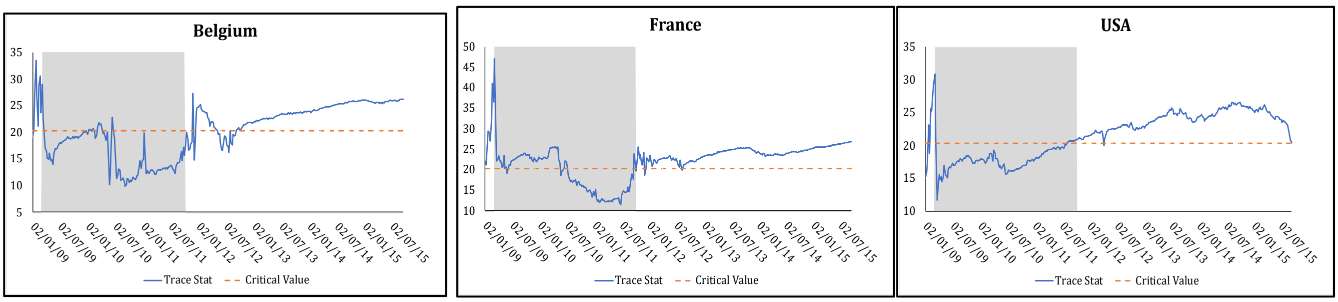
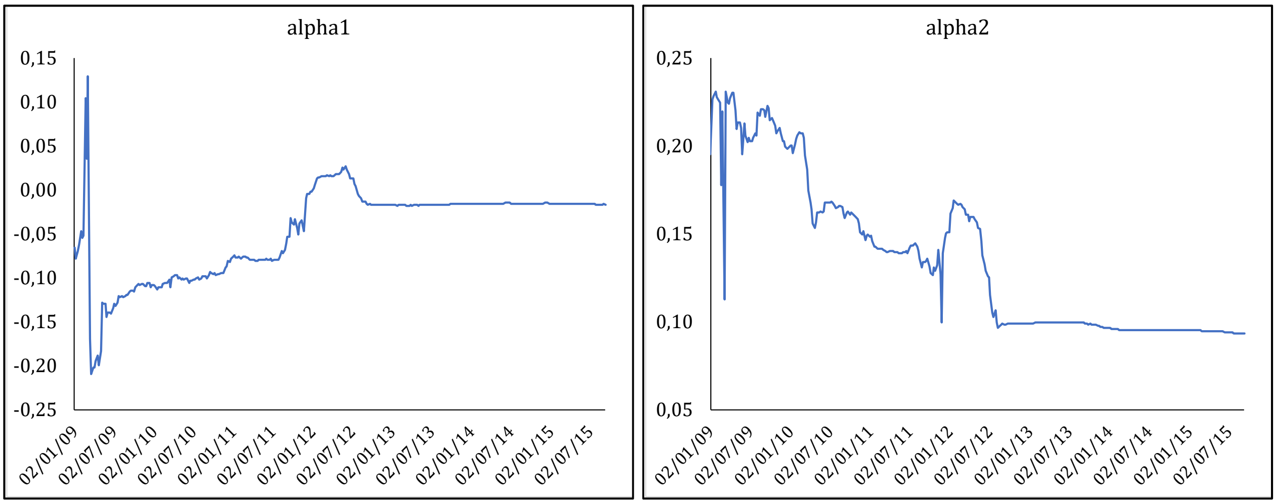
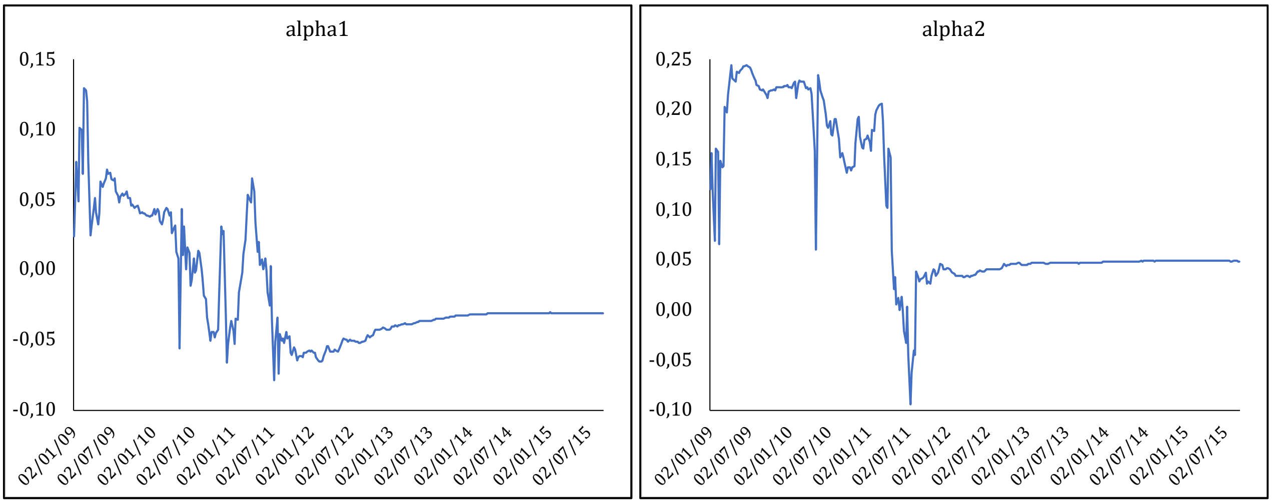


Figure 3 - Plots of Alpha Coefficients resulting from a VECM estimation performed recursively over the sample period January 01, 2006 – September 11, 2015, considering an expanding window with initial sample January 01, 2006 – January 02, 2009.

Austria



Ireland



Italy

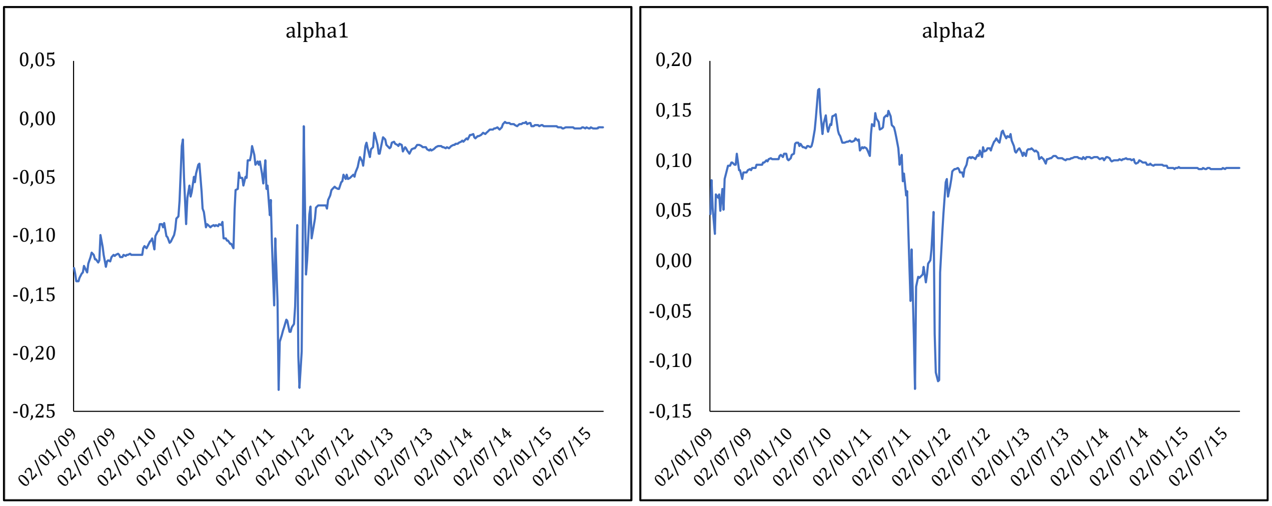
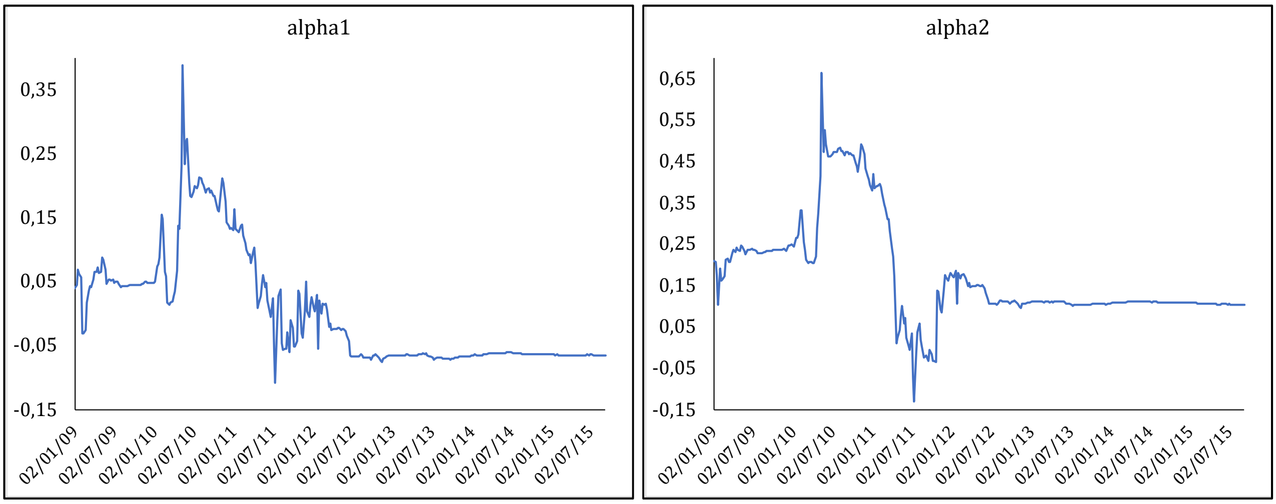
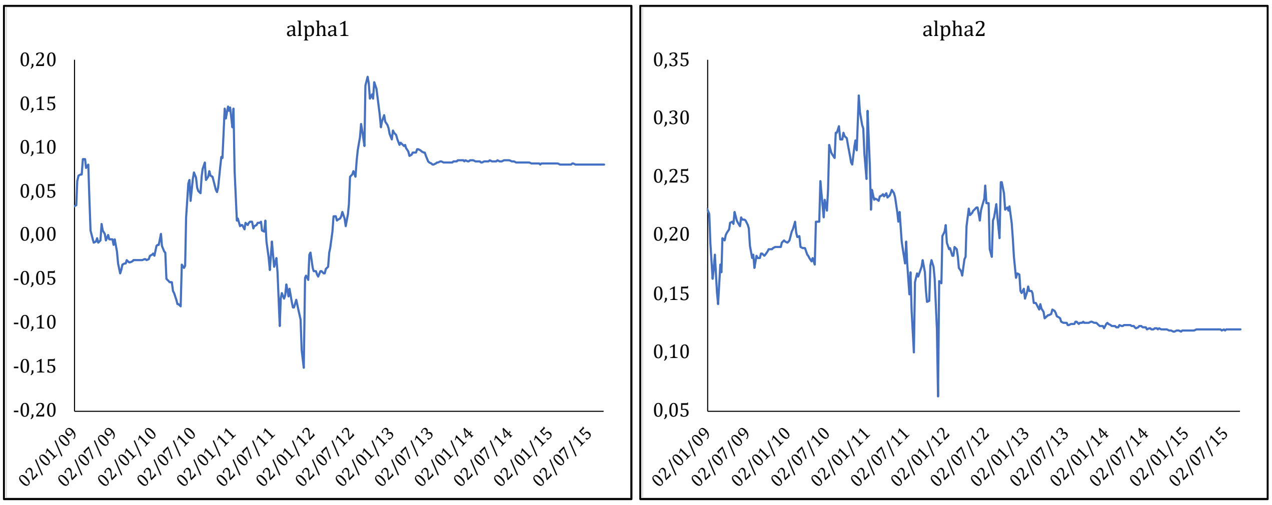


Figure 3 (continued)

Portugal



Spain



Greece

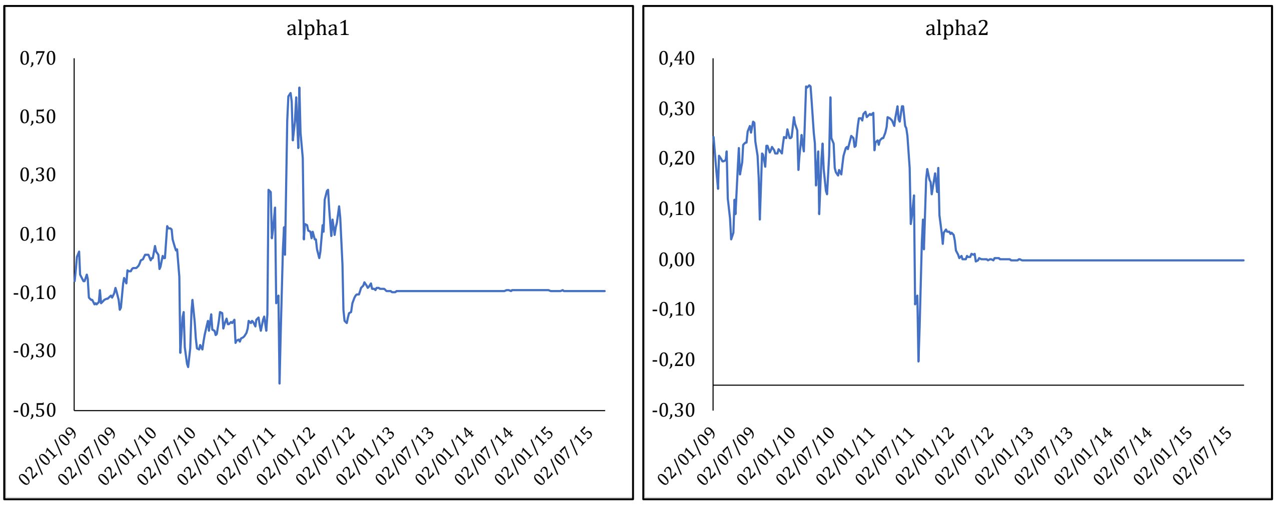


Table 1 - Summary statistics for CDS premia, bond spreads, and basis.

Key summary statistics for five-year Treasury bond spreads (over the Overnight Index Swap), five-year CDS premia, and CDS-bond spread basis over the sample period January 01, 2006 – September 11, 2015 for 12 European and extra-European countries. The statistics are expressed in basis points. We also report the correlation between CDS premia and bond spreads.

		CDS premia		Bond spread		CDS-Bond spread basis		CDS vs. Bond spread
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Correlation
Core	Austria	56.01	54.85	25.10	32.57	30.91	28.88	0.91
	Belgium	77.16	79.18	46.88	60.87	30.27	29.34	0.95
	France	56.82	53.95	21.72	26.05	35.10	33.37	0.88
	Germany	30.20	26.50	-4.96	10.15	35.16	30.13	-0.19
	Netherlands	38.00	32.66	11.34	17.87	26.66	23.21	0.73
Peripheral	Greece	2031.05	4009.41	693.88	897.39	1337.18	3532.33	0.61
	Ireland	207.95	245.57	206.06	264.00	1.90	74.30	0.96
	Italy	152.45	136.34	129.33	126.44	23.12	30.53	0.98
	Portugal	328.13	425.33	294.51	349.04	-33.62	93.88	0.99
	Spain	152.04	143.30	135.30	141.46	16.74	38.79	0.96
Others	UK	40.98	33.35	-39.79	19.44	80.77	38.86	-0.02
	USA	26.50	18.69	-9.90	23.34	36.41	18.95	0.61

Table 2 - VECM Estimates and Contribution to Price Discovery

The table reports estimates of the adjustment coefficients, α_1 and α_2, and of the parameters in the cointegrating vector, β and *c,* of the VECM for the 5 countries for which the Johansen's test points to the presence of cointegration in the entire sample period. The table also reports the Gonzalo-Granger's measure.

		Vector Error Correction Estimates				Restrictions	Price Discovery		
		Adjustment Coefficients		Cointegrating Vector					
	Lags	α_1	α_2	β	c	[1,-1,c]	GG Bond	GG CDS	Leading market
Austria	2	-0.016	0.0933***	-1.774***	-11.56**	20.856	0.15	0.85	CDS
		[-0.81]	[5.19]	[-14.93]	[-2.39]	(0.000)			
Ireland	3	-0.031	0.049*	-0.979***	-6.948	0.170	0.39	0.61	CDS
		[-1.60]	[1.93]	[-21.19]	[-0.45]	(0.680)			
Italy	1	-0.008	0.093***	-1.078***	-12.800	2.982	0.08	0.92	CDS
		[-0.24]	[3.40]	[-25.68]	[-1.69]	(0.084)			
Portugal	1	-0.065	0.104**	-0.822***	-25.536**	21.559	0.38	0.62	CDS
		[-1.56]	[2.05]	[-43.36]	[-2.51]	(0.000)			
Spain	3	0.081***	0.119***	-1.053***	-7.622	0.864	-2.13	3.13	CDS
		[3.49]	[5.10]	[-20.28]	[-0.75]	(0.353)			

Table 3 - VECM and VAR Estimates and Contribution to Price Discovery

The table reports estimates of the adjustment coefficients, α_1 and α_2, and of the parameters in the cointegrating vector, β and *c,* of the VECM for the period for which the Johansen's test points to the presence of cointegration (January 2006 – March 2009), and estimates of the VAR coefficients for the period for which the Johansen's test did not find evidence of cointegration (March 2009 – September 2015). The table also reports the Gonzalo-Granger's measure when the VECM is estimated and the Granger Causality statistics when the VAR model is estimated.

Germany (Lags: 2)

January 2006 - March 2009

Country	Lags	Vector Error Correction Estimates: Adjustment Coefficients α_1	α_2	Cointegrating Vector β	c	Restrictions [1,-1,c]	Price Discovery: GG Bond	GG CDS	Leading market
Germany	2	0.033**	0.083***	-1.678***	-18.523***	1.275	-0.66	1.66	CDS
		[2.26]	[3.61]	[-3.04]	[-2.89]	(0.259)			

March 2009 - September 2015

Vector AutoRegressive Estimates	D(CDS)	D(Bond)	Granger Causality: Ho: Bond does not cause CDS	Ho: CDS does not cause Bond	Leading market
D(CDS(-1))	0.004	0.074	1.164	2.189	None
	[0.08]	[1.48]	(0.559)	(0.335)	
D(Bond(-1))	-0.062	-0.284***			
	[-1.07]	[-5.33]			
D(CDS(-2))	0.022	-0.007			
	[0.41]	[-0.13]			
D(Bond(-2))	-0.024	-0.234***			
	[-0.41]	[-4.41]			

January 2006 - March 2009

Country	Lags	Vector Error Correction Estimates: Adjustment Coefficients α_1	α_2	Cointegrating Vector β	c	Restrictions [1,-1,c]	Price Discovery: GG Bond	GG CDS	Leading market
Netherlands	2	-0.034	0.118***	-1.725***	-19.570***	5.350	0.22	0.78	CDS
		[-0.91]	[2.98]	[-11.24]	[-7.34]	(0.021)			

March 2009 - September 2015

Vector AutoRegressive Estimates	D(CDS)	D(Bond)	Granger Causality: Ho: Bond does not cause CDS	Ho: CDS does not cause Bond	Leading market
D(CDS(-1))	-0.028	0.136**	0.371	5.488	CDS
	[-0.52]	[2.02]	(0.831)	(0.064)	
D(Bond(-1))	-0.014	-0.406***			
	[-0.31]	[-7.48]			
D(CDS(-2))	-0.012	0.087			
	[-0.22]	[1.29]			
D(Bond(-2))	-0.026	-0.150***			
	[-0.60]	[-2.77]			

January 2006 - March 2009

Country	Lags	Vector Error Correction Estimates: Adjustment Coefficients α_1	α_2	Cointegrating Vector β	c	Restrictions [1,-1,c]	Price Discovery: GG Bond	GG CDS	Leading market
UK	1	0.028***	-0.031***	0.989	59.360*	5.385	0.47	0.53	Both
		[3.03]	[-3.21]	[1.57]	[1.70]	(0.020)			

March 2009 - September 2015

Vector AutoRegressive Estimates	D(CDS)	D(Bond)	Granger Causality: Ho: Bond does not cause CDS	Ho: CDS does not cause Bond	Leading market
D(CDS(-1))	-0.044	0.0003	1.553	0.000	None
	[-0.82]	[-0.01]	(0.213)	(0.994)	
D(Bond(-1))	-0.087	-0.080			
	[-1.25]	[-1.46]			

Table 4 - VECM and VAR Estimates and Contribution to Price Discovery

The table reports estimates of the adjustment coefficients, α_1 and α_2, and of the parameters in the cointegrating vector, β and *c*, of the VECM for the periods for which the Johansen's test points to the presence of cointegration (January 2006 – March 2009 and October 2011 – September 2015), and estimates of the VAR coefficients for the period for which the Johansen's test did not point to the presence of cointegration (March 2009 – September 2011). The table also reports the Gonzalo-Granger's measure when the VECM is estimated and the Granger Causality statistics when the VAR model is estimated.

Country	Lags								
		January 2006 - March 2009							
		Vector Error Correction Estimates				**Restrictions**	**Price Discovery**		
Belgium	1	**Adjustment Coefficients** α_1	α_2	**Cointegrating Vector** β	c	**[1,-1,c]**	**GG Bond**	**GG CDS**	**Leading market**
		-0.103***	0.047	-1.250***	-13.637***	3.802	0.69	0.31	Bond
		[-2.99]	[1.03]	[-11.82]	[-4.63]	(0.0512)			
		March 2009 - September 2011							
		Vector AutoRegressive Estimates					**Granger Causality**		
				D(CDS)	**D(Bond)**		**Ho: Bond does not cause CDS**	**Ho: CDS does not cause Bond**	**Leading market**
			D(CDS(-1))	-0.145	-0.074		0.354	0.426	None
				[-1.04]	[-0.65]		(0.552)	(0.514)	
			D(Bond(-1))	-0.102	-0.138				
				[-0.60]	[-0.99]				
		October 2011 - September 2015							
		Vector Error Correction Estimates				**Restrictions**	**Price Discovery**		
		Adjustment Coefficients α_1	α_2	**Cointegrating Vector** β	c	**[1,-1,c]**	**GG Bond**	**GG CDS**	**Leading market**
		-0.016	0.058	-1.233***	-20.103*	2.410	0.22	0.78	CDS
		[-0.53]	[1.49]	[-10.26]	[-1.77]	(0.1206)			
	Lags								
		January 2006 - March 2009							
France	1	**Vector Error Correction Estimates**				**Restrictions**	**Price Discovery**		
		Adjustment Coefficients α_1	α_2	**Cointegrating Vector** β	c	**[1,-1,c]**	**GG Bond**	**GG CDS**	**Leading market**
		-0.009	0.070***	-3.279***	29.974***	8.853	0.11	0.89	CDS
		[-0.84]	[3.65]	[-6.34]	[3.52]	(-0.003)			
		March 2009 - September 2011							
		Vector AutoRegressive Estimates					**Granger Causality**		
				D(CDS)	**D(Bond)**		**Ho: Bond does not cause CDS**	**Ho: CDS does not cause Bond**	**Leading market**
				D(CDS(-1))	-0.052	0.172	0.361	1.096	None
					[-0.32]	[1.05]	(0.548)	(0.295)	
				D(Bond(-1))	-0.091	-0.337**			
					[-0.60]	[-2.16]			
		October 2011 - September 2015							
		Vector Error Correction Estimates				**Restrictions**	**Price Discovery**		
		Adjustment Coefficients α_1	α_2	**Cointegrating Vector** β	c	**[1,-1,c]**	**GG Bond**	**GG CDS**	**Leading market**
		0.023	0.121***	-1.768***	-6.846	26.739	-0.23	1.23	CDS
		[0.76]	[5.23]	[-18.78]	[-1.22]	(0.000)			

Table 4 (continued)

Country	Lags	January 2006 - March 2009							
		Vector Error Correction Estimates				Restrictions	Price Discovery		
		Adjustment Coefficients		Cointegrating Vector		[1,-1,c]	GG Bond	GG CDS	Leading market
		α_1	α_2	β	c				
USA	2	0.031	0.087***	-0.680**	-30.619**	0.960	-0.55	1.55	CDS
		[1.86]	[3.85]	[-2.17]	[-2.34]	(0.327)			

March 2009 - September 2011

Vector AutoRegressive Estimates			Granger Causality		
	D(CDS)	D(Bond)	Ho: Bond does not cause CDS	Ho: CDS does not cause Bond	Leading market
D(CDS(-1))	0.104	-0.079	0.200	2.849	None
	[1.26]	[-1.11]	(0.905)	(0.241)	
D(Bond(-1))	-0.005	-0.500***			
	[-0.06]	[-6.09]			
D(CDS(-2))	0.024	-0.085			
	[0.29]	[-1.20]			
D(Bond(-2))	-0.041	-0.216***			
	[-0.43]	[-2.64]			

October 2011 - September 2015

Vector Error Correction Estimates				Restrictions	Price Discovery		
Adjustment Coefficients		Cointegrating Vector		[1,-1,c]	GG Bond	GG CDS	Leading market
α_1	α_2	β	c				
-0.053***	0.024	-1.623***	-11.428**	1.399	0.69	0.31	Bond
[-2.77]	[1.16]	[-3.76]	[-2.39]	(0.237)			

Table 5 – VECM and VAR Estimates and Contribution to Price Discovery for Greece

The table reports estimates of the VAR coefficients for the period for which the Johansen's test did not point to the presence of cointegration (January 2006 – April 2010) and estimates of the adjustment coefficients, α_1 and α_2, and of the parameters in the cointegrating vector, β and *c,* of the VECM for the period for which the Johansen's test points to the presence of cointegration (May 2010 – September 2015). The table also reports the Gonzalo-Granger's measure when the VECM is estimated and the Granger Causality statistics when the VAR model is estimated.

Country	Lags	January 2006 - April 2010		
		VAR Granger Causality		
		Ho: Bond does not cause CDS	Ho: CDS does not cause Bond	Leading market
Greece	7	24.271	12.608	Bond
		(0.001)	(0.082)	

Country	Lags	May 2010 - September 2015							
		Vector Error Correction Estimates				Restrictions	Price Discovery		
		Adjustment Coefficients		Cointegrating Vector					
		α_1	α_2	β	c	[1,-1,c]	GG Bond	GG CDS	Leading market
Greece	7	-0.091***	-0.001	-5.031***	2272.35**	19.929	1.01	-0.01	Bond
		[-5.34]	[-0.28]	[-6.86]	[2.11]	(0.000)			