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N. Apergis
University of Piraeus, Greece

E. Mamatzakis
University of Piraeus, Greece
The Rimini Centre for Economic Analysis (RCEA), Italy

C. Staikuras
Athens University of Economics and Business, Greece

THE GREEK SOVEREIGN DEBT CRISIS: TESTING FOR REGIME CHANGES

The Rimini Centre for Economic Analysis
Legal address: Via Angherà, 22 – Head office: Via Patara, 3 - 47900 Rimini (RN) – Italy
www.rcfea.org - secretary@rcfea.org

The Greek sovereign debt crisis: testing for regime changes.

N. Apergis[1], E. Mamatzakis[2] and C. Staikuras[3]

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Abstract

This paper examines whether the efficiency market hypothesis for the Greek sovereign debt holds. As in Blanco et al. (2005) we test the theoretical equivalence of credit default swap (CDS) and spreads that dictates a cointegration relationship between the two. The main innovation of the present analysis is the use of a threshold vector error-correction (TVECM) model, thus allowing thresholds within the sample covering the period 1990-2010. Moreover, by employing this methodology we are able to evaluate the degree and dynamics of transaction costs resulting from various events due to external market imperfections but also domestic factors. The main hypothesis we test is to what extent spreads and CDS are indeed integrated that may result in an efficient and integrated segniorage capital market. Our findings support the gradual integration hypothesis. We find that spreads and CDS are cointegrated, though threshold effects are also revealed in terms of events that have impacted on markets.

Keywords: Threshold cointegration, Greek sovereign debt, Spreads over bund, CDS, ML Estimation.

JEL Classifications: G12, G14, G15.

[1] Department of Banking and Financial Management, University of Piraeus, Karaoli and Dimitriou 80, Piraeus 18534, Greece, napergis@unipi.gr.

[2] University of Piraeus, Department of Economics, tzakis@unipi.gr.

[3]Member of Greek Parliament and Department of Accounting and Finance, Athens University of Economics and Business, 76 Patision Street, 104 34, Athens, Greece, cstaik@aueb.gr .

1. Introduction

Recent events of the Greek sovereign debt crisis could very well indeed resemble a novel version of ancient tragedy. For some long time period it has been imminent a sacrifice yet to date there is not a clear indication that what such an act will entail. However, all more often it appears that this tragedy is bound to fulfill its main nature of existence and ending up as a catastrophe. Greek sovereign debt crisis has its origin back in the late seventies yet it was in December 2009 it burst, leading the spreads over bund and Credit Default Swaps (CDS) to unprecedented levels. For some time in early 2010 it appeared that the Greek tragedy would spread out to other Member States of the Euro-area, such as Ireland, Portugal, and Spain, alas it was not too late before it became clear that the markets perceive the Greek case as class on its own with no other members.

The event that triggered the recent Greek sovereign crisis can be traced back in the second half of 2007, when the sub-prime crisis sent big waves of distress across the financial markets. But the second half of 2007 was still early days as the interest rate on the 10-year maturity Irish sovereign bond was lower than the rate of German sovereign bond. However, soon in 2008 the Irish rates started rising whereas the German rates remained low. The spreads between Greek and German rates also rose rapidly during the same period, and in fact the Greek spreads lead a race to the top that led to spreads of above 1000 basis points by summer 2010. Effectively, although only in 2007 would have been unheard of to claim that a Member State of the euro-group could default[4], the stratospheric recent Greek spreads show the magnitude of the crisis and the market's perception that Greece faces a very high risk of default.

[4] The introduction of the euro in 2001 has brought convergence in the spreads of sovereign debts across Member States, insinuating a process of economic and financial integration. Alas, by the end of this decade all have changed and expectations about the future appear gloomy. External shocks, in light of

In the credit risk models literature (see Duffle and Singleton, 1999, and Hull and White, 2000) is argued that there could be an arbitrage type of relationship between CDS and credit spreads for a given level of maturity. Duffle (1999) argues that this type of arbitrage would imply that the CDS prices and the credit spreads share a cointegration relationship. A cointegration relationship between the CDS and EU corporate spreads is also reported in Norden and Weber (2004), Zhu (2006) and De Wit (2006). Along these lines, Blanco et al. (2005) show that there is long run relationship between corporate bonds and CDS markets in the US. Moreover, Blanco et al. (2005) argue that there is an equivalence of CDS and spreads that dictates a cointegration relationship between the two for corporate bonds in US.[5]

The goal of this article is to build on this literature and examine whether there is a cointegration relationship between CDS and spreads of Greek sovereign bonds. In addition, we go a step further and opt for the threshold cointegration analysis of Hansen and Seo (2002). This methodology allows for regime shifts over the sample period and by doing so it will give us an opportunity to show whether the arbitrage relationship expected by the literature is subject to thresholds effects. The regime shift could occur in the intercept, trend or the entire cointegration vector. The main

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the subprime crisis, play an important role in the widening of sovereign spreads in the euro-zone. However, what the Greek sovereign debt crisis reveals is that there are deep rooted domestic factors that affect spreads. As a result, even if global financial constraints may easy, some Greek spreads would not drop.

[5] One could consider that CDS is an insurance that the holder of e.g. Greek sovereign debt, buys against the event of default. To define a default event is not an easy task. There are various events that could be thought as default such as; bankruptcy, failure to pay, obligation default or acceleration, repudiation or moratorium (for sovereign entities), restructuring. The last one, restructuring, has steered some heated debates in the CDS market. According to the International Swaps and Derivatives Association (ISDA) restructuring is a default event in case that the interest rate or the principal paid at maturity are lowered or delayed.

hypothesis we test is to what extent spreads and CDS are indeed integrated that may result in an efficient and integrated segniorage capital market. The Threshold Vector Error Correction Model (TVECM) has the advantage of allowing thresholds within the sample covering the period 1990-2010. Moreover, by employing this methodology we are able to evaluate the degree and dynamics of transaction costs resulting from various events due to external market imperfections and domestic factors as well.

Our findings support the gradual integration hypothesis. Moreover, we find that spreads over bund and CDS are cointegrated whilst two regimes are identified. This implies that a significant threshold exists. Thus, adjustment costs in the error correction are present and they are valid at the typical regime one that is the dominant, and as a result should not be ignored.

The rest of this article is structured as follows: Section 2 presents a brief literature review of existing studies that have applied cointegration tests. Section 3 present some stylized facts of the Greek sovereign debt crisis, while Section 4 outlines the methodology employed. Section 5 discusses the data, including dates of potential structural breaks. Section 6 presents the results and finally Section 7 discusses the implications of the results.

2. Existing studies on credit risk

The corner stone of credit risk can be traced back to the seminal work of Black and Schols (1974) and the structural model of Merton (1974) where the default takes place in terms of the value of the firm exciding a certain low threshold. More recently, Das (1995) and Pierides (1997) employ similar structural models so as to examine the underlying pricing of credit derivatives. Another channel of credit risk can be found on reduced form models such as Jarrow and Turnbull (1995), Duffle and Singleton (1999), and Hull and White (2000).[6]

An interesting presumption of the reduced form credit risk models (see Duffle, 1999, and Hull and White, 2000) is that there could be an arbitrage type of relationship between CDS and credit spreads for a given level of maturity. Based on Duffle (1999), this type of arbitrage would imply that the CDS price and the credit spread share a cointegration relationship. Moreover, a cointegration relationship between the CDS and EU corporate spreads is also reported in Norden and Weber (2004), Zhu (2006) and De Wit (2006). A word of caution is warranted as arbitrage relationships do not always hold. Duffie and Singleton (1999), Hull and White (2000) show that this arbitrage relationship holds for corporate bonds trading close to par, though interest rates should not be high whereas yield curves should also be relatively flat, whereas Levin et al. (2005) emphasise the importance of market frictions.

In a recent paper, Blanco et al. (2005) show that there is long run relationship between corporate bonds and CDS markets in the US. The authors further argue that due the liquidity of the CDS markets, especially in periods of credit constraints, the price discovery process should happen in the CDS markets. In addition, corporate bond prices are affected by interest rate risk and taxation issues that could blur an accurate measure of credit risk.

[6] For a detailed review of the literature see Schonbucher (2000).

3. Stylized facts of the Greek sovereign debt crisis

Over the past year, euro area sovereign yields have exhibited an unprecedented degree of volatility. In March 2009 the spread between the yield on a 10-year Greek government bond and the yield on a German Bund of equivalent maturity was as high as 280 basis points (bp). By September 2009 the same spread had dropped below 120 bp. In January 2010, it had climbed back up to over 380 bp. Alas, things got worst over recent months, in April 2010 the spread reach 670 bp only to climb even higher to the level of 1287 bp in May 2010, the month that Emergency Financing Mechanism (EFM) and the memorandum of understanding regarding policy conditionality, a joint initiative of the IMF, the EU Commission and the ECB were signed. In July 2010 it registered some decline to 770 bp, only to start rising again to above 820 bp. in August 2010. Likewise, the CDS, the premium investors are willing to pay to insure the same Greek bond against a credit event, follows similar trajectory as the spread. Note that, although spreads of other Euro-area Member States also exhibit a positive slope, no other sovereign bond spread has followed a similar trajectory as the Greek spread.

Moreover, four distinct phases can be identified. Between July 2007 and September 2008 marked the phase of financial crisis build-up, spreads remained within a relatively narrow, albeit widening, range. Between October 2008 and March 2009, there was a systemic outbreak due to the collapse of Lehman Brothers, sovereign spreads started diverging markedly. With the exception of German Bunds, Euro-area government bond yields moved sharply above the swap yield, as problems in the banking sector spilled over to sovereign balance sheets. Between April and September 2009, characterized the systemic response phase, spreads converged, although at wider levels. As financial spillovers were contained and systemic risk subsided, all bond yields fell back closer to the level of the swap yield, particularly those which had gone up considerably in the earlier phase. Finally, since October 2009, rising idiosyncratic sovereign risk led to greater differentiation among countries, with the yields on specific government bonds climbing to record highs. Then, in December 2009, the Greek sovereign debt crisis burst leading spreads and CDS to unprecedented levels. And while in the beginning it appeared as if the Greek tragedy would expand to other Member States of the Euro-area, it soon became clear that the markets perceive the Greek case as class on its own with no other members. The Greek sovereign debt crisis eventually led to financial assistance programme to Greece, a joint initiative of EU Commission, ECB and the IMF (for a detailed chronology of events please see Box 1).

Box1. The Sovereign Debt Crisis in Greece: Chronology of Events.

23 December 2009: Parliament adopts the 2010 budget setting a general government deficit target of 9.1 percent of GDP.
15 January 2010: Government submits the updated stability programme (SP), projecting a reduction of the government deficit of 4 percentage points to 8.7 percent of GDP in 2010, and correction of the excessive deficit by 2012. The debt ratio was projected to peak at 121 percent of GDP in 2011.
1 February 2010: 2-year bond spreads reach 347 basis points; 10-years bond spreads reach 270 basis points.
3 February 2010: The Commission adopts (i) a proposal for a Council Decision, in view of the excessive deficit correction in Greece by 2012, (ii) a draft Council Recommendation with a view to ending the inconsistency with the broad guidelines of the economic policies, and (iii) a draft Council Opinion on the SP.
2 February 2010: Greece announces a set of measures in addition to those announced in the SP (freezing wages and raising excises with the aim of reducing the government deficit).
16 February 2010: Council adopts the above-mentioned documents, after discussion in the Eurogroup.
8 April 2010: 2-year bond spreads reach 652 basis points; 10-years bond spreads reach 430 basis points.
15 April 2010: Greece requests 'discussions with the European Commission, the ECB and the IMF on a multi-year programme of economic policies (…) that could be supported with financial assistance, if the Greek authorities were to decide to request such assistance.'
23 April 2010: Greece requests financial assistance from the euro-area Member States and the IMF.

27 April 2010: 2-year bond spreads reach 1552 basis points; 10-years bond spreads reach 755 basis points.
2 May 2010: Greece, the Commission, the ECB and IMF announce an agreement on a three-year programme of economic and financial policies. The Eurogroup unanimously agrees to activate stability support to Greece via bilateral loans centrally pooled by the European Commission
6 May 2010: The Greek Parliament votes to accept a series of policy measures included in the programme of economic and financial policies, including an increase in VAT and excises, as well as further reductions in public sector wages and pensions.
6 May 2010: ECB adopts temporary measures relating to the eligibility of marketable debt instruments issued or guaranteed by the Greek Government.
7 May 2010: 2-year bond spreads reach 1739 basis points; 10-years bond spreads reach 1287 basis points.
7 May 2010: The Council adopts a Decision according to Articles 126(9) and 136 of the Treaty including the main conditions to be respected by Greece in the context of the financial assistance programme.
9 May 2010: IMF executive board approves the Stand-by arrangement (SBA).
9 and 10 May 2010: The Council and the EU Member States endorse a financial stabilisation mechanism.
18 May 2010: The euro-area Member States disburse the first instalment (EUR 14.5 billion) of a pooled loan to Greece.

Source: EU Commission.

3. The Threshold Vector Error Correction Model

Hansen and Seo (2002) examine a two-regime vector error-correction model with a single cointegrating vector and a threshold effect in the error-correction term. Let $x_t = (P_{ft}, P_{st})$ be a 2-dimensional vector of I(1) time series of spread over bund and CDS respectively with *t* observations. It is assumed that there exists a long-run relationship between these two time series with a cointegrating vector $\beta = (\beta_0, \beta_1)'$.

The two regime threshold model where the γ is the threshold parameter takes the following form,

$$\Delta x_t = \begin{cases} \begin{pmatrix} A_1^{'} X_{t-1}(\beta) + u_t, z_{t-1}(\beta) \leq \gamma \\ A_2^{'} X_{t-1}(\beta) + u_t, z_{t-1}(\beta) \geq \gamma \end{pmatrix} \end{cases}$$

where $X_{t-1}(\beta)=\begin{pmatrix}1\\ z_{t-1}(\beta)\\ \Delta x_{t-1}\\ \Delta x_{t-2}\\ .\\ .\\ .\\ \Delta x_{t-l}\end{pmatrix}$

$z_t(\beta)$ denote the I(0) error-correction term, the γ is the threshold parameter, $X_{t-1}(\beta)$ is *kx1* regressor and *A* is *kx2* where $k=2l+2$.[7]

This may alternatively be written as

$$\Delta x_t = A_1^{'} X_{t-1}(\beta) d_{1t}(\beta,\gamma) + A_2^{'} X_{t-1}(\beta) d_{2t}(\beta,\gamma) + u_t$$

where

$$d_{1t}(\beta,\gamma) = 1(z_{t-1}(\beta) \leq \gamma)$$

$$d_{2t}(\beta,\gamma) = 1(z_{t-1}(\beta) \geq \gamma)$$

and 1( ) denotes the indicator function and z_{t-1} is the error correction term spreads and CDS.

There are two regimes defined by the error correction terms value. As described in Hansen and Seo (2002), the parameters A_1 and A_2 are coefficient matrices and require the dynamics in these regimes. If $0 \langle P(w_{t-1}(\beta) \leq \gamma) \langle 1$, this signifies the threshold effect; otherwise, the model characterizes linear cointegration.

They also form the following constraint:

[7] Note that as in Hansen and Seo (2002), the error u_t is assumed to be a vector martingale sequence (MDS) with finite covariance matrix $\Sigma = E(u_t u_t^{'})$. $X_{t-1}(\beta)$ and $z_{t-1}(\beta)$ note variables at generic values of β, whilst z_{t-1} and X_{t-1} note variables evaluated at the true value of the cointegrating vector.

$$\pi_0 \leq P(z_{t-1}(\beta) \leq \gamma) \leq 1 - \pi_0$$

where the trimming parameter is $\pi_0 > 0$.

The algorithm for the TVECM estimation involves procedure in three steps. The first step consists of testing for stationarity and cointegration using ADF and Johnansen (1991) tests, respectively. In the second step, the series that are integrated of order one are used in a standard linear error-correction model. In the final step, the TVECM is estimated for the cointegrated series using the maximum likelihood procedure described Hansen and Seo (2002). For this purpose, the threshold parameter γ is determined using the following selection criterion:

$$\xi(\hat{\gamma}) = \min \quad \log \left(\left| \frac{1}{n} \sum_{t=1}^{n} \hat{\varepsilon}_t(\gamma) \hat{\varepsilon}_t(\gamma)' \right| \right)$$

Once the value of γ that minimises the above is chosen, an additional restriction that each regime should contain at least a prespecified fraction of the total sample (π_0) is imposed on this grid search procedure:

$$\pi_0 \leq P(|z_{t-1}| \leq \gamma) \leq 1 - \pi_0$$

The statistical significance of the threshold parameter γ (the nuisance parameter) contains elements of non-standard inference. Therefore, the p-values are calculated using SupLM test and the bootstrapping techniques proposed by Hansen and Seo (2002).

Moreover, Hansen and Seo (2002) proposed two heteroskedastic-consistent LM test statistics to test whether there is linear cointegration under the null against the alternative threshold cointegration. If there is no threshold under the null, the model reduces to a conventional linear VECM. The first test statistic would be used when the true cointegrating vector is known a priori, and is denoted as:

$$SupLM^0 = \underset{\gamma_L \le \gamma \le \gamma_U}{Sup} \; LM(\beta_0 \gamma),$$

where β_0 is the known value at fixed β (thereafter, set β_0 at unity), while the second case can be used when the true co-integrating vector is unknown, and the test statistic is given by:

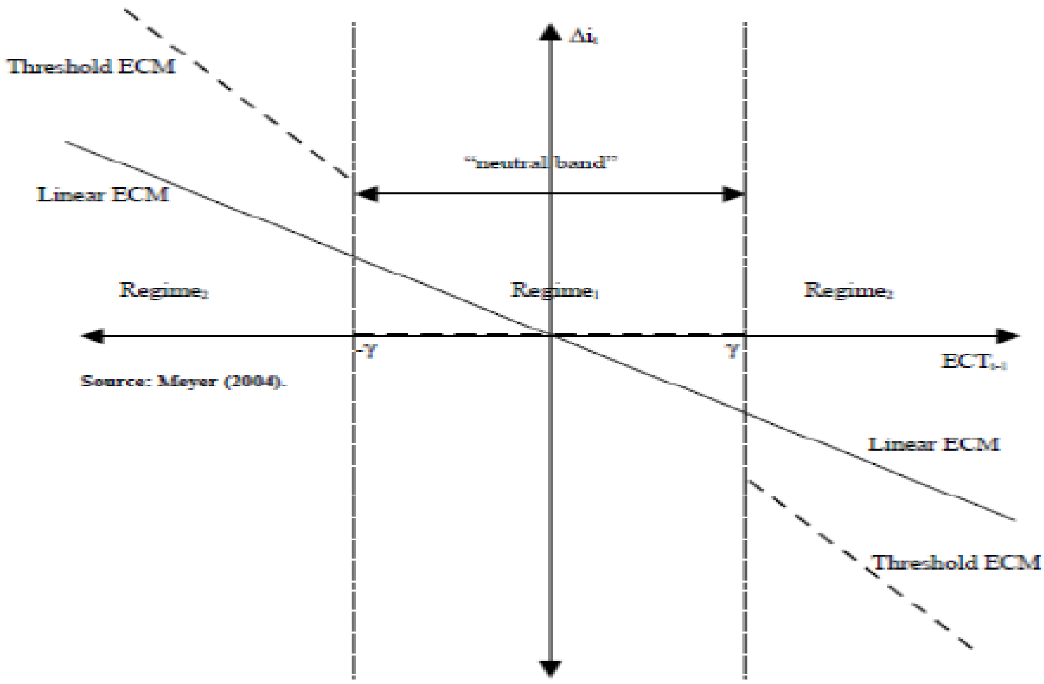
$$SupLM = \underset{\gamma_L \le \gamma \le \gamma_U}{Sup} \; LM(\tilde{\beta} \gamma),$$

where $\tilde{\beta}$ is the null estimate of β .

In both tests, $[\gamma_L, \gamma_U]$ is the search region so that γ_L is the π_0 percentile of $\tilde{w}_{t-1}$, and γ_0 is the $(1-\pi_0)$ percentile.

In terms of diagrammatic analysis Diagram 1 as in Meyer (2004) depicts the two regimes as identified by $[\gamma_L, \gamma_U]$ thresholds. Moreover, Figure 1 shows the discontinuous adjustment within a TVECM. Horizontal axis plots deviations from the long-run equilibrium between spread over bund and CDS, which is the error-correction term (ECT). The vertical axis plots spread – CDS adjustment. The linear error correction model predicts that the size of this adjustment would be a linear function of the error-correction term (continuous adjustment). Unlike the linear model, the threshold error-correction model predicts that the linear adjustment takes place only in the second regime, in which the deviation from the long-run equilibrium exceeds the threshold in absolute terms. If the deviations from the long run equilibrium are relatively low (the first regime), then the difference between spread and CDS do not adjust, implying persistent disequilibrium. The larger is the size of the threshold, the greater is the extent to which the persistent disequilibrium can exist, implying lower degree of integration in the market. As a result, one would interpret the size of the threshold parameter as a measure of integration in the Greek public deb market.

Figure 1. The Threshold VECM.



Source: Meyer (2004).

The TVECM has been applied to various financial and commodity prices but not to spread and CDS. Clements and Beatriz Galvao (2003) find strong evidence of non-linearities in the response of US interest rates to the spread (i.e. the difference between long and short rates). Meyer (2004) applies a TVECM to pig prices in Germany and the Netherlands. He finds evidence of non-linearities. Ben Kaabia, et al. (2005) apply a TVECM to the Spanish poultry sector, and Ben Kaabia and Gil (2007) apply a similar model to the Spanish lamb sector. Chung, et al. (2005) apply the version of Hansen and Seo (2002) to American Depository Receipts (ADRs) with symmetric regimes. They reject the null of no thresholds. Finally, Wu and Chen (2006) apply a symmetric TVECM model to quotations on the FW20 and the underlying WIG20 index on the Warsaw Stock Exchange. They find evidence of threshold non-linearities.

4. Data and empirical results

We use data a set that comprises spreads over bund of five-years maturity and CDS of the same maturity. The principal source is Bloomberg, covering the period from 31st March 2003 to 29th October 2010. The frequency of the data is monthly.

Note, that the estimation of TVECM depends crucially on the assumption that the underlying data generating process of our variables is I(1) (Im et al., 2003). We would expect that our variables are not stationary, given that there is an underlying premium in futures. To this end, unit roots tests were carried out, providing evidence of non stationarity. Table 1 reports DF-GLS, KPSS, Phillips-Perron, and Ng-Perron stationarity tests for spreads over bund and swaps and CDS. All stationarity tests report evidence that our time series are I(1).

Table 1: Unit Root Tests for Spread over Bund-Swaps and CDS

Spread over bund				
	In levels		In first differences	
	Statistic	Prob.	Statistic	Prob.
DF – GLS	-1.38		-8.56	
KPSS	1.97		0.048	
Phillips-Perron	-1.60	0.58	-10.33	0.0000
Ng-Perron	-1.56		-7.78	
Spread over Swaps				
	In levels		In first differences	
DF – GLS	-1.42		-7.96	
KPSS	1.71		0.032	
Phillips-Perron	-1.59	0.38	-9.78	0.0000
Ng-Perron	-1.36		-7.63	
CDS				
	In levels		In first difference	
	Statistic	Prob.	Statistic	Prob.
DF – GLS	-1.20		-10.0	
KPSS	1.49		0.011	
Phillips-Perron	-1.53	0.54	-10.07	0.00
Ng-Perron	-1.33			-7.06

Notes. DF – GLS is based on Elliott-Rothenberg-Stock statistic. Critical values for DG-GLS test are -2.56 and -1.94 at 1% and 5% significance level, respectively. Critical values for KPSS test are 0.73 and 0.46 at 1% and 5% significance level, respectively, whilst for Ng-Perros test are -2.58 and -1.98 at 1% and 5% significance level, respectively.

Given the above evidence, our series are being first-difference stationary. Next, we test for the presence of threshold effects and a two-regime cointegration vector.

4.1 The TVECM findings

Following Hansen and Seo (2002), we use maximum likelihood estimation (MLE) of the following threshold model:

$$\begin{pmatrix} \Delta CDS_t \\ \Delta Spread_t \end{pmatrix} = \mu_1 - \beta_1 z_{t-1} - \Gamma_1 \begin{pmatrix} \Delta CDS_t \\ \Delta Spread_t \end{pmatrix} + u_{1t}, v_{t-1} \leq \gamma$$

$$\begin{pmatrix} \Delta CDS_t \\ \Delta Spread_t \end{pmatrix} = \mu_2 - \beta_2 z_{t-1} - \Gamma_2 \begin{pmatrix} \Delta CDS_t \\ \Delta Spread_t \end{pmatrix} + u_{2t}, v_{t-1} \rangle \gamma$$

In terms of our empirical findings we have two sets of results: for the spread over bund and for the spread over swaps.[8]

$$\Delta CDS_t = \begin{cases} -0.01 + 0.01z_{t-1} - 0.08\Delta CDS_{t-1} + 0.81\Delta Spread_{t-1} + u_{1t} \\ (0.006) \quad (0.005) \qquad (0.01) \qquad (0.02) \end{cases}, z_{t-1} \leq 0.89$$

$$\Delta CDS_t = \begin{cases} 0.02 + 0.03z_{t-1} + 0.04\Delta CDS_{t-1} + 0.01\Delta Spread_{t-1} + u_{1t} \\ (0.01) \quad (0.01) \qquad (0.03) \qquad (0.04) \end{cases}, z_{t-1} \rangle 0.89$$

$$\Delta Spread_t = \begin{cases} -0.04 + 0.07z_{t-1} - 0.05 Spread_{t-1} - 0.05\Delta CDS_{t-1} + u_{1t} \\ (0.04) \quad (0.07) \qquad (0.04) \qquad (0.04) \end{cases}, z_{t-1} \leq 0.73$$

$$\Delta Spread_t = \begin{cases} -0.04 + 0.07z_{t-1} - 0.05\Delta Spread_{t-1} - 0.07\Delta CDS_{t-1} + u_{1t} \\ (0.04) \quad (0.07) \qquad (0.04) \qquad (0.06) \end{cases}, z_{t-1} \rangle 0.73$$

The estimated threshold value is $\gamma = 0.89$. Next we test the significance of the threshold coefficient. The LM test gave a value of 49.65 with 5% critical value of 26.37 (0.01), whilst the 5% bootstrap critical value is 28.77 (p-values=0.02). These results show that the threshold effect is significant and a simple cointegration analysis would have not had revealed these types of effects.

The first regime takes place when $CDS_t \leq 0.99 Spread_t + 0.89$, that is the spread over bund is more than 0.89 percentage points above the CDS. This is something that one would expect as the spread is mostly above the CDS. This point is verified by the present findings as 73.9 percent of the observations fall within the first regime. So, this is the *'typical'* regime case. Consequently, the first regime obtained from the analysis is the dominant as it contains 73.9 percent of the whole period. Thus, based

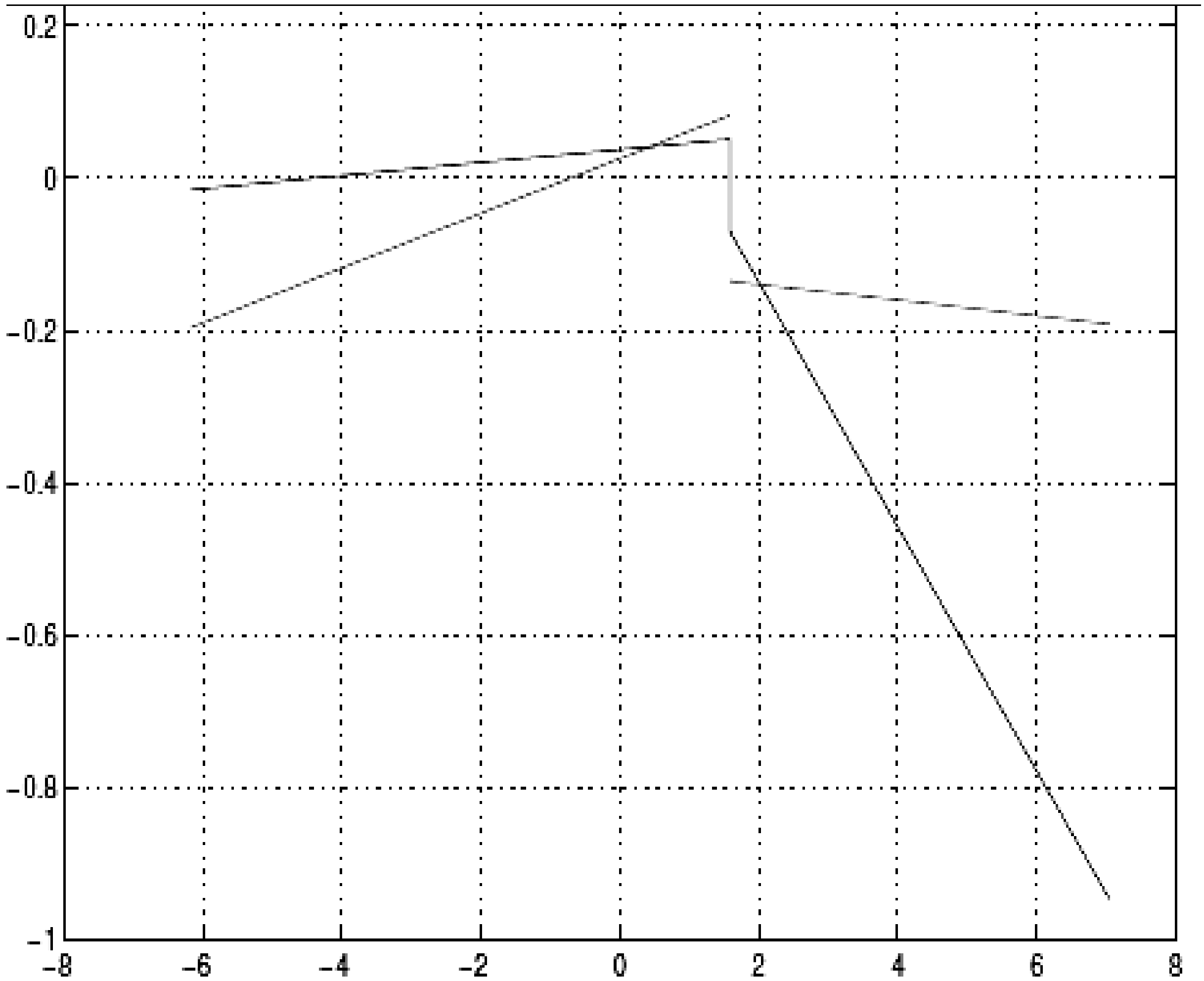
[8] The Eicker-White standard errors are given in parentheses for the estimated TVAR model. The number of bootstrap replications are set to 100, while the number of Gridpoints for the CI vector to 300.

on this evidence, the second regime ($CDS_t \rangle 0.99\, Spread_t + 0.89$) is what we call the *'extreme'* regime, containing 26 percent of the observations. Note that the *'extreme'* regime covers a substantial portion of the sample and as such it should not be ignored.

Note that in the case of the *'typical'* regime, there exist significant error-correction effects and dynamics both for ΔCDS_t and $\Delta Spread_t$ equations. On the other hand, for the *'extreme'* regime, the error-correction effects are not significant, whilst also dynamics both for ΔCDS_t and $\Delta Spread_t$ equations are less profound. These findings, in turn, imply that that ΔCDS_t and $\Delta Spread_t$ are close to white noise in the second regime, insinuating that CDS_t and Spread_t are close to driftless random walks. Note that under the *'typical'* regime, where the spread over bund is much above CDS, error correction in terms of magnitude can not be ignored.

Figure 2 provides diagrammatic evidence of the discontinuous and asymmetric adjustment within the TVECM of the spreads. Horizontal axis plots deviations from the long-run equilibrium, which is the error-correction term (ECT). The vertical axis plots spread - CDS adjustment. The linear ECM predicts that the size of this adjustment would be a linear function of the error-correction term in the case of continuous adjustment. Unlike the linear model, the TVECM predicts that the linear adjustment takes place in the second regime, in which the deviation from the long-run equilibrium exceeds the threshold in absolute terms. If the deviations from the long-run equilibrium are relatively low (the first regime), then the difference between spread and CDS do not adjust, implying persistent disequilibrium. To this end, the larger is the size of the threshold, the greater is the extent to which the persistent disequilibrium can exist, implying higher adjustment costs and a lower degree of integration in the market. As a result one would interpret the size of the threshold parameter as a measure of integration in the market.

Figure 2. Spreads over Bund (dash line) and CDS Responses to Error Correction Term.



Source: Own estimations.

Moreover, Figure 2 depicts the error correction effect that is the estimated regression functions of spread, *ΔR(2)*, and CDS, *ΔR(1)*, as a function of the error correction term, z_{t-1}. Figure 2 shows that there is a positive effect of the error correction term on the left hand side of the threshold on the CDS, while for the spread is stable. However, interestingly, on the right hand side, there is clear evidence of asymmetry and break as the effect of the error correction term is positive (negative) for the spread.

For the case of the spread over bund with CDS with two, lags results come as follows:

$$\Delta CDS_t = \begin{cases} 0.008 + 0.03\mathrm{z}_{\mathrm{t-1}} - 0.27\Delta\mathrm{CDS}_{\mathrm{t-1}} + 0.25\Delta\mathrm{Spread}_{\mathrm{t-1}} + u_{1t} \\ (0.01) \quad (0.01) \qquad (0.07) \qquad\qquad (0.06) \end{cases}, z_{t-1} \leq 1.59$$

$$\Delta CDS_t = \begin{cases} 0.03 \quad + 0.02\mathrm{z}_{\mathrm{t-1}} - 0.02\Delta\mathrm{CDS}_{\mathrm{t-1}} + 0.06\Delta\mathrm{Spread}_{\mathrm{t-1}} + u_{1t} \\ (0.01) \quad (0.01) \qquad (0.074) \qquad\qquad (0.06) \end{cases}, z_{t-1} \rangle 1.59$$

$$\Delta Spread_t = \begin{cases} -0.16 + 0.18\mathrm{z}_{\mathrm{t-1}} - 0.19\mathrm{Spread}_{\mathrm{t-1}} + 0.1\Delta\mathrm{CDS}_{\mathrm{t-1}} + u_{1t} \\ (0.13) \quad (0.28) \qquad (0.16) \qquad\qquad (0.17) \end{cases}, z_{t-1} \leq 1.59$$

$$\Delta Spread_t = \begin{cases} -0.01 \quad -0.11\mathrm{z}_{\mathrm{t-1}} + 0.24\Delta\mathrm{Spread}_{\mathrm{t-1}} - 0.33\Delta\mathrm{CDS}_{\mathrm{t-1}} + u_{1t} \\ (0.14) \quad (0.31) \qquad (0.15) \qquad\qquad (0.16) \end{cases}, z_{t-1} \rangle 1.59$$

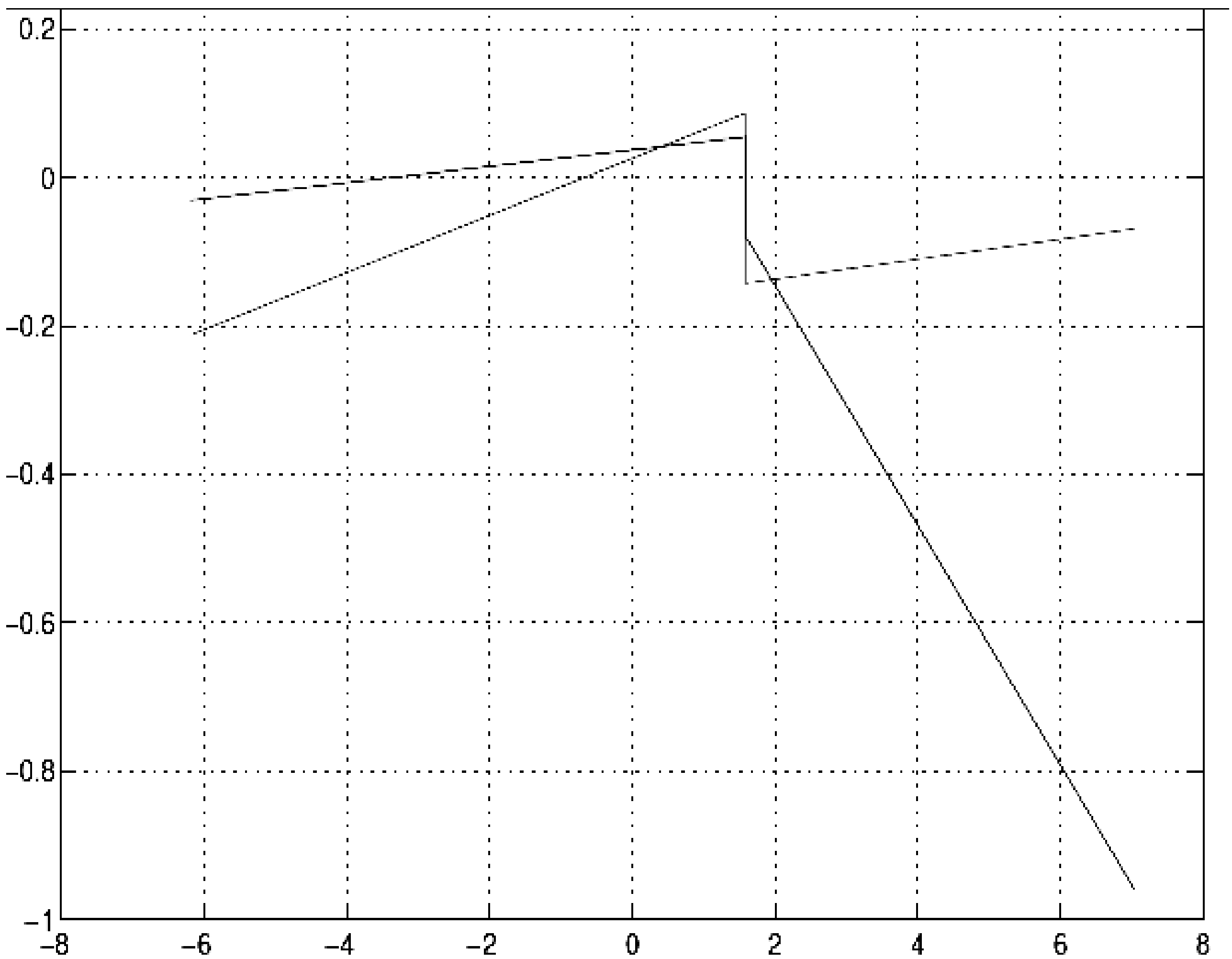
Note: The Eicker-White standard errors are given in parentheses for the estimated Threshold VAR model. The number of bootstrap replications are set to 100, while the number of Gridpoints for CI vector to 300.

The estimated threshold value is quite large, γ= 1.59. This implies that the adjustment costs are much higher in the case of two lags. The test for the significance of the threshold coefficient LM gave a value of 39.14 with 5% critical value of 27.59, whilst the 5% bootstrap critical value is 29.22 (p-value=0.00).

Moreover, the first regime takes place when $CDS_t \leq Spread_t + 1.59$, that is the spreads over swaps is more than 1.59 percentage points above the CDS. This is the *'typical'* regime confirmed by the data as 89 percent of the observations fall within this first regime. The second regime captures 10.8 percent of the whole period, still substantial to be ignored. Based on this evidence the second regime ($CDS_t \rangle Spread_t + 1.59$) is the *'extreme'* regime. Note that in the case of the '*typical*' regime there are significant error-correction effects and dynamics both for ΔCDS_t and $\Delta Spread_t$.

Figure 3 bellow depicts the error correction effect that is the estimated regression functions of spreads over swaps, *ΔR(3)*, and CDS, *ΔR(1)*, as a function of the error correction term, z_{t-1}. The Figure shows that there is a positive effect of the error correction term on the left had side of the threshold, whilst the effect becomes negative on the right hand side, in particular for the case of spreads over swaps.

Figure 3. Spreads over Swaps (dash line) and CDS Responses to Error Correction Term (With 2-Lags).



Source: Own estimations.

Once again, the results show that persistent disequilibrium should raise serious concerns. Moreover, regime 1 describes the situation when spreads over swaps are priced much above CDS. One would expect that CDS should be more variable than spreads over swaps in the short-run as temporary factors may temporally increase demand (Fama and French, 1988). Despite CDS and spreads over swaps might significantly diverge in the short-run, spreads over swaps should converge to CDS as both are driven by the same fundamentals. The present results verify this as CDS and spreads over swaps are threshold cointegrated.

In addition, our analysis, by estimating the threshold parameter, suggests that the underlying adjustment costs related to deviations between CDS and spreads over swaps is not negligible as it depends on the size of gamma, γ. Many factors can contribute to the adjustment costs that in turn lead to deviations, i.e. thin trading, lags in information transmission. These factors are, though, reported to impact mostly in the short-run.

5. Conclusions and Policy Implications

Over the past year, euro area sovereign yields have exhibited an unprecedented degree of volatility. In March 2009 the spread between the yield on a 10-year Greek government bond and the yield on a German Bund of equivalent maturity was as high as 280 basis points (bp). By September 2009 the same spread had dropped below 120 bp. In January 2010, it had climbed back up to over 380 bp. Alas, in April 2010 the spread reach 670 bp only to climb even higher to the level of 1287 bp in May 2010, the month that Emergency Financing Mechanism and the memorandum of understanding regarding policy conditionality, a joint initiative of the IMF, the EU Commission and the ECB were signed.

The goal of this paper was to examine whether there is a cointegration relationship between CDS and spreads of Greek sovereign bonds. We employed the threshold cointegration analysis of Hansen and Seo (2002). This methodology allows for regime shifts over the sample period and by doing so it would give us an opportunity to show whether the arbitrage relationship expected by the literature is subject to thresholds effects. The regime shift could occur in the intercept, trend or the entire cointegration vector. The main hypothesis we tested was to what extent spreads and CDS were indeed integrated that may result in an efficient and integrated segniorage capital market. The TVECM model has the advantage of allowing thresholds within the sample covering the period 2003-2010.

Our findings support the gradual integration hypothesis. Moreover, we found that spreads over swaps and CDS were cointegrated and two regimes were identified. This implies that a threshold exists and it is indeed significant. Thus, adjustment costs in the error correction are present, and they are valid at the typical regime one that is the dominant, and as a result should not be ignored.

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