Revealing animal spirits of the Euro Area Debt Crisis?

A. Koutsomanoli-Filippaki, E. Mamatzakis[1] and E. Tsionas

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This paper examines the underlying market's preferences for euro area debt crisis. It builds on the *'basis'*, the difference between the spread over swap and Credit Default Swap (CDS) for sovereign bonds. The sample covers those euro area Member States most at risk of default, namely Greece, Portugal, Ireland, Spain and Italy. A generalised flexible, lin-lin and quad-quad, loss function is employed to reveal market's preferences for the first time. Having uncovered market's preferences the paper examines whether they have shifted over time and, in particular, post the initial Greek bail out in May 2010, but also the Private Sector Involvement (PSI) in 2012. Market's appraisal of euro area debt crisis post Greek bail out points to the direction of serious misalignment in sovereign yields fuelled by growing pessimism and thus uncertainty. The paper also explores the impact of specific market characteristics and fiscal rules on preferences. Fiscal rules appear to improve market's perception over fiscal sustainability, whilst the 3M Euribor and the outstanding debt to GDP also shape market's preferences.

Keywords: euro area debt crisis, spreads, CDS, loss function, rationality.

JEL Classifications: E43, E44, G00, G01, G10.

1 E.Mamatzakis, Business, Management and Economics School, University of Sussex, Jubilee Building, Falmer, Brighton BN1 9SL.
e.mamatzakis@sussex.ac.uk.

1. Introduction

Unraveling Ariadne's thread of the euro area debt crisis is by no means an easy task. Undoubtedly though, one cannot fail to notice that the euro area sovereign debt crisis has open Pandora's box with far reaching implications. The debt crisis in the last two years has been escalated with some euro area Member States being under enormous pressure to finance their debt, whilst others experiencing unprecedented low financial cost to serve their debt. Rather than attempting to disentangle the causes of this crisis, that has been the norm in the literature to date, we opt to focus on revealing the underlying market's preferences based on the notion of arbitrage opportunities. To this end, our attention is directed towards the echo that comes out of sovereign debt market in light of the on going fiscal sustainability crisis. To capture this echo, we employ a novel approach that builds on a loss function with reference to the *'basis'*, the difference between the sovereign spread over swaps and sovereign Credit Default Swaps (CDS). Moreover, this paper assesses whether the market behaves rationally as it would do if there exist a symmetric underlying loss function or all interest parties share the same loss function.[1]

The assumption that market's participants should have a symmetric loss function and thus behave rational so as to exclude the possibility of market failure is of key importance. Most previous studies (Crowder and Hamed, 1993; Moosa and Al-Loughani, 1994; and Peroni and McNown, 1998, and Kellard et al. 1999) argue that this assumption is plausible. In absence of market imperfections one would expect that CDS spreads and sovereign bond spreads of the same maturity should be bounded by no-arbitrage conditions (Blanco et al. 2005). This in turn, implies that the buyer of the sovereign bond could also buy protection for this bond in the CDS market so as to hedge against the default. No-arbitrage would imply that the price of the CDS approximates the sovereign bond yield spread. In some respect the research by Blanco et al. (2005) is central for the current paper, as the main focus is the *'basis'*, the difference between the CDS and spread. The authors show that there is a long run

[1]Elliott et al. (2005) argue that rationality in sovereign bonds would imply that the underlying loss function, whether linear or non-linear, is symmetric. Asymmetry in the loss function would be compatible with rationality if all share the same loss function or information regarding the asymmetry is revealed and thus taken into account. Please note that the classical notion of rational expectations is build around a quadratic and symmetric loss function.

linear relationship between US corporate bond and CDS (see also similar findings for EU markets Norden and Weber, 2004; Zhu, 2006; and De Wit, 2006). However, the existence of this long-run relationship may not imply that short run arbitrage opportunities do not exist. Levin et al. (2005) show that market frictions generate non-zero *'basis'* between CDS and bond spread. Systematic and idiosyncratic factors can explain market frictions (De Wit, 2006, Levin et al., 2005). In a recent paper Favero et al (2010) argue that yields differentials in the euro area increase with liquidity and risk. Setting aside those systematic and idiosyncratic factors, the documented short run frictions would imply arbitrage opportunities as reflected in the *'basis'*.

Departing from what is norm in the literature in this paper we build on the perception of market frictions and the resulted arbitrage opportunities that could emerge, but instead of focusing on deviations from equilibrium, our main aim is to reveal market preferences using high frequency data. Moreover, for the first time we fit a loss function of a generalised loss functional form proposed by Elliot et al. (2005). The shape parameter of this loss function is a-priori unknown and could reveal information regarding market's preferences. One of the advantages of this methodology is that it is not necessary to observe the underling model of forming sovereign bond spreads and CDS in order to test for asymmetries in preferences.

The data set used in this paper comes from Bloomberg and Datastream and covers 5 years maturity for daily and weekly sovereign spreads over swap and CDS. We focus on those countries in the euro area at higher risk of default compared to the core of the euro-area, namely: Greece, Ireland, Portugal, Spain and Italy. The shape parameter of the underlying loss function would identify whether there is asymmetry in preferences. Deviations from symmetry would indicate specific preferences towards optimism or pessimism, useful information for those member states with difficulties to finance their long-term obligations. Our empirical evidence is robust across information sets and shows that overall loss preferences lean towards pessimism, notably for Greece. This could be interpreted that for certain Member States sovereign bond market is not *'quite'* rational in terms of its underlying loss preferences as the present empirical evidence reveals that asymmetry towards pessimistic preferences prevail over time. However, if all interest parties share the same underlying loss function or information about market's preferences becomes common knowledge then rationality could be restored. This paper assists towards that direction as it reveals for the first time market's preferences over euro area debt crisis.

In addition, as part of sensitivity analysis, we explore a novel methodology proposed by Giacomini and Rossi (2009) to assess whether there exist structural breakdowns in sovereign bonds market's preferences over time. Such breakdowns could be caused by unexpected events, but also institutional interventions aiming at alleviating sovereign debt crisis in euro area. Such interventions could alter market's preferences and thus the shape of the loss function. This would essentially mean that the underlying loss function might not remain stable over time. Based on those breakdowns tests, we estimate the shape parameter of the loss function for the sub-periods identified so as to investigate whether those breaks in time have an impact on market's behavior. For example, post May 2010, the month the Emerging Financing Mechanism (EFM thereafter) and the memorandum of understanding with strong policy conditionality was signed by Greek Republic, arbitrage opportunities appear to be reinforced and markets clearly lean towards pessimism regarding the prospects of euro area sovereign debt crisis.

Having derived market's preferences over time, we subsequently study the impact of fiscal policy institutions and fiscal rules on those preferences in recent years. Over the last decade the number of fiscal rules in the euro area has substantially increased (Public Finances in EMU, 2006 and 2007). The empirical evidence shows that there is a link between fiscal rules and market's expectations. Fiscal rules appear to improve market's perceptions over the long-term sustainability of public finances. In terms of fiscal institutions, providing an independent assessment of compliance with existing national fiscal rules also improves market's preferences. The results demonstrate that enhancing fiscal governance plays an important role in shaping market behaviour towards optimism, as it is perceived to contain debt crisis. In addition, market specific characteristics such as 3M Euribor, the spread between Euribor and Eurepo of the same duration, and iTraxx Main Investment Grade index also play a detrimental role in shaping market preferences.

This paper contributes to the literature in several aspects. First, we fit a loss function in sovereign bonds of those euro area member states most at risk of default for the first time in the literature. Second, we estimate the shape parameter of the underlying generalized flexible loss function. Third, given the shape of the loss function we test for structural breakdowns over time. Fourth, we re-examine asymmetries in the shape of loss function for periods identified by breakdowns tests. Fifth, we explore the impact of specific market characteristics on shape parameter of the underlying loss function. Lastly, we also assess the impact of fiscal rules and fiscal institutions on underlying market's preferences over sovereign bonds.

The remainder of the paper is organized as follows. The second section presents some recent stylized facts about the euro area sovereign debt crisis. Section three provides the methodology of the loss function. Sections four and five report the data and discuss empirical results respectively. The last section offers some concluding remarks.

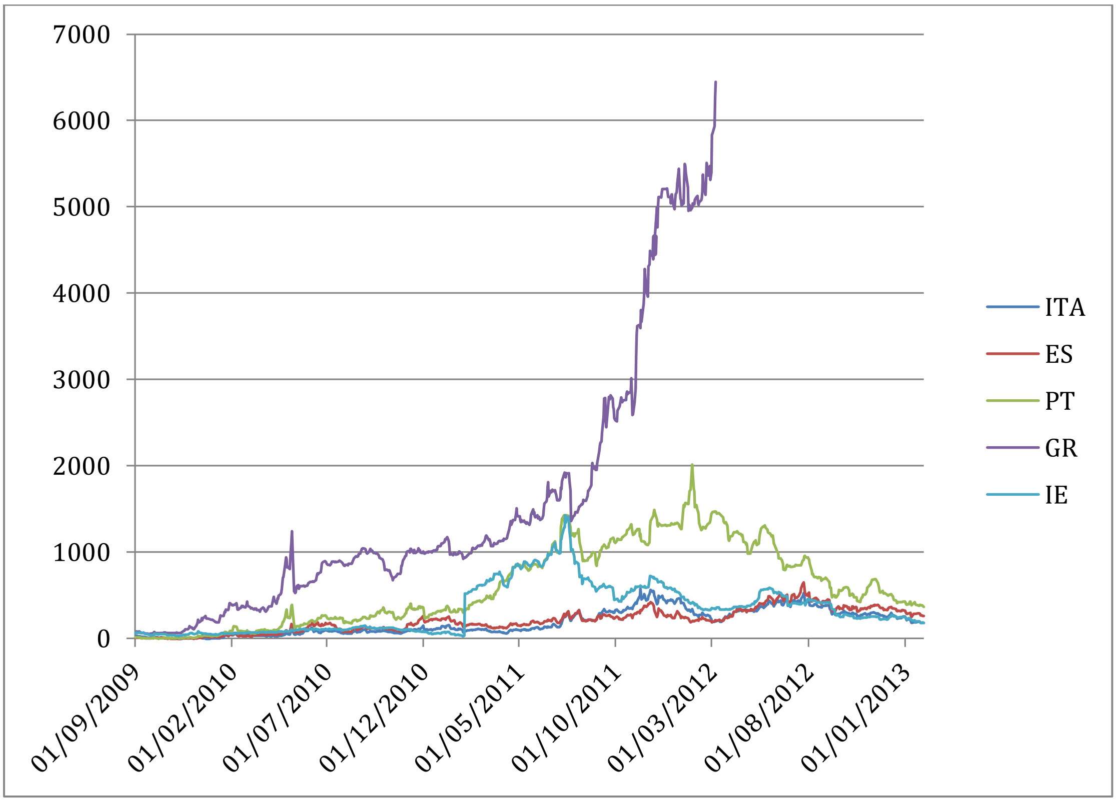
2. Stylized facts of the euro area sovereign debt crisis

Back in spring 2007 there was hardly any evidence of the storm in sovereign bonds that was about to break. At the time, sovereign bonds across euro area Member States appeared to be on track for convergence in terms of yields. Moreover, the yield on the 10-year German sovereign bond was even somewhat lower than the Irish equivalent in July 2007. Alas, a dramatically different picture surfaced not long thereafter. As investors fled to safety German bonds started to appeal to them whilst euro area Member States of south periphery and Ireland, for whom the subprime crisis was detrimental in exposing perilous state of their fiscal balances, faced the harsh reality of rising borrowing costs. By December 2009 it became clear that the Greek economy faced with the blink reality of not being able to finance its sovereign debt from markets. The Greek sovereign bonds spread over five years maturity was 215 basis points above the swap rate at the end of December 2009. The equivalent spread for Ireland was about 45 basis points, whilst it was 28 basis points for Portugal. Those spreads have continued to rise ever since, and reached their pick in March 2011 at the height of the euro crisis when the Greek spread jumped to above 1100 basis points, the Irish and Portuguese spreads reached 772 basis points and 636 basis points respectively. There have been some fluctuations thereafter, but overall the sovereign spreads of southern euro area and Ireland have remained at high levels. These dramatic developments have led to the euro area debt crisis and have raised questions regarding even the viability of the euro.

In some detail, there exist some distinct episodes in the euro area sovereign debt crisis. In the beginning, as early as mid 2007, the subprime crisis did not bite into euro sovereign spreads, giving false impressions to national governments at the time that they had weathered out the crisis. The collapse of Lehman Brothers and the resulted credit crunch triggered the widening of spreads for fiscally exposed economies within the euro area, in particular towards the end of 2009. During this period sovereign spreads for some southern euro area member states and Ireland showed blunt divergence from triple 'A_s' economies such as Germany. Then, in spring 2010, the Greek sovereign debt crisis burst and led spreads and CDS to record high levels. Hikes in Greek sovereign yields and CDS affected the rest of fiscally vulnerable southern euro area countries and Ireland. The underlying causes are not common to all. The debt crisis for Greece has been mainly driven by chronic fiscal imbalances, whilst for Portugal, Ireland and Spain non-performing loans of private banks have been the main concern.

Diagram 1 presents the euro area spreads over time for southern periphery and Ireland. In May 2010 when Greece applied for financial assistance to the euro area and the IMF, the spread of a 5-year Greek sovereign bond reached values higher than 1100 basis points. The Greek memorandum of understanding contained strong policy conditionality of Emergency Financing Mechanism (EFM thereafter), a joint initiative of the IMF, the EU Commission and the ECB, and it was signed in May 2010. Following the EFM, the Greek spread fell to around 607 basis points in end May 2010. Alas, markets have been suspicious all along on whether the EFM is the answer to the debt crisis and could act as a therapy to the sovereign credit crisis and thereby sovereign spreads started to rise once more in summer of 2010. In 2011 the Greek spread reached levels beyond 5500 basis point whilst it went beyond this threshold in first quarter of 2012 prior to the Private Sector Involvement, that is the haircut of private holders of Greek bonds. Essentially the PSI was a default for the Greek sovereign and as a result since March 2012 there is no more record of Greek 5-year sovereign bonds. The spreads for the remaining countries of the euro-area periphery also hiked around the same period, but there signs of a reversal in the trend since spring 2012.

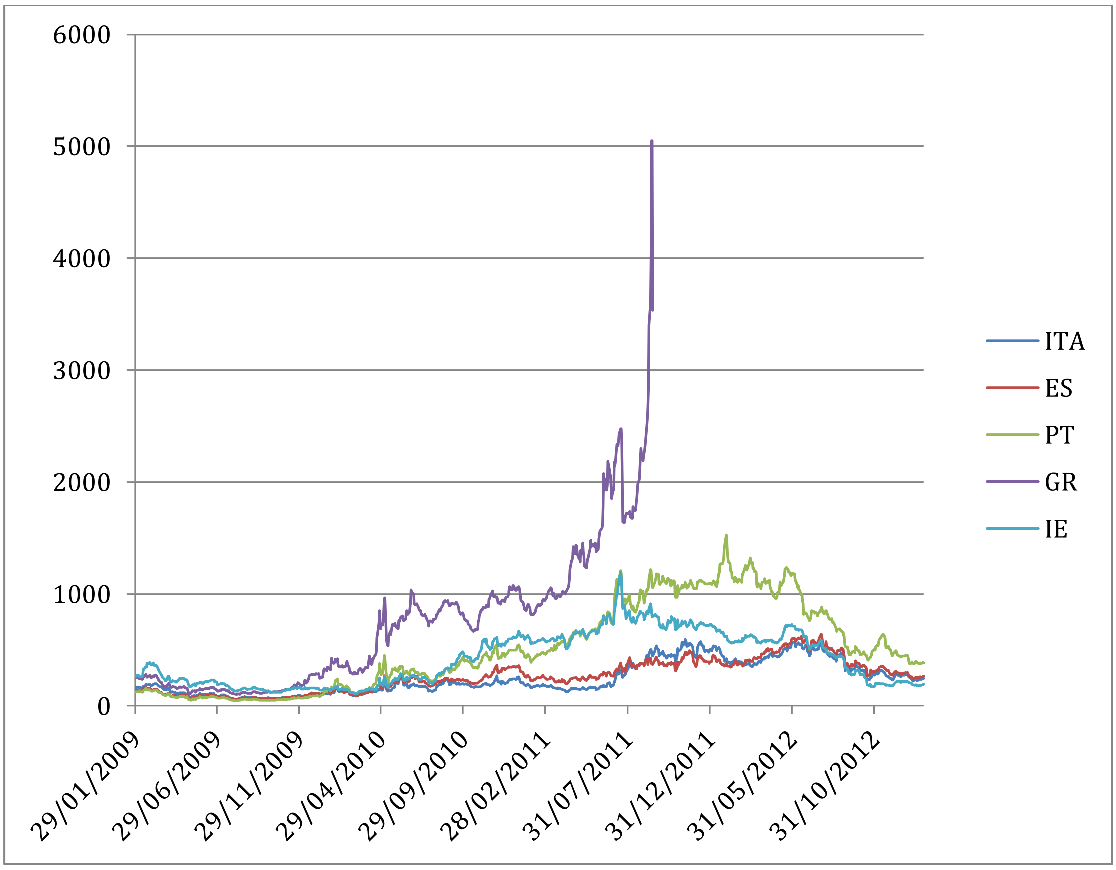
Diagram 1: Spreads over Swaps, 5 years maturity, weekly.



Source: Bloomberg.

In parallel with sovereign spreads that provide guidance over the credit risk, CDS could act as a forward-looking signal of credit risk. CDS reflect the premium investors are willing to pay to insure against a credit event. Diagram 2 presents recent developments in euro area CDS and shows that there have been hikes similar in pattern with the ones of spreads. It is factual to observe that prior to the Greek debt tragedy, sovereign CDS for euro area have not been so interesting to examine, as there was hardly any sign of a strong market. Once the Greek sovereign default in May 2010 became a real threat, sovereign CDS market for euro area sparked into life. Duffie (2010) argues that hikes in CDS could show remarkably obstinacy in the aftermath of credit crunch. He suggests that there are several reasons behind these hikes, such as: severe depletion of capital, large distortions in arbitrage, funding risk and market liquidity risk, whilst counterparty risk and default risk could also play a role but not as significant. Fontana and Scheicher (2010) argue that short-term expectations regarding sovereign yields in the light of imminent increases in sovereign bond issuance, together with market's expectations regarding the probability of default, could contribute to high CDS. What the literature fail to account is that the *'basis'* could echo some market's concerns, preferences over the unfolding euro area debt crisis.

Diagram 2: Credit Default Swaps, 5 years maturity, weekly.



Source: Bloomberg.

Undoubtedly, the dramatic developments of euro area sovereign debt crisis warrant a study of underlying market's preferences that, in turn, could shed new light. However, most studies examine the role of fiscal imbalances (Sgherri and Zoli, 2009, Mody, 2009, Haugh et al., 2009), of market liquidity or market integration (Manganelli and Wolswijk, 2009), of migration risk (rating downgrades), and to less extend the risk of outright default (Fontana and Scheicher, 2010). Fontana and Scheicher (2010) were the first to study the movement of euro area sovereign spreads and CDS using various covariates. The authors build on the earlier study of Blanco et al. (2005) where a long run linear relationship between US corporate bond and CDS is found, whilst Levin et al. (2005) show that market frictions generate non-zero CDS-bond spread *'basis'*. In addition, Favero et al (2010) demonstrate that liquidity and risk affect government bonds yields in the euro area.

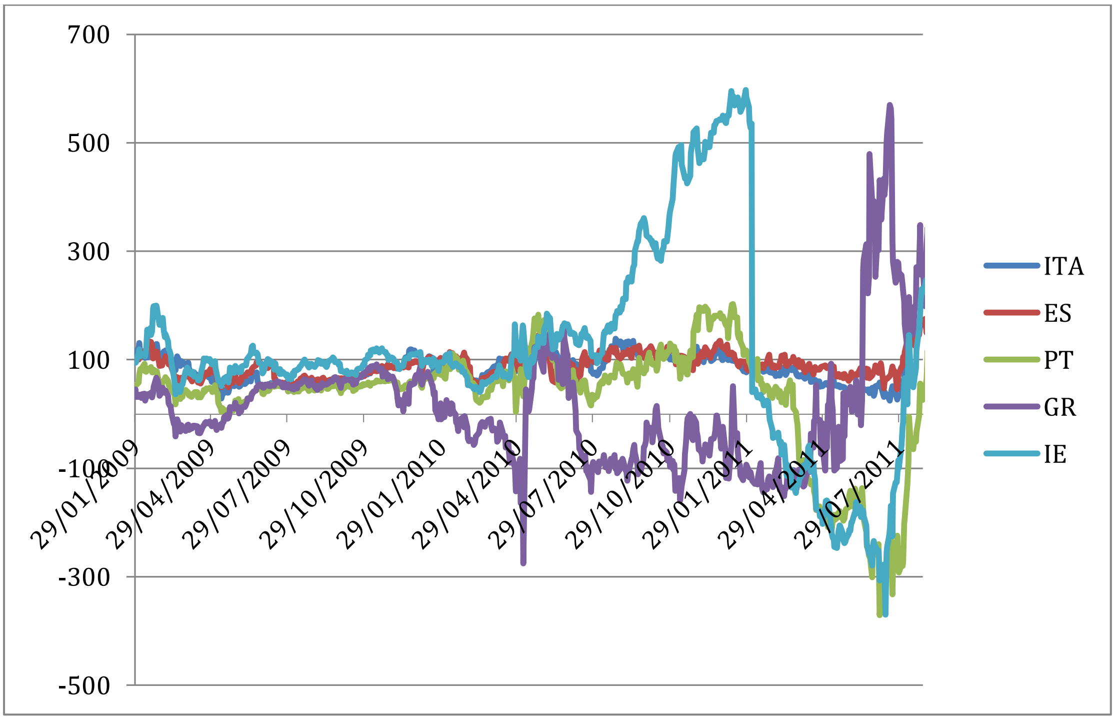
Moreover, the CDS market is set so as the seller pays the buyer in the event of default before maturity of the contract. What defines a default event is not always forthright. Default events could take the form of bankruptcy, failure to pay, obligation default or acceleration, repudiation or moratorium (for sovereign entities), and restructuring. Albeit *restructuring*, as it is demonstrated by the Greek case, may not constitute default. Based on the 1999 International Swaps and Derivatives Association (ISDA) documentation *restructuring* establishes '*a default event if either the interest rate or principal paid at maturity are reduced or delayed, or an obligation's ranking in payment priority is lowered or there is a change in currency or composition of any payment*'.

The sovereign CDS also is a trading instrument and not a pure insurance instrument. Moreover, taking an outright position on spreads depends on traders' expectations over a short horizon. To this end, CDS could be used for hedging macroeconomic uncertainty or risks. That is CDS could be used as a relative-value trading instrument by taking a short position in country X and a long position in country Y. This may also result to arbitrage trading that is sovereign bonds versus CDS.

The observed high CDS premium during crisis could imply underling declining risk appetite, falling market liquidity, credit rating downgrades (migration risk) (Fontana and Scheicher, 2010), or even '*economic catastrophe risk*' (Berndt and Obreja, 2010), and not so much principal losses on outstanding debt.

For example, when the *'basis'* is negative sovereign bonds are costlier than CDS, implying that bond spreads are lower than CDS (see Diagram 3). This, in turn, means that profit could be realised if *'basis'* trade takes place that is to buy bond and CDS protection. It is worth noting that in the immediate months prior to the Greek haircut, the Greek '*basis*' takes positive values, implying a strategy of selling bonds and CDS protection. In reality liquidity constraints do not abate and as a result buying bonds to short-sell, via a repo transaction, is not inexpensive (Duffie, 2010). In addition, in case repo rates are low hedging positions is costly as bonds are hard to get and short-sell. The main drawback of costly bonds is that not all deliverable bonds could be necessarily due and payable should restructuring occur. Some deliverable bonds could be cheaper, whilst deliverable bonds with long maturity or convertible bonds would be traded at a discount to short maturity bonds.

Diagram 3: The ***'basis'*** **(**Spread$_t$ **-*CDS$_t$*),** 5-years maturity, weekly.



Source: Bloomberg.
Note: the sample covers up till 2011:Q3 due to the anticipation of the Greek sovereign haircut.

Moreover, the negative *'basis'* strategy (see Greece) requires funding for buying bond position. During market turbulence traders are unwilling to enter such a position due to the price volatility, therefore *'haircuts'* for the position could prove to be volatile and sizable. Gorton and Metrick (2009) show that repo market haircut takes central part during financial crisis. Note the striking difference between movements in the *'basis'* of Greece compared to Portugal and Ireland in recent months.

To make things even more complicate what constitutes a default event is not an easy task. For example, concerning the histrionic Greek case, ISDA communication on 31th of October 2011 EU over the restructuring of the Greek sovereign debt argues: *'Based* *on what we know now, it appears from news reports that the Eurozone proposal involves a voluntary exchange that would not be binding on all holders.'* On 1st March 2012 ISDA in another communication argues that in the case of Greece and the voluntary haircut '…*a Restructuring Credit Event has not occurred under Section 4.7(a) of the 2003 Definitions.*'

Alas, on 9th March 2012 ISDA declared that '…*the invoking of the collective action clauses by Greece to force all holders to accept the exchange offer for existing Greek debt constituted a credit event under the 2003 ISDA Credit Derivatives Definitions.*' In legal terms, Greek sovereign has defaulted in March 2012.

3. Methodological Framework

We build on the notion of *'basis'* as a result of market frictions and arbitrage opportunities in the short run (Blanco et al, 2005). This would imply that an investor with a long position in sovereign bond could also buy protection in CDS market to hedge against the risk of default given liquidity constrains and equal maturity in both the bond and CDS. In the event of no-arbitrage the CDS should equal the sovereign bond spread over swap. [2]

3.1 The Underlying Loss Function

We consider that the sovereign debt for the euro area market follows a generalized loss function based on the '*basis*', as deviations from equilibrium whether negative or positive would imply misalignment from an efficient market. The classical analysis (Theil, 1958; Mincer and Zarnowitz, 1969) would suggest testing if the *'basis'*, the difference between spread and CDS, has zero mean and is uncorrelated with any information available at the time that the CDS, as forward looking, is formed.

[2] There are numerous trading strategies in the sovereign CDS market. First, a trader could take a long and short position simultaneously to exploit misalignments in prices. Second, one could sell CDS protection on sovereign bonds and buy CDS protection on corporate bonds in the same country. Third, one could be net buyer of sovereign CDSs. The last case is particularly popular among hedge funds. Fourth, portfolio managers could buy sovereign CDSs to hedge against macroeconomic risks. There are also synthetic options such as first to default CDSs on sovereign risk. These strategies are only a portion of the existed ones and point out to the direction of complexities one could face attempting to disentangle the impact of market's expectations on sovereign CDS spreads. For example, the recent hikes in CDS spreads could be the outcome of expectations regarding future increases in sovereign bond issuance.

However, if the underlying los function were asymmetric then the Theil-Mincer-Zarnowitz test would be biased. Elliott et al. (2005 and 2008) relax this limitation by proposing a test for estimating the shape of the underlying univariate loss function.

Herein, we follow the generalised loss function ala Elliot et al. (2005). The importance of this loss function lies on the shape parameter as it reveals symmetry/asymmetry of the underlying loss function that in turn it could be used to infer market preferences. Note that this framework is flexible, could be linear and non-linear, and there is not a prerequisite to observe the underlying models of forming sovereign spreads and sovereign CDS so as to estimate the shape parameter of the loss function.

Moreover, we define $CDS_t \equiv \theta' W_t$ be the CDS_t conditional on the information set F_t in which θ is an unknown k-vector of parameters, $\theta \in \Theta$, with Θ compact in R^k, and W_t is an h-vector of variables that are F_t measurable.[3] Essentially, W_t represents the full set of factors and is known to the market at time t and could affect their preferences. Sovereign $Spread_t$ forms part of W_t.

When the CDS_t is valued we assume that given the $Spread_t$ and W_t, the market follows a generalized flexible loss function L, which could reveal preferences, defined by

$$L(p,\alpha) \equiv [\alpha + (1-2\alpha)1(Spread_t - CDS_t < 0)]\left|Spread_t - CDS_t\right|^p \qquad (1)$$

, where p takes values 1,2, if p=1 the loss function is linear and for p=2 is quadratic, whilst $\alpha \in (0,1)$ and depicts the shape parameter of the loss function. **1** is an indicator and ($Spread_t$ -CDS_t) is the difference between the spread over swap and CDS, implying market imperfections and thus short run arbitrage opportunities.

The key parameter in equation (1) is $\alpha \in (0,1)$, '*alpha*', as it contains information regarding the shape of the loss function and thus its symmetry or asymmetry.

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[3] Within this framework it is not necessary to know the underlying model of forming spreads and CDS. CDS could be considered as forward-looking prediction of spread plus a premium (Blanco et al, 2005). The premium is considered as fixed, and thus exogenous to the loss function.

By observing the sequence of CDS_t, $\tau \leq t < T+\tau$ the estimate of *'α'* is given using a linear GMM Instrumental Variable estimator[4] $\hat{\alpha}_T$, as follows:

$$\hat{\alpha} = \frac{\left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} v_t \left|Spread_t - CDS_t\right|^{p_0-1}\right]' \hat{S}^{-1} \left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} v_t \mathbf{1}(Spread_t - CDS_t < 0)\left|Spread_t - CDS_t\right|^{p_0-1}\right]}{\left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} v_t \left|Spread_t - CDS_t\right|^{p_0-1}\right]' \hat{S}^{-1} \left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} v_t \left|Spread_t - CDS_t\right|^{p_0-1}\right]} \quad (2)$$

, where v_t is a dx1 vector of instruments which is a subset of the information set used to generate f, while $\hat{S}$ is given by:[5]

$$\hat{S} = \frac{1}{T}\sum_{t=\tau}^{T+\tau-1} v_t v_t' (\mathbf{1}(Spread_t - CDS_t < 0) - \hat{\alpha}_\tau)^2 \left|Spread_t - CDS_t\right|^{2p_0-2} \quad (3)$$

As in Elliott *et al.* (2005) the estimator of α_T is considered to be asymptotically normal and a J-statistic follows $X^2(d-1)$ for d>1 and takes the form:

$$J = \frac{1}{T}\left[\begin{array}{l} \left(\sum_{t=\tau}^{T+\tau-1} v_t \left[\mathbf{1}(Spread_t - CDS_t < 0)\right]\left|Spread_t - CDS_t\right|^{p_0-1'}\right)\hat{S}^{-1} \\ \times\left(\sum_{t=\tau}^{T+\tau-1} v_t \left[\mathbf{1}(Spread_t - CDS_t < 0) - \hat{\alpha}_T\right]\left|Spread_t - CDS_t\right|^{p_0-1}\right) \end{array}\right] \sim X^2_{d-1} \quad (4)$$

If preferences were asymmetric then CDS_t under the generalised loss function of equation 1 would be an optimal forward looking of $Spread_t$ if and only if the following first order optimality condition is met:

$$E\left[W_t\left(\mathbf{1}_{(\text{Spread}_t - CDS_t < 0)} - a\right)\left|Spread_t - CDS_t\right|^{p-1}\right] = 0 \quad (5)$$

[4] In the empirical part of the paper three instruments are opted, a constant, the lagged difference between CDS and spread, and the lagged difference of CDS.

[5] $\hat{S}$ depends on α_T and as a result the estimation takes place iteratively, assuming $\hat{S}$ =I in the first iteration to estimate α_T until convergence.

, where W_t is as above the full set of factors and are known to the market at time *t* and *a* is the loss asymmetry parameter. Once *'alpha'* and *p* are known the market could use the first order condition to define CDS_t in a unique way as proved by Elliott et al (2005). In another step, once CDS_t is identified one could employ first order condition (5) to retrieve *'alpha'* in a unique way. Moreover, Elliott et al. (2005) proves in Lemma 2 that the above first order condition is necessary to estimate *'alpha'* employing a sub vector V_t of W_t.

3.2 Testing for structural breakdowns

As we are dealing with a period of time of the euro area debt crisis that saw many incidents, starting from the first financial assistance to Greece by troika and the subsequent financial assistance to Ireland, Portugal and Spain, and notably the largest sovereign debt haircut in the history (Private Sector Involvement for Greece), one could reasonably argue that the shape parameter, *'alpha'*, of the underlying loss function varies over time. To this end, we apply a structural break test proposed by Giacomini and Rossi (2009) that builds on the framework of generalized loss function of equation (1).

Following Giacomini and Rossi (2009) we consider $Z \equiv \{Z_t : \Omega \to R^{s+1}, s \in N, t = 1,...,T\}$ a stochastic process defined on a complete probability space *(Ω, F, P),* and partition the observed vector Z_t as $Z \equiv (Spread_t, X_t^{'})^{'}$, where $Spread_t : \Omega \to R$ is the variable of interest, that is the spread, and $X_t : \Omega \to R^s$ is the variable that form spreads, that is CDS.

This methodology builds a succession of τ-step-ahead $\text{Spread}_{t+\tau}$ using an out of sample process that encompasses dividing the sample T into an in-sample size *m* and an out-of-sample size $n=T-m-\tau+1$. The time *t* future, $\varphi_t(\hat{\beta}_t)$, is produced by estimating a model over in-sample window at time *t*, with $\hat{\beta}_t$ indicating the *kx1* parameter estimate. Then the spread is evaluated by a loss function *L( ),* with each out-of-sample loss $L_{t+\tau}(\hat{\beta}_t) \equiv L(f_{t+\tau}, \varphi_t(\hat{\beta}_t))$ corresponding to in-sample losses $L_j(\hat{\beta}_t) \equiv L(P_j, \hat{p}_j(\hat{\beta}_t))$.

Now given the in-sample and the out-of-sample loss we define *'surprise loss'* as the difference between the out-of-sample loss at time t + τ and the average in-sample loss:

$$SL_{t+\tau}(\hat{\beta}_t) = L_{t+\tau}(\hat{\beta}_t) - \bar{L}_t(\hat{\beta}_t) \text{ for } t = m, \ldots, T\text{-}\tau. \quad (6)$$

where $\bar{L}_t(\hat{\beta}_t)$ is the average in-sample loss computed over the in-sample window.

The out-of-sample mean of the surprise losses is:

$$\overline{SL}_{m+n} \equiv n^{-1} \sum_{t=m}^{T-\tau} SL_{t+T}(\hat{\beta}_t) \quad (7)$$

We could state that out-of-sample mean of the surprise loss is simply:

$$SL_{t+t} = L_{t+t} - \bar{L}_t \text{ for } t = m, \ldots, T - t \qquad (7)$$

, where the out-of-sample loss is given by

$$L_{t+t} = L\left(Spread_{t+t} - CDS_{t+t}\right)$$

The average in sample loss $\bar{L}_t$ would be estimated by certain underlying schemes, such as: (i) a fixed scheme, where the in-sample window at time *t* contains observations indexed 1,…,m; (ii) a rolling scheme, where in-sample window at time *t* contains observations indexed *t-m+1,…,t*; and (iii) a recursive scheme, where the in-sample window includes observations indexed *1,…,t*.

$$\text{Fixed Scheme:} \qquad \bar{L}_t = \frac{1}{m}\sum_{j=1}^{m-\tau} L\left(Spread_{j+\tau} - CDS_{j+\tau}\right)$$

$$\text{Rolling Scheme:} \qquad \bar{L}_t = \frac{1}{m}\sum_{j=t-m+1}^{t-\tau} L\left(Spread_{j+\tau} - CDS_{j+\tau}\right)$$

$$\text{Recursive Scheme:} \qquad \bar{L}_t = \frac{1}{t}\sum_{j=1}^{t-\tau} L\left(Spread_{j+\tau} - CDS_{j+\tau}\right) \qquad (8)$$

Based on equation (7), and given the underlying schemes (8), the test has as null hypothesis:

$$H_0 : E\left(n^{-1}\sum_{t=m}^{T-\tau} SL_{t+T}(\beta^*) \right) = 0 \text{, for all } m, n. \text{ (9)}$$

And, the structural breakdown test statistic is:

$$t_{m,n,\tau} = \sqrt{nSLm,n} \,/\, \hat{\sigma}_{m,n} \quad (10)$$

The main advantage of the methodology of Giacomini and Rossi (2009) is the robustness to the presence of unstable regressors.[6] In terms of our analysis, breakdowns are defined as unexpected events, exogenous to the market. In the event that a breakdown in spreads would arise the out-of-sample performance of the spread model is significantly worse than its in-sample performance.

3.3 A multivariate loss function.

We could extend the above model for the case of a multivariate loss function, as it could be that the euro area sovereign debt crisis led to a non-separable loss functions among the main countries within the cyclone. We extend our analysis by rewriting the loss function of equation (1) as

$$L_p(\tau, e) = 2[1 - \alpha + \tau\mathbf{1}\,(\mathrm{e})]|e|^p \qquad (11)$$

[6] For information regarding the construction of the asymptotic variance estimator $\hat{\sigma}_{m,n}$ see Giacomini and Rossi (2009). Giacomini and Rossi (2009) have applied their method on the Phillips curve for the economy of US.

, where $\tau = 2\alpha - 1$, and $0 < \alpha < 1$ is the shape parameter of the univariate loss function ($\alpha = 0.5$, notifying the symmetric loss function), $p \geq 1$, $e = Spread_t - CDS_t$, p takes values 1,2, if p=1 the loss function is linear (lin-lin loss) and for p=2 (quad-quad loss) is quadratic, whilst **1** is an indicator function $\mathbf{1}: \mathbb{R} \longrightarrow [0,1]$.

Kirchgassner and Muller (2006) propose that a vector rationality test under the strong assumption that the underlying losses are additive separable and quadratic in individual variables. This is rather a restrictive assumption as it regards, for example, that the marginal loss for the spread of Greece is independent of the Irish spread. Thus, under the assumption of separable loss no interactions between different spreads are present. Non-separable loss functions are of importance, as there exist complementarities in the utility functions of market participants.

Komunjer and Owyang (2012) show that assuming additive separability of the underlying loss function will result to bias. To this end, any asymmetry found in the first step of univariate Elliott et al (2005) rationality test could be biased if in a multivariate rationality test the asymmetry is restrained due to the non-separability of the underlying loss function based on *n-variate.*

In the univariate case, given an exponent p, $1 \leq p < \infty$, Elliott et al (2005) show that the asymmetry parameter τ, $-1 \leq \tau \leq 1$, could be mapped as a non-negative function of a scalar error $e \in \mathbb{R}$;[4]. There are many losses based on this mapping that are flexible to represent the absolute value or quadratic losses along with asymmetries. Komunjer and Owyang (2012) extend the above univariate family of losses to a vector-valued argument $e \in \mathbb{R}^n$. For this $\| e \|_p$ denote the l_p-norm of any n-vector $e = (e_1, \ldots, e_n)' \in \mathbb{R}^n$.

For any $e \in \mathbb{R}^n$ Komunjer and Owyang (2012) defines a *n-variate* loss function as:

$$L_p(\tau, e): \mathbb{C}_q^n \times \mathbb{R}^n \longrightarrow \mathbb{R} \quad (12)$$

with $1 \leq p < \infty$ and $1/p + 1/q = 1$ the loss becomes:

$$L_p(\tau, e) \equiv (\|e\|_P + \tau' e)\|e\|_p^{p-1} \quad (13)$$

, for *p=1*, the multivariate loss $L_1(\tau, e)$ expresses the geometric quantiles of the *n-vector* $\boldsymbol{e}$ (Chaudhuri, 1996). To this end, the loss function $L_1(\tau\ , \cdot)$ is a multivariate extension of the univariate loss, which refers to quantile estimation (Koenker and Bassett, 1978).

Similar to the single variable case, an *n-variate* forecast vector is said to be rational if it minimizes the expected value of the *n-variate* loss L_p in Equation (13).

Komunjer and Owyang (2012) show that the asymmetry parameter $\boldsymbol{\tau}$ is globally identified on $\mathcal{B}_q^n$. Moreover, Komunjer and Owyang (2012) propose GMM estimation, where the estimation of $\boldsymbol{\tau_0}$ comes from solving a minimization problem. It is important to note that the optimal errors (the difference between spread and CDS, meaning no arbitrage) e_{t+1}^* cannot be justified always. However, for every t, $R \leq t \leq T = P + R - 1$, we observe $\hat{e}_{t+1} = spread_{t+1} - \widehat{CDS}_{t+1,t}$, which takes into account of all forward looking estimation uncertainty in $\widehat{CDS}_{t+1,t}$.[7]

Given p, $1 \leq p \leq \infty$, v_t instruments and observations for $((v_{R,}' \hat{e}_{R+1}')', \dots, (v_{T,}' \hat{e}_{T+1}')')'$ the GMM estimator of the *n-variate* loss asymmetry parameter τ_0, denoted by $\hat{\tau}_p$ comes from the solution to minimisation problem:

$$\min_{\tau \in \mathcal{B}_q^n} \left[P^{-1} \sum_{t=R}^{T} g_p\,(\tau; \hat{e}_{t+1}, v\right]' \times \hat{S}^{-1} \left[P^{-1} \sum_{t=R}^{T} g_p\,(\tau; \hat{e}_{t+1}, v_t\right] \quad (14)$$

where $\hat{S}$ is consistent estimator of:

$$S = E\left[g_p(\tau_0; e_{t+1}^*, v_t) g_p(\tau_0; e_{t+1}^*, v_t)'\right] \qquad (15)$$

[7] Note that this framework applies both for separable and non-separable losses and thus there is no difference on whether the market applies one model to price CDS and spreads across countries or different models.

Based on the above GMM estimation a rationality test for *n-vector* of $\{CDS^{*}_{t+1,t}\}$ under a *n-variate* loss L_p with *d>1* instruments v_t as

$$\hat{J}_P \equiv P^{-1}\left[\sum_{t=R}^{R+P+1} g_p\,(\hat{\tau}_P; \hat{e}_{t+1}, v_t)\right]' \times \hat{S}^{-1}\left[\sum_{t=R}^{R+P+1} g_p\,(\hat{\tau}_P; \hat{e}_{t+1}, v_t)\right] \sim \chi^2_{n(d-1)} \quad (16)$$

, where $\hat{S} = P^{-1}\sum_{t=R}^{T} g_p(\tilde{\tau}; \hat{e}_{t+1}, v_t) g_p(\tilde{\tau}; \hat{e}_{t+1}, v_t)'$ with $\tilde{\tau}$ being an initial consistent estimate of τ_0.

4. The data set and empirical results.

As proposed earlier, the main focus of the current research is on the periphery of the euro-area, given the intense fiscal challenges to finance its sovereign debt outside financial assistance mechanisms. To this end, we focus on the sovereign spread for Greece, Ireland, Portugal, Italy and Spain at time *'t'*, (*Spread$_t$)* measured as the difference between secondary-market yield on the country's 5-year bond and the swap rate.[8] Since the swap rate is widely regarded by the markets as a *'risk-free'* rate, the spread is considered as premium against risk of default. On the other hand, CDS_t is forward-looking with regards to spreads. All variables are derived from Bloomberg and where missing from Datastream and cover the period mid 2007 to late 2012.

4.1 Estimates of the shape parameter: '*alpha*'.

Table 1 reports results equations (2) and (3) using GMM with instruments for both the linear (*p*=1, lin-lin) and non-linear case (*p*=2, quad-quad). Three instruments are opted: a constant (that is D=1), lagged difference between Spread and CDS (D=2), as well as the lagged difference Spread (D=3).[9] Our estimated loss function parameters are all statistically different from zero. For most cases *'α'* takes values somewhat

[8] All countries in the sample, but Italy, have applied for financial assistance to the EU. In July 2012 the Eurogroup agreed Spain's financial assistance programme. The programme has provisions of up to EUR 100 billion to assist Spanish financial institutions under stressed and in need to recapitalize. Greek programme was agreed in May 2012 and has already disbursed close to EUR 150 billion. The bailout for Ireland and Portugal in 2011 sum to a total amount up to EUR 48.5 billion.
[9] To assist the exposition and presentation of results we report, thereafter, results of weekly frequency. Results of daily frequency reaffirm weekly findings whilst are available under request.

higher than 0.5 but close to 0.5 (see lin-lin case for D=1 and D=2 and quad-quad case for D=3), indicating rational loss preferences associated with a symmetric loss function. However, there is some variability for different set of instruments and also for the quad-quad case. Moreover, for the case of D=2 in quad-quad *'α'* takes values below 0.5 and away from symmetry. Note that for *'alpha'* greater than 0.5 the slope of the generalised loss function would be steeper for positive *'basis'*, which would imply that the market preferences would support higher CDS than spread. If this is so, the perceived loss by the market is much higher when the CDS, the insurance premium against default, is lower than the spread. As a result market's preferences would lean towards rising CDS. This, in turn, would imply as CDS is forward looking that the Greek sovereign debt crisis would be far from over and therefore higher yields would be warranted. On the other hand, if *'alpha'* is lower than 0.5, once more we would observe asymmetry but this time market's preferences would suggest that the loss of a negative *'basis'* is high, and as result Spread should be higher than CDS. Thus, when the shape parameter *'alpha'* takes values less than 0.5 would indicate optimistic preferences associated with an asymmetric loss function whereas when it is higher than 0.5 would indicate pessimism.

TABLE 1: '*alpha*' for spreads over swap - 5 yr CDS, weekly.
Linear case, 05/09/2008 to 30/11/2012.

Greece

	Linear				Non Linear			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.528	180.12	4.8027	136.03	0.595	139.80	1.81E-3	75.023
D=2	0.547	201.06	120.56	162.60	0.451	149.67	177.90	165.97
D=3	0.581	268.36	273.84	302.57	0.493	160.41	208.58	285.52

Portugal

	Linear				Non Linear			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.480	813.47	3.1425	983.40	0.471	349.52	2.2327	534.03
D=2	0.480	820.31	42.578	990.85	0.414	357.49	214.95	575.01
D=3	0.375	1.2E+03	1.4403	1.3E+03	0.397	386.67	405.83	621.91

Italy

	Linear				Non Linear			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.480	813.47	3.1E-25	983.40	0.471	349.52	2.2E-27	534.03
D=2	0.480	820.31	42.5789	990.85	0.414	357.49	214.959	575.01
D=3	0.375	1.2E+03	1.4E+03	1.3E+03	0.397	386.67	405.833	621.91

Spain								
	Linear				Non Linear			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.480	813.47	3.1E-25	983.40	0.471	349.52	2.2E-27	534.039
D=2	0.480	820.31	42.5789	990.85	0.414	357.49	214.959	575.017
D=3	0.375	1.2E+03	1.4E+03	1.3E+03	0.397	386.67	405.833	621.918

Ireland								
	Linear				Non Linear			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.250	1.421	23.41	66.673	0.407	7.6663	1.1E-29	45.713
D=2	0.058	48.50	23.40	70.963	0.136	19.694	15.2392	69.731
D=3	0.057	51.22	23.49	88.375	0.089	30.764	16.0958	83.780

Estimates are based on D=1, 2, 3 instruments. The instruments are: a constant (that is D=1), lagged difference between Spread and CDS (D=2), as well as the lagged Spread (D=3). The equations (2) and (3) are estimated using GMM both the linear (p=1) and non-linear case (p=2). J-statistics are distributed as X^2 (D-1 for D>1) $J_{\hat{a}}$ and X^2(D) for the remaining J. Critical values for X^2 (2): at 1% 9.21, at 5% 5.99, and at 10% 4.60.

Elliott et al (2005) argue that deviations from symmetry would lead to deviations from rational behaviour unless all interest parties share the exact same loss function. This is something that will be hard to meet as different parties have different objectives. However, rationality could still be achieved if the underlying market loss function for sovereign debt is revealed to all interest parties so they, then, can adjust their preferences accordingly. This paper for the first time reveals the underlying preferences for a key market that has been in the epicentre of a financial turmoil in recent years.

We also report *J-statistics* for three alternative null hypotheses, $H_0 : a = \hat{a}$ (from the estimation), α*=0.2*, and α*=0.8*, the latter two representing optimistic and pessimistic preferences respectively. In particular for all cases we report strong evidence towards the likelihood to reject the null of 0.8, but also 0.2.

Table 1 also reports results for the remaining Member States of the periphery euro area.[10] Our estimated loss function parameters are all statistically different from zero. For all countries, but Ireland, *'alpha'* takes values around 0.5, indicating rational loss preferences associated with a symmetric loss function. Ireland is an interesting case as it indicates asymmetry towards optimism as *'alpha'* takes values much lower than 0.5.

[10] Results of daily frequency are available under request whilst reaffirm weekly findings.

However note that in the case of D=3 for all countries *'alpha'* takes clearly values less than 0.5, suggesting that there is exist asymmetry in the underlying loss function towards the direction of the market assigning higher loss when the spread is lower than CDS. In this case, once more we would have observed asymmetry but this time market's preferences lean towards high loss when there exist negative *'basis'*, and as result Spread should be higher than CDS.

4.2 Structural breakdowns tests

There have been events of some considerable significance in euro area chronicle. Notably in May 2010 euro area in parallel with IMF initiated the Emergency Financing Mechanism (EFM), a financial assistance framework that aims to alleviate euro area countries under pressure to finance their debt at a reasonable cost. Moreover, on 7th of May 2010 Greece signed the memorandum of understanding of the Emergency Financing Mechanism.[11] The memorandum of understanding contains unprecedented strong conditionality as part of 110bn-euro loan that has been in place so as to protect Greece from defaulting on its debt. The memorandum of understanding gave birth to troika that is the IMF, the EU Commission and the ECB. Troika has been granted with powers to appraise Greek progress so as to disburse the next instalment of financial assistance and demand further measures should there are shortfalls in correcting Greek fiscal imbalances. Since May 2010, Greece fiscal imbalances have remained excessive whilst the country has witnessed a large-scale debt restructuring operation in March 2012, named as Private Sector Involvement (PSI), effectively the largest sovereign debt haircut in history. Alas the philology of

[11] The EFM pave the way for the European Financial Stabilisation Mechanism (EFSM). It builds on the Balance of Payments Regulation of EU for non euro area Member States. The bailout for Ireland and Portugal has been carried out by the EFSM for a total amount up to EUR 48.5 billion that is distributted up to EUR 22.5 billion for Ireland and up to EUR 26 billion for Portugal. The EFSM is a part of the wider safety net. In parallel to EFSM, the European Financial Stability Facility (EFSF) operates to fund euro area Member States. The EFSF funds are guaranteed by the euro area Member States and International Monetary Fund (IMF). On 8th of October 2012, EU came up with a new mechanism, the European Stability Mechanism (ESM), as the nect step of EFSF. Note also that the Financial Assistance Programme for the Recapitalisation of Financial Institutions in Spain as agreed in 2012 has provisions of a total amount up to EUR 100 billion.

the need of yet another restructuring underway is evident in policy making as noted in the last round of appraisal by EU[12] (see European Economy, 2012).

Given the financial assistance programmes for a number of euro area Member states since the Greek bailout in May 2010 it would be interesting to examine possible structural breaks in the underlying loss function around the dates of these events. Table 3 reports structural break tests based on the surprised loss function of Giacomini and Rosi (2009) marking the date of the Greek bailout that was on 7th May 2010. We also test for the June 2011, marking the date Portugal joined the financial assistance mechanism, as well as April 2012 when the Greek PSI took place. For robustness we consider time horizon at $\tau=1$, $\tau=5$ and $\tau=10$ weeks ahead and opt for four lags. We report p-values in Table 3. Under all schemes and for all time horizons the null of no structural breakdown is rejected in the case of Greece, as there is evidence of a significant surprise losses over time. This result implies that the *'basis'* does not remain stable over time, and this may result to shifts in the shape of the underlying loss function. Thus, as part of sensitivity analysis, we should re-examine the shape parameter *'alpha'* for the different sub-periods identified by the structural break test.

TABLE 3. *p*-values of structural break in the linear loss function.

	7/05/2010: Greek Bail Out			01/06/2011: Portuguese Bail Out			01/04/2012: Greek PSI		
Greece									
	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive
$\tau=1$	0.000	0.001	0.000	0.001	0.002	0.060	0.000	0.000	0.000
$\tau=5$	0.001	0.000	0.002	0.013	0.000	0.012	0.020	0.003	0.020
$\tau=10$	0.001	0.000	0.001	0.002	0.000	0.001	0.010	0.012	0.030
Portugal									
	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive
$\tau=1$	0.001	0.000	0.000	0.000	0.002	0.000	0.999	0.999	0.999
$\tau=5$	0.000	0.000	0.000	0.001	0.013	0.001	0.999	0.999	0.999
$\tau=10$	0.000	0.000	0.000	0.001	0.001	0.021	0.999	0.999	0.999
Italy									
	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive
$\tau=1$	0.000	0.000	0.000	0.999	0.999	0.999	0.996	0.999	0.994
$\tau=5$	0.001	0.000	0.030	0.998	0.999	0.999	0.997	0.995	0.993
$\tau=10$	0.001	0.001	0.040	0.998	0.999	0.999	0.994	0.996	0.998
Spain									
	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive
$\tau=1$	0.001	0.000	0.001	0.999	0.999	0.999	0.999	0.999	0.999

[12] Greek fiscal sustainability remains, despite the restructuring of its debt, questionable and it has worsened compared to March 2012 (see European Economy, 2012). The latest appraisal by Troika highlights that risks of financial assistance to Greece remain considerable. Greece has received EUR 148.6 billion to date.

τ=5	0.020	0.000	0.010	0.999	0.999	0.999	0.999	0.999	0.999
τ=10	0.000	0.010	0.020	0.999	0.999	0.999	0.999	0.999	0.999
				Ireland					
	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive	Fixed	Rolling	Recursive
τ=1	0.856	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
τ=5	0.837	0.999	0.997	0.999	0.998	0.999	0.999	0.999	0.999
τ=10	0.844	0.999	0.999	0.997	0.999	0.999	0.999	0.999	0.999

Scheme 1 is the fixed scheme, where the in-sample window at time *t* contains observations indexed 1,…,m; scheme 2 is a rolling scheme, where in-sample window at time *t* contains observations indexed *t-m+1,…,t*; and last scheme 3 is a recursive scheme, where the in-sample window includes observations indexed *1,…,t*. The lag for the Newey-West estimator is opted as $n^{1/3}$ of the asymptotic variance.

For the rest of the periphery of the euro area (see Table 3) results are mixed. No structural breakdown is rejected in all countries for selected dates, but Ireland. These results show that the events unfolded from the Greek bailout and thereafter have resulted in breaks in the underlying loss functions also for other periphery euro-area Member States. To this end, in the next section we shall examine the shape of the loss function before and after the identified structural break.

4.3 '*alphas*' in selected sub-periods

Having identified a surprise loss in May 2010 we report next '*alpha*' prior and post that date. Table 4 presents parameter estimates of *'alpha'* for spreads for the sub period from 05/09/2008 to 27/04/2010, signifying the date that Greece sent a letter asking for financial assistance. For this sub-period, an asymmetric loss function that leans towards optimism occurs as '*alpha'* takes values les than 0.5 and thus away from symmetry. For the non-linear case *'alpha'* is estimated even lower than 0.3. Interestingly, in the second period preferences seem to dramatically shift towards pessimism as *'alpha'* is much higher than 0.5 in all cases. Moreover, in the case of D=3 '*alpha'* takes values higher than 0.9. Interestingly the same pattern is observed for the remaining Member States of the euro area periphery, but Ireland. Post the first bail out of the Greek sovereign debt market's loss function asymmetry reveals pessimistic preferences as '*alpha*' takes values higher than 0.5. The case of Ireland is different as the asymmetry is towards optimism. This would imply that whilst the market is somewhat certain for the prospects of the Irish sovereign debt is less so for the remaining periphery of the euro-area.

TABLE 4: '*alpha*' for 5 yr Spreads over swap and CDS, weekly, linear case.

Greece

	period from 05/09/2008 to 27/04/2010				period from 28/04/2010 to 30/11/2012			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.460	70.8429	8.252	104.53	0.762	173.871	1.6828	2.3913
D=2	0.342	153.243	146.8	117.15	0.764	173.884	0.1497	2.4975
D=3	0.442	212.920	150.7	137.50	0.940	187.688	56.304	121.64

Italy

	period from 05/09/2008 to 27/04/2010				period from 28/04/2010 to 30/11/2012			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.447	258.47	0.00	666.15	0.606	529.76	0.00	569.51
D=2	0.446	258.57	0.03	666.15	0.606	529.76	0.00	569.51
D=3	0.401	585.96	31.34	667.09	0.660	546.04	21.00	635.31

Spain

	period from 05/09/2008 to 27/04/2010				period from 28/04/2010 to 30/11/2012			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.416	46.201	0.000	587.36	0.739	325.48	0.000	547.332
D=2	0.480	88.452	30.463	587.50	0.739	325.48	0.000	547.332
D=3	0.402	623.770	81.862	599.45	0.701	490.08	65.560	580.552

Portugal

	period from 05/09/2008 to 27/04/2010				period from 28/04/2010 to 30/11/2012			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.553	240.039	0.000	141.67	0.668	186.39	0.000	45.437
D=2	0.548	276.338	229.43	216.93	0.668	186.39	0.000	45.437
D=3	0.413	321.020	312.00	406.72	0.758	190.19	202.515	304.226

Ireland

	period from 05/09/2008 to 27/04/2010				period from 28/04/2010 to 30/11/2012			
	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$	$\hat{a}$	$J_{\alpha=0.2}$	$J_{\hat{a}}$	$J_{\alpha=0.8}$
D=1	0.268	16.556	0.000	422.71	0.165	5.395	0.000	314.081
D=2	0.267	18.050	2.575	422.93	0.165	5.395	0.000	314.081
D=3	0.136	488.949	187.35	450.98	0.111	269.43	127.70	353.170

Note: Estimates are based on D=1, 2, 3 instruments. The instruments are: a constant (that is D=1), lagged difference between Spread and CDS (D=2), as well as the lagged Spread (D=3). The equations (2) and (3) are estimated using GMM both the linear (p=1) and non-linear case (p=2). J-statistics are distributed as X^2 (D-1 for D>1) $J_{\hat{a}}$ and X ^{2}(D) for the remaining J. Critical values for X^2 (2): at 1% 9.21, at 5% 5.99, and at 10% 4.60.

In addition, we report (see Table 5) '*alpha*' for the period from 05/09/2008 to 07/05/2010, marking the period prior Greece signing the memorandum. Table 5 show that '*alpha*' takes value lower than 0.5 for the period prior to the Greek bailout as above. But, interestingly, in the aftermath of Greek first bailout preferences seem to dramatically shift towards pessimism as '*alpha*' is much higher than 0.5 in all cases in the second sub-period from 10/05/2010 to 30/11/2012. In the case of using three instruments (D=3) the non-linear loss function exhibits the highest value of asymmetry, *'alpha'* = 0.94.

Table 5: '*alpha*' for 5 yr Greek Spreads over swap and CDS, weekly.
Linear case, period from 05/09/2008 to 07/05/2010.

	$\hat{a}$	SE	$J_{\hat{a}}$	$J_{\alpha=0.2}$	$J_{\alpha=0.5}$	$J_{\alpha=0.8}$
D=1	0.3465	0.0262	1.089	2.851	31.0061	156.5886
D=2	0.2994	0.0253	38.6074	43.394	89.9243	168.7441
D=3	0.0853	0.0154	103.6182	156.80	238.2036	208.511

Linear case, period from 10/05/2010 to 30/11/2012.

	$\hat{a}$	SE	$J_{\hat{a}}$	$J_{\alpha=0.2}$	$J_{\alpha=0.5}$	$J_{\alpha=0.8}$
D=1	0.7765	0.0256	4.3E-28	173.4414	80.7424	0.8364
D=2	0.7795	0.0255	1.4317	173.541	82.3179	2.0246
D=3	0.9456	0.014	50.0866	186.8996	188.9191	121.003

Non-Linear case, period from 05/09/2008 to 07/05/2010.

	$\hat{a}$	SE	$J_{\hat{a}}$	$J_{\alpha=0.2}$	$J_{\alpha=0.5}$	$J_{\alpha=0.8}$
D=1	0.2844	0.0318	3.923	6.5131	42.6959	142.4559
D=2	0.1792	0.0202	15.4318	17.1666	113.7006	163.3697
D=3	0.0931	0.0136	48.8528	90.0204	163.7189	170.6493

Non-Linear case, period from 10/05/2010 to 30/11/2012.

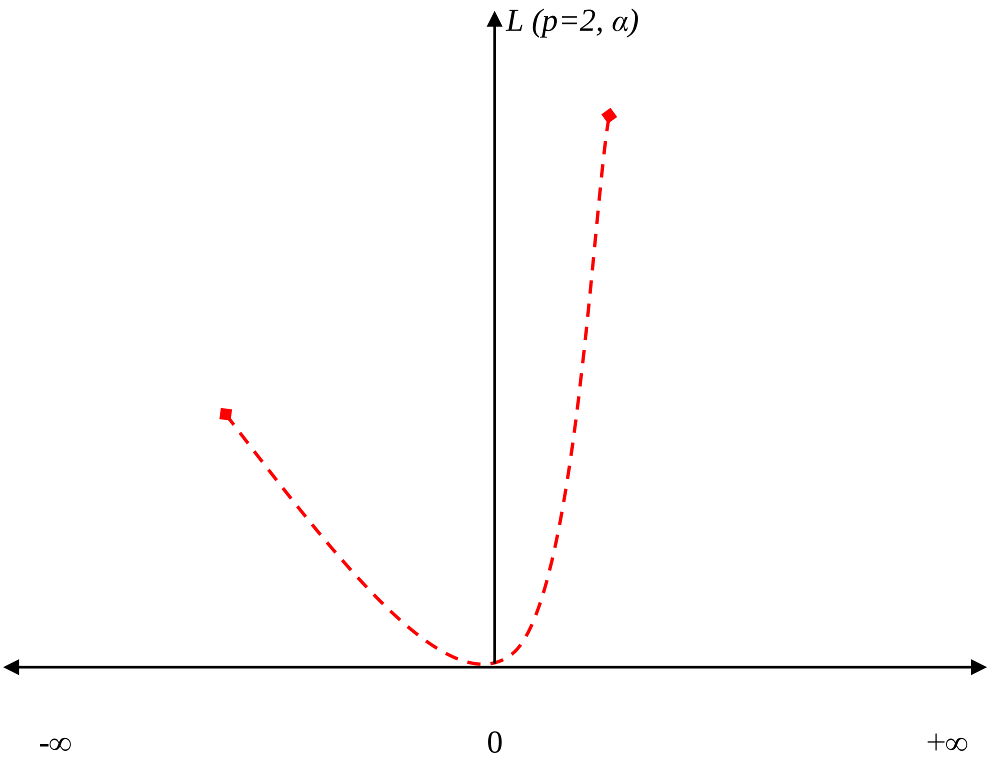
	$\hat{a}$	SE	$J_{\hat{a}}$	$J_{\alpha=0.2}$	$J_{\alpha=0.5}$	$J_{\alpha=0.8}$
D=1	0.8135	0.0261	1.4528	143.904	80.9995	0.2669
D=2	0.8545	0.0227	9.8816	143.9304	86.8275	14.5188
D=3	0.9462	0.0066	37.5591	144.1306	145.9172	139.4704

Estimates are based on D=1, 2, 3 instruments. The instruments are: a constant (that is D=1), lagged difference between Spread and CDS (D=2), as well as the lagged difference Spread (D=3). The equations (2) and (3) are estimated using GMM both the linear (*p*=1) and non-linear case (*p*=2).
J-statistics are distributed as X^2(D-1 for D>1) $J_{\hat{a}}$ and X^2(D) for the remaining J.
Critical values for X^2(2): at 1% 9.21, at 5% 5.99, and at 10% 4.60.

We also use *J-statistics* for three null hypotheses, $H_0 : a = \hat{a}$ (from the estimation), *α=0.2*, and *α=0.8*, the latter two representing optimistic and pessimistic preferences respectively. In particular for the first sub-period and for *'alpha'* that are statistically different from 0.5 the likelihood to reject the null of 0.8 is much higher than for the null of 0.2. However, for the second sub-period, post the Greek bailout, we have evidence that the opposite is true as now the likelihood to reject the null of 0.8 is much lower than for the null of 0.2. Indeed, in many specifications, the asymmetric *J-stat* of the null of $\alpha = 0.8$ is not rejected. This is evidence in favour of the hypothesis of pessimism.

These results indicate that post May 2010 the market assigns higher loss for the case that CDS is lower than the spread that is for positive values in the *'basis'* (see Diagram 4, right hand scale of the horizontal axis). Diagram 4 depicts the asymmetry of the loss function as estimated post May 2010, implying that there is asymmetry and *'alpha'* takes values close to 0.8. Note, that post May 2010, the slope of the loss function is steeper for positive values in the *'basis'*. This implies that the loss for the market is much higher when the CDS, the insurance premium against default, is lower than the spread. Thus, post May 2010 the market clearly displays a preference towards higher CDS than Spreads. This may not imply departure from prudency, but rather a safety mechanism against higher probability of sovereign default, in particular for Greece. This revealed information regarding market's preference insinuate that Greek sovereign debt crisis would eventually lead to default post May 2010.

Diagram 4: Asymmetric loss functions (α>0.5).



Note: horizontal axis shows $Spread_t$-CDS_t, whilst on the vertical axis is the quadratic loss function, $L(p=2,\alpha)$.

A question might arise then, could the reported *'alpha'* prior and post the Greek bailout suggest a realignment of market's preferences towards pessimism which under specific circumstances could be judged as prudent behaviour? Note that assigning higher loss for the case that spread is higher than the CDS suggests that the market sees arbitrage opportunities in the case of Greek sovereign debt that might be too good to miss out. To this end, an asymmetric loss function that leans towards pessimism could be considered under those preferences to reflect prudency, as it could reveal the market's perception that the Greek economy eventually would default. So, an asymmetric loss function despite deviating from rational expectations hypothesis of symmetry and thus efficiency could still be prudent. However, note that unless all participants of Greek sovereign bonds share the same underlying loss function or all information regarding asymmetry, the resulted pessimism would indicate deviation from rationality.

4.4 '*alphas*' of the multivariate loss

Having derived estimations of the shape of the loss function in the univariate case w now shift our attention to the multivariate case. This is justified in light of the evidence of the previous section where we observe co movement of '*alphas*' over time for most euro-area periphery, implying that a non-separable common multivariate loss function could reflect the underlying preferences of the sovereign debt crisis in the euro area. We estimate *'α'* both for the lin-lin case (p=1) and quad-quad case (p=2).[13] The non-separable loss function would allow counting for possible complementarities in the underlying utility functions of participants in sovereign bonds markets.

Table 6 reports results for the linear and non-linear case respectively for the non-separable multivariate loss functions. We include three instruments as in previous sections. It is striking that the parameter *'α'* takes values close to, or around, 0.5 in both linear and non-linear case for most cases in the periphery of the euro area, but

[13] The assumption of separable losses is rather strong as it is based on the notion that the marginal loss of the i.e. Portuguese *'basis'* is independent of the Greek or Spanish *'basis'*. Thus, if separability were imposed then no interactions between the euro-area sovereign *'basis'* would be present.

Greece. The case of Greece is singled out as it clearly demonstrates irrational loss preferences associated with an asymmetric loss function. This clear evidence of deviation of rationality for Greece would imply that sovereign debt market participants do not attach equal weight loss for positive and negative '*basis*'. Moreover, for Italy, Spain and Portugal, and to less extend Ireland sovereign bonds markets attach higher loss for positive '*basis*', that is case when spread is higher than CDS, whilst for Greece the opposite is true.

TABLE 6: '*alpha'* for euro-area debt crisis: Spreads over swap - 5 yr CDS. 05/09/2008 to 30/11/2012.

Linear multivariate loss (p=1)					
D (=1,…,3)	Italy	Spain	Portugal	Greece	Ireland
1	0.455***	0.422***	0.468***	0.720***	0.481**
2	0.472**	0.468***	0.437***	0.700***	0.470*
3	0.453***	0.471***	0.430**	0.716***	0.489**
Non linear multivariate loss *(p=2)*					
1	0.472***	0.461**	0.486**	0.721**	0.520*
2	0.469***	0.472**	0.468*	0.721**	0.530**
3	0.471***	0.471***	0.468**	0.721**	0.581

Note: Estimates are based on D=1, 2, 3 instruments. The instruments are: a constant (that is D=1), lagged Spread (D=2), as well as the lagged difference between Spread and CDS (D=3). The linear is notified by *p*=1 case, whilst the non-linear case by *p*=2. ***,**,* notes significance at 1%, 5%, and 10% respectively.

Note that for the quad-quad case (see Table 6) there is evidence of lower degree asymmetry in the underlying losses as '*alphas*' takes values closer to 0.5 for most countries but Greece.

What the multivariate loss function reveals is that for Greece the sovereign debt market attaches higher loss for negative *'basis'*, that is case when spread is lower than CDS. To the extend that CDS reflect the risk of default by assigning higher loss when CDS is greater than spread, markets reveal preference in favour of negative *'basis'* trading, whilst for the remaining countries the opposite is true.[14] Under certain

[14]Negative *'basis'* implies that government bonds are more expensive than CDS. A trading strategy would be to buy bond and buy CDS protection. This in effect would ease the pressure in the sovereign bond markets.

assumptions concerning market liquidity conditions, the revealed preferences for Greece would imply pessimism, in contrast with the remaining countries.

Clearly for Italy, Spain, Portugal and Ireland markets assign higher loss for positive '*basis*' that is the case of spread is being higher than CDS. However, note that for Greece and Ireland, the Countries that first entered the financial assistance mechanism, *'α'* takes values less than 0.5, indicating a slight optimistic loss preferences associated with an asymmetric loss function. Moreover, the results indicate that in the non-linear case the markets assign higher loss for the case that the CDS is higher than the spread. This result would reveal optimistic preferences, insinuating the existence of market imperfections as we observe a departure from a symmetric loss function.

Table 7 presents *'alphas'* for the sub period post June 2011, the month Portugal joined the financial assistance mechanism, marking the period post Emergency Financing Mechanism (EFM thereafter) and the memorandum of understanding regarding policy conditionality. Early in summer 2011 the second bailout of Greece (109 bn-euros) was also approved as an act to stop contagion across the south of the euro-area. For this sub-period, as reported previously, an asymmetric loss function that clearly leans towards pessimism, despite the second rescue package, is reported for Greece, and interestingly for Porugal. In detail, *'alpha'* takes a value much higher than 0.5 for both Portugal and Greece. For Ireland, Italy and Spain '*alpha'* takes values close to 0.5, implying symmetry.

TABLE 7: '*alpha'* for euro-area debt crisis: Spreads over swap - 5 yr CDS, 01/06/2011 to 30/11/2012.

Linear multivariate loss (p=1)					
D (1,…,3)	Italy	Spain	Portugal	Greece	Ireland
1	0.458*	0.429	0.696**	0.760**	0.486*
2	0.467*	0.476	0.693**	0.888**	0.464
3	0.491***	0.489*	0.693**	0.906**	0.466
Non linear multivariate loss *(p=2)*					
1	0.466*	0.464	0.639*	0.832**	0.471*
2	0.476	0.463	0.624*	0.868**	0.474*
3	0.478***	0.478*	0.623**	0.876**	0.476

Note: Estimates are based on D=1, 2, 3 instruments. The instruments are: a constant (that is D=1), lagged Spread (D=2), as well as the lagged difference between Spread and CDS (D=3). The linear is notified by p=1 case, whilst the non-linear case by p=2. ***, **,* notes significance at 1%, 5%, and 10% respectively.

Interestingly, in the aftermath of the Emergency Financing Mechanism preferences seem to dramatically shift towards pessimism for the small Member States of the euro-area, whilst for the larger ones symmetry prevails.

Overall, our results provide a first insight of the underlying markets' preferences regarding the sovereign debt crisis in the periphery of the euro area. Often it is referred that the market speculates and that is the main reason that sovereign CDS and the sovereign spreads are driven up. Our evidence show that rationality has not been met though once a corrective mechanism, in terms of financial assistance from the euro-area and the IMF, has been established there is some evidence of symmetry in the underlying loss function for larger countries and Ireland. However, this shift of preferences over time could highlight the fragility of the underlying fiscal consolidation of the euro-area.

4.5 Explaining *'alphas': panel regression analysis.*

Post May 2010 and June 2011 the underlying market's preferences show a clear shift towards higher loss for the case that CDS is lower than spread. This implies that market's preferences have clearly shifted towards pessimism over time, notably for Greece and Portugal.

Having derived market's preferences over the euro area sovereign debt crisis, as reflected by the shape parameter '*alpha*', we examine next the impact of market specific variables and sovereign debt on those preferences over time; from 1st quarter 2009 to 4th quarter of 2012. The sample includes Greece, Portugal, Ireland, Italy and Spain and all variables, including '*alpha*', are of quarterly frequency.

Table 8 reports empirical evidence of a fixed effects regression of '*alpha*' with respect to a vector of variables. Moreover, we include variables to account for general economic and financial conditions such as Euribor 3 M, iTraxx Main Investment

Grade index, outstanding bonds as a ratio to GDP capturing sovereign debt on quarterly base, and the spread (defined as the difference between 3 month Euribor-Eurepo).[15] In addition, in order to capture fiscal governance we include in our analysis fiscal rules. Over the last decade the number of fiscal rules in the euro area has substantially increased (Public Finances in EMU, 2006 and 2007). There are many different fiscal rules, i.e. on the revenue side, on the expenditure side at the level of central and/or of regional government. We adopt the classification of fiscal rules as appear in Public Finances in EMU (2006).[16] Interestingly, fiscal rules appears to assert a negative impact on '*alpha*', shifting market preferences towards optimism. On the other hand, Euribor asserts a positive impact on '*alpha*'. Overall, the fit of the fixed effect regression is good.

Table 8: Panel regressions for '*alpha*'.

C	0.6659	0.6214	0.6167	0.6604	0.6410
	0.1876	0.1687	0.1637	0.1946	0.1722
bid	-0.0002	-0.0003	-0.0004	-0.0001	-0.0002
	0.0001	0.0001	0.0002	0.0001	0.0001
d	-0.0342	-0.0414	-0.0410	-0.0366	-0.0375
	0.0200	0.0188	0.0176	0.0208	0.0184
EUbor		0.1086	0.1515		
		0.0400	0.0989		
spread			-0.1204	0.0150	-0.0678
			0.1718	0.0205	0.1136
fr				-0.0653	-0.0810
				0.0193	0.0344
iTraxx					0.0004
					0.0005

[15] The difference between bid and ask for sovereign debt counts for liquidity. Euribor 3M accounts for the risk free rate. The risk free rate could assert a negative impact on spreads, as an increase in risk-free rate would decrease the present value of the expected future cash flows. The iTraxx Main Investment Grade index counts for corporate credit risk. As a measure of fiscal sustainability issues we opt for the total outstanding bonds as percentage to GDP. Bloomberg reports the amount of bonds outstanding on a monthly frequency.

[16] Moreover, following the methodology of Deroose, Moulin, and Wierts (2005) EU Commission constructs a Fiscal Rule Index based on certain criteria (see EU Commission, DG ECFIN, Fiscal Rules, 2009). In this paper we shall follow this methodology and adopt EU Commissions Fiscal Rule Index as our fiscal rule variable.

					0.6410
R-sq(within)	0.088	0.165	0.105	0.143	0.154
F	21.21	24.99	26.4	29.12	31.47

The Fixed effects estimation is opted and the sample covers the period from Q1 2009 to Q4 2012. Robust S.E. in parentheses. The panel is unbalanced, as for some countries (Ireland and Greece) data are available for shorter period.
Note that Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, EUbor is the 3M Euribor, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules, iTraxx is the Main Investment Grade index.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

A common criticism on simple panel regression analysis relates to issues of static nature of such analysis and endogeneity. To deal with these issues we opt for a flexible Dynamic Panel Analysis (DPD) that employs instruments and a GMM estimator (Arellano and Bover, 1995).

Table 6 reports empirical evidence of DPD panel regressions. As above, both fiscal rules and fiscal institutions assert a negative impact on ‘*alpha’*. Fiscal rules and fiscal institutions assert a negative impact on ‘*alpha’*, though only in the former case the result is significant. This implies that enhancing fiscal rules would improve market’s expectations over fiscal sustainability. Similarly to above, the Euribor-Eurepo spread asserts a positive impact on *‘alpha’*, but it is not significant. This result would imply that when the repo rate is lower that the Euribor then it is costly to implement negative *‘basis’* trade, buying sovereign bond and CDS. It is worth noting that in this specification the outstanding debt asserts a small but positive and significant impact on ‘*alpha*’, suggesting that the stock of sovereign debt enhances market’s pessimism by increasing ‘*alpha*’.

Table 6: Dynamic Panel Data regression for *‘alpha’*.

Lag-alpha	-0.2522	-0.2901	-0.3250	-0.2570	-0.2445
	0.2649	0.2143	0.1813	0.2513	0.2528
bid	-0.0001	-0.0003	-0.0008	-0.0004	-0.0006
	0.0001	0.0001	0.0002	0.0002	0.0002
d	-0.0545	-0.0622	-0.0811	-0.0646	-0.0664
	0.0226	0.0219	0.0183	0.0208	0.0256
EUbor		0.1291	0.1771		
		0.0988	0.0719		

spread			-0.9618	-0.6830	-1.2599
			0.4083	0.3072	0.4029
fr				-0.0418	-0.1865
				0.0745	0.1110
itrx					0.0011
					0.0005
Wald	22.18	168.84	723.7	564.9	628.2
AR(2)	0.88	1.06	1.56	1.33	1.08
Hansen	3.94	3.47	0.00	0.00	0.00

Note: Dynamic Panel Analysis using Arelano & Bover method for the period from Q1 2009 to Q4 2012. Robust S.E. in parentheses. The panel is unbalanced, as for some countries (Ireland and Greece) data are available for shorter period.
Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, EUbor is the 3M Euribor, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

The empirical evidence of random effect panel regression and dynamic panel analysis shows that there is a link between fiscal rules, outstanding debt and market's preferences. Moreover, fiscal rules appear to improve expectations over the long-term fiscal sustainability. Fiscal rules appear to improve market's preference towards optimism, whereas outstanding debt deteriorates preference towards pessimism. Fiscal governance could play an important role in shaping preferences over the current sovereign debt crisis.

4.5.1 A Panel-VAR for '*alphas*'.

Next, we shall extend our analysis using a Panel-VAR model. The main advantage of such model is that all variables within the panel VAR enter as endogenous. Thus, the underlying causality between the estimated *'alpha'* and fiscal rules and market specific variables would be identified.

For assisting the exposition we consider a first order 4x4 panel-VAR model:

$$X_{it} = \mu_i + \Phi X_{it-1} + e_{i,t}\,, \quad i = 1,\ldots, \mathrm{N},\ t = 1,\ldots,\mathrm{T}. \quad (18)$$

, where X_{it} is a vector of four random variables, that is, *'alpha'* (α_{it}) and *Bid* (Bid_{it}) as well as a market specific variable the spread between euribor and eurepo ($Spread_t$) and debt measured as outstanding bonds over GDP (d_{it}).

The moving averages (MA) form of the above model sets α_{it}, bid_{it}, d_{it} and $Spread_t$ equal to a set of present and past residuals e_1, e_2, e_3 and e_4 from the panel-VAR estimation.[17]

4.5.2 Panel-VAR estimations.

As a first step and prior to estimate the panel-VAR model we follow Lutkepohl (2006) to test for the optimal lag order *j*. An optimal lag order of one is employed based on the Akaike Information Criterion (AIC) and Arellano-Bond AR tests.[18] Additional lags have been added when testing for autocorrelation. Sargan tests show that for lag order of one the null hypothesis is accepted. Normality tests for the residuals based on Sahpiro-Francia W-test have been also applied.[19]

The impulse response functions (IRF) derived from the unrestricted panel-VAR in the case of *'alpha'* are reported in Diagram 5. The plots report the response of each variable in the panel-VAR to its own innovation and to the innovations of the other variables.

The first row shows the response of *'alphas'* on a one standard deviation shock in liquidity (*bid*), sovereign debt (*d*) and term structure (*spread*). It is clear from the graph that the response of *'alphas'* to liquidity is negative in the first two periods and reverses thereafter to take positive values before convergence. Similar is the response

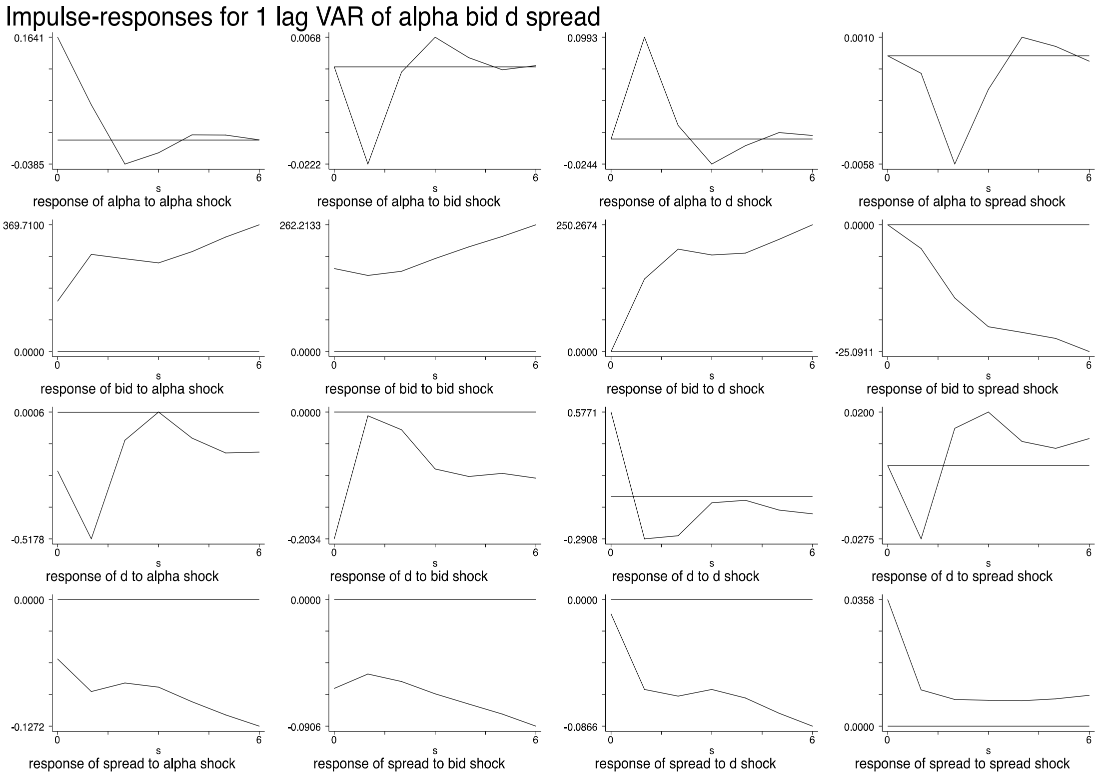
[17] The moving averages (MA) form of the model sets the vector of variables equal to a set of present and past residuals e_1, e_2, e_3 and e_4 from the panel-VAR estimation. The endogeneity assumption implies residuals are correlated and therefore one can not interpret the coefficients of the MA representation. Thus, residuals are orthogonalised by multiplying the MA representation with the Cholesky decomposition of the covariance matrix of the residuals ε_1, ε_2, ε_3 and ε_4.

[18] Results are available upon request.

[19] The results do not show violation of the normality. Panel Var results are available under request. Note that we follow Love and Zicchino (2006) and apply forward mean-differenced using the Helmert procedure in all variables within the VAR. In addition, we report standard errors for impulse response functions (IRF) generated with Monte Carlo simulations.

of alpha to a shock in spread. On the other hand, a shock in outstanding debt asserts a positive impact on *'alphas'* in the first two periods before converging to zero thereafter. These results are in line with the dynamic analysis and suggest that liquidity improve market's preferences towards optimism by lowering '*alphas'*, but outstanding debt contribute to the opposite direction.

Diagram 5: Impulse Response Function (IRF), one lag for *alpha*, liquidity, sovereign debt and term structure.



Note: '*alpha'* counts for the shape parameter of the underlying loss function, Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

Note that there is also some reverse causation, notably in the case of response of spread to a shock in *'alpha'*, which is negative and substantial in magnitude over the whole period. Similarly, the response of outstanding debt to *'alpha'* is also negative for most of the period. These results are of some significance as they provide evidence that market's preferences feed back to the cost of financing debt but also to the level of debt. For example, large values for '*alpha*' by insinuating pessimism would act as a warning signal to fiscally vulnerable economies and could eventually induce fiscal consolidation. On the other hand the response of *bid* on a shock in *‘alpha’* is is positive. To the extent that there is an increase in ‘*alpha*’ away from symmetry and towards high values the underlying market’s pessimism could enhance the role and the necessity of liquidity.

Table 7 presents the variance decomposition (VDC) estimations. These results are consistent with the impulse response functions (IRF) and provide further evidence of the importance of outstanding debt, but also to less extend of fiscal rules, in explaining the variation in ‘*alpha’*. Specifically, close to 25% of forecast error variance of ‘*alpha’* after 10 years is explained by outstanding debt. Furthermore, *bid spread* explains 12.6% of the variation of ‘*alpha*’. Overall, the VDC analysis reaffirms that markets closely monitor fiscal fundamentals and accordingly shape their preferences.

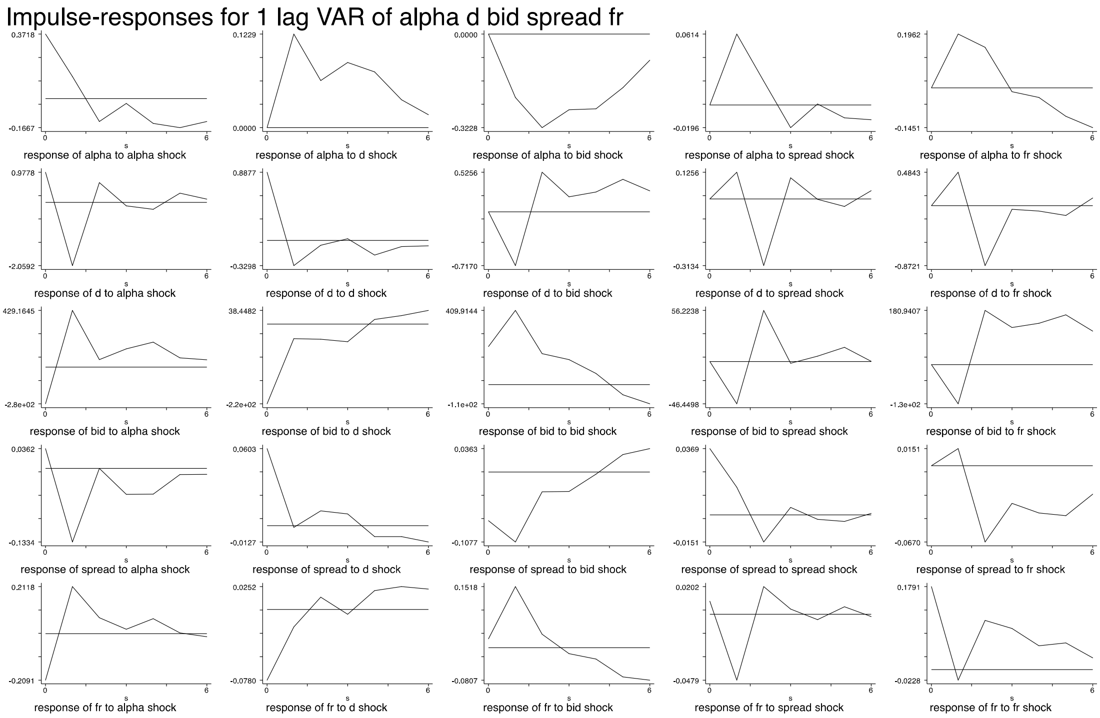
Table 7: Variance Decompositions (VDCs), one lag.

	s	alpha	bid	d	spread
alpha	10	0.7397	0.0126	0.2468	0.0009
bid	10	0.5105	0.2603	0.2270	0.0022
d	10	0.4197	0.1133	0.4652	0.0017
spread	10	0.5030	0.2616	0.2280	0.0073
alpha	20	0.7387	0.0136	0.2467	0.0009
bid	20	0.5069	0.2595	0.2313	0.0024
d	20	0.4820	0.2181	0.2977	0.0022
spread	20	0.5060	0.2596	0.2314	0.0030

Notes: s defines the periods ahead of VDCs.
Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

Diagram 6 reposts IRFs including fiscal rules. Interestingly, both the outstanding debt and fiscal rules assert a positive impact on *‘alphas’*. It is clear from the graph that the response of *‘alphas’* to liquidity is negative over the whole period, whereas the response to spread is positive in the first two periods before reversing. On the other hand, a shock in outstanding debt asserts a positive impact on *‘alphas’* in the first two periods before converging to zero thereafter. These results are in line with the dynamic analysis and suggest that liquidity improve market’s preferences towards optimism by lowering ‘*alphas’*, but outstanding debt contribute to the opposite direction.

Diagram 6: Impulse Response Function (IRF) with fiscal rules.



Note: '*alpha'* counts for the shape parameter of the underlying loss function, Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

Table 8 presents the variance decompositions of the above panel Var.

Table 8: Variance Decompositions (VDCs), 1 lag with fiscal rules.

	s	alpha	d	bid	spread	fr
alpha	10	0.3289	0.3617	0.1253	0.0063	0.1778
d	10	0.3775	0.3409	0.1270	0.0064	0.1482
bid	10	0.6314	0.1076	0.1278	0.0137	0.1196
spread	10	0.3603	0.3260	0.1329	0.0274	0.1534
fr	10	0.4583	0.1780	0.0851	0.0128	0.2658
alpha	20	0.3046	0.3805	0.1323	0.0054	0.1772
d	20	0.3655	0.3408	0.1272	0.0058	0.1606
bid	20	0.6180	0.1165	0.1281	0.0133	0.1240
spread	20	0.3509	0.3251	0.1315	0.0248	0.1676
fr	20	0.4414	0.1885	0.0870	0.0119	0.2712

Notes: s defines the periods ahead of VDCs.
Bid counts for liquidity the difference between bid and ask for sovereign debt, d is the upstanding debt, Spread is the difference between the 3M $Euribor_t$ and $Eurepo_t$, fr_{it} counts for fiscal rules.
The sample includes the following countries: Greece, Ireland, Portugal, Spain and Italy.

Duffie (2010) argue that banks tend to be undercapitalised during financial crisis and this in effect would lead to arbitrage opportunities, whilst Mitchell and Pulvino (2009) demonstrate that during the credit crunch of 2008 illiquid markets contributed to rising costs of holding sovereign bonds due to possible high haircuts. In turn, worsening liquidity conditions would feed into higher sovereign bonds spreads and CDS. The IRFs and VDCs imply that the shift towards pessimism that has taken place post Greek bailout could be the outcome, also, of liquidity constraints through Euribor. But, most importantly, the arbitrage opportunities for sovereign debt along the lines of Duffie (2010) as reflected in the '*basis*' have created a market, the CDS market for euro-area sovereign bonds, that has been rather limited a few years ago. Once CDS market gain significance, a sovereign credit risk mechanism, almost in real time, start to be in operation. [20] This paper shows market's pessimism post Greek bailout, whilst outstanding debt being one of the driving forces. In addition, strengthening fiscal rules could reverse the negative spiral of pessimism, as it appears to improve market's expectations over the fiscal sustainability.

5. Conclusion

In the early years of the euro, the risk premiums on the euro area sovereign bonds were narrowed, whilst exhibited remarkably low volatility. The market considered from 2004 to 2009 that the probability of sovereign default in euro area was negligible. Since late 2009 market's perception has been dramatically shifted towards asserting high probabilities of default for some euro area member states, with Greece having the highest probability of default.

Our results provide a useful source of information for understanding the market's preferences regarding the sovereign debt in euro area. Often it is referred that animal spirits are to be blamed for the very high spreads for some in euro area. This paper reveals that market behavior over time has clearly shifted towards pessimism, insinuating that the risk attitude of major market participants has been altered. We find asymmetry in the underlying loss function, in particular for Greece.

[20] Note that the revealed underlying preferences of the *'basis'* due to CDS in illiquid market conditions would also have financial stability implications. Negative feedback effects could emerge together with counterparty risk, which refers to creditworthiness of protection providers that in turn could feed back to the *'alpha'* dynamics. In general as risk in the inter bank sector increases default protection becomes less valuable.

Nonetheless, an increase in market's pessimism could be considered under certain circumstances, such as periods of excessive credit risk and depletion of capital, to reflect prudent preferences. Therefore, assigning higher loss when the spread is above CDS could improve market efficiency. Yet, as there is no *'one size fits all'* case, judgement over what is prudent behaviour away from a symmetric loss function must be applied with extreme caution. Moreover, if not all participants of sovereign bond markets share the same underlying loss function or have full information about asymmetry, an asymmetric loss function would indicate deviation from rationality.

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