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Fundamentally wrong: market pricing of sovereign and the Greek financial crisis

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Discussion:
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Editorial

On 23-24 May 2013, the Bank of Greece organised a conference on "The Crisis in the Euro Area", in Athens.

The papers and commentaries presented at the conference addressed many important issues related to the functioning of the euro area. Our hope is that these contributions will help improve understanding of the nature of Europe's monetary union, the underpinnings of its crisis, and the changes that are needed so that crises will be prevented in the future.

The papers examined two main sets of issues. One group of papers, adopting a union-wide perspective, assessed the aspects of the euro area's institutional architecture that, with the benefit of hindsight, may have contributed to the crisis, and the policy responses to the crisis at the union level. A second group of papers focused on developments in three crisis countries -- Greece, Ireland, and Portugal.

The papers presented at the conference, with their discussions, will be published in the *Journal of Macroeconomic*s.

Here we present the paper by Heather D. Gibson (Bank of Greece), Stephen G. Hall (University of Leicester, Bank of Greece and University of Pretoria) and George S. Tavlas (Bank of Greece) with its discussion by Thanassis Kazanas (Athens University of Economics and Business) and Elias Tzavalis (Athens University of Economics and Business).

FUNDAMENTALLY WRONG: MARKET PRICING OF SOVEREIGNS AND THE GREEK FINANCIAL CRISIS

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ABSTRACT

We investigate the impact of the economic fundamentals, sovereign credit ratings, political uncertainty, and the ECB's Securities Markets Program (SMP) on Greek sovereign spreads. Our findings show that sovereign downgrades and political uncertainty appear to have been drivers of the sharp rises in Greek sovereign spreads from 2008-9 onwards, over-and-above the impact of the economic fundamentals. Our findings also show that prior to 2008-2009, the markets failed to incorporate Greece's deteriorating fundamentals into the price of Greek sovereigns. We demonstrate that, once markets reassessed their pricing of Greek credit risk, the change in the influence of the fundamentals came swiftly and abruptly, exhibiting overshooting characteristics. The SMP reduced spreads while it was in operation.

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1. Introduction

The unfolding of the Greek sovereign debt crisis beginning in late 2009 -- and the euro-area crisis more generally -- has called into question the extent to which the price of sovereign risk, as reflected in the interest rate spread on sovereigns, can be explained by macroeconomic fundamentals. In the run-up to Greece's entry into the euro area in 2001, the 2-year spread between Greek and German sovereigns fell precipitously, from about 500 basis points in the late 1990s to about 40 basis points at the time when Greece became a member of the single-currency area on January 1, 2001; during that period, the spread on 10-year sovereigns fell from about 600 basis points to about 50 basis points. Over the following years, both the 2-year and 10-year spreads stabilized within a fairly narrow range of 10 to 50 basis points until the end of 2008, despite Greece's large and growing fiscal and external deficits (as we explain below). Then, in October of 2009, a newly-elected Greek government stunned the markets with news that the fiscal deficit for 2009 would likely turn out to be more than twice the outgoing government's projection of 6 per cent of GDP[1].

That news set-off a relentless upward rise of spreads and a succession of ratings' downgrades of Greek sovereigns and Greek banks (which held large portfolios of sovereigns), resulting in what appeared to be self-reinforcing feedback loops between ratings and spreads. The increases in spreads contributed to a sharp contraction of real output, which had a negative impact on the debt-dynamics, a process which itself contributed to rating downgrades, further rises in spreads, and, ultimately, an increase in political uncertainty.[2] This process took place despite an adjustment program agreed between the Greek government and official lenders -- the International Monetary Fund, the European Commission, and the European Central Bank – in May 2010 a program that aimed to stabilize the debt dynamics. The self-reinforcing process finally came to an end in early 2012. By that time it had become clear that the debt dynamics were unsustainable. In March 2012, the Greek government restructured its debt and agreed to a second adjustment program with official lenders. Prior to those actions, the 10-year spread had

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[1] The final figure would be 15.6 per cent of GDP.
[2] Between the end of 2008 and the end of 2012, real GDP contracted by about 20 per cent. As of this writing, it is projected to contract by additional 4 ¾ per cent in 2013, before a return to positive growth in early 2014.

reached 4,000 basis points and, with an inversion of the yield curve (reflecting market expectations of a sovereign restructuring in the near term), the 2-year spread had peaked at 26,000 basis points.

A substantial empirical literature examining the contributions of economic fundamentals to spreads both for the euro area as a whole and for individual euro area countries has already emerged (e.g., De Santis, 2012; Gibson, Hall and Tavlas, 2012; De Grauwe and Ji, 2013; Aizenman, Hutchison, and Jinarak, 2013; Beirne and Fratzscher, 2013; and Mink and de Haan, 2013). Typically, that literature posits that, to the extent that sovereign credit risk cannot be explained by the economic fundamentals, factors related to contagion -- or, more generally, market psychology -- accounted for the unexplained portions of spreads. An earlier study by the present authors followed that approach (see Gibson, Hall and Tavlas, 2012). In that study, we examined the macroeconomic determinants of spreads between the 10-year benchmark Greek government bond and the German 10-year sovereign. Our data sample was monthly and covered the period from January 2000 through September 2010. Thus, our data covered the pre-crisis period (*i.e.*, the period prior to the fall of 2009) and the early part of the crisis period. Our results suggested that spreads were significantly below the levels that would have been predicted on the basis of the fundamentals during the mid-2000s, but significantly above what had been predicted by the fundamentals for much of 2010.

As in our previous study, in this paper we focus on the determinants of Greek sovereign spreads. However, in light of the intensification of the Greek financial crisis after the fall of 2010 (the end-point of our earlier sample period), here we extend the sample period through the first quarter of 2012[3]. Moreover, in addition to examining the determinants of 10-year spreads, we examine the determinants of 2-year spreads. In early-2011, 2-year spreads began to rise far above 10-year spreads, leading (as noted above) to an inverted yield curve. By examining the determinants of the 2-year spread, we are able to focus on the short-term risk (or volatility) that predominated in the markets.

In this paper, we aim to contribute to the existing literature on spreads during the euro-area financial crisis in several ways. First, in addition to investigating the

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[3] The termination date reflected the unavailability of data past 2012:Q1.

relationship between spreads and economic fundamentals, we investigate the relationship between spreads and (a) political uncertainty and (b) sovereign credit ratings. Both of those factors appear, *a priori*, to have played an especially important role during the Greek financial crisis. As explained further below, political uncertainty in Greece underwent a sharp rise in 2008 and again in 2011 and early 2012; the latter period was marked by a political debate that had implications for Greece's remaining in the euro area, thereby introducing *currency* risk into interest-rate spreads.[4] With regard to credit ratings, as mentioned above, a succession of sovereign downgrades created negative feedback loops among (i) spreads, (ii) real economic activity, (iii) debt sustainability, and (iv) credit ratings. The impact of credit downgrades on debt sustainability appears to have been pronounced in the case of Greece since the country began the crisis with a very high debt-to-GDP ratio. Consequently, credit downgrades and the ensuing rises in spreads had the potential to set-off unstable debt-dynamics, leading to the need of debt restructuring, a potential that was, in fact, realized. In other words, debt dynamics in Greece were especially sensitive to credit downgrades and changes in spreads.

Second, we examine the extent to which the determinants of spreads changed over time. In this connection, we use the Kalman filter to estimate the underlying time-varying coefficients of those determinants. By doing so, we are able to measure both the speed with which the impact of the determinants of spreads changed, and the timing of the changes that took place in the coefficients. To preview of our results, we find that for a number of years after Greece's entry into the euro area, markets appeared to effectively discount the economic fundamentals in pricing Greek sovereign credit risk. With the collapse of Lehman Brothers in September 2008, and especially with the unexpected news about Greece's fiscal situation in the fall of 2009, the markets went through a process of learning as they increasingly priced credit (and, perhaps, currency) risk into Greek spreads, at times overpricing risk, thereby contributing to the self-reinforcing character of the crisis.

The remainder of this paper is structured as follows. Section 2 provides a brief overview of the recent literature on the macroeconomic determinants of spreads in the

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[4] The political instability culminated in two national elections in the first half of 2012 -- in May and June, respectively. The latter election led to the formation of a coalition government.

euro area. Section 3 describes our data. Section 4 presents our methodology and the empirical results. Section 5 concludes.

2. Related literature

The recent macro-international finance literature has focused on two presumably separate measures of sovereign risk -- (1) spreads on government bond yields, and (2) CDS spreads. As Aizenman, Hutchison and Jinjarak (2013, p.41) pointed out, however, recent studies suggest that both reference measures have common underlying determinants, rather than being entirely separate measures.[5] As is the case for the literature more broadly, studies that have focused on euro-area countries have found that macroeconomic fundamentals play an important role in determining sovereign risk (*e.g.*, Doetz and Fischer, 2010; Gibson, Hall and Tavlas, 2012; Aizenman, Hutchison and Jinjarak, 2013; Beirne and Fratzscher, 2013; DeGrauwe and Ji, 2013).[6]

A common finding that has emerged from the literature dealing with spreads in the euro area is that there is a substantial difference between the effects of macroeconomic variables on sovereign risk when the sample period excludes the crisis period and the effects of those variables when the sample period includes the crisis period. The precise dating of the start of the crisis period varies, however, depending upon whether the start of the period is considered to be the outbreak of the U.S. subprime crisis in the summer of 2007, the collapse of Lehman Brothers in September 2009, or the eruption of the Greek sovereign debt crisis in the fall of 2009. Bernoth, von Hagen and Schuknecht (2012), treating the former (subprime) episode as the start of the crisis period, found that macroeconomic fundamentals were not significant determinants of spreads in the pre-crisis period but were significant if the sample is extended to include the crisis period. Von Hagen, Schuknecht and Wolswijk (2011) found that, while bond yield spreads in the euro area before and during the crisis can be explained largely by fundamentals, the market has penalized fiscal imbalances much more severely in the period after the collapse of Lehman Brothers than in the period before that episode. Similarily, Afonso,

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[5] See, also, Ammer and Cai (2007) and Fontana and Scheicher (2010).
[6] Typically, the literature has found roles for other factors, including measures of international market volatility and capital flows into government bond markets, as drivers of sovereign risk.

Argyrou and Kontonikas (2012) found that euro-area bond spreads are well-explained by the macroeconomic fundamentals if account is taken of the onset of the global financial crisis in the summer of 2007, but spreads are not well-explained by the same fundamentals in the pre-crisis period.

An inference that can be drawn from the results of the above studies is that markets understated -- or even overlooked -- the role of some of the macroeconomic fundamentals in the determination of sovereign risk in the years leading up to the global financial crisis. In what follows, we investigate the reasons for this market behavior with respect to spreads on Greek sovereigns. In particular, we examine the relationship between macroeconomic fundamentals and Greek spreads, whether the fundamentals were important determinants of spreads prior to the outbreak of the Greek sovereign crisis, and, if not, whether and when they became significant determinants of spreads. In investigating the role of fundamentals, we control for potential independent influences stemming from political stability and ratings downgrades.

3. Data and stylized facts

Typically, studies that deal with the macroeconomic determinants of sovereign risk focus on fundamentals that capture fiscal sustainability and external sustainability and/or competitiveness. Measures of fiscal sustainability include the fiscal balance and public debt. Measures of external sustainability and/or competitiveness include the current account balance, external debt, relative prices, trade openness and real growth (an important determinant of the sustainability of a country's external obligations). Where appropriate, variables are specified as ratios to GDP. Note that the foregoing variables tend to be interrelated. For example, an expanding fiscal deficit is often accompanied by an expanding external deficit and growing external debt, while a deterioration in competitiveness, as defined by movements in relative prices, tends to be accompanied by growing external and fiscal imbalances. In addition to variables representing macroeconomic fundamentals, in our previous study (Gibson, Hall and Tavlas, 2012) we introduced a fiscal "news" variable in our specification of the determinants of Greek bond spreads on the supposition that unexpected (positive or negative) news -- especially a

series of unexpected developments -- about fiscal fundamentals can drive market dynamics, particularly in the short term. We found that the accumulation of fiscal news had a significant impact on Greek sovereign spreads, a finding corroborated in a different context (both in terms of the definition of a news variable and in terms of countries considered) by Beetsma, Giuliodori, de Jong and Widijanto (2013).

We now turn to a description of the variables used in this study. Our sample period runs from January 2000 to March 2012; the data frequency is monthly. Figure 1 shows the evolution of spreads during the period from January 2008 until March 2012. (Prior to January 2008, both 2-year and 10-year spreads remained in a fairly narrow range of 20 to 50 basis points.) With the collapse of Lehman Brothers in September 2008, 2-year and 10-year spreads both began to rise. That rise became highly accentuated with the news about Greece's fiscal situation in the fall of 2009. By May 2010, the time of the first Greek adjustment program, 2-year spreads had reached around 850 basis points and 10-year spreads had reached 565 basis points. The agreement of Greece's adjustment program contributed to a narrowing of spreads until the fall of 2010, under the presumption in the markets that the debt-dynamics had stabilized. However, in late 2010 it became increasingly evident that the adjustment program had gone off-track. Markets began to speculate that Greece would need to restructure its debt; spreads accelerated sharply upward, with the acceleration of the 2-year spread far outpacing that of the 10-year spread.

The above story is reflected in the yield curves. Figure 2 shows the Greek sovereign yield curve at specific dates. The upper part of Figure 2 shows the yield curve at four dates – 30 December 2005; 30 December 2008; 26 February 2010; and 30 April 2010. For the first three dates, the yield curve displays a normal upward slope, while steepening and shifting upward over time. By 30 April 2010, just prior to the agreement on the Greek adjustment program (2 May), the yield curve had become inverted while shifting farther upward, with 10-year yields reaching 9 per cent and 2-year yields reaching 13 per cent. The lower part of Figure 2 shows the yield curve at three dates: 30 April 2010 (repeating the upper part of the figure for that date); 30 September 2011; and 29 February 2012. (Note the difference in the y-axes between the upper and lower parts of Figure 2.)

The inversion of the yield curve became more pronounced, reflecting increased market expectations of a debt restructuring.

To capture the effects of the fundamentals (economic and political) on spreads, we use the following variables. We include three measures of the fiscal situation.

(1) *The ratio of government debt to GDP.* The upper part of Figure 3 shows the evolution of this variable. Greece entered the euro area with a debt ratio that was close to 100 per cent. By 2006 that ratio had risen to about 110 per cent, where it remained until 2009. The sustainability of the debt-to-GDP ratio was clearly dependent on the sustainability of robust real GDP growth rates; between 2001 and 2007 real GDP rose at an average rate of almost 4 per cent a year. Real growth moved into negative territory beginning in late 2008, leading a sharp upward jump in the debt ratio in 2009 and the debt dynamics became unsustainable.

(2) *The government fiscal balance relative to GDP.* The middle part of Figure 3 shows the evolution of this variable. During much of the period from 2001 through 2006, the deficit exceeded 5 per cent of GDP, despite the high GDP growth rates. This situation is explained by the fact that government spending was used to help generate economic growth.[7] By 2007, the deficit-to-GDP ratio began rising, peaking at 15 ½ per cent in 2009.

(3) *Fiscal news.* Since Greece's entry to the euro area in 2001, Greek fiscal data have been subjected to a number of revisions, sometimes several years after the initial (real-time) release of the data. These revisions have often involved upward revisions of the fiscal imbalances, generating negative surprises. In order to capture the news (or surprise) element that has figured prominently in the Greek experience, we construct real-time fiscal data. In particular, using the European Commission spring and autumn forecasts, we create a series of forecast revisions. We define, the revision in the spring 2001 forecasts, for example, as the 2001 deficit/GDP ratio in the spring compared to the forecast for 2001 made in the autumn of 2000. This procedure allows us to generate a series of revisions which,

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[7] Between 2001 and 2009 the share of government spending in GDP rose by 9 percentage points, to 54 per cent.

when cumulated over time, provides a cumulative fiscal news variable. As shown in the lower part of Figure 3, the fiscal news variable deteriorated throughout 2000-2010, especially during the latter part of the period.

We use three variables to capture competitiveness.

(1) *Relative prices.* With Greece's nominal exchange rate fixed against those of the other euro-area countries, we use the Greek consumer price level relative to that of Germany as a measure of the change in competitiveness. The top part of Figure 4 displays this variable. As shown in the figure, Greece's competitiveness deteriorated markedly throughout the sample period.

(2) *Oil prices.* The Greek economy is the most oil-dependent in the euro area. Consequently, changes in oil prices have substantial effects on Greece's current account balance. Our oil price variable is the US dollar price of a barrel of Brent crude, and is displayed in the middle part of Figure 4.

(3) *Current-account balance.* As shown in the bottom part of Figure 4, Greece entered the euro area with a current account deficit of about 7 per cent of GDP. In the years leading up to the outbreak of the Greek crisis, the deficit widened, peaking at 15 per cent of GDP in 2008.

In addition to fundamentals dealing with the fiscal and external situations, we use the following variables.

(1) *Real GDP growth.* High real growth helps improve debt sustainability; therefore, all other factors held equal, we expect higher growth to reduce spreads. Figure 5 displays the growth rate. As noted above, real growth averaged almost 4 per cent per year during 2001-07, before plunging in late 2008.

(2) *Securities Markets Program (SMP).* In May 2010, the European Central Bank (ECB) embarked on a program under which the ECB purchased Greek sovereigns. The objective was to reduce spreads. The SMP was implemented at various times during the period from May 2010 through January 2011. We use a dummy variable to capture the impact of the SMP.

(3)   *Sovereign Downgrades.* We use the ratings assigned to Greek sovereigns by Moody's, S&P and Fitch. From March 2001 until the end of 2008, Greek sovereigns were rated A/A$^+$ by all three rating agencies. A series of downgrades began in early 2009, with the frequency of the downgrades accelerating in 2011. In February 2010, the Greek sovereign was downgraded to selective default. These downgrades are displayed in Figure 6. We assign values of 1-22 to different possible ratings (higher values represent a deterioration in ratings); changes in the ratings variable are based on which of the three agencies moved first. In this way, we capture what might be termed "important" rating downgrades or upgrades. However, ratings are dependent, in part, on the economic fundamentals. To deal with the issue of endogeneity, we regress our ratings variable against the economic fundamentals and use the residuals in our spreads' equations as a measure of the impact of ratings agencies, purged of economic fundamentals. The objective is to examine the extent to which rating downwards may themselves have exerted an independent influence on spreads -- over-and-above the influence of the fundamentals.

(4)   *Political uncertainty.* We use the IFO World Economic Survey Index of Political Stability for Greece. Figure 6 shows the evolution of this index. A fall in the index signifies an increase in political uncertainty. The drop in the index in 2007-2008 reflects a series of domestic developments that seriously weakened the then-ruling Conservative Party. The further drop in the index in 2011 reflects the impact of the sovereign debt crisis.

    The evolutions of the above variables tell a coherent story. Upon entry into the euro area, Greece benefited from a low-interest rate environment, which contributed to high real growth rates. Nevertheless, the Greek economy walked a razor's edge between debt sustainability and unsustainability. Throughout the period 2001 to 2009, fiscal imbalances built up, despite robust real growth rates and low interest rates, and competitiveness deteriorated. Until late 2009, however, spreads displayed little sensitivity to the warning alarms embedded in the fundamentals. Did the markets pay attention to any of the foregoing fundamentals? If so, which fundamentals? When did the markets begin to use the fundamentals to price risk into spreads? What roles did political

uncertainty, SMP interventions, and rating downgrades play in the determination of spreads, over-and-above the role of the economic fundamentals? To answer these questions, we now turn to a formal analysis.

4. Empirical results

We begin by testing for cointegration among the above variables for both the 10-year and the 2-year spread, assuming that the SMP dummy is exogenous. The results are reported in Table 1 for the 10-year spread and Table 2 for the 2-year spread. For the 10-year spread there is strong evidence of up to six cointegrating vectors. As shown in Table 2 for the 2-year spread, there is evidence of at least five -- and possibly six (using the trace statistic) -- cointegrating relationships. Again, the hypothesis that spreads are exogenous is rejected. An implication of these results is that we can treat spreads as endogenous. We now proceed to an investigation of their determinants.

We begin with a simple static regression, which we interpret as the long-run determination of spreads. Given our above intuitive account of the evolution of the fundamentals and spreads, we do not expect this relationship to necessarily exhibit stable parameters and we are not especially concerned with the economic interpretation of each of the fundamentals. Our objective here is simply to use the basic specification as a point of departure for a time-varying analysis.

The results for the 10-year and 2-year spreads are reported in Tables 3 and 4, respectively[8]. The main findings can be summarized as follows. For the 10-year spread equation, seven variables are correctly signed and significant -- the debt-to-GDP ratio, fiscal news, real growth, oil prices, political uncertainty, the SMP program, and the residuals of an equation in which the economic fundamentals are used to determine ratings (see Appendix 1)[9]. The remaining four variables (the current account deficit-to-

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[8] In interpreting these results, note that both the current-account balance and the fiscal balance (as percentages of nominal GDP) are treated in the following way. Declines in the current account and fiscal deficits should reduce spreads; hence, the signs on both variables are expected to be negative.
[9] The results are also economically significant. Thus, for example, a one standard deviation rise in the debt-to-GDP ratio (equivalent to a rise of 17.5 percentage points) leads to a rise in 10-year spreads of almost 240 basis points. A one standard deviation rise in growth (0.6 of a percentage point) causes spreads to fall by 90 basis points. A one standard deviation rise in oil prices leads to a 90 basis points rise in spreads.

GDP ratio, relative prices, and fiscal deficit-to-GDP ratio) are either insignificant or incorrectly signed. This finding is not surprising; these three variables are measures of either the fiscal situation or competitiveness. Hence, they are collinear with other variables in the regression. For the 2-year spread equation, six variables are significant and correctly signed -- fiscal news, growth, oil prices, political uncertainty, the SMP program, and the residuals from the ratings equation[10].

In interpreting these results, several points merit comment. First, to the extent that ratings were determined by the existing fundamentals -- and not the expected future fundamentals -- ratings downgrades appear to have played a very important effect on spreads, over-and-above the impact of the economic fundamentals. To explain, consider that for the 10-year spread regression, the adjusted R-squared *without* the residuals from the ratings equation is 0.733 (see Appendix 1), with the residuals from the ratings equation included the adjusted R-squared rises to 0.916. For the 2-year-spread equation, the adjusted R-squared without the ratings variable is 0.594 (see Appendix 1); with the ratings variable the adjusted R-squared is 0.876. An implication of these findings is that ratings downgrades led to a self-perpetuating rise in spreads. Second, political uncertainty also appears to have contributed to the rise in spreads -- higher stability reduces spreads. The decline in political stability beginning in 2007 and continuing in 2011 raised spreads. Third, the SMP program appears to have reduced spreads during the short period during which it operated in Greece. In the case of the 10-year spread, SMP intervention reduced spreads by about 3 percentage points. For the 2-year spread, SMP intervention reduced spreads by about 33 percentage points. Fourth, the explanatory power of the equation for the 10-year spread is somewhat higher than the equation for the 2-year spread (0.916 for the former equation, 0.876 for the latter equation). Evidently, market psychology played a greater role in the evolution of the 2-year spread than the 10-year spread.

As we indicated above, it may have been the case that rating agencies formulated their ratings of Greek sovereigns on the basis of both present and *projected* fundamentals. In that case, the residuals from a ratings regression involving both present and projected

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[10] The impact of a one standard deviation increase in the explanatory variables on 2-year spreads is much greater than their impact on 10-year spreads,, reflecting the high levels to which 2-year spreads rose in the latter part of the sample.

fundamentals would have been smaller than a regression based only on present fundamentals, and the impact of these residuals on spreads would (likely) have been smaller as well. Thus, to the extent that ratings were made on the basis of both present and projected fundamentals, our conjecture that ratings downgrades led to self-perpetuating rises in spreads needs to be tempered. Nevertheless, there are also several reasons to suppose that our empirical methodology does not fully capture the self-reinforcing impact of downgrades. First, we focused on the effects of *sovereign* downgrades. In fact, the developments during 2010-2012 were more complex. Sovereign downgrades led to downgrades of bonds issued by Greek banks, in part, since the banks held large amounts of Greek sovereigns in their portfolios. The downgrades of the banks affected their ability to provide liquidity to the economy, thus contributing to the contraction of real output, and to further sovereign downgrades. Our methodology does not fully capture such dynamics. Second, the actual *pattern* of downgrades was much more complex than what we assumed. Typically, each sovereign downgrade led to a rise in spreads. Each rise in spreads led to further downgrades --of both sovereigns and banks-- in a chain of self-reinforcing moves. In our measure of ratings, we include only the first downgrade in any chain – the first being what we identify to be a downgrade to a new lower level (*e.g.,* BBB- to BB+). After accounting for a downgrade of the sovereign to a specific rating, we do not account for subsequent downgrades of the sovereign by *other* rating agencies to the some rating level (another agency effectively downgrading from BBB- to BB+). Yet these follow-on downgrades affected spreads in much the same way as the initial downgrade to the new lower level. These various feedback loops appear to have contributed to unfolding of events that in fact took place.

We now consider how precisely the effects of the fundamentals have changed over time.[11] To do so, we use the Kalman filter. The specific Kalman filter model we use is a time-varying parameter model (see Cuthbertson, Hall and Taylor, 1992) that provides consistent estimates of the underlying time-varying coefficients. It is set up in the form of a state space model consisting of a measurement equation and a set of state equations which govern the evolution of the parameters. Our measurement equation is exactly the

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[11] We tested the above models for stability using recursive estimation and found that both equations are highly unstable. Recursive estimation does not, however, provide consistent estimates of the underlying parameters if there is instability, as each recursion is based on the assumption of constant parameters

same specification as the two estimated models above. The state equations, for the parameters, specify that they follow a simple random walk, thus allowing them considerable freedom to change over time.

The time-varying-parameter model, with the appropriate Kalman filter equations for the univariate case, following Harvey (1987), is given by the following. Let

$$Y_t = \delta' z_t + \varepsilon_t \tag{1}$$

be the measurement equation, where y_t is a measured variable, z_t is the state vector of unobserved variables, δ is a vector of known parameters, which in this case are our explanatory variables, and $\varepsilon_t \sim \text{NID}(0, \Gamma_t)$. The state equation is then given as:

$$z_t = \Psi z_{t-1} + \psi \tag{2}$$

where Ψ are parameters and $\psi \sim \text{NID}(0, Q_t)$, Q_t is sometimes referred to as the hyperparameters. The appropriate Kalman filter prediction equations are then given by defining z_t^* as the best estimate of z_t based on information up to t, and P_t as the covariance matrix of the estimate z_t^*, and stating:

$$z_{t|t-1}^* = \Psi z_{t-1}^* \tag{3}$$

and

$$P_{t|t-1} = \Psi P_{t-1} \Psi' + Q_t \tag{4}$$

Once the current observation on y_t becomes available, we can update these estimates using the following equations:

$$z_t^* = z_{t|t-1}^* + P_{t|t-1}\delta(Y_t - \delta' z_{t|t-1}^*)/(\delta' P_{t|t-1}\delta + \Gamma_t) \tag{5}$$

and

$$P_t = P_{t|t-1} - P_{t|t-1}\delta\delta' P_{t|t-1}/(\delta' P_{t|t-1}\delta + \Gamma_t) \tag{6}$$

Equations (1)-(6) then represent jointly the Kalman filter equations.

If we then define the one-step-ahead prediction errors as,

$$v_t = Y_t - \delta' z^*_{t|t-1} \tag{7}$$

then the concentrated log likelihood function can be shown to be proportional to

$$\log(l) = \sum_{t=k}^{T} \log(f_t) + N\log(\sum_{t=k}^{T} v^2{}_t \, / \, Nf_t) \tag{8}$$

where $f_t = \delta' P_{t|t-1}\delta + \Gamma$ and N=T-k, where k is the number of periods needed to derive estimates of the state vector; that is, the likelihood function can be expressed as a function of the one-step-ahead prediction errors, suitably weighted.

We now turn to the results of the Kalman filter exercise. Did markets continuously focus on the same fundamentals throughout the sample period? Was the sensitivity of spreads to those fundamentals stable? In Figures 7 and 8, we plot the coefficients from Kalman filter estimates of the regressions for the 10-year spread and the 2-years spread, respectively from 2006 onwards. Looking first at the 10-year spread, several conclusions can be drawn. First, for the period before the international financial crisis, markets largely ignored all fundamentals in pricing spreads. Specifically, the coefficients on most of the variables are near zero until 2008-9. Second, for those variables which were correctly signed and significant (debt, fiscal news, growth, oil prices and political stability in our above static regression), there is evidence that markets began to price developments into yields and spreads as early as 2008, and more strongly from 2009. Third, the time-varying coefficients on those variables (the current account, the deficit-to-GDP ratio and, to a lesser extent, relative prices), that had incorrect signs (in our static regressions), move much later – in 2010 and 2011 – reflecting the large volatility of spreads which characterizes the latter part of the sample period. Fourth, the influence of political stability kicks in from early 2009 and then more strongly in 2011, as would be expected. Finally, the residuals from the ratings equations show a sharp increase from early 2011, reflecting the large number of downgrades that occurred along with the fact that they

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were multiple notch downgrades – in early 2011 Greece was BB+; by the end of the sample, she had been downgraded to Selective Default.

In the case of 2-year spreads (Figure 8), the coefficients are more unstable than they are for the 10-year spreads. The current account actually has the correct sign (negative) until the latter part of the sample; the same pertains to the fiscal deficit. Nevertheless, as in the case of the 10-year spread, the coefficients on the fundamentals are again close to zero until 2008-9. There is again evidence that the markets slowly woke up to the fundamentals after the surprise news about Greece's fiscal situation in late 2009.

5. Conclusions

The main conclusions of this paper are as follows. First, the time-varying results indicate that the coefficients on most, if not all, of the variables were near zero until 2008-9. In other words, prior to 2008-9, financial markets paid little attention to the deteriorating Greek economic fundamentals in pricing spreads. Effectively, the markets treated Greek sovereigns almost on a par with German sovereigns. Thus, the markets failed to incorporate credit risk in the price of Greek sovereigns, presumably because the markets expected that Greek sovereigns would be protected by the core euro-area countries should the need arise. Second, sovereign downgrades and political uncertainly appear to have been drivers of the sharp rises in Greek sovereign spreads from 2008-9 onwards, over-and-above the impact of the economic fundamentals. An implication of our finding of a separate effect on spreads from the credit downgrades is the following; negative feedback loops between spreads, real economic activity, debt sustainability and credit ratings, perpetuating and deepening the financial crisis. Third, the Eurosystem's SMP programme had a pronounced effect on reducing spreads whilst the programme was in place. Fourth, our time-varying results provide support for the view that once markets reassessed their pricing of Greek credit risk, the change in the influence of the fundamentals came swiftly and abruptly, exhibiting overshooting characteristics, thus suggesting that market psychology played an independent role in the pricing of spreads.

These conclusions suggest that markets were not rational during the sample period considered in this paper. While the above evidence is consistent with the self-reinforcing-feedback-loop hypothesis, a fuller analysis would require that ratings and spreads be modeled as a simultaneous system. Such a system could be used to quantify the degree of overshooting of spreads from the fundamentals. We leave this idea as a suggestion for future research.

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Table 1: Cointegration tests: 10-year spread

Sample (adjusted): 2000M04 2012M03   144 observations
Lags interval (in first differences): 1 to 2
Endogenous variables included: 10-year spreads, current-account-to-GDP ratio, relative prices, general government balance, good fiscal news (squared), growth, oil prices, political stability, residuals from ratings regression. Exogenous variable: SMP

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
None *	0.601	497.59	239.24	132.41	64.50
At most 1 *	0.518	365.18	197.37	105.12	58.43
At most 2 *	0.460	260.06	159.53	88.83	52.36
At most 3 *	0.293	171.23	125.62	50.02	46.23
At most 4 *	0.254	121.21	95.75	42.14	40.08
At most 5 *	0.226	79.06	69.82	36.80	33.88
At most 6	0.134	42.26	47.86	20.70	27.58
At most 7	0.087	21.56	29.80	13.17	21.13
At most 8	0.053	8.39	15.49	7.86	14.26
At most 9	0.004	0.53	3.841	0.53	3.84

Test for exogeneity of 10-year spreads
Cointegration restrictions: A(1,1)=0, A(1,2)=0, A(1,3)=0, A(1,4)=0, A(1,5)=0, A(1,6)=0
LR test for binding restrictions: Chi-square(6)=43.60   Probability=0.00
* denotes rejection of the hypothesis at the 0.05 level.

Table 2: Cointegration tests: 2-year spread

Sample (adjusted): 2000M04 2012M03   144 observations
Lags interval (in first differences): 1 to 2
Endogenous variables included: 2-year spreads, current-account-to-GDP ratio, relative prices, general government balance, good fiscal news (squared), growth, oil prices, political stability, residuals from ratings regression. Exogenous variable: SMP

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
None *	0.596	504.37	239.24	130.37	64.50
At most 1 *	0.552	373.99	197.37	115.67	58.43
At most 2 *	0.450	258.32	159.53	86.17	52.36
At most 3 *	0.306	172.15	125.62	52.57	46.23
At most 4 *	0.251	119.58	95.75	41.66	40.08
At most 5 [+]	0.193	77.93	69.82	30.80	33.88
At most 6	0.144	47.125	47.86	22.42	27.58
At most 7	0.103	24.70	29.80	15.67	21.13
At most 8	0.053	9.03	15.49	7.88	14.26
At most 9	0.008	1.15	3.84	1.15	3.84

Test for exogeneity of 10-year spreads
Cointegration restrictions: A(1,1)=0, A(1,2)=0, A(1,3)=0, A(1,4)=0, A(1,5)=0, A(1,6)=0
LR test for binding restrictions: Chi-square(6)=43.60   Probability=0.00
* denotes rejection of the hypothesis at the 0.05 level; [+] denotes rejection by the trace statistic at 0.05 level.

Table 3: 10-year spread – OLS regression

Sample: 2000M01 2012M03   Observations: 147

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-6.411	3.29	-1.95	0.05
Current account to GDP	5.886	3.39	1.74	0.08
Relative prices	-14.754	6.39	-2.31	0.02
Government balance to GDP	0.277	0.05	5.89	0.00
Debt to GDP	0.136	0.02	6.51	0.00
Fiscal news	-0.038	0.01	-6.16	0.00
Growth	-149.108	38.27	-3.90	0.00
Oil prices	0.030	0.01	2.73	0.01
Political stability	-0.831	0.21	-3.92	0.00
SMP	-3.230	0.83	-3.89	0.00
Residuals from ratings equation	1.718	0.09	18.18	0.00

R-squared	0.922	Mean dependent var	2.913
Adjusted R-squared	0.916	S.D. dependent var	6.428
S.E. of regression	1.857	Akaike info criterion	4.148
Sum squared resid	469.232	Schwarz criterion	4.3726
Log likelihood	-293.893	Hannan-Quinn criter.	4.239
F-statistic	161.176	Durbin-Watson stat	0.764
Prob(F-statistic)	0.000		

Table 4: 2-year spread – OLS regression

Sample: 2000M01 2012M03   observations   147

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	90.955	21.34	4.26	0.00
Current account to GDP	-6.290	21.98	-0.29	0.78
Relative prices	-161.857	41.43	-3.91	0.00
Government balance to GDP	1.77497	0.31	5.81	0.00
Debt to GDP	-0.283	0.14	-2.09	0.04
Fiscal news	-0.307	0.04	-7.74	0.00
Growth	-1943.101	248.33	-7.82	0.00
Oil prices	0.182	0.07	2.55	0.01
Political stability	-7.197	1.38	-5.23	0.00
SMP	-32.695	5.39	-6.07	0.00
Residuals from ratings equation	10.804	0.61	17.62	0.00

|			
R-squared	0.876	Mean dependent var	8.813
Adjusted R-squared	0.867	S.D. dependent var	33.078
S.E. of regression	12.0528	Akaike info criterion	7.888
Sum squared resid	19756.59	Schwarz criterion	8.112
Log likelihood	-568.794	Hannan-Quinn criter.	7.979
F-statistic	96.366	Durbin-Watson stat	0.393
Prob(F-statistic)	0.000		

Figure 1: Greek government bond yield spreads (relative to Germany)
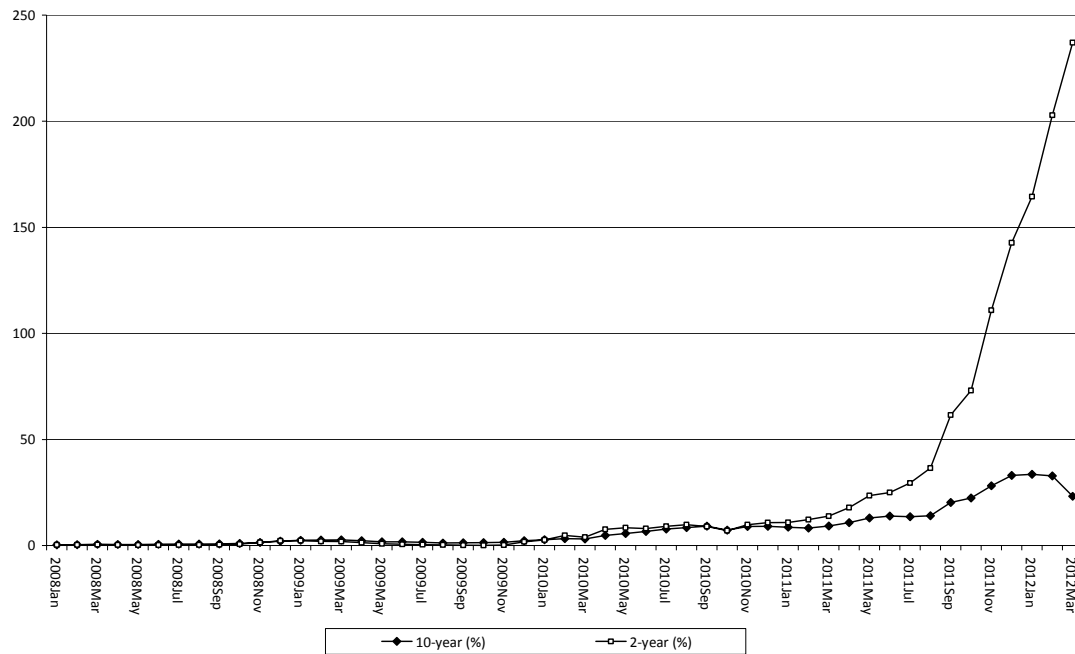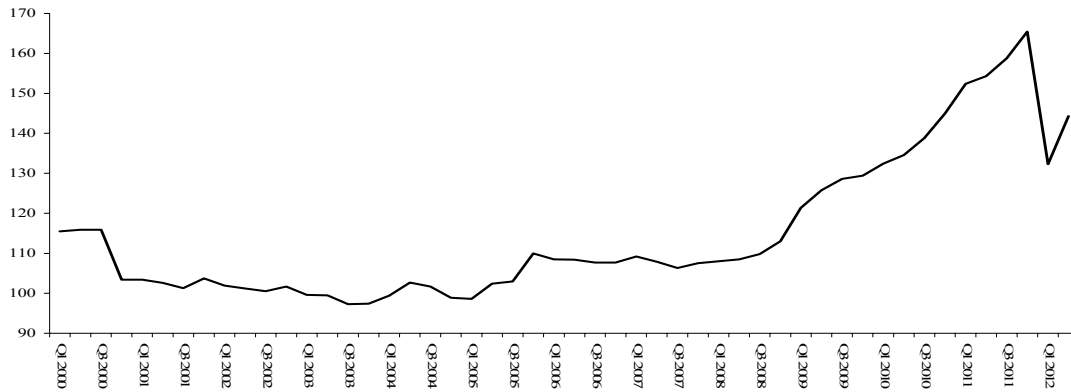

Source: ECB Statistical Data Warehouse

Figure 2: The Greek yield curve at selected dates

Greek Yield Curve - preMoU

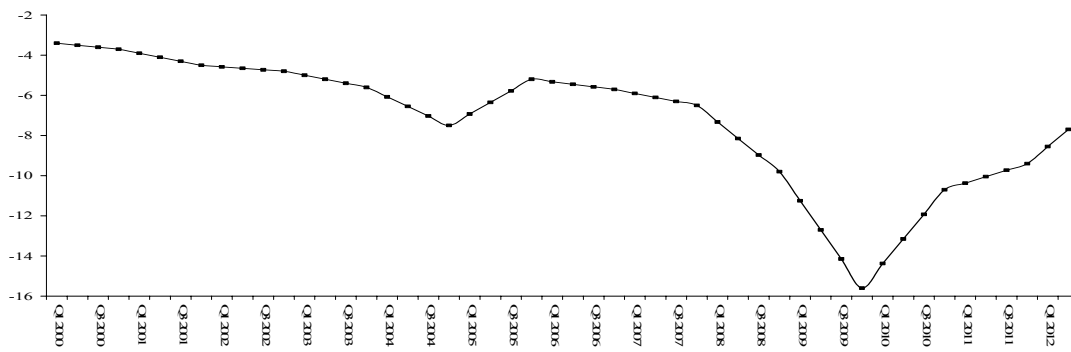Greek Yield Curve - MoU and after
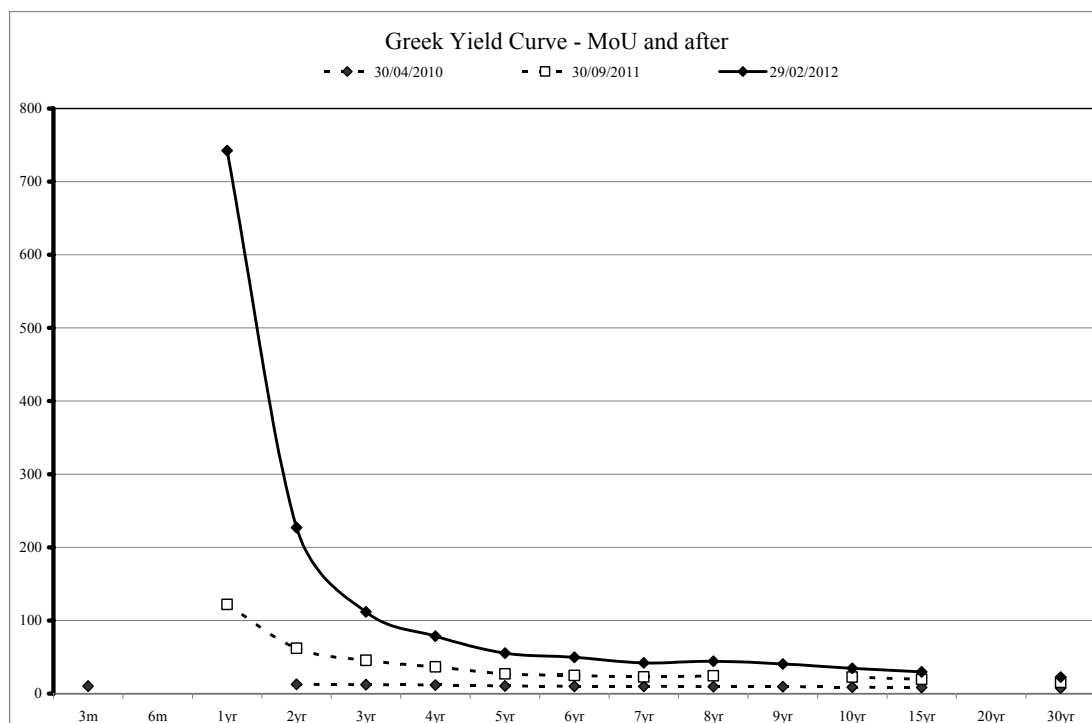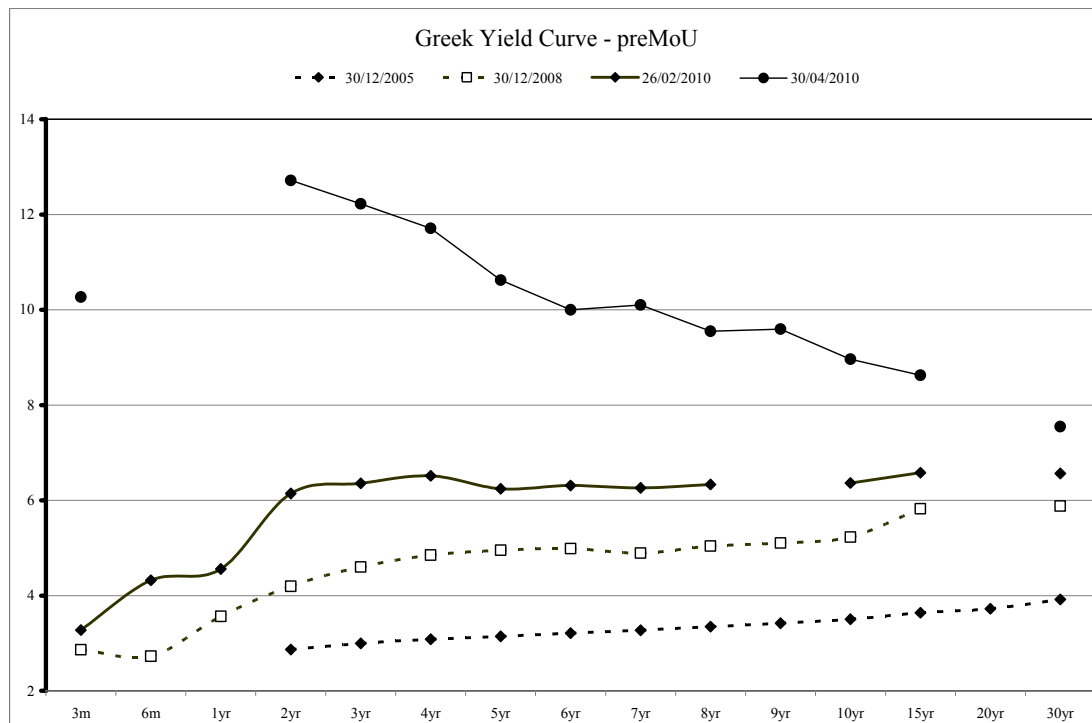
Source: Bloomberg

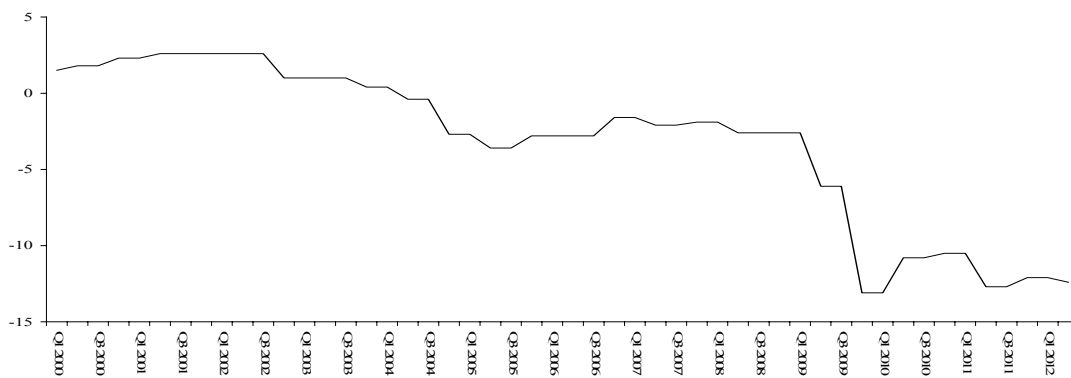**Figure 3: Fiscal indicators**

Debt-to-GDP ratio
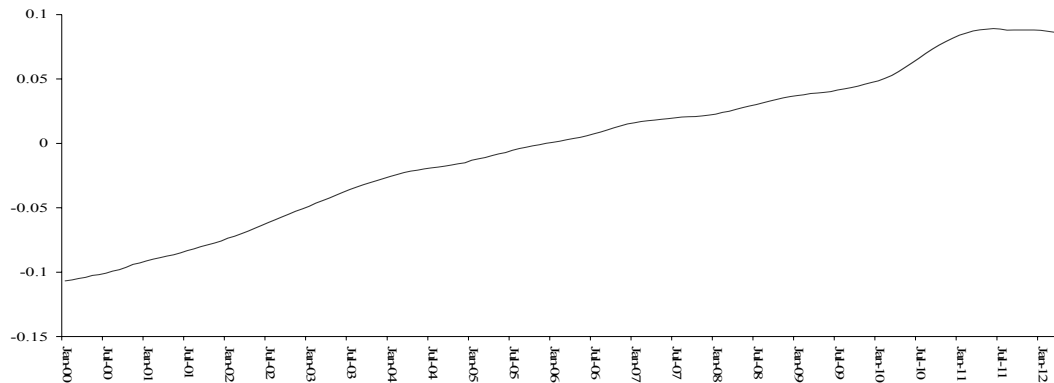

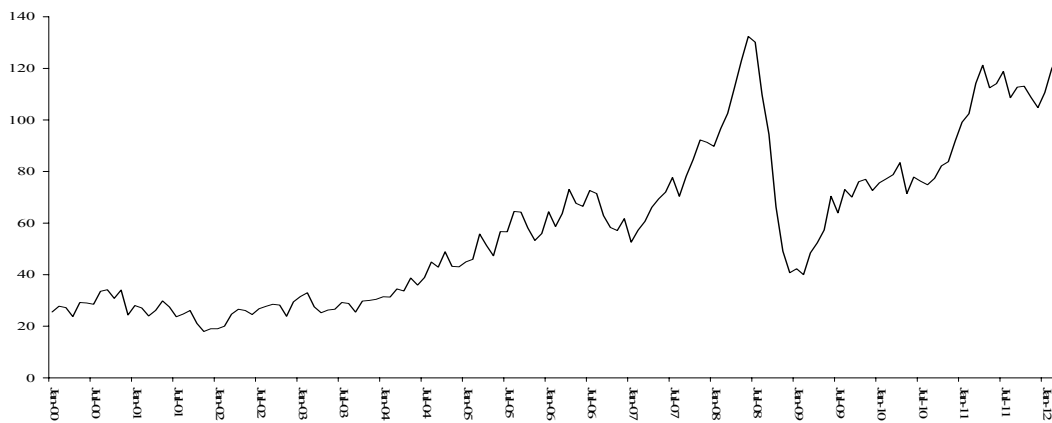**Fiscal balance to GDP ratio**

Fiscal news

Source: Debt and general government balance, Datastream; Fiscal news, own calculations from EC forecasts.

Figure 4: Competitiveness indicators
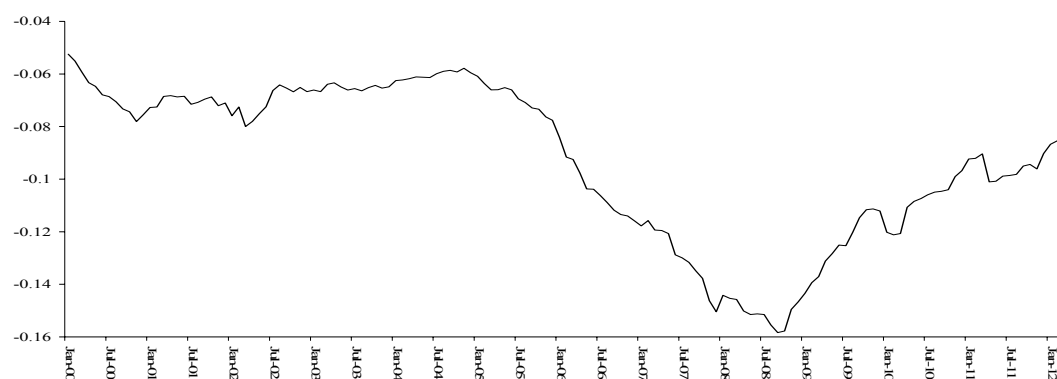
Relative prices (ln HICP Greece – ln HICP Germany)

Brent oil price (US$ per barrel)

Current account balance (proportion of GDP)
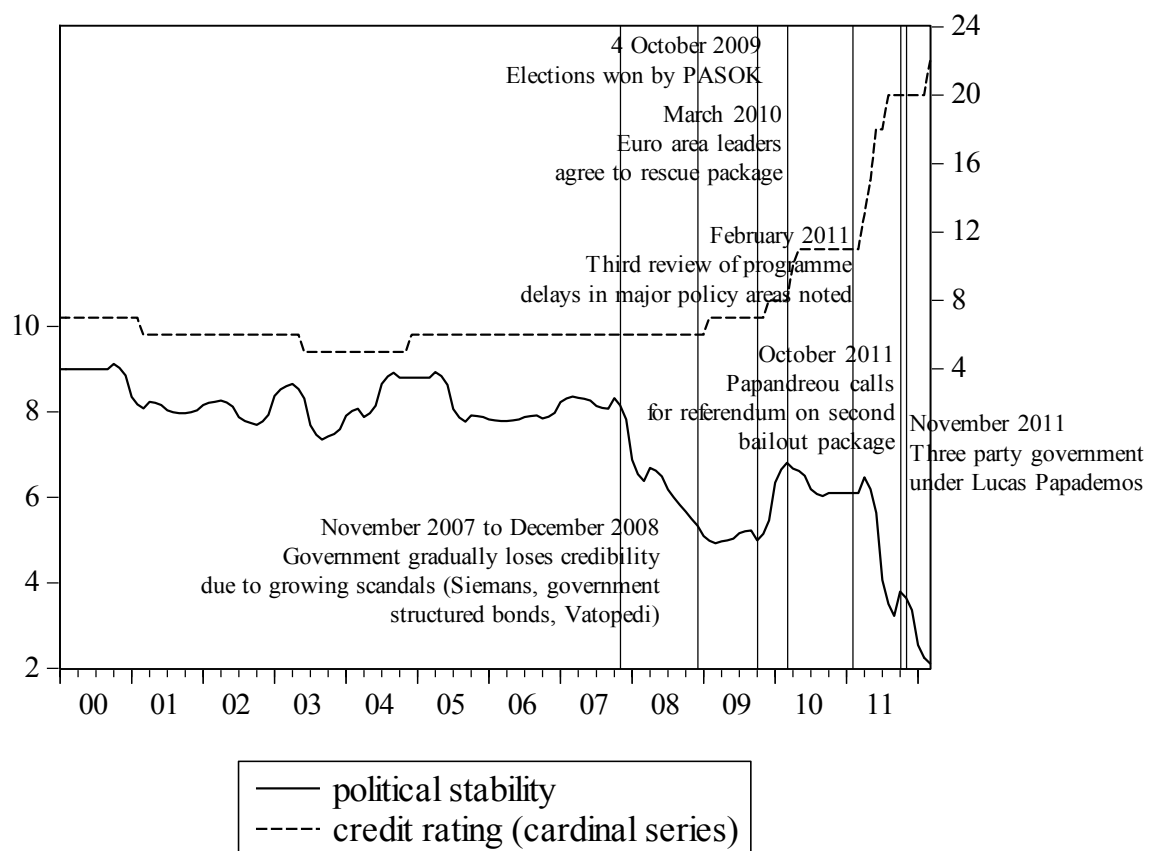

Source: Datastream

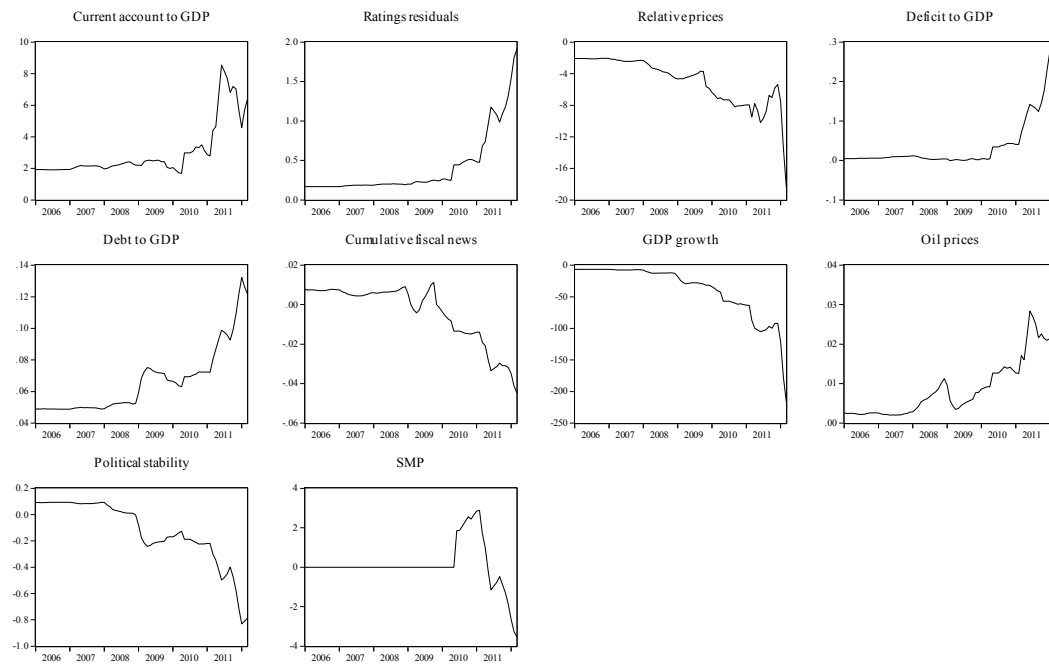**Figure 5: Real GDP growth**
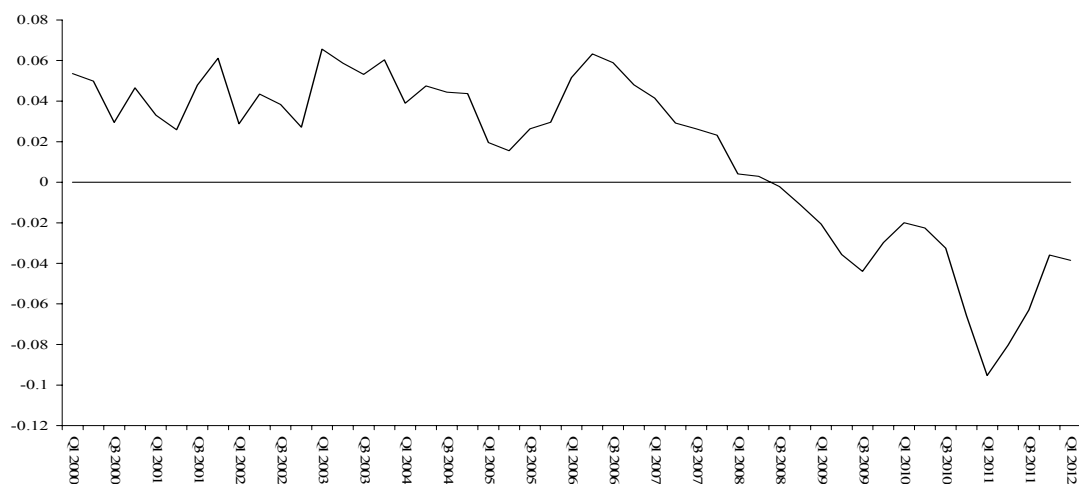
Source: Bank of Greece

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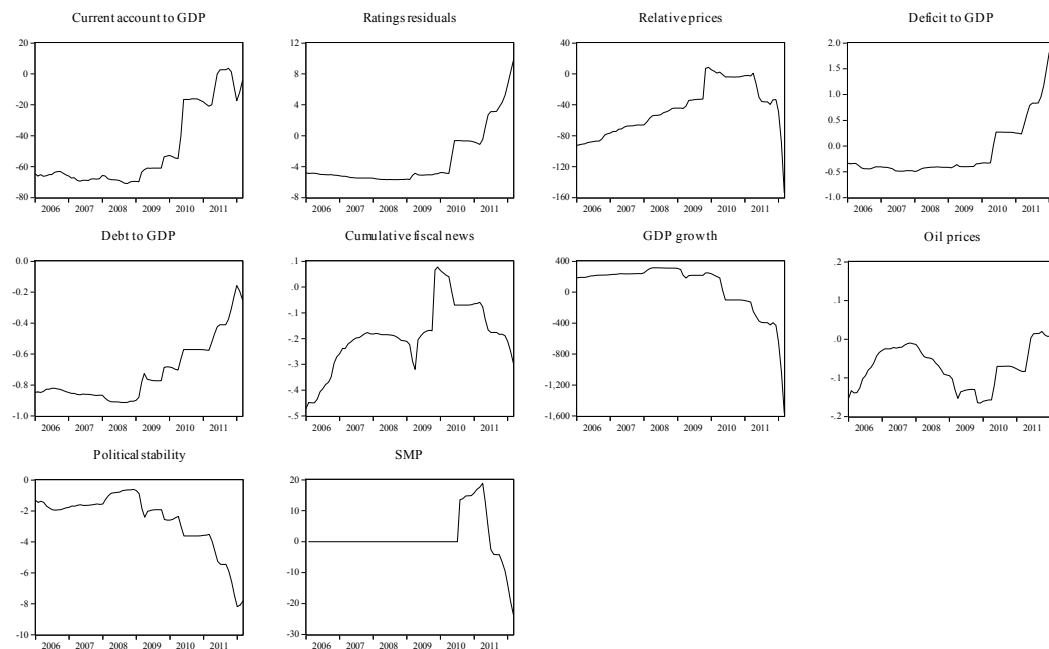**Figure 6: Sovereign ratings and political stability**

Source: CESifo Political stability index, Datastream; Sovereign ratings, Bloomberg

Figure 7: Kalman filter estimates of regression coefficients: 10-year spreads

Figure 8: Kalman filter estimates of regression coefficients: 2-year spreads

Appendix 1: Ratings regression and regressions for spreads without ratings

Ratings regression (ratings are a cardinal measure taking values of 1-22, increase implies a deterioration)

Sample: 2000M01 2012M03
Observations: 147

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-7.332	2.027	-3.62	0.00
Current account to GDP	6.856	3.092	2.22	0.03
Relative prices	-14.49	6.071	-2.39	0.02
Government balance to GDP	0.086	0.042	2.04	0.04
Debt to GDP	0.122	0.019	6.44	0.00
Fiscal news	-0.024	0.006	-4.08	0.00
Growth	-66.480	34.054	-1.95	0.05
Oil prices	0.031	0.010	3.18	0.00
SMP	-2.144	0.752	-2.85	0.01

R-squared	0.789	Mean dependent var	7.544
Adjusted R-squared	0.777	S.D. dependent var	3.742
S.E. of regression	1.766	Akaike info criterion	4.035
Sum squared resid	430.482	Schwarz criterion	4.218
Log likelihood	-287.558	Hannan-Quinn criter.	4.109
F-statistic	64.674	Durbin-Watson stat	0.255
Prob(F-statistic)	0.000		

Regression for 10-year spreads (excluding ratings residuals)

Sample: 2000M01 2012M03
observations: 147

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	8.150	5.886	1.39	0.17
Current account to GDP	0.352	6.227	0.06	0.95
Relative prices	-15.108	11.783	-1.28	0.20
Government balance to GDP	0.364	0.086	4.22	0.00
Debt to GDP	0.100	0.038	2.61	0.01
Fiscal news	-0.035	0.011	-3.12	0.00
Growth	-70.683	70.17	-1.01	0.32
Oil prices	0.004	0.020	0.22	0.83
Political stability	-2.064	0.371	-5.57	0.00
SMP	-1.758	1.525	-1.15	0.25

R-squared	0.733	Mean dependent var	2.913
Adjusted R-squared	0.716	S.D. dependent var	6.427
S.E. of regression	3.428	Akaike info criterion	5.367
Sum squared resid	1609.457	Schwarz criterion	5.571
Log likelihood	-384.486	Hannan-Quinn criter.	5.450
F-statistic	41.811	Durbin-Watson stat	0.256
Prob(F-statistic)	0.000		

Regression for 2-year spreads (excluding ratings residuals)

Sample: 2000M01 2012M03
observations: 147

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	182.5424	37.36704	4.885117	0.0000
Current account to GDP	-41.09448	39.52812	-1.039626	0.3003
Relative prices	-164.0789	74.80131	-2.193530	0.0300
Government balance to GDP	2.324847	0.548414	4.239217	0.0000
Debt to GDP	-0.509748	0.243703	-2.091673	0.0383
Fiscal news	-0.291854	0.071600	-4.076161	0.0001
Growth	-1449.818	445.4583	-3.254665	0.0014
Oil prices	0.020377	0.127947	0.159262	0.8737
Political stability	-14.95379	2.354271	-6.351771	0.0000
SMP	-23.43783	9.681497	-2.420889	0.0168

R-squared	0.594	Mean dependent var	8.813
Adjusted R-squared	0.567	S.D. dependent var	33.078
S.E. of regression	21.759	Akaike info criterion	9.064
Sum squared resid	64866.13	Schwarz criterion	9.267
Log likelihood	-656.173	Hannan-Quinn criter.	9.146
F-statistic	22.266	Durbin-Watson stat	0.201
Prob(F-statistic)	0.000		

A COMMENT ON "FUNDAMENTALLY WRONG: MARKET PRICING OF SOVEREIGNS AND THE GREEK FINANCIAL CRISIS"

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ABSTRACT

Gibson, Hall and Tavlas (2013) provide evidence that credit ratings have exerted an independent influence on credit (sovereign) spreads for Greece beyond that implied by economic fundamentals. Based on the Markov Regime-switching model of Hamilton (1989), we show that this happens during the recent financial crisis regime, characterized by a higher mean and volatility of credit spreads. It is also true for Ireland and Portugal, also bailed out by their EU partners and IMF. We show that, for Greece and Portugal, the shift of credit spreads to their higher mean-volatility regime occurred before the collapse of Lehman brothers, thus discounting a higher price of sovereign credit risk for these two countries. In contrast to Ireland, this regime shift has not been triggered by rating downgrades for Greece and Portugal. In this regime, credit ratings seem to significantly influence future changes in credit spreads independently of economic fundamentals, for Greece and Portugal. For Ireland, they constitute the main factor of determining credit spreads.

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1   Introduction

There is recently growing interest in investigating the determinants of credit (sovereign) spreads of EMU countries relative to Germany and, in particular, of Greece, Ireland and Portugal bailed out by their EU partners and IMF (see, e.g., Arghyrou and Kontonikas (2012), De Santis (2012), Bernoth and Erdogan (2012) and Afonso et al (2013)). Most of these studies show that the factors affecting the EMU credit spreads are associated with aggregate (mainly international), country-specific and contagion sources of risk. The country-specific risks are related to economic fundamentals such as fiscal and/or other macroeconomic imbalances, which increase the likelihood of a country to default on its sovereign debt.

Gibson's, Hall and Tavlas paper (2013) examines if credit ratings, announced by credit rating agencies, exert an independent impact on credit spreads, over-and-above that of the above economic fundamentals for Greece. This is an interesting question given that credit ratings are determined by movements in the above economic fundamentals such as fiscal imbalances, competitiveness, debt sustainability and economic growth. As aptly argued by De Santis (2012), credit ratings can also bring contagion risk to the force. The paper finds that, indeed, credit ratings have a significant impact on the EMU credit spreads for Greece, beyond that implied by economic fundamentals. Based on Kalman filter estimation procedure (or recursive least squares, see an earlier version of the paper), the authors indicate that this result is even stronger after the outbreak of the recent international financial crisis in year 2008.

In this short note, we examine how robust is Gibson's et al (2013) above result with respect to explicitly modelling a regime shift in the relationship between credit spread and economic fundamentals. To this end, we re-estimate this relationship for Greece allowing for a regime shift in its conditional mean and volatility functions, based on Hamilton's (see Hamilton (1989)) Markov regime-switching model (MRS). This is also done for Portugal and Ireland, the two other countries bailed by their EU partners and IMF. The MRS model can reveal if the large in magnitude, time-varying changes of the coefficients of the credit spread

and economic fundamental relationship of the above three EMU periphery countries, found by Gibson's et al paper for Greece, can be explained by economic fundamentals or credit ratings, in the different regimes of our sample identified by the applying the MRS model to our data.

2 Estimation of the credit spread - economic fundamentals relationship allowing for regime-switching

Table 1 presents estimates of the following credit spread relationship for the above three EMU-periphery countries, without allowing for regime-switching:

$$spr_{jt} = const_j + b_{j2}\frac{gd_{jt-1}}{gdp_{jt-1}} + b_{j3}\frac{ca_{jt-1}}{gdp_{jt-1}} + b_{j4}ipg_{jt-1} + b_{j5}\frac{gb_{jt-1}}{gdp_{jt-1}} + b_{j6}cr^*_{jt-1} + e_{jt}, \qquad (1)$$

for $j=\{$Greece, Ireland and Portugal$\}$, where $spr_{jt} = r_{jt} - r_t^{GE}$ is the credit spread between the 10-year government bond yield of country j and that of Germany (GE), $\frac{gd_{jt-1}}{gdp_{jt-1}}$, $\frac{ca_{jt-1}}{gdp_{jt-1}}$ and $\frac{gb_{jt-1}}{gdp_{jt-1}}$ stand for the government deficit (gd), current account (ca) and government debt (gb) as ratio to GDP, respectively, IPG_{jt-1} is the annual growth rate of industrial production (ipg) and, finally, $cr^*_{jt-1} = cr_{jt-1} - average(cr_{jt-1})$ is a variable capturing the impact of a new rating at time $t-1$ (denoted as cr_{jt}) compared to the average ($average$) of those of the last twelve-months. To construct credit rating's variable cr_{jt}, we use the ratings assigned to each country j by Moody's, S&P and Fitch. We assign values of 22-1 to different rating of the above three agencies and we extract their common factor, based on principal components analysis. This approach of measuring cr_{jt} mitigates any small, indiosyncratic differences of ratings across the three agencies. Our frequency of our data is monthly and covers period 2001:02-2012:12. The three ratio to gdp variables are given in quarterly basis, and thus have been interpolated, as in Gibson et al (2013).

The results of Table 1 indicate that there are economic fundamentals, such as $\frac{gb_{jt-1}}{gdp_{jt-1}}$, or $\frac{ca_{jt-1}}{gdp_{jt-1}}$ and ipg_{jt-1} also for Greece at 10% level, which influence future credit spread changes one-period ahead. However, with the exception of $\frac{gb_{jt-1}}{gdp_{jt-1}}$, the other two variables

have the incorrect sign. Apart from $\frac{gb_{jt-1}}{gdp_{jt-1}}$, the results of Table 1 also indicate that the credit rating news variable, cr^*_{jt-1}, has also an important effect on credit spread spr_{jt}. Its sign is also negative and it is consistent with the theory, meaning that a rating downgrade of a country's sovereign will lead to an increase of spr_{jt}. Note that, in terms of magnitude, the effects of cr^*_{jt-1} on spr_{jt} are found to be larger for Greece.

Table 1: Estimates of model (1)

	$const_j$	$\frac{gd_{jt-1}}{gdp_{jt-1}}$	$\frac{ca_{jt-1}}{gdp_{jt-1}}$	ipg_{jt-1}	$\frac{gb_{jt-1}}{gdp_{jt-1}}$	cr^*_{jt-1}	$\bar{R}^2$
Greece	-12.77	-0.04	0.13	0.27	0.14	-4.08	0.82
	(-2.54)	(-0.49)	(1.75)	(1.87)	(2.69)	(-2.57)	
Portugal	-1.36	0.03	0.013	-0.03	0.03	-2.94	0.90
	(-2.17)	(0.85)	(0.34)	(-0.96)	(1.98)	(-6.11)	
Ireland	-0.49	-0.014	-0.03	0.030	0.023	-1.87	0.90
	(-1.28)	(-0.76)	(-1.10)	(1.31)	(2.01)	(-4.70)	

Notes: Sample period: 2001:02-2012:12, t statistics are in parentheses correct for White-heteroscedasticity and Newey-West standard errors allowing for one lag.

The results of the MRS specification of model (1) are given in Table 2. This specification assumes that all parameters of model (1) switch between two regimes, denoted as $s_t = "0"$ and $s_t = "1"$, respectively. The first regime is characterized by a lower level of the volatility and conditional mean functions of spread spr_{jt}, while the second by a higher. Note that the table presents estimates of the slope coefficient of cr^*_{jt-1} only in regime "1", given that there are found to be insignificant in regime "0".

The results of Table 2 and Figure 1 lead to a number of interesting conclusions. First, the very small values of the transition probabilities between regimes "0" and "1", denoted as p_{01} and p_{10}, reported in the table indicate that there is a small transition probability across them. This result implies a high degree of persistency of each regime, during our sample. This can be also confirmed by the inspection of Figure 1, which presents smoothed over-the-whole-sample estimates of the probability that the economy is in regime "1" in each point of time of our sample. This probability is labelled as PSTAR in Figure 1. Second, by allowing for regime-switching in model (1), economic fundamentals seem to affect future changes in

credit spread spr_{jt}. Note that some of them are significant even in the low volatility regime "0" (i.e., $\frac{gb_{jt-1}}{gdp_{jt-1}}$, ipg_{jt-1}, for all countries, and $\frac{ca_{jt-1}}{gdp_{jt-1}}$ for Ireland and Portugal). Some of these fundamentals (i.e., $\frac{gb_{jt-1}}{gdp_{jt-1}}$ for Greece, and also $\frac{gd_{jt-1}}{gdp_{jt-1}}$ and ipg_{jt-1} for Portugal) can still predict changes of spr_{jt} in regime "1". Third, credit rating news cr^*_{jt-1} clearly influences spr_{jt} in the high-volatility credit spread regime "1", for all three countries examined. Note that, for Ireland, cr^*_{jt-1} constitutes the main variable determining future changes in spr_{jt} for regime "1". This can be attributed to the fact that the sovereign debt crisis of Ireland was mainly due to the insolvency of the banking system triggered by the recent financial crisis and not on the government and/or current account imbalances of this country.

Table 2: Estimates of the Markov regime-switching specification of model (1)

	$constj$	$\frac{gd_{jt-1}}{gdp_{jt-1}}$	$\frac{ca_{jt-1}}{gdp_{jt-1}}$	$ipig_{jt-1}$	$\frac{gb_{jt-1}}{gdp_{jt-1}}$	cr^*_{jt-1}	p_{j01}	p_{j10}	σ^2_{j0}	σ^2_{j1}
				Greece						
$s_t=$"0"	-0.63	-0.001	0.0000	-0.0099	0.009		0.02	0.01	0.06	4.05
	(-3.00)	(-0.56)	(0.04)	(-1.92)	(4.18)		(7.01)	(9.12)	(11.40)	(11.33)
$s_t=$"1"	-7.68	0.13	0.22	0.39	0.13	-3.63				
	(-1.20)	(0.81)	(2.20)	(1.44)	(2.39)	(-3.64)				
				Portugal						
$s_t=$"0"	0.65	-0.004	-0.007	0.030	-0.009		0.02	0.01	0.06	0.90
	(8.54)	(-1.44)	(-2.13)	(6.28)	(-6.95)				(10.58)	(10.59)
$s_t=$"1"	-6.46	0.10	-0.10	-0.11	0.09	-2.33				
	(-2.93)	(2.62)	(-1.79)	(-1.98)	(3.12)	(-8.37)				
				Ireland						
$s_t=$"0"	-1.22	0.003	-0.04	-0.008	0.004		0.08	0.02	0.15	0.83
	(-23.88)	(1.36)	(-7.41)	(-1.90)	(6.78)		(6.32)	(8.23)	(15.01)	(8.64)
$s_t=$"1"	1.59	0.004	0.05	-0.022	0.008	-1.74				
	(1.64)	(0.31)	(1.12)	(-0.39)	(0.55)	(-8.36)				

Notes: Sample period: 2000:12-2012:12, t statistics are in parentheses based on Quasi ML standard errors.

Finally, inspection of the graphs of Figure 1, which also presents the values of variable cr^*_{jt} through our sample, indicates that the shift of credit spread spr_{jt} to regime "1" for Greece and Portugal was occurred before the collapse of Lehman brothers in September of year 2008. This shift can be taken to reflect a higher price of Greek and Portuguese sovereign credit risk than regime "0" due to the steady deterioration of the economic fundamentals of these two countries, mainly $\frac{gd_{jt-1}}{gdp_{jt-1}}$, started before year 2008. Credit rating news cr^*_{jt-1} have

appeared affecting these countries almost a year after the collapse of Lehman's brothers. However, for Ireland, cr^*_{jt-1} seems to play a critical role in determining the regime shift of spr_{jt} to regime "1", immediately after the collapse of Lehman brothers. This is consistent with our interpretation, given above, that the origin of the Irish debt sovereign crisis may be attributed to the insolvency of this country's banking system, mainly triggered by the start of the recent international financial crisis.
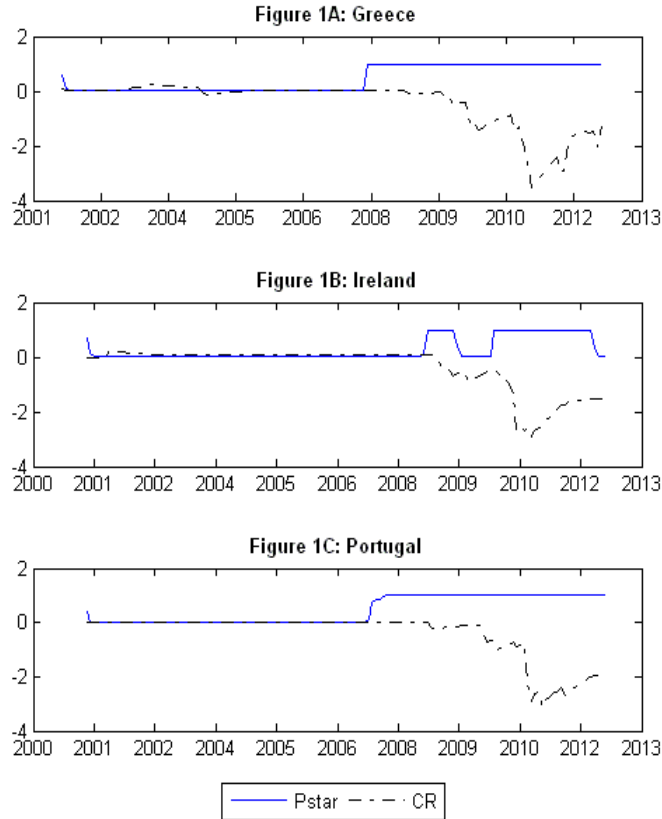
3   Conclusions

Based on the Markov regime-switching model, we show that credit spreads of Greece and Portugal have moved to a new regime of higher mean and volatility even before the start of the recent financial crisis. Credit ratings are found to critically determine the level of credit spreads in this regime independent of the underlying economic fundamentals, as argued by Gibson et al (2013) for Greece. There are not found to trigger this regime shift for Greece and Portugal. However, for Ireland, credit ratings seem to play an important role in determining

this regime shift. We argue that this may happen due to the insolvency problems of the Irish banking crisis, faced immediately after the collapse of Lehman brothers.

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