EUROPEAN ECONOMY

Economic Papers 436 | February 2011

The EMU sovereign-debt crisis: Fundamentals, expectations and contagion

Michael G. Arghyrou
and Alexandros Kontonikas

Economic and Financial Affairs
DIRECTORATE-GENERAL

EUROPEAN COMMISSION

Economic Papers are written by the Staff of the Directorate-General for Economic and Financial Affairs, or by experts working in association with them. The Papers are intended to increase awareness of the technical work being done by staff and to seek comments and suggestions for further analysis. The views expressed are the author's alone and do not necessarily correspond to those of the European Commission. Comments and enquiries should be addressed to:

European Commission
Directorate-General for Economic and Financial Affairs
Publications
B-1049 Brussels
Belgium
E-mail: Ecfin-Info@ec.europa.eu

This paper exists in English only and can be downloaded from the website ec.europa.eu/economy_finance/publications

A great deal of additional information is available on the Internet. It can be accessed through the Europa server (ec.europa.eu)

KC-AI-11-436-EN-N

ISSN 1725-3187
ISBN 978-92-79-14922-1
doi: 10.2765/47739

The EMU sovereign-debt crisis: Fundamentals, expectations and contagion

Michael G. Arghyrou[a *] and Alexandros Kontonikas[b *]

[a] *Economics Section, Cardiff Business School*

[b] *Economics Department, University of Glasgow Business School*

Abstract

We offer a detailed empirical investigation of the European sovereign debt crisis. We find evidence of a marked shift in market pricing behaviour from a 'convergence-trade' model before August 2007 to one driven by macro-fundamentals and international risk thereafter. The majority of EMU countries have experienced contagion from Greece. There is no evidence of significant speculation effects originating from CDS markets. Finally, the escalation of the Greek debt crisis since November 2009 is confirmed as the result of an unfavourable shift in country -specific market expectations. Our findings highlight the necessity of structural, competitiveness-inducing reforms in periphery EMU countries and institutional reforms at the EMU level enhancing intra-EMU economic monitoring and policy co-ordination.

JEL classification: E43, E44, F30, G01, G12

Keywords: euro-area, crisis, spreads, fundamentals, expectations, contagion, speculation.

---

* Email addresses: arghyroum@Cardiff.ac.uk; Alexandros.Kontonikas@glasgow.ac.uk

We would like to acknowledge financial support from the European Commission's Directorate General for Economic and Financial Affairs (DG-ECFIN) under the Visiting Fellows Programme (Contract Numbers: 005/2010/SI2.555762; 004/2010/SI2.555749). We would like to thank staff of the DG-ECFIN for academic input and administrative support during our visit (14/6-25/6 2010). We would also like to thank participants at the seminar organised by DG-ECFIN on 22/6/2010, as well as seminar participants at the German Bundesbank on 30/7/2010 for very useful comments and suggestions. We also thank Aman Saggu for his valuable help with data collection.

The views expressed in this paper are the authors' only and should not be attributed to the European Commission or to DG ECFIN.

1. Introduction

Recent months have seen the transformation of the global financial crisis into a sovereign debt crisis in the euro-area. Starting from Greece in autumn 2009, the euro-area crisis has since caused Greece to withdraw from international bonds markets and has put intense pressure on the bonds of other EMU countries, most notably Ireland, Portugal and Spain. The intensity of the crisis has prompted European policy makers to take extraordinary measures aiming to limit its fall-out on the real sector of the affected countries and prevent its further spreading. These measures, ratified in May 2009, include an unprecedented in size (110 billion euros) three-year EU/IMF-financed emergency rescue package for Greece; and the creation of a European stabilisation mechanism ring-fencing 750 billion euros for countries that may find themselves in a position similar to the Greek one within the following three years. These measures, however, have so far not proved enough to ease the crisis. In November 2010 Ireland became the second EMU country to seek and obtain a rescue package for 85 billion euros. This event fuelled further debates on issues ranging from the optimum short-run response to the crisis to the eurozone's overall long-term sustainability.

With so much political and economic capital at stake, it is not surprising that the economics literature has responded actively to the eurozone crisis through a series of empirical studies. The consensus emerging from this literature, reviewed in section 2, is summarised in two main findings. First, both the amount and the price of the perceived global risk associated with investments in sovereign bonds, relative to the safe havens of US and Germany, have increased during the global economic downturn. This explains the across-the-board increase in EMU spread values. In this process, the transfer of banking sector risk to sovereign borrowers, through bank bail-outs, has been central. Second, intra-EMU differences in spreads' increases are explained by heterogeneous transfer of banking sector risk to sovereign borrowers and the pricing of heterogeneous macro-fundamentals. The penalties imposed by markets are further exacerbated by the interaction of macro-fundamentals with the common international risk factor.

The existing studies have shed much-needed light on the factors driving increasing EMU spreads, greatly enhancing our understanding of the eurozone crisis. Important questions, however, still remain unanswered. First, almost all existing studies are purely empirical. However informative, without a theoretical mapping to the events it aims to analyse no study can offer a full set of explanations and traceable future policy implications. Second, existing studies have not explained the events characterising the most recent and intense phase of the crisis. Why did the Greek spread escalate from 140 basis points in early

November 2009 to 250 points by the end of the year and nearly 600 in late March 2009? Third, why has the Greek spread been taking so much higher values compared to other periphery countries? Is the Greek macro-outlook so much worse than Portugal's to justify spread values two or three times as high? Fourth, has contagion really taken place? Despite this widely held belief, no study has so far tested the hypothesis of contagion explicitly. Finally, what has been the role, if any, of speculative trading in the market for credit default swaps (CDS) on Greek and other EMU government bonds? Such speculation has been suggested as one of the potential culprits behind the present turmoil with subsequent proposals ranging from tighter regulation of the CDS market to an outright permanent ban on naked CDS trading. Are such proposals justified or is the role of CDS speculation overestimated in the ongoing debate?

This paper aims to make a contribution to the study of the EMU sovereign debt crisis by addressing each of the five questions raised above. It is the first paper to pursue an empirical analysis of the crisis based on a theoretical model, namely the one by Arghyrou and Tsoukalas (2010). Using insights from the literature on currency crises (Obstfeld, 1996; Krugman, 1998), these authors build a model of the eurozone debt crisis which effectively allows sovereign spreads to reflect both currency risk and default risk. Their model offers an explanation for all the events characterising the EMU debt crisis up to the activation of the Greek rescue package, including the sudden escalation of the Greek debt crisis in November 2009. The model by Arghyrou and Tsoukalas offers testable hypotheses relating to the full set of questions posed above. Our empirical analysis puts these hypotheses directly into the test. We use monthly data covering the period January 1999 – February 2010, as well as a range of specification and estimation techniques (time series and panel-based). Our main findings can be summarised as follows:

First, during the period preceding the global credit crunch (January 1999 – July 2007), with the possible exception of expected fiscal deficits, markets priced neither macro-fundamentals nor the very low at the time international risk factor. This finding is consistent with the 'convergence-trading' hypothesis, according to which markets were discounting only the optimistic scenario of full real convergence of all EMU economies to the German one. This pricing behaviour has changed decidedly during the crisis period (August 2007 – February 2009), with markets now pricing both the international risk factor and individual macro-fundamentals on a country-by-country basis.

Second, we obtain evidence in favour of the hypothesis that the Greek debt crisis is due to a background of deteriorating macro-fundamentals and a double shift in private

expectations: Starting from November 2009, Greece was transferred from a regime of fully-credible commitment to future EMU participation under the perception of fully guaranteed (by other EMU countries) fiscal liabilities, to a regime of non-fully credible EMU commitment without fiscal guarantees. This regime-shift not only explains the sudden escalation of the Greek debt crisis but also the difference in spread values observed between Greece and other periphery EMU countries with not too dissimilar macroeconomic outlook: Compared to Ireland, Portugal and Spain, markets perceive a much higher probability of a Greek voluntary exit from the EMU, and/or a Greek default. In short, Greece's problems are as much about trust as they are about economics.

Third, we confirm that up to the point covered by our econometric analysis (February 2010), the overwhelming majority of EMU countries had experienced contagion from Greece, most prominently Portugal, Ireland and Spain. This is interpreted as evidence that the Greek bond yield has become a proxy for EMU-specific systemic risk, increasing borrowing costs in other EMU countries beyond the level justified by the common international risk factor and their idiosyncratic fundamentals. In short, the Greek problem has become an EMU-wide problem.

Finally, we do not find evidence in favour of the hypothesis that speculation in the CDS market, including the Greek one, is a major force driving the eurozone debt crisis. This does not imply that CDS speculation is not taking place or it does not drive EMU spreads at higher data frequencies. What it implies is that in the longer-term perspective captured by our monthly data frequency, EMU spreads are mainly driven by accumulated intra-EMU macroeconomic imbalances and international risk conditions. Although the latter may improve as global economic activity gradually picks-up, the former is unlikely do so without significant intra-EMU economic/institutional reforms outlined in the concluding section.

The remainder of the paper is structured as follows: Section 2 reviews the literature on the post-1999 determinants of EMU government bonds. Section 3 discusses the theoretical framework by Arghyrou and Tsoukalas (2010) on which our empirical analysis is based. Section 4 describes our data. Section 5 presents and discusses our empirical findings. Finally, section 6 summarises and offers concluding remarks.

2. Related literature

Existing studies on EMU government bond yields and their spreads against Germany can be classified in two broad categories, respectively covering the period prior to and

following the onset of the global financial crisis in August 2007. Both groups typically follow the approach of the general literature conditioning yields/spreads on three variables (see e.g. Manganelli and Wolswijk, 2009):[1] First, a common international risk factor, capturing international risk appetite. The latter captures both the level of perceived risk and its unit price thought to be higher during periods of financial stress. The common risk factor is typically measured using indexes of US stock volatility or the spread between the yields of various categories of US corporate bonds against US treasury bills. Second, credit risk, capturing the probability of partial or total default on behalf of a sovereign borrower. This is typically measured using indicators of past or projected fiscal performance.[2] Third, liquidity risk. This refers to the size and depth of the sovereign bonds market and captures the risk of capital losses in the event of early liquidation or significant price changes resulting from a small number of transactions. Liquidity is a variable acknowledged to be particularly difficult to measure, with bid-ask spreads, volumes of transaction and the level of or the share of a country's debt in total EMU sovereign debt used as proxies. Furthermore, the literature acknowledges a high degree of co-linearity between empirical measures of liquidity and the global risk factor.

Studies on EMU government bonds covering the period prior to the global financial crisis are not unanimous regarding the role of each of the three determinants discussed above. However, the prevailing view can be summarised as follows: First, the international risk factor was important in determining spreads against Germany (see Codogno et al. (2003), Geyer et al. (2004), Longstaff et al. (2007), Barrios et al. (2009), Sgherri and Zoli (2009), Manganelli and Wolswijk (2009) and Favero et al. (2010)). This effect was particularly strong during periods of tightening international financial conditions (see Haugh et al., (2009) and Barrios et al., (2009)) as well as for countries with high levels of public debt (see Codogno et al., (2003)). Second, credit risk was priced, as suggested by Faini (2006), Bernoth et al. (2004), Bernoth and Wolff (2008), Manganelli and Wolswijk (2009) and Schuknecht et al. (2009).[3] These findings are interpreted by Bernoth and Wolff (2008) and Schuknecht et al. (2009) as evidence that the Stability and Growth Pact was a credible mechanism imposing

[1] See, among others, Alesina et al. (1992) for OECD countries; Bayoumi et al.(1995) for US states; Booth et al. (2007) for Canadian provinces; and Laubach (2009) for the US federal government.

[2] Credit risk includes three types of risk: default risk, capturing the probability of default on coupon payments or/and repayment of the principal on maturity date; credit-spread risk, capturing the risk that the market value of a sovereign bond will underperform the value of bonds of comparable quality; and downgrade risk, reflecting the probability of capital losses due to a bond's downgrade by leading rating agencies (see Barrios et al., 2009).

[3] By contrast, Codogno et al. (2003) find that markets penalised fiscal imbalances only in two EMU countries (Italy and Spain). Furthermore, Hallerberg and Wolff (2008) find that fiscal conditions affected EMU sovereign bond yields but this effect had became weaker following the euro's introduction.

fiscal discipline among EMU members. This view, however, is not uncontested: Manganelli and Wolswijk (2009) raise the question as to whether the penalties imposed by markets were sufficiently high to encourage EMU governments to change unsustainable fiscal policies. Finally, the role of liquidity risk is controversial. Codogno et al. (2003), Bernoth et al. (2004), Pagano and Von Thadden (2004), and Jankowitsch et al. (2006) find a limited or declining liquidity effect on EMU spreads. By contrast, Gomez-Puig (2006), Beber et al. (2009), and Manganelli and Wolswijk (2009) argue in favour of a more prominent effect, particularly during periods of tightening financial conditions and higher interest rates.[4]

Moving to the literature covering the crisis period, consensus emerges on two points. First the observed widening in EMU spreads is mainly driven by the increased global risk factor. In this process, the role of domestic banking sectors is crucial, with the financial system transforming global risk into sovereign risk through two channels (see Gerlach et al., 2010): First, in periods of financial distress the government might be obliged to recapitalise banks using public money, thus increasing its fiscal liabilities. Second, shortages in banking liquidity restrict credit to the private sector causing economic recession increasing fiscal imbalances further. With national banking sectors having different degrees of exposure to global financial conditions the increase in the common global risk factor causes a heterogeneous impact on national spreads.[5] Attinasi et al. (2009), Sgherri and Zoli (2009), Mody (2009), Barrios et al. (2009), Gerlach et al. (2010) and Schuknecht et al. (2010) have all established the importance of the global risk factor during the crisis period and its impact on the latter through the financial sector.

The second point of consensus is that during the crisis markets have been penalising fiscal and other macroeconomic imbalances (e.g. excessive current accounts) much more heavily than they used to prior to the crisis. Furthermore, markets not only attach a higher weigh on fiscal imbalances, but they may also price their interaction with the common international risk factor (see Barrios et al. (2009), Haugh et al el. (2009), Manganelli and

[4] Favero et al. (2010), on the other hand, provide theoretical justification and empirical evidence according to which during the early EMU-years liquidity had a smaller effect on sovereign spreads in periods of high risk. This is intuitively explained by the fact that in crisis periods investors choose from a reduced set of alterative investment opportunities, limiting their willingness to move away from sovereign bonds.

[5] Manganelli and Wolswijk (2009) emphasise the role of monetary policy during the crisis, captured by shifts in the main refinancing operations rate of the ECB. They argue that interest rates affect spreads through two channels. First, low interest rates increase funding liquidity and provide incentives to financial managers to take risks to increase expected returns on their investments. Second, interest rates affect a country's fiscal outlook through their effect on the state of the business cycle. They acknowledge, however, that interest rates are strongly correlated with risk aversion, in which case the interpretation of their empirical findings is similar to the studies quoted above.

Wolswijk (2009) and Schuknecht et al. (2010)). Increased focus on heterogeneous fiscal outlooks and the non-linearities caused by the aforementioned interaction is another major factor explaining the differential spread increases observed among EMU countries. On the other hand, on balance, the evidence suggests that although the role of country-specific liquidity risk is non-negligible, it is rather limited (see Attinasi et al. (2009), Sgherri and Zoli (2009), Barrios et al. (2009), Haugh et al. (2009), and Manganelli and Wolswijk (2009)).[6]

The studies quoted above have shed much-needed light on the factors driving spreads during the eurozone crisis, thus enhancing significantly our understanding of the latter. Important questions, however, remain unanswered. First, existing studies do not capture the most recent and intense phase of the eurozone crisis (November 2009 onwards). Second, they are purely empirical. But without reference to a theoretical model of the eurozone crisis, no study can provide a full set of explanation of events, and perhaps more importantly, a set of traceable future policy implications. Our study fills this void by anchoring its empirical analysis to the theoretical treatment of the eurozone crisis provided by Arghyrou and Tsoukalas (2010). We proceed to review this model immediately below.

3. Theoretical background

Arghyrou and Tsoukalas (2010) present a theoretical model of the Greek/European debt crisis. The main insight of their analysis is that the current debt crisis is caused by systemic/macroeconomic risk which in the presence of national currencies would have resulted into currency upheaval, while in their absence is diverted to the markets for sovereign bonds, strongly reinforced by the introduction of default risk. Based on this insight, they develop a model of rational EMU exit combining elements from the second- and third-generation currency crisis models, by Obstfeld (1996) and Krugman (1998) respectively. They treat EMU participation as commitment to a system of fixed exchange rates and, following Obstfeld (1996), assume one control variable for the government, namely the decision to stay in or exit the euro. The government decides rationally its optimal course of action by balancing the costs of the two options. The cost of exiting the euro is assumed to be constant, given by C. This can be interpreted as the difference between the steady-state inflation rates under an independent monetary policy regime and the EMU caused by a higher

[6] Manganelli and Wolswijk (2009) find a stronger effect for liquidity risk, which they interpret as evidence of incomplete integration among national EMU sovereign bond markets. Based on this finding, they argue in favour of a higher degree of urgency in completing the ongoing process of intra-EMU financial integration.

inflation bias under monetary independence; or/and the political cost associated with a voluntary or forced withdrawal from the EMU. The cost of staying in the EMU is a positive quadratic function of the deviation of the exchange rate at which the country has joined the euro, denoted by $\bar{s}$, from the PPP-consistent exchange rate, denoted by s^*. This deviation is captured by the value of the real exchange rate $q = (s^* - \bar{s})$, a variable summarising the effect of all macroeconomic shocks (internal and external) hitting the domestic economy. Overvaluation relative to the PPP-consistent equilibrium is costly, as it reduces external competitiveness leading to lower output, increased unemployment, higher external and public debt and higher interest payments to domestic and foreign creditors.

The government's optimal choice is endogenous to the status of the expectations of the private sector, which has two rather one, control variables. As in Obstfeld (1996), the private sector determines the credibility of the government's commitment to EMU participation (credible versus non-credible commitment). Second, and in a way similar to the assumptions of Krugman's (1998) model, the private sector determines whether the government's fiscal liabilities are perceived as guaranteed or not guaranteed by the rest of the EMU members. The above give rise to three possible regimes for private expectations. In the first regime markets perceive the country's EMU participation as fully credible and outstanding fiscal liabilities fully guaranteed. In that case, the loss of staying in the euro is given by L_1:

$$L_1 = [\gamma_1 (s^* - \bar{s})]^2 \qquad \gamma_1 \geq 0 \qquad (1)$$

By allowing γ_1 to take a zero value, Arghyrou and Tsoukalas account for the possibility that the interest rate on government bonds, capturing the cost of continued EMU participation, is de-linked from the present state of macro-fundamentals, in the same way assets' prices are de-linked from their expected returns in Krugman's (1998) model through government guarantees to the liabilities of financial institutions under lax financial supervision.[7] The intuition underlying $\gamma_1 = 0$ is that with future EMU participation regarded as fully credible, markets fully expect the government to take all necessary action to correct

[7] In Krugman's (1998) model the perception of government guarantees transforms projects financed by financial institutions from fair bets to "heads-you-win-tails you-do-not-lose" bets. Under conditions of high international liquidity, investors switch their pricing model from one based on expected outcomes to one based on best-case outcomes. This results into bubbles in assets' prices, rendering them vulnerable to sudden, abrupt drops when market expectations shift back to non-guaranteed financial liabilities status.

any macro-imbalances;[8] and while it does so the risk of capital losses due to government default is zero, as a result of the perceived fiscal guarantees. Equation (1) also allows for another mechanism of macroeconomic correction, also consistent with fully credible EMU participation: By allowing γ_1 to take values greater than zero, the model captures the possible existence of a market-discipline mechanism, where the private sector sends signals to the government, through the imposition of higher cost of servicing public debt, that macroeconomic correction is necessary, maintaining at the same time absolute certainty that the government will respond to this signal by taking all necessary corrective action.

In the second regime markets continue to regard fiscal liabilities to be guaranteed as long the country remains in the EMU, but do not regard commitment to EMU participation as fully-credible. Rather, they perceive a non-zero probability that the government will choose to exit the EMU on its own, to avoid the welfare cost of macroeconomic correction necessary for long-term participation in the single currency.[9] Assuming real overvaluation, the interest rate on government bonds now incorporates an exchange rate risk premium. In comparison to L_1 the same value of real exchange rate $q = (s^* - \bar{s})$ results into a higher loss value, giving rise to the loss function described by (2) below:

$$L_2 = [(\gamma_1 + \gamma_2)(s^* - \bar{s})]^2 \qquad \gamma_1, \gamma_2 > 0 \qquad (2)$$

Finally, in the third expectations' regime markets regard commitment to the EMU as non-fully credible and do not perceive government liabilities to be guaranteed.[10] In that case, the interest rate on government bonds incorporates not only an exchange rate premium but also a default premium. For every level of overvaluation the cost of continued EMU participation increases even further and is now given by:

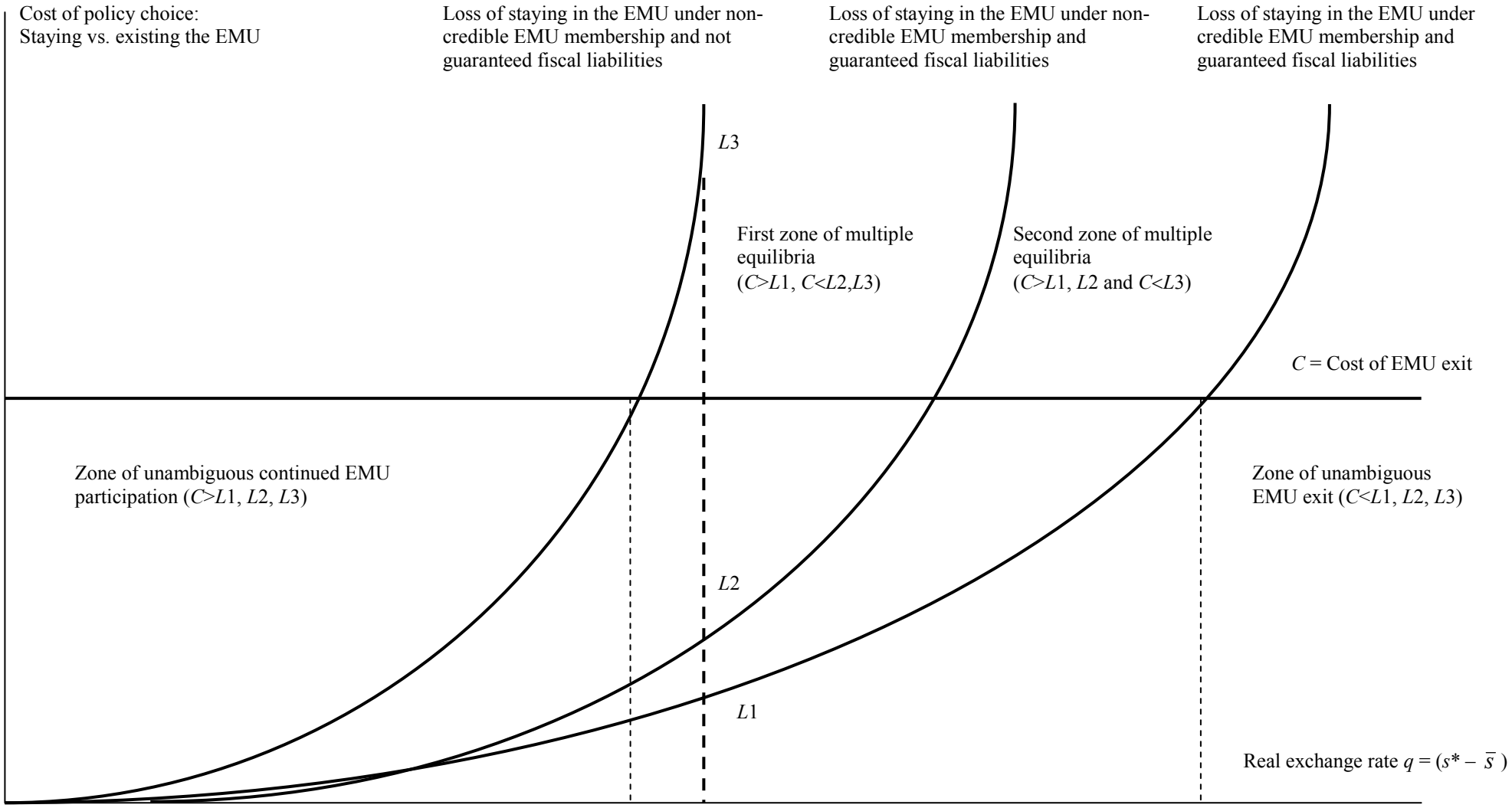
$$L_3 = [(\gamma_1 + \gamma_2 + \gamma_3)(s^* - \bar{s})]^2 \qquad \gamma_1, \gamma_2, \gamma_3 > 0 \qquad (3)$$

[8] This is analogous to the smooth-pasting effect predicted by target-zone models of the exchange rate under conditions of full market credibility for the target zone.

[9] The possibility that markets perceive a positive probability of eventual EMU failure resulting into a re-introduction of exchange rate risk had been considered since the early years of the eurozone's existence (see e.g. Geyer et al., 2004). The model by Arghyrou and Tsoukalas (2010) implies that during the EMU sovereign debt crisis this probability and the premium associated with it have increased significantly.

[10] There is a fourth regime, where the private sector views future EMU participation as credible without fiscal guarantees of government bonds from EMU partners. In this case however the country's commitment to EMU participation implies a strong incentive for sound fiscal finances. Therefore, Arghyrou and Tsoukalas (2010) treat this case as isomorphic to the first regime, i.e. credible EMU participation and guaranteed fiscal liabilities.

Figure 1: A model of EMU exit under shifting membership expectations and withdrawal of fiscal guarantees



Under all expectations' regimes the government chooses to stay in the EMU as long as the cost of continued EMU participation is lower than the cost of euro exit. For every expectations regime Arghyrou and Tsoukalas derive critical thresholds of overvaluation above which the government finds it optimal to leave the EMU. The value of these thresholds declines with negative shifts in expectations reducing the range of successful defence of EMU participation, as presented diagrammatically in Figure 1. Like Obstfeld (1996) the model predicts that shifts in expectations can result in self-fulfilling prophesies of EMU exit. However, the availability of two control variables for the private sector gives rise to two rather than one zone of multiple equilibria: The government might find it optimal to leave the EMU not only following an adverse shift of expectations regarding future EMU participation but also following a shift in perceptions regarding the availability of fiscal guarantees.

The analysis quoted above provides a number of testable hypotheses for explaining the movements of spreads of EMU government bonds against Germany since the euro's launch in 1999. Arghyrou and Tsoukalas interpret the near-zero spread values observed between January 1999 to July 2007 as evidence of expectations of fully credible EMU commitment under the perception of fiscal guarantees. This resulted in de-linking macro-fundamentals from interest rates on government bonds, i.e. EMU governments operated under L_1 with $\gamma_1 = 0$ or γ_1 taking values very close to zero. During that period the increasingly deteriorating macroeconomic fundamentals of periphery EMU countries (see section 4 below) were not penalised with higher interest rates on government bonds, as markets, endowed with ample global liquidity, continued to discount full real convergence of periphery EMU economies to the core ones.[11]

Arghyrou and Tsoukalas propose that following the onset of the global credit crunch in August 2007 and the resulting significant capital losses sustained on corporate portfolios, markets started pricing sovereign bonds on a country-by-country basis based on macroeconomic performance. Initially, they continued to regard all countries' participation to the EMU as fully credible, still pricing bonds under L_1 but now setting $\gamma_1 > 0$. This explains the differences in spreads observed since August 2007, reflecting different degrees of real exchange rate overvaluation, caused by different degrees of competitiveness losses and fiscal imbalances. The subsequent escalation of the Greek debt crisis is attributed to a double shift in expectations, from a regime of fully credible EMU commitment under guaranteed fiscal liabilities to a regime of non-credible EMU commitment and non-guaranteed fiscal liabilities.

[11] See Adalid and Detken (2007) and Belke et al. (2010), among others, for empirical analyses that identify a link between global liquidity and financial asset prices.

This double expectations' shift moved Greece from L_1 to L_3, explaining the sudden, pronounced increase in Greek spreads without any significant news on Greek fundamentals.[12]

The data suggests that this shift has taken place in a two-step fashion, initially from L_1 to L_2 and then from L_2 to L_3. The first shift occurred in mid-November 2009, with the Greek spread subsequently increasing from 130 basis points to 240 basis points by the end of the year. Arghyrou and Tsoukalas explain this shift as the result of the too cautious, under the circumstances, nature of the proposed 2010 budget submitted by the Greek authorities to the European Commission. The limited only envisaged progress in terms of promoting long overdue fiscal reform resulted into public critical comments on behalf of top EU officials (including the president of the ECB) and, according to Arghyrou and Tsoukalas (2010) validated fears that Greece was not determined to address its long-standing structural problems necessary for long-term EMU participation. This view is also supported by Lynn (2011) who reports intense market scepticism regarding the credibility of the proposed Greek plan in achieving the necessary fiscal correction in the wake of its announcement. On the basis of the above, Arghyrou and Tsoukalas argue that the submission of the proposed 2010 budget was an event that operated as the catalyst for the shift in market expectations from credible to non-credible EMU participation, introducing a previously non-existent exchange rate risk causing Greece to shift from L_1 to L_2.

An alternative view is that this shift was caused by the introduction of default risk, particularly following the downgrading of Greek sovereign bonds from various credit rating agencies in early December 2009. Distinguishing between the two types of risk, exchange-rate versus default, is not a straightforward task especially since the two are very likely to reinforce each other (a country thought as more likely to default will be seen as more likely to leave the EMU and vice-versa). There exists substantial survey evidence[13] as well as statements by influential market analysts (see e.g. Lynn, 2011, p. 133) suggesting that in the aftermath of the outbreak of the Greek debt crisis markets perceived a non-negligible exchange rate risk associated with investments in Greek sovereign bonds. On the other hand, the significant increase in the Greek CDS spread over the same period also suggests the

[12] On 13 October 2009 Greece announced a revision of its projected 2009 public deficit from 6% of GDP to 13.7% of GDP. However, the Greek spread did not react to this news, as markets seem to have fully anticipated the substantial worsening of the Greek fiscal position well before it was announced. The Greek spread started its steep ascend in mid-November 2009, following the submission by Greek authorities of the Greek proposed 2010 public budget to the European Commission (see below).

[13] See, for example, the articles titled "Confidence in the euro still low", published by The Financial Times Advisor on September 20, 2010, and "Economists' survey of the UK: will the euro survive with its current membership for the next five years?" published by The Telegraph, on 9 June 2010.

introduction of significant default risk (see also our analysis in section 5.3 below). Overall, it is very likely that the shift from L_1 to L_2 in November 2009 was the result of both exchange-rate and default risk.

The second shift from L_2 to L_3 occurred in the first quarter of 2010, when the Greek spread increasing from 240 basis points at the end of 2009 to nearly 700 basis points in late April 2010. Arghyrou and Tsoukalas explain this shift as the result of intra-EMU disagreements regarding the necessity and extent of a Greek bail-out. They argue that these disagreements were interpreted by markets as withdrawal of the previously perceived fiscal guarantees, resulting into the introduction of significant default risk or, if this already existed since November 2009, its substantial increase.[14] By applying to all EMU members, the withdrawal of the perceived fiscal guarantee spread the Greek debt crisis to other EMU periphery countries, which have also sustained significant competitiveness losses over the period 1999-2007.

If the model summarized above were correct, an econometric investigation of the movements of EMU spreads over the period 1999-2010 should produce the following findings: First, prior to the credit crunch crisis, i.e. during January 1999-July 2007, the real exchange rate, a variable used in our analysis as a measure of overall macroeconomic performance, should not be statistically significant in explaining spreads' movements. Second, following the onset of the global credit crunch crisis in July 2007, the real exchange rate should be significant in explaining spread movements, i.e. real appreciation should cause higher spread values. Finally, and to capture the assumed contagion effect, during the crisis period the Greek spread should be significant in explaining spreads in other EMU countries, even when real appreciation and the effect of the global risk aversion has been accounted for. All the above constitute testable hypotheses, which we address immediately below.

4. Data description

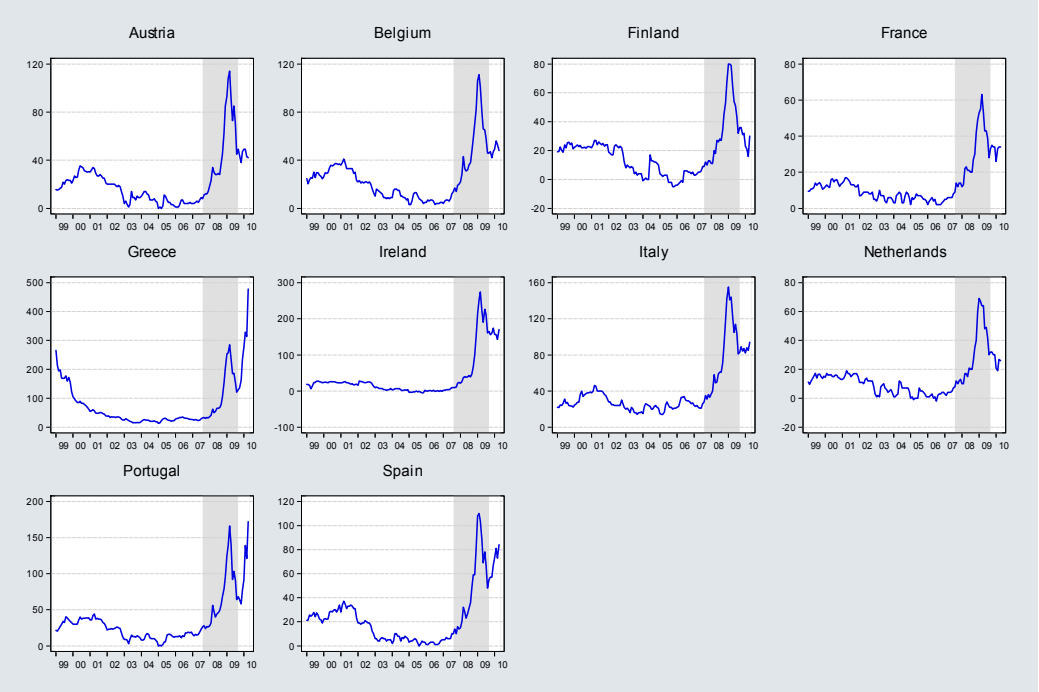
The dependent variable in our empirical analysis is the monthly 10-year government bond yield spread relative to Germany for ten euro-area countries: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. We exclude Luxembourg,

[14] In May 2010 Greece was eventually given a bail-out rescue loan package of 110 billion euros, financed by the EU, the ECB and the IMF. Later that month the EU announced a European stabilisation mechanism, making available a total of up to approximately 750 billion euros to EMU countries funder market pressure over the next three years. Arghyrou and Tsoukalas (2010) argue that EMU spreads failed to respond to these measures, as they were taken too late and were not enough to reverse the adverse shift in expectations caused by the original handling of the crisis.

where the outstanding government debt and the associated market are very small, as well as the countries that joined the euro since 2008 (Cyprus, Malta, Slovakia and Slovenia). The yield spreads sample covers the period 1999.01-2010.04. The data sources for bond yields are Bloomberg (1999.01-2000.12) and the European Central Bank (2001.01-2010.04).[15]

Figure 2 plots the 10-year euro-area government bond yield spreads. Four important stylised facts should be noted. First, before the credit crisis (1999-mid 2007) spreads against Germany had stabilised at very low levels despite deteriorating macroeconomic fundamentals in many countries.[16]

Figure 2: 10-year government bond yield spreads



Note: Spreads are calculated versus Germany and are expressed in basis points. The shaded area corresponds to the period 2007.08-2009.08.

As Table 1 shows, during the pre-crisis period, the average spread ranged from 8.4 basis points in France to 53.5 basis points in Greece, with most countries exhibiting spreads of less than 20 basis points. Figure 3 plots the (log) real effective exchange rate of the euro-area economies and shows that the real exchange rate appreciation that commenced in 2001 persists after 2004 in Greece, Ireland, Portugal and Spain reflecting lower international

[15] The ECB interest rate data is available at: http://www.ecb.int/stats/money/long/html/index.en.html.
[16] The onset of the crisis is generally accepted to be late July 2007. On 9 August 2007, the European Central Bank made the first large emergency loan to banks in response to increasing pressures in the interbank market.

competitiveness.[17] On the other hand, in Germany the trend from 2004 onwards is relatively flat.

Table 1: Average 10-year government bond yield spreads

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
Full sample	22.3	25.4	17.8	13.8	76.4	36.4	39.4	13.8	34.1	23.6
Pre-crisis	14.4	17.8	12.6	8.4	53.5	11.6	26.2	8.6	20.9	14.2
Crisis	46.8	49.2	34.3	30.4	147.9	113.8	80.5	30.2	75.2	52.8
Crisis-contagion	45.1	48.5	28.1	32.9	257.4	160.1	86.5	27.1	98.8	68.4

Note: Spreads are expressed in basis points. The full sample period is 1999.01-2010.04. The pre-crisis period is 1999.01-2007.07. The crisis period is 2007.08-2010.04. The crisis-contagion period is 2009.09-2010.04.

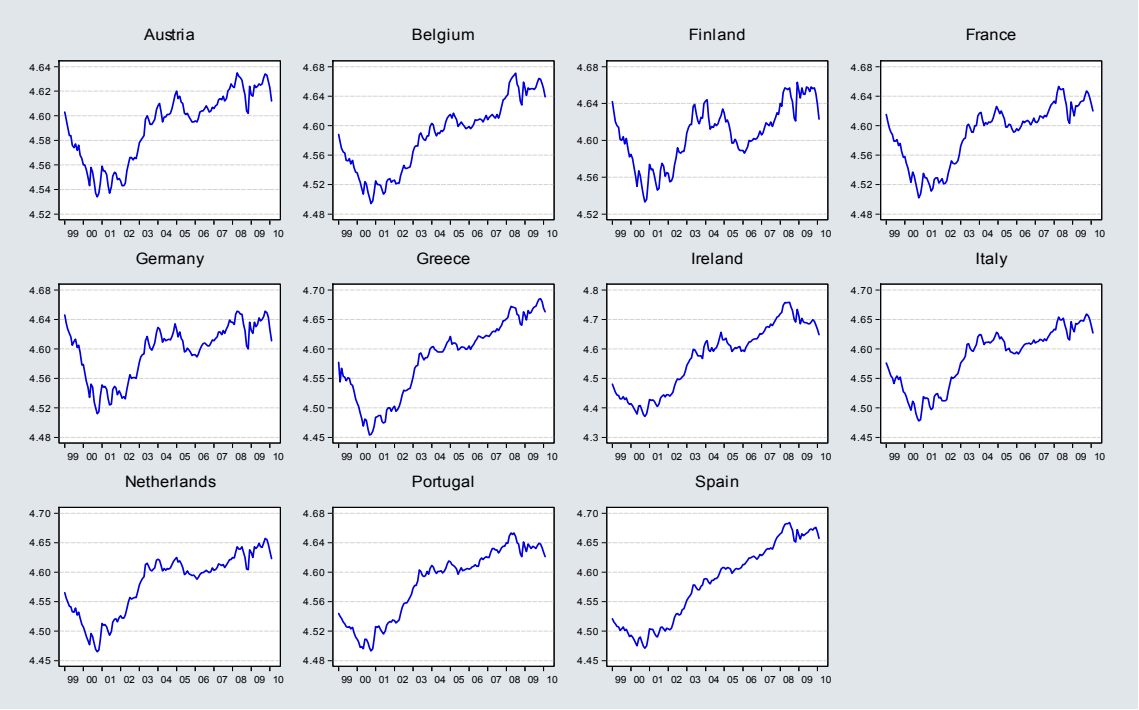
This divergence in external competitiveness within the euro-area is also reflected in Figure 4 which plots the current account balance as percentage of GDP. The data in Germany, Austria and the Netherlands is characterised by an overall positive trend, indicating the current account is improving over time. However, in the rest of the euro-area countries the current account is generally deteriorating over time. The deterioration has been particularly pronounced in Greece, Portugal and Spain where the current account deficit takes increasingly high values throughout the entire sample period, signifying the presence of important internal imbalances within the euro-area.[18]

Second, during the credit crisis all euro-area economies experienced a large increase in their spread versus Germany. As Table 1 indicates, since August 2007, average spreads increased by a factor of around three or four, on average, in most countries and by a factor of ten in Ireland. German government bonds operated as a 'flight-to-quality' asset during the crisis putting an upward pressure in all euro-area government bond yield spreads. This 'flight-to-quality' feature of German bonds is apparent in Figure 5, which plots the 10-year German yield together with a general indicator of common international risk, the Chicago Board Options Exchange (CBOE) Volatility Index (VIX).

[17] Between January 2001 and February 2010, the real effective exchange rate appreciated by 22, 18, 15 and 10 percent in Ireland, Greece, Spain and Portugal, respectively. Becker (2009, p.4) stresses that developments in a country's external competitiveness "can be summarized in one single number: the real effective (i.e. trade-weighted) exchange rate".

[18] The real effective exchange rate, current account balance and GDP series were obtained from the International Monetary Fund's International Financial Statistics dataset. The real effective exchange rate is defined so that an increase describes a real appreciation.

Figure 3: Log real effective exchange rate



Note: The real effective exchange rate is calculated using consumer price indices. An increase indicates a real appreciation.

Figure 4: Current account balance as percentage of GDP

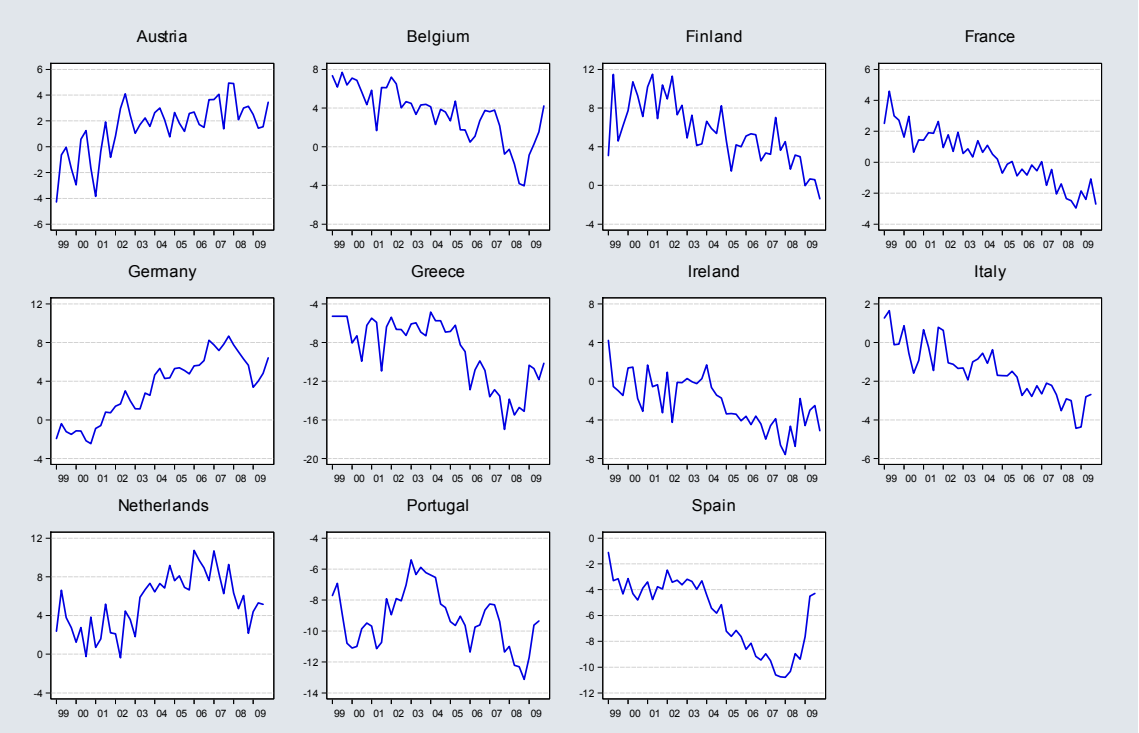
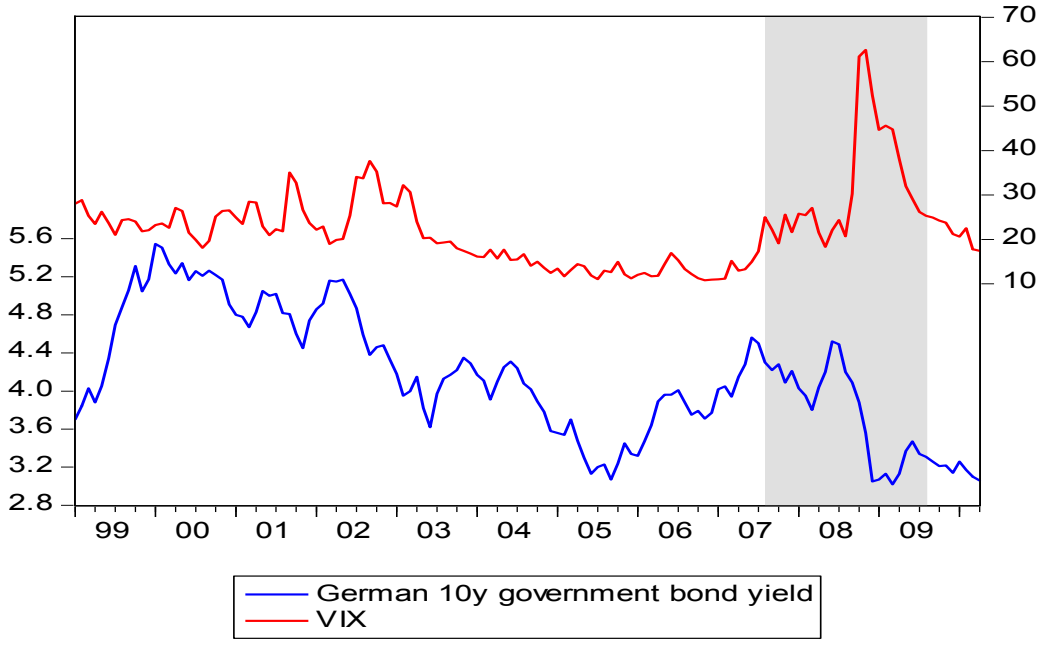


Figure 5: German 10-year government bond yield and VIX



Note: The shaded area corresponds to the period 2007.08-2009.08.

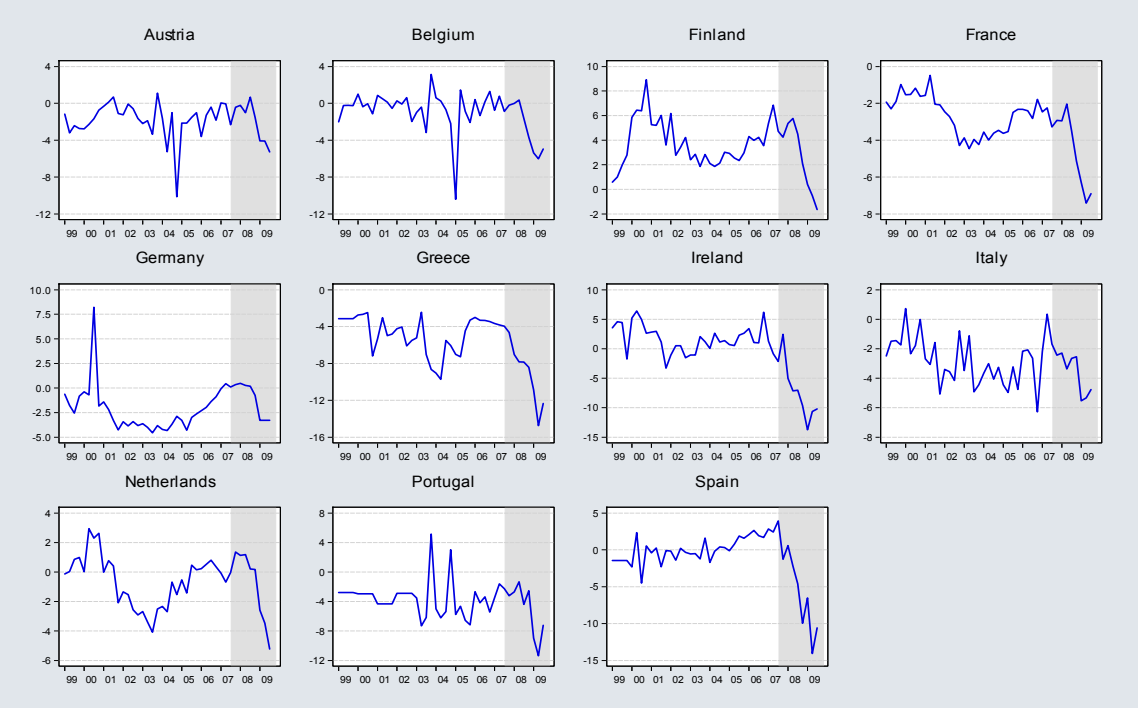
The VIX is a measure of US implied stock market volatility obtained via Bloomberg.[19] Towards the end of 2008, following the collapse of Lehman Brothers, the credit crisis reached its peak. During that period of market turmoil, the VIX increased sharply, while the 10-year German government bond yield moved in the opposite direction indicating that in an environment of heightened uncertainty, investors flock to the perceived safety of German bonds.

Figures 6 and 7 depict the transformation of the credit crisis into a sovereign debt crisis with euro-area government budget balances deteriorating sharply and government debt as a proportion of GDP increasing significantly since mid-2008.[20] The fiscal deterioration reflects lower tax revenues for the euro-area governments, due to economic contraction, as well the fiscal stimulus packages that were implemented to prevent further contraction.

[19] The VIX is constructed using call- and put-implied volatilities from the S&P 500 index 30-day options. Implied volatility measures are forward-looking, as opposed to historical volatility measures which are backward-looking. An index value of e.g. 20 for the VIX indicates that the implied volatility of 30-day options on the S&P 500 is 20 percent. Note that prior to 22 September 2003, the S&P 100 index was used for the calculation of the VIX. Monthly averages of the VIX are calculated from daily observations. Econometric analysis using regime-switching models in IMF (2003) suggests that 'flight-to-quality' periods and high levels of the VIX tend to coincide.

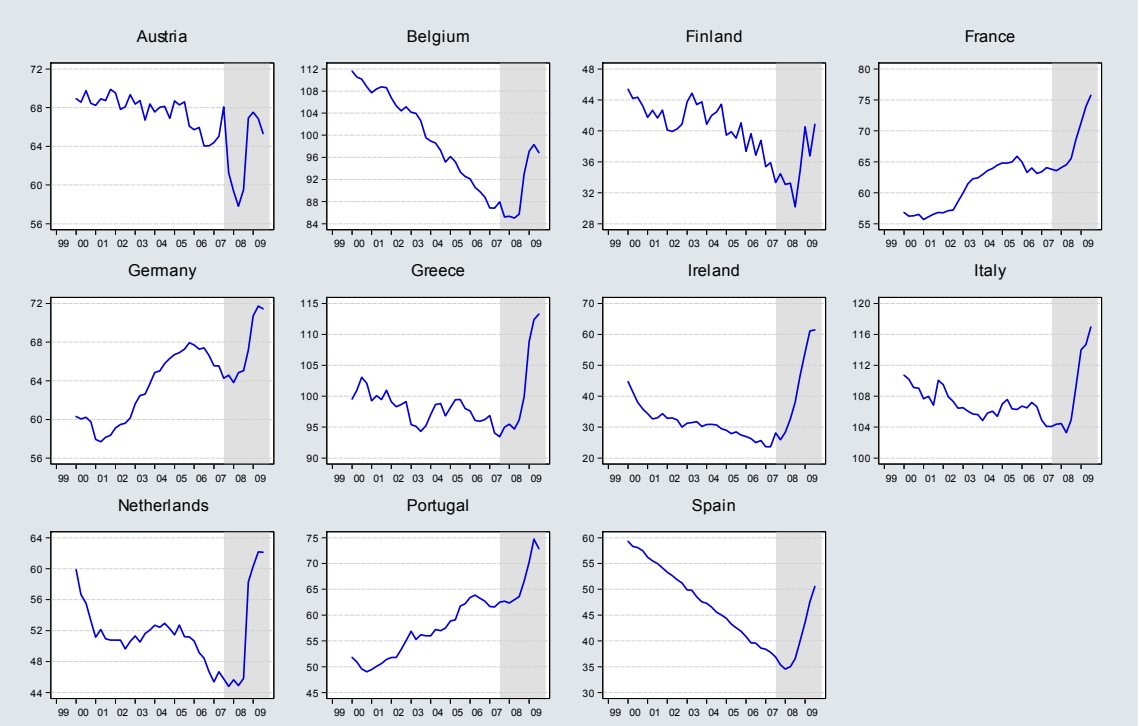
[20] The general government lending/borrowing and gross government debt series were obtained from the International Monetary Fund's International Financial Statistics dataset.

Figure 6: General government net lending or borrowing as percentage of GDP



Note: The shaded area corresponds to the period 2007.Q3-2009.Q4.

Figure 7: Gross government debt as percentage of GDP



Note: The shaded area corresponds to the period 2007.Q3-2009.Q4

Furthermore, governments faced the additional major fiscal cost of having to support the financial sector, via significant capital injections in the euro-area banks' balance sheets, guarantees, such as the Irish government bank guarantee scheme (29/09/2008), and outright purchases of assets from banks.[21]

Third, despite reductions in the second half of 2008, no country has returned to its pre-crisis spread level. Finally, and very importantly, there is initial evidence of contagion from the Greek debt crisis to other EMU members. In particular, the average spread in Greece increased significantly since September 2009, at 257.4 basis points, marking the Greek debt crisis. During the latter part of the sample, average spreads increased also in the other Club-Med countries (Italy, Portugal and Spain) as well as in Ireland, indicating the possibility of contagion from Greece. This conjecture is explicitly tested by our econometric analysis below.

In our benchmark pre-crisis econometric specification, spreads are modelled on their lagged level, the log of the real effective exchange rate and the VIX. This specification maps directly our empirical analysis to the theoretical model presented in section 3, also controlling for the effects of momentum trading and international risk aversion. The VIX, often called the 'investor fear gauge' since it tends to spike during market turmoil periods (Whaley, 2000), is a reasonable proxy for global financial instability (Mody, 2009). Other studies that employ the VIX as an aggregate risk proxy in analyses of euro-area government bond yield spreads include Beber et al. (2009) and Gerlach et al. (2010). Furthermore, we estimate alternative, extended specifications where the set of explanatory variables for spreads also includes a measure of bond market liquidity, industrial production growth and the expected fiscal position, as suggested by expected public debt and budget balance to GDP ratios. All aforementioned variables are calculated as *differentials versus Germany*.

Bond market liquidity is measured by the size of government bond market as in Bernoth et al. (2004), Gomez-Puig (2006), Haugh et al. (2009) and Attinasi et al. (2009) among others. In particular, we use the ratio of a country's outstanding general government debt to euro-area-wide total.[22] As Table 2 shows, Italy, Germany and France have the largest government bond markets in the euro-area, while the three smallest markets are those of

[21] Sgherri and Zoli (2009) argue that the discretionary euro-area fiscal stimulus is estimated to around 1.1 and 0.9 percent of GDP in 2009 and 2010, respectively. They also point out that the immediate euro-area fiscal cost of the banks' support measures is, on average, around 3.5 percent of (2008) GDP.

[22] The data on outstanding amounts of general government long-term securities other than shares is obtained from the ECB's Securities Issues Statistics: http://sdw.ecb.europa.eu/browse.do?node=17102.

Ireland, Finland and Portugal. We use the annual growth rate of industrial production as a proxy for the state of business cycle. [23] As Alesina et al. (1992) point out, sovereign debt becomes riskier during periods of economic slowdown (see also Bernoth et al., 2004). Table 2 indicates that prior to the crisis Ireland exhibited the highest growth rate while Portugal underperformed exhibiting negative average growth. During the crisis, industrial production declined in all euro-area members, with Spain and Italy being particularly affected.

Moving on to frequently used measures of credit risk, we obtained data on the expected fiscal position of the euro-area economies from the European Commission's Economic Forecasts Database.[24] The expected fiscal position provides a proxy for credit quality, with an expected fiscal deterioration implying higher risk. We use the one-year-ahead expected balance, that is, net lending or borrowing (as percentage of the GDP) and the one-year-ahead expected gross debt of the general government (as percentage of the GDP). The utilisation of expected, as opposed to historical fiscal data, is in line with a number of recent studies including Attinasi et al. (2009), Sgherri and Zoli (2009) and Gerlach et al. (2010). The descriptive statistics in Table 2 indicate that only during the last months of the crisis subsample period expectations appear to shift sharply towards fiscal deterioration. For example, in Greece, the latest figures from the European Commission's Economic Forecasts (Spring 2010) indicate that debt is expected to rise to almost 134% of the GDP by 2011, signifying an enormous fiscal strain. Finally, we obtained data from Bloomberg on the CDS spreads for the euro-area 10-year government bonds. The CDS is a credit derivative which allows the buyer to purchase insurance against the risk of default.[25] The CDS market for developed country sovereign debt is relatively new but has experienced significant growth over the last years.[26] Nevertheless, according to the BIS (2010), the amount of sovereign risk which is reallocated through CDS

[23] The industrial production series were obtained from the International Monetary Fund's International Financial Statistics dataset.

[24] These forecasts are produced by the DG ECFIN twice a year (spring and autumn). They result from analyses made by the DG ECFIN's country-desks, as opposed to a centralised econometric model. The data is available at: http://ec.europa.eu/economy_finance/publications/european_economy/forecasts_en.htm. As Attinasi et al. (2009) point out, given the prominent role of the European Commission's forecasts, investors may use them a source of information to form their expectations.

[25] The buyer of a CDS contract on sovereign bonds agrees to make regular payments (CDS premium) to the seller in return for a payment by the seller if the credit event (default of the reference entity) occurs. The CDS spread is equal to the total amount that the buyer pays per year divided by the total face value of the bonds (notional principal). The payment that the buyer receives if the credit event occurs is equal to the notional principal multiplied by: (1- recovery rate); where the recovery rate is equal to the ratio of the post-default value of the bond to its face value. For example, the recovery rate for CDS contracts with Lehman Brothers as the reference entity was only about 8% (see Hull, 2009, Chapter 23).

[26] 10-year CDS data for Greek, French, Italian and Spanish contracts commence on 01/12/2003 in Bloomberg. However, German data commences on 15/03/2004 and hence this is the earliest starting point for the calculation of CDS spreads relative to Germany. Data for Austria, Belgium, Finland and Portugal commence on

Table 2: Bond market size, industrial production growth and expected fiscal position

Full sample

	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NEL	POR	SPA
Bond Mkt Size	3.3	5.9	1.4	19.2	23.7	3.8	0.8	28.1	4.7	1.6	7.5
Ind. Prod.	2.7	-0.1	0.9	-0.9	0.5	-0.2	4.4	-1.7	0.8	-1.6	-1.2
Exp. Budg. Bal.	-1.6	-0.9	2.5	-3.0	-2.3	-2.5	-1.1	-2.8	-1.1	-3.3	-1.0
Exp. Debt	63.0	96.3	40.2	64.3	64.7	101.6	36.3	107.3	53.5	63.2	49.9

Pre-crisis

	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NEL	POR	SPA
Bond Mkt Size	3.3	6.1	1.5	18.9	23.4	3.4	0.7	28.6	4.8	1.6	7.6
Ind. Prod.	4.7	2.0	4.0	0.6	2.8	1.1	6.3	0.7	1.5	-0.3	1.6
Exp. Budg. Bal.	-1.2	-0.3	3.0	-2.4	-2.3	-1.8	1.0	-2.5	-0.9	-2.9	0.0
Exp. Debt	62.7	98.4	41.1	61.5	63.5	101.5	31.6	106.9	54.0	60.3	50.5

Crisis

	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NEL	POR	SPA
Bond Mkt Size	3.2	5.2	1.0	20.3	24.3	5.1	1.0	26.4	4.2	1.8	7.4
Ind. Prod.	-3.6	-6.4	-8.2	-5.7	-6.7	-4.3	-1.3	-9.0	-1.3	-5.4	-9.9
Exp. Budg. Bal.	-2.6	-2.8	1.0	-4.8	-2.2	-4.8	-7.4	-3.4	-1.9	-4.6	-4.1
Exp. Debt	64.2	89.8	37.4	72.9	68.7	102.0	50.8	108.5	52.1	72.3	47.8

Crisis-contagion

	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NEL	POR	SPA
Bond Mkt Size	3.1	5.2	1.0	20.0	23.4	5.4	1.4	26.2	4.2	1.8	8.3
Ind. Prod.	-6.2	-11.1	-15.1	-4.2	-8.6	-7.7	-4.0	-9.0	-1.3	-3.0	-7.0
Exp. Budg. Bal.	-5.4	-5.7	-4.1	-8.0	-5.1	-11.1	-14.5	-5.2	-6.0	-7.8	-9.9
Exp. Debt	73.9	101.1	48.1	83.7	77.6	123.9	83.1	116.9	65.8	85.0	66.6

Note: All the data in Table 2 is expressed in percentages. The full sample period for the bond market size and expected fiscal position variables is 1999.01-2010.04, while for the industrial production growth the full sample period is 2000.01-2010.01. The pre-crisis period extends from the start of the sample until 2007.07, while the crisis period extends from 2007.08 until the end of the sample. The crisis-contagion period extends from 2009.09 until the end of the sample.

markets is not as large as the gross outstanding volumes would imply since net CDS positions as proportion of the outstanding sovereign debt are only close to 5% in Portugal and even less in Greece, Ireland and Spain.[27] CDS spreads have been used by Barrios et al. (2009) and Beber et al. (2009) as a proxy for credit risk in high-frequency empirical investigations of eurozone spreads (weekly and intraday, respectively), where expected fiscal position

05/04/2004, while in Ireland and Netherlands the CDS contracts become available towards the end of the sample period, on 29/01/2009 and 23/01/2008, respectively.

[27] The BIS (2010) suggests that sovereign reallocated risk is better captured by net CDS positions since a large proportion of trades reflect offsetting transactions as CDS market participants frequently do not terminate or replace the former contracts. This feature of the CDS market generates a chain of linked exposures with market participants having limited information about the parties beyond their direct counterparties (see ECB, 2009).

measures are not available. Figure 8 plots the 10-year government bond yield spreads together with the corresponding CDS spreads. It appears that in most euro-area economies the two series tend to broadly co-move over time, especially during the credit/debt crisis. Sharp increases in CDS spreads are observed in Greece, Portugal and Spain since autumn 2009, with the cost of insuring against default reaching a historical high by the end of April 2010.

5. Empirical framework and results

This section presents our estimated econometric models and empirical results. Subsection 5.1 contains the findings from the pre-crisis period (1999.01-2007.07). Subsection 5.2 refers to the crisis period (2007.08-2010.04). Subsection 5.3 focuses on the Greek debt crisis; and subsection 5.4 on robustness tests.

5.1 Modelling spreads during the pre-crisis period

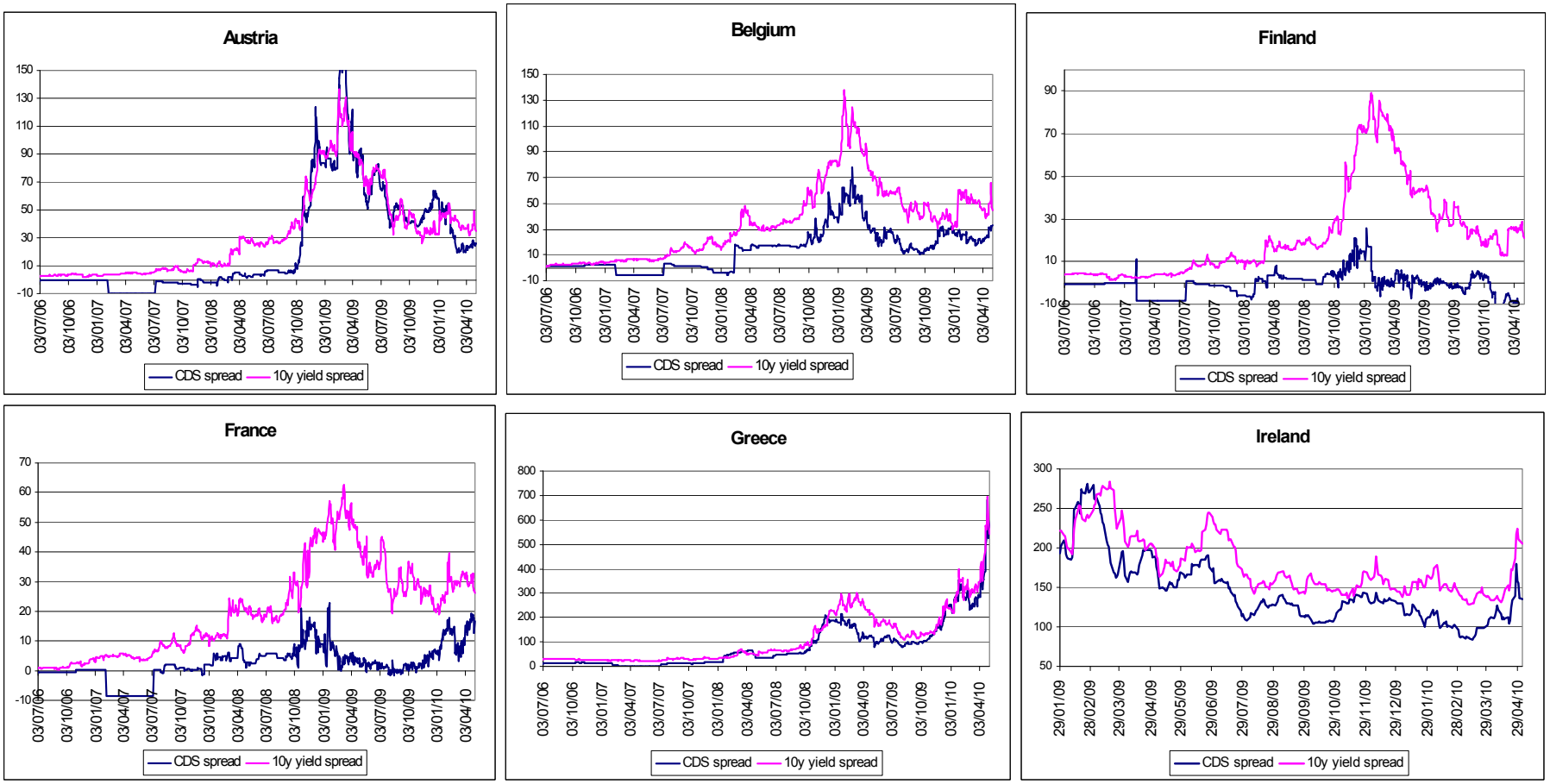
The baseline model for spreads prior to the crisis relates them to country-specific macroeconomic fundamentals, captured by the value of the real exchange rate, and the international risk factor, accounting at the same time for persistence in the data. The model is given by Eq. (4) below:

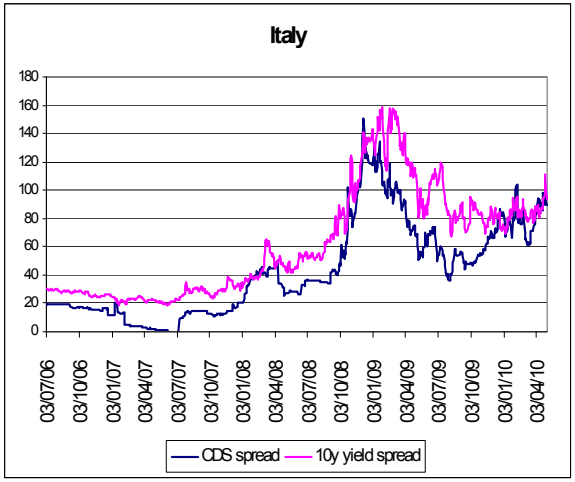
$$spread_t = a + \beta_1 spread_{t-1} + \beta_2 q_t + \beta_3 vix_t + u_t \qquad (4)$$

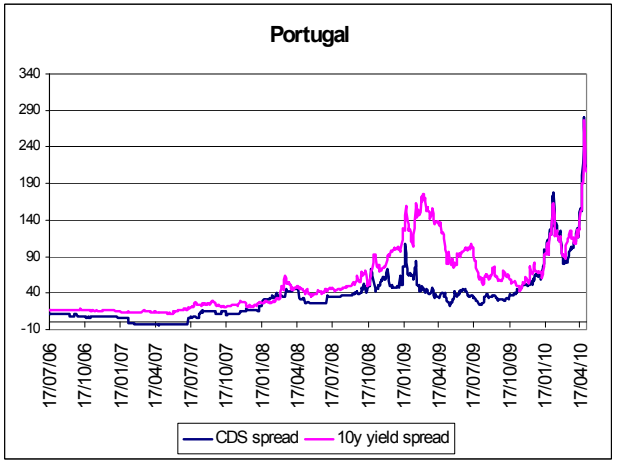
where $spread_t$ denotes the 10-year government bond yield spread relative to Germany, q_t is the logarithm of the real effective exchange rate, vix_t denotes the logarithm of the CBOE Volatility Index and u_t is a white noise error term.

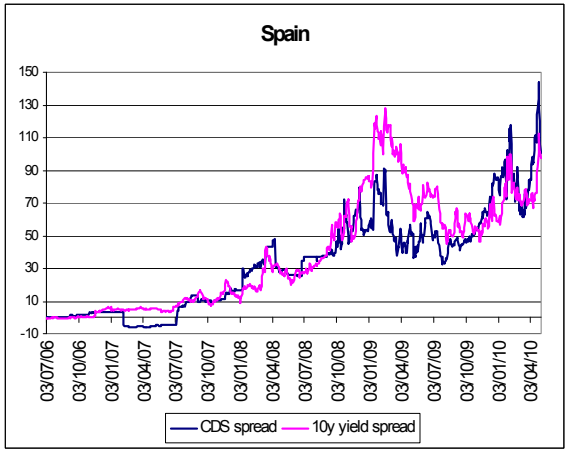
Table 3 - A presents the time-series estimates of the baseline model correcting for heteroskedasticity and autocorrelation of unknown form in the residuals (OLS-HAC; see Newey and West, 1987). Spreads are quite persistent as indicated by the estimates of the autoregressive parameter (β_1) which range from 0.74 in Netherlands to 0.96 in Austria and are significantly different from zero at the 1% level in all cases. Beyond autoregressive dynamics however, spreads either do not react or exhibit the wrong sign in their reaction to

Figure 8: Credit Default Swap spreads and 10-year government bonds yields spreads









Note: Spreads are calculated versus Germany and are expressed in basis points in the case of the 10-year bond yields and thousands of US dollars (USD) in the case of the Credit Default Swaps (cost of insuring 10,000,000 USD holdings of government debt against default).

Table 3

A: Pre-crisis time-series estimates, OLS-HAC, baseline

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.96 ***	0.91 ***	0.87 ***	0.81 ***	0.91 ***	0.78 ***	0.84 ***	0.74 ***	0.90 ***	0.91 ***
q_t	-0.01	-0.20	-0.21 **	-0.08	-0.04	-0.20 **	-0.21 *	-0.23 ***	-0.29	-0.19
vix_t	0.01	0.00	0.02 *	0.01	-0.01	0.01	-0.01	0.01	-0.01	-0.01
$Adj\text{-}R^2$	0.94	0.96	0.93	0.83	0.94	0.94	0.86	0.88	0.94	0.96

B: Pre-crisis time-series estimates, OLS-HAC, controlling for liquidity

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.93 ***	0.90 ***	0.81 ***	0.81 ***	0.91 ***	0.78 ***	0.84***	0.71 ***	0.90 ***	0.93 ***
q_t	0.17	0.17	-0.13	-0.05	0.21	-0.23 **	-0.30	-0.19 **	-0.38 *	-0.31 **
vix_t	-0.003	-0.001	0.01	0.01 *	-0.004	0.01	-0.001	0.006	-0.007	-0.002
liq_t	0.01	0.002	0.01	0.006	0.02	-0.004	-0.002	0.004	-0.006	-0.008
$Adj\text{-}R^2$	0.94	0.96	0.93	0.83	0.94	0.93	0.86	0.88	0.94	0.96

C: Pre-crisis time-series estimates, OLS-HAC, controlling for liquidity and output growth

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.92 ***	0.91 ***	0.81 ***	0.75 ***	0.86 ***	0.82 ***	0.84 ***	0.72 ***	0.91 ***	0.88 ***
q_t	0.10	-0.23	0.19	-0.14	0.09	-0.21 **	-0.31	-0.22 **	-0.31	-0.41 ***
vix_t	-0.005	-0.001	0.01	0.01	-0.001	0.01	-0.001	0.006	-0.01	-0.002
liq_t	0.01	-0.001	0.01	0.01	0.02	-0.007	-0.002	0.001	-0.006	-0.007
$gind_t$	0.01	0.00	0.001 *	0.00	-0.002 *	0.00	-0.001	0.00	0.0001	-0.002
$Adj\text{-}R^2$	0.94	0.96	0.93	0.82	0.94	0.95	0.86	0.88	0.94	0.96

D: Pre-crisis time-series estimates, OLS-HAC, controlling for liquidity and expected fiscal position

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.82 ***	0.82 ***	0.77 ***	0.80 ***	0.79 ***	0.79 ***	0.79 ***	0.65 ***	0.82 ***	0.83 ***
q_t	0.07	0.25	-0.16	-0.11	-0.41	-0.22 **	-0.35 *	-0.35 ***	-0.51 ***	-0.27
vix_t	-0.004	-0.004	0.02 *	0.01 *	0.01	0.02	0.007	0.003	-0.002	-0.005
liq_t	0.02	0.002	0.002 ***	0.01	0.01	-0.003	0.002	0.008	0.01	0.005
bal_t	-0.01 **	-0.01 *	-0.01 ***	-0.003	-0.01 *	0.001	-0.01 *	-0.01 ***	-0.01 **	-0.01 **
$debt_t$	0.00	0.00	-0.001	0.001	-0.002 *	0.00	-0.002	-0.001	0.00	-0.001
$Adj\text{-}R^2$	0.94	0.96	0.93	0.83	0.94	0.93	0.86	0.89	0.94	0.96

Note: In Table 5 - A, B and D, the regression models are estimated over the time period 1999.01-2007.07 in all cases apart from Greece where the sample period is 2001.01-2007.07, due the later entrance of Greece into the EMU. In Table 5 - C the regression models are estimated over the time period 2000.01-2007.07 in all cases apart from Greece (2001.01-2007.07). Ordinary Least Squares (OLS) estimates of the parameters with heteroskedasticity and autocorrelation (HAC) consistent estimates of the standard errors are shown. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

the international and country-specific explanatory variables. Specifically, the VIX is not significant at the 5% level of significance as determinant of spreads in any country, thereby suggesting that the link between spreads and global financial risk was not active during the pre-crisis period. Furthermore, there is evidence of non-pricing, as well as mispricing in certain instances, of the country-specific macroeconomic fundamental since the real effective exchange rate coefficient is either statistically insignificant or negative and significant. This indicates that during the pre-crisis period real exchange rate appreciation and the associated loss of competitiveness were not penalised by bond market participants in the form of higher spreads. This finding is robust to controlling for contemporaneous correlation in the error terms across the equations reflecting, for example, common aggregate shocks.[28]

Table 3 - B reports the OLS-HAC time-series estimates of the parameters of the baseline model augmented by the proxy for bond market liquidity (liq_t). In all cases, the coefficient of liq_t is not significantly different from zero, indicating that spreads were not affected by bond market liquidity risk considerations during the pre-crisis period. Similar evidence, in terms of the limited explanatory power of country-specific factors as determinants of spreads, is provided by Table 3 - C. This table shows the results from regressions where, in addition to the bond market liquidity proxy, a proxy for the state of business cycle (output growth differentials, $gind_t$) is included in the baseline model. At the 5% level of significance, both additional variables are statistically insignificant. It is only when the expected fiscal position variables (expected budget balance, i.e. net lending/borrowing differentials, bal_t; and expected gross debt differentials, $debt_t$) are incorporated in the baseline model, that we obtain some evidence supporting the role of a country-specific factor with the theoretically expected sign. As we can see in Table 3 - D, an improvement in the fiscal position captured by an increase in the value of the government's balance bal_t (i.e. a movement away from net borrowing towards net lending) leads to lower spreads in the majority of countries, with the coefficient of bal_t being negative and statistically significant at the 10% or less in eight cases. On the other hand, the evidence does

[28] The average cross-country correlation coefficient in the residuals of Eq. (4) is equal to 0.43. In order to empirically account for this correlation, we form a system of equations, representing the baseline model in each country, and estimate it with the seemingly unrelated regression method (SUR). SUR estimates of the system's parameters account for heteroskedasticity and contemporaneous correlation in the errors across equations. The pre-crisis estimates are shown in Table A1 in the Appendix. In line with the OLS-HAC time-series estimates in Table 3 - A, SUR estimates of the real exchange rate coefficient are either statistically insignificant or statistically significant with a negative sign. Using SUR, there is more evidence, as compared to the robust OLS estimates, of the degree of financial market volatility being a determinant of spreads, since the VIX coefficient is positive and statistically significant in some countries. See also Barrios et al. (2009) for evidence from weekly data supporting the view that the degree of risk aversion affected the euro-area government bond yield spreads during the pre-crisis period (2003-2009), while country-specific factors did not exert much influence.

not support the existence of a strong link between spreads and expected debt during the pre-crisis period. Hence, the credit risk channel appears to mainly operate via the expected fiscal balance, as opposed to expected debt.

Table 4 reports panel estimates of the baseline model and its extensions:

$$spread_{it} = a_i + \beta_1 spread_{it-1} + \beta_2 q_{it} + \beta_3 vix_t + \mathbf{\Theta}' \mathbf{X}_{it} + u_{it} \quad (5)$$

where $\mathbf{X}_{it} = [x_{1it} \quad ... \quad x_{jit}]'$, and $\mathbf{\Theta} = [\theta_1 \quad ... \quad \theta_j]'$ denote the vector of additional explanatory variables and the relevant coefficient vector, respectively.

Table 4: Pre-crisis panel estimates, fixed effects

	(1)	(2)	(3)	(4)
$spread_{it-1}$	0.90 ***	0.89 ***	0.89 ***	0.86 ***
q_{it}	-0.08 **	-0.06	-0.06	-0.13 ***
vix_t	0.001	0.00	0.00	0.002
liq_{it}	-	0.21 *	0.21 *	0.36 **
$gind_{it}$	-	-	0.00	0.00
bal_{it}	-	-	-	-0.005 ***
$debt_{it}$	-	-	-	0.00
Test for FE	0.01	0.006	0.006	0.00
***Adj-R*^{2}**	0.95	0.95	0.95	0.95

Note: Specification (1) corresponds to the baseline model during the pre-crisis period. Specification (2) augments the baseline model by the liquidity measure. Specifications (3) and (4) add output growth differentials and the expected fiscal position variables. The regression models are estimated over the time period 2001.01-2007.07. The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. Fixed effects panel estimates with GLS cross-section weights in order to account for cross-sectional heteroskedasticity are shown. Test for Fixed Effects (FE) shows the *p*-value for the null hypothesis of redundant fixed effects. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Eq. (5) represents a fixed-effects panel data model and is estimated using Generalised Least Squares (GLS)-based cross-section weights which account for cross-sectional heteroskedasticity. The null hypothesis of redundant fixed effects is strongly rejected both for baseline and the three alternative models. The pre-crisis results from panel estimation of the baseline model (see column 2 in Table 4) are similar to those from time-series estimation as spreads are found to be quite persistent, the real effective exchange link remains either statistically insignificant or significant with the wrong (negative) sign, while global financial market volatility does not have any explanatory power over spreads. Similarly, panel

estimation results of the extended models (see specifications 2, 3 and 4 in Table 4) are also in line with the previously presented time-series estimates since output growth and expected debt differentials are statistically insignificant, while the expected fiscal balance is a significant determinant of spreads. The main difference between pre-crisis time-series and panel estimates is that within the latter bond market liquidity conditions become statistically significant but not with the theoretically expected negative sign, thereby indicating mispricing of liquidity risk. [29]

Thus, overall, the pre-crisis results can be viewed as being supportive of the 'convergence trade' conjecture, according to which investors "…bought the bonds of peripheral European governments in the hope that their yields would convergence with those of Germany" (The Economist, 12/06/2010). In terms of the theoretical model presented in section 3, these findings offer support to the hypothesis that prior to the global credit crunch, spreads were de-linked from macro-fundamentals, as markets discounted full convergence between core and periphery EMU countries, i.e. a state of the world with EMU countries operating under L_1 with $\gamma_1 = 0$. The resulting high demand for the bonds of periphery countries exerted a downward pressure on their spreads and the expectation of convergence, which lay at the heart of this trading strategy, became self-fulfilling leading to profits for bond market investors and lower borrowing costs for the governments. It appears that markets were myopically discounting, in a way similar to the predictions of Krugman's (1998) model for asset prices, only the best-case scenario of full convergence to German fundamentals and failed to react to deteriorating domestic fundamentals as indicated by falling competitiveness. Consequently, 'convergence trade', along with the absence of an effective EU-sponsored mechanism of economic monitoring imposing reform, relaxed considerably the degree of pressure on many governments to improve fundamentals. This contributed to increasing real divergence within the eurozone and put in place the necessary background for the developments taking place during the crisis period.

5.2 Modelling spreads during the crisis period

The Greek spread variable is added to the baseline model for the spreads of the other eurozone members during the turmoil period allowing us to explicitly test the hypothesis of euro-area contagion from the Greek debt crisis:

[29] A negative sign is theoretically expected since improvements in the liquidity of the market for government bonds should lead to lower spreads as the liquidity premium declines.

$$spread_t = a + \beta_1 spread_{t-1} + \beta_2 q_t + \beta_3 vix_t + \beta_4 spread_t^{GR} + v_t \quad (6)$$

where $spread_t^{GR}$ denotes the 10-year Greek government bond yield spread relative to Germany, v_t is a white noise error term and all other variables are as previously defined.

Table 5 - A presents the OLS-HAC time-series estimates of Eq. (6). The crisis results are strikingly different in comparison to the pre-crisis results as international and country-specific explanatory variables are now strongly significant in most cases. More specifically, first, the persistence of spreads is considerably lower during the crisis with the estimates of the autoregressive parameter ranging from 0.34 in Portugal to 0.75 in Ireland. Second, the link between spreads and global financial risk becomes strongly active since August 2007, as indicated by the statistical significance of the VIX in all countries. The Italian spread exhibits the greatest degree of exposure to the global risk factor, followed by Austrian and Irish spreads. Third, the real exchange rate coefficient is positive and statistically significant in most countries. Hence, in contrast to the pre-crisis period, where there was either non-pricing or mispricing of the risk associated with competitiveness losses and other adverse macro-developments, during the crisis this country-specific macroeconomic risk is reflected in the spreads. Fourth, contagion from the Greek debt crisis appears to have taken place almost everywhere since the coefficient associated with the Greek spread variable is positive and significant in most countries. The degree of contagion is not uniform ranging from a low level of contagion in France to high levels in Portugal, Ireland and Spain. The high degree of exposure of Portugal, Ireland and Spain to the Greek debt crisis does not come as a surprise given that, like Greece, since the euro's introduction in 1999 these countries have all experienced significant deterioration in their fundamentals.[30] These findings are robust to accounting for contemporaneous correlation in the errors across equations.[31]

In Table 5 - B and C we report the results from augmenting the baseline model by the bond market liquidity and business cycle conditions proxies. In Table 5 - B, the estimated coefficient of the liquidity measure is negative and statistically significant in Austria, Belgium, Finland and Portugal, indicating that liquidity risk is priced in the spreads of these

[30] As Arghyrou and Tsoukalas (2010, p.18) point out, "These include competitiveness losses leading to substantial current account deficits, particularly in the cases of Portugal and Spain (see also Arghyrou and Chortareas, 2009); and…a major fiscal deterioration in 2008-2009".
[31] See SUR estimates of the baseline model during the crisis in Table A2 in the Appendix.

Table 5

A: Crisis time-series estimates, OLS-HAC, baseline

	AUS	BEL	FIN	FRA	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.52 ***	0.49 ***	0.59 ***	0.50 ***	0.75 ***	0.44 ***	0.60 ***	0.34 ***	0.36 ***
q_t	4.88 ***	1.66 ***	2.29 ***	1.69 **	1.63	4.28 ***	2.01 **	4.36 *	2.74 ***
vix_t	0.31 ***	0.26 ***	0.23 ***	0.16 ***	0.30 ***	0.43 ***	0.22 ***	0.19 **	0.21 ***
$spread_t^{GR}$	0.09 ***	0.07 ***	0.02	0.05 **	0.22 **	0.11 ***	0.01	0.27 ***	0.17 ***
$Adj\text{-}R^2$	0.95	0.94	0.95	0.94	0.96	0.97	0.94	0.94	0.96

B: Crisis time-series estimates, OLS-HAC, controlling for liquidity

	AUS	BEL	FIN	FRA	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.55 ***	0.49 ***	0.59 ***	0.50 **	0.73 ***	0.45 ***	0.58 ***	0.38 ***	0.36 ***
q_t	5.18 **	1.88 ***	2.65 ***	1.69 **	1.79 *	4.51 ***	2.73 **	3.73	2.74 ***
vix_t	0.27 ***	0.22 ***	0.19 ***	0.16 ***	0.33 **	0.42 ***	0.20 ***	0.11	0.20 ***
liq_t	-0.05 **	-0.05 *	-0.05 *	0.00	0.03	-0.03	-0.05	-0.08 **	-0.004
$spread_t^{GR}$	0.12 ***	0.10 ***	0.04 **	0.05 ***	0.21 **	0.12 ***	0.04	0.32 ***	0.17 ***
$Adj\text{-}R^2$	0.95	0.95	0.96	0.94	0.96	0.97	0.95	0.95	0.96

C: Crisis time-series estimates, OLS-HAC, controlling for liquidity and output growth

	AUS	BEL	FIN	FRA	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.49 ***	0.41 ***	0.56 ***	0.43 ***	0.49 ***	0.43 ***	0.58 ***	0.36 *	0.28 **
q_t	3.77 ***	1.75 ***	2.56 ***	1.72 **	1.53 *	4.44 ***	2.58 *	5.17 **	2.68 ***
vix_t	0.21 ***	0.21 ***	0.19 ***	0.16 ***	0.27 *	0.42 ***	0.20 ***	0.16 *	0.20 ***
liq_t	-0.06 ***	-0.06 *	-0.06 **	-0.01	0.11	-0.03	-0.04	-0.08	-0.01
$gind_t$	0.003	0.002	-0.002	0.002	0.01 **	0.002	-0.001	0.003	0.003
$spread_t^{GR}$	0.14 ***	0.12 **	0.06 **	0.05	0.31 ***	0.13 ***	0.04	0.28 ***	0.21 ***
$Adj\text{-}R^2$	0.95	0.95	0.96	0.94	0.96	0.96	0.95	0.95	0.96

Note: In Table 5 - A and B the regression models are estimated over the time period 2008.07-2010.02, while in Table 5 - C the end of the sample period is 2008.07-2010.01. Ordinary Least Squares (OLS) estimates of the parameters with heteroskedasticity and autocorrelation (HAC) consistent estimates of the standard errors are shown. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Table 6: Crisis panel estimates, fixed effects

	(1)	(2)	(3)	(4)
$spread_{it-1}$	0.73 ***	0.74 ***	0.74 ***	0.74 ***
q_{it}	0.76 **	0.80 **	0.92 **	0.95 **
vix_t	0.17 ***	0.16 ***	0.17 ***	0.15 ***
liq_{it}	-	-1.29	-1.30	-2.53 **
$gind_{it}$	-	-	0.00	-0.004
bal_{it}	-	-	-	-0.02 ***
$debt_{it}$	-	-	-	0.00
$spread_t^{GR}$	0.03 ***	0.04 ***	0.04 ***	0.04 ***
Test for FE	0.00	0.00	0.00	0.00
$Adj\text{-}R^2$	0.94	0.94	0.95	0.95

Note: Specification (1) corresponds to the baseline model during the crisis period. Specification (2) augments the baseline model by the liquidity measure. Specifications (3) and (4) further add output growth differentials and the expected fiscal position variables. The regression models (1) and (2) are estimated over the time period 2007.08-2010.02, while the end of the sample period is 2010.01 in (3) and (4). The panel members include Austria, Belgium, Finland, France, Ireland, Italy, Netherlands, Portugal and Spain. Fixed effects panel estimates with GLS cross-section weights in order to account for cross-sectional heteroskedasticity are shown. Test for Fixed Effects (FE) shows the *p*-value for the null hypothesis of redundant fixed effects. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

countries. In line with the pre-crisis results, however, output growth differentials are not successful in explaining spreads since the relevant coefficient is statistically significant only in Ireland and, furthermore, does not have the expected sign.[32] The rest of our findings remain robust, as real exchange rates, the VIX and the Greek spread, remain significant in most countries' when the additional explanatory variables enter the regressions. Results from panel estimation of the baseline model (now excluding Greece) and its extensions are presented in Table 6. These are in line with the time-series evidence since real exchange rate appreciation, higher global financial volatility and increases in the Greek spread exert a positive and statistically significant effect on the spreads of other eurozone countries during the crisis period. Furthermore, the effect from output growth differentials is statistically insignificant, while the liquidity effect on spreads is negative and significant at the 5% level using the most general specification (see specification 4 in Table 6).[33] Expected fiscal position variables were not included in the time-series regressions because, due to their bi-

[32] An increase in the growth rate of industrial production (relative to Germany) should lead to lower spreads, hence a negative sign is expected.

[33] The difference in the statistical significance of market liquidity observed between the time-series and panel-estimates for our crisis-period models can be explained by the limited variation in relative market shares of individual countries in total EMU debt observed over our sample period. In view of this limited variation, liquidity effects are expected to be better captured by the higher variation of relative market shares across member states. Indeed, our panel estimates in column (4) of Table 6 seem to be capture this effect.

annual frequency, there is limited variability in the time-series dimension during the crisis period. Hence, this motivates the use of a panel regression to estimate their impact on spreads over the crisis. The panel estimation results indicate that, as in the pre-crisis period, increases in expected deficits lead to higher spreads.

Overall, our findings in this section suggest that significant shifts have taken place in the market for euro-area government bonds since August 2007. The evidence suggests that the predictive power of country-specific fundamentals and international risk conditions over spreads varies over time and is activated during the crisis period. It appears that the credit/debt crisis put a halt on 'convergence trade' and bond market participants start to differentiate between countries on the basis of macroeconomic risk reflected in competitiveness losses as well as liquidity risk, thereby putting pressure on the bonds of uncompetitive and/or small issuers. In terms of the theoretical model presented in section 3, this is consistent with a state of the world where EMU governments (with the exception of Greece, whose case is examined below) operate (at least up to February 2010) under L_1 but γ_1 now takes a positive value. If this important change in the behaviour of investors persists over time then it will mark the ascent of a new era where losses of competitiveness are penalised by higher spreads. Such a development would be consistent with historic experience from the US states-debt market, where the New York City debt crisis in 1975 resulted into a permanent discrimination among USA states on the basis of the latter's fiscal performance (see Schuknecht et al, 2010). A permanent increase in focus on national fiscal performance will increase the degree of market pressure on governments of less competitive eurozone members for fiscal consolidation and structural reforms to boost competitiveness and promote real convergence. Contagion from the Greek debt crisis and the withdrawal of the implicit EMU/German fiscal guarantee further intensify the need for urgent reforms in the periphery EMU countries.

5.3 The Greek debt crisis

We now turn our attention to Greece, the country which sparked the EMU sovereign debt crisis in autumn 2009 and has since been at the centre of focus of investors and policymakers. Table 7 shows the OLS-HAC time-series estimates of the crisis baseline model and its variants for Greece. When the models are estimated over the entire crisis period (see columns 1 and 2 in Table 7), the results are at first sight non-plausible since the VIX and the real effective exchange rate are not strongly significant, while the bond market liquidity

measure does not have the expected negative sign. Adding the business cycle proxy, and removing the insignificant liquidity proxy from the model of Greek spreads leads to an improved specification with all the explanatory variables being statistically significant at the 5% level, or less (see columns 3 and 4 in Table 7). Note that unlike other EMU countries, the coefficient of output growth differentials is negative and significant, indicating that Greek spreads react positively to a slowdown in growth.

As argued above, the lack of significance for international risk aversion and external competitiveness, captured by the VIX and real exchange rate respectively, in the benchmark specifications (columns 1 and 2) reported in Table 7 seem implausible given Greece's central position in the eurozone debt crisis. These findings are likely to be the result of econometric misspecification due to the omission of variables capturing the double regime-switch occurring over the period November 2009 – February 2010, as suggested by Arghyrou and Tsoukalas (2010). Hence, we re-estimated the Greek specifications over the sub-period August 2007 to October 2009, thereby excluding the months covered by the assumed shift in expectations. Doing so we obtain findings consistent with those of the other eurozone members, as both the Greek real exchange rate and the global risk factor are now found to be priced by bond markets with the theoretically expected signs (see columns 5 and 6 in Table 7). Our next step is to test explicitly for the existence of the shift in expectations by incorporating a slope dummy for the coefficient of the real exchange rate taking the value of unity since November 2009.[34] The results provide evidence in favour of a regime-switch in the relationship between spreads and the real exchange rate within the crisis-period, with the coefficient of the latter increasing since November 2009 (see columns 7 and 8 in Table 7). Given that in our analysis the real exchange rate measures overall macroeconomic performance, this suggests that Greek spreads have become more responsive to the overall state of Greek macro-fundamentals.[35]

[34] The dummy variable (D2009.11) is equal to 1 from November 2009 onwards, zero otherwise. The theoretical model in section 3 predicts a second shift in expectations in January/February 2010. However, with our estimation sample covering 2007.08-2010.02, it is not possible to capture this second regime shift using a second dummy, as thus applies only to two observations and turns out to be perfectly collinear with the first one.

[35] We have tested the statistical significance of the slope dummy variable on the coefficient of the real exchange rate term for all EMU countries. Unlike Greece, where this dummy was found significant with a positive sign, for the remaining EMU countries we obtained a small but statistically significant negative coefficient. The only exception was Ireland, for which the dummy was insignificant. These findings (available upon request), confirm that the negative shift in expectations discussed above is specific to Greece. The negative sign found for other countries is consistent with a substitution effect, according to which less risk-averse investors, still interested in higher returns reallocate their portfolios from the unacceptably high macroeconomic risk of Greek bonds to the more acceptable risk of other EMU countries. However, the very small values found for the coefficient of this slope dummy, as well as the observed movements in spreads, suggest that this reallocation effect is too small to moderate the contagion effects reported in Tables 5 and 6.

Table 7: Crisis time-series estimates for Greece, OLS -HAC

	2007.08-2010.02		2008.08-2010.01		2007.08-2009.10		2007.08-2010.01	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$spread_{t-1}$	1.54 ***	1.45 ***	1.38 ***	1.36 ***	0.75 ***	0.80 ***	0.88 ***	0.93 ***
$spread_{t-2}$	-0.64 ***	-0.67 ***	-0.39 ***	-0.43 ***	-	-	-	-
q_t	5.89 *	0.16	8.27 **	6.08 *	5.07 **	8.34 **	4.35 **	7.08 **
vix_t	0.21	0.23 *	0.48 ***	0.47 ***	0.70 ***	0.71 ***	0.64 ***	0.65 ***
liq_t	-	0.17 *	-	0.06	-	-0.10	-	-0.08
$gind_t$	-	-	-0.02 ***	-0.02 **	-	-	-0.01	-0.01
q_t*D2009.11	-	-	-		-	-	0.12 **	0.12 **
$Adj\text{-}R^2$	0.93	0.93	0.95	0.94	0.95	0.95	0.95	0.95

Note: The sample periods over which the regression models are estimated are shown in the first row. We report Ordinary Least Squares (OLS) estimates of the parameters with heteroskedasticity and autocorrelation (HAC) consistent estimates of the standard errors. The dummy variable (D2009.11) is equal to 1 from November 2009 onwards and 0 otherwise. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Table 8: Explaining the Greek CDS, time-series estimates, OLS-HAC

	2007.08-2010.02	2007.08-2009.10	2007.08-2010.01	2007.08-2010.01
	(1)	(2)	(3)	(4)
CDS_{t-1}	1.67 ***	0.62 ***	1.37 ***	0.97 ***
CDS_{t-2}	-0.81 ***	-	-0.30 *	-
q_t	5.46 **	5.87 ***	7.31 **	5.06 **
vix_t	0.16	0.61 ***	0.38 **	0.51 ***
$gind_t$	-	-	-0.03 ***	-0.02 ***
q_t*D2009.11	-	-	-	0.10 ***
$Adj\text{-}R^2$	0.93	0.92	0.94	0.96

Note: The sample periods over which the regression models are estimated are shown in the first row. We report Ordinary Least Squares (OLS) estimates of the parameters with heteroskedasticity and autocorrelation (HAC) consistent estimates of the standard errors. The dummy variable (D2009.11) is equal to 1 from November 2009 onwards and 0 otherwise. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

We repeated our estimations for Greece defining the dependent variable as the Greek Credit Default Swap (CDS) spread versus Germany (the results of a similar exercise for the rest of the EMU members are discussed in section 5.4 below). The CDS is a credit derivative which allows the buyer to purchase insurance against the risk of default.[36] During the Greek debt crisis, both government bond yield spreads and CDS spreads widened raising questions about the role that trading in the CDS market has played in these developments.[37] Our findings from the CDS-model time-series estimation are reported in Table 8. They indicate that Greek CDS spreads during the crisis period reflect global financial instability as well as business cycle risk and external competitiveness considerations (see columns 1, 2 and 3 in Table 8). Furthermore, the post-November 2009 regime shift in expectations is confirmed by the statistical significance of the slope dummy variable associated with the real exchange rate (see column 4 in Table 8). Note that unlike columns (7) and (8) in Table 7, where the inclusion of the slope dummy variable rendered industrial production growth marginally insignificant, industrial production now remains significant at the 5% level even after the inclusion of the dummy variable (see column 4 in Table 8).

These findings reject the hypothesis that CDS spreads do not reflect any country-specific or international fundamentals and simply react positively to past increases in their level. Excluding the first lag of the CDS spread, which captures momentum-trading, from our preferred specification reported in column 4 in Table 8 does not change our results and yields an adjusted R^2 equal to 75%. Repeating the same experiment for the corresponding equation modelling the Greek government bond yield spread yields an adjusted R^2 of 80% (full results available upon request). The high explanatory power of the models obtained after removing the lagged dependent variable from the set of regressors provides further evidence that international risk and macro-fundamentals explain most of the variation in Greek sovereign bond and CDS spreads during the crisis period.

Overall, our finding are consistent with the prediction of the theoretical model by Arghyrou and Tsoukalas (2010), according to which by early 2010 Greek spreads were reflecting substantial default risk and currency risk, which were strongly reinforcing each

[36] The buyer of a CDS contract on sovereign bonds agrees to make regular payments (CDS premium) to the seller in return for a payment by the seller if the credit event (default of the reference entity) occurs. The CDS spread is equal to the total amount that the buyer pays per year divided by the total face value of the bonds.

[37] The hypothesis that speculators operating through the CDS market reinforced the Greek debt crisis has received strong support from euro-area political leaders. According to this hypothesis, buyers of sovereign CDS contracts raise the cost of insurance against sovereign default leading to rises in the underlying government bond yield spreads. This increases debt interest costs making default more probable. Consequently, CDS spreads widen further thereby generating a new episode in the vicious cycle of rising insurance and borrowing costs.

other, making it very difficult to distinguish between the two, as previously discussed. Another element differentiating Greece from other periphery EMU members is that Greece is the only country for which markets may price the state of the business cycle. This is consistent with the view that markets assign an additional premium in Greek bonds, reflecting doubts regarding the ability of Greek authorities to push through the reforms necessary to achieve the required macro-adjustment within an environment of deepening economic recession. This finding, combined with the one regarding a Greek-specific negative shift in market expectations, suggest that the Greek debt crisis is as much a problem of trust as it is one of economics. Finally, our findings confirm that Greek CDS spreads are determined by the same fundamentals that drive Greek bonds yield spreads. This is a strong indication against the hypothesis that spreads in the bond market are driven by momentum-based speculative trading in the CDS market unrelated to developments in the Greek economy.

5.4 Robustness tests

We tested the robustness of our findings in a number of ways. To save space the results are not reported but are available upon request. First, we repeated the estimation of our crisis-period benchmark model for all EMU countries using CDS spreads instead of bond yield spreads.[38] The findings obtained both from time-series and panel estimations are consistent with those reported in section 5.2 for bond yield spreads as they confirm the significance of real exchange rates, international risk and contagion from Greece in explaining CDS spreads during the crisis period. The marginal contribution of lagged CDS spreads to the explanatory power of the model is typically small. Overall, the findings obtained from modelling CDS spreads offer further support to the argument that the main drivers of the EMU debt crisis are international risk, macro-fundamentals and contagion rather than momentum-trading speculation in the CDS market.

Second, we excluded the first lag of spreads from the set of regressors in our benchmark model. For the post-crisis period the estimation results remain unaltered. For the pre-crisis period we obtain more instances of mispricing of competitiveness (i.e. more negative and statistically significant real exchange rate coefficients) with all other findings remaining unchanged.[39] Hence, this experiment yields even stronger evidence of a switch in the market's pricing behaviour towards a fundamentals-based model.

[38] Ireland was excluded from this part of the analysis due to the small number of available observations. Ten-year CDS data on Irish contracts is available since 29/01/2009.
[39] Note that the resulting residuals from almost all equations (pre-crisis and crisis models) are stationary.

Finally, we estimated our benchmark model using alternative measures of the global risk factor. We experimented with US corporate spreads as in Codogno et al. (2003), Manganelli and Wolswijk (2009) and Schuknecht et al. (2009, 2010). Our findings remain similar to those obtained using the VIX. The VIX, however, is found to dominate corporate spreads as an indicator of global risk in our yield spreads regressions. We also experimented with a measure of European implied stock market volatility, the VSTOXX, calculated using implied option prices written on the DJ Euro STOXX 50 index. Using the VSTOXX we obtain similar results to those obtained using the VIX (see also Beber et al., 2009).

6. Summary and concluding remarks

This paper offered a detailed empirical investigation of the European sovereign debt crisis. Compared to existing studies our paper is the first to base its empirical analysis on a theoretical model of the eurozone crisis, namely the one by Arghyrou and Tsoukalas (2010). We use data of monthly frequency, as well as time series and panel estimation techniques, to model the spreads of 10-year EMU government bonds against Germany during the pre- and post-crisis periods, respectively covering January 1999 – July 2007 and August 2007 – February 2010. We obtain a number of novel and interesting findings which can be summarised as follows: First, during the pre-crisis period, with the possible exception of expected fiscal deficits, markets did not price macro-fundamentals and international risk conditions. Second, during the crisis period, markets have been pricing both factors on a country-by-country basis. Third, and in relation to the country at the epicentre of the EMU debt crisis, Greece, our findings support the hypothesis by Arghyrou and Tsoukalas (2010) explaining the escalation of the Greek debt crisis in November 2009 as the result of an unfavourable country-specific shift in market expectations, increasing further the penalty already imposed by markets due to the country's deteriorating macroeconomic performance. Fourth, up to point covered by our analysis (February 2010), the overwhelming majority of EMU countries have experienced contagion from Greece, most prominently Portugal, Ireland and Spain. Finally, we do not find evidence in favour of significant speculation effects on EMU spreads, neither through a direct nor an indirect, contagion channel.

Our findings support the 'convergence trade' hypothesis for the pre-crisis period, according to which markets were discounting only the best-case scenario of full convergence to German fundamentals, even for countries displaying a clear deterioration of their macro-fundamentals. This can be explained as the result of three factors: First, conditions of amble

global liquidity and low risk over the best part of the past decade; second, expectations that accession to the euro would result in growth-inducing reforms in periphery EMU economies; and third lack of a mechanism establishing credibility for the "no-bail out" clause of the Maastricht Treaty. With the benefit of hindsight, it can now be argued that markets were operating under a perceived implicit guarantee according to which there was very little default risk associated with investment in EMU sovereign bonds, rendering them a "heads-you-win, tails-you-do-not-lose" bet. Combined with the absence of an effective EU-sponsored mechanism of economic monitoring imposing reform this relaxed market pressure on EMU governments to improve fundamentals, which in turn resulted into further real divergence within the eurozone. The increasing un-sustainability of this divergence was bound to result into a change in market behaviour. The trigger for the latter was the onset of the global credit crunch in 2007 which prompted markets to switch to a more rational bond pricing model largely based on idiosyncratic macro-fundamentals. If this important change in the behaviour of investors persists over time, as it did in the US following the New York debt crisis in 1975, then it will mark the ascent of a new era where markets will be imposing much higher penalties on macro-imbalances. As a result, although a gradual normalisation of the global economic outlook may narrow EMU spreads, as long as intra-EMU macro-imbalances persist spreads are likely to remain in high, by historical standards, levels.

Our empirical findings lead to policy implications both at the national as well as the union level which are directly traceable to the theoretical model discussed in section 3. First, for EMU-periphery countries spreads to decline a marked improvement in fiscal position and external competitiveness appears necessary. Second, periphery EMU countries, and Greece in particular, must pursue a reversal of private expectations to a more favourable status than the present one.[40] In other words, governments must maintain, and in the case of Greece regain, the confidence of markets that they are *fully* committed to a *permanent* improvement in macro-fundamentals. Such a shift in expectations can only be achieved through the announcement of a credible and realistic reforms strategy, backed by unequivocal evidence of its determined implementation. In the absence of strong signals on behalf of periphery governments that they are determined to implement the necessary reforms, even in the face of significant short-term welfare losses, it is very likely that markets will continue to doubt the

[40] The first policy recommendation corresponds to achieving values of q closer to the axes' origin; while the second one implies starting from L_2 or L_3 to achieve a shift back to L_1. Both developments imply a lower cost of continued EMU participation, i.e. a narrowing of spreads.

sustainability of these countries' long-term participation in the EMU, and the risk that these expectations will become self-fulfilling will remain.

At the union level, the crisis has highlighted the necessity of institutional reforms in two directions. First, to prevent a future crisis similar to the current one, the eurozone must develop effective mechanisms of fiscal supervision and policy co-ordination. Second, if a debt crisis does occur in an EMU country, it is important to prevent its escalation in the affected country and its contagion to other countries.[41] This objective can be achieved through the creation of an EMU-run permanent mechanism of emergency financing. For such a mechanism to be successful in stabilising expectations, its rules and terms must be transparent and known ex-ante. At the same time, the terms of emergency finance must be such as to eliminate the risk of moral hazard discouraging fiscal discipline and necessary reforms. Identifying rules achieving both objectives simultaneously is a challenging task calling for significant attention from academics and policy-makers alike. Recent proposals calling for the introduction of a competitiveness pact, more binding fiscal rules, and the creation of a permanent European emergency finance mechanism ultimately allowing for an orderly default of EMU members move towards the direction of establishing a credible deterministic endgame.

Finally, a note is due relating to future research. Following the announcement of the Greek bailout package and the establishment of the EFSF in May 2010, the EMU sovereign debt crisis has now entered a new phase, marked by the Irish bailout in November 2010, increased market pressure on Portuguese bonds and extensive public debate regarding the possibility of extending the terms of reference of the EFSF. These events raise the spectrum of multiple and reverse contagion effects, running among Greece, Ireland and Portugal as well as from each of these countries to the rest of the EMU countries. Our analysis in this paper covers a period of time up to which one may plausibly argue that developments relating to the EMU sovereign debt crisis were predominantly driven by the Greek debt crisis, in which case contagion could be plausibly approximated by the Greek spread alone. With events still unfolding, future research would not only be useful to update the findings of the present study but, perhaps more importantly, to identify and measure the size of each of the possible multiple contagion channels, as well as their combined effect on European sovereign bond yields.

[41] These recommendations are also traceable to the theoretical model by Arghyrou and Tsoukalas (2010). The first aims to prevent an increase in the value of q to levels resulting in a cost of staying in the eurozone beyond the critical threshold defined by C. The second aims to prevent changes in expectations moving countries from L_1 to L_2 or L_3.

APPENDIX

Table A1: Pre-crisis time-series estimates, SUR, baseline

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.89 ***	0.83 ***	0.86 ***	0.75 ***	0.89 ***	0.81 ***	0.87 ***	0.75 ***	0.88 ***	0.88 ***
q_t	-0.11	-0.26 **	-0.11	-0.07	-0.01	-0.12 **	-0.03	-0.14 **	-0.11	-0.13
vix_t	0.02	0.02 *	0.03 **	0.01 **	0.01	0.02	0.01	0.02 **	-0.01	0.01
$Adj\text{-}R^2$	0.94	0.95	0.93	0.83	0.98	0.93	0.85	0.88	0.93	0.96

Note: A system of equations, representing the pre-crisis baseline model in each country, is estimated over the time period 2001.01-2007.07. Seemingly unrelated regression method (SUR) estimates of the system's parameters correcting for heteroskedasticity and contemporaneous correlation in the errors across equations are shown. The asterisks ***, **, * indicate the 1, 5, 10% level of significance respectively.

Table A2: Crisis time-series estimates, SUR, baseline

	AUS	BEL	FIN	FRA	IRE	ITA	NEL	POR	SPA
$spread_{t-1}$	0.55 ***	0.51 ***	0.60 ***	0.53 ***	0.77 ***	0.39 ***	0.60 ***	0.35 ***	0.44 ***
q_t	4.10 ***	1.25 **	1.82 ***	1.54 **	0.89	4.45 ***	1.87 ***	3.34 *	2.20 ***
vix_t	0.29 ***	0.25 ***	0.22 ***	0.15 ***	0.31 ***	0.45 ***	0.22 ***	0.19 ***	0.19 ***
$spread_t^{GR}$	0.09 ***	0.07 ***	0.02	0.04 ***	0.19 ***	0.12 ***	0.01	0.27 ***	0.15 ***
$Adj\text{-}R^2$	0.94	0.94	0.95	0.94	0.95	0.97	0.94	0.94	0.96

Note: A system of equations, representing the crisis baseline model in each country (apart from Greece), is estimated over the time period 2007.08-2010.02. Seemingly unrelated regression method (SUR) estimates of the system's parameters correcting for heteroskedasticity and contemporaneous correlation in the errors across equations are shown. The asterisks ***, **, * indicate the 1, 5, 10% level of significance, respectively.

References

Adalid, R., Detken, C., 2007. Liquidity shocks and asset price boom/bust cycles. ECB Working Paper Series No. 732.

Alesina, A., De Broeck, M., Prati, A., Tabellini, G., 1992. Default risk on government debt in OECD countries. Economic Policy 15, 427-451.

Arghyrou, M.G., Chortareas, G., 2008. Current account imbalances and real exchange rates in the euro-area". Review of International Economics 16, 747-764.

Arghyrou, M.G., Tsoukalas, J. 2010. The Greek debt crisis: Likely causes, mechanics and outcomes. The World Economy, forthcoming.

Attinasi, M-G., Checherita, C., Nickel, C., 2009. What explains the surge in euro-area sovereign spreads during the financial crisis of 2007-09? ECB Working Paper Series No. 1131.

Barrios, S., Iversen, P., Lewandowska, M., Setzer, R., 2009. Determinants of intra-euro-area government bond spreads during the financial crisis. European Commission, Directorate General for Economic and Financial Affairs, Economic Papers No. 388.

Bayoumi, T.A., Goldstein, M. Woglom, G., 1995. Do credit markets discipline sovereign borrowers? Evidence from US states. Journal of Money Credit, Credit and Banking 27, 1046-1059.

Belke, A., Orth, W., Setzer, R., 2010. Liquidity and the dynamic pattern of asset price adjustment: A global view. Journal of Banking and Finance 34, 1933-1945.

Beber, A., Brandt, M.W., Kavajecz, K.A., 2009. Flight-to-quality or flight-to-liquidity? Evidence from the euro-area bond market. Review of Financial Studies 22, 925-957.

Becker, S., 2009. EMU sovereign spread widening: Reasonable market reaction or exaggeration? Deutsche Bank Research, Reports on European Integration, EU Monitor 68.

Bernoth, K., Wolff, G. 2008. Fool the markets? Creative accounting, fiscal transparency and sovereign risk premia. Scottish Journal of Political Economy 55, 465-487.

Bernoth, K., von Hagen, J., Schuknecht, L., 2004. Sovereign risk premia in the European government bond market. ECB Working Paper Series No. 369.

BIS, 2010. International Banking and financial market developments. Bank for International Settlements, Quarterly Review, March 2010.

Booth, L., Georgakopoulos, G., Hejazi, W. 2007. What drives provincial-Canada yield spreads? Canadian Journal of Economics 40, 1008-1032.

Codogno, L., Favero, C., Missale, A., 2003. Yield spreads on EMU government bonds. Economic Policy 18, 505-532.

ECB, 2009. Credit default swaps and counterparty risk. European Central Bank, August 2009.

Faini, R. 2006. Fiscal policy and interest rates in Europe. Economic Policy 21, 443-489.

Favero, C., Pagano, M., von Thadden, E.-L., 2010. How does liquidity affect government bond yields? Journal of Financial and Quantitative Analysis 45, 107-134.

Gerlach, S., Schulz, A., Wolff, G.B., 2010. Banking and sovereign risk in the euro-area. CEPR Discussion Paper No. 7833.

Geyear, A., Kossmeier, S., Pichler, S., 2004. Measuring systemic risk in EMU government yield spreads. Review of Finance 8, 171-197.

Gomez-Puig, M., 2006. Size matters for liquidity: Evidence from EMU sovereign yield spreads. Economics Letters 90, 156-162.

Hallerberg, M., Wolff, G.B., 2008. Fiscal institutions, fiscal policy and sovereign risk premia in EMU. Public Choice 136, 379-396,

Haugh, D., Ollivaud, P., Turner, D., 2009. What drives sovereign risk premiums? An analysis of recent evidence from the euro-area. OECD Economics Department Working Papers No. 718.

Hull, J.C., 2009. Options, futures, and other derivatives. Upper Saddle River, N.J.: Pearson Prentice Hall, 7th edition.

IMF, 2003. International Monetary Fund, Global Financial Stability Report, September 2003, Chapter 3.

IMF, 2009. International Monetary Fund, Global Financial Stability Report, April 2009, Chapter 3.

Jankowitsch, R., Mosenbacher, H., Pichler, S., 2006. Measuring the liquidity impact on EMU government bond prices. European Journal of Finance 12, 153-169.

Krugman, P.R. (1979). A model of balance of payments crises. Journal of Money Credit and Banking 11, 311-25.

Laubach, T., 2009. New evidence on the interest rate effects of budget deficits and debt. Journal of the European Economic Association 7, 858-885.

Longstaff, F., Pan, J., Pedersen, L., Singleton, K. (2007). How sovereign is sovereign credit risk? National Bureau of Economic Research Working Paper 13658.

Lynn, M. (2011). *Bust: Greece, the euro and the sovereign debt crisis*. John Wiley and Sons: London.

Manganelli, S., Wolswijk, G., 2009. What drives spreads in the euro-area government bond market? Economic Policy 24, 191-240.

Mody, A., 2009. From Bear Sterns to Anglo Irish: How eurozone sovereign spreads related to financial sector vulnerability. IMF Working Paper No. 09/108.

Newey, W., and West, K., 1987. A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica 55, 703-70.

Obstfeld, M. (1996). Models of currency crises with self-fulfilling features. European Economic Review 40, 1037-48.

Pagano, M., von Thadden, E.-L., 2004. The European bond markets under EMU. Oxford Review of Economic Policy 20, 531-554.

Reinhart, C.M, Rogoff, K., 2010. From financial crash to debt crisis. NBER Working Paper No. 15795.

Schuknecht, L., von Hagen, J., Wolswijk, G., 2009. Government risk premiums in the bond market: EMU and Canada. European Journal of Political Economy 25, 371-384.

Schuknecht, L., von Hagen, J., Wolswijk, G., 2010. Government bond risk premiums in the EU revisited: The Impact of the financial crisis. ECB Working Paper Series No. 1152

Sgherri, S., Zoli, E., 2009. euro-area sovereign risk during the crisis. IMF Working Paper No. 09/222.

The Economist, 12/06/2010. When markets go wrong. Buttonwood column.

Whaley, R., 2000. The Investor fear gauge. Journal of Portfolio Management 26, 12-17.