The determinants of sovereign bond yield spreads in the EMU*

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Abstract

We use a panel of euro area countries to assess the determinants of long-term sovereign bond yield spreads over the period 1999.01-2010.12. We find that the European sovereign debt crisis is more strongly linked to developments in macro and fiscal fundamentals rather than to downgrades in sovereign ratings. We also find that after early 2010 the risk of periphery countries relative to the core ones increased rapidly causing contagion effects; expected debt ratios start being positively reflected in spreads since August 2007; and the response of spreads to debt becomes much more pronounced after March 2009.

JEL: C23, E62, H50.
Keywords: sovereign yields, government debt, panel analysis, credit ratings

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Non-technical summary

Following the 2008-2009 international financial crisis, and notably in the aftermath of the Lehman Brothers bankruptcy in autumn 2008, fiscal imbalances increased in most European economies and the euro area in particular, reflecting the high fiscal cost of the measures taken to contain the fallout from the credit crisis. These developments have been followed by a sovereign debt crisis, which started from Greece in autumn 2009 and gradually engulfed the whole of the European Economic and Monetary Union (EMU), particularly the so-called periphery EMU economies. Greece Ireland and Portugal were all forced in 2010-11 to resort to financial rescue schemes. These rescue packages, however, failed to put a halt to the crisis. Not only all three countries remain, effectively, cut-off from international bond markets, but in the second half of 2011 Spanish and Italian government bonds came under significant market pressure.

A number of ideas have been put forward to achieve a permanent resolution of the EMU sovereign debt crisis. These include the creation of permanent European Stability Mechanism emphasising sound fiscal and other macro-fundamentals; institutional changes aiming to improve the effectiveness of economic governance at national and EMU levels; common debt issuance (Eurobond) to benefit from improved liquidity conditions and reduced risks of crises contagion; stricter regulation of speculative bond/CDS trading; and an overhaul of the regulatory framework governing the operation of credit rating agencies.

In this paper we assess the determinants of long-term government bond yields in the euro area with a view to assess the importance of each of the options outlined above. We employ a panel of ten euro area countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain) over the period 1999:01-2010:12 (monthly data). We assess the role of an extended set of potential spreads' determinants, namely macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions, contagion, speculation and institutional intervention and sovereign credit ratings. We consider three distinct time periods: first, the period preceding the global credit crunch (1999.01 – 2007.07); second the period during which the global credit crunch had not yet mutated into a sovereign debt crisis (2007.08 – 2009.02); and third the period during which the global financial crisis mutated into a sovereign debt crisis (2009.03 – 2010.12).

Our main findings can be summarised as follows: i) the second principal component of yield spreads, including Greece, Portugal, Spain, Ireland and Italy, captures the risk involved in investing to periphery relative to core countries' bonds. Starting from early 2009, the two groups decoupled, with the risk of periphery countries relative to core ones increasing rapidly. The developing periphery crisis caused contagion effects increasing spreads in all EMU countries since early 2010; ii) since August 2007 higher global financial volatility and real exchange rate appreciation have been associated with higher spreads; iii) since March 2009 bond yield spreads increase as a response to a slowdown in growth and tightening bond market liquidity (higher bid-ask spreads); iv) the expected public debt to GDP ratio starts being positively reflected in spreads since August 2007, and in line with the expected budget balance finding, the response of spreads to debt becomes much more pronounced since March 2009; v) the relationship between spreads and debt is non-linear, especially for the so-called periphery countries; vi) between the summer of 2007 and the spring of 2009, the decrease in long-term debt issuance in most euro area countries was associated with lower yield spreads, while since March 2009 the relationship between the two variables reverses; vii) interestingly, after March 2009 spreads are lower as compared to what the

increasingly stressed bond market conditions would imply, suggesting additional demand for sovereign bonds, after the effect of all other determinants of spreads has been accounted for, potentially reflecting institutional intervention in the sovereign bonds' markets; viii) credit ratings are statistically significant in explaining spreads but their role does not appear to be critical; ix) during the pre-crisis period rating agencies have not been reacting to macroeconomic and fiscal developments, such as budgetary imbalances and growth conditions, a behaviour which has changed since March 2009.

Overall, our findings indicate that the European sovereign debt crisis is significantly more strongly linked to developments in macro and fiscal fundamentals rather than to downgrades in sovereign ratings. This conclusion implies that for a successful and permanent resolution of the European debt crisis a substantial improvement in macroeconomic fundamentals, such as fiscal sustainability and external competitiveness, is much more important relative to a change in the regulatory framework under which credit rating agencies operate, or regulatory changes in the framework governing the trade of sovereign bonds' derivatives.

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1. Introduction

Following the 2008-2009 international financial crisis, and notably in the aftermath of the Lehman Brothers bankruptcy in autumn 2008, fiscal imbalances increased in most European economies and the euro area in particular, reflecting the high fiscal cost of the measures taken to contain the fallout from the credit crisis. These developments have been followed by a sovereign debt crisis, which started from Greece in autumn 2009 and gradually engulfed the whole of the European Economic and Monetary Union (EMU), particularly the so-called periphery EMU economies. With their government bond yields soaring, and following a series of credit rating downgrades, Greece Ireland and Portugal were forced in 2010-11 to resort to financial rescue schemes organised by the European Union (EU), the European Central Bank (ECB) and the International Monetary Fund (IMF) in the context of the newly-created mechanism, the European Financial Stabilisation Facility (EFSF). These rescue packages, however, failed to put a halt to the crisis. Not only all three countries remain, effectively, cut-off from international bond markets, but in the second half of 2011 Spanish and Italian government bonds came under significant market pressure.

With the European sovereign debt crisis still unfolding and threatening the stability of the single currency, a number of ideas have been put forward to achieve its permanent resolution. These include the creation of permanent European Stability Mechanism (ESM), from 2013, emphasising sound fiscal and other macro-fundamentals, as already agreed in principal by European Heads of State; institutional changes aiming to improve the effectiveness of economic governance at national and EMU levels (De Grauwe, 2010); common debt issuance (Eurobonds) to benefit from improved liquidity conditions and reduced risks of crises contagion (Favero and Missale, 2011); stricter regulation of bond/Credit Default Swaps markets to restrict speculative trading (European Central Bank, 2009); and an overhaul of the regulatory framework governing the operation of credit rating agencies (see European Commission, 2010).

A necessary condition for determining the optimal policy response to the European sovereign debt crisis is knowledge of the determinants of EMU government bonds. Previous literature, reviewed in section 2 below, has explained the crisis on the basis of a transfer of global financial risk to sovereign bonds through banking bailout schemes (Acharya et al., 2011); changing private expectations regarding the probability of default risk and/or a country's exit from the euro (Arghyrou and Tsoukalas, 2011)

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leading to 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 (Arghyrou and Kontonikas, 2011); increased attention to fiscal developments. (Afonso, 2010); contagion effects (De Santis, 2011) and sovereign credit ratings events (Afonso et al., 2011).

In this study we investigate the determinants of European government bond yield spreads against Germany using an empirical approach which allows us to evaluate the proposals for a successful resolution of the crisis outlined above. Compared to existing studies, we use a widened set of fundamentals enabling us to capture further insights, some of which are unreported in the previous literature, relevant to the factors determining sovereign spreads in the euro area. These include macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions and contagion effects, which we capture using principal components analysis as in Longstaff et al. (2011). In addition, our empirical analysis provides an insight on the existence and impact of speculation and institutional intervention on government bond spreads, as well as the effect of sovereign credit ratings which is additional to the information that markets have already priced through observation of the remaining determinants of spreads. Furthermore, we model credit ratings themselves to determine whether credit ratings react to similar information to that affecting spreads. Our empirical approach also has the innovative in the literature on the EMU crisis aspect of differentiating between three distinct time periods: first, the period preceding the global credit crunch (1999.01 – 2007.07); second the period during which the global credit crunch had not yet mutated into a sovereign debt crisis (2007.08 – 2009.02); and third the period during which the global financial crisis mutated into a sovereign debt crisis (2009.03 – 2010.12).

We employ a panel of ten euro area countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain) over the period 1999:01-2010:12 (monthly data). Our main findings can be summarised as follows: i) the second principal component of yield spreads, including Greece, Portugal, Spain, Ireland and Italy, captures the risk involved in investing to periphery relative to core countries' bonds. Starting from early 2009, the two groups decoupled, with the risk of periphery countries relative to core ones increasing rapidly. The developing periphery crisis caused contagion effects increasing spreads in all EMU countries since early 2010; ii) since August 2007 higher global financial volatility and real exchange rate appreciation

have been associated with higher spreads; iii) since March 2009 bond yield spreads increase as a response to a slowdown in growth and tightening bond market liquidity (higher bid-ask spreads); iv) the expected public debt to GDP ratio starts being positively reflected in spreads since August 2007, and in line with the expected budget balance finding, the response of spreads to debt becomes much more pronounced since March 2009; v) the relationship between spreads and debt is non-linear, especially for the so-called periphery countries; vi) between the summer of 2007 and the spring of 2009, the decrease in long-term debt issuance in most euro area countries was associated with lower yield spreads, while since March 2009 the relationship between the two variables reverses; vii) interestingly, after March 2009 spreads are lower as compared to what the increasingly stressed bond market conditions would imply, suggesting additional demand for sovereign bonds, after the effect of all other determinants of spreads has been accounted for, potentially reflecting institutional intervention in the sovereign bonds' markets; viii) credit ratings are statistically significant in explaining spreads but their role does not appear to be critical; ix) during the pre-crisis period rating agencies have not been reacting to macroeconomic and fiscal developments, such as budgetary imbalances and growth conditions, a behaviour which has changed since March 2009.

Overall, our findings indicate that the European sovereign debt crisis is significantly more strongly linked to developments in macro and fiscal fundamentals rather than to downgrades in sovereign ratings. This conclusion implies that for a successful and permanent resolution of the European debt crisis a substantial improvement in macroeconomic fundamentals, such as fiscal sustainability and external competitiveness, is much more important relative to a change in the regulatory framework under which credit rating agencies operate, or regulatory changes in the framework governing the trade of sovereign bonds' derivatives. Our findings also suggest that by increasing the size, liquidity and maturity of debt issuances, spreads in EMU countries, especially the periphery ones, could decline.

The remainder of the paper is organised as follows. Section two reviews the related literature on the determinants of euro area sovereign spreads before and during the European debt crisis; section three presents and discusses our dataset, methodology, and empirical results; section four concludes.

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2. Related literature

Existing studies on EMU government bond yields, or their spread against Germany, fall into two broad categories, respectively covering the period prior to and following the global financial crisis. Both groups of studies typically follow the general literature on government bond yields modelling the latter on three main variables (see e.g. Manganelli and Wolswijk, 2009): First, an international risk factor capturing the level of perceived financial risk and its unit price. Typically, this is empirically approximated using indexes of US stock market implied volatility or the spread between the yields of US corporate bonds against US treasury bills. Second, credit risk, reflecting the probability of default on behalf of a sovereign borrower, typically approximated using indicators of past or projections of future fiscal performance. Indeed, existing evidence suggests that markets attach additional risks to the loosening of observed fiscal positions (see e.g. Ardagna et al., 2004; Afonso and Rault, 2010) and shifts in fiscal policy expectations (see e.g. Elmendorf and Mankiw, 1999). Third, government bond yields are linked to liquidity risk. This source of risk refers to the size and depth of the sovereign bonds market and captures the possibility of capital losses due to early liquidation or significant price reductions resulting from a small number of transactions. Liquidity is a variable particularly difficult to measure empirically, usually approximated using bid-ask spreads, transaction volumes and the level of or the share of a country's debt in global/EMU-wide sovereign debt (see e.g. Favero et al., 2010, Arghyrou and Kontonikas, 2011).

The literature on European government bonds for the period preceding the global credit crunch is not unanimous regarding the role of each of the three variables discussed above. Having said so, the balance of reported evidence leads to the following conclusions: First, prior to summer 2007 the international risk factor was an important determinant of bond yields and spreads, as suggested by studies including 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 stronger during periods of tightening international financial conditions (see e.g. Haugh et al., 2009; Barrios et al., 2009) and more prominent in countries with high levels of public debt (see e.g. Codogno et al., 2003).

Second, sovereign credit risk was priced in government bond yields, as suggested by Codogno et al (2003), Faini (2006), Bernoth et al. (2004), Bernoth and Wolff (2008), Manganelli and Wolswijk (2009) and Schuknecht et al. (2009). Bernoth and Wolff

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(2008) and Schuknecht et al. (2009) interpret this finding as evidence that the Stability and Growth Pact operated as credible mechanism enforcing fiscal discipline among EMU members. This interpretation, however, has been contested by Manganelli and Wolswijk (2009), who suggest that the penalties imposed by markets were not sufficiently high to prevent unsustainable national fiscal policies. Similarly, Afonso and Strauch (2007) report that the fiscal policy events in 2002 in the EU had only small effects on government bond yield spreads, while Hallerberg and Wolff (2008) find that the effect of fiscal performance on EMU sovereign bond yields has weakened following the euro's introduction. Overall, default risk in the EMU context has been seen in the past, at least before the global financial crisis, to be present but rather subdued (see e.g. Bernoth et al., 2004).

Finally, the effect of liquidity risk for the period preceding the global financial crisis is disputed. Codogno et al. (2003), Bernoth et al. (2004), Pagano and Von Thadden (2004), and Jankowitsch et al. (2006) find a limited and declining liquidity effect on EMU spreads. On the other hand, Gomez-Puig (2006), Beber et al. (2009), and Manganelli and Wolswijk (2009) find that liquidity was an important determinant of yields spreads. Liquidity effects are found to be stronger during periods of tightening financial conditions and higher interest rates, during which market participants are willing to trade lower yields for higher sovereign debt liquidity.[1]

There is a growing literature on EMU sovereign bond during the current period of financial turmoil. More specifically, existing studies share two common findings. First, the observed widening in EMU spreads is largely driven by the increased global risk factor.[2] In this process, the role of domestic banking sectors is crucial, as suggested by Candelon and Palm (2010), Gerlach et al. (2010) and Acharya et al. (2011).[3] Global banking risk appears to have been transformed into sovereign risk through three

[1] 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 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.

[2] Holló et al (2011) develop a comprehensive indicator of financial stress for the EMU composed using information from numerous financial markets, covering the period 1987-2010. Their findings suggest an unprecendented increase in financial systemic risk in the euro area since mid-2007, whose peak coincides with the immediate aftermath of the Lehman Brothers crisis.

[3] An important feature of the model by Acharya et al. (2011) is its prediction of the existence of two-way causality between financial and sovereign debt crisis. They show theoretically the existence of a feedback contagion effect, running from sovereign credit risk to financial risk, which they explain on the basis of a loss of value in the financial sector's holdings of sovereign bonds, as well as the value of any implicit and/or explicit government guarantees to the financial sector as a form of bailout. Acharya et al. (2011) present empirical evidence supporting the existence of this feedback effect.

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channels. First, shortages in banking liquidity restricted credit to the private sector causing economic recession and increasing fiscal imbalances. Second, governments were obliged to recapitalise banks using public money increasing fiscal liabilities further. In relation to this, if bank bailouts are perceived to be (even partly) financed through future taxation, they reduce the non-financial sector's incentives to invest, hurting growth and, implicitly, expected future public revenue. Finally, the announcement of a banking bailout itself lowers the price of government debt due to the anticipated dilution from newly issued debt. 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. Attinasi et al. (2009), Sgherri and Zoli (2009), Mody (2009), Barrios et al. (2009), Gerlach et al. (2010), Schuknecht et al. (2010), Caceres et al. (2010), Ejsing and Lemke (2011) and Acharya et al. (2011) have all established the importance of the global risk factor during the crisis period and its impact on the latter through the financial/banking sector.

The second point of consensus is that during the crisis period markets have been penalising fiscal and other macro-imbalances much more heavily than before. According to Arghyrou and Kontonikas (2011), unlike the pre-crisis period, when markets did not price macro-fundamentals and international risk conditions (with the possible exception of expected budget deficits), during the crisis period markets have been pricing both factors on a country-specific basis, and several factors, notably fiscally related, have become relevant determinants of spreads. Similar findings are obtained by Bernoth and Erdogan (2010) and Ejsing et al. (2011). Furthermore, markets not only attach a higher weight on fiscal imbalances, but they also price their interaction with the common international risk factor (see e.g. Barrios et al., 2009; Haugh et al., 2009; Manganelli and Wolswijk, 2009; Schuknecht et al., 2010). Increased focus on heterogeneous fiscal performance/outlook and the latter's interaction with the global risk factor is another major factor explaining the differential spread increases observed among EMU countries (see Favero and Missale, 2011).

Moreover, the literature has uncovered important cross-country contagion/spill-over effects among several euro countries both in the market for sovereign EMU bonds and Credit Default Swaps (CDS), particularly in the case of less well-rated sovereigns (see e.g. Caceres et al. 2010; Arghyrou and Kontonikas, 2011; De Santis, 2011; EC, 2011; Favero and Missale, 2011). The European sovereign debt crisis has also caused spill-over effects to the exchange rate of the euro versus the US dollar (see Hui and

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Chung, 2011). By contrast, and in line with the pre-crisis period, the evidence suggests a rather limited role for country-specific liquidity risk (see e.g. Attinasi et al., 2009; Sgherri and Zoli, 2009; Barrios et al., 2009; Haugh et al., 2009; Arghyrou and Kontonikas, 2011; De Santis, 2011; Favero and Missale, 2011).

Finally, recent studies have investigated the link between EMU government bond yields and sovereign credit ratings, as well as the determinants of credit ratings themselves. With regards to the former, Afonso et al (2011) find notably significant responses of government bond yield spreads to changes in rating notations and outlook (from Standard & Poor's, Moody's, Fitch), particularly in the case of negative announcements. In addition, rating announcements in so-called event countries affect more significantly sovereign yields in non-event countries when the sovereign rating of the event country is lower than those of non-event countries. Therefore, such spill-over effects run from lower rated countries to higher rated countries. Similar findings, confirming the significance of sovereign credit agencies in determining yields in the market for CDS on EMU sovereign bonds, as well as the existence of substantial spill-over effects both across countries and financial markets, are presented by Arezki et al (2011) and De Santis (2011). On the other hand, Afonso et al (2010) study the determinants of sovereign debt ratings from the three main rating agencies, for the period 1995–2005. Their empirical findings suggest that changes in GDP per capita, GDP growth, government debt and government balance have a short-run impact on a country's credit rating, while government effectiveness, external debt, foreign reserves, and default history are important long-run determinants.

3. Analysis

3.1. Methodology

We use a unified framework of analysis capturing simultaneously and extending the insights of the studies by Arghyrou and Kontonikas (2011) and Afonso et al. (2011). In its simplest version the proposed specification to assess the potential determinants of the sovereign long-term bond yields can be written as:

$$spr_{it} = a + \beta_1 spr_{it\text{-}1} + \beta_2 vix_t + \beta_3 ba_{it} + \beta_4 balance_{it} + \beta_5 debt_{it} + \beta_6 q_{it} + \beta_7 gind_{it} + \beta_8 pc2_t + \gamma_i + \varepsilon_{it.} \quad (1)$$

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Equation (1) models the 10-year government bond yield spread versus Germany, spr_{it}, on international financial risk, bond market liquidity conditions, macroeconomic and fiscal fundamentals, and contagion effects. This specification incorporates country-specific fixed effects (γ_i) and will be estimated using Feasible Generalised Least Squares (FGLS)-based cross-section weights which account for cross-sectional heteroskedasticity (see also Attinasi et al., 2009).

Following standard practice in the empirical literature on EMU spreads we also include lagged spreads to account for spreads persistence (see also Gerlach et al., 2010). As Hallerberg and Wolff (2008) explain, while the persistent nature of spreads implies that the exclusion of the lagged spread term from the model will generate omitted variable bias, inclusion of the lagged dependent variable as a regressor generates a different bias since the latter variable is correlated with the fixed effects (see Nickell, 1981). Nevertheless, as Hallerberg and Wolff (2008) point out, the latter bias declines as the time-series dimension of the panel (T) increases and becomes quite small once T reaches 20. As in our sample $T = 144$ we expect any bias introduced by the inclusion of the lagged dependent variable to be very small and in all likelihood smaller than the omitted variables bias that would arise by its exclusion. However, in the robustness tests that follow our estimations, we have also estimated the base line model excluding the lagged spread term. The results, as we shall see in section 3.4 below, remain qualitatively very similar.

vix_t is the logarithm of the S&P 500 implied stock market volatility index (VIX), our proxy for international financial risk. 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) and is extensively used in the literature on euro area government bond spreads (see e.g. Beber et al., 2009) and Gerlach et al., 2010).[4] We expect a higher (lower) value for the global risk factor to cause an increase (reduction) in government bond spreads.

ba_{it} denotes the 10 year government bond bid-ask spread. This is our measure of bond market illiquidity, with a higher (lower) value of this spread indicating a fall (increase) in liquidity leading to an increase (reduction) in government bond yield spreads. Bid-ask spreads are used to capture liquidity effects in EMU sovereign bond

[4] 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 Econometric analysis using regime-switching models in IMF (2003) suggests that 'flight-to-quality' periods and high levels of the VIX tend to coincide.

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markets by a number of previous studies including Barrios et al. (2009), Favero et al. (2010), Gerlach et al. (2010), and Bernoth and Erdogan (2010).

$balance_{it}$ and $debt_{it}$ denote the expected fiscal position variables, namely, the expected (one-year ahead) government budget balance-to-GDP ratio and the expected government debt-to-GDP ratio, respectively, both measured as differentials versus Germany. The expected fiscal position provides a proxy for credit quality, with an expected fiscal deterioration implying higher risk. The utilisation of expected, as opposed to historical fiscal data, is in line with a number of recent studies on EMU government bond yield spreads including Attinasi et al. (2009), Sgherri and Zoli (2009), Gerlach et al. (2010) and Favero and Missale (2011). We expect a higher (lower) value for the expected government budget balance to reduce (increase) spreads; while higher (lower) expected public debt should cause an increase (reduction) in spreads.

q_{it} is the log of the real effective exchange rate. This variable captures credit risk originating from general macroeconomic disequilibrium. An increase (reduction) in q denotes real exchange rate appreciation (depreciation), which is expected to increase (reduce) spreads as theoretically justified by the analysis of Arghyrou and Tsoukalas (2011). The empirical significance of real exchange rates in explaining spreads in the EMU area has been confirmed by Arghyrou and Kontonikas (2011). In the empirical specification shown above, we use trade-weighted real exchange rates calculated against our sample countries' main trading partners. As Germany is the main trading partner of all countries included in our panel, the level of the real effective exchange rate q_{it} captures the effect of relative productivity shocks against Germany, as well as the shocks relative to the remaining trading partners. However, in our robustness tests, we also estimate our baseline model using the real exchange rate differential against Germany (qd_{it}), given by the difference between the log of a country's real effective exchange rate and the log of the German real effective exchange rate. As we report in section 3.4 below, this does not affect our results.

$gind_{it}$ is the annual growth rate of industrial production (differential versus Germany). This variable is used as a proxy for the effects of economic growth on spreads, capturing the argument by Alesina et al. (1992) according to which sovereign debt becomes riskier during periods of economic slowdown (see also Bernoth et al., 2004). Therefore, an increase (reduction) in growth performance is assumed to improve (deteriorate) credit worthiness reducing (increasing) government bond spreads.

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Finally, $pc2_t$ denotes our proxy for contagion from the sovereign debt crisis. This proxy is derived using principal components analysis on government bond yields spreads (see Longstaff et al, 2011) and is fully explained in Section 3.3 below. If contagion is present, an increase (reduction) in $pc2_t$ should increase (reduce) spread values.

We estimate Equation (1) allowing for the possibility of two structural breaks in the relationship between spreads and their aforementioned potential determinants, using slope dummy variables. The first dummy variable ($D2007.08_t$) aims to capture the effects of the global financial crisis specified to begin in August 2007. This date is widely acknowledged in the literature to be the starting point of the global credit crunch given that the first large emergency loan that the ECB provided to European banks in response to increasing pressures in the interbank market took place on 9/8/2007 (see also Arghyrou and Kontonikas, 2011; Attinasi et al., 2009).

The second dummy variable ($D2009.03_t$) intends to capture the point in time when the global credit crisis started being transformed into the European sovereign debt crisis. We date this development back to March 2009 for two reasons. First, the most intense period of the credit crisis was over by the spring of 2009 with major stock market indices experiencing their lowest levels in early March 2009 and since then recording significant gains. Second, by spring 2009 the cost of fiscal activism and the bank bailout packages that were implemented during the credit crisis period became apparent. The very substantial revision of projected public debt in the spring of 2009, an increase of 19% on average across euro area members according to ECFIN data, defines a key point in the European debt crisis, as markets were made officially aware of these costs. As we explain in section 3.2 below, the effect of these events are strikingly apparent in expected fiscal balances and public debt to GDP ratios, with both series registering a sharp step-increase in March 2009. This renders the choice of March 2009 as marking the beginning of a new phase in the EMU sovereign debt a data-driven one.

After estimating the baseline model given by Equation (1) we extend it by adding variables aiming to capture further insights relating to the movements of spreads within the EMU area. First, we consider the role of the share of long-term general government debt (defined as debt maturing at least after one year) in total general government debt (differential against Germany). The rational for adding this variable ($ltsdebt_{it}$) is that all else equal, a country with a large stock of debt maturing in the near future might be considered less credit-worthy compared to a country whose debt

repayment is scheduled in the more distant future. Second, we allow the expected debt to GDP ratio differential versus Germany to enter in the second power (deb_{it}^2) to capture possible non-linear effects of expected fiscal performance on government bond spreads, as suggested by Bernoth et al (2004) and Bernoth and Erdogan (2010).

Third, we allow for the effect of a multiplicative term capturing the interaction between past spread movements and illiquidity conditions (see Llorente et al, 2002). Given that sovereign bond yield spreads and bid-ask spreads are highly positively correlated,[5] the product of the two variables typically increases (declines) because both terms increase (decline). Therefore, the multiplicative term ($spr_{it-1}*ba_{it-1}$) can be interpreted as a stress indicator for bond markets, since a rise is associated with falling bond prices and higher illiquidity. Assuming, as it is the case in recent months for EMU countries, an increase in spreads and illiquidity, a positive coefficient for ($spr_{it-1}*ba_{it-1}$) would indicate the existence of market forces pushing bond prices below their equilibrium value, as this is determined by the remaining spreads' determinants. This would be consistent with (though not definitely proving) speculation trading (e.g. bond short-selling) pushing bond prices below their fair value. From a policymaker's perspective, such speculation would be detrimental, as it would intensify the existing crisis.

On the other hand, and assuming the same tightening market conditions, a negative coefficient for ($spr_{it-1}*ba_{it-1}$) would indicate the existence of market forces pushing bond prices above their equilibrium value, as this is determined by the remaining spreads' determinants. This would be consistent with bond purchases originating from two possible sources: (a) purchases by private agents, speculating that the rest of market participants have underpriced the fair value of bonds, which they proceed to buy in anticipation of a future increases in their value. This movement would reduce market pressure on bonds; (b) bond purchases by institutional investors, in an effort to mitigate the effect of private sales and prevent a collapse of the bonds' market. Whatever the source of such bond purchases, a negative sign for the multiplicative term ($spr_{it-1}*ba_{it-1}$) would exclude the possibility that speculation of the former (detrimental) kind increases spreads beyond the level justified by their fundamental determinants.

Fourth, we account for the role of sovereign credit ratings/announcements on government bond spreads, denoted by $averagerating_{it}$ and $averageoutlook_{it}$ respectively.

[5] In the panel used for our estimations the correlation coefficient between sovereign bond yields spreads and bid-ask spreads is 0.77.

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This allows us to assess the net effect caused by credit ratings/announcements on government bond spreads which is additional to information markets have already priced through observation of the remaining determinants of spreads. In a fully efficient (strong-form) market, credit ratings and outlook announcements should not affect bonds' prices, therefore their coefficients should equal zero. If, however, markets are efficient only in the semi-strong form, credit ratings and credit announcements may be treated by markets as revealing information, which was previously private to credit rating agencies. In other words, we test whether sovereign credit ratings announcements convey some kind of information that the market treats as news.

Overall in its most general form our empirical model of spreads takes the form of equation (2) below:

$$spr_{it} = a + \beta_1 spr_{it\text{-}1} + \beta_2 vix_t + \beta_3 ba_{it} + \beta_4 balance_{it} + \beta_5 debt_{it} + \beta_6 q_{it} + \beta_7 gind_{it} + \beta_8 pc2_t + \beta_9 ltsdebt_{it} + \beta_{10} debt_{it}^2 + \beta_{11} spr_{it\text{-}1} ba_{it\text{-}1} + \beta_{12} averagerating_{it} + \beta_{13} averageoutlook_{it} + \gamma_i + \varepsilon_{it} . \quad (2)$$

As with our baseline model, we estimate the extensions described by equation (2) using the slope dummies $D2007.08_t$ and $D2009.03_t$. Finally we examined whether credit ratings/announcements react to similar information to that affecting spreads; and conducted a number of robustness checks related to estimation and model specification issues.

3.2. Data and stylised facts

We employ a panel of ten euro area countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain), measured in a monthly frequency, over the time period 1999:01-2010:12.[6] The data sources and definition of the variables can be seen in Table A1 of Appendix 1.

Figure 1 presents the 10-year euro area government bond yield spreads. Before the economic and financial crisis of 2007-8, spreads against Germany had stabilised at very low levels despite deteriorating macroeconomic fundamentals in many countries. During the credit crisis all euro area economies experienced a large increase in their spread versus Germany. German government bonds operated as a 'flight-to-quality'

[6] We exclude Luxembourg, 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).

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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 2, which plots the 10-year German yield together with the general indicator of common international risk, the VIX. Figure 2 shows that during the peak of the credit crisis in the autumn of 2008, following the collapse of Lehman Brothers, the VIX increased sharply while the 10-year German government bond yield plummeted as investors flock to the perceived safety of German bonds.

[Figures 1 and 2]

Figures 3 and 4 depict the transformation of the credit crisis into a sovereign debt crisis with euro area governments expected fiscal position deteriorating sharply in early 2009.[7] The fiscal deterioration reflects lower tax revenues for the euro area governments, due to the economic contraction, as well to the fiscal stimulus packages that were implemented to prevent further deterioration. 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, provision of guarantees, such as the Irish government bank guarantee scheme (29/09/2008), and outright purchases of assets from banks.[8]

[Figure 3, 4]

Finally, Figures 5 and 6 link present information on credit ratings and their link to the European sovereign debt crisis. We use data on euro area sovereign debt credit rating and credit outlook from each of the three main rating agencies, Standard and Poor's, Moody's and Fitch, as well as for the simple average rating calculated using rating scores from all three agencies. Following existing literature (see e.g. Gande and Parsley, 2005; Afonso et al, 2011), we transform sovereign credit rating scores into the linear scale presented in Table A2 in Appendix 1.[9] A worse sovereign credit rating should be perceived by the markets as implying higher credit risk, therefore having an upward effect on the yield spread. Indeed, as Figures 5 and 6 indicate, the significant

[7] These forecasts are produced by the European Comission's DG ECFIN twice a year (spring and autumn).

[8] Sgherri and Zoli (2009) argue that the discretionary euro-area fiscal stimulus is estimated to have been 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.

[9] See Afonso, Gomes and Rother (2011) for the details of the construction of the rating scales presented inTable A2 in Appendix 1. See also Figure A1 in the Appendix for graphs of the three agencies credit rating scores over time.

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deterioration in the expected fiscal position in early 2009 was soon followed by downgrades of periphery euro area government debt and liquidity withdrawal, marking the escalation of the euro area debt crisis.

[Figure 5, 6]

3.3. Measuring contagion

An important feature of the recent movements of government bond yield spreads in the euro area is the dichotomy observed between core and periphery EMU countries. Following the spike in all countries' spreads at the height of the global credit crunch, the spreads of the core group have been relatively stable albeit at levels higher compared to those of the pre-crisis period. At the same time, following a temporary reduction in the immediate aftermath of the Lehman Brothers crisis, the spreads of the periphery group have been on an ascending path. This dichotomy raises the possibility of contagion effects from one periphery country to another, as well as from the periphery to the core group of countries. To test this hypothesis we need a quantitative measurement of contagion, which we pursue through a principal components analysis, In a nutshell, the principal components are uncorrelated linear combinations of the original variables, which are then ranked by their variances in descending order. Principal components analysis on government bond spreads allows us to capture both the percentage of data variation due to global co-movement across all spreads, as well as the variation of data explained by the movement of one group of countries against another (see Longstaff et al, 2011).

The results from such analysis are presented in Table 1. Interestingly, the reported eigenvalues and the cumulative proportion figures suggest that the variance of the spreads is essentially captured by the first two principal components. Those two components explain around 97% of the variation of the full variable set. This also implies that we only take into account the components whose associated eigenvalues are above 0.7, a rule suggested by Jollife (1972).

[Table 1]

The first component can be interpreted as an EMU-wide indicator of sovereign risk (roughly a general index of spreads) since it incorporates all EMU national spreads with all countries entering with approximately equal weights. The second component differentiates between two groups of countries, with the two groups distinguished by the

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sign of the reported weights. Table 1 suggests that the first group (denoted by a positive sign) includes Finland, the Netherlands, Austria, France and, marginally, Belgium. The second group (denoted by a negative sign) includes Greece, Portugal, Spain, Ireland and Italy. The absolute size of the reported weights is indicative of the markets' perception regarding the definitiveness of a country's position within its group. The country composition of the two groups identified by the second principal component coincides with the core- and periphery-groups widely assumed to exist within the euro area.

The second principal component provides a measure of divergence between the core and periphery groups, roughly a kind of spread between the core and periphery countries (see Longstaff et al. 2011, p.81) As such, it can be interpreted as the risk involved in investing in core bonds relative to the risk of investing in periphery bonds. Intuitively, an increasing divergence between the core and periphery groups indicates an increasing probability of a sovereign default within the periphery group. From that point of view, the core-periphery divergence is directly linked to the concept of contagion through two channels:

First, a default within the periphery group may operate as a precedent for the occurrence of subsequent defaults within the periphery group (the so-called domino effect). Hence, increasing core-periphery divergence caused by increased spreads in one periphery country may cause an increase in the spreads of other periphery countries, causing intra-periphery contagion.

Second, increasing core-periphery divergence denoting increased probability of default within the periphery group simultaneously signals an increased probability of possible future sovereign rescues, ultimately to be funded by non-default countries. Given the superior state of their fiscal fundamentals, the latter are more likely to be members of the core group. Therefore, increasing core-periphery divergence signals an increased probability of aggregating fiscal risks at the EU-level, and increased future borrowing requirements from the core group to cover the potential support efforts. Hence, increasing divergence may cause contagion from the periphery group to the core group.

Figure 7 plots the first two estimated principal components for the period 1999-2010. Focusing on the second principal component, we can infer that starting from early 2009 the two groups are decoupled, with the risk of periphery countries relative to the core ones increasing rapidly. Furthermore, it should be noted that the first principal component has also been rising since early 2010 indicating the possibility of contagion

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to the euro area as a whole from the developing periphery crisis. Overall, the movements of the second principal component in Figure 7 provide clear evidence for core-periphery relative risk divergence since early 2009, which in association with the recent increase in the first principal component, and on the basis of our arguments above, renders the former variable an appropriate proxy for contagion. In our empirical models variable $pc2_t$, which is defined as minus the second principal component, is used to capture the contagion effects.[10] If the latter are present then $pc2_t$ is expected to enter the empirical models of spread determination with a significantly positive sign.

[Figure 7]

3.4. Panel estimation results

Table 2 reports the results from fixed effects panel estimation of the models for spreads using FGLS-based cross-section weights which account for cross-sectional heteroskedasticity. Column (1) in Table 2 presents the results from the baseline model. Spreads are quite persistent as indicated by the estimate of the autoregressive parameter (0.883), while the reported adjusted R-squared coefficient is close to one. An important finding that emerges is international risk, liquidity conditions, macroeconomic and fiscal fundamentals and contagion effects are all priced in the spreads during the credit-debt crisis period. The point in time where these links become active is not the same for all the variables, indicating different responses to the different phases of the crisis. For instance, the international risk and real exchange rate coefficients become positive and statistically significant since August 2007, indicating that higher global financial volatility and real exchange rate appreciation have been associated with higher spreads since the onset of the credit crisis. On the other hand, the coefficients associated with the growth rate of industrial production and bond market liquidity conditions become statistically significant only since March 2009. Their respective signs indicate that bond yield spreads increase as a response to a slowdown in growth and tightening bond market liquidity, as suggested by higher bid-ask spreads.

[Table 2]

Regarding the expected fiscal position, it appears that markets price the expected budget balance position throughout the entire sample period, with the (positive) reaction

[10] Increases in $pc2_t$ indicate higher periphery risk. The negative sign of the second pricipal component in the definition of $pc2_t$ is an adjustment for the fact that periphery countries load negatively in the former.

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of spreads to budget deficits however becoming much stronger (relevant overall coefficient more than doubles) since March 2009. On the other hand, the expected debt ratio starts being positively reflected in spreads since August 2007, and in line with the expected budget balance finding, the response of spreads to debt becomes much more pronounced since March 2009. Hence, expected fiscal deterioration is more heavily penalised by the markets during the latter part of the sample period, which captures the escalating debt crisis.

Finally, the March 2009 slope dummy associated with $pc2_t$ is positive and significant indicating that during the debt crisis contagion from the periphery countries has led to higher spreads. This finding is in line with previous evidence by Arghyrou and Kontonikas (2011) who report evidence of contagion from the Greek debt crisis. Prior to the credit crisis, however, the periphery countries were not considered as being excessively risky by the markets, with the coefficient of $pc2_t$ being negative and significant, suggesting a mispricing of periphery risk.

Columns (2) and (3) in Table 2 report the estimates of the parameters of extended specifications, which incorporate the share of long-term to total government debt and the product of the past bond yield spread and the past bid-ask spread as explanatory variables. The long-term share of debt coefficient becomes statistically significant during the crisis period. The two slope dummy variable coefficients exhibit opposite sign but their sum is negative indicating that overall, a higher long-term share of debt is associated with lower spreads.[11] It appears then that the ability to successfully issue and place increasing amounts of long-term debt in the market is associated with lower borrowing costs, with the ratio of long-term to total debt thereby operating as a credibility indicator.

While the effect of the long-term share of debt on spreads is significantly negative since March 2009, as well as overall, the coefficient of the slope dummy variable associated with the August 2007 break is positive. This indicates that between the summer of 2007 and the spring of 2009, the decrease in the share of long-term debt to total debt was not penalised by the markets in the form of higher spreads.[12] This finding can be interpreted within the 'flight to safety' trading that took place during the credit crisis and saw a massive rebalance of portfolios at global level, away from falling

[11] The Wald test F-statistic indicates that the null hypothesis of zero sum of the two slope dummy variable coefficients can be rejected at the 10% level of significance.
[12] Figure A2 in the Appendix shows that in most euro area countries the long-term share of debt declined since August 2007.

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equities and towards government debt securities. It is consistent with the theoretical prediction by Favero et al. (2010) according to which in crisis periods investors choose from a reduced set of alterative investment opportunities, limiting their willingness to move away from government debt securities. In the process of fleeing the stock market and given an environment of high uncertainty which did not favour long-term commitment of funds, investors increased their demand for liquid short term instruments, such as Treasury bills. At the same time, sovereign bond issuers had an incentive to increase short term debt issuance in order to avoid locking themselves into (the prevailing at the time) high long-term borrowing costs.

In column (3) the multiplicative term involving past spreads and past illiquidity is statistically significant only during the debt crisis period. The sign of coefficient of the slope dummy variable associated with the March 2009 break is negative indicating that after the effect of all other determinants of spreads has been accounted for, spreads are lower as compared to what the increasingly stressed bond market conditions would imply. This finding suggests the existence of demand that helped bond prices from falling further (such as the market interventions by the ECB in the form of euro area periphery bonds purchases since May 2010). Nevertheless, in column (4), which presents the results from a parsimonious specification obtained by moving from a general towards a more specific model, both slope dummy variables that are associated with the multiplicative term are significant at the 10% level with opposite sign.

The squared them for expected debt is also statistically significant in explaining spreads indicating the existence of non-linearities in the relationship between the two variables. Interestingly, when we interact a squared debt term with a dummy variable that separates periphery from non-periphery euro area members, the results in column (5) suggest that the aforementioned non-linearities arise only for periphery countries. Moreover, we find that during the crisis period the impact of higher expected debt on spreads is stronger for periphery countries, highlighting the importance of fiscal developments for periphery bond markets. Finally, the statistical significance of the periphery dummy which is associated with the bid-ask spread measure indicates that periphery markets are more exposed to liquidity conditions. The very significant drop in periphery markets bond market liquidity (see Figure 6) exerted additional upward pressure on spreads.

We conducted a number of robustness checks involving alternative estimation methods and/or alternative specifications and the main findings were overall robust.

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First, we estimated our baseline model defining the real effective exchange rate as a differential versus Germany (qd_{it}) rather than as level (q_{it}). The estimates of the modified baseline model and its parsimonious version are reported in columns (1) and (2) of Table A3a respectively in Appendix 1. The results of the modified baseline model are very similar to those of the initial one reported in column (1) of Table 2. Indeed, the model using differentials suggests an even more prominent role for real exchange rates during the crisis period, as both slope dummies on qd_{it} ($D2007.08_t$ and $D2009.03_t$) are statistically significant with a positive sign; whereas in the case of the model using real exchange rate levels, only the first slope dummy on q_{it} ($D2007.08_t$) was significant.

Second, we estimated our baseline model excluding from the set of regressors the first lag of the dependent variable (spr_{t-1}). The purpose of this exercise is to determine whether the high explanatory power of our models is mainly due to the autoregressive term (spr_{t-1}) or to the fundamentals on which we model spreads. The results are presented in Table A3a in Appendix 1, with columns (3) and (4) reporting the estimates of the modified baseline model and its parsimonious version respectively. The explanatory power of the model which excludes spr_{t-1} remains very high, with an adjusted R^2 coefficient equal to 0.86. Therefore, we can conclude that macroeconomic and fiscal fundamentals, international risk, liquidity conditions and contagion effects are indeed the variables explaining the bulk of the spreads' variation during the current crisis period. Despite some differences, the empirical findings of the model that excludes spr_{t-1} are broadly consistent to those of the model including it. However, given the high autocorrelation present in the spreads data and the subsequent statistical significance of spr_{t-1} in Table 2, specifications which include spr_{t-1} are likely to avoid the omitted variable bias.

Finally, in Table A3b in Appendix 1 we show the parsimonious specifications obtained from two further experiments. In column (1) we use an alternative proxy for bond market liquidity, that is, the size of government bond market relative to Germany as in Arghyrou and Kontonikas (2011), Haugh et al. (2009) and Attinasi et al. (2009) among others.[13] This measure of liquidity is statistically significant even in the pre-crisis period, with the appropriate negative sign indicating that a more liquid market is associated with lower spreads. The effect of liquidity on spreads becomes stronger

[13] In particular, we use the ratio of a country's outstanding general government debt to euro area-wide total. Italy, Germany and France have the largest government bond markets in the euro area, while the three smallest markets are those of Ireland, Finland and Portugal.

during the credit-debt crisis. Accounting for observation specific heteroskedasticity in the residuals (see column (2) in Table A3) we obtain broadly similar results to those from the benchmark model.

3.5. Sovereign ratings

3.5.1. Relevance for the spreads

One of the aspects of the European sovereign debt developments that have been extensively debated is the role of credit ratings in determining intra-EMU government bond yield spreads. In this section we attempt to shed light on this matter. We start with a causality analysis, where spread values and credit ratings scores are regressed on their own and on each other lagged values. We perform the analysis for credit ratings referring to each of the three main rating agencies, Standard and Poor's, Moody's and Fitch, as well as for the simple average rating calculated using scores from all three agencies. The results are reported in Table 3. In all cases lagged values of credit ratings are statistically significant in explaining spreads; while lagged values of spreads are statistically significant in explaining the average and Moody's credit rating score. Therefore, overall, Table 3 suggests bidirectional causality, which at first site does not exclude the possibility that credit ratings may play a major role in European sovereign debt developments (also in line with the results of Afonso et al, 2011).

[Table 3]

To explore this hypothesis further, we first estimate specifications where current spread values are regressed on current credit ratings and, for robustness, current credit outlook announcements. The results are reported in Table 4. In all cases we obtain a statistically significant rating/outlook announcement with the theoretically expected negative sign, suggesting that a higher credit rating or a positive outlook results into a lower spread. Moreover, the estimated coefficients of the ratings in the regressions using average values suggest an almost one-to-one relationship between sovereign spreads and ratings/outlook announcements in absolute terms. The reported adjusted R^2 coefficients suggest that spreads are better explained by credit ratings rather than by outlook announcements, with the explanatory power of the models using average values being superior to those using individual agency scores. Nevertheless, the explanatory power of even the best-performing models in Table 4 is significantly lower compared to the models reported in section 3.4. This is a strong indication that the ratings/outlook

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announcements do not drive spreads on their own but, at best, moderate or intensify movements of spreads determined by past spreads, macroeconomic and fiscal fundamentals, international risk, liquidity conditions and contagion effects.

[Table 4]

To test this hypothesis explicitly we repeat the panel estimations of section 3.4 adding to the set of explanatory variables the average credit rating and outlook scores. The results obtained using average ratings and outlook scores are reported in Table 5.[14] Column (1) and (3) present general models, including all the variables used to explain spreads in section 3.4 plus average credit ratings and outlooks respectively. In column (1) all three variables referring to average ratings are statistically significant, while international risk, contagion effects, macroeconomic and fiscal fundamentals (excluding projected debt and industrial production growth differentials) and liquidity conditions remain statistically significant, particularly during the period of the credit-debt crisis. This pattern is more obvious in column (2), which reports the estimates of a parsimonious model obtained from applying a general-to-specific estimation approach to the general model reported in column (1). The same inference is obtained from columns (3) and (4), which respectively report the estimates of a general and parsimonious model using credit outlook scores, as well as column (5), which reports the results of a parsimonious model accounting for both credit ratings and credit announcements.

[Table 5]

All in all, our findings reported in Table 5 suggest that the role of credit rating agencies in spreads determination within the euro area is relevant. Nevertheless, even after controlling for the effect of ratings/outlook announcements, the main drivers of intra-EMU spreads continue to be macroeconomic and fiscal fundamentals, contagion effects, international risk and liquidity conditions. There is also a significant reduction in the size of the cumulative coefficient of credit ratings and outlook announcements observed in Table 5 relative to Table 4. From that point of view, our findings in this

[14] The results of the models reported in Table 5 obtained using individual credit ratings and outlook scores are available upon request. The qualitative inference obtained using individual agency scores is identical to the one obtained using average scores, with the latter, however, resulting in higher adjusted R^2 coefficients.

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section provide support to the argument that the EMU sovereign debt crisis is primarily driven by fundamentals but that credit downgrades announced by rating agencies also seem to have played a role in explaining spread developments.

3.5.2. The determinants of sovereign credit ratings

In the previous section we concluded that sovereign ratings and outlook announcements have a statistically significant role, in explaining government bond yield spreads in the EMU. An important question that then arises refers to the nature of the determinants of credit ratings themselves. In other words, do credit agencies determine their ratings focusing on fundamentals and, if yes, which particular ones? We explore this question by estimating specifications conditioning the average and individual agencies credit ratings on the full set of variables used to model government bond spreads in section 4.3, excluding lagged spread values, accounting for breaks capturing the effects of the global credit crunch and of the European sovereign debt crisis.

The results reported in Table 6 show estimates of general and parsimonious equations modelling average rating scores, and the scores assigned by each of the three main agencies. In the discussion that follows we focus on the equations modelling average ratings reported in columns (1) and (2), but it is worthy to note that our findings for individual credit rating agencies, reported in columns (3) to (8), are very similar. We obtain a number of interesting findings:

First, during the pre-crisis period (1999:01–2007:07) credit rating agencies have collectively not been pricing, or have even been mispricing, into their ratings important risk factors, as suggested by the latter's non-statistically significant or wrongly signed significant variable coefficients. More specifically, agencies have been mispricing international risk and external competitiveness, in the sense that rises in VIX and real exchange rate appreciation have been associated with improved ratings. Furthermore, agencies have not been pricing liquidity conditions, budgetary imbalances and growth conditions.[15] The only fiscal fundamental that agencies seem to have been appropriately penalising during the pre-crisis period was the expected debt. We also find that an increase in the ratio of long-term to total debt during the pre-crisis period led to higher

[15] The coefficient associated with industrial production growth differentials during the pre-crisis period is significant at the 10% level (see column (1) in Table 6) but becomes inisgnificicant during the general to specific test-down and is subsequently dropped from the parsimonious model in column (2) of Table 6.

credit ratings suggesting that this ratio can operate under certain circumstances as a credibility indicator.

[Table 6]

During the global economic and financial crisis (2007:08–2009:02) sovereign ratings became more sensitive to high values of government debt. Credit rating agencies, however, switched from a mispricing to a non-pricing of external competitiveness developments and international risk. Moreover, they reduced their focus on the share of long-term debt to total debt (maintaining however the positive cumulative sign for the coefficient of this variable) and, also, introduced mispricing of the budgetary balance. These last two findings are at first sight paradoxical, however they can be rationalised along the lines explained in section 3:4 above, i.e. they suggest that at a time of intense capital flight from collapsing equity markets, rating agencies, like bond market participants, still perceived investments in European sovereign debt to be a safe investment instrument for the foreseeable future.

The agencies' credit rating assessment changed fundamentally following the very significant upward revision of projected budget balance and government debt figures in early 2009. As soon as the fiscal cost of banking bailout schemes, magnified by the fiscal fallout of the global economic recession, became apparent, rating agencies collectively adopted a rating approach more consistent with theoretical expectations. More specifically, since March 2009, debt agencies introduced more strongly into their ratings' model such determinants as international risk, liquidity conditions, external competitiveness and economic growth. At the same time they neutralised, at least to a large extent, the mispricing of budgetary imbalances observed over the period 2007:08-2009:02. Finally, and very importantly, for the post-2009:03 period we obtain evidence of credit ratings being determined by contagion effects in the market for European sovereign bonds.

Overall, our evidence presented in this section reveals that the rating model adopted by credit rating agencies over the period under examination resembles closely the pricing model adopted by market participants determining government bond yields. This, combined with our findings in section 3.5.1, suggesting bidirectional causality between sovereign spreads and ratings, as well as the somewhat limited marginal contribution of incorporating credit rating scores into empirical models of spread determination, seems to indicate that the role of credit rating agencies in the escalation

of the European sovereign debt crisis since March 2009 is at best, only reinforcing already existing market forces. Therefore, this lends further support to the conclusion we reached in the previous sub-section according to which the European sovereign debt crisis has more to do with unfavourable developments in macro and fiscal fundamentals rather than to the, largely endogenous to the latter, changes in credit ratings scores.[16]

4. Conclusion

We studied the determinants of long-term government bond yields in the euro area. We employ a panel of ten euro area countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain) over the period 1999:01-2010:12 (monthly data). We investigate the role of an extended set of potential spreads' determinants, namely macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions, contagion, speculation and institutional intervention and sovereign credit ratings. We considered three distinct time periods: first, the period preceding the global credit crunch (1999.01 – 2007.07); second the period during which the global credit crunch had not yet mutated into a sovereign debt crisis (2007.08 – 2009.02); and third the period during which the global financial crisis mutated into a sovereign debt crisis (2009.03 – 2010.12).

Overall, our results indicate that the European sovereign debt crisis is more strongly linked to developments in macro and fiscal fundamentals rather than to downgrades in sovereign ratings. This conclusion implies that for a successful and permanent resolution of the European debt crisis a substantial improvement in macroeconomic fundamentals, such as fiscal sustainability and external competitiveness, is much more important relative to a change in the framework under which credit rating agencies operate, or regulatory changes in the framework governing the trade of sovereign bonds' derivatives.

Our results also suggest that by increasing the size, liquidity and maturity of debt issuances, spreads in EMU countries, especially the periphery ones, could decline. However, there are two important caveats. First, the size of this reduction will not necessarily be sufficient to produce on its own a permanent resolution to the crisis. Macroeconomic adjustment in the form of structural reforms enhancing fiscal sustainability and external competitiveness will remain of paramount importance under all circumstances. Second, the benefits of a common debt issuance on periphery spreads

[16] Finally, we also undertook a country specific analysis, which we report in Appendix 2.

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have to be assessed against any potential moral hazard side effects hindering the achievement of a lasting improvement in macroeconomic fundamentals. It is therefore important for a common issuance of debt to be successful, to be accompanied by mechanisms of effective intra-EMU monitoring and policy co-ordination addressing the moral hazard problem in a credible way. Recent proposals for a competitiveness pact, more binding fiscal rules and the creation of a permanent European Stabilisation Mechanism establishing credible deterministic endgames move towards that direction.

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Tables and Figures

Table 1: Principal component analysis of government bond yield spreads

Number	Eigenvalues	Cumulative proportion	Eigenvectors (Loadings)	*First principal component*	*Second principal component*
1	8.193	0.819	Austria	0.315	0.330
2	1.477	0.967	Belgium	0.343	0.070
3	0.121	0.979	Finland	0.278	0.458
4	0.058	0.985	France	0.336	0.160
5	0.049	0.990	Greece	0.290	-0.424
6	0.034	0.993	Ireland	0.323	-0.265
7	0.022	0.995	Italy	0.340	-0.058
8	0.019	0.997	Netherlands	0.295	0.422
9	0.016	0.999	Portugal	0.307	-0.380
10	0.011	1.000	Spain	0.327	-0.273

Note: the principal component analysis is carried out over the time period 1999.01-2011.01 (T=145).

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Table 2: Modelling bond yield spreads

	(1)	(2)	(3)	(4)	(5)
spr_{it-1}	0.883 ***	0.885 ***	0.877 ***	0.880 ***	0.865 ***
vix_t	-0.008	-0.008	-0.008		
vix_t*$D2007.08_t$	0.116 ***	0.122 ***	0.130 ***	0.108 ***	0.116 ***
vix_t*$D2009.03_t$	-0.005	-0.016	-0.018		
$pc2_t$	-0.024 ***	-0.024 ***	-0.026 ***	-0.022 ***	-0.024 ***
$pc2_t$ *$D2007.08_t$	0.002	-0.002	0.005		
$pc2_t$ *$D2009.03_t$	0.032 ***	0.036 ***	0.030 ***	0.030 ***	0.035 ***
ba_{it}	0.000	0.000	0.000		
ba_{it}*$D2007.08_t$	0.000	0.000	0.000		
ba_{it} *$D2009.03_t$	0.004 ***	0.005 ***	0.005 ***	0.004 ***	0.003 ***
q_{it}	0.021	0.029	0.022		
q_{it}*$D2007.08_t$	0.670 ***	0.532 **	0.525 **	0.605 ***	0.686 ***
q_{it} *$D2009.03_t$	0.036	0.136	0.215		
$balance_{it}$	-0.006 ***	-0.006 ***	-0.006 ***	-0.006 ***	-0.006 ***
$balance_{it}$ *$D2007.08_t$	0.002	0.003	0.004		
$balance_{it}$ *$D2009.03_t$	-0.008 **	-0.008 **	-0.009 **	-0.007 **	-0.008 ***
$debt_{it}$	0.000	0.000	0.000		
$debt_{it}$ *$D2007.08_t$	0.001 *	0.001 **	0.001 **	0.001 **	0.0003 *
$debt_{it}$ *$D2009.03_t$	0.001 ***	0.001 ***	0.001 ***	0.002 ***	0.001 ***
$gind_{it}$	0.000	0.000	0.000		
$gind_{it}$ *$D2007.08_t$	0.000	0.000	-0.001		
$gind_{it}$ *$D2009.03_t$	-0.004 ***	-0.004 ***	-0.003 **	-0.004 ***	-0.003 ***
$ltsdebt_{it}$		-0.013	-0.027		
$ltsdebt_{it}$ *$D2007.08_t$		0.279 ***	0.262 ***	0.194 **	0.232 ***
$ltsdebt_{it}$ *$D2009.03_t$		-0.429 ***	-0.390 ***	-0.374 ***	-0.252 **
spr_{it-1}* ba_{it-1}			-0.001		
spr_{it-1}* ba_{it-1}*$D2007.08_t$			0.003	0.001 *	0.001 **
spr_{it-1}* ba_{it-1}*$D2009.03_t$			-0.002 **	-0.001 *	-0.001 **
$debt_{it}^2$				1.14E-05 **	0.000
$debt_{it}^2$*$Dper_{it}$					2.99E-05 *
ba_{it}*$D2009.03_t$*$Dper_{it}$					0.002 ***
$debt_{it}$*$D2007.08_t$*$Dper_{it}$					0.001 *
$debt_{it}$*$D2009.03_t$*$Dper_{it}$					0.006 ***
N*T	1420	1420	1420	1420	1420
$Adj\text{-}R^2$	0.970	0.971	0.970	0.971	0.972

Notes: The regression models are estimated over the time period 1999.02-2010.11 (T=142). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are reported. The dummy variables *D2007.08* and *D2009.03* which are equal to one from August 2007 and March 2009 onwards, respectively, and zero otherwise were also included as intercept dummies. Colum 1 reports the estimates from the baseline model, while Column 3 reports the estimates from the fully specified model. Column 4 reports the estimates of the parsimonious model that results from applying the general-to-specific approach to the fully specified model. Column 5 interacts some of the variables of the parsimonious model with the *Dper* dummy variable which is equal to one for Greece, Ireland, Portugal and Spain, and zero for the other countries. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Table 3: Causality analysis for sovereign yield spreads and credit ratings

Panel A: Modelling bond yield spreads on lagged bond yield spreads and lagged credit ratings F-statistic *p*-values on joint insignificance of lagged credit ratings			
(1) S&P	(2) Moody's	(3) Fitch	(4) Average
0.00 ***	0.00 ***	0.00 ***	0.00 ***
Panel B: Modelling credit ratings on lagged credit ratings and lagged bond yield spreads F-statistic *p*-values on joint insignificance of lagged bond yields spreads			
(1) S&P	(2) Moody's	(3) Fitch	(4) Average
0.34	0.00 ***	0.37	0.02 **

Notes: The regression models are estimated over the time period 1999.07-2010.12 with six lags for bond yields and credit ratings included (T=138). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are reported. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Table 4: Modelling bond yield spreads on credit ratings and credit outlook announcements

	Credit rating				Credit outlook			
	(1) S&P	(2) Moody's	(3) Fitch	(4) Average	(5) S&P	(6) Moody's	(7) Fitch	(8) Average
$rating_{it}$	-0.578 ***	-0.822 ***	-0.583 ***	-0.925 ***				
$outlook_{it}$					-0.506 ***	-0.300 ***	-0.611 ***	-0.931 ***
*N*T*	1440	1440	1440	1440	1440	1440	1440	1440
Adj-R^2	0.466	0.366	0.344	0.556	0.205	0.155	0.146	0.230

Notes: The regression models are estimated over the time period 1999.01-2010.12 (*T*=144). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (*N*=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are re-ported. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

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Table 5: Modelling bond yield spreads controlling for average credit ratings and average credit outlook

	(1)	(2)	(3)	(4)	(5)
spr_{it-1}	0.812 ***	0.807 ***	0.856 ***	0.856 ***	0.800 ***
vix_t	-0.002		-0.006		
vix_t*$D2007.08_t$	0.120 ***	0.124 ***	0.132 ***	0.109 ***	0.122 ***
vix_t*$D2009.03_t$	0.001		-0.022		
$pc2_t$	-0.032 ***	-0.029 ***	-0.030 ***	-0.025 ***	-0.031 ***
$pc2_t$ *$D2007.08_t$	0.001		0.008		
$pc2_t$ *$D2009.03_t$	0.040 ***	0.040 ***	0.029 ***	0.034 ***	0.041 ***
ba_{it}	0.000		0.000		
ba_{it}*$D2007.08_t$	0.000		0.000		
ba_{it} *$D2009.03_t$	0.005 ***	0.004 ***	0.004 ***	0.004 ***	0.004 ***
q_{it}	0.047		0.000		
q_{it}*$D2007.08_t$	0.523 **	0.560 ***	0.735 ***	0.531 ***	0.554 ***
q_{it} *$D2009.03_t$	-0.147		-0.219		
$balance_{it}$	-0.007 ***	-0.005 ***	-0.007 ***	-0.006 ***	-0.004 ***
$balance_{it}$ *$D2007.08_t$	0.000		0.005 *		
$balance_{it}$ *$D2009.03_t$	-0.013 ***	-0.013 ***	-0.005		-0.012 ***
$debt_{it}$	-0.001		0.000		
$debt_{it}$ *$D2007.08_t$	0.000		0.001 ***	0.001 **	
$debt_{it}$ *$D2009.03_t$	0.001		0.001 ***	0.002 ***	
$gind_{it}$	0.000		0.000		
$gind_{it}$ *$D2007.08_t$	0.000		0.000		
$gind_{it}$ *$D2009.03_t$	-0.002	-0.002 **	-0.003 **	-0.003 ***	-0.002 **
$ltsdebt_{it}$	0.059		-0.033		
$ltsdebt_{it}$ *$D2007.08_t$	0.188 *	0.233 ***	0.234 **	0.213 ***	0.233 ***
$ltsdebt_{it}$ *$D2009.03_t$	-0.324 ***	-0.292 ***	-0.398 ***	-0.406 ***	-0.293 ***
spr_{it-1}* ba_{it-1}	0.001		-0.001		
spr_{it-1}* ba_{it-1}*$D2007.08_t$	0.001	0.002 ***	0.003	0.001 **	0.002 ***
spr_{it-1}* ba_{it-1}*$D2009.03_t$	-0.002 ***	-0.002 ***	-0.002 **	-0.001 **	-0.002 ***
$debt_{it}^2$	1.05E-05 *		1.17E-05 **	1.15E-05 **	
$average\ rating_{it}$	-0.037 ***	-0.027 ***			-0.032 ***
$average\ rating_{it}$ *$D2007.08_t$	-0.019 **	-0.015 ***			-0.016 ***
$average\ rating_{it}$ *$D2009.03_t$	-0.031 ***	-0.039 ***			-0.037 ***
$average\ outlook_{it}$			-0.003		-0.028 **
$average\ outlook_{it}$ *$D2007.08_t$			-0.095 *		
$average\ outlook_{it}$ *$D2009.03_t$			-0.069	-0.168 ***	
$N*T$	1420	1420	1420	1420	1420
$Adj\text{-}R^2$	0.972	0.972	0.971	0.971	0.972

Notes: The regression models are estimated over the time period 1999.02-2010.11 (T=142). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are reported. The dummy variables *D2007.08* and *D2009.03* which are equal to one from August 2007 and March 2009 onwards, respectively, and zero otherwise were also included as intercept dummies. Columns 1 and 3 report the estimates from the fully-specified model, while Columns 2, 4 and 5 report the estimates of parsimonious models that result from applying the general-to-specific approach to the most extended model. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Table 6: Modelling credit ratings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average	rating	S&P		Moody's		Fitch	
vix_t	0.100 ***	0.089 ***	0.126 ***	0.099 ***	0.032	0.054 ***	0.046	0.081 ***
vix_t*$D2007.08_t$	-0.015		-0.004		0.031		0.024	
vix_t*$D2009.03_t$	-0.251 **	-0.255 ***	-0.571 ***	-0.541 ***	-0.286 ***	-0.306 ***	-0.174	-0.164 **
$pc2_t$	0.021		0.013		0.000		-0.036	
$pc2_t$ *$D2007.08_t$	-0.016		0.018		-0.021		0.039	
$pc2_t$ *$D2009.03_t$	-0.045 *	-0.037 ***	-0.105 ***	-0.072 ***	-0.039	-0.069 ***	-0.012	
ba_{it}	0.000		0.014 ***	0.014 ***	-0.003 **	-0.002 **	-0.004 ***	-0.002 *
ba_{it}*$D2007.08_t$	0.001		-0.013 ***	-0.013 ***	0.002		0.004 *	
ba_{it} *$D2009.03_t$	-0.010 ***	-0.009 ***	-0.015 ***	-0.014 ***	-0.006 ***	-0.006 ***	-0.007 ***	-0.005 ***
q_{it}	1.118 ***	1.191 ***	0.260		1.619 ***	1.263 ***	1.582 ***	1.519 ***
q_{it}*$D2007.08_t$	-0.189		-0.312		-0.905		0.529	
q_{it} *$D2009.03_t$	-7.400 ***	-7.226 ***	-12.086 ***	-11.65 ***	-7.402 ***	-8.937 ***	-5.385 ***	-4.247 ***
$balance_{it}$	-1.90E-05		-0.047 ***	-0.047 ***	0.010		0.017 **	0.020 ***
$balance_{it}$ *$D2007.08_t$	-0.044 ***	-0.043 ***	-0.002		-0.005		-0.046 ***	-0.042 ***
$balance_{it}$ *$D2009.03_t$	0.024 **	0.030 ***	0.039 **	0.039 ***	0.006		0.051 ***	0.046 ***
$debt_{it}$	-0.023 ***	-0.021 ***	-0.019 ***	-0.020 ***	-0.010 ***	-0.010 ***	-0.029 ***	-0.028 ***
$debt_{it}$ *$D2007.08_t$	-0.006 ***	-0.007 ***	-0.008 ***	-0.008 ***	0.001	0.002 **	-0.005 ***	-0.004 ***
$debt_{it}$ *$D2009.03_t$	-0.002		0.000		-0.003 *	-0.003 **	0.002	
$gind_{it}$	0.003 *		-0.004 *	-0.004 **	0.004 **		0.003	
$gind_{it}$ *$D2007.08_t$	-0.005		0.003		-0.007 *		-0.005	
$gind_{it}$ *$D2009.03_t$	0.013 ***	0.010 ***	0.019 ***	0.022 ***	0.011 **	0.008 ***	0.014 **	0.011 ***
$ltsdebt_{it}$	3.003 ***	2.951 ***	2.967 ***	2.870 ***	1.731 ***	1.553 ***	2.267 ***	2.364 ***
$ltsdebt_{it}$ *$D2007.08_t$	-2.085 ***	-2.300 ***	-1.610 ***	-1.381 ***	-0.713 **	-0.918 ***	-2.183 ***	-2.014 ***
$ltsdebt_{it}$ *$D2009.03_t$	-0.293		0.142		-0.280		-1.00 **	-1.145 ***
$debt_{it}^2$	1.29E-05		2E-04 ***	2E-04 ***	-1E-04 ***	-1E-04 ***	-3E-04 ***	-4E-04 ***
$N*T$	1430	1430	1430	1430	1430	1430	1430	1430
Adj- R^2	0.963	0.964	0.930	0.930	0.950	0.953	0.952	0.952

Notes: The regression models are estimated over the time period 1999.01-2010.11 (T=143). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are reported. The dummy variables *D2007.08* and *D2009.03* which are equal to one from August 2007 and March 2009 onwards, respectively, and zero otherwise were also included as intercept dummies. Columns 1, 3, 5 and 7 report the estimates from the fully-specified model, while Columns 2, 4, 6 and 8 report the estimates of parsimonious models that results from applying the general-to-specific approach to the fully-specified model. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Figure 1: 10-year government bond yield spreads

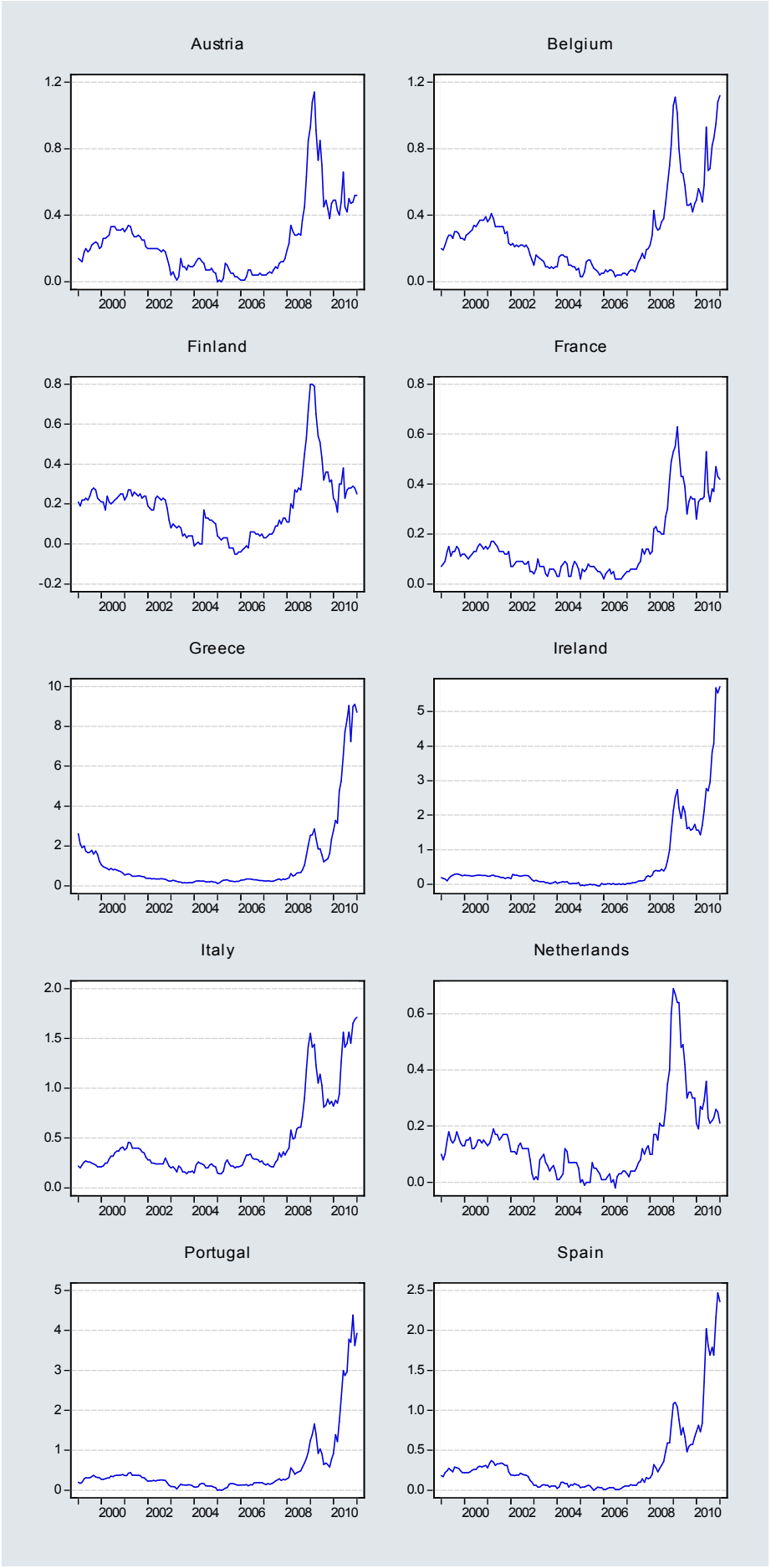


Figure 2: German 10-year government bond yield and VIX

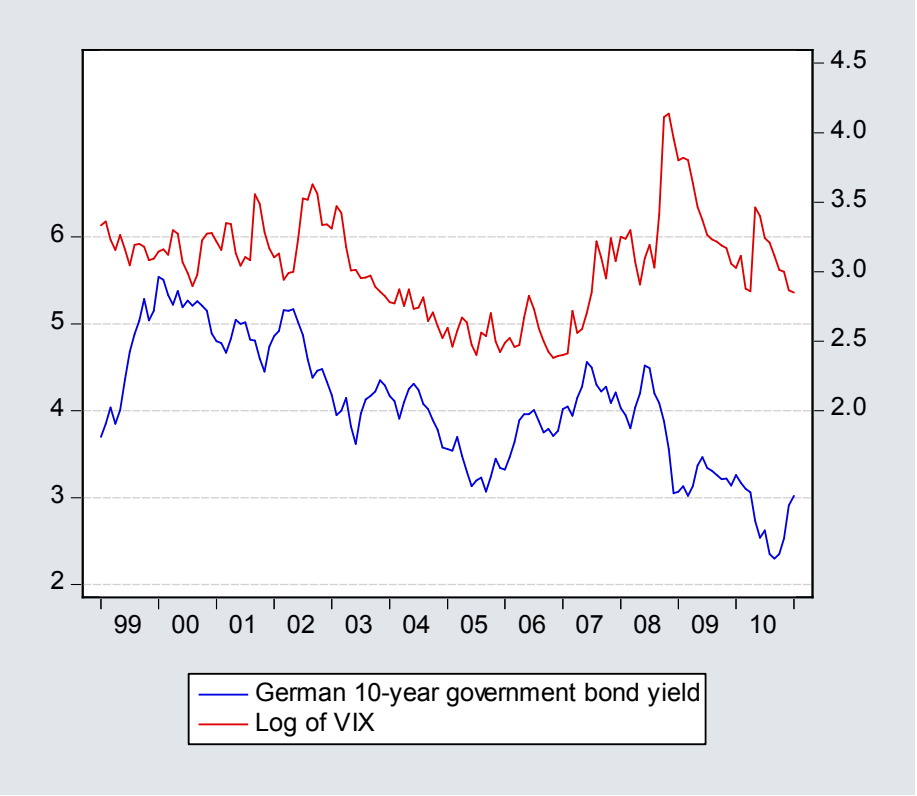


Figure 3: Expected budget balance as percentage of GDP

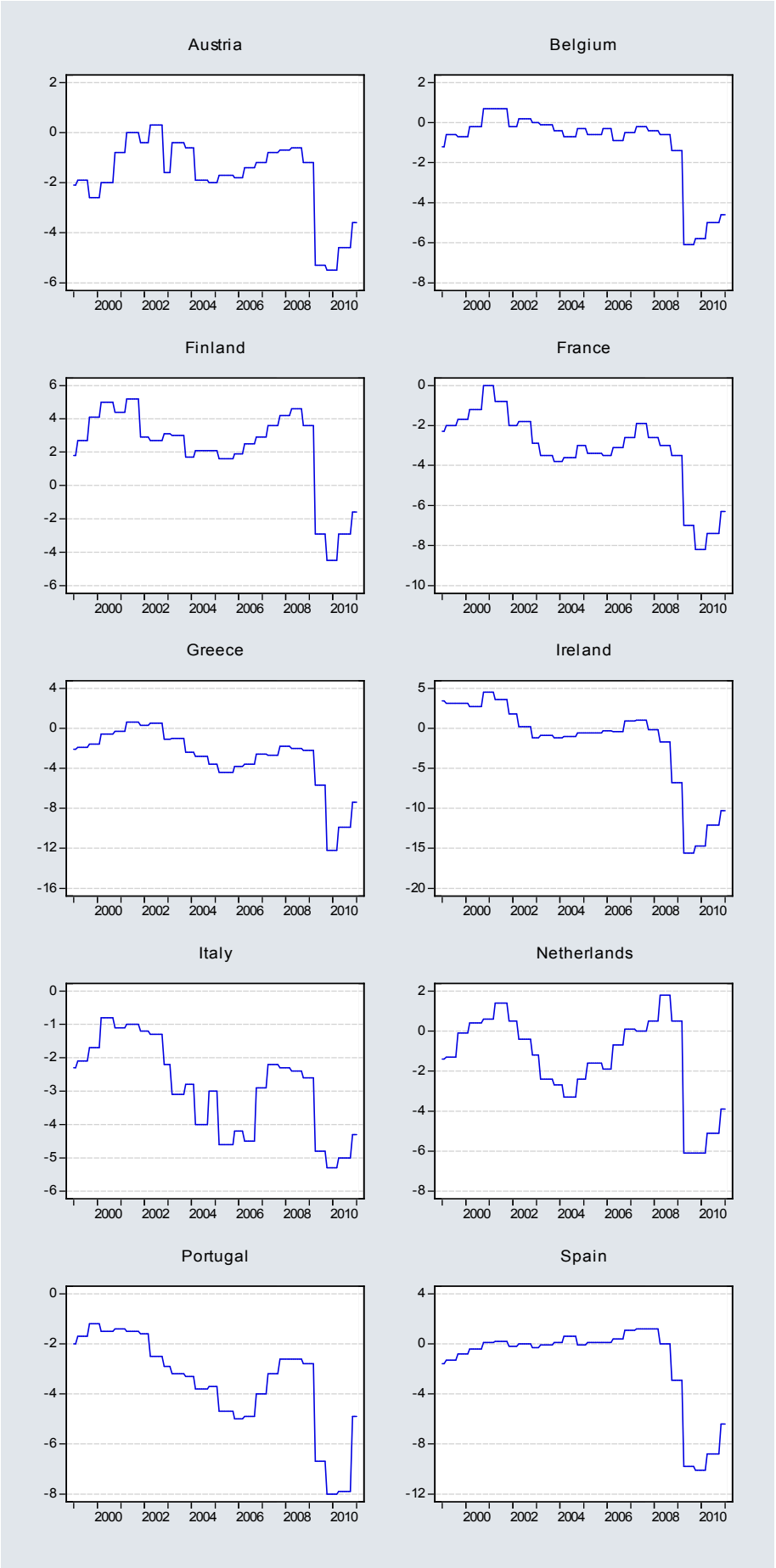


Figure 4: Expected debt as percentage of GDP

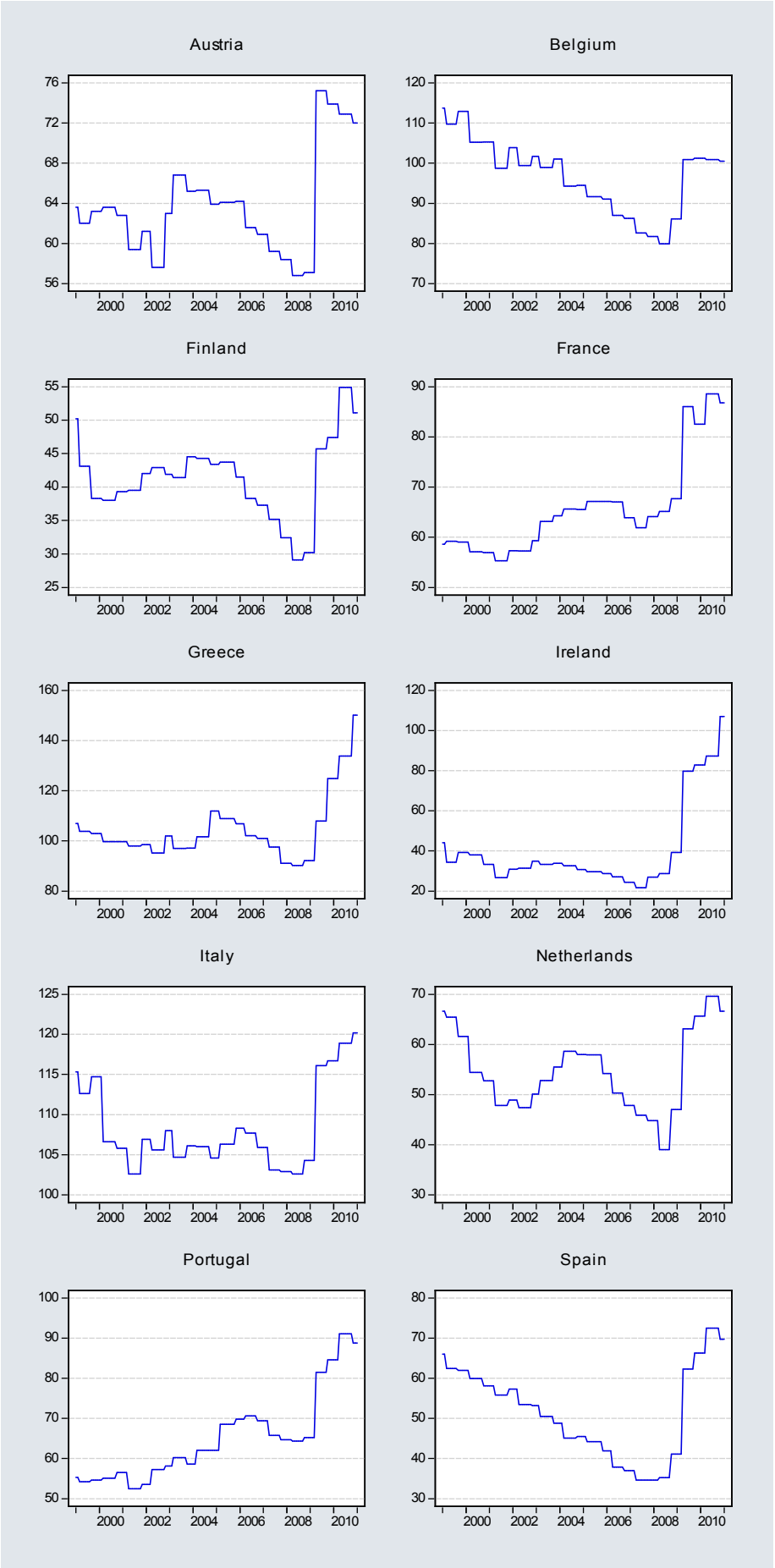


Figure 5: Average credit rating

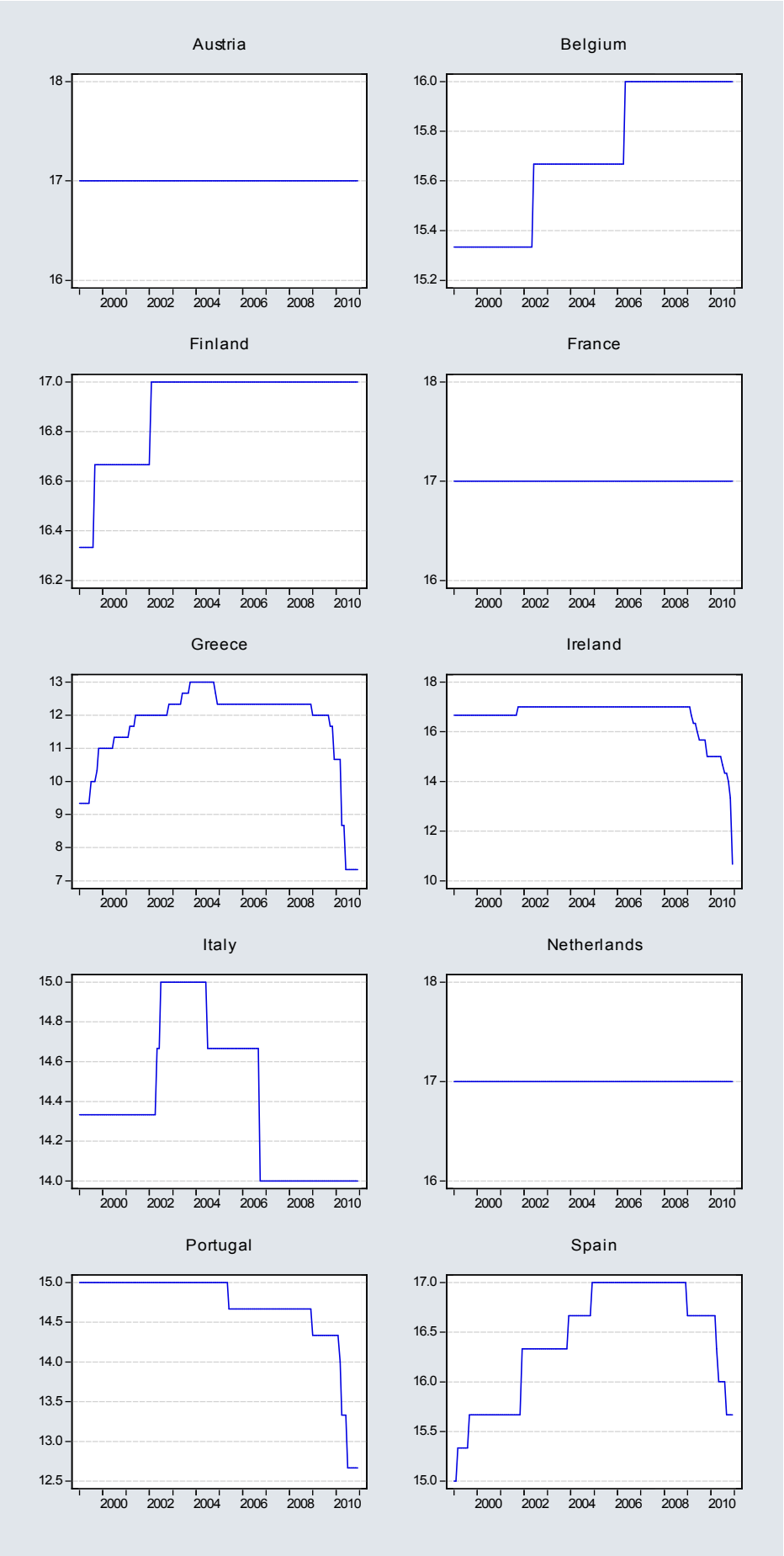
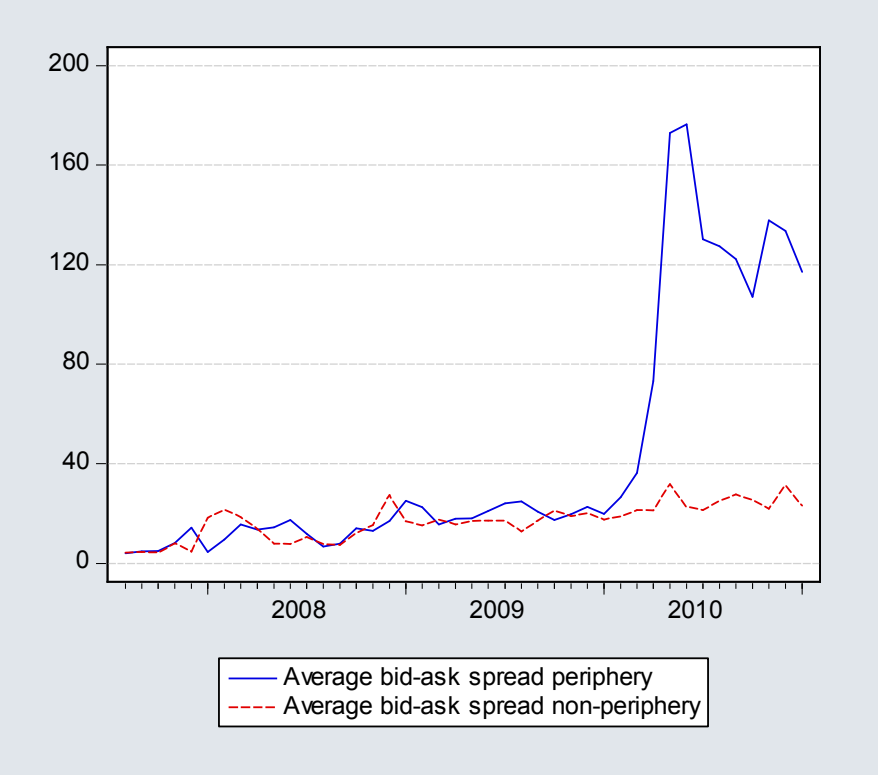
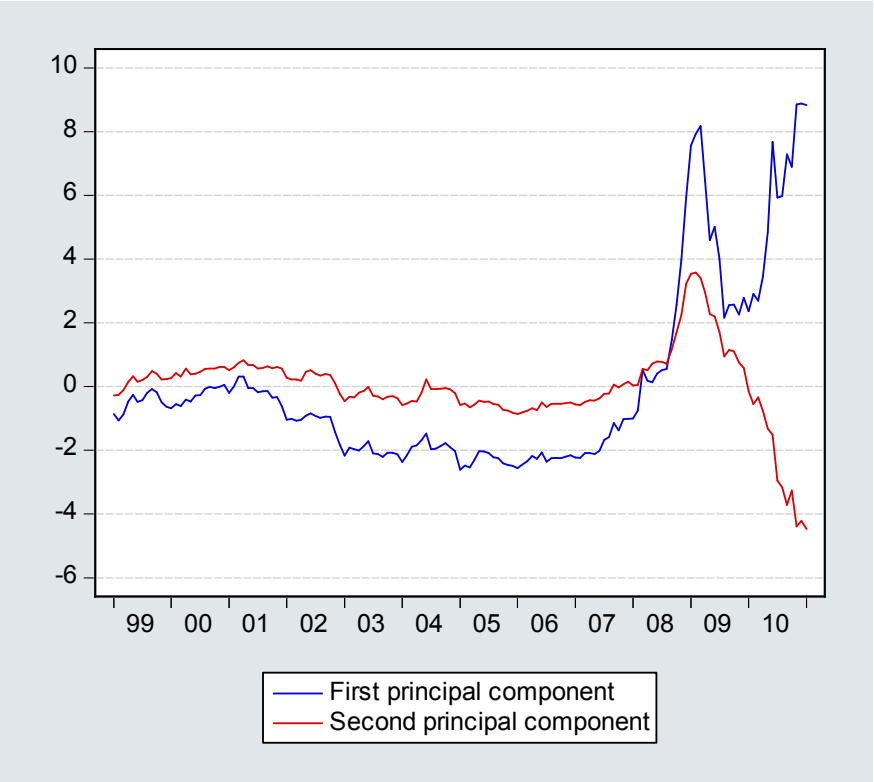


Figure 6: Average bid-ask spread in periphery and non-periphery countries



Notes: Periphery countries include Greece, Ireland, Portugal and Spain. Non-periphery countries include Austria, Belgium, Finland, France, Italy and Netherlands.

Figure 7: Principal components of 10-year government bond yield spreads



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Appendix 1

Table A1: Data definition and sources

Variable	Sample	Description	Source
spr	1999.01-2011.01	10 year government bond yield (differential vs. Germany)	ECB/Reuters
vix	1999.01-2011.01	(Log of) S&P 500 implied stock market volatility index (VIX)	Bloomberg
pc2	1999.01-2011.01	(Minus) Second principal component of *spread*	Own calculations
ba	1999.01-2011.01	10 year government bond bid-ask spread	ECB
q	1999.01-2010.12	(Log of) CPI based real effective exchange rate	IMF
balance	1999.01-2011.01	Expected budget balance/GDP (differential vs. Germany)	European Comission
debt	1999.01-2011.01	Expected debt/GDP (differential vs. Germany)	European Comission
gind	1999.01-2010.11	Industrial production annual growth (differential vs. Germany)	IMF
ltsdebt	1999.01-2011.01	Long-term/Total general government debt	ECB
D2007.08	1999.01-2011.01	Dummy variable: 1 from 2007.08 onwards, zero otherwise	Own calculations
D2009.03	1999.01-2011.01	Dummy variable: 1 from 2009.03 onwards, zero otherwise	Own calculations
Dper	1999.01-2011.01	Dummy variable: 1 if GRE, IRE, POR, SPA, zero otherwise	Own calculations
rating	1999.01-2010.12	Credit rating (Fitch, Moody's, S&P, Average of three agencies)	1/
outlook	1999.01-2010.12	Credit outlook (Fitch, Moody's, S&P, Average of three agencies)	1/

1/ Afonso, A., Furceri, D. and Gomes, P. (2011).

Table A2: S&P, Moody's and Fitch rating systems

Characterization of debt and issuer (source: Moody's)		Rating			Linear transformation
		S&P	Moody's	Fitch	
Highest quality	Investment grade	AAA	Aaa	AAA	17
High quality		AA+	Aa1	AA+	16
		AA	Aa2	AA	15
		AA-	Aa3	AA-	14
Strong payment capacity		A+	A1	A+	13
		A	A2	A	12
		A-	A3	A-	11
Adequate payment capacity		BBB+	Baa1	BBB+	10
		BBB	Baa2	BBB	9
		BBB-	Baa3	BBB-	8
Likely to fulfil obligations, ongoing uncertainty	Speculative grade	BB+	Ba1	BB+	7
		BB	Ba2	BB	6
		BB-	Ba3	BB-	5
High credit risk		B+	B1	B+	4
		B	B2	B	3
		B-	B3	B-	2
Very high credit risk		CCC+	Caa1	CCC+	1
		CCC	Caa2	CCC	
		CCC-	Caa3	CCC-	
Near default with possibility of recovery		CC	Ca	CC	
				C	
Default		SD	C	DDD	
		D		DD	
				D	

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Table A3a: Modelling bond yield spreads - robustness checks I

	(1)	(2)	(3)	(4)
spr_{it-1}	0.870***	0.868***		
vix_t	-0.010	-0.014*	-0.017	
vix_t*$D2007.08_t$	0.089***	0.088***	0.062	
vix_t*$D2009.03_t$	-0.024		0.806***	0.843***
$pc2_t$	-0.024***	-0.029***	-0.132	-0.129***
$pc2_t$ *$D2007.08_t$	-0.006		-0.056**	
$pc2_t$ *$D2009.03_t$	0.028***	0.029***	0.288***	0.298***
ba_{it}	0.000		-0.001	
ba_{it}*$D2007.08_t$	0.000		0.0002	
ba_{it} *$D2009.03_t$	0.004***	0.005***	0.016***	0.153***
q_{it}			-0.126	
q_{it}*$D2007.08_t$			2.110***	1.570***
q_{it} *$D2009.03_t$			8.481***	8.672***
$balance_{it}$	-0.005***	-0.006***	-0.022***	-0.022***
$balance_{it}$ *$D2007.08_t$	0.003		0.007	
$balance_{it}$ *$D2009.03_t$	-0.005		-0.008	
$debt_{it}$	0.001*	0.0006**	0.004***	0.004***
$debt_{it}$ *$D2007.08_t$	0.001**	0.0004**	0.003***	0.002***
$debt_{it}$ *$D2009.03_t$	0.001	0.0017***	0.008***	0.008***
$gind_{it}$	0.000		-0.001	
$gind_{it}$ *$D2007.08_t$	0.000		0.008***	0.006**
$gind_{it}$ *$D2009.03_t$	-0.002	-0.002**	-0.011***	-0.009***
qd_{it}	0.031			
qd_{it}*$D2007.08_t$	0.648**	0.652***		
qd_{it} *$D2009.03_t$	1.238***	1.315***		
$N*T$	1420	1420	1420	1420
$Adj\text{-}R^2$	0.97	0.97	0.86	0.86

Notes: In Table A3a the regression models are estimated over the time period 1999.01-2010.11 (T=142). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). Fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity are reported. The dummy variables *D2007.08* and *D2009.03* which are equal to one from August 2007 and March 2009 onwards, respectively, and zero otherwise were also included as intercept dummies. Columns (2) and (4) report the estimates of parsimonious models that result from applying the general-to-specific approach to the modified baseline models shown in Columns (1) and (3). The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

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Table A3b: Modelling bond yield spreads - robustness checks II

	(1)	(2)
spr_{it-1}	0.995 ***	0.888 ***
vix_t*D2007.08*	0.125 ***	0.105 ***
$pc2_t$		-0.023 ***
$pc2_t$ *D2009.03*	0.011 ***	0.032 ***
ba_{it} *D2009.03*		0.005 ***
liq_t	-0.415 **	
liq_t*D2007.08*	-0.195 **	
liq_t*D2009.03*	-0.350 ***	
q_{it}*D2007.08*		0.643 **
q_{it}*D2009.03*	0.049 **	-
$balance_{it}$		-0.008 ***
$balance_{it}$ *D2009.03*	-0.016 ***	
$debt_{it}$	0.001 **	
$debt_{it}$ *D2007.08*	0.001 ***	0.001 **
$debt_{it}$ *D2009.03*	0.001 ***	0.002 ***
$gind_{it}$ *D2009.03*	-0.007 ***	-0.004 **
$ltsdebt_{it}$ *D2007.08*	0.170 *	0.184 *
$ltsdebt_{it}$ *D2009.03*	-0.362 ***	-0.405 **
$debt_{it}^2$	1.86E-05 ***	1.13E-05 *
*N*T*	1420	1420
Adj-R^2	0.966	0.971

Notes: In Table A3b the regression models are estimated over the time period 1999.01-2010.11 (T=142). The panel members include Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain (N=10). This Table reports the estimates of the parsimonious models that result from applying the general-to-specific approach to a model that also incorporated the dummy variables D2007.08 and D2009.03 which are equal to one from August 2007 and March 2009 onwards, respectively, and zero otherwise as intercept dummies. Colum 1 reports fixed effects panel estimates with Feasible Generalised Least Squares cross-section weights which account for cross-sectional heteroskedasticity. In Column 2 White diagonal standard errors which account for observation specific heteroskedasticity in the residuals are used. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively.

Figure A1: Credit ratings by Fitch, Moody's and S&P

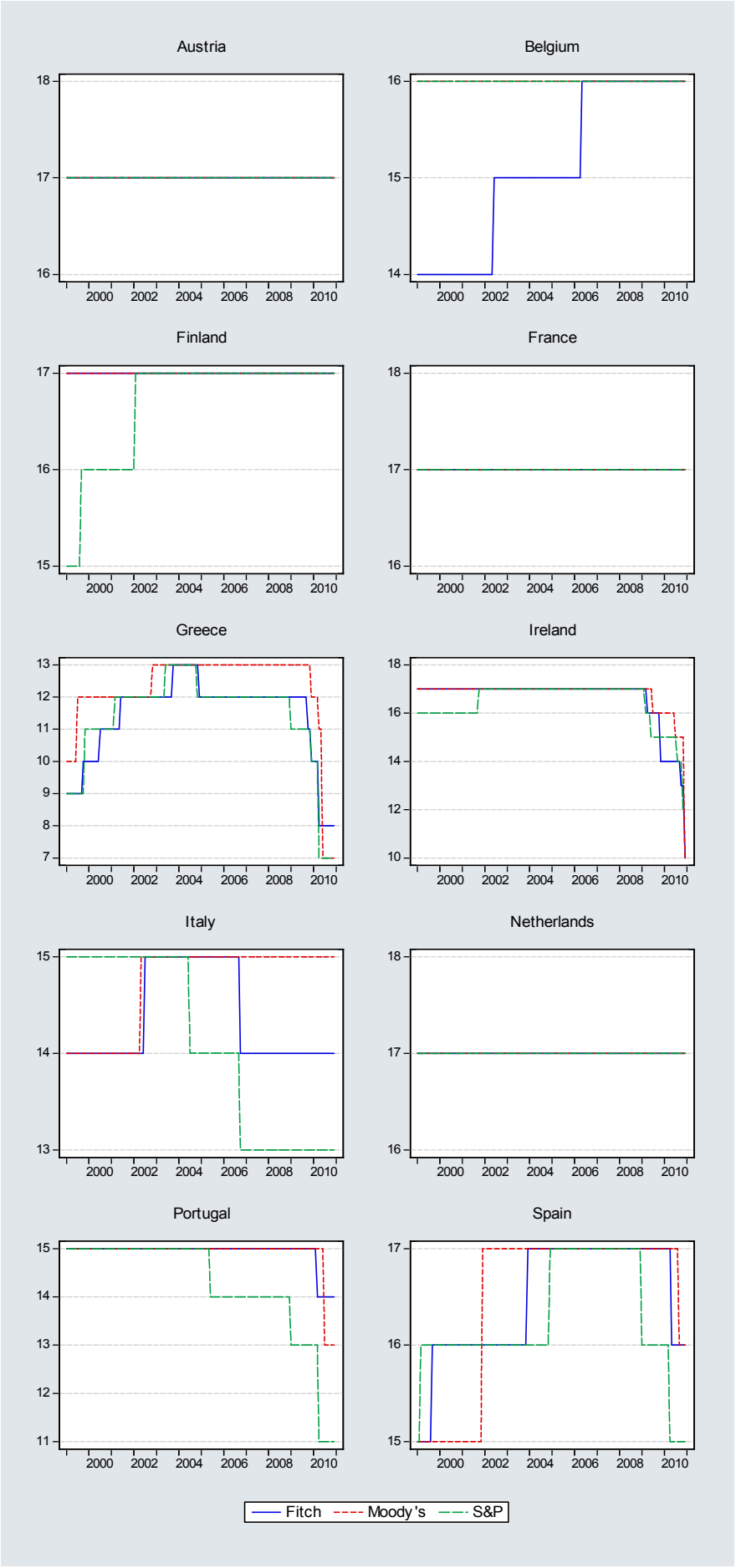
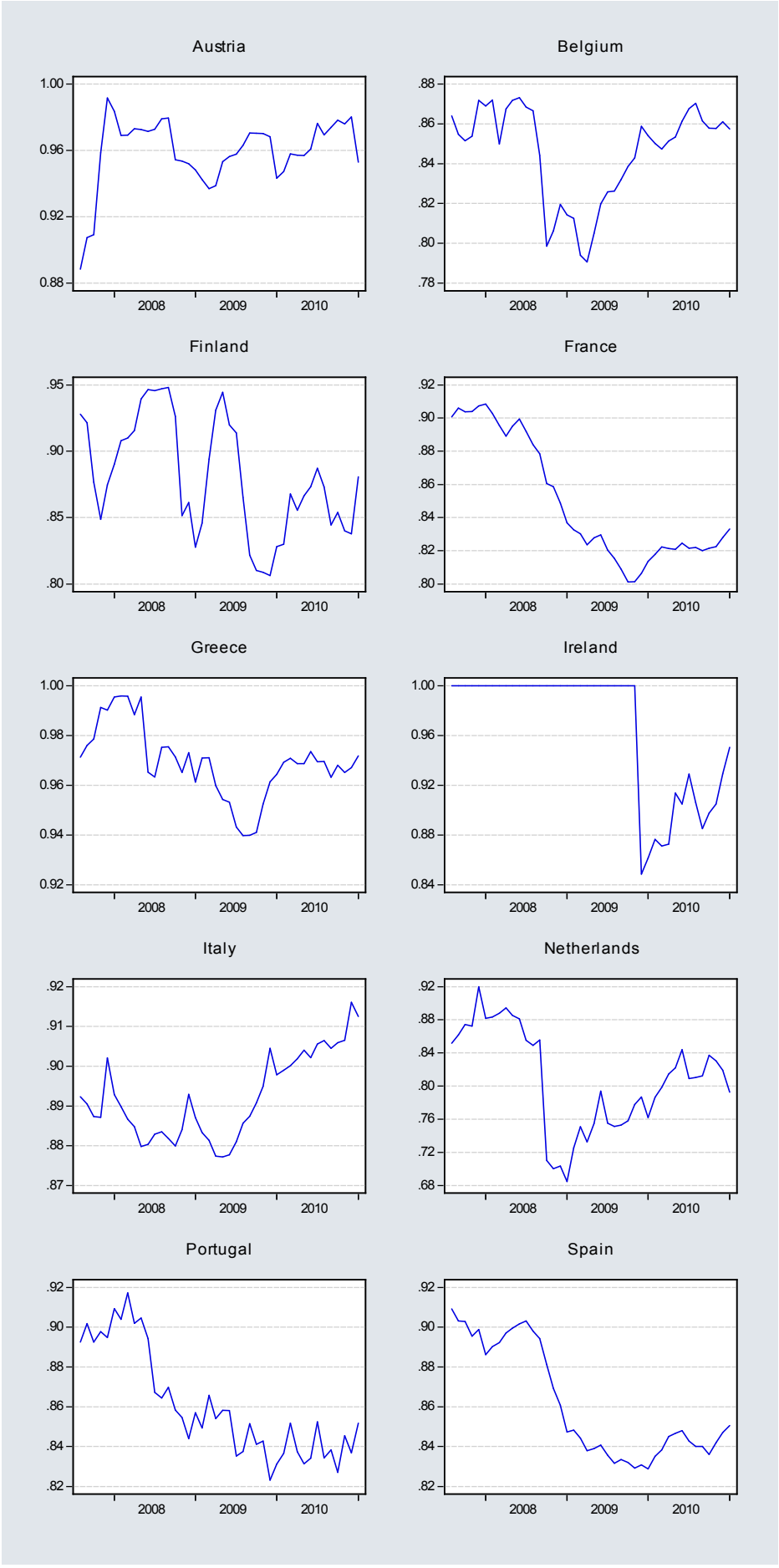


Figure A2: Share of long-term debt in total general government debt



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Appendix 2: Time series analysis

In this section we model the government bond yields spreads of individual EMU countries against Germany using monthly data for the time period 1999.01 – 2010.12. To keep the discussion within reasonable limits we only report, in Table A2.1, the parsimonious estimates of our most extended model obtained using a general-to-specific approach.[17] In each country we have considered a general specification including 13 variables each of which (with the exception of the lagged interest rate) enters the estimated models in three forms, i.e. the original series and its two slope-dummy variants (post-2007.09 and post-2009.03). For Greece we have also investigated the significance of a third slope-dummy variant for each variable, with the relevant dummy taking the value of unity since November 2009 and zero otherwise (*D2009.11*). This captures the Greek-specific shift in expectations proposed by Arghyrou and Tsoukalas (2010) and empirically documented by Arghyrou and Kontonikas (2011).[18]

With a sample of 143 observations and 39 coefficients to be estimated in the most general specification for each country (49 coefficients in the case of Greece), it is in advance expected that our time series estimates will not be as well defined as those the panel estimations. It is also unlikely to obtain the theoretically expected sign for each individual estimated parameter. Nevertheless the bulk of our time-series findings are consistent with those obtained by our panel analysis and also reveals some interesting country-specific characteristics. More specifically, out of 130 total coefficients reported in Table A2.1 (total being the sum of the estimated coefficients on the original series and its slope-dummy variants) we obtain 80 intuitive total coefficients, 17 counter-intuitive total coefficients and 33 total coefficients that do not enter the specifications.

Starting from the role of the international risk factor (*vix*) we confirm that prior to the global credit crunch markets generally did not price it in individual countries' spread (the only exception being Finland). This changed since 2007.08, when international risk was introduced in national spreads (most notably in the case of Greece). In some cases (notably Portugal) this effect was reinforced since 2009.03. Overall, the total coefficient on *vix* suggests that the two countries most exposed to international risk conditions are Greece and Portugal.

Moving on to contagion effects, captured by *pc2*, our proxy variable for the risk of periphery countries bonds relative to the core countries, we get negative coefficients

[17] We use robust standard errors to account for possible residuals' heteroskedasticity and autocorrelation of unknown form (OLS-HAC; see Newey and West, 1987).

[18] We have tested for the effect of this third dummy variable for all the variables included the equations estimated of all other countries without obtaining any statistically significant parameter.

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before 2007.08, negative between 2007.08 and 2009.02, and positive since 2009.03. Therefore, prior to the global credit crunch (pre-2007.08) the periphery countries were not considered as being excessively risky by the markets. As a result, the negative coefficients obtained for that period suggest a mispricing of periphery risk. It is interesting that this mispricing is reinforced between 2007.08 and 2009.02, as the coefficient of the August 2007 slope dummy on *pc2* is negative. This is not surprising since, as our principal component analysis indicates, that was still a period when periphery countries have not started diverging from the core countries in terms of long-term government bond yields. In other words, periphery bonds were not yet considered significantly riskier than the core countries' bonds.[19] By contrast, since 2009.03 and with the sovereign debt crisis in full swing, we find significant evidence of contagion, with the relative risk of periphery countries, as captured by *pc2* increasing the spreads.[20]

As far as bond market illiquidity is concerned, captured by the bid-ask spread (*ba*) we obtain evidence of a relatively moderate effect, in the form of the expected positive sign, for 5 out of 10 countries. Interestingly, these do not include Greece and Portugal but they do include the remaining three periphery group members, namely Ireland, Italy and Spain (the other two being Austria and Finland).

Turning to real exchange rate (q) developments, our findings suggest that before 2007.08 this was not priced in any country with the expected positive sign and was mispriced in Italy. Some evidence of mispricing is also obtained over 2007.08 – 2009.02 for Belgium and Ireland. However, over the same period we observe the introduction of appropriately priced real exchange rate risk in Austria, Italy and Spain, further reinforced since 2009.03 when the coefficient on q becomes positive and significant for Finland, Greece, Ireland and the Netherlands.

We now examine the effects of the expected fiscal position variables. Starting with the fiscal balance, over the period 1999.01 – 2007.07 this is found to be priced with the expected negative sign only in Finland and Italy. During the period 2007.08 – 2009.02 markets start pricing the fiscal balance appropriately in Greece and the Netherlands but misprice it in Portugal and Spain. For Portugal, this mispricing is corrected since

[19] It could be argued that during the period 2007.08–2009.02 the increased risk aversion that markets showed towards the equity segment of the market is stronger than the risk aversion shown towards periphery bonds. As a result, periphery risk continued to be mispriced.

[20] To say that this contagion effect has fully reversed the previous mispricing, the total sum of the *pc2* coefficients should be positive in all countries. This is not the case for the core countries of Finland, France and the Netherlands, but it is clearly the case for Greece, Ireland and Portugal. Finally, in the cases of Austria, Belgium, Italy and Spain the total coefficient is slightly positive.

2009.03, with further evidence of correct pricing obtained for Austria, Belgium, France and Italy. Overall, the fiscal balance is correctly priced in 7 out of 10 countries, with the highest total coefficients obtained for Greece and Belgium.

Moving on to the effects of expected public debt, we have tested the significance of both the level of debt and squared debt. Prior to the global credit crunch the level of public debt is not priced, with the exception of the Netherlands. This changed during the period 2007.08 – 2009.02 for which we obtain the theoretically expected positive sign for Austria, Belgium and Portugal. However, we also obtain a counter-intuitive negative sign for Italy and Greece, reversed for the latter country since 2009.11. Since 2009.03 we obtain further evidence of correct debt pricing in Finland and Spain, as well as stronger debt pricing in the Netherlands; at the same time, however, we obtain a counter-intuitive negative sign for Austria and Portugal. Overall, the estimated total coefficients suggest that at the end of our sample period expected public debt has an overall positive coefficient for Belgium, Finland, the Netherlands and Spain. For the last three countries this result is further strengthened by an overall positive coefficient on the square of expected debt. On the other hand, there are two countries for which the overall coefficient on expected debt is negative, namely Austria and Italy. For both countries the overall coefficient on squared debt is also negative. Finally, the total coefficient on the squared debt is positive for France and Ireland and zero or near zero for Greece and Portugal, respectively. Overall, taking both sets of coefficients into consideration (level of expected debt and its square) we conclude that at the end of our sample (post 2009.03) public debt is appropriately priced in 6 out of 10 EMU countries.

The next fiscal variable we consider is the share of long-term debt in total debt (*ltsdebt*). For this variable we expect to obtain a negative sign. We test the significance of both the level and the square of this series. As far as the former is concerned, we obtain a total negative coefficient for France, Greece, Italy and the Netherlands. By contrast, we obtain a counter-intuitive positive coefficient for Ireland. For the latter country, however, we obtain a highly negative overall estimated coefficient on the square of *ltsdebt*. The same holds true for Austria, Finland, Greece and Portugal while for Italy and the Netherlands we obtain a positive sign. Overall, and taking into consideration the total estimated coefficients on both the level and the square of *ltsdebt* we have unambiguous evidence of correct pricing of *ltsdebt* in 5 countries.

The next variable to consider is the rate of growth of industrial production (*gind*) for which we expect a negative sign. This is obtained only in 4 out of 10 countries

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including, however, Greece and Portugal (the remaining two being France and Netherlands). We obtain evidence of mispricing (positive and significant sign) in Finland, whereas for the remaining five countries industrial production is not priced.

We now turn our attention to the term capturing the interaction between lag spreads and lagged illiquidity conditions, $spr_{it-1} * ba_{it-1}$. This term provides an indication regarding the nature of the net effect of speculation- and risk aversion-based selling of bonds relative to the effect of speculation- and risk aversion-based purchases of bonds and/or bond purchases due to institutional intervention. If the coefficient of that variable is positive, the former effect is stronger than the latter, which implies that spreads are higher than the level justified by their fundamental determinants, and vice-versa.

The results obtained from time-series analysis are broadly consistent with those obtained from our panel-based estimations. Prior to the global credit crisis the coefficient of the multiplicative term is positive for three countries, Austria, Belgium and Italy, and insignificant for the remaining seven. Interestingly, however, over the period 2007.08-2009.03, this coefficient changes to negative for all three countries mentioned above, as well as for Ireland and Spain. This suggests that over 2007.08 – 2009.02 the bonds of these countries were actually in higher demand than justified by their fundamental determinants. This is consistent with our previous argument according to which over the initial period of the global financial turmoil, the market for European government bonds was generally regarded as safer than equity markets, prompting risk-averse to readjust their portfolios by buying the bonds of the these countries. For the remaining countries, the coefficient of the multiplicative term is either not significant or close to zero over the period 2007.08 – 2009.02, with one important exception. This exception is Greece, for which the coefficient on the slope dummy of the multiplicative term is positive, significant and substantial in size.[21] This positive sign is consistent both with speculation-based selling of Greek bonds but also with excessive selling of Greek bonds due to increased risk aversion specific to Greek bonds.

However, this effect was subsequently neutralised completely, as suggested by the negative and substantial in size value obtained in the case of Greece for the coefficient of the slope dummy on the multiplicative term since 2009.03, despite a small increase following the escalation of the Greek debt crisis since 2009.11. With the total estimated coefficient of the multiplicative term for Greece near zero, our findings suggest that Greek spreads are not higher than the level justified by their fundamental determinants.

[21] For the period 2007.08-2009.02 we also obtain a positive and significant coefficient for the multiplicative term in the case of Finland. The size of the coefficient, however, is very close to zero.

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This is almost certainly the result of institutional intervention, i.e. purchases of Greek bonds by the ECB at a large scale. In fact, the slightly negative total coefficient on the interactive term the multiplicative term suggests that ECB intervention may have resulted in Greek spreads actually taking values lower than those justified by their fundamental determinants.

Another interesting aspect of our findings on the multiplicative term is the lack of significant positive coefficients for the rest of the EMU periphery countries over the period 2009.03 – 2010.12. For Portugal none of the coefficients on spr_{it-1}* ba_{it-1} are statistically significant; for Ireland, the total coefficient is slightly negative; the same applies for Spain (though since 2009.03 the bonds of that country have lost the safety status they enjoyed over the period 2007.08 – 2009.02); while for Italy the total coefficient on the multiplicative term is slightly positive but close to zero. These findings are consistent with the hypothesis that institutional intervention on behalf of the ECB has neutralised the effects of speculative- or risk aversion-based selling of the bonds of these countries, if such selling has indeed taken place.

We conclude our discussion on our time-series estimates with a reference to the effect of credit ratings, captured by the *average rating* variable and its slope dummies, for which we theoretically expect to obtain coefficients with negative sign. Our findings suggest that the latter is significant and substantial in size for Greece since the escalation of the Greek debt crisis in November 2009. For the remaining periphery EMU countries, we obtain no significant ratings' effects for Ireland and Italy; an overall moderate effect for Spain, which has increased since 2007.08; and an overall zero effect for Portugal. For the core EMU countries ratings are not significant once the rest of the spreads' determinants have been accounted for. The only exception is Finland for which we obtain a very small, in size, overall negative sign.

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Table A2.1: Time series estimations – Sample 1999.01 – 2010.12

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
spr_{t-1}	0.594 ***	0.473 ***	0.380 ***	0.144	0.367 **	0.933 ***	0.500 ***	0.234 ***	0.648 ***	0.651***
vix_t			0.028 ***							
vix_t*$D2007.08_t$	0.0862 **	0.129 ***		0.012 ***	0.548 ***		0.236 ***		0.317 ***	0.134 **
vix_t*$D2009.03_t$				0.153 ***				0.147 ***	0.714 **	
$pc2_t$	-0.046 **	-0.027 *	-0.115 ***	-0.050 ***				-0.087 ***	-0.098 ***	-0.060 ***
$pc2_t$ *$D2007.08_t$	-0.112 ***	-0.116 ***		-0.068 ***		-0.146 ***	-0.088 ***	-0.042 ***		-0.147 ***
$pc2_t$ *$D2009.03_t$	0.151 ***	0.156 ***	0.062 ***	0.090 ***		0.287 ***	0.133 ***	0.096 ***	0.227***	0.217 ***
$pc2_t$ *$D2009.11_t$					0.556 **					
ba_t	-0.002 *									
ba_t *$D2007.08_t$	0.003 ***					0.005 ***	0.004 ***		0.035 **	
ba_t *$D2009.03_t$	0.006 *		0.001 *						-0.036 **	0.006 ***
q_t							-0.776 ***			
q_t*$D2007.08_t$	0.026 *	-0.765 ***				-2.501 ***	1.126 ***			0.990 ***
q_t *$D2009.03_t$			0.844 ***		0.498 ***	7.518 **		1.117 **		
q_t * $D2009.11_t$					3.873 **					
$balance_t$			-0.014 ***				-0.011 **			
$Balance_t$ *$D2007.08_t$					-0.744 ***			-0.020 ***	0.410 ***	0.054 **
$balance_t$ *$D2009.03_t$	-0.036 *	-0.220 ***	0.074 ***	-0.031 ***	0.471 ***	0.107 ***	-0.083 ***		-0.577 ***	
$debt_t$								0.003 ***		
$debt_t$ *$D2007.08_t$	0.092 ***	0.334 **			-0.107 ***		-0.015 *		17.768 ***	
$debt_t$ *$D2009.03_t$	-0.461***		0.212 ***					0.183 ***	-18.215 ***	0.141 ***
$debt_t$ *$D2009.11_t$					0.108***					
$debt_t^2$			3.32E-05 ***	-0.002 ***			-4.22E-05***	0.0001 ***		5.32E-05 ***
$debt_t^2$ *$D2007.08_t$		-0.009 **							-3.740 ***	
$debt_t^2$ *$D2009.03_t$	-0.031 ***	0.0004 ***	0.003 **	0.004 ***		0.0008 ***		0.007 ***	3.773 ***	0.004 ***
$ltsdebt_t$				0.501 ***	-3.452 **					
$ltsdebt_t$ *$D2007.08_t$						22.205 *	-5.914 ***	0.022 ***		
$ltsdebt_t$ *$D2009.03_t$				-0.572 ***		11.701 ***		-12.463 ***		
$ltsdebt_t^2$	-0.171***					-34.052 ***				
$ltsdebt_t^2$ *$D2007.08_t$			0.152 ***							
$ltsdebt_t^2$ *$D2009.03_t$	-1.295 ***		-0.243 **				0.338 ***	8.729 **	-5.433 **	
$ltsdebt_t^2$ *$D2009.11_t$					-13.121 *					
$gind_t$			0.002 ***		-0.004 *					
$gind_t$ *$D2007.08_t$									-0.029 ***	
$gind_t$ *$D2009.03_t$				-0.008 ***				-0.007***		
spr_{t-1}* ba_{it-1}	0.020 **	0.044 ***					0.021 ***			
spr_{t-1}* ba_{t-1}*$D2007.08_t$	-0.020 ***	-0.041 ***	0.003 ***		0.062 ***	-0.002 ***	-0.019***			-0.016 ***
spr_{t-1}* ba_{t-1}*$D2009.03_t$	-0.007 ***			0.007 ***	-0.071 ***			0.006 **		0.014 ***
spr_{t-1}* ba_{t-1}*$D2009.11_t$					0.008 *					
$aver.\ rating_t$			-0.053 ***		-0.173 ***				-0.137 ***	-0.048 ***
$aver.\ rating_t$*$D2007.08_t$			-0.009 ***						-1.110 ***	-0.299 ***
$aver.\ rating_t$*$D2009.03_t$									1.297 ***	0.084 ***
$aver.\ rating_t$*$D2009.11_t$					-0.966 ***					
$Adj\text{-}R^2$	0.98	0.97	0.98	0.97	0.99	0.99	0.99	0.98	0.99	0.99