Working papers

The determinants of government yield spreads in the euro area

L. Giordano, N. Linciano, P. Soccorso

71

October 2012

CONSOB
Commissione Nazionale
per le Società e la Borsa

Consob
00198 Rome
Via G.B. Martini, 3
t 06.8477.1
f 06.8477612
e studi_analisi@consob.it

Authorisation no. 432 of 4.7.1990 by the Court of Rome
(Managing Director Alberto Aghemo)

The determinants of government yield spreads in the euro area

*L. Giordano, N. Linciano, P. Soccorso**

Abstract

This paper analyses the determinants of sovereign spreads in the euro area from January 2002 to May 2012. The objective is to disentangle the role of country-specific fundamentals, driven by fiscal and macroeconomic factors, from what is referred to as contagion. Following the existing empirical literature, the work estimates a model of the determinants of 10-year yield spreads relative to Germany for ten euro zone countries. The results show that since the eruption of the 2007-2008 financial crisis, sovereign spreads have shown a time-dependent contagion component. On average, such a component explains almost one third of the spreads dynamic in 2009-2010 and almost 10 per cent since 2011. However, results at the country level are quite different between core and peripherals. As shown by the analysis, core countries (excluding Germany, which is our benchmark to measure spreads) were not affected by contagion till 2011; since the worsening of the sovereign debt crisis they seem to have benefited from a flight-to-quality effect. For example, in the first months of 2012, France shows spreads lower than what implied by fundamentals by an amount ranging from roughly 50 to 90 basis points, depending on the model specification, while for Netherlands such a "discount" can be as high as roughly 60 basis point. Peripheral countries, which at the onset of the European Monetary Union took advantage from a mispricing of their actual economic and fiscal fragility, since 2009 have suffered from the abrupt revision of market expectations, showing spreads on average significantly higher than what justified by macroeconomic and fiscal factors. In 2012, for most of these countries contagion has a role comparable to fundamentals in explaining the level of the spreads. For example, it accounts for an amount ranging from roughly 170 to 240 basis points for Spain, while for Italy – probably penalized by its historically highest debt to GDP ratio – contagion explains something between roughly 150 and 180 basis points of the spread, depending on the model specification.

JEL Classification: G12, E43, H63.

Keywords: government yield spreads, sovereign risk premia, government debt, financial crisis, sovereign debt crisis, contagion.

* Consob, Research Division. The authors wish to thank Giovanni Siciliano for helpful comments; of course they are liable for any error or inaccuracy.
The views expressed are those of the authors and do not necessarily reflect the opinions of Consob.

Contents

1 Introduction

This paper analyses the determinants of government yields in the euro area from January 2002 to May 2012. The aim is to disentangle the role of country-specific fundamentals, driven by fiscal and macroeconomic factors, from what is referred to as contagion.

Since the beginning of 2010, when irregularities in Greece's budget were disclosed, a relentless rise in the spreads against the German Bund occurred for Greece, Ireland and Portugal. Since July 2011, other non-core countries, such as Spain and Italy, have recorded a strong increase in bond yields, while core countries, such as Germany, have benefited from a flight-to-quality effect. Overall, as the crisis developed, the observed pattern of the spreads appeared to be more sensitive to changes in global conditions rather than to actual changes in the country-specific fiscal position.

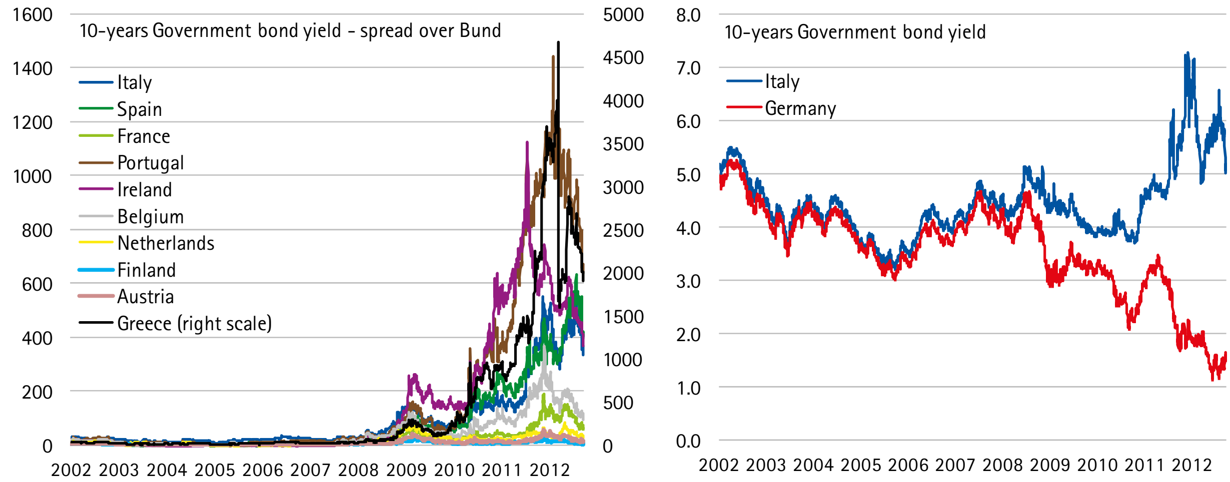
This paper brings evidence that supports this view. Following the existing empirical literature, the work estimates a model of the determinants of 10-year yield spreads relative to Germany for ten euro zone countries. The results show that since the eruption of the 2007-2008 financial crisis, sovereign spreads have shown a time-dependent contagion component. On average, such a component explains almost one third of the spreads dynamic in 2009-2010 and almost 10 per cent since 2011. However, results at the country level are quite different between core and peripherals. For core countries (excluding Germany, which is our benchmark to measure spreads) the analysis shows that model-predicted spreads are basically in line with fundamentals, though since the onset of the debt crisis some countries exhibit spreads lower than what predicted by fundamentals. For example, in the first months of 2012, France shows spreads lower than what implied by fundamentals by an amount ranging from roughly 50 to 90 basis points, depending on the model specification, while for Netherlands such a "discount" can be as high as roughly 60 basis point. On the other hand, since 2009, spreads of peripheral countries are on average significantly higher than what predicted by fundamentals due to a contagion effect; for most of these countries, contagion has a role comparable to fundamentals in explaining the level of the spreads in 2012. For example, contagion accounts for an amount ranging from roughly 170 to 240 basis points for Spain, while for Italy contagion explains something between roughly 150 and 180 basis points of the spread, depending on the model specification.

The work is organised as follows. The next section recalls some stylised facts of the sovereign debt crisis. Section 3 reviews the most recent empirical literature on the determinants of yields spread in the euro area. Section 4 presents the sample, the structural model and the estimation results. Conclusions are drawn in the last section.

2 The pattern of the sovereign risk premia since the introduction of the euro

Sovereign risk premia for eurozone countries have shown a strong convergence since the onset of the Monetary union till January 2010.[1] From then on, after the disclosure of the irregularities in Greek government budget accounting, Greek yields rose relentlessly followed by those of Ireland and Portugal. Since July 2011 other countries (namely Spain, Italy and for a more limited time Belgium) have experienced a marked increase in their spreads relative to Germany (Figure 1).

Figure 1 Ten year government bonds: yields and spreads relative to the German Bund for some euro area countries
(January 1, 2002 – September 14, 2012)



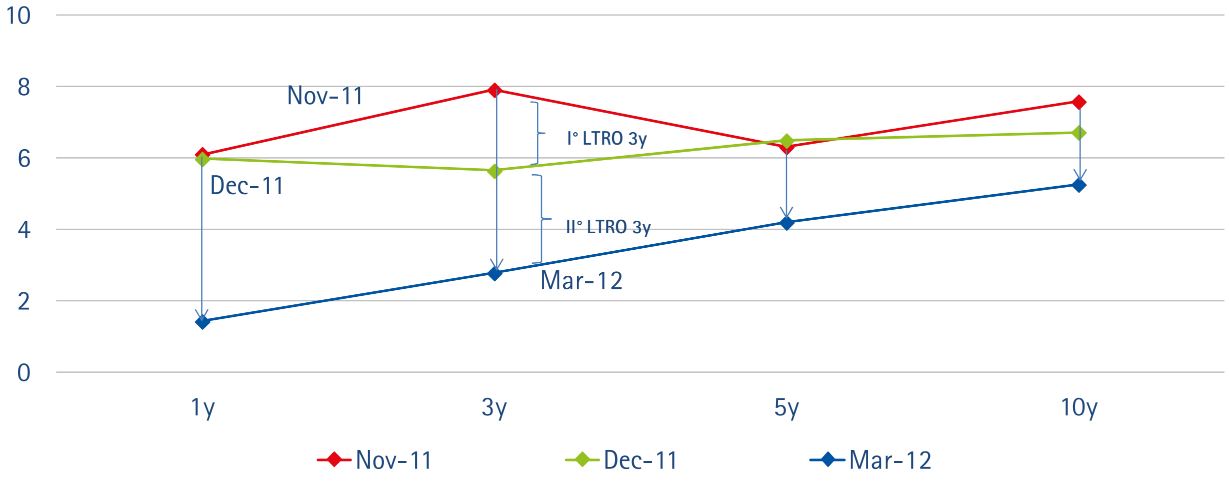
Source: authors' calculations based on Thomson Reuters data.

For the countries hit by the sovereign debt crisis the yield differentials relative to the German Bund declined in the first quarter of 2012, thanks to the successful private sector involvement in the Greek debt restructuring plan (which eased the fears of a disorderly default by Greece), the fiscal adjustment and structural reforms undertaken by some eurozone countries and the actions carried out by the EU leaders to improve fiscal discipline and to contain the crisis. Also the two long-term refinancing operations by the European Central Bank (ECB) – the first on December 26, 2011 for € 486 billion and the second on February 29, 2012 for € 530 billion – contributed to the decline in spreads. As for Italy, the government bond yield curve experienced a significant downward shift: in fact following the ECB operations, net purchases of Italian bonds by domestic banks are estimated to have reached about € 80 billion (Figure 2).

1 As documented by Pagano and Von Thadden (2004) , the mean yield spread of the initial EMU participants over the German yield drop from *"218 basis points in 1995 to 111 in 1996, 29 in 1997, 19 in 1998, and 20 in 1999"*. The downward trend resumed after 2002, following a slight rebound.

However renewed tensions started to hit high debt countries at the beginning of April 2012; the renewed uncertainties spurred by the new developments of the Greek crisis, the difficulties experienced by the Spanish banking sectors and the expectation of a negative growth rate for the euro area countries exacerbated the perception of the sovereign risk for the peripheral countries. Spain, as well as Italy, recorded new pressures in the government bond markets, while long term rates drop considerably in Germany, Netherlands and France.[2] Such pressures eased again in September 2012, following the approval by the ECB of the "outright open market operation plan", contemplating unlimited buying of member States' bonds to drive down their borrowing costs.

Figure 2 Yield curve of the Italian government bonds



Source: authors' calculations based on Ministry of Finance and Bank of Italy data.

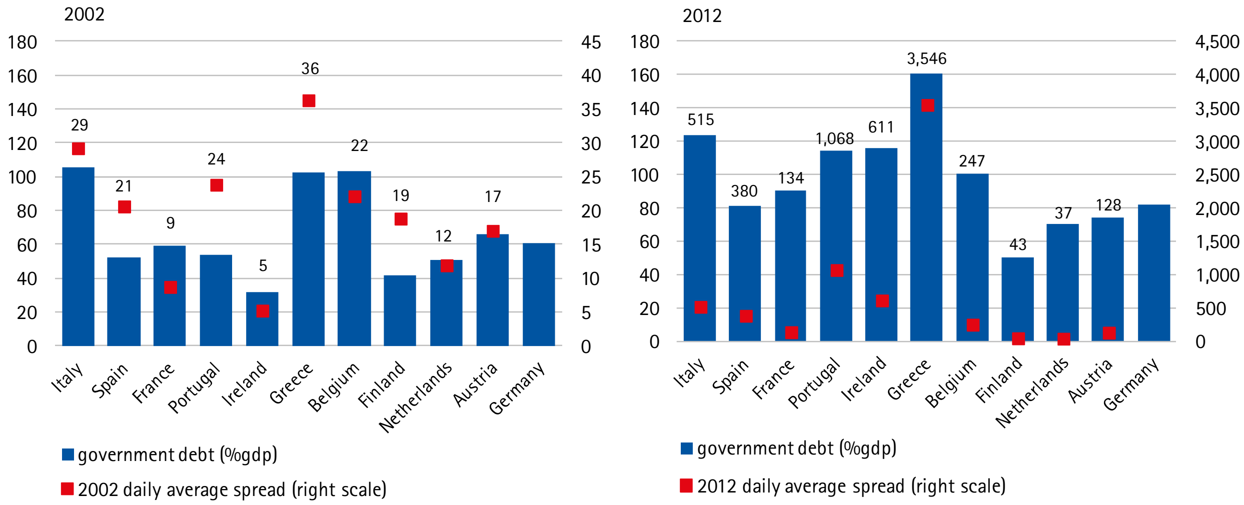
Given these stylized facts, many researchers and practitioners have recently wondered to what extent the dramatic movements in government bond spreads occurred in the euro area in the last years are due to fundamental factors (as proxied by the countries fiscal position and other macroeconomic indicators) or rather to a negative market sentiment (see next section for a review of the recent literature). To this end, it is useful to look at the relationship between the spreads and the countries specific default risk as proxied by the debt-to-GDP ratios, the deficit-to-GDP ratios and the fiscal space (i.e. debt-to-tax revenues ratio).

Figure 3 plots the yearly average spread and the end-of-period public debt to GDP for major euro area countries in 2002 (left panel) and in the first half of 2012 (right panel). In the time span considered all euro area countries, apart from Belgium, have experienced a sharp increase in the levels of government debt relative to their GDP. This resulted mainly from the 2008 financial crisis, and the consequent govern-

2 For the peripheral countries the increase in the spread relative to the German Bund was driven also by the decline of the yield of the German Bund itself (steadily lower than 2% since March 2012). Such decline reflected both a flight to quality effect and the investors' preferences for high rated government bonds allowing to lower the cost of refinancing operations with central counterparties and with the ECB.

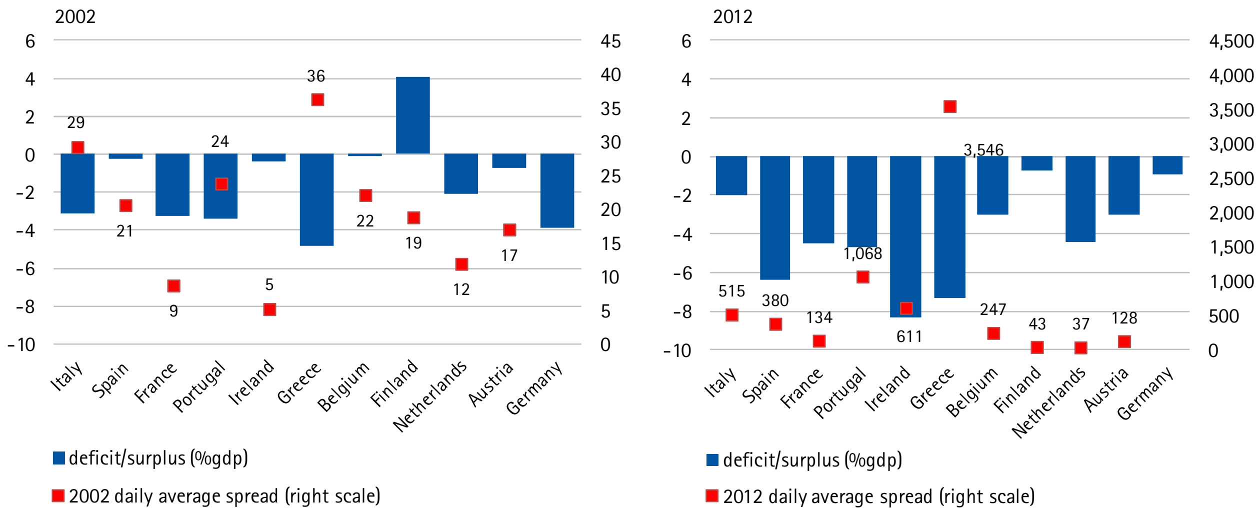
ment financed rescue plans of the banking system, and the recession following the financial crisis. Italy was less affected by the financial crisis and therefore recorded one of the lowest increase in the debt-to-GDP ratio (roughly 18 percentage points, followed by Austria and Finland, whose ratio went up by 9 and 8 percentage points respectively); Ireland, Greece and Portugal are at the lowest end of the ranking (with debt-to-GDP ratio increases by roughly 84, 58 and 60 percentage points, respectively); as for the remaining countries the less hit were the Netherlands (slightly more than 20) followed by Germany (almost 22), Spain (more than 28) and France (almost 32).

Figure 3 Ten year government bond yield spreads and public debt to GDP ratios for some euro area countries
(ten year government yield spreads are computed as averages of daily data; public debt to GDP ratios are end-of-period data; for 2012 the Spring economic forecast of the European Commission is considered)



Source: calculation on Thomson Reuters and European Commission.

Figure 4 Ten year government bond yield spreads and deficit to GDP ratios for some euro area countries
(ten year government yield spreads are computed as averages of daily data; deficit to GDP ratios are end-of-period data; for 2012 the Spring economic forecast of the European Commission is considered)

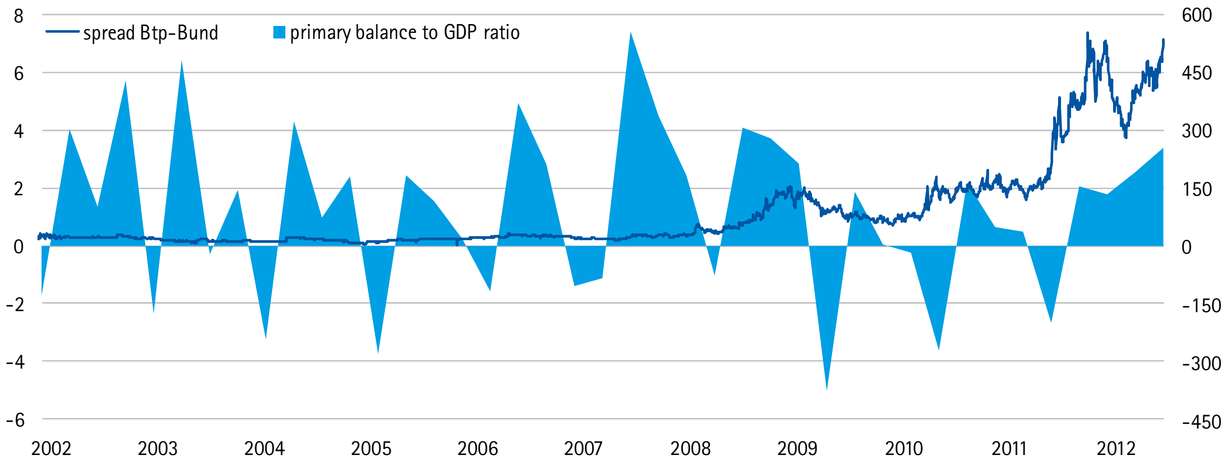


Source: calculation on Thomson Reuters and European Commission.

Another relevant indicator of fiscal fragility is the ratio of government deficit to GDP and Figure 4 shows this variable coupled with the yearly average spread at the end of 2002 (left panel) and in the first half of 2012 (right panel) for the 11 euro area countries considered. Apart from Italy and Germany, in 2012 all countries are expected to record a public deficit to GDP ratio higher than ten years before. In particular, Italy is expected to mark a deficit to GDP ratio equal to 2 percentage points (3,1% in 2002).

For Italy Figure 5 plots the evolution of the ratio of primary budget balance to GDP and of the sovereign bond spread.

Figure 5 Italy: ten year government bond yield spread and primary balance to GDP ratio
(January 1, 2002 – June 30, 2012; data on daily spread in percentage points – right scale; quarterly primary deficit to GDP ratio – left scale; the Spring forecast of the European Commission is considered for 2012 annual value of primary deficit to GDP ratio)

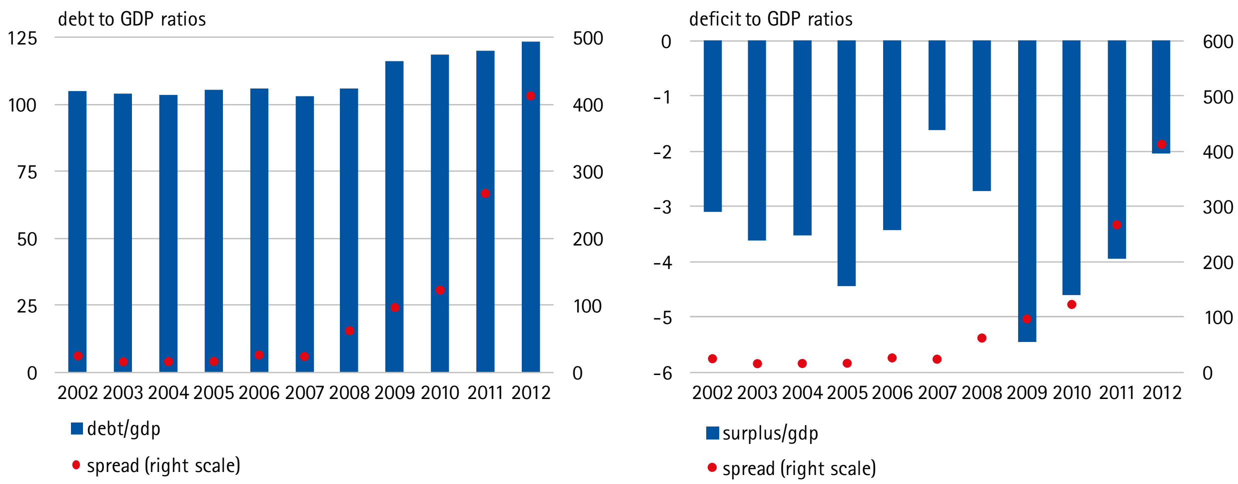


Source: Thomson Reuters, ECB and European Commission.

Since 2010 the spread of the Italian government bonds has shown a departure from the overall positive dynamics of the primary budget balance to GDP. In fact, Italy is penalized by the high stock of debt, which *ceteris paribus* requires larger primary surpluses to offset interest payments. On the other hand more virtuous euro area countries are able to run larger primary deficits or the same primary surpluses at a lesser cost. This clearly stems out from the comparison between fiscal position and spreads for Italy and France over the period January 2002 through June 2012 (Figures 6 and 7).

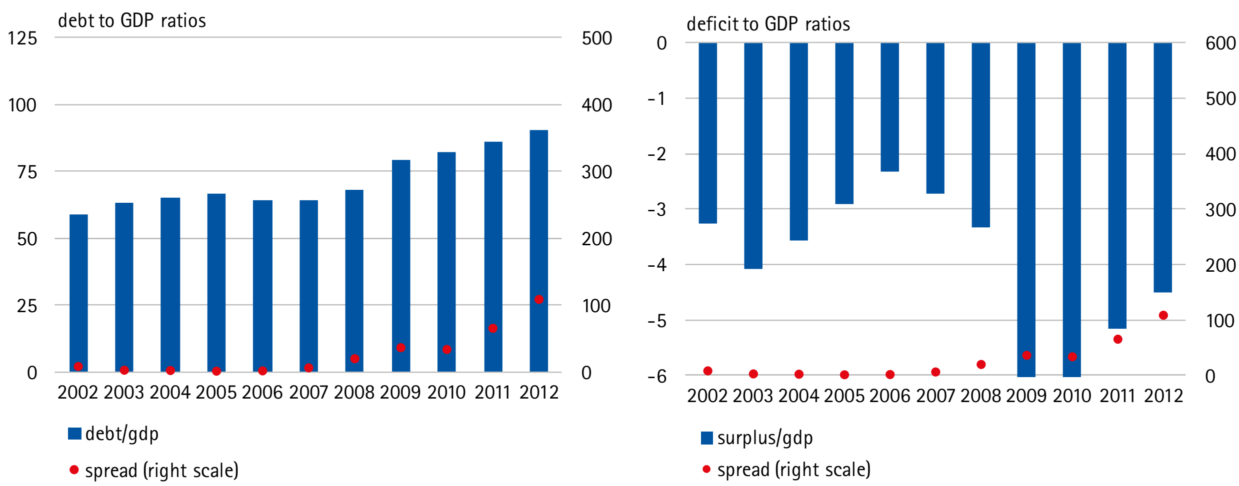
The inspection of Figure 6 allows to draw two considerations for Italy. First, especially since 2008, the relationship between debt-to-GDP ratio and the (average) sovereign spread shows a non-linear and convex pattern. This relationship, implying that as the debt rises the impact on the spread of a one percentage point increase in the debt-to-GDP ratio rises too, is an empirical regularity, which generally holds for high debt countries. Indeed, as the public debt goes up the likelihood of a default grows too, thus leading investors in government bonds to demand a proportionally higher risk premium. Second, since 2010 the surge in the spread seems to be disconnected from the dynamics of the fiscal fundamentals; to a lesser extent this holds also for France and other non-core countries (see also Appendix, Table A.1 and Figures A.1, A.2 and A.3).

Figure 6 Italy: Ten year government bond yield spreads and fiscal fundamentals
(ten year government yield spreads are computed as averages of daily data; public debt and deficit to GDP ratios are end-of-period data; for 2012 the Spring economic forecast of the European Commission is considered)



Source: Thomson Reuters and European Commission.

Figure 7 France: Ten year government bond yield spreads and fiscal fundamentals
(ten year government yield spreads are computed as averages of daily data; public debt and deficit to GDP ratios are end-of-period data; for 2012 the Spring economic forecast of the European Commission is considered)



Source: Thomson Reuters and European Commission.

Overall, for the majority of the high-debt countries, including Italy, fiscal fundamentals appear to have been underpriced in the period prior to the global financial crisis and overpriced during the crisis. Therefore the departures from the fiscal fundamentals look to be time dependent. At the onset of the EMU a positive market sentiment led to the convergence of government bond risk premia, which benefited high-debt countries; as the financial and the sovereign crises erupted a negative market sentiment on the resilience of the euro area favored the dispersion of the spreads, hitting more the high debt countries and favoring countries perceived as safer.

3 The determinants of government yield spreads: a review of the recent empirical evidence

A large empirical literature has studied the determinants of government bond spreads in the euro area since the beginning of EMU. Many of these studies estimate a reduced form model by regressing the sovereign spreads at certain maturities on a set of explanatory variables. These variables may be grouped into factors affecting the public debt sustainability, other macroeconomic factors, such as the external position of the economy, the liquidity of the sovereign bonds, international risk and global risk aversion indicators.

Public debt sustainability, which proxies sovereign default risk, is affected by fiscal variables, economic growth, inflation rates and interest rates. Rising budget deficit as well as a rising primary budget deficit are obvious indicators of increasing fiscal fragility. Also a high stock of debt weakens public finance sustainability, since it implies burdensome debt service payments and, consequently, a greater exposure to small changes in interest rates.[3] As deficit and debt grow, sovereign default risk rises too, thus prompting a surge in the risk premium demanded by the investors.

The empirical evidence for the euro area mostly confirms the role of fiscal fundamentals, although its significance varies across countries. As pointed out by earlier studies, at the onset of the EMU the ratio of debt-to-GDP turned out to be relevant for some of the eurozone countries (namely, Spain and Italy) and to affect bond yields according to a non-linear relationship, that is only if interacted with international risk indicators (Pagano and von Thadden, 2004).

The relevance of fiscal fundamentals seems to change not only across countries but also over time. Most recent studies analyzing the impact of the latest crises provide evidence in this sense. Schuknecht et al. (2010) confirm that during the 2008 financial crisis fiscal imbalances were penalized much more than before and that also general risk aversion played a crucial role. Also Favero and Missale (2012) find evidence that the long-run fluctuations in yield spreads of euro countries are related to fundamentals, but that such a relation is not constant over time. They estimate a global VAR model for ten EMU countries using as explanatory variables debt and def-

3 To this respect, it was pointed out that all the measures of fiscal fragility potentially suffer from an endogeneity problem, given that they are affected by changes in the bond yields. However, as long as the average maturity of the debt is not too short, the contemporaneous impact of movements in interest rates on either the deficit to GDP ratio or the debt to GDP ratio is rather low.

icit ratios as well as a global spread index standing for the interdependence among countries driven by the distance in their fiscal fundamentals. Their results show that contagion is very important and that in the case of Italy it accounts for about 200 basis points.

De Grauwe and Ji (2012) show that during 2010-11 a significant portion of the rise in the spreads of Portugal, Ireland, Greece and Spain was unrelated with the underlying fiscal fundamentals, being rather driven by the surge in negative market sentiment. Such sentiment did not acted with respect to stand-alone countries, i.e. countries that issue debt in their own currencies, in spite of their debt-to-GDP ratios and fiscal space variables equally high and increasing. According to the authors this phenomenon is mainly due to the perceived fragility of the euro-area, due to the fact that member countries issue debt in a currency they cannot control.[4]

The same evidence stems from the analysis of the premia on 5-year sovereign CDS by Aizenman et al. (2011): sovereign risk for the eurozone peripheral countries was underpriced relative to fiscal space variables and other economic fundamentals before the 2008 financial crisis and then substantially overpriced after 2008. As advocated by the authors, this pattern could signal either mispricing or the expectation of the deterioration of fiscal and macroeconomic fundamentals, raising sovereign risk premia.

According to more recent analyses by the IMF, the observed sovereign spreads with respect to Germany of countries more vulnerable to market tensions are well above what could be explained by fiscal and other long-term fundamentals (IMF, 2012). For Italy and Spain, in the first half of 2012 the estimated values of the spreads are around 200 basis points.

Along the same lines, a recent study by Di Cesare et al. (2012) suggests that after the financial crisis the spread of several euro countries has increased to levels that are well above those that could be justified on the basis of fiscal and macroeconomic fundamentals. Among the possible reasons for this finding, the analysis focuses on the perceived risk of a break-up of the euro area.

All the mentioned studies assume that the coefficients of the relationship between fiscal fundamentals and spreads are time invariant till a discrete structural break occurs. Bernoth and Erdogan (2010) depart from this hypothesis and use a time varying coefficient model to capture the gradual shift of such relationship affecting 10 EMU countries between 1999 and 2010. According to their results, the government debt level along with the global investors' risk aversion were relevant at the onset of EMU and declined in the subsequent years; however two years before the default of Lehman Brothers fiscal position started to matter again, reaching its highest impact during the turmoil period.

4 In other words for eurozone countries there is no guarantee that the central bank would step in to pay bondholders were they in a liquidity crisis.

Attinasi et al. (2009) and Gerlach et al. (2010) identify the events that contributed to the re-pricing of the sovereign risk for some euro area countries since the eruption of the 2008 financial crisis. Attinasi et al. (2009) focus on the announcements of bank rescue packages in 2007 and 2008 and find that they accounted for 9% of the daily changes in sovereign bond spreads, versus a 56% and a 21% due, respectively, to the rise in the international risk aversion and the expected fiscal position. Gerlach et al. (2010) also bring evidence showing that a high level of systemic risk may lead to an upward re-assessment of sovereign risk premia. The authors test whether the size of the domestic banking sector affects sovereign spreads along with macroeconomic fundamentals and global risk. A higher aggregate risk may make banks and, consequently, public budgets more vulnerable to financial crises. The results show that the overall effect of the banking sector on sovereign spreads is significant and rises when the aggregate risk factor is high; this effect can reverse in tranquil periods.

Alessandrini et al. (2012) show that a structural break occurred in 2010 leading to an upward re-assessment of the default risk of high debt countries. Moreover, they show that not also fiscal variables but also differentials in wage and labor productivity growth played a role: according to their results, poor fundamentals may fuel a debt problem independently from a country fiscal responsibility.

As recalled above, besides fiscal fundamentals, the overall state of the economy is of crucial importance in determining the country's ability to meet its payment obligation. In principle, a rising debt is not a problem as long as the economy grows at a faster pace than its public debt. To this respect the empirical evidence is mixed; however most recent studies confirm the relevance of the negative impact of economic growth on spreads (Alessandrini et al., 2012; De Grauwe and Ji, 2012).

The role of the external sector has also being investigated by several analyses. Both current account balance, that is exports minus imports, and real effective exchange rate are found to be significant (Alessandrini et al., 2012; De Grauwe and Ji, 2012; Maltriz 2012). Current account balance is expected to affect negatively government bond yields, being an indicator of competitiveness and of a country's ability to raise funds for debt servicing; therefore as it improves, the sovereign spreads should decline. Vice versa, as pointed out by De Grauwe and Ji (2012), current account deficits signal an increase in net foreign debt which either directly (if spurred by public overspending) or indirectly (if due to private sector's overspending) undermine government's ability to meet its payment obligations.

According to Maltriz (2012) the relationship between spreads and current account balance may also have a positive sign. A positive current account surplus, which for the balance of payment identity is coupled with net capital outflows, might in fact signal either the inability of a country to borrow from abroad or a capital flight. In both cases, sovereign spread should rise. Such a relationship would reflect short-term liquidity issues, while the negative sign of the current account recalled above would be related to long-term solvency arguments.

Also the movements in the real effective exchange rate, accounting for price level differences between trading patterns, provide an indication of the evolution of a country's competitiveness. By construction, if this rate increases, the external position of an economy deteriorates, since its residents pay relatively more for their imports and raise relatively less from their exports, thus signaling possible future current account deficits. Therefore an appreciation of the real effective exchange rate is likely to lead to an increase in the sovereign risk premium demanded by the investors.

Sovereign yield spreads may also be influenced by the liquidity risk, that is the risk of having to sell or buy the asset in an illiquid market, at an unfair price and therefore bearing high transaction costs. The liquidity risk is usually measured either through bid-ask spreads or the size of the sovereign bond markets. The evidence brought by the empirical literature so far is controversial.

Beber et al. (2009), who use intraday European bond quotes from April 2003 to December 2004, show that in times of market stress investors chase liquidity more than credit quality.[5] Along the same lines Haugh et al. (2009) find that liquidity made a large contribution to the yields of Irish and Finnish government bonds in late 2008 and early 2009. Also Favero and Missale (2012) show that for Finland the liquidity premium has risen during the global crisis determining a positive co-movement between Finnish spreads and those of the other member countries. On the contrary, Bernoth and Erdogan (2010) find that liquidity premia never play a significant role: according to the authors this evidence is explained by the fact that after entering into EMU the debt has risen substantially for all member countries, thus making liquidity differences across government bonds irrelevant.[6]

Besides the mentioned country specific variables, there is strong evidence showing that spreads are driven by a common international factor (Favero et al., 2003). Such relationship is usually captured though a proxy such as the spread between the yields of US corporate bonds and the yields of US Treasuries (Favero et al., 2004; Attinasi et al., 2009; Bernoth and Erdogan, 2010; Gerlach et al. 2010; Schuknecht et al. 2010; Favero and Missale, 2012; Maltriz, 2012)[7] or as a composite index of several measures of risk (Alessandrini et al., 2012). As pointed out by Borgy et al. (2011), principal component analysis regularly reveals that the first principal component (usually interpreted as time-varying risk aversion of international investors) accounts for more than 80% in the total variation of spreads.

5 Pagano and Von Thadden (2004) point out that liquidity may interact with default risk differently depending on whether one considers current or future liquidity. High current transaction costs should reduce the impact of a rise in fundamental risk: ceteris paribus the lower the liquidity, the lower the initial return net of transaction costs and hence the lower the impact of an increase in the sovereign credit risk. Vice versa in case of future transaction costs, resulting for instance from a liquidity shock which is anticipated to hit a country, illiquidity amplifies the effect of a rise in credit risk.

6 Moreover, as recalled by Pagano and von Thadden (2004), the emergence of pan-European trading platforms after the EMU has spurred the integration and improved the liquidity of secondary government bond markets.

7 Pagano and von Thadden (2004) recall that the appropriateness of such a measure as a proxy of the global risk factor is supported by empirical evidence showing significant spillovers between the volatilities of the return series of the European and the US bonds.

4 Estimation and results

4.1 The model

This section introduces the empirical models used to estimate the determinants of sovereign bond yields in the euro area over the period from January 2002 to May 2012. The analysis refers to the monthly 10-year spreads relative to Germany for the following ten countries: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain.

First of all we estimate a simple reduced form model regressing spreads on the country's fiscal position, economic growth and external sector position as well as on a global risk aversion indicator according to the following specification:

$$Spread_{it} = \alpha + \beta_1 FS_{it} + \beta_2 FS_{it}^2 + \beta_3 Gr_{it-1} + \beta_4 IP_{it} + \beta_5 CA_{it-2} + \beta_6 REE_{it-1} + \beta_7 Liq_{it} + \beta_8 GRA_t + u_{it} \quad (1.a)$$

In (1.a) FS_{it} stands for *Fiscal space* (defined as the ratio between sovereign debt and tax revenues) of country i at time t; this variable enters both in level and quadratic terms (on this point more details are given below). Gr_{it} refers to the GDP growth rate while IP_{it} denotes industrial production of country i at time t: both variables account for the *economic activity*. Also *external competitiveness* variables are included, that is CA_{it-2}, standing for the current account balance relative to GDP, and REE_{it-1}, the real effective exchange rate. Liq_{it} refers to the share of country i public debt over the total debt outstanding in the euro area at time t. Finally, GRA_t (*Global risk aversion*) is an indicator of international risk. An alternative specification to (1.a) replaces the fiscal space with the debt to GDP ratio ($Debt_{it}$) as follows:

$$Spread_{it} = \alpha + \beta_1 Debt_{it} + \beta_2 Debt_{it}^2 + \beta_3 Gr_{it-1} + \beta_4 IP_{it} + \beta_5 CA_{it-2} + \beta_6 REE_{it-1} + \beta_7 Liq_{it} + \beta_8 GRA_t + u_{it} \quad (1.b)$$

For the sake of brevity and clarity we will refer to (1.a) and (1.b) also as the *Basic models*.

We neglect other variables, such as the inflation rate and the short term interest rate, which according to some empirical contributions may be relevant (Alessandrini et al., 2012), because they were never statistically significant; we also tested the relevance of the primary deficit/surplus over GDP and of the budget balance over GDP but they were never significant. Moreover, following De Grauwe and Ji (2012), we do not add sovereign ratings or other measures of systemic risk (such as the first component of the CDS of euro area countries or similar) because they might introduce an endogeneity bias, given that they tend to react to changes in government bonds yields.

Before going through the estimation of the model, we addressed the empirical issues raised by two features of the data set used: the first is the presence of seasonal cycles in the macro data; the second is the discrepancy between the frequency of the dependent variable and the frequency of the explanatory variables.

Cyclical fluctuations characterize many monthly or quarterly time series. If not removed, such fluctuations may hinder the understanding of the underlying trends; this problem is easily overcome by using adequate seasonal adjustment tools.

In the present work we applied a moving average (MA) filter to smooth both fiscal data (namely *tax revenues*, which is the numerator of the *fiscal space variable* FS), whose time series exhibit the typical step-shape due to the cyclicality in public finance data, and economic activity data (e.g. GDP growth, industrial production index and current account data), which are affected by external seasonality conditions, holydays etc..

The MA smoothing allowed us also to extract observations with a higher time variability from the aggregated observations of the low moving variables (for example, monthly values from the quarterly data of the GDP growth rate). This helped to address the biases that may have resulted from the combination of the daily data of the government bond spreads with the quarterly data of the fiscal and macroeconomic variables. In empirical work this combination is usually accomplished by lowering the frequency of the variables with higher moving periodicity through aggregation, and by keeping the low frequency variables constant until a new observation occurs. However, on statistical grounds this is equivalent to introduce a measurement problem, which may bias the estimated coefficients of the explanatory variables towards zero (Gerlach et al., 2010). Hence we preferred to extract monthly observations from the quarterly observed information through the application of the MA smoothing. This in turn allowed to limit the extent of the aggregation of the daily data on the spreads (to the monthly rather than to the quarterly frequency) and to have all the variables in the model at a monthly frequency.

Finally, the MA smoothing also helped us to collapse together in every single observation the values at time t, one or more lagged values and one or more leading values recorded at some future dates, depending on the width of the time-window which was appropriately chosen on a case-by-case basis[8]. In this way we averaged across the different values which may have been relevant for the investors at time t.[9] In other words, the spread at time t may have reacted to the GDP growth recorded in t, to its past values to the extent in which past realizations of the GDP growth affect the country credit risk with a delay (on this point more below) and to the expected value of the GDP growth, proxied by the values observed after t .

8 For example we apply a MA (2,1,2) filter to the *industrial production* variable (IP_{it}). As we chose a symmetric time-window we put equal weight on past and future values.

9 High frequency financial data (such as the bond yields) reflect the investors' reaction to an information set which may differ from the one available to the researchers, commonly using revised macro data. However macro data are subject to revisions, which are made available to the public with a lag. Therefore the market can still react in t to the release of the information referring to past periods if it differs significantly from its forecast value. Especially during turbulent periods, revisions may be substantial.

The models specified above regress the spread at time *t* on a set of variables observed either at *t*, *t-1* or *t-2*. In fact, it may take some time before the change in a macro variable impacts the sovereign default risk, depending on the features of the transmission mechanism in place. For example, a current fall of the GDP growth rate will lower tax revenues in the future, which in turn will result into a future deterioration of a country solvency. The same line of reasoning holds for the degree of competitiveness, as captured by the current account balance and the real effective exchange rate, affecting both the GDP growth (and hence tax revenues and country solvency) and the ability of a country to raise external funds to meet its payment obligations.

The estimation results are robust with respect to the choice of different lags, as confirmed by the fact that they remain qualitatively the same using lags different from those applied in (1.a) and (1.b) (more details in Section 4.2).

Let us now turn to a deeper analysis of the variables included in (1.a) and (1.b) and of their expected sign (see also the Appendix for details on the definition, the source and the frequency of the variables).

Fiscal position. As re-called in the previous section, the role of the variables accounting for a country fiscal position have long been investigated in the literature. In particular, we followed Aizenman et al. (2012) and De Grauwe and Ji (2012), who advocate that fiscal space, defined as the ratio of debt-to-total tax revenues, is a better measure of debt sustainability because it takes into account the government ability to raise taxes: in fact a low-debt country can face as many difficulties as a high-debt country if it takes a lot of time to generate the revenues necessary to meet its payment obligation.[10] Therefore, in this study fiscal space (FS) and debt-to-GDP ($Debt$) were used as alternative measures of a country fiscal fragility. Moreover, following the literature and given the evidence substantiated by the descriptive analysis reported in section 2, these variables are included both in levels and quadratic terms to account for a non-linear relationship. As recalled by the Grauwe and Ji (2012), theoretical studies model the default decision as a discontinuous one, becoming more and more likely as the debt to GDP ratio rises. This in turn implies that the higher the debt-to-GDP ratio, the more sensitive the investors are to a given increase in the ratio itself.

Economic activity. Following the literature, we included variables capturing the overall state of the economy such as GDP growth rate (Gr), lagged by one period, and the industrial production index (IP). Both these variables are expected to contribute negatively to the spread, given that the higher they are the better the country's fiscal position. We use the industrial production index because it is a leading indicator and as such plays an important role in the formation of investors' expectation. Indeed, it

10 As pointed out by Borgy et al. (2011), the choice of the most appropriate measure of the fiscal fundamentals is a matter of debate. For instance, Bernoth et al. (2006) argue that debt service (i.e. the ratio of gross interest payments to current government revenue) is preferable since governments have less incentives to manipulate it than other indicators that are used officially to monitor the individual country's fiscal position.

is released at a higher frequency than the GDP growth rate and, as a contributor to economy's growth, is regarded as an early indicator of the state of the economy.[11]

External competitiveness. Following the literature we included both the current account balance relative to GDP (CA) and the real effective exchange rate (REE). We included the lagged values of such variables under the hypothesis that, as mentioned above, their impact on the spread may exhibit a certain sluggishness.

Liquidity. As a measure of the market liquidity of government bonds (Liq) we use countries' debt relative to the overall debt of all EMU countries in order to take into account the countries' market size with respect to the whole euro area. For lack of data, we did not use the bid-ask spread; however our measure is quite used in the empirical literature, which also shows that it is highly related to other liquidity proxies (see Maltriz, 2011, for a deeper discussion of this issue). The expected sign of the impact of liquidity on spreads is negative: the deeper the secondary markets of government bonds, the lower the liquidity premium priced into sovereign spreads.

Global risk aversion. As already recalled in the previous section, sovereign bond spreads are driven not only by country specific factors but also by a time-varying international risk factor (GRA), which in turn affect international risk appetite. Following the literature, in our analysis we capture such a factor with the spread between the yield on AAA and BBB US corporate bonds. A widening of this spread signals shifts in investors' preferences from the riskier to the safer private sector assets. We also run the model with alternative international risk indicators, such as the VIX, obtaining results similar to those reported in Table 1 (see section 4.2).

We also expanded the *Basic model* in order to account for time dependency and for country fixed effects. As showed by the descriptive analysis in section 2 and as documented by the most recent empirical contributions recalled in section 3, both the convergence of sovereign spreads recorded since the onset of the EMU and the dispersion arisen after the eruption of the Greek crisis signal a mispricing of the fundamental fiscal factors. Till 2010 the market was not much worried about the vulnerabilities of high debt countries. Since the beginning of 2010, however, the market has been over-reacting to the fiscal position factors by penalizing especially the non-core member countries. To account for a possible mispricing of the fundamental fiscal factors, we included yearly time dummies in (1.a) and in (1.b). Moreover, in order to capture non linearities in the contribution of the debt to GDP ratio driven by the evolution of the global conditions, we combined the debt-to-GDP ratio with the global risk aversion by using an interacted variable since mid-2011 onwards. In this way we tested whether changes in the perception of the countries' default risk and hence of their fiscal fundamentals can be traced back also to the evolution of international risk factors, thus introducing another source of non-linearity in the relationship between fiscal variables and spreads. Finally, we also added country dummies, in order

11 However we also tested the industrial production significance in t-1 and the results were basically unchanged with respect to those reported in Table 1 (see section 4.2).

to capture country fixed effects due to institutional and structural features which are time invariant and may impact the spread:

$$Spread_{it} = \alpha + \beta_1 FS_{it} + \beta_2 FS_{it}^2 + \beta_3 Gr_{it-1} + \beta_4 IP_{it} + \beta_5 CA_{it-2} + \beta_6 REE_{it-1} + \beta_7 Liq_{it} + \beta_8 GRA_t + \beta_8 Debt_{it} * GRA_t * D_{post\ July\ 2011} + \sum_{t=1}^{10} \mu_t D_t + \sum_{i=1}^{10} \delta_i Z_i + u_{it} \qquad (2.a)$$

where D_t stands for a vector of unit quarter time dummies, covering the interval from 2003 to the first semester of 2012 and Z_i stands for the dummy for country i; the term $Debt_{it} * GRA_t * D_{post\ 2011}$ is the interacted variable between the debt-to-GDP ratio and the global risk aversion indicator from the second semester of 2011 onwards. We will refer to (2) as the *Time dependent model*. As the *Basic model*, also (2) was run by using two alternative measures of the country's fiscal position, that is the fiscal space variable (model 2.a) and the debt-to-GDP ratio (model 2.b; this latter does not include the debt-risk aversion interacted variable to prevent collinearity problems).

Finally, we took into consideration a well known salient feature of most economic time series, that is the inertia (or sluggishness) which may make consecutive observations interdependent. Time series data on government yield spreads exhibit trend. Therefore, we performed a variety of test for unit roots (or stationary) in panel datasets which confirmed that the government yield spreads variable has a unit root (see Appendix, Table A.3). In order to prevent the misspecification problems due to the omission of the lagged value of the dependent variable in the model we use the feasible generalized least square estimator (FGLS) accounting for the presence of AR(1) autocorrelation within panels.[12]

4.2 The estimation results

This section presents the estimation results (Table 1). The variables accounting for countries' fiscal position, that is the debt-to-GDP ratio ($Debt$) and the fiscal space (FS), are statistically significant in all specifications. Moreover the non-linear relationship between these factors and the spread is confirmed.

Consistently with the previous studies, the variables proxing countries' economic activity, GDP growth (Gr) and industrial production (IP), have always a significant and negative effect.

12 Autocorrelation makes the OLS estimator inefficient. Therefore, inference based on the OLS estimates is biased. Depending on the underlying process, however, GLS and FGLS estimators can be devised that circumvent these problems (Greene, 2012). In GLS we incorporate any additional information we have (e.g., the nature of the autocorrelation) directly into the estimating procedure by transforming the variables, whereas in OLS such side information is not directly taken into consideration. The formal proof that GLS parameters are best linear unbiased estimator can be found in Kmenta (1971).

Table 1 Estimation results

variables	basic model (1)		time dependent model (2)	
	1.a (using fiscal space)	1.b (using debt ratio)	2.a (using fiscal space)	2.b (using debt ratio)
fiscal space	0.0453		-0.4561 (***)	
fiscal space squared	0.0138 (*)		0.0563 (***)	
debt/GDP		-0.0212 (*)		-0.0300 (**)
debt/GDP squared		0.0345 (***)		0.0551 (***)
GDP growth (in t-1)	-0.1952 (**)	-0.2543 (***)	-0.2423 (***)	-0.3377 (***)
industrial production	-0.0068 (**)	-0.0071 (***)	-0.1059 (***)	-0.0082 (***)
current account (in t-2)	-0.0391 (**)	-0.0381 (**)	0.0077	0.00846
real effective exchange rate (in t-1)	0.0206 (**)	0.0224 (**)	0.0121	0.0139
liquidity (debt share)	-0.0457 (**)	-0.0679 (***)	-0.0539	-0.1967 (**)
GRA	0.1373 (***)	0.1516 (***)	0.0929 (*)	0.1573 (***)
debt*GRA post July 2011			0.9457 (***)	
time component				
2003			-0.0000	0.0004
2004			0.0002	0.0012
2005			0.0010	0.0027 (**)
2006			0.0016	0.0034 (**)
2007			0.0021	0.0040 (***)
2008			0.0033 (**)	0.0056 (***)
2009			0.0060 (***)	0.0076 (***)
2010			0.0092 (***)	0.0100 (***)
2011			0.0108 (***)	0.0106 (***)
2012			0.0115 (***)	0.0119 (***)
constant	-0.0098	-0.0059	0.0060	0.0139
country fixed effect			controlled	controlled

Note: fiscal space, GDP growth, industrial production and current account balance were seasonally adjusted through a moving average (MA) filter; the length of the moving window was appropriately chosen depending on the time series. Such smoothing allowed to obtain monthly estimated values for the variables, which were used in the estimation.
(***) significant at 1% (p<0.01), (**) significant at 5% (p<0.05), (*) significant at 10% (p<0.1).

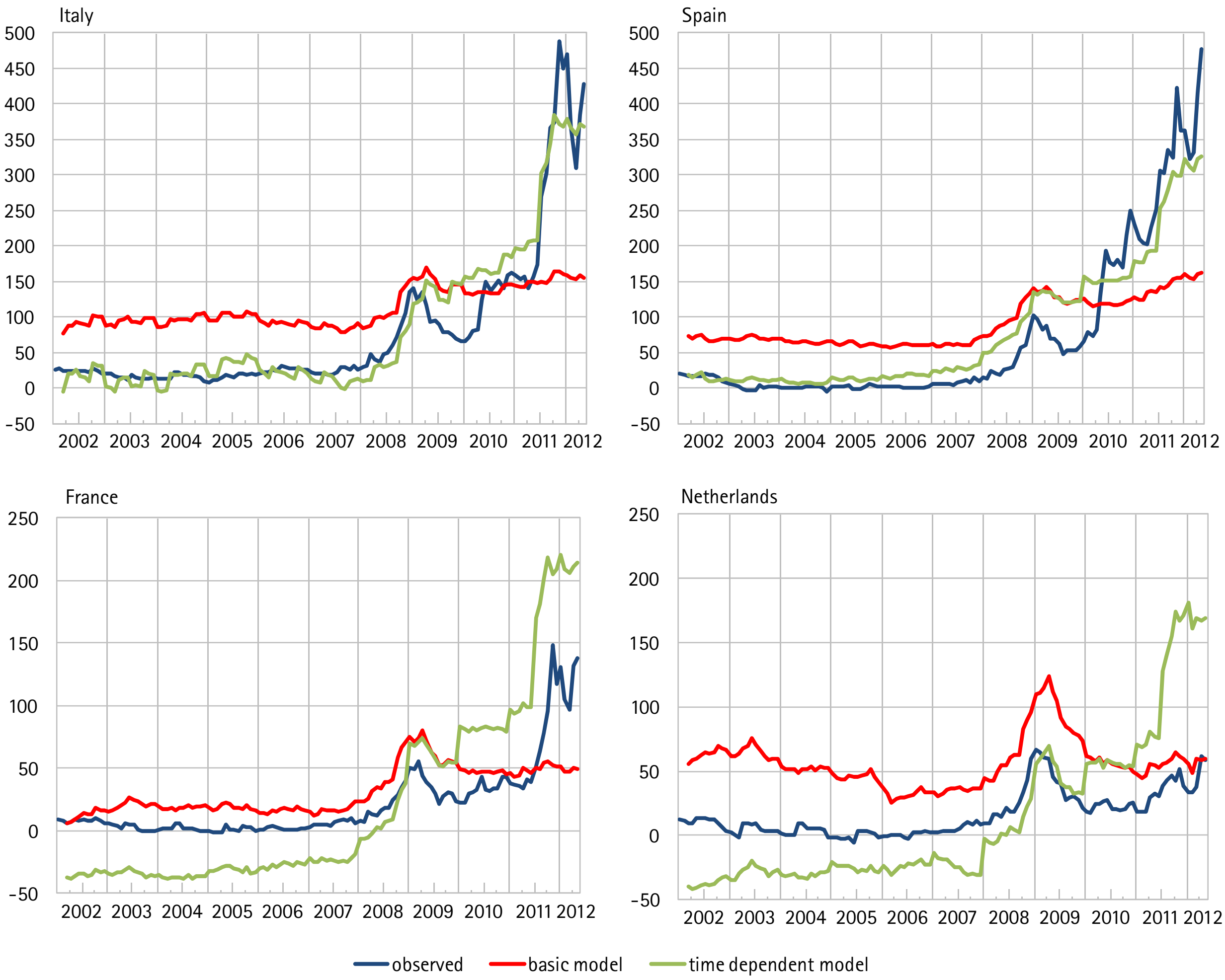
Also the variables accounting for the external position of a country, that is the current account balance (CA) and the real effective exchange rate (REE), are significant. However these variables lose significance when time dependency is accounted for (i.e. in the *Time dependent model* 2.a and 2.b).

Government bond liquidity (Liq), as proxied by each country debt market share over the debt of all the EMU members, is almost always estimated to be important. It gains significance in the *Time dependent model* (2.b), thus confirming existing empirical evidence claiming that during turbulent periods investors value more liquidity.

Finally, as expected, the time dummies are strongly significant in the aftermath of the 2008 financial crisis, that is when the sovereign debt crisis involved countries perceived as safe till then (Spain, Italy and Belgium). Moreover, the inclusion of the time dummies make the fiscal variables to gain statistical and economic significance. This supports the hypothesis that the investors' valuation of a country's fiscal position is time varying, that is dependent on the level of the international risk (GRA), which is significant in all specifications. Along the same line of argument we can interpret the significance in the specification (2.a) of the debt-risk aversion interacted variable ($Debt * GRA * D_{post\ July\ 2011}$), which turns out to be relevant.

Figure 8 plots the observed spreads and the fitted spreads resulting from the *Basic Model* 1.a and the *Time dependent model* 2.a for Italy, Spain, France and Netherlands (the fitted values look similar when using other specifications, that is 1.b and 2.b; for the other countries see the Appendix, Figure A.4).

Figure 8 Actual and fitted values of sovereign spreads for Italy, Spain, France and Netherlands
(values in basis point)



For Italy and Spain, the *Basic model* predicts that their sovereign risk should have been priced more till 2010 and much less from then on. This brings evidence supporting the hypothesis that investors demanded a premium which, relative to the economic and financial fundamentals, was too low till the financial crisis and too high after 2010. Thenceforth, a relevant fraction of the relentless increase in both the Italian and Spanish spreads is explained by the contagion phenomenon: the *Time dependent model*, accounting for the impact of negative market sentiment, tracks quite closely the pattern of observed spreads.

In order to disentangle the role of country-specific contagion effects from fundamentals factors we estimate the share of predicted spreads due to each components (macroeconomic and fiscal variables *versus* contagion) without assuming that contagion is equal to the difference between observed and fitted spreads (i.e.: residuals), but rather implementing specific econometric tools (margins and marginal effects) that investigate how much of total predicted spreads can be accounted for by each components included in the model.

The calculation of margins of responses and derivatives of responses (marginal effects) allowed us to obtain the percentage share of average annual variation of spreads due to contagion for all euro area countries (so called *systemic contagion*) and the amount of spread that for each single country is solely ascribed to contagion (so called *idiosyncratic contagion*).

Margins are statistics calculated from predictions of a previously fitted model at fixed values of some covariates and averaging or otherwise integrating over the remaining covariates (Searle et al., 1980). In our model the covariates are the time dummies which incorporate the effects of contagion. For instance, after a regression fit on time t and $t+1$, the marginal mean for time t is the predicted mean of dependent variable ($Spread_{it}$) where every observation is treated as if it were observed at time t.[13]

In other words, margins of responses give us the magnitude of the contagion effect within the sample, that is the percentage share of the annual variation of the spreads due to time-varying market sentiment (*systemic contagion*), keeping constant all other economic fundamentals.

Table 2 shows for the selected two models previously estimated (*Time dependent models* 2.a and 2.b) the percentage share of total annual variation of observed spreads which can be ascribed to systemic contagion, that is the annual movement of spreads solely due to the impulse transmitted by time dummies. As already mentioned these contagion effects were computed following Searle et al. (1980).

13 Standard errors are obtained by the delta method which assumes that the values at which the covariates are evaluated to obtain the marginal responses are fixed.

Both models confirm that systemic contagion reached its peak during 2009-2010, in the aftermath of the subprime crisis, when it explains almost one third and almost one fourth of the increase in the spreads. According to specification (2.a), almost 36% of the increase in spreads during 2009 was due to contagion, which was occurring as a consequence of the financial turmoil, rather than to the deterioration of the credit risk or the solvency risk of single countries.

Coefficients for time determinants increase rapidly during the financial crises and seem to flatten in the last two years of the estimation period. However, according to model (2.b) the impact of systemic contagion rebounds in the first semester of 2012 (accounting for a 9.09% increase against the 3.6% in 2011).[14]

Table 2 Percentage share of annual spreads' variation due to systemic contagion

	Time dependent model (2.a) Margins of Responses (ΔS)	Time dependent model (2.b) Margins of Responses (ΔS)
2007	--	9.63%
2008	19.13%	19.96%
2009	35.57%	21.11%
2010	31.57%	22.03%
2011	11.56%	3.62%
2012	4.05%	9.09%

In order to obtain a country specific measure of contagion (*idiosyncratic contagion*), we calculate the derivatives of the responses (marginal effects), which are an informative way of summarizing fitted results.[15]

To compute these marginal effects (*idiosyncratic contagion*) we include nine multiplicative time-country dummies in our models (Italy, Spain, France, Portugal, Ireland, Greece, Finland, Netherlands, Austria)[16] and obtain nine specific country

14 Note also that we have only 5 monthly observations for 2012 (January-May 2012).

15 The change in a response for a change in the covariate is not equal to the parameters estimated; one should take into account interactions between country and time specific covariates (country dummies*time dummies). In order to overcome this complications we need to run the fitted model and then compute the partial derivatives and make inference on these (Buis, 2010; Baum, 2010). Consider a very simple model, such as

$$y = \beta_0 + \beta_1 x + \beta_2 d_{time} + \beta_3 d_{country} + \beta_4 (d_{time} * d_{country}) + \varepsilon$$

The partial derivative in d_{time} is

$$dy/d(time) = \beta_2 + \beta_4 d_{country}$$

that is the sum of two components, a time effect which is common to all sample (β_2) and a time effect that changes by country (β_4) and represents the specific country response to the time fluctuations (in other words, how severe is the impact of financial contagion to one country compared with others responses).

16 Belgium is the country omitted.

coefficients for each year, representing the specific country's response to the time effects (Tables 3 and 4).[17]

Marginal effects measure to what extent spreads are greater or lower than the fitted values predicted by the model on the basis of the economic and fiscal factors only.

Table 3 Idiosyncratic contagion effects – *Fiscal space model (2.a)*

	Italy	Spain	France	Portugal	Ireland	Greece	Finland	Netherlands	Austria
2007	65 (**)	0.00	0.00	0.00	0.00	-59 (**)	0.00	0.00	0.00
2008	86 (***)	0.00	0.00	0.00	0.00	-48 (*)	0.00	0.00	0.00
2009	80 (*)	0.00	0.00	0.00	124 (***)	-74 (**)	0.00	0.00	53 (*)
2010	113 (**)	110 (***)	0.00	168 (***)	166 (***)	164 (***)	0.00	0.00	48 (*)
2011	155 (***)	155 (***)	0.00	446 (***)	247 (***)	340 (***)	0.00	0.00	0.00
2012	181 (***)	167 (***)	-53 (*)	665 (***)	0.00	--	0.00	-57 (*)	0.00

Note: amount of spread (in basis points) due to country specific contagion.
(***) α=0.001, (**) α=0.005, (*) α=0.01, (--) not estimable.

Table 4 Idiosyncratic contagion effects – *Debt model (2.b)*

	Italy	Spain	France	Portugal	Ireland	Greece	Finland	Netherlands	Austria
2007	67(***)	0.00	0.00	0.00	0.00	-78 (***)	0.00	0.00	0.00
2008	81 (***)	0.00	-41 (*)	0.00	0.00	-80 (***)	0.00	0.00	52 (*)
2009	0.00	0.00	-70 (***)	0.00	91 (**)	-126(***)	0.00	0.00	56 (**)
2010	0.00	117 (***)	-98 (***)	79 (***)	137 (***)	63 (*)	0.00	0.00	53 (**)
2011	91 (***)	193 (***)	-100 (***)	307 (***)	242 (***)	128 (***)	47 (*)	0.00	62 (**)
2012	147 (***)	242 (***)	-86 (***)	507 (***)	86 (*)	--	0.00	0.00	79 (***)

Note: amount of spread (in basis points) due to country specific contagion.
(***) α=0.001, (**) α=0.005, (*) α=0.01, (--) not estimable.

Results can be summarized as follows.

– Core countries (France, Finland, Netherlands and Austria) were not affected by the upsurge in financial turmoil during the subprime crisis: in fact the share of

17 The derivatives of responses showed in the following tables are obtained from the fitted models illustrated above and use statistical properties of covariates to make inference. Tables 3 and 4 highlight marginal effects results (derivatives of responses) referred to specifications (2.a) and (2.b) for the period 2007-2012. Based on the theoretical predictions of a fair value of government yield spreads for each country in every years – that is the value of the spreads derived from fundamentals variables incorporating credit risk of debtors – the marginal effects methodologies give us the share (in basis points) of that fair value which is ascribable to idiosyncratic contagion. We don't take this value from residuals of estimations (as residuals are unexplained components and it's subject to some degree of arbitrary to impute those to specific roots), but we estimate coefficients of time dummy, country dummy and interactions between them as they correctly represent the weight of non-core fundamental variables in transmission of financial contagion to the selected countries.

the predicted spreads attributable to contagion is estimated to be equal to zero. Since the eruption of sovereign debt crises, such countries have experienced a spread lower than what would be justified by their economic fundamentals (in the first half of 2012 France and Netherland are predicted to have benefited of a discount of 53 and 57 b.p. respectively).

– Some peripheral countries (Spain, Portugal, Ireland) suffered an abrupt revision of their credit risk since the insurgence of the sovereign debt crisis, which triggered the market revision of their already known economic fragility. As a consequence, starting from 2010 they experienced an overpricing phenomenon on their spreads due to contagion (for Spain, the contagion effect reached its peak in the first months of 2012, with values ranging from 167 to 242 basis points, depending on the specification adopted).

– Italy experienced a rising contagion effect that in the first semester of 2012 reached a value ranging, depending on the specification adopted, between 147 to 181 basis points. This penalization may be probably explained by its historically highest debt to GDP ratio, which makes Italy particularly exposed to the reversals of market sentiment.[18]

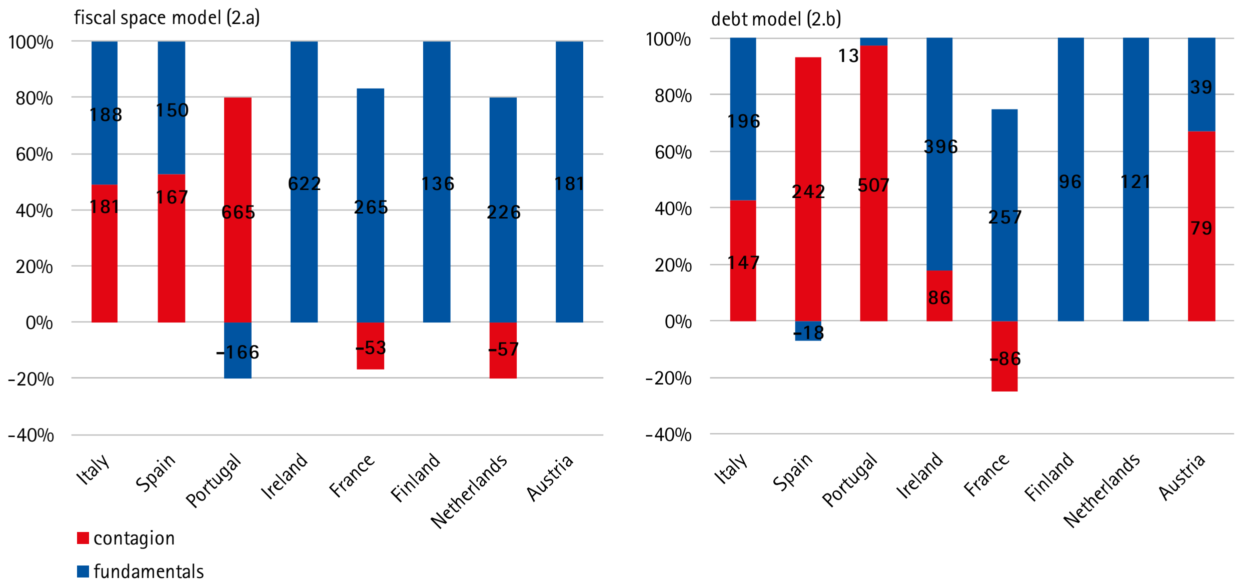
Figure 9 shows for each country the share of annual average predicted spread due to fundamentals and to contagion. Left panel refers to what we called *Time dependent model with fiscal space* (2.a) and points out that Italy suffered in 2012 from a contagion which accounts for almost 50% of total predicted spread (i.e.: predicted spread was equal to 369 b.p., of which 181 b.p. due to contagion). According to *Time dependent model with debt* (2.b - right panel), the share of annual predicted spread related to contagion is equal to 147 b.p. which accounts for around 43% of the total.

Other peripheral countries, such as Spain and Portugal, show similar pattern while for Ireland contagion can explain something up to 18% of the spread (that is 86 b.p. on 482 total b.p. predicted), depending on the model specification.

With regards to core countries, Finland shows a predicted spread in line with fundamentals, France shows a spread lower than what implied by fundamentals by an amount ranging from roughly 50 to 90 basis points, depending on the model specification, while for Netherlands such a "discount" can be as high as roughly 60 basis point (for 2011 estimates see Appendix Figure A.5).

18 As a results robustness tests we re-estimated equations (1.a, 1.b, 2.a and 2.b) by applying different lags to the independent variables. For the sake of brevity we only recall the main differences which emerged (detailed results are available upon request from the authors). If the industrial production variable is taken at time *t-1* (instead of *t*) we'll get these different results in table 3 (we only report 2012): Spain 176 b.p., France -47 b.p. and Netherlands -63 b.p., all other results being equal. If we take GDP growth at time *t* (instead of *t-1*) we'll have: Italy 192 b.p., Spain 180 b.p. and Portugal 671 b.p.. In the case of fiscal position variables (fiscal space and fiscal space squared) taken at *t-1* (rather than *t*) results will change a bit more: Italy -240 b.p., France -90 b.p., Spain 150 b.p., Netherlands -52 b.p. and Portugal 620 b.p.. We did the last robustness check by taking the external competitiveness variables (current account and real effective exchange rate) at time *t* instead of *t-1* and we obtained, other things being equal, that for Italy the amount of spread due to contagion is 195 b.p. (181 in the basic model of Table 3), for France is -46 b.p. and for Netherlands -70 b.p..

Figure 9 Percentage contribution of fundamentals and contagion to the model-predicted spreads of some European countries – 2012 estimates
(labels indicate the contributions of fundamentals and contagion in basis points)



We conclude our analysis by presenting, only for Italy and from 2007 onwards, the disaggregation of the predicted average spread, obtained through the *Time dependent model 2.a* (hereafter $\overline{\widehat{Spread}}_{ITA}$), into two components:

– the contribution of contagion ($\overline{\widehat{Spread}}_{ITA,C}$), i.e. the *time marginal effect* for Italy computed as above,

– the component of the fitted spread driven by fundamentals (i.e. excluding the time dummies): $\overline{\widehat{Spread}}_{ITA,F} = \overline{\widehat{Spread}}_{ITA} - \overline{\widehat{Spread}}_{ITA,C}$.

On the other hand $\overline{\widehat{Spread}}_{ITA,F}$ can be computed as the sum of the relative contributions of all the statically significant variables included in (2):

$$\overline{\widehat{Spread}}_{ITA,F} = \widehat{\beta_1}\overline{FP} + \widehat{\beta_2}\overline{Gr} + \widehat{\beta_3}\overline{IP} + \widehat{\beta_7}\overline{GRA} + \widehat{\beta_8}\overline{Debt_{it} * GRA_t * D_{post\ 2011}}$$

where for each regressor the yearly average is taken into account.[19]

Figure 10 shows the estimated relative contributions of contagion and fundamental factors. For 2007 and 2008, fundamentals are estimated to have reduced the (fitted yearly average) spread; this is quite plausible given that at that time the overall state of economy remained still unaffected by the financial crisis. From 2009 onwards, as the general economic conditions deteriorated, fundamentals are estimated to have raised the spread.

19 As an example, the relative contribution of IP is equal to $\frac{\widehat{\beta_3}\overline{IP}}{\widehat{\beta_1}\overline{FP}+\widehat{\beta_2}\overline{Gr}+\widehat{\beta_3}\overline{IP}+\widehat{\beta_7}\overline{GRA}+\widehat{\beta_8}\overline{Debt_{it}*GRA_t*D_{post\ 2011}}}$. This ratio is then multiplied by $\overline{\widehat{Spread}}_{ITA,F}$ to get the contribution in basis point.

Figure 10 Estimates of the contribution of fundamentals and contagion to the Italian government bond spread
(fitted values of the spread as estimated through the *Time dependent model* - 2.a)

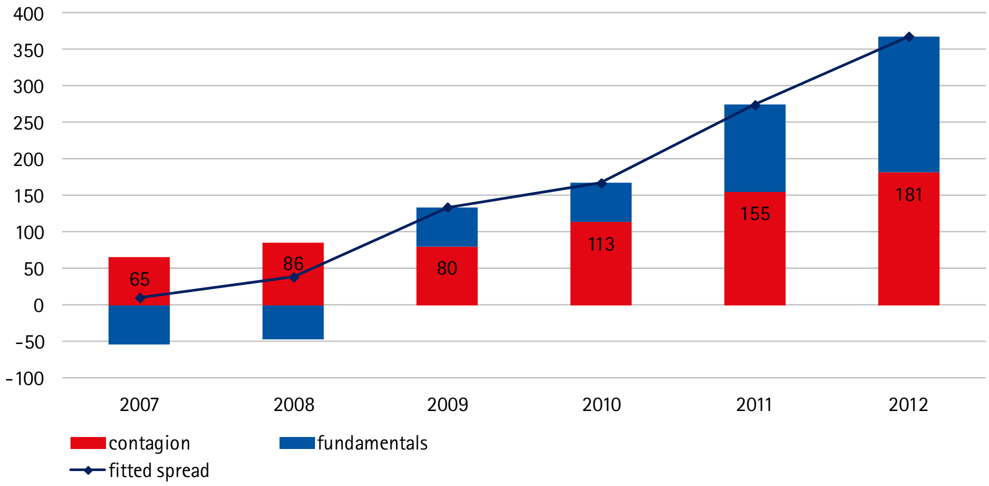
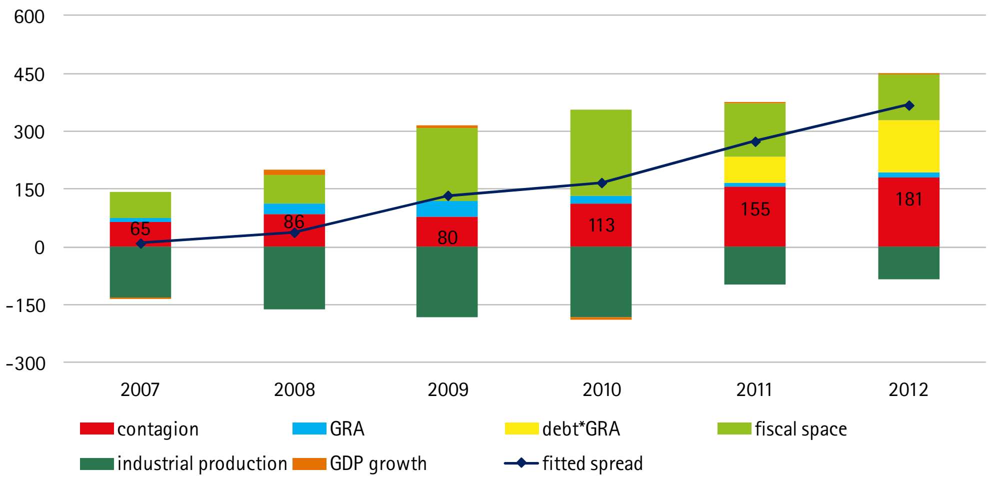


Figure 11 disaggregates the contributions of all the fundamental regressors and of the global risk aversion to the (fitted yearly average) spread. The estimated impact of the fiscal position considered on its own (i.e. neglecting the post-2011 interaction with the international risk aversion) increase till 2010 (to 225 b.p. from about 68 b.p. in 2007) and then decreased (to about 120 b.p. in the first half of 2012). However, when accounting for the interaction with international aversion, the overall impact of the fiscal components (i.e. the sum of fiscal space and $debt * GRA$) is always rising (reaching almost 260 b.p.). Finally, the positive contribution of the industrial production shrink as it slows down.

Figure 11 Estimates of the disaggregated contribution of fundamentals to the Italian government bond spread
(fitted values of the spread as estimated through the *Time dependent model* - 2.a)



5 Conclusions

Since the eruption of the sovereign debt crisis at the beginning of 2010, peripheral countries of the euro area have experienced a relentless rise in the spread against the German Bund. On the other hand, the core countries have benefited from a flight-to-quality effect, leading to a considerable reduction of their government bond yields.

This paper analyses the determinants of sovereign spreads in the euro area from January 2002 to May 2012. The objective is to disentangle the role of country-specific fundamentals, driven by fiscal and macroeconomic factors, from what is referred to as contagion.

Following the existing empirical literature, the work estimates a model of the determinants of the 10-year yield spreads relative to Germany for ten euro zone countries. The results show that since the eruption of the 2007-2008 financial crisis, sovereign spreads have shown a time-dependent contagion component. On average, such a component explains almost one third of the spreads dynamic in 2009-2010 and almost 10 per cent since 2011.

However, results at the country level are quite different between core and peripherals. As shown by the analysis, core countries (excluding Germany, which is our benchmark to measure spreads) were not affected by contagion till 2011; since the worsening of the sovereign debt crisis they seem to have benefited from a flight-to-quality effect. For example, in the first months of 2012, France shows spreads lower than what implied by fundamentals by an amount ranging from roughly 50 to 90 basis points, depending on the model specification, while for Netherlands such a "discount" can be as high as roughly 60 basis point.

Peripheral countries, which at the onset of the European Monetary Union took advantage from a mispricing of their actual economic and fiscal fragility, since 2009 have suffered from the abrupt revision of market expectations, showing spreads on average significantly higher than what justified by macroeconomic and fiscal factors. In 2012, for most of these countries contagion has a role comparable to fundamentals in explaining the level of the spreads. For example, it accounts for an amount ranging from roughly 170 to 240 basis points for Spain, while for Italy – probably penalized by its historically highest debt to GDP ratio – contagion explains something between roughly 150 and 180 basis points of the spread, depending on the model specification.

References

Aizenman, J., M. Hutchison, and Y. Jinjarak, (2011), *"What is the Risk of European Sovereign Debt Defaults? Fiscal Space, CDS Spreads and Market Pricing of Risk"*, NBER Working Papers, No. 17407.

Alessandrini, P., M. Fratianni, A. Hughes Hallett, and A. Presbitero, (2012), *"External imbalances and financial fragility in the Eurozone"*, MoFiR working paper No. 66.

Attinasi, M.G., C. Checherita, and C. Nickel, (2009), *"What explains the surge in Euro area sovereign spreads during the financial crisis of 2007-2009?"*, ECB, WP NO 1131.

Baum, C.F., (2010), *"Efficiently evaluating elasticities with the margins command"*, Stata Journal 10:309–312.

Beber, A., M.W. Brandt, and K.A. Kavavejc, (2009), *"Flight-to-Quality or Flight-to-Liquidity? Evidence from the Euro-Area Bond Market"*, Review of Financial Studies 22, 925 - 957.

Bernoth, K., and B. Erdogan, (2010), *"Sovereign bond yield spreads: a time-varying coefficient approach"*, DIW Berlin, Discussion Papers 1078.

Bernoth, K., J. von Hagen, and L. Schuknecht, (2006), *"Sovereign Risk Premiums in the European Government Bond Market"*, GESY DP n. 151, May.

Borgy, V., T. Laubach, J. Mésonnier, and J. Renne, (2011), *"Fiscal Sustainability, Default Risk and Euro Area Sovereign Bond Spreads"*, Paris December 2011 Finance Meeting EUROFIDAI - AFFI.

Breitung, J., (2000), *"The local power of some unit root tests for panel data"*, Advances in Econometrics, Volume 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels, ed. B. H. Baltagi, 161–1778.

Buis, M.L., (2010), *"Interpretation of interactions in nonlinear models"*, Stata Journal 10: 305–308.

Codogno, L., C. Favero, and A. Missale, (2003), *"Yield spreads on EMU government bonds"*, Economic Policy, October, pp. 505–532.

De Grauwe, P., and Y. Ji, (2012), *"Self-Fulfilling Crises in the Eurozone: An Empirical Test"*, CEPS Working Document, June.

Di Cesare, A., G. Grande, M. Manna, and M. Taboga, (2012), *"Recent estimates of sovereign risk premia for euro-area countries"*, Bank of Italy, Questioni di Economia e Finanza (Occasional papers), September.

Favero, C., and A. Missale, (2012), *"Sovereign spreads in the eurozone: which prospects for a Eurobond?"*, Economic Policy, Vol. 107, pp. 231-273.

Favero, C., M. Pagano, and E.L. von Thadden, (2005), *"Valutation, Liquidity and Risk in Government Bond Markets"*, Working Papers 281, IGIER (Innocenzo Gasparini Institute for Economic Research), Bocconi University.

Gerlach, S., A. Schulz, and G.B. Wolff, (2010), *Banking and Sovereign Risk in the Euro Area*. Available at http://www.ecb.int/events/pdf/conferences/fip/Paper_Alexander_Schulz.pdf.

Greene, W.H., (2012), *Econometric Analysis*, 7th ed., Upper Saddle River, NJ: Prentice Hall.

Harris, R.D.F., and E. Tzavalis, (1999), *"Inference for unit roots in dynamic panels where the time dimension is fixed"*, Journal of Econometrics 91: 201–226.

Haugh, D, P. Ollivaud, and D. Turner, (2009), *"What Drives Sovereign Risk Premiums? An Analysis of Recent Evidence from the Euro Area"*, OECD Economics Department, Working Paper No. 718.

International Monetary Fund, (2012), *IMF Fiscal Monitor Update*, July 2012.

Kmenta, J., (1971), *Elements of Econometrics*, New York: Macmillan, pp. 274-275.

Levin, A., C.F. Lin, and C.S.J. Chu, (2002), *"Unit root tests in panel data: Asymptotic and finite-sample properties"*, Journal of Econometrics 108: 1–24.

Maltritz, D., (2012), *"Determinants of sovereign yield spreads in the Eurozone: A Bayesian approach"*, Journal of International Money and Finance, 31:657-672.

Pagano, M. and E.L. von Thadden, (2004), *"The European bond markets under EMU"*, Oxford Review of Economic Policy, vol. 20. No. 4: 531-554.

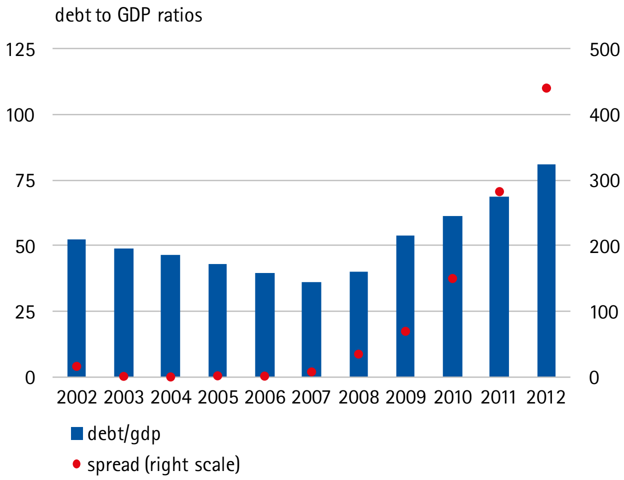
Searle, S.R., F.M. Speed, and G.A. Milliken, (1980), *"Population marginal means in the linear model: An alternative to least squares means"*, American Statistician 34: 216–221.

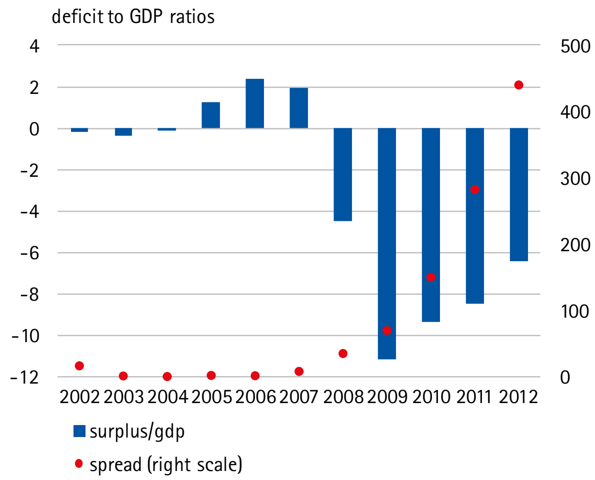
von Hagen, J., L. Schuknecht, and G. Wolswijk, (2011), *"Government bond risk premiums in the EU revised: The impact of the financial crisis"*, European Journal of Political Economy, 27: 36-43.

Appendix

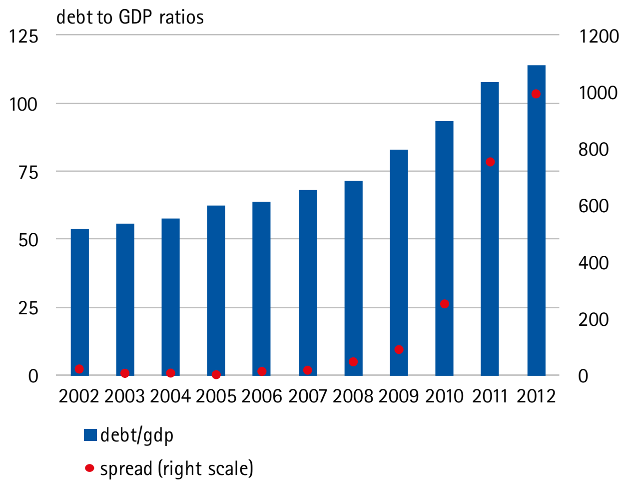
Figure A.1 Ten year government bond yield spreads and fiscal fundamentals for some euro area countries
(ten year government yield spreads are computed as averages of daily data; public debt and deficit to GDP ratios are end-of-period data; for 2012 the economic forecast of ECB is considered)

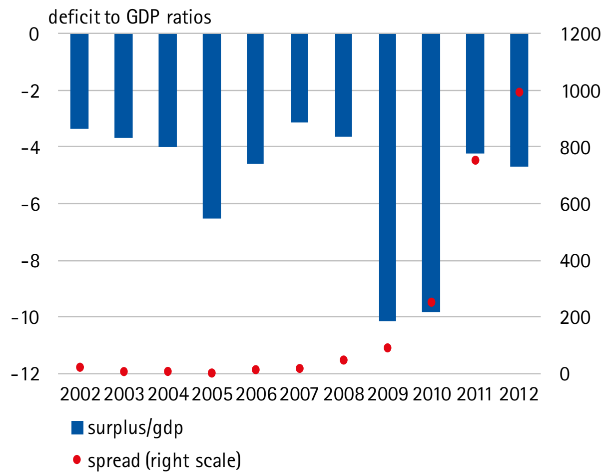
SPAIN





PORTUGAL

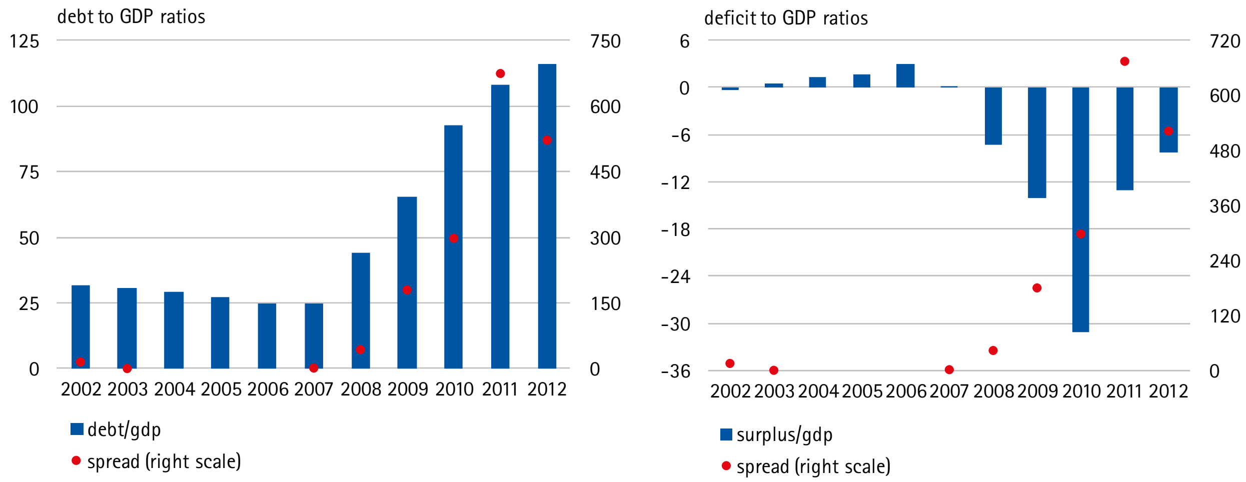




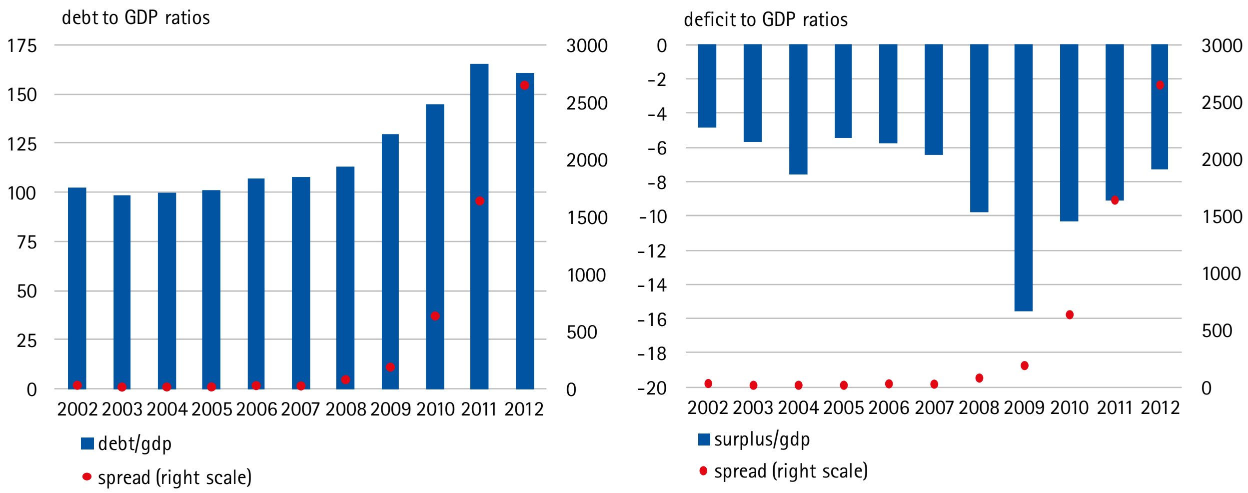
--- cont. ---

--- Figure A.1 cont. ---

IRELAND

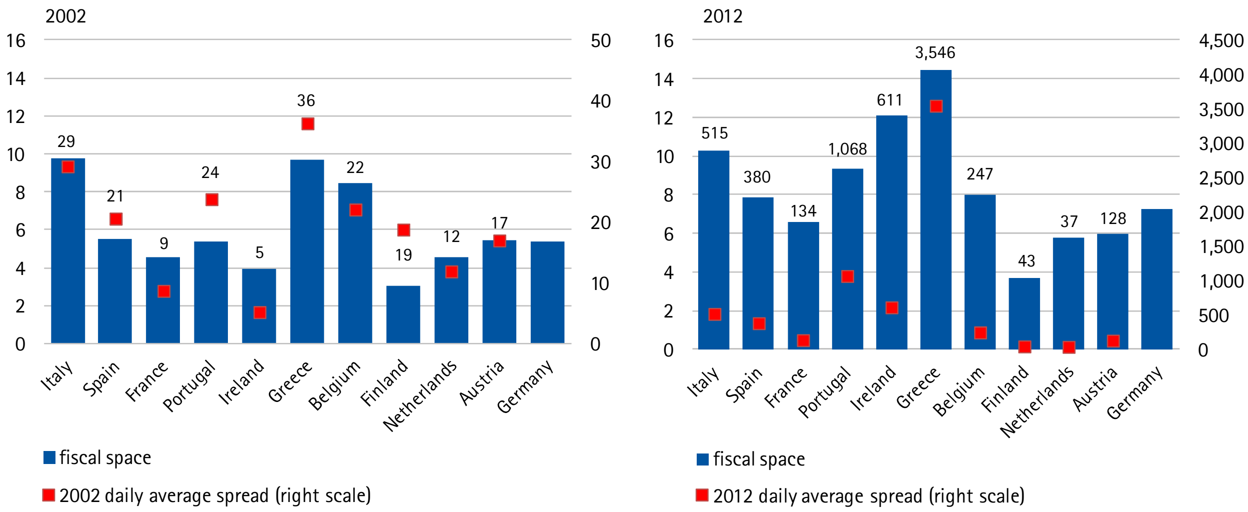


GREECE



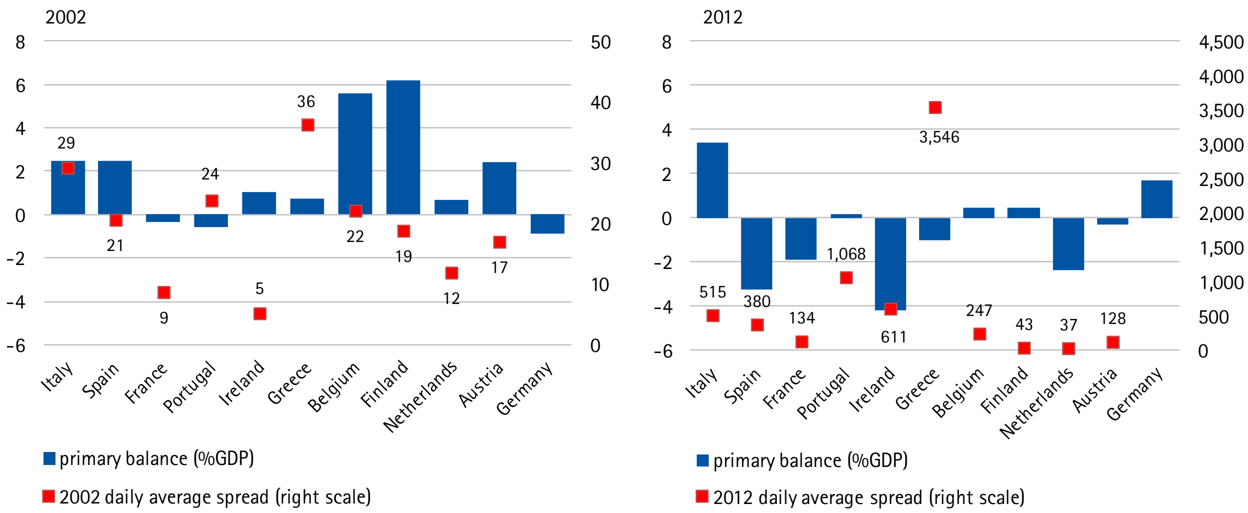
Source: Thomson Reuters and ECB.

Figure A.2 Ten year government bond yield spreads and fiscal space for some euro area countries
(ten year government yield spreads are computed as averages of daily data; fiscal space are computed as averages of monthly data; for 2012 only the first semester is considered)



Source: Thomson Reuters and Eurostat.

Figure A.3 Ten year government bond yield spreads and primary balance to GDP ratio for some euro area countries
(ten year government yield spreads are computed as averages of daily data; primary balance to GDP ratios are end-of-period data; for 2012 the Spring economic forecast of the European Commission is considered)



Source: Thomson Reuters and European Commission.

Table A.1 The main explanatory variables for some euro area countries: values in 2002 and in 2012

	Italy	Spain	France	Netherlands	Ireland	Portugal	Finland	Austria
spread (in basis point)								
2002	29.2	20.6	8.7	11.9	5.2	23.8	18.8	17.0
2012 (1st H)	515.4	380.4	134.4	36.6	611.4	1067.5	42.8	127.5
%	*16.65*	*17.47*	*14.45*	*2.08*	*116.58*	*43.85*	*1.28*	*6.50*
GDP growth[1] (percentage change over previous year)								
2002	0.5	2.7	0.9	0.1	5.6	0.8	1.8	1.7
2012 (E)	-1.4	-1.8	0.5	-0.9	0.5	-3.3	0.8	0.8
industrial production (index)								
2002	101.7	97.2	99.5	96.7	89.9	102.3	93.9	86.0
2012 (1st H)	83.9	79.1	90.9	107.0	109.1	87.0	98.8	111.6
%	*-0.18*	*-0.19*	*-0.09*	*0.11*	*0.21*	*-0.15*	*0.05*	*0.30*
real effective exchange rate (index)								
2002	94.0	92.5	94.7	93.1	88.4	96.2	98.5	96.6
2012 (1st H)	97.1	100.4	94.9	93.1	97.4	97.9	94.8	97.5
%	*0.03*	*0.09*	*0.00*	*0.00*	*0.10*	*0.02*	*-0.04*	*0.01*
current account to GDP ratio (percentage point)								
2002	-0.004	-0.033	0.012	0.026	-0.010	-0.082	0.088	0.025
2012 (1st H)	-0.005	-0.011	-0.031	0.074	0.080	-0.028	-0.037	0.009
%	*0.17*	*-0.67*	*-3.50*	*1.81*	*-9.05*	*-0.66*	*-1.42*	*-0.65*
debt share (percentage point)								
2002	27.60	7.73	18.39	4.74	0.82	1.60	1.20	2.94
2012 (1st Q)	23.06	9.18	21.20	4.76	2.06	2.25	1.11	2.64
%	*-0.16*	*0.19*	*0.15*	*0.00*	*1.52*	*0.40*	*-0.08*	*-0.10*

Source: authors' calculations based on Thomson Reuters and Eurostat data.
Note: ten year government yield spreads are computed as averages of daily data; the Eurostat forecast is considered for 2012 GDP growth rate; for industrial production and real effective exchange rate we computed the average of monthly data; current account to GDP ratios and debt shares are end-of-period data.

Table A.2 Summary of the most recent empirical work on the determinants of the government bond yield spreads in the euro area

reference	sample	variables and econometric models
Alessandrini et al. (2012)	Ten euro area countries, Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain, from 2000:q1 to 2011:q2.	**Dependent**: spread computed for yields to maturity of 10-y government bonds (quarterly data). **Explanatory**: primary balance to GDP; public debt to GDP; bid-ask; general risk aversion, as first component of 4 measures of risk; real GDP growth; inflation; labor productivity growth; trade balance to GDP; liabilities to German banks; political risk rating; dummies for crises (where appropriate, variables are measured relative to German values). **Model**: panel corrected standard error (PCSE).
Aizenman, Hutchison and Jinjarak (2011)	60 countries (advanced and emerging) from 2005 to 2010	**Dependent**: 5-year sovereign CDSs. **Explanatory**: ratio of government debt to tax revenue, ratio of the fiscal deficit to tax revenue, US interest rates, trade openness (import plus export/GDP), GDP growth, per capita GDP. **Model**: Arellano-Bond dynamic panel estimator.
Attinasi et al. (2009)	Ten EMU countries; 31/7/2007 till 25/3/2009.	**Dependent**: daily yield spread and monthly averages. **Explanatory**: expected general government budget balance and debt to GDP taken from the EC forecasts released on a bi-annual basis and differenced vis-à-vis Germany; a dummy for individual countries' announcements of bank rescue packages; size of recapitalization and the size of guarantees; credit risk transfer captured by the difference between sovereign CDS premia and CDS premia for European financial corporations; total debt issuance as a share of the Euro area bond market differenced vis-à-vis to the German ratio; international risk aversion (spread between the yield of US AAA corporate bonds and the yield of US 10-year sovereign bonds). Additional variables: expected economic growth rate and a proxy for the expected external imbalances (the saving-investment balance of the private sector as a share of GDP); ECB refi interest rate. **Model**: Dynamic panel approach (Feasible Generalised Least Squares (FGLS) estimator.
Bernoth and Erdogan (2010)	Ten EMU countries between 1999:q1 and 2010:q2. Almost all variables	**Dependent:** yield spreads of individual countries calculated as the end-quarter yield differential of their 10-year benchmark bonds relative to the 10-year German Bund. **Explanatory**: debt to GDP ratio (quarterly from Eurostat) and the projected (12-months ahead) decit to GDP ratio (semi-annually – OECD Economic Outlook) both in level and quadratic (to account for a punishment effect by the market); bid-ask spread (Bloomberg); general risk aversion measured as the spread between the yield of US BBB corporate bonds and the yield of US Treasuries (for Europe data available only from 2002). **Model**: Semiparametric time-varying coefficient model (Sun et al., 2009).
De Cesare et al. (2012)	A number of EMU countries	**Dependent**: monthly and quarterly averages of the yield spread. **Explanatory**: public debt to GDP ratio, GDP growth, private debt to GDP, current account to GDP, the VIX index, financial factors (volatility of the sovereign spread, volatility of bank stocks, spread on corporate bonds having the same rating), systemic risk indicators. **Model**: Panel model.
De Grauwe and Ji (2012)	EMU countries and 14 "stand-alone" developed countries from 2000 to 2011	**Dependent**: yield spread with respect to the German Bund. **Explanatory**: public debt to GDP ratio, fiscal space, current account, real effective exchange rate, GDP growth, time dummies. **Model**: Fixed effect model.

--- cont. ---

--- Table A.2 cont. ---

reference	sample	variables and econometric models
Favero and Missale (2012)	Ten EMU countries; weekly data from June 2006 – August 2011. Weekly data.	**Dependent**: yield spread. **Explanatory**: expected deficit and debt to GDP (EC forecast) differenced to Germany; global risk factor (US corporate Baa-Aaa spread), "global spread" (at t and t-1; see. p. 242). **Model**: VAR; Multivariate GARCH model for Italy and Spain.
Gerlach et al. (2010)	EMU 12, no Luxembourg, Germany is benchmark. Greece included from 2001 on. Estimations: 01 Jan 1999 to 28 Feb 2009. Data have weekly frequency, unless stated otherwise. Bank data have monthly frequency.	**Dependent**: yield to maturity spread. **Explanatory**: lag of spread, time to maturity, debt to GDP, three-year-ahead deficit forecasts (EC), banking sector total assets to GDP and the equity over total assets ratio (from ECB's MFI data base) (also interacted with aggregate risk), aggregate risk factor (seven to ten year US corporate bond spread – vis a vis US treasuries – for the rating category BBB)[4], liquidity (proxied by: yield bid-/ask spreads, total amount of outstanding bonds, turnover from MTS), dummies for crises. Non linearity is tested including squared terms; also German yield is included. **Model**: Panel fixed effect model, random effect model, dynamic panel (Pesaran and Smith, 1995, using Swamy 1971).
Maltritz (2012)	Ten EMU countries; 1999-2009. Data frequency: annual. Two alternative approaches: end-of the year observations for both dependent and independent variables; lagged independent variables and average spread observed in the next year. Explanatory variables are differenced with respect to Germany; robustness check with original data.	**Dependent**: yield spread. **Explanatory**: deficit to GDP, debt to GDP, average interest rate paid on debt, GDP growth, Trade balance to GDP, openness (import+export) to GDP, change in terms of trade index, inflation and its variation, capital formation to GDP, liquidity (proxied by: total amount of outstanding bonds and country's debt in relation to the overall debt of all EMU countries), US riskless interest rate (bond yield from US treasury yield curve for one-year maturity), spread between the yield of BBB US corporate bonds and the yield of US Treasuries. **Model**: Bayesian Model Averaging.
Schuknecht et al. (2010)	EU15 US$, DM and euro denominated government bonds issued between 1991 and mid-May 2009 (overall 330 obs).	**Dependent**: nominal yields at issue for single bond issues. **Explanatory**: public debt and deficit relative to GDP measured as differences with respect to the benchmark country; size of debt issue as a proxy for its liquidity; general investors' risk aversion measured as the yield spread between low grade US corporate bonds (BBB) and benchmark US government bonds; short-term interest rate as additional proxy for investors' risk aversion[2]; time to maturity of the bonds at the time of issue as additional control related to the investors' risk premium; fiscal variables interacted with EMU dummy and Lehman default dummy. **Model**: Panel analysis with time fixed effects.
Borgy et al. (2011)	The sample includes data for Germany France, Ireland, Italy, Portugal, Spain and Greece since 2000.	**Dependent**: monthly observations of spreads at 1, 5 and 10 years maturities. **Explanatory**: 1-month risk free short term rate (1-month OIS swaps), a measure of global volatility in financial markets (the log of the Chicago Board VIX), a monthly indicator for the position in the euro-area business cycle (Eurostat's business confidence indicator), a measure of national fiscal balances (the change expected in the debt/GDP ratio over the next 12 months meant as a forward looking measure).[3] **Model**: Affine models.

[1] The financial market literature suggests that, if long-term rates are generally low compared to short-term rates, investors ask for lower risk premiums as they are eager to find investment opportunities offering attractive spreads over short-term interest rates. [2] The authors use also debt/GDP from the OECD Economic Outlook database, which is published semi-annually and provides data at quarterly frequency. They interpolate these quarterly series using simple cubic splines; moreover, monthly fiscal variables are extracted from available quarterly information using the Kalman filter. [3] As aggregate risk factor also the swap spread and equity market volatility have been used, besides the Ted spread (3 month LIBOR versus T-Bill rate) and the Refcorp spread (10 year agency versus Treasury yield).

Table A.3 The explanatory variables: description and sources

variables	definition	frequency	source
spread	difference in yields to maturity of 10-year government bonds of ten euro member countries relative to Germany's	Monthly	Thomson Reuters
fiscal position	gross government debt over GDP	Quarterly	Eurostat
	primary balance over GDP	Quarterly	ECB
	government budget deficit/surplus over GDP	Quarterly	ECB
	fiscal space: Gross government debt over total tax revenues	Quarterly[1]	Eurostat
economic activity	GDP growth; percentage change with respect to previous quarter	Quarterly[1]	Thomson Reuters
	industrial production	Monthly[1]	Thomson Reuters
external sector	current account balance over GDP	Monthy[1]	Thomson Reuters
	real effective exchange rate	Monthly	Thomson Reuters
global risk aversion indicator	spread between the yield of US AAA corporate bonds and the yield of US BBB corporate bonds	Monthly	Fred database
debt share	countries' debt relative to the overall debt of all EMU countries	Quarterly	Eurostat

[1] Fiscal space, GDP growth, industrial production and current account balance were seasonally adjusted through a moving average (MA) filter; the length of the moving window was appropriately chosen depending on the time series. Such smoothing allowed to obtain monthly estimated values for the variables, which were used in the estimation.

Table A.4 Unit root test (H_0 hypothesis: Panels contain unit roots)

variable	LLC test		Harris-Tsavalis test		Breitung test	
	adjusted t*	P-value	rho	P-value	lambda	P-value
spread	7.57	1.00	1.009	1.00	3.98	1.00

We considered a simple panel-data model with a first-order autoregressive component:

$$y_{it} = \rho_i y_{it-1} + z'_{it}\gamma_i + \varepsilon_{it}$$

where $i=1,\ldots,N$ indexes panels; $t=1,\ldots,T_i$ indexes time; y_{it} is the variable being tested (government yield spreads) and ϵ_{it} is a stationary error term. By default we impose z_{it}=1 so that the term $z'_{it}\gamma_{it}$ represents panel-specific means (fixed effects). Panel unit-root tests are used to test the null hypothesis H_0: ρ_i=1 for all i versus the alternative H_a: $\rho_i < 1$. We adopted three alternative specification test proposed by Levin-Lin-Chu (2002), Harris-Tzavalis (1999) and Breitung (2000).

Figure A.4 Actual and fitted values for Ireland, Portugal, Finland and Austria
(values in basis point)

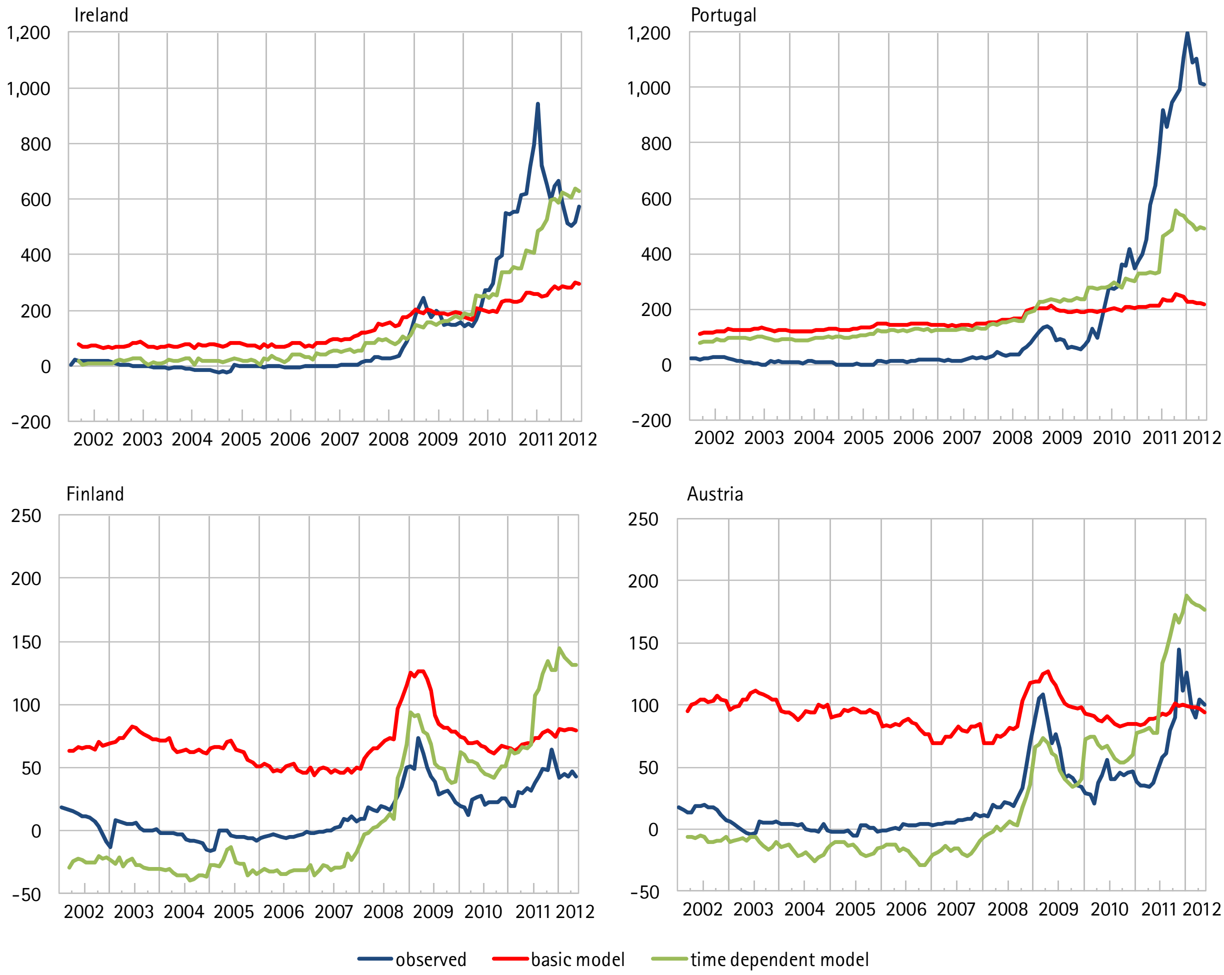


Figure A.5 Percentage contribution of fundamentals and contagion to the model-predicted spreads of some European countries – 2011 estimates
(labels indicate the contributions of fundamentals and contagion in basis points)