

# Self-Fulfilling Crises in the Eurozone: An Empirical Test

Paul De Grauwe and Yuemei Ji\*

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## Abstract

This paper tests the hypothesis that government bond markets in the eurozone are more fragile and more susceptible to self-fulfilling liquidity crises than those in 'stand-alone' countries, i.e. countries that issue debt in their own currencies. We find evidence that a significant part of the surge in the spreads of the PIGS countries (Portugal, Ireland, Greece and Spain) in the eurozone during 2010-11 was disconnected from underlying increases in the debt-to-GDP ratios and fiscal space variables, but rather was the result of negative self-fulfilling market sentiments that became very strong starting at the end of 2010. We argue that this phenomenon can drive member countries of the eurozone into bad equilibria.

We also find evidence that after years of neglecting high government debt, investors became increasingly worried about it in the eurozone, and reacted by raising the spreads. No such worries developed in stand-alone countries, despite the fact that debt-to-GDP ratios and fiscal space variables were equally high and increasing in these countries.

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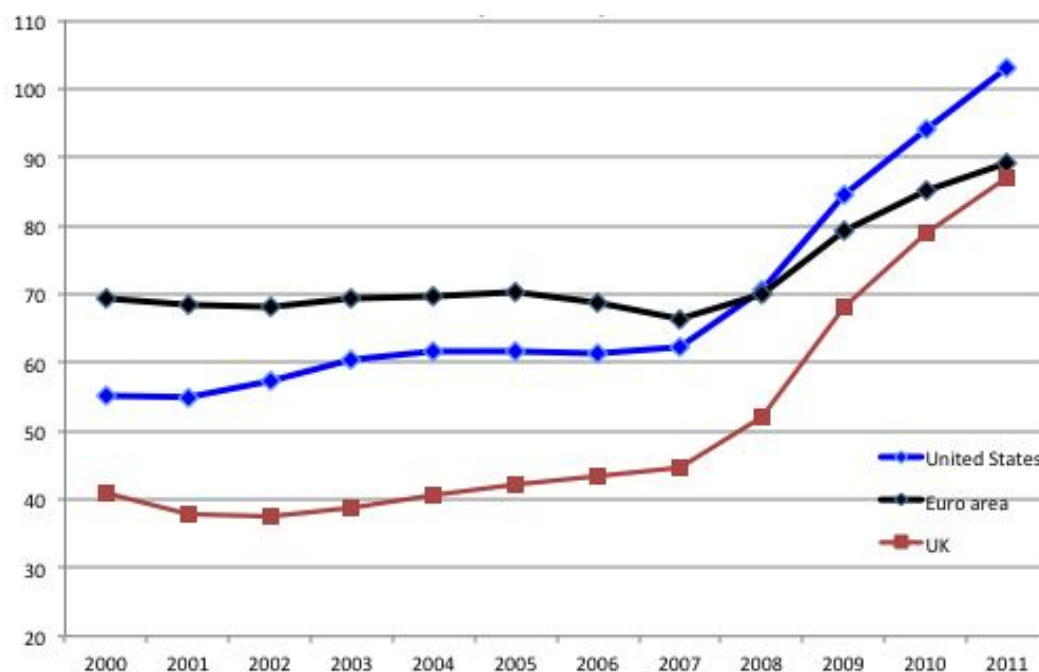
**Paul De Grauwe and Yuemei Ji**

## Introduction

The financial crisis that erupted in the industrialised world in 2007 forced governments to save their domestic banking systems from collapse and to sustain their economies that experienced their sharpest post-war recession. As a result, these governments saw their debt levels increase dramatically. Figure 1 shows this for the US, the UK and the eurozone.

Figure 1 is also interesting for another reason. We observe that the increase in the debt-to-GDP ratios since 2007 is significantly faster in the US and the UK than in the eurozone, so much so that at the end of 2011 the US surpassed the eurozone's debt-to-GDP ratio and the UK is soon to do so. Yet it is the eurozone that has experienced a severe sovereign debt crisis and not the US nor the UK. The severity of the sovereign debt crisis in the eurozone is illustrated in Figure 2, which shows the spectacular increase in the spreads of a large number of eurozone countries.<sup>1</sup>

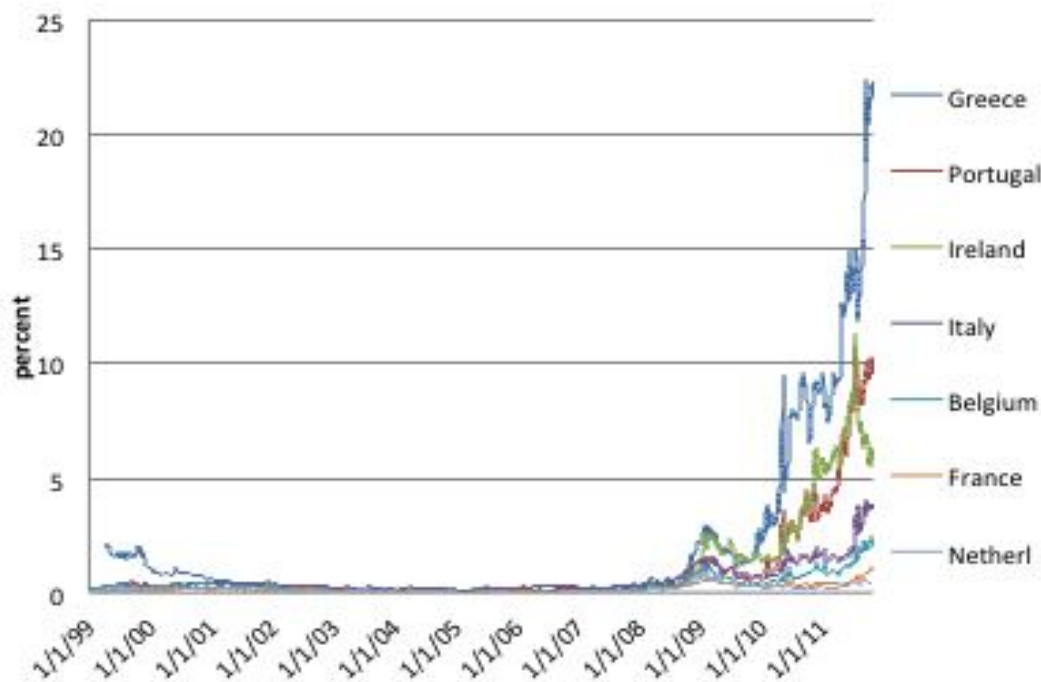
*Figure 1. Gross government debt in the eurozone, the US and the UK*



Source: European Commission, Ameco.

<sup>1</sup> The spreads are defined as the differences of 10-year government bond rates of each country and that of German government bonds.

Figure 2. Spreads in 10-year government bond rates



Source: Datastream.

In De Grauwe (2011a), a theory of the fragility of the eurozone is developed that explains why the eurozone countries are more prone to experience a sovereign debt crisis than countries that are not part of a monetary union, even when these countries experience a worse fiscal situation. The purpose of this paper is to provide a further empirical test of this theory.

Section 1 summarises the main features of the fragility theory of the eurozone and derives the testable implications. Section 2 presents some preliminary data and section 3 describes the econometric testing procedure and discusses the results. Section 4 derives some policy implications.

## 1. The fragility of the eurozone

The key to understanding the sovereign debt crisis in the eurozone has to do with an essential feature of a monetary union.<sup>2</sup> Members of a monetary union issue debt in a currency over which they have no control. As a result, the governments of these countries cannot give a guarantee that the cash will always be available to pay out bondholders at maturity. It is literally possible that these governments find out that the liquidity is lacking to pay out bondholders.

This is not the case in 'stand-alone' countries, i.e. countries that issue debt in their own currency. These countries can give a guarantee to the bondholders that the cash will always be available to pay them out. The reason is that if the government were to experience a shortage of liquidity, it could call upon the central bank to provide the liquidity. And there is no limit to the capacity of a central bank to do so.

The absence of a guarantee that the cash will always be available creates fragility in a monetary union. Member countries are susceptible to movements of distrust. When investors

<sup>2</sup> See De Grauwe (2011b) for a more detailed analysis. See also Kopf (2011).

fear some payment difficulty, e.g. triggered by a recession, they sell the government bonds. This has two effects. It raises the interest rate and leads to a liquidity outflow as the investors who have sold the government bonds look for safer places to invest. This 'sudden stop' can lead to a situation in which the government cannot roll over its debt except at prohibitive interest rates.

The ensuing liquidity crisis can easily degenerate into a solvency crisis. As the interest rate shoots up, the country is likely to be pushed into a recession. This tends to reduce government revenues and to increase the deficit and debt levels. The combination of increasing interest rates and debt levels can push the government into default.

There is a self-fulfilling element in this dynamics. When investors fear default, they act in such a way that default becomes more likely. A country can become insolvent because investors fear default.

The problem of member countries of a monetary union described above is similar to the problems faced by emerging countries that issue debt in a foreign currency, usually the dollar. These countries can be confronted with a 'sudden stop' when capital inflows suddenly stop, leading to a liquidity crisis (see Calvo et al., 2006). This problem has been analysed extensively by economists, who have concluded that financial markets acquire great power in these countries and can force them into default (see Eichengreen et al., 2005).

The liquidity crises in a monetary union also make it possible for the emergence of multiple equilibria. Countries that are distrusted by the market are forced into a bad equilibrium characterised by high interest rates and the need to impose strong budgetary austerity programmes that push these countries into a deep recession. Conversely, countries that are trusted become the recipients of liquidity inflows that lower the interest rate and boost the economy. They are pushed into a good equilibrium. In De Grauwe (2011a), a formal model inspired by the Obstfeld (1986) model of foreign currency crises is presented in which multiple equilibria are a possible outcome.<sup>3</sup> In the Appendix a simple version of this model is presented.

Finally it should also be mentioned that the fragility of member countries of a monetary union has a similar structure as the fragility of banks. The latter are fragile because of the unbalanced maturity structure of their assets and liabilities. The latter have shorter maturities than the former ('banks borrow short and lend long'). As a result, banks are vulnerable to runs. When depositors fear liquidity problems, they run to the bank to convert their deposits into cash, thereby precipitating the liquidity crisis that they fear. (See the classic model of bank runs in Diamond & Dybvig, 1983.) This problem can be solved by the central bank promising to step in and to provide liquidity in times of crisis ('lender of last resort').

Governments in a monetary union that cannot rely on a lender of last resort face a similar fragility. Their liabilities (bonds) are liquid and can be converted into cash quickly. Government assets (physical assets, claims on taxpayers), however, are illiquid. In the absence of a central bank that is willing to provide liquidity, these governments can be pushed into a liquidity crisis because they cannot transform their assets into liquid funds quickly enough.

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<sup>3</sup> There exist many formal theoretical models that create self-fulfilling liquidity crises. Many of these have been developed for explaining crises in the foreign exchange markets (see Obstfeld, 1986). Other models have been applied to the government debt (Calvo, 1988, Gros, 2012 and Corsetti & Dedola, 2011).

## 2. How to test the theory?

The theory presented in the previous section leads to a number of testable propositions.

We have seen that in a monetary union movements of distrust vis-à-vis one country lead to an increase in the government bond rate of that country and thus to an increase in the spread (the difference) with the bond rates of other countries. When such movements of distrust occur, these spreads are likely to increase significantly without much movement of the underlying fundamentals that influence the solvency of the country. More precisely when market sentiments turn against a country, the spreads are likely to exhibit the following features:

- Large movements in the spreads occur over short periods.
- Changes in the fundamental variables cannot account for the total change in the spreads.<sup>4</sup> Movements in the spreads appear to be dissociated from the fundamentals.
- The changes in the spreads are clustered in time.

Thus one way to test the theory is first to estimate a model that explains the spreads by a number of fundamental variables. In a second stage we track the estimated errors of the model, i.e. the deviations of the observed spreads from the spreads as estimated by the model. More specifically we wish to identify periods during which market sentiments drive the spreads away from their underlying fundamentals. In a third stage we estimate the model with time dummies that are independent from the fundamentals, and analyze how much of the total variation of the spreads can be accounted for by these time dummies.

In order for such a test to be convincing, it will be important to analyze a control group of countries that do not belong to a monetary union. We will therefore take a sample of 'stand-alone' countries and analyze whether in this control group one observes similar movements of the spreads away from their underlying fundamentals. Our theory predicts that this should not happen in countries that have full control over the currency in which they issue their debt.

## 3. The facts about spreads and debt-to-GDP ratios

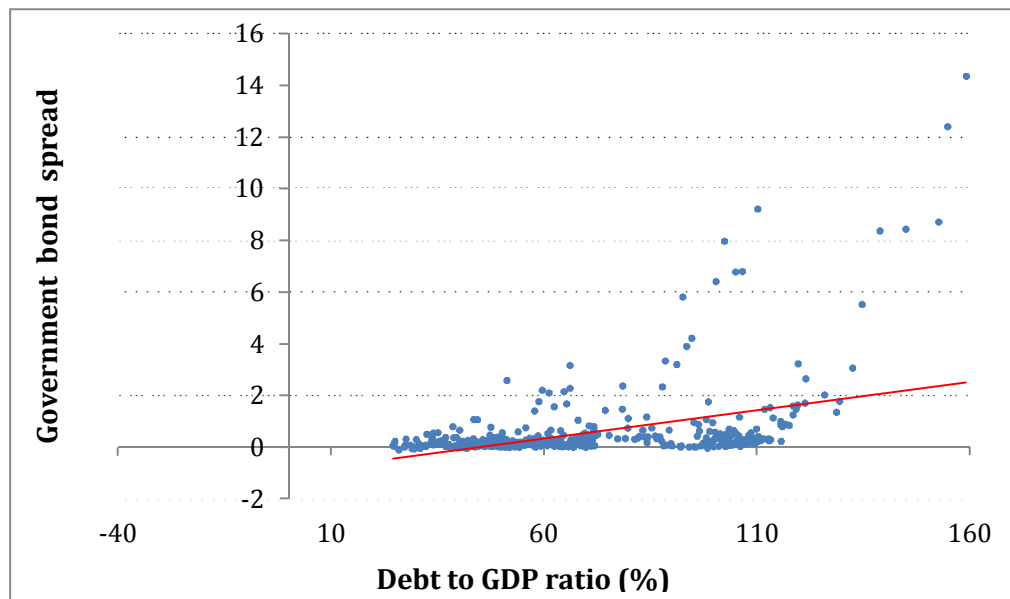
Before performing a rigorous econometric analysis explaining the spreads, it is useful to look at how the spreads and the debt-to-GDP ratios have evolved over time in the eurozone and in the sample of 'stand-alone' countries. We look at the relation between the spreads and the debt-to-GDP ratio, as the latter is the most important fundamental variable influencing the spreads (as will become clear from our econometric analysis).

We first present the relation between the spreads and the debt-to-GDP ratios in the eurozone. This is done in Figure 3, which shows the spreads on the vertical axis and the debt-to-GDP ratios on the horizontal axis in the eurozone countries. Each point is a particular observation of one of the countries in a particular quarter (sample period 2000Q1-2011Q3). We also draw a straight line obtained from a simple regression of the spread as a function of the debt-to-GDP ratio.

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<sup>4</sup> Note that we are not implying that fundamentals do not matter; in fact small movements of fundamentals can trigger large movements in spreads, because they trigger the fear factor (like in a bank run).

Figure 3. Spreads and debt-to-GDP ratio in eurozone (2000Q1-2011Q3)

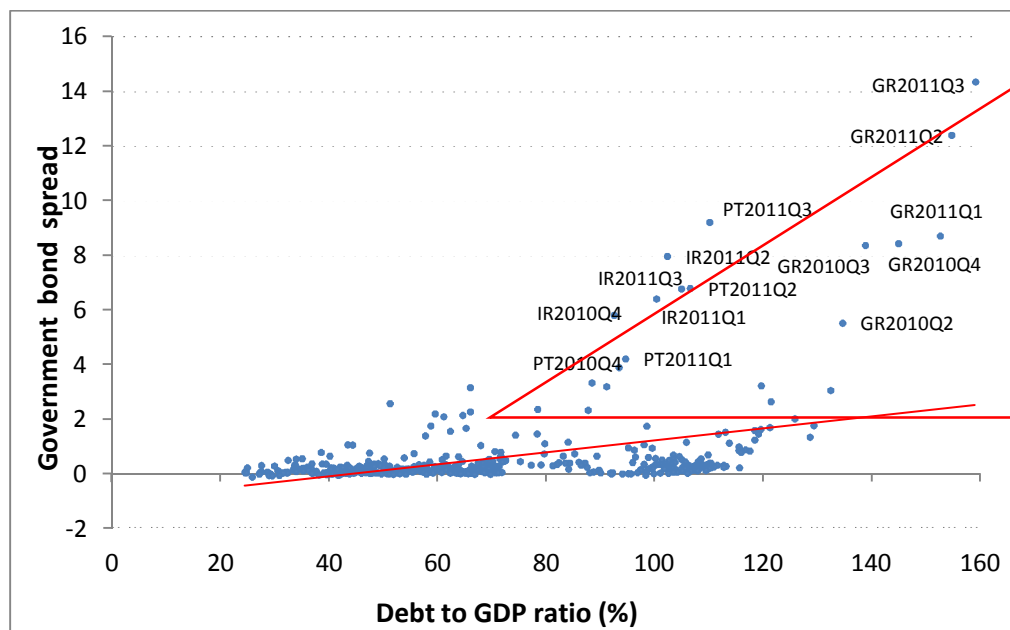


Sources: Eurostat and Datastream.

We observe first that there is a positive relation (represented by the positively sloped regression line) between the spread and the debt-to-GDP ratio, i.e. higher spreads are associated with higher debt-to-GDP ratios. We will return to this relationship and present more precise statistical results in the next section.

A second observation to be made from Figure 3 is that the deviations from the fundamental line (the regression line) appear to occur in bursts that are time dependent. We show this in Figure 4, which is the same as Figure 3 but where we have highlighted all observations that are more than 3 standard deviations from the fundamental line in a triangle.

Figure 4. Spreads and debt-to-GDP ratio in eurozone (2000Q1-2011Q3)



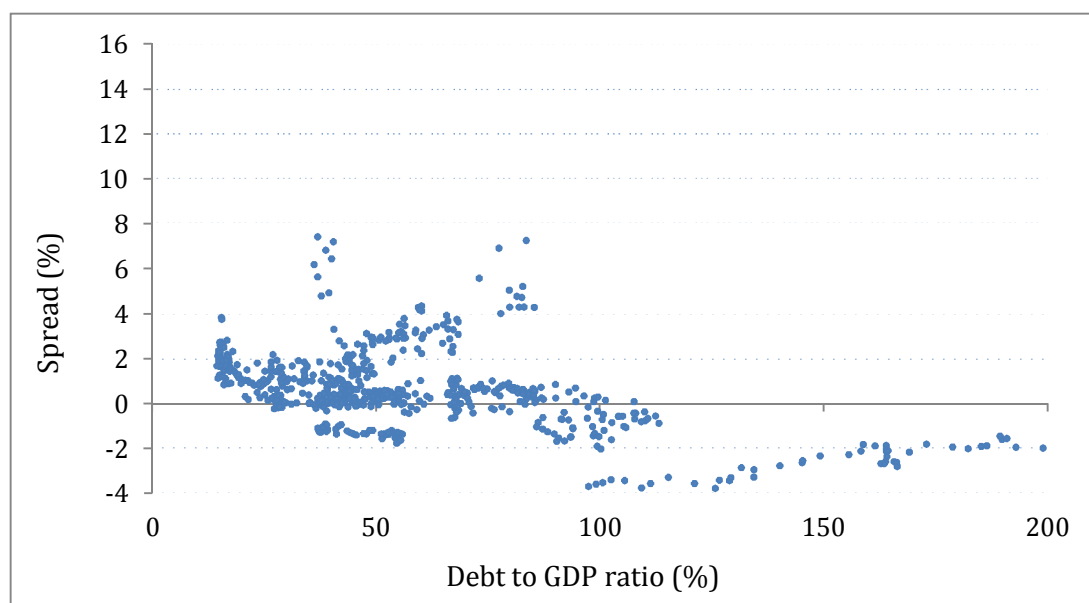
Sources: Eurostat and Datastream.

It is striking to find that all these observations concern three countries (Greece, Portugal and Ireland) and that these observations are highly time dependent, i.e. the deviations start at one particular moment of time and then continue to increase in the next consecutive periods. Thus, the dramatic increases in the spreads that we observe in these countries from 2010 on do not appear to be much related to the increase in the debt-to-GDP ratios during the same period. This is as the theory predicts. We will analyze whether this result stands the scrutiny of econometric testing.

Do the same developments occur in 'stand-alone' countries, i.e. countries that are not part of a monetary union and issue debt in their own currencies? We selected 14 'stand-alone' developed countries (Australia, Canada, Czech Republic, Denmark, Hungary, Japan, South Korea, Norway, Poland, Singapore, Sweden, Switzerland, the US and the UK)<sup>5</sup> and computed the spreads of the 10-year government bond rates. In order to make the analysis comparable with our analysis of the eurozone countries, we selected the same risk-free government bond, i.e. the German government bond. We could also have selected the US government bond. In fact doing so leads to very similar results.

It is important to stress that the spreads between 'stand-alone' countries reflect not only default risk but also exchange rate risk. It is even likely that the latter dominates the default risk, as exchange rates exhibit large fluctuations thereby creating large risks resulting from these fluctuations. In the econometric analysis we will therefore introduce exchange rate changes as an additional explanatory variable of the spreads. Before we do this, we present the plots of the spreads and the debt-to-GDP ratios in the same way as we did for the eurozone countries in Figures 3 and 4. The result is shown in Figure 5.

Figure 5. Spreads of 'stand-alone' countries (2000Q1-2011Q3)



Sources: OECD and Datastream.

Comparing Figure 5 with Figure 3 of the eurozone countries we find striking differences. A first difference with the eurozone countries is that the debt-to-GDP ratio seems to have a

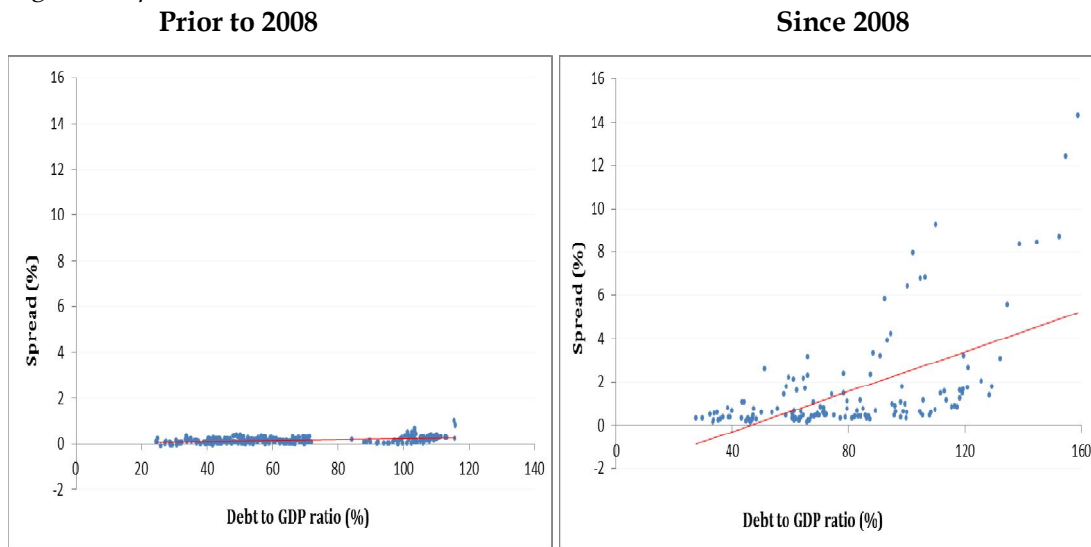
<sup>5</sup> Countries whose GDP per capita  $\geq$  \$20,000 and population  $\geq$  5 million are selected. Saudi Arabia and the United Arab Emirates are excluded because their economies are heavily dependent on oil exports. Hong Kong, Israel and Taiwan are excluded because of a lack of some relevant data. Slovakia is a special case as it joined the eurozone in 2009 and should not be included in the stand-alone sample.



very weak effect on the spreads. Second, and most importantly, we do not detect sudden and large time-dependent departures of the spreads from their fundamentals. All the observations, although volatile in the short-run, cluster together around some constant number between -4% and 8%.

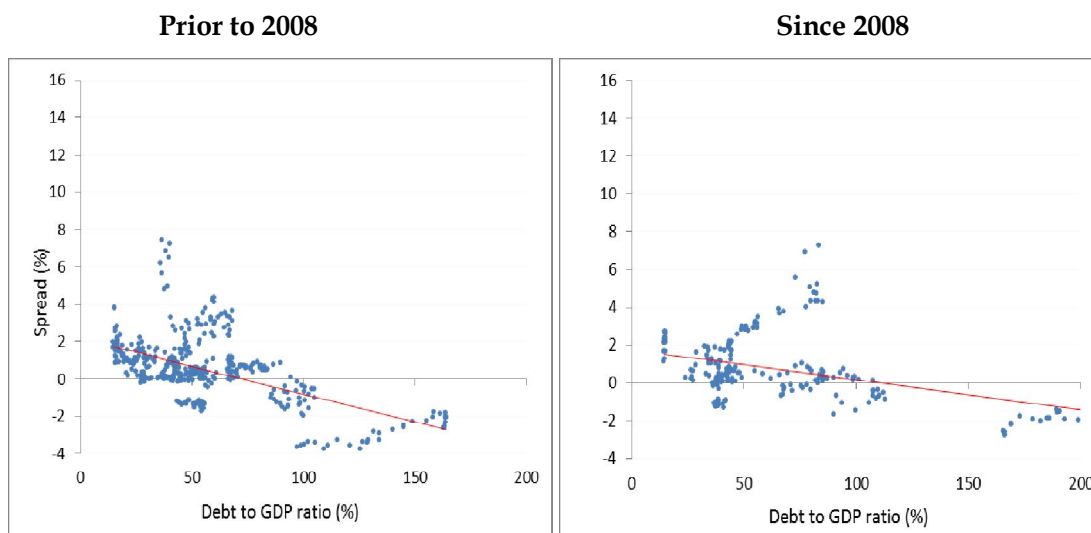
The contrast between the eurozone countries and the sample of stand-alone countries also appears in the occurrence of structural breaks. We split the sample between the pre- and the post-financial crisis period. We show the results in Figures 6 and 7.

Figure 6. Spreads and debt-to-GDP ratios in eurozone



Sources: Eurostat and Datastream.

Figure 7. Spreads and debt-to-GDP ratios of 'stand-alone' countries



Sources: OECD and Datastream.

The most striking difference is that a significant break in the relationship between the spreads and the debt-to-GDP ratio seems to have occurred in the eurozone. While before the crisis the debt-to-GDP ratios in the eurozone do not seem to have affected the spreads (despite a large variation in these ratios), after 2008, this relationship becomes quite significant. This contrasts with the stand-alone countries where the financial crisis does not

seem to have changed the relationship between spreads and debt-to-GDP ratios, i.e. it appears that since the financial crisis the link between spreads and debt-to-GDP ratios has remained equally weak for the stand-alone countries. Thus, financial markets are not eager to impose more discipline on the stand-alone countries since the start of the financial crisis, while they have become very eager to do so in the eurozone. This by itself also tends to confirm the fragility hypothesis formulated earlier, i.e. it appears that financial markets are less tolerant towards high debt-to-GDP ratios in the eurozone than in the stand-alone countries. We also note that after 2008 time-dependent departures of the spreads from the fundamentals seem to occur.

#### 4. Implementing the testing procedure

In this section we implement the statistical testing procedure of the fragility hypothesis. We will proceed in two steps. We first specify and estimate a fundamentals' based model of the spreads. In the second step we introduce a time variable that will allow us to track time dependent movements of the spreads that are unrelated to the fundamentals.

In our specification of the fundamentals model we rely on the existing literature.<sup>6</sup> The most common fundamental variables found in this literature are: variables measuring the sustainability of government debt. We will use two alternative concepts, i.e. the debt-to-GDP ratio and the 'fiscal space'. In addition, we use the current account position, the real effective exchange rate and the rate of economic growth as fundamental variables affecting the spreads. The effects of these fundamental variables on the spreads can be described as follows.

- When the *government debt-to-GDP ratio* increases, the burden of the debt service increases leading to an increasing probability of default. This then in turn leads to an increase in the spread, which is a risk premium investors demand to compensate them for the increased default risk.<sup>7</sup>
- 'Fiscal space' is defined as the ratio of the government debt to total tax revenues. Aizenman & Hutchinson, 2012 argue that this is a better measure of debt sustainability than the debt-to-GDP ratio. A country may have a low debt-to-GDP ratio, yet find it difficult to service its debt because of a low capacity of raising taxes. In this case the ratio of government debt to tax revenues will be high, i.e. it takes a lot of years to generate the tax revenues necessary to service the debt.
- The *current account* has a similar effect on the spreads. Current account deficits should be interpreted as increases in the net foreign debt of the country as a whole (private and official residents). This is also likely to increase the default risk of the government for the following reason. If the increase in net foreign debt arises from the private sector's overspending it will lead to default risk of the private sector. However, the government is likely to be affected because such defaults lead to a negative effect on economic activity, inducing a decline in government revenues and an increase in

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<sup>6</sup> Attinasi et al. (2009), Arghyrou & Kontonikas (2010), Gerlach et al. (2010), Schuknecht et al. (2010), Caceres et al. (2010), Caporale & Girardi (2011), Gibson et al. (2011), Aizenman & Hutchinson (2012) and Beirne & Fratzscher (2012). There is of course a vast literature on the spreads in the government bond markets in general. See for example the classic Eaton et al. (1986) and Eichengreen & Mody (2000). Much of this literature has been influenced by the debt problems of emerging economies. See for example, Edwards (1984 and 1986) and Min (1998).

<sup>7</sup> We also experimented with the government deficit to GDP ratio. But this variable does not have a significant effect in any of the regressions we estimated.

government budget deficits. If the increase in net foreign indebtedness arises from government overspending, it directly increases the government's debt service, and thus the default risk.

- The *real effective exchange rate* as a measure of competitiveness can be considered as an early warning variable indicating that a country that experiences a real appreciation will run into problems of competitiveness, which in turn will lead to future current account deficits, and future debt problems. Investors may then demand an additional risk premium.
- *Economic growth* affects the ease with which a government is capable of servicing its debt. The lower the growth rate the more difficult it is to raise tax revenues. As a result a decline of economic growth will increase the incentive of the government to default, raising the default risk and the spread.

We specify the econometric equation both in a linear and a non-linear form. The reason why we also specify a non-linear relationship between the spread and the debt-to-GDP ratio comes from the fact that every decision to default is a discontinuous one, and leads to high potential losses. Thus, as the debt-to-GDP ratio increases, investors realize that they come closer to the default decision, making them more sensitive to a given increase in the debt-to-GDP ratio (Giavazzi & Pagano, 1996).

The linear equation is specified as follows:

$$I_{it} = \alpha + z * CA_{it} + \gamma * Debt_{it} + \mu * REE_{it} + \delta * Growth_{it} + \alpha_i + u_{it}$$

where  $I_{it}$  is the interest rate spread of country  $i$  in period  $t$ ,  $CA_{it}$  is the current account surplus of country  $i$  in period  $t$ , and  $Debt_{it}$  is either the government debt-to-GDP ratio or the fiscal space of country  $i$  in period  $t$ ,  $REE_{it}$  is the real effective exchange rate,  $Growth_{it}$  is GDP growth rate,  $\alpha$  is the constant term and  $\alpha_i$  is country  $i$ 's fixed effect. The latter variable measures the idiosyncrasies of a country that affect its spread and that are not time dependent. For example, the efficiency of the tax system, the quality of the governance, and many other variables that are country-specific are captured by the fixed effect.

The non-linear specification is as follows:

$$I_{it} = \alpha + z * CA_{it} + \gamma_1 * Debt_{it} + \mu * REE_{it} + \delta * Growth_{it} + \gamma_2 * (Debt_{it})^2 + \alpha_i + u_{it}$$

A methodological note should be made here. In the existing empirical literature there has been a tendency to add a lot of other variables on the right hand side of the two equations. In particular, researchers have added risk measures and ratings by rating agencies as additional explanatory variables of the spreads. The problem with this is that risk variables and ratings are unlikely to be exogenous. When a sovereign debt crisis erupts in the eurozone, all these risk variables increase, including the so-called 'systemic risk' variables. Similarly, as rating agencies tend to react to movements in spreads, the latter also are affected by increases in the spreads. Including these variables in the regression is likely to improve the fit dramatically without, however, adding to the explanation of the spreads. In fact, the addition of these variables creates a risk of false claims that the fundamental model explains the spreads well.

After having established by a Hausmann test that the random effect model is inappropriate, we used a fixed effect model. A fixed effect model helps to control for unobserved time-invariant variables and produces unbiased estimates of the 'fundamental' variables. The results of estimating the linear and non-linear models are shown in Tables 1 (eurozone) and 2 ('stand-alone' countries). These results lead to the following interpretations.

Table 1. Government bond spread in eurozone (2000Q1-2011Q3)

	(1)	(2)	(3)	(4)
Current account GDP ratio	0.0243 [0.0417]	0.0409 [0.0425]	0.0191 [0.0442]	0.0356 [0.0414]
Real effective exchange rate	0.0278 [0.0179]	0.0181 [0.0201]	0.0206 [0.0179]	0.0047 [0.0136]
Growth rate	-0.0698 [0.0496]	-0.0526*** [0.0103]	-0.0604 [0.0411]	-0.0427*** [0.0053]
Debt-to-GDP ratio	0.0818*** [0.0148]	-0.0553* [0.0300]		
Debt-to-GDP ratio squared		0.0009*** [0.0002]		
Fiscal space			2.7284*** [0.4589]	-1.8316*** [0.2557]
Fiscal space squared				0.9270*** [0.0634]
Country fixed effect	controlled	controlled	controlled	controlled
Observations	470	470	470	470
R <sup>2</sup>	0.6601	0.7989	0.6960	0.8549

Cluster at country level and robust standard error is shown in brackets. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 2. Government bond spread in 'stand-alone' countries (2000Q1-2011Q3)

	(1)	(2)	(3)	(4)
Current account GDP ratio	0.0184 [0.0166]	0.0200 [0.0182]	0.0161 [0.0183]	0.0137 [0.0211]
Real effective exchange rate	0.0019 [0.0082]	0.0030 [0.0074]	0.0013 [0.0081]	0.0006 [0.0081]
Change in exchange rate	-0.0273** [0.0098]	-0.0234** [0.0098]	-0.0274** [0.0097]	-0.0264** [0.0095]
Growth rate	-0.0229 [0.0284]	-0.0253 [0.0286]	-0.0249 [0.0290]	-0.0282 [0.0304]
Debt-to-GDP ratio	0.0102 [0.0077]	-0.0164 [0.0124]		
Debt-to-GDP ratio squared		0.0001*** [0.0000]		
Fiscal space			0.2258 [0.2014]	-0.2155 [0.4528]
Fiscal space squared				0.0474 [0.0444]
Country fixed effect	controlled	controlled	controlled	controlled
Observations	658	658	658	658
R <sup>2</sup>	0.8423	0.8504	0.8409	0.8439

Cluster at country level and robust standard error is shown in brackets. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

First, the debt-to-GDP ratio and the fiscal space variables have significant effects on the spreads in the eurozone. The fiscal space variable appears to have a slightly higher explanatory power as can be seen from the fact that the R<sup>2</sup> is higher when we use the fiscal space variable instead of the debt-to-GDP ratio. In contrast, the debt-to-GDP ratio and the fiscal space variables have little impact on the spreads in the stand-alone countries (the coefficients are much lower and insignificant).

Second, the non-linear specification both for the debt-to-GDP ratio and the fiscal space variables improve the fit in the eurozone countries. This can be seen from the fact that the R-square in Table 1 increases in the non-linear specification. In addition, the squared debt-to-GDP ratio and the fiscal space variables are very significant. Thus, an increasing debt-to-

GDP ratio and fiscal space have a non-linear effect on the spreads in the eurozone, i.e. a given increase of these ratios have a significantly higher impact on the spread when these ratios are high. The contrast with the stand-alone countries is strong. In these countries no such non-linear effects exist. Financial markets do not seem to be concerned with the size of the government debt and of the fiscal space and their impacts on the spreads of stand-alone countries, despite the fact that the variation of these ratios is of a similar order of magnitude as the one observed in the eurozone. This result tends to confirm the fragility hypothesis of the eurozone, i.e. financial markets are less tolerant towards high debt-to-GDP ratios and fiscal space in the eurozone countries than in the stand-alone countries.

As the theory predicts, the GDP growth rate has a negative impact on the spreads in the eurozone. In the 'stand-alone' countries no significant growth effect is detected. The other fundamental variables (current account GDP ratio and real effective exchange rate) do not seem to have significant effects on the spreads, both in the eurozone and in the 'stand-alone' countries. The change of exchange rate seems to have a significant impact on the spread but the sign is not expected. The negative sign suggests that the 'carry trade' has been a significant factor, i.e. countries have low (high) interest rates tend to experience currency depreciations (appreciations).

The graphical analysis of the previous section suggests that a structural break occurs at the time of the financial crisis. A Chow test revealed that a structural break occurred in the eurozone and the 'stand-alone' countries around the year 2008. This allows us to treat the pre- and post-crisis periods as separate and we show the results in Table 3.

In general, the results confirm that since 2008 the markets have become more cautious towards some key economic fundamentals that are associated with higher spreads. To be specific, in both the eurozone and 'stand-alone' countries, the coefficients of the debt-to-GDP ratio and the fiscal space variable are low and insignificant prior to the crisis. In the post-crisis period these coefficients become larger and are statistically significant.<sup>8</sup> Moreover, the coefficient of the real effective exchange rate is negative prior to the crisis and this negative effect does not last any more.

However, the contrast in the post-crisis period between the eurozone and 'stand-alone' countries are striking. The coefficients of the debt-to-GDP ratio and the fiscal space in the eurozone are much larger than in the 'stand-alone' countries. Similarly, the coefficient of the real effective exchange rate in the eurozone is significant, while no significant relationship exists in the 'stand-alone' countries.

The contrast between the eurozone and 'stand-alone' countries is also made clear by a pooled regression of the eurozone and the 'stand-alone' countries. We do this in Table 4. We have added three interaction variables "Debt-to-GDP\*eurozone", "Debt-to-GDP\*Fiscal Space" and "Real effective exchange rate\* eurozone". The "Debt-to-GDP\*eurozone" and the "Debt-to-GDP\*Fiscal Space" measure the degree to which these measures of debt sustainability affect the eurozone spreads differently from the 'stand-alone' countries. The "Real effective exchange rate\* eurozone" measures the degree to which the real effective exchange rate affects the eurozone spreads differently from the 'stand-alone' countries. The results of Table 4 confirm the previous results. The debt sustainability measures and the real effective exchange rate are much stronger and significant variables in the eurozone than in the 'stand-alone' countries, especially in the post-crisis period. The 'stand-alone' countries seem to be able to "get away with murder" and still not be disciplined by financial markets.

<sup>8</sup> Similar results are obtained by Schuknecht et al. (2010), Arghyrou & Kontonikas (2010), Borghy et al. (2011), Gibson et al. (2011), Beirne & Fratzscher (2012) and Ghosh & Ostry (2012).

Table 3. Government bond spread (structural break) in eurozone and “stand-alone” countries

	Eurozone				‘Stand-alone’ countries			
	Pre-crisis	Post-crisis	Pre-crisis	Post-crisis	Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
Current account GDP ratio	-0.0057	0.0521	-0.0058	0.0203	-0.0272	0.0078	-0.0299	0.0108
	[0.0056]	[0.0592]	[0.0054]	[0.0524]	[0.0230]	[0.0130]	[0.0243]	[0.0137]
Real effective exchange rate	-0.0144**	0.2912**	-0.0144**	0.2961**	-0.0208*	0.0024	-0.0195*	0.0018
	[0.0035]	[0.1111]	[0.0034]	[0.1044]	[0.0101]	[0.0112]	[0.0103]	[0.0116]
Growth rate	-0.0007	0.0003	-0.0013	0.0087	-0.0098	-0.0133	-0.0104	-0.0116
	[0.0032]	[0.0236]	[0.0034]	[0.0195]	[0.0582]	[0.0193]	[0.0568]	[0.0203]
Debt-to-GDP ratio	0.0032	0.1485**			-0.0015	0.0246**		
	[0.0019]	[0.0293]			[0.0139]	[0.0073]		
Fiscal space			0.1412	4.8318**			0.0657	0.6736**
			[0.0831]	[0.8438]			[0.3292]	[0.1973]
Change in exchange rate					-0.0555**	-0.0008	-0.0558**	-0.0011
					[0.0127]	[0.0079]	[0.0128]	[0.0077]
Country fixed effect	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled
Observations	320	150	320	150	448	210	448	210
R <sup>2</sup>	0.6820	0.7929	0.6888	0.8128	0.8356	0.9493	0.8357	0.9486

Cluster at country level and robust standard error is shown in brackets. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

Table 4. Government bond spread in 'stand-alone' countries and eurozone (%)

	(1)	(2)	(3)	(4)	(5)	(6)
	Total sample	Pre-crisis	Post-crisis	Total sample	Pre-crisis	Post-crisis
Current account GDP ratio	0.0204 [0.0175]	-0.0198 [0.0129]	0.0167 [0.0164]	0.0172 [0.0188]	-0.0211 [0.0131]	0.0122 [0.0150]
Debt-to-GDP ratio	0.0095 [0.0076]	-0.0016 [0.0136]	0.0240*** [0.0070]			
Debt-to-GDP ratio*eurozone	0.0748*** [0.0195]	0.0052 [0.0137]	0.1274*** [0.0325]			
Real effective exchange rate	0.0014 [0.0080]	-0.0205* [0.0100]	0.0014 [0.0112]	0.0009 [0.0079]	-0.0195* [0.0101]	0.0010 [0.0116]
Real effective exchange rate*eurozone	0.0343 [0.0219]	0.0041 [0.0104]	0.2818** [0.1112]	0.0256 [0.0210]	0.0029 [0.0108]	0.2810** [0.1060]
Growth rate	-0.0384 [0.0253]	-0.0086 [0.0390]	-0.0103 [0.0148]	-0.0365 [0.0238]	-0.0091 [0.0376]	-0.0065 [0.0152]
Change in exchange rate	-0.0296*** [0.0105]	- 0.0554*** [0.0111]	-0.0008 [0.0082]	-0.0291*** [0.0103]	- 0.0557*** [0.0112]	-0.0006 [0.0079]
Fiscal space				0.2152 [0.1992]	0.0455 [0.3236]	0.6615*** [0.1827]
Fiscal space*eurozone				2.5743*** [0.5977]	0.1127 [0.3298]	4.1517*** [0.9305]
Country fixed effect	controlled	controlled	controlled	controlled	controlled	controlled
Observations	1128	768	360	1128	768	360
R <sup>2</sup>	0.7785	0.8376	0.8652	0.7904	0.8377	0.8761

Cluster at country level and robust standard error is shown in brackets. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

To summarize, we find a great contrast between the eurozone and the 'stand-alone' countries. In the former, we detected a significant increase in the effect of the debt sustainability measures and the real effective exchange rate on the spreads since 2008. Such an increase is completely absent in the 'stand-alone' countries. Second, there appears to be significant departures of the spreads from their fundamental values in the eurozone countries after the start of the crisis, suggesting that time dependent movements in market sentiments become important. This does not seem to be observed in the 'stand-alone' countries. We analyze these time-dependent departures in the next section.

## 5. Introducing time dependency

As will be remembered, an important element of the fragility hypothesis and of its capacity to generate self-fulfilling crises is that it can lead to movements in the spreads that appear to be unrelated to the fundamental variables of the model. We want to test this hypothesis by measuring the importance of time-dependent effects on the spreads that are unrelated to the fundamentals. In order to do so, we introduce time dependency in the basic fixed-effect model. In the non-linear specification this yields:

$$I_{it} = \alpha + z * CA_{it} + \gamma_1 * Debt_{it} + \mu * REE_{it} + \delta * Growth_{it} + \gamma_2 * (Debt_{it})^2 + \alpha_i + \beta_t + u_{it}$$

where  $\beta_t$  is the time dummy variable. This measures the time effects that are unrelated to the fundamentals of the model or (by definition) to the fixed effects. If significant, it shows that the spreads move in time unrelated to the fundamentals forces driving the yields.

We estimated this model for both the stand-alone and the eurozone countries. In addition, we estimated the model separately for two subgroups of the eurozone, i.e. the core and the periphery.<sup>9</sup> The results are shown in Table 5.

Table 5. Government bond spread regression with time component (%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Stand-alone	Eurozone	Core	Periphery	Stand-alone	Eurozone	Core	Periphery
Current account/GDP ratio	0.0190 [0.0216]	0.0628 [0.0380]	-0.0099 [0.0133]	0.0381 [0.0541]	0.0149 [0.0208]	0.0544 [0.0343]	-0.0093 [0.0111]	0.0551 [0.0539]
Real effective exchange rate	0.0065 [0.0077]	0.0140 [0.0226]	0.0647** [0.0234]	0.0040 [0.0353]	0.0066 [0.0075]	0.0090 [0.0121]	0.0557** [0.0171]	0.0014 [0.0264]
Growth rate	-0.0245 [0.0425]	- 0.1311*** [0.0324]	0.0032 [0.0144]	- 0.0958** [0.0247]	-0.0308 [0.0408]	-0.0788** [0.0275]	0.0012 [0.0157]	-0.0885** [0.0247]
Change in exchange rate	-0.0145 [0.0093]				-0.0135 [0.0094]			
Debt/GDP ratio	0.0115 [0.0087]	-0.0538* [0.0242]	-0.0610* [0.0256]	-0.0619* [0.0234]				
Debt/GDP ratio squared		0.0008*** [0.0002]	0.0004* [0.0002]	0.0008** [0.0001]				
Fiscal space					0.3074 [0.2261]	- 2.1116*** [0.3851]	-3.0513* [1.1941]	-2.0340** [0.5729]
Fiscal space squared						0.8667*** [0.0699]	0.8207** [0.3186]	0.7331*** [0.1226]
2010Q2	-0.1454 [0.2881]	0.0326 [0.3726]	0.1081 [0.0880]	0.4846 [0.6592]	-0.1690 [0.3156]	0.2263 [0.2407]	0.1847* [0.0872]	0.6809 [0.5280]
2010Q3	-0.1042 [0.2598]	0.3226 [0.4801]	0.1343 [0.1057]	1.2979 [1.0810]	-0.1348 [0.2901]	0.4971 [0.4057]	0.2054 [0.1235]	1.5075 [1.0300]
2010Q4	-0.1275 [0.3048]	0.5379 [0.5322]	0.1856 [0.1337]	1.7012** [0.3813]	-0.1582 [0.3322]	0.6920* [0.3332]	0.2665 [0.1531]	1.9527*** [0.3231]
2011Q1	-0.4190 [0.3019]	0.4821 [0.5273]	0.1714 [0.1478]	1.5040** [0.2808]	-0.4517 [0.3284]	0.5814* [0.3140]	0.2571 [0.1699]	1.7363*** [0.2098]
2011Q2	-0.5446 [0.3360]	1.0023 [0.7615]	0.1524 [0.1307]	3.0390** [0.9228]	-0.5906 [0.3599]	1.1379* [0.5739]	0.2468 [0.1496]	3.3287** [1.0161]
2011Q3	-0.2805 [0.2722]	1.4995* [0.7627]	0.7036* [0.3462]	3.5781* [1.2372]	-0.3174 [0.3073]	1.6226** [0.6665]	0.7946 [0.3944]	3.8471* [1.4454]
Other quarterly dummies	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled

<sup>9</sup> Chow test shows a split between the new and early members. Core eurozone = Austria, Belgium, France, Finland, Italy, Netherlands. Periphery: Ireland, Greece, Portugal and Spain.



Country fixed effect	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled
Observations	658	470	282	188	658	470	282	188
R <sup>2</sup>	0.8602	0.8581	0.8287	0.9566	0.8600	0.9066	0.8288	0.9575

Cluster at country level and robust standard error is shown in brackets. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

The contrast between ‘stand-alone’ and eurozone countries is striking. The effect of the time variable in the stand-alone countries is weak. In the eurozone we detect some increasing positive time effect since 2010Q2. Noticeably there exist significant and positive time effects from 2010Q4 to 2011Q3 in the periphery of the eurozone. Thus, during the post-crisis period, the spreads in the peripheral countries of the eurozone were gripped by surges that were independent from the underlying fundamentals.

Finally we plot the time effects obtained from Table 5 in Figure 8a and 8b. This suggests, especially in the periphery, that ‘departures’ occurred in the spreads, i.e. an increase in the spreads that cannot be accounted for by fundamental developments, in particular by the changes in the debt-to-GDP ratios and fiscal space during the crisis.

This result can also be interpreted as follows. Before the crisis, the markets did not see any risk in the peripheral countries’ sovereign debt. As a result they priced the risks in the same way as the risk of core countries’ sovereign debt. After the crisis, spreads of the peripheral countries increased dramatically and independently from observed fundamentals. This suggests that the markets were gripped by negative sentiments and tended to exaggerate the default risks. Thus, mispricing of risks (in both directions) seems to have been an endemic feature in the eurozone.

Figure 8a. Time component (debt/GDP ratio regression)

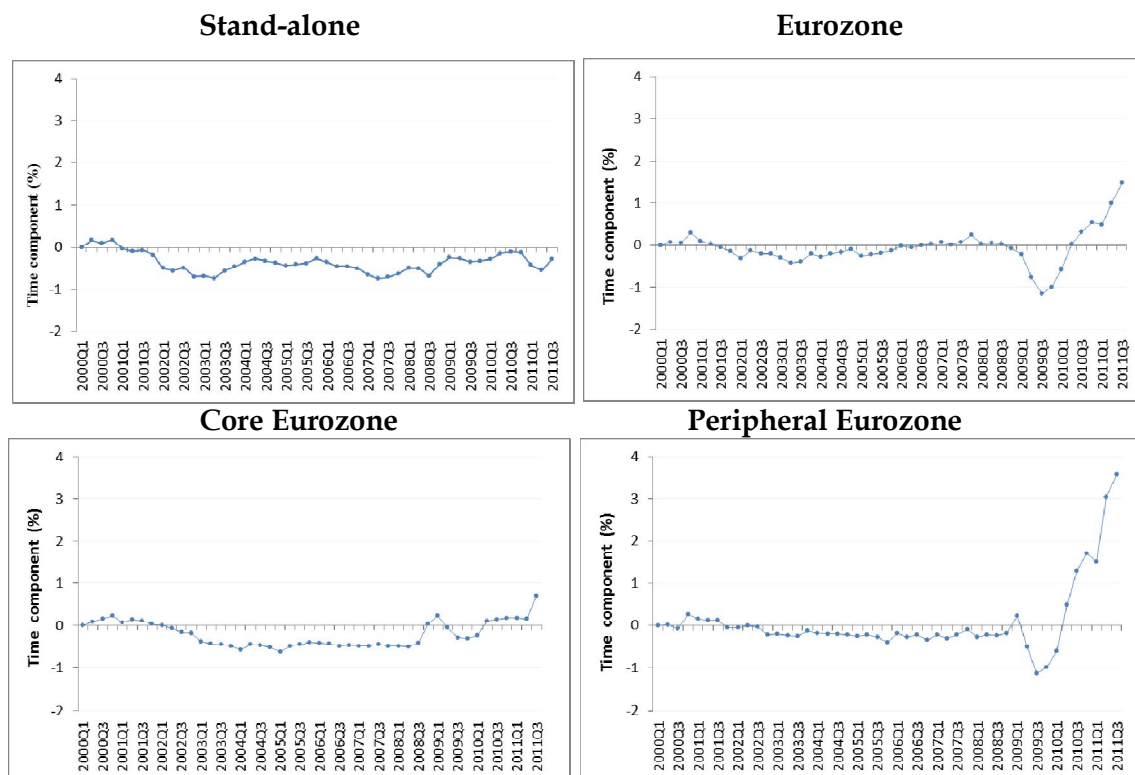
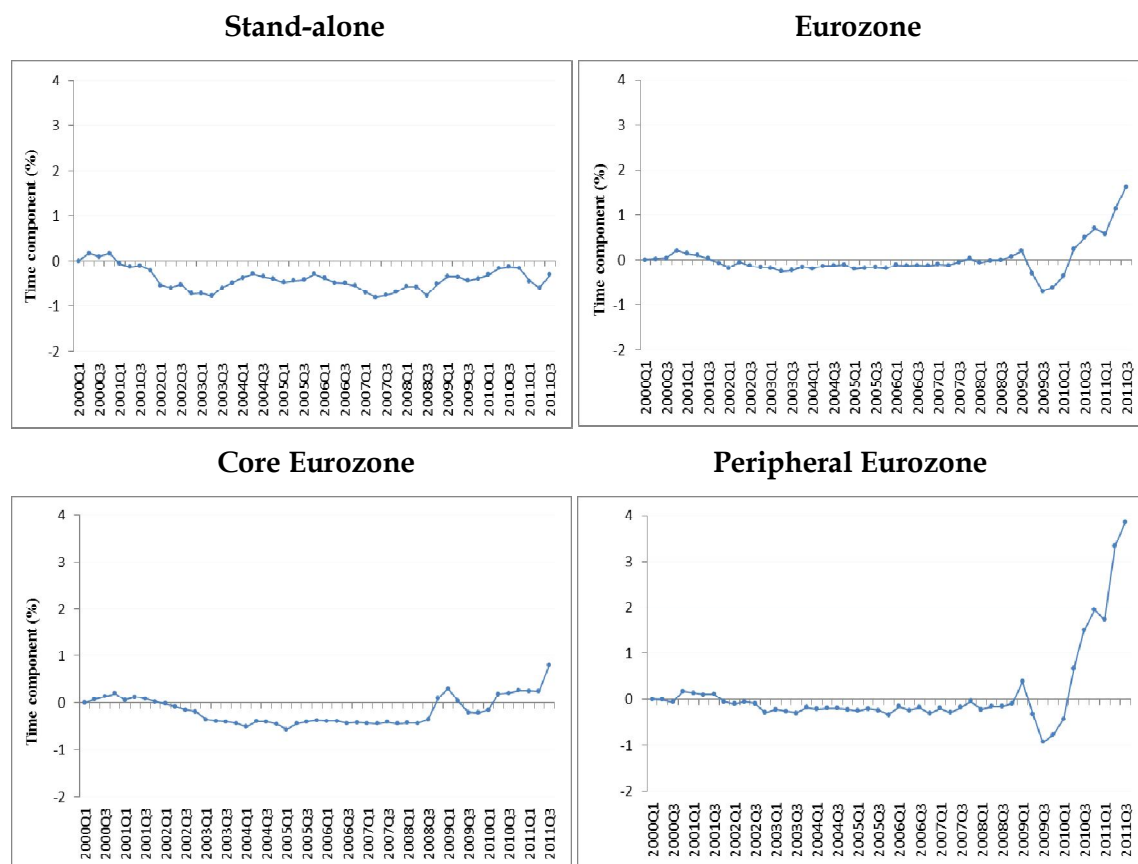


Figure 8b. Time component (fiscal space regression)



## 6. Tests for cross-sectional independence

The previous results suggest that a common factor, i.e. market sentiments, influences the spreads in the eurozone. Such a common factor does not seem to influence the spreads in the 'stand-alone' countries. The existence of a common factor in the eurozone spreads will create cross-country dependence in the error terms when we estimate the eurozone model without the common time variables. This cross-sectional dependence should disappear when we estimate the model with the time variables. We tested this by applying Pesaran's test for cross-sectional independence. For  $i \neq j$ , the null hypothesis is  $H_0: cov(u_{it}, u_{jt}) = 0$ .

The results are presented in Table 6. We observe that without the time variables the null hypothesis of cross-sectional independence should be rejected, while we maintain the hypothesis of independence when time variables are included. Thus when we estimate the model without time variables there is a common time factor in the error terms that disappears when we estimate the model with time variables. Table 6 also confirms that in the sample of stand-alone countries the error terms are not cross-sectionally correlated.

Finally we also performed unit root cointegration tests. These are presented in Appendix B. We find that the debt sustainability variables in both the eurozone and 'stand-alone' countries have a unit root. In addition, the variables of the eurozone model with time variables are cointegrated. The variables in the 'stand-alone' countries without time variables are cointegrated.

Table 6. Pesaran's test of cross sectional independence

	Debt to GDP ratio regression	Fiscal space regression
<b>Eurozone (without time variables)</b>	Reject cross sectional independence (p-value=0.0000)	Reject cross sectional independence (p-value=0.0000)
<b>Eurozone (with time variables)</b>	Cannot reject cross sectional independence (p-value=1.996)*	Cannot reject cross sectional independence (p-value=1.9917)
<b>Stand-alone (without time variable)</b>	Cannot reject cross sectional independence (p-value=1.483)	Cannot reject cross sectional independence (p-value=0.4497)

Note: \*p-value>1 is possible because of the two-sided p-values for non-symmetric distributions.

## 7. Explanatory power analysis

In this section we analyze the quantitative importance of the fundamental variables relative to the time dummies in explaining the changes in the spreads that have occurred since the start of the debt crisis. We proceed in two stages. We first compute the estimated spreads obtained from the models with and without the time dummies, and compare these with the observed spreads. In a second stage we perform a variance decomposition that allows us to measure the relative importance of the fundamentals and the time dummies in explaining the total variation in the spreads since 2008.

Figure 9 shows the simulated spreads obtained from the models with and without dummies together with the observed spreads for Greece, Ireland, Portugal and Spain. We observe that the model without the time dummies fails to track the large increases in the spreads observed since 2008. In contrast the model with time dummies closely tracks these observed surges in the spreads. This confirms our previous results, i.e. a large part of the increases in the spreads in the peripheral countries is the result of time dependent movements in sentiments that were independent from the underlying fundamentals.

This conclusion is confirmed by the variance decomposition of the total observed variation from 2008 to 2011. This decomposition is shown in Figure 10. The results lead to additional insights. We observe that in Portugal and Ireland about half of the total variation of the spreads is due to the time dummies and the other half to the fundamentals. In the case of Spain most of the surge in the spreads is due to the time dummies. Thus in the case of Spain the fundamentals had little to do with the increasing spread and most of the explanation comes from the changes in market sentiments vis-à-vis Spain. The opposite holds for Greece. In this country the surge in the spreads is mostly explained by deteriorating fundamentals (about 70%) while the time dummies explain less than 30%. The contrast between Spain and Greece is interesting. In the case of Spain it is mostly distrust that moved the spreads, while in the case of Greece it is mostly bad fundamentals. This suggests that financial markets were pricing the risk of Greek bonds correctly, but may have mispriced the risk of Spanish government bonds. Note that we observe a similar phenomenon in the cases of Italy and Belgium where the largest part in the surge of the spreads is explained by the time dummies. This creates the risk that markets may be pushing Spain (and Italy and Belgium) into a bad equilibrium, which could be avoided by policies aimed at taking the fear factor out of the market. Elsewhere we have argued that this could be done by lender-of-last-resort operations of the ECB (De Grauwe, 2011).

Figure 9. Simulated (with and without times dummies) and observed spreads in peripheral countries

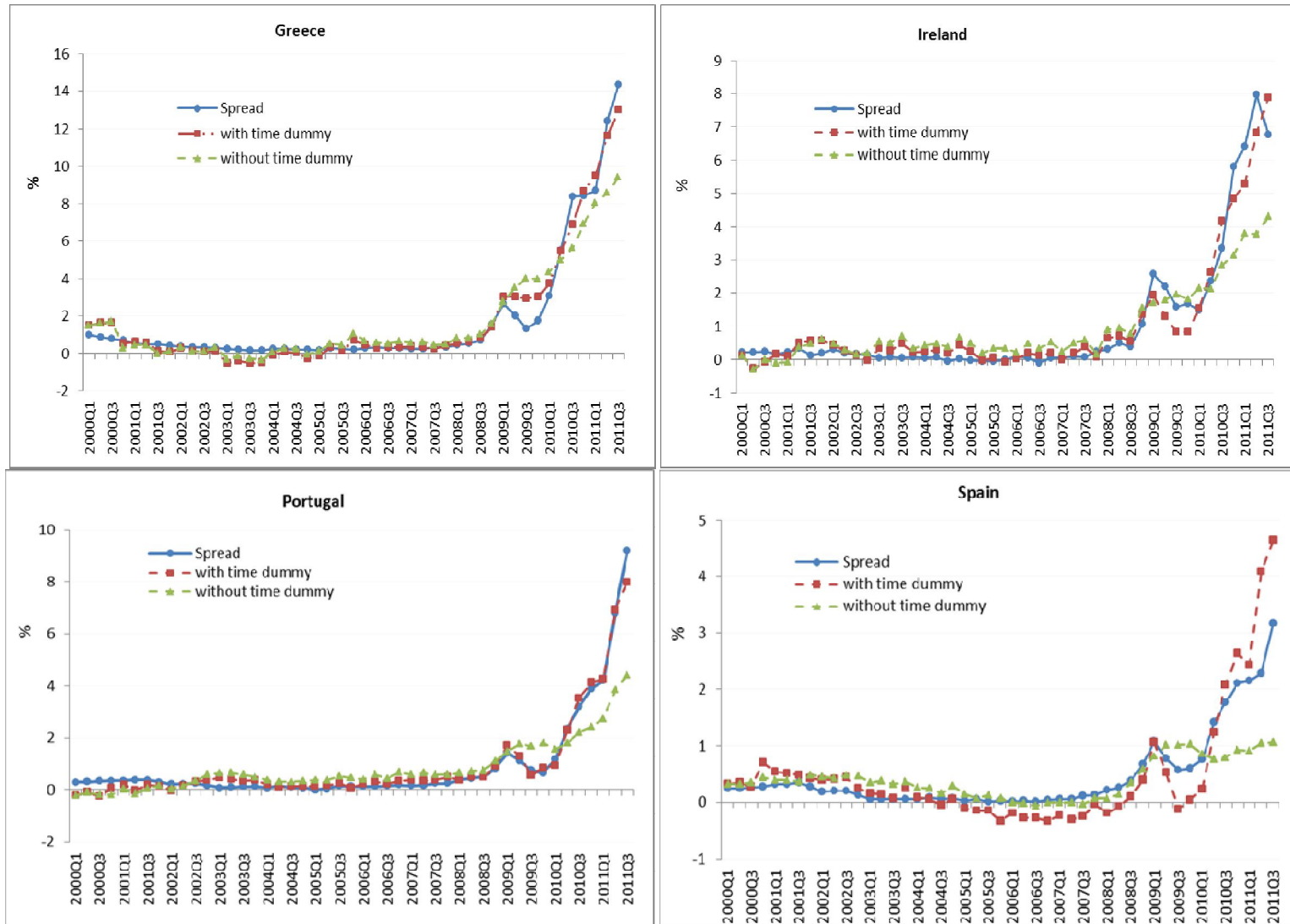
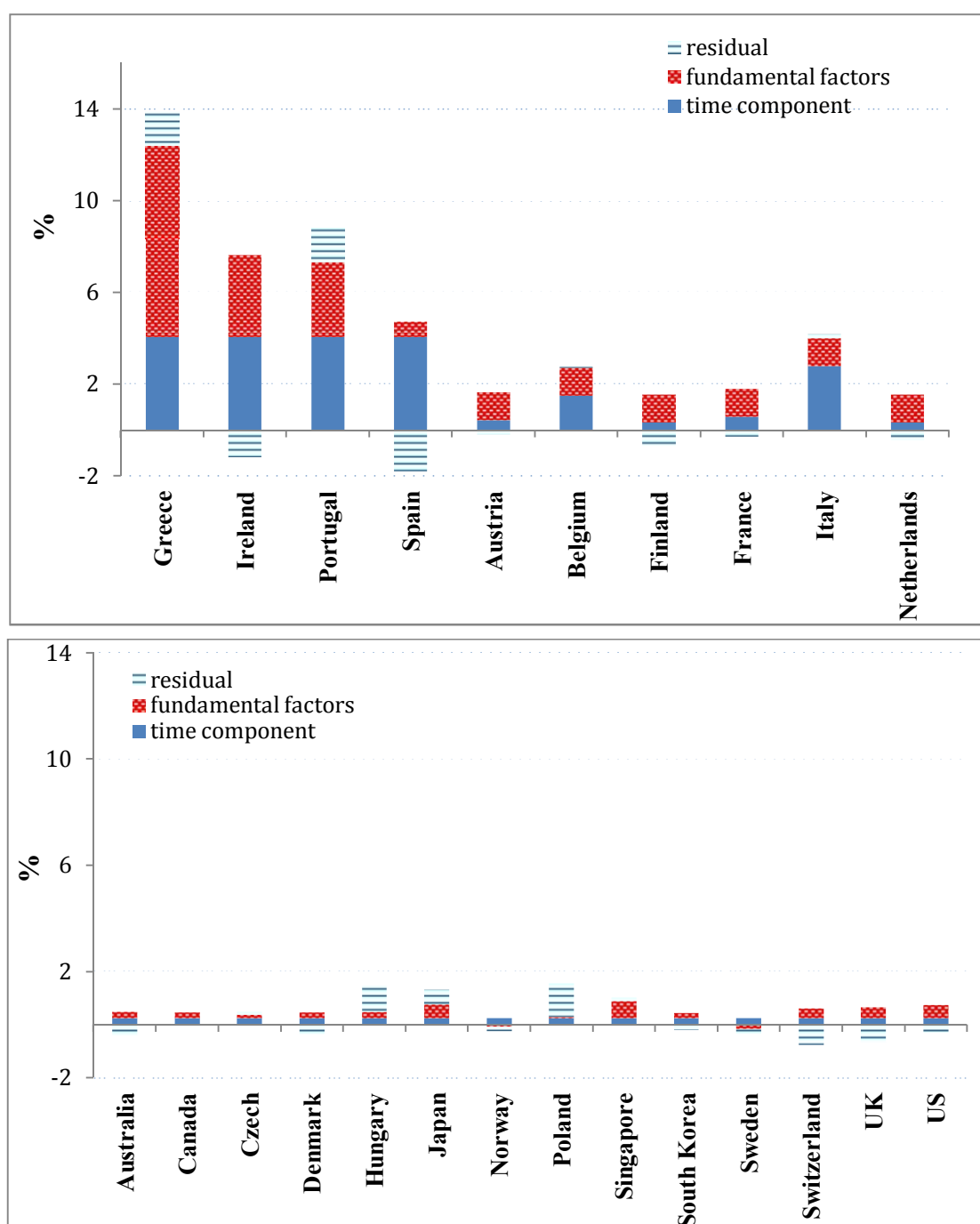


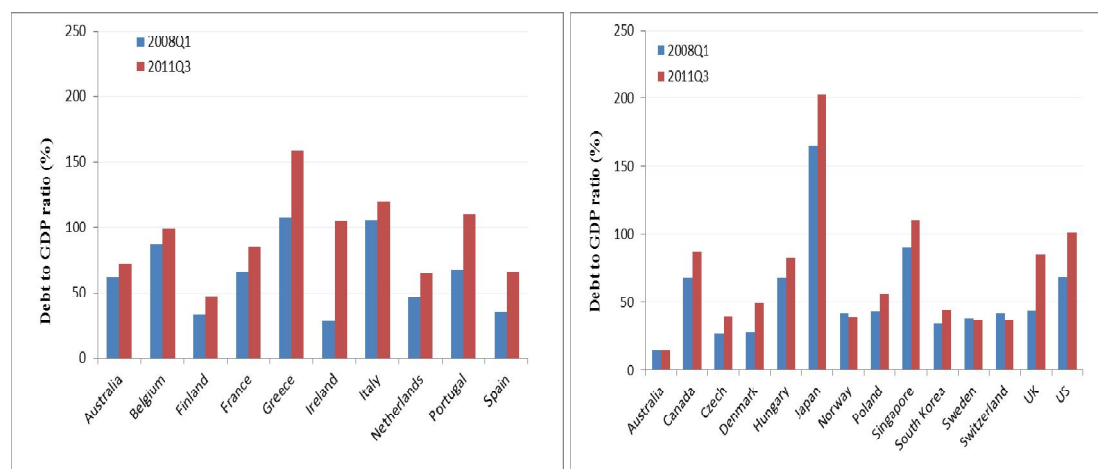
Figure 10. Variance decomposition of spreads



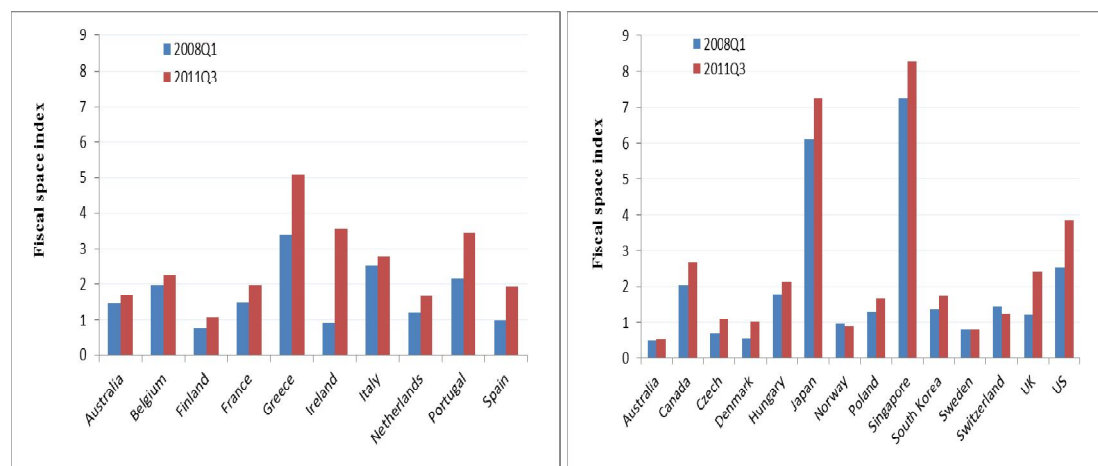
The contrast between the eurozone countries and the 'stand-alone' countries is made clear in Figure 11. As noted earlier, in the case of the 'stand-alone' countries, there is no significant increase in the spreads since the start of the financial crisis. As a result, there is very little to explain. This is remarkable because the variation in the two variables that measure debt sustainability in these countries (debt-to-GDP ratios and fiscal space) are at least as large as in the case of the eurozone countries. This is shown very vividly in Figure 11. Thus financial markets take the view that the build-up of the government debt measures does not lead to a default risk in 'stand-alone' countries. Financial markets do not punish 'stand-alone' countries for public debt accumulation that appears to be equally unsustainable as in the eurozone countries. This result also confirms our hypothesis that a monetary union is fragile

and can easily be hit by negative market sentiments, which can drive countries into default in a self-fulfilling manner.

Figure 11. Fiscal space index (pre-crisis and post-crisis)



Debt-to GDP-ratio (pre-crisis and post-crisis)



## 8. Conclusion

An important empirical puzzle concerning the sovereign debt crisis is that it erupted in the eurozone despite the fact that the fiscal position of the eurozone as a whole was better than the fiscal position of countries like the US and the UK that were left unscathed by the crisis. True Greece had accumulated unsustainable debt and deficit levels, but the other eurozone countries that were hit by the debt crisis were not in a worse fiscal position than the US and the UK.

Our explanation of this puzzle is along the lines developed in De Grauwe (2011), who argues that government bond markets in a monetary union are more fragile and more susceptible to self-fulfilling liquidity crises than in 'stand-alone' countries. The reason is that as the latter issue their own money, they give a guarantee to bondholders that the cash will always be available at maturity. The members of a monetary union cannot give such a guarantee and as a result are more vulnerable to negative market sentiments which can create a liquidity crisis in a self-fulfilling way. The purpose of this paper was to develop a test of this fragility hypothesis.

On the whole we confirm this hypothesis. We found evidence that a large part of the surge in the spreads of the PIGS countries during 2010-11 was disconnected from underlying increases in the debt-to-GDP ratios and fiscal space, and was the result of time dependent negative market sentiments that became very strong since the end of 2010. The stand-alone countries in our sample have been immune from these liquidity crises and weathered the storm without the increases in the spread.

We also found evidence that after years of neglecting high debt-to-GDP ratios, investors became increasingly worried about the high debt-to-GDP ratios in the eurozone, and reacted by raising the spreads. No such worries developed in 'stand-alone' countries despite the fact that debt-to-GDP ratios were equally high and increasing in these countries. This result can also be said to validate the fragility hypothesis, i.e. the markets appear to be less tolerant towards large public debt accumulations in the eurozone than towards equally large public debt accumulations in the 'stand-alone' countries.

Thus, the story of the eurozone is also a story of self-fulfilling debt crises, which in turn lead to multiple equilibria. Countries that are hit by a liquidity crisis are obliged to apply stringent austerity measures which force them into a recession, thereby reducing the effectiveness of these austerity programmes. There is a risk that the combination of high interest rates and deep recessions turns the liquidity crisis into a solvency crisis.

In a world where spreads are tightly linked to the underlying fundamentals such as the debt-to-GDP ratio and fiscal space, the only option the policy-makers have to reduce the spreads is to improve the fundamentals. This implies measures aimed at reducing the debt burden. If, however, there can be a disconnection between the spreads and the fundamentals, a policy geared exclusively towards affecting the fundamentals (i.e. reducing the debt burden) will not be sufficient. In that case policy-makers should also try to stop countries from being driven into a bad equilibrium. This can be achieved by more active liquidity policies by the ECB that aim at preventing a liquidity crisis from leading to a self-fulfilling solvency crisis (Wyplosz, 2011 and De Grauwe, 2011).

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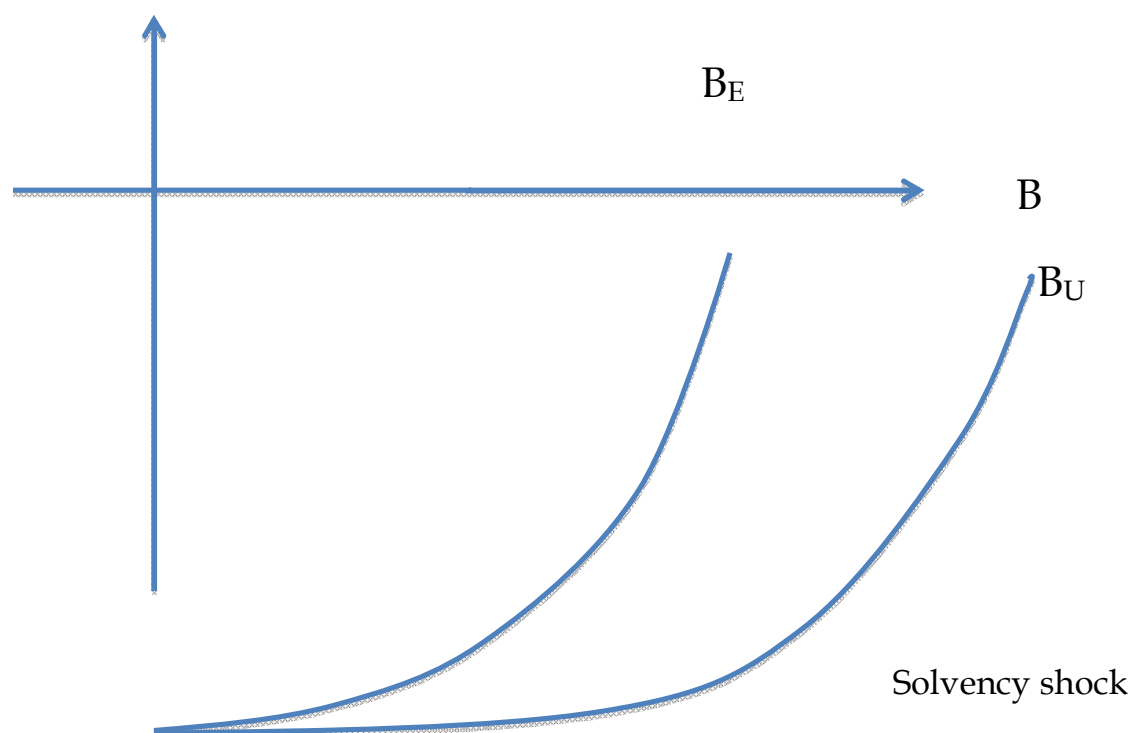
## Appendix A. A model of good and bad equilibria

In this section we present a very simple model illustrating how multiple equilibria can arise. The starting point is that there is a cost and a benefit of defaulting on the debt, and that investors take this calculus of the sovereign into account. We will assume that the country involved is subject to a shock, which takes the form of a decline in government revenues. The latter may be caused by a recession, or a loss of competitiveness. We'll call this a solvency shock. The higher this shock the greater is the loss of solvency. We concentrate first on the benefit side. This is represented in Figure A1. On the horizontal axis we show the solvency shock. On the vertical axis we represent the benefit of defaulting. There are many ways and degrees of defaulting. To simplify we assume this takes the form of a haircut of a fixed percentage. The benefit of defaulting in this way is that the government can reduce the interest burden on the outstanding debt. As a result, after the default it will have to apply less austerity, i.e. it will have to reduce spending and/or increase taxes by less than without the default. Since austerity is politically costly, the government profits from the default.

A major insight of the model is that the benefit of a default depends on whether this default is expected or not. We show two curves representing the benefit of a default.  $B_U$  is the benefit of a default that investors do not expect to happen, while  $B_E$  is the benefit of a default that investors expect to happen. Let us first concentrate on the  $B_U$  curve. It is upward sloping because when the solvency shock increases, the benefit of a default for the sovereign goes up. The reason is that when the solvency shock is large, i.e. the decline in tax income is large, the cost of austerity is substantial. Default then becomes more attractive for the sovereign. We have drawn this curve to be non-linear, but this is not essential for the argument. We distinguish three factors that affect the position and the steepness of the  $B_U$  curve:

- *The initial debt level.* The higher is this level, the higher is the benefit of a default. Thus with a higher initial debt level the  $B_U$  curve will rotate upwards.
- *The efficiency of the tax system.* In a country with an inefficient tax system, the government cannot easily increase taxation. Thus in such a country the option of defaulting becomes more attractive. The  $B_U$  curve rotates upwards.
- *The size of the external debt.* When external debt takes a large proportion of total debt there will be less domestic political resistance against default, making the latter more attractive (the  $B_U$  curve rotates upwards).

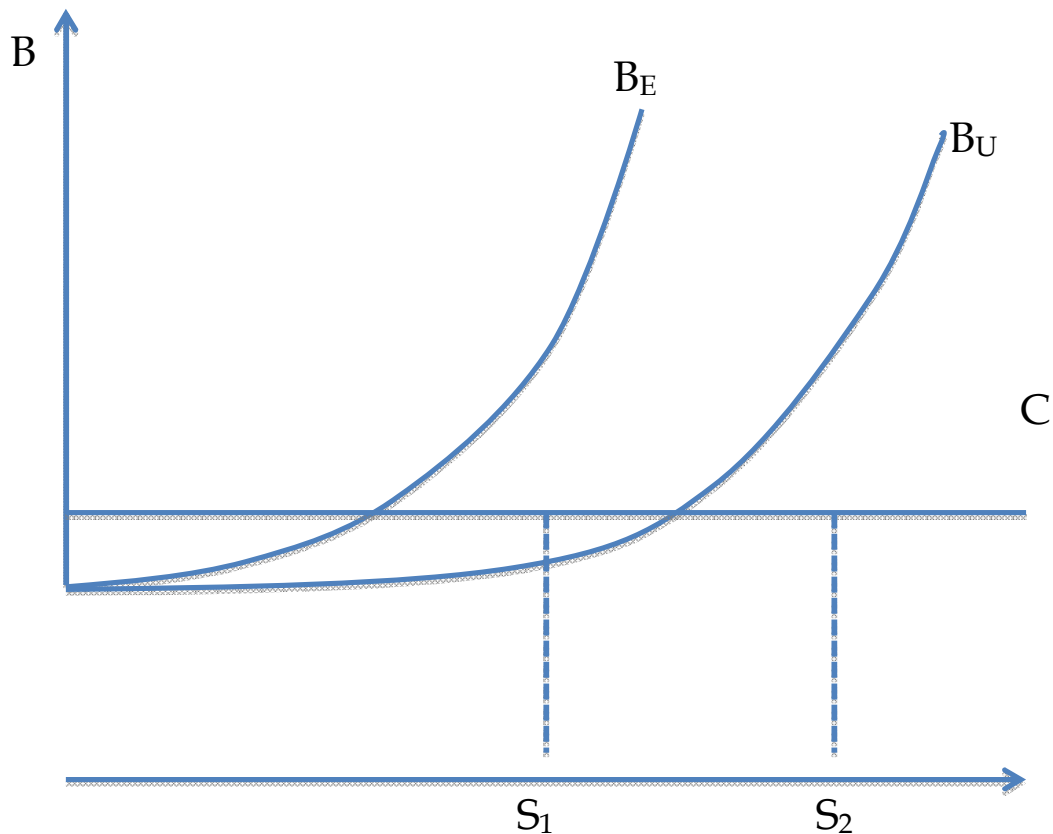
Figure A1. The benefits of default after a solvency shock



We now concentrate on the  $B_E$  curve. This shows the benefit of a default when investors anticipate such a default. It is located above the  $B_U$  curve for the following reason. When investors expect a default, they will sell government bonds. As a result, the interest rate on government bonds increases. This raises the government budget deficit requiring a more intense austerity program of spending cuts and tax hikes. Thus, default becomes more attractive. For every solvency shock, the benefits of default will now be higher than they were when the default was not anticipated.

We now introduce the cost side of the default. The cost of a default arises from the fact that, when defaulting, the government suffers a loss of reputation. This loss of reputation will make it difficult for the government to borrow in the future. We will make the simplifying assumption that this is a fixed cost. We now obtain Figure A2, which presents the fixed cost (C) with the benefit curves.

Figure A2. Cost and benefits of default after a solvency shock



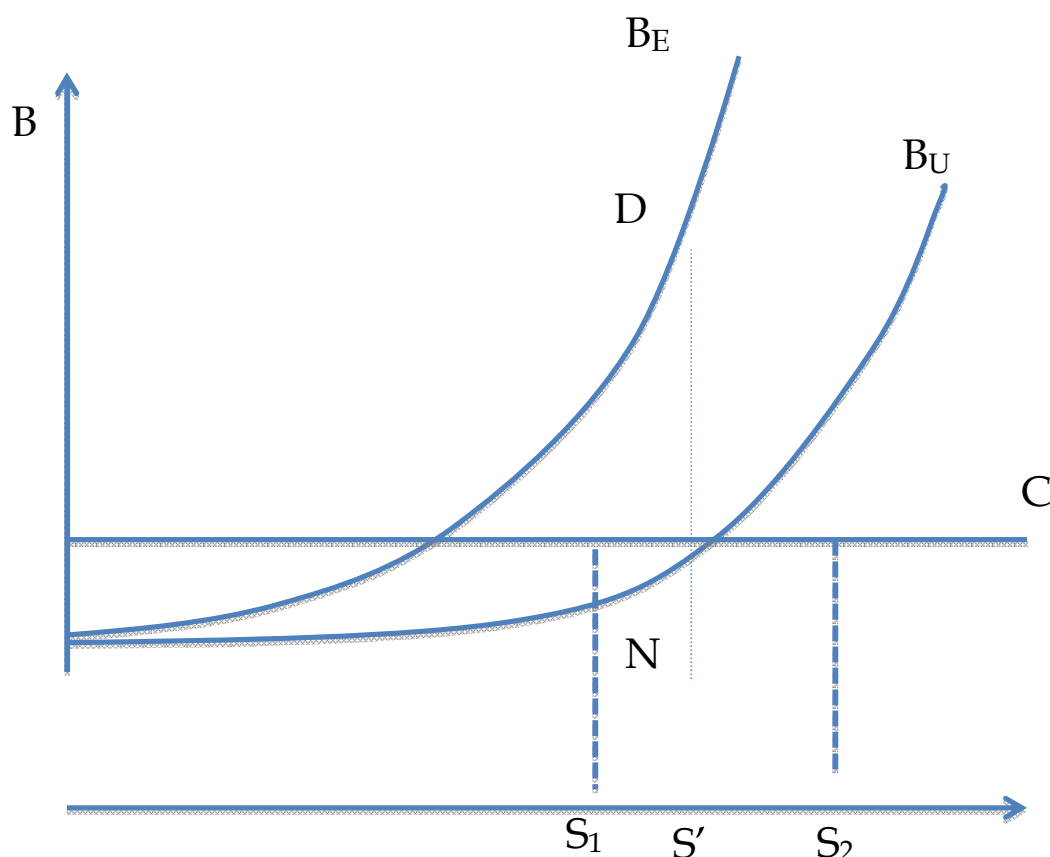
We now have the tools to analyze the equilibrium of the model. We will distinguish between three types of solvency shocks, a small one, an intermediate one, and a large one. Take a small solvency shock: this is a shock  $S < S_1$  (This could be the shocks that Germany and the Netherlands experienced during the debt crisis). For this small shock the cost of a default is always larger than the benefits (both of an expected and an unexpected default). Thus the government will not want to default. When expectations are rational investors will not expect a default. As a result, a no-default equilibrium can be sustained.

Let us now analyze a large solvency shock. This is one for which  $S > S_2$ . (This could be the shock experienced by Greece.) For all these large shocks we observe that the cost of a default is always smaller than the benefits (both of an expected and an unexpected default). Thus the government will want to default. In a rational expectations framework, investors will anticipate this. As a result, a default is inevitable.

We now turn to the intermediate case:  $S_1 < S < S_2$ . (This could be the shocks that Ireland, Portugal and Spain experienced). For these intermediate shocks I obtain an indeterminacy, i.e. two equilibria are possible. Which one will prevail only depends on what is expected. To see this, suppose the solvency shock is  $S'$  (see Figure A3). In this case there are two potential equilibria, D and N. Take point D. In this case investors expect a default (D is located on the  $B_E$  line). This has the effect of making the benefit of a default larger than the cost C. Thus, the government will default. D is an equilibrium that is consistent with expectations.

But point N is an equally good candidate to be an equilibrium point. In N, investors do not expect a default (N is on the  $B_U$  line). As a result, the benefit of a default is lower than the cost. Thus the government will not default. It follows that N is also an equilibrium point that is consistent with expectations.

Figure A3. Good and bad equilibria



Thus we obtain two possible equilibria, a bad one (D) that leads to default, a good one (N) that does not lead to default. Both are equally possible. The selection of one of these two points only depends on what investors expect. If the latter expect a default, there will be one; if they do not expect a default there will be none. This remarkable result is due to the self-fulfilling nature of expectations.

Since there is a lot of uncertainty about the likelihood of default, and since investors have very little scientific foundation to calculate probabilities of default (there has been none in Western Europe in the last 60 years), expectations are likely to be driven mainly by market sentiments of optimism and pessimism. Small changes in these market sentiments can lead to large movements from one type of equilibrium to another.

The possibility of multiple equilibria is unlikely to occur when the country is a stand-alone country, i.e. when it can issue sovereign debt in its own currency. This makes it possible for the country to always avoid outright default because the central bank can be forced to provide all the liquidity that is necessary to avoid such an outcome. This has the effect that there is only one benefit curve. In this case the government can still decide to default (if the solvency shock is large enough). But the country cannot be forced to do so by the whim of market expectations.

## Appendix B. Additional tests: Unit root and cointegration

Unit root test ( $H_0$  hypothesis: Panels contain unit roots)

Variable	LLC test: p-value	Breitung test: p-value	IPS test: p-value
<b>Eurozone:</b>			
Spread	1.0000	1.0000	1.0000
Debt-to-GDP ratio	0.9985	1.0000	1.0000
Fiscal space	1.0000	1.0000	1.0000
Current account to GDP ratio	0.4763	0.2533	0.5324
Real effective exchange rate	0.2553	0.5947	0.7914
Growth rate	0.0042	0.0281	0.0277
<b>Stand-alone:</b>			
Spread	0.0001	0.0961	0.0209
Debt-to-GDP ratio	0.2222	0.9940	0.9567
Fiscal space	0.4199	0.9949	0.9878
Current account to GDP ratio	0.0227	0.0043	0.0981
Real effective exchange rate	0.0378	0.3613	0.1941
Growth rate	0.0000	0.0001	0.0000
Change of exchange rate	0.0000	0.0000	0.0000

**Cointegration Test:** Kao Residual Cointegration Test (reject “no cointegration”)

Econometrics Reference:

Kao, C. “Spurious Regression and Residual-Based Tests for Cointegration in Panel Data”, *Journal of Econometrics*, 1999, 90, 1-44.

$$\hat{u}_{it} = \rho \hat{u}_{it-1} + \sum_{j=1}^p \varphi_j \Delta \hat{u}_{it-j} + v_{it}$$

Non-hypothesis  $\rho = 1$ , no cointegration

	<b>Debt/GDP ratio regression</b>	<b>Fiscal Space regression</b>
<b>Eurozone countries (with time component)</b>	Reject “no cointegration” (p-value=0.0000)	Reject “no cointegration” (p-value=0.0000)
<b>Stand-alone countries (without time component)</b>	Reject “no cointegration” (p-value=0.0000)	Reject “no cointegration” (p-value=0.0000)



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