The importance of expectations in determining sovereign spreads

Natalia Poiatti[†]

Abstract This paper investigates how changes in expectations regarding the ability of the European Monetary Union to address the debt crisis have asymmetrically impacted the cost of sovereign borrowing in central and peripheral European countries. It shows that most of the variations in sovereign spreads can be explained by fundamentals in a model that allows for structural breaks. We test for both the presence and the time of structural breaks, deriving their asymptotic distribution and confidence intervals. The two estimated breakpoints are: the second quarter of 2010, a period when financial markets lacked confidence in a resolution for the crisis; and the third quarter of 2010, when financial markets regained confidence following Mario Draghi's 'whatever it takes' announcement. Market fears, measured by the degree of international risk aversion, became more important to price sovereign debt only for peripheral economies during the crisis.

Keywords: Debt crisis; Expectations; Macroeconomic fundamentals; Sovereign spreads; Structural breaks.
JEL Code: C23, D84, E44, F34, H63.

1. Introduction

Since the European sovereign debt crisis, criticisms against the existence of the European Monetary Union (EMU) have surged. According to theory, an optimum currency area requires either symmetric business cycles or a high degree of economic integration across member countries when they forego the discretion of monetary policies to mitigate negative economic outcomes. However, some EMU members do not exhibit a high degree of labor mobility, export diversification or symmetric economic shocks compared to other members.

In addition, some member countries have violated the Stability and Growth Pact, accumulating debt surpassing the 60% of GDP threshold. It is likely that both peripheral and central EMU bonds were perceived as safe or low-risk assets in international financial markets, despite the Maastricht treaty containing a "no bailout" clause. When the global financial crisis severely hit Europe, the implementation of expansionary fiscal policies, aimed at financially stim-

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ulating the recovery of national banks and firms, ended up exacerbating the accumulation of unsustainable stocks of debt.

In the second quarter of 2010, EMU authorities agreed on a plan to partially bailout Greece, contingent on the implementation of fiscal austerity. However, protests in Greece against wage cuts and other unpopular measures, combined with the opposition of the German society to participate in the rescue plan, led to fears of crisis contagion to other European countries. At that moment, EMU governments and the ECB were not prepared to fully bailout Greece, and faced significant popular and political opposition in addressing the crisis. Financial markets were not confident there would be an EMU solution for the crisis.

Subsequently, we show that the European sovereign spreads may have started to reflect more closely the domestic economic realities and ability to repay of individual issuers, exerting a more pronounced impact on sovereign spreads. Congruently, we also show that changes in the domestic economic fundamentals may also have had a lower impact on spreads following July 2012, when Mario Draghi, then president of the ECB, announced: "within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." After this declaration of financial solidarity, financial markets could regain confidence in the ability of the EMU to solve the crisis. Chang and Leblond (2014) also argue the ECB announcement was successful in controlling market fears of a euro breakup, employing a qualitative methodology.

By applying an econometric model, we explore the dynamic of sovereign euro spreads over business cycles, as a function of macroeconomic fundamentals. This model accounts for multiple structural breaks that can be linked to changes in expectations regarding the ability of the EMU to solve the crisis.

A strand of the literature underscores the importance of parameter instability in the relationship between European spreads and their explanatory factors, imposing exogenous breakpoints (Arghyrou and Kontonikas, 2012). In fact, assuming the parameters are constant when they are subject to structural breaks can lead to incorrect inference. Conversely, specifying breakpoints where none exist also leads to inconsistent estimators.

Instead, Bernoth and Erdogan (2012) model the endogenous time-varying relationship between spreads and their determining variables, by applying a semiparametric methodology to panel data for the euro area. Nevertheless, they overlook potential sources of heterogeneity across countries. To address this issue, Afonso et al. (2015) allow for country-specific slopes in monthly frequency panel data, focusing solely on financial explanatory variables.

In this paper, we also consider the impacts of macroeconomic fundamentals on spreads in a panel of euro countries, adopting a model that accommodates multiple breakpoints. We employ the methodology of Ditzen et al. (2021), which allows testing for both the number and the time of occurrence of breakpoints. To implement it, we run the sequential test for multiple breaks at unknown breakpoints (Bai and Perron, 1998; Ditzen et al., 2021), applying the asymptotic distributions reported in Ditzen et al. (2021) for panel data.

We consider the richness of information provided by panel data to consistently identify the breakpoints, which can be achieved by assuming these breakpoints are shared by all countries in the sample (Bai, 2010). In fact, the estimated breakpoints can be interpreted as changes in expectations regarding the ability of the EMU to manage the euro crisis. The first, when popular protests in Greece against the fiscal austerity conditionalities of the ECB partial bailout programs lead to fears of crisis contagion across Europe; and the second, when Mario Draghi, then president of the ECB, said they would do whatever it takes to save the euro. This methodology also controls for possible sources of unobserved heterogeneity, which is important in panel data usually employed in macro-finance where included regressors do not account for important sources of co-movement across asset prices. This is especially important when the unobserved source of co-movement is correlated with the included regressors, leading to inconsistency.

All in all, this paper shows how the confidence on the ability of the EMU to solve the European debt crisis has impacted the cost of sovereign borrowing in both central and peripheral European countries. We argue the cost of sovereign borrowing became more responsive to changes in domestic economic fundamentals since the second term of 2010, when markets became hesitant that there would not be a solution for the crisis. Since then, we show the peripheral European bonds became more vulnerable to market fears and to the increase in global risk aversion, being subject to a severe market sell-off and financial outflow to better quality assets 'flight to quality' (Caballero and Krishnamurthy, 2008). In contrast, central European bonds remained relatively insulated from escalating market anxieties, although also becoming more sensitive to changes in domestic economic fundamentals.

After Mario Draghi's 'whatever it takes' announcement and the recovery of confidence in the EMU's crisis-resolution capabilities, the cost of sovereign borrowing became less responsive to changes in domestic economic fundamentals and the peripheral bonds became less subject to market fears.

The next sections are organized as follows: Section 2 shows the empirical facts; Section 3 defines the methodological approach; Section 4 gives the

model estimation results and Section 5 concludes.

2. Empirical facts

This paper analyzes the dynamics of sovereign spreads for the peripheral European countries most severely affected by the European debt crisis: Portugal, Ireland, Italy, Greece and Spain (PIIGS), and for the central countries: Austria, Belgium, Finland, France, and the Netherlands. Germany is not included since spreads are computed over German sovereign borrowing costs. We aim to compare the behavior of spreads of central and peripheral countries to discern how they were impacted by the crisis. The quarterly panel data spans from the first quarter of 2001 to the last quarter of 2013.

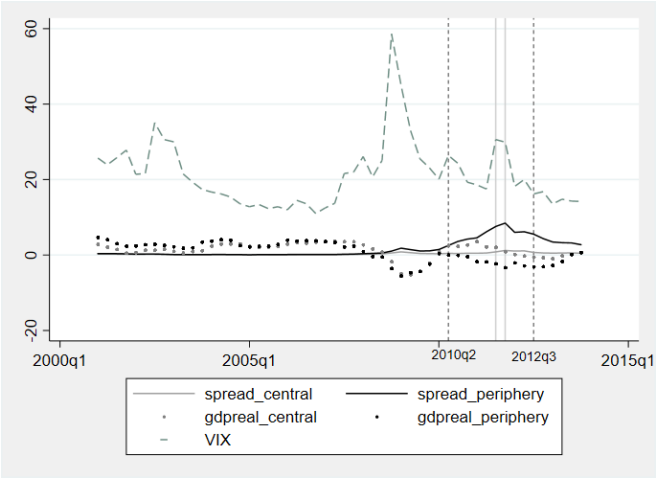
A sovereign spread is defined as the difference between a government's yield and the yield of the anchor country, which is characterized by the lowest risk of default. In this study, Germany is assumed to be the anchor country, a common assumption in studies on European sovereign spreads. The sovereign spread represents the additional compensation an investor requires to lend to a government with a higher default risk than the anchor country. This spread depends on both the relative probability of default and the price of default risk.

Figure 1 illustrates the dynamics of the average value of the spreads and real GDP growth rate for peripheral (spread_periphery and gdpreal_periphery, respectively) and central countries (spread_central and gdpreal_central, respectively), as well as international risk aversion as measured by the VIX. Averages are taken over the corresponding values for each country, year by year.

It is noticeable that the dynamics of spreads are countercyclical, meaning that in periods of falls in the output growth rate, spreads rise. However, the degree of countercyclicality is substantially higher for peripheral countries, especially since 2010. This surge occurred when the European Monetary Union institutions did not commit or coordinate effectively to provide a reliable solution to the European debt crisis. However, output growth increases and spreads decrease substantially after the ECB announced it would do whatever it takes to assist countries facing financial difficulty, in the third quarter of 2012.

When the global financial crisis started, in the end of 2007, there was a sharp decline in output growth accompanied by a significant surge in international risk aversion (VIX). However, the spreads did not respond dramatically. The vertical solid gray lines between 2011q3 and 2011q4 represent a period of jump in the VIX, coinciding with a significant increase in spreads,

Figure 1
Sovereign spreads, real GDP growth and the VIX: Peripheral and central European economies



Data source: Author's elaboration with sovereign spreads (spread) and real GDP growth (gdpreal) from Eurostat and VIX from Bloomberg

mainly in the peripheral European countries. The two vertical dashed gray lines align with the structural breakpoints estimated in this paper, by applying the method developed by Karavias et al. (2022) and Ditzen et al. (2021), detailed in the methodological section of the paper.

The first break, in 2010q2, corresponds to the moment when the EMU agreed to a partial bailout for Greece conditional on the imposition of austere fiscal measures. However, confidence in this plan's efficacy to help solve the crisis was low: there were protests happening throughout Greece against these austerity measures. Concurrently, German society expressed reluctance to contribute to the bailout for what they deemed 'profligated Greece'. The crisis was severe and spreading to other European countries, triggering a market sell-off of European assets. There was no confidence there would be a credible coordination among European institutions to solve the escalating crisis.

The second break, in 2011q3, marks the ECB's declaration that it would do whatever it takes to save the Euro. This announcement revived market confidence and, with the promise of a solution to the European crisis, European spreads decreased and became less countercyclical.

3. Methodology

We implement the methodology originally developed by Karavias et al. (2022) and Ditzen et al. (2021) to address structural breaks in panel data. This method allows one to test for the presence of breaks and, if detected, to estimate the break dates, their asymptotic distribution, and confidence intervals. Karavias et al. (2022) consider the presence of an unknown breakpoint and estimates it by minimizing the sum of squares of CCE residuals. They also derive the asymptotic distribution and confidence interval for the breakpoint. The motivation behind this methodology is to understand the impact of a significant event, specifically the Covid-19 pandemic, on asset prices.

In this study, we allow for multiple structural breaks in the parameters after major events that marked the European debt crisis and potentially affected expectations about the ability of the EMU to solve the crisis. In the second quarter of 2010, public protests in Greece against the fiscal austerity conditions of the partial bailout program provided by the EMU and concerns of crisis contagion to other European countries led to significant increase in spreads. This increase occurred even though macroeconomic conditions did not deteriorate significantly at the same time. While some European countries were facing rapid debt accumulation and lower output growth following the global financial crisis, sovereign spreads suffered major increases only after 2010. This pattern suggests a potential structural break in the model explaining spreads.

Subsequently, we argue that European sovereign bonds began to reflect more closely the domestic economic realities and ability to repay of each issuer. If our assertion holds, changes in the domestic economic fundamentals may also have had a lower impact on sovereign spreads after July 2012, when Mario Draghi, then-president of the ECB, announced integral financial solidarity: "within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." After this declaration, financial markets regained confidence in the ability of the EMU to solve the crisis. As a result, sovereign spreads declined significantly, although macroeconomic conditions improved at a slower pace. It may also suggest the possibility of another structural break explaining spreads.

The methodology developed by Ditzen et al. (2021) allows one to test for both the number and the time of occurrence of the breakpoints. Differently from a single time series, the richness of information provided by panel data allows one to find the breakpoints consistently (Bai, 2010). This methodology also controls for possible sources of unobserved heterogeneity, what is important in panel data employed in macro-finance where the included re-

gressors do not usually account for important sources of co-movement across asset prices. This is especially important when the unobserved source of co-movement is correlated with the included regressors, leading to inconsistency. Ditzen et al. (2021) and Karavias et al. (2022) build on the common correlated effects (CCE) method of Pesaran (2006), which allows to consistently estimate the unknown factors. Differently from the principal components' method, this methodology is applicable even when the time series is not large enough and can control for unobserved common heterogeneity. Karavias et al. (2022) consider the presence of an unknown breakpoint and estimates it by minimizing the sum of squares of CCE residuals, deriving the asymptotic distribution and confidence interval for the breakpoint. Ditzen et al. (2021) extend the work of Karavias et al. (2022) by allowing for the presence of multiple breakpoints.

In this paper, we consider the dynamics of sovereign spreads over the business cycles. On the finance literature, the countercyclical movement of spreads has been consistently evidenced. Cline (1995), Cantor and Packer (1996), Poiatti (2020) and Uribe and Yue (2006) show that during economic downturns sovereign spreads increase, what could be attributed to the higher the probability of default or price of default risk.

When the level of output falls significantly in an economy, the government can become illiquid enough to repay its debt obligations. Therefore, the probability of default can be higher. Also, Caballero and Krishnamurthy (2008) show that during economics crisis, investors can become uncertain about the economic outlooks. The increase in Knightian uncertainty leads investors to disengage from risk taking causing an increase in the price of risk.

Since the ability to honor the future debt obligations inherent to new sovereign debt issuances depends on the availability of public resources, the models also usually include measures of fiscal sustainability. Cline (1995), Cantor and Packer (1996), Hilscher and Nosbusch (2010), and Akitoby and Stratmann (2008) have considered the ratio of total government debt to output to be a measure of fiscal sustainability important to determine sovereign spreads. The higher is the level of debt in relation to the size of the economy, the lower the availability of resources to repay new debt obligations *ceteris paribus*. A higher level of debt means that more of current and future public revenues are already compromised to repay debt obligations issued previously.

Hilscher and Nosbusch (2010) and De Grauwe and Ji (2013) show that sovereign spreads can be impacted by changes on the availability of resources generated though international trade to repay debt obligations, measured by

the current account balance, the terms of trade, or the real effective exchange rate.

The current account balance, defined by the difference between the value of exports and imports, is a measure of net lending/borrowing to foreigners, given the level of reserves. The terms of trade is the ratio between the value of exports and imports. If the value of imports is higher than the level of exports, the government is borrowing from abroad or reducing its stock of international reserves to finance the current account deficit. Therefore, the change in the stock of external debt depends directly on the current account balance. The terms of trade, the ratio between the value of exports and imports and is an alternative measure of the ability to generate financial resources though international trade. However, these measures can suffer from reverse causality since the ability to borrow in order to import or to produce goods to export is directly impacted by sovereign spreads.

Therefore, we employ the real effective exchange rate, defined by the ratio between the average level of prices on the country main trade partners and the level of national prices, which is a measure of the relative cost between foreign and domestic products. Probably, a country facing a higher relative price of foreign produced goods may be more competitive in international trade and get a higher volume of net exports.

According to Caballero and Krishnamurthy (2008) and Krishnamurthy (2010), during international financial crisis, investors sell off relatively risky assets and hold safer assets due to an increase in the global risk aversion. This phenomenon was named "flight-to-quality". To control for global risk aversion, we include the VIX, the equity volatility index. We also controlled for liquidity in international financial markets, by including the FED funds rate in a previous version of the paper, but it was not statistically significant.

Therefore, the dynamics of sovereign spreads can be expressed by a function of domestic macroeconomic fundamentals and global risk aversion:

$$\begin{aligned} \text{SPREAD}_{it} = \beta_0 + \beta_1^j \text{DEBT}_{it} + \beta_2^j \text{GDP}_{it} \\ + \beta_3^j \text{REER}_{it} + \beta_4^j \text{VIX}_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

where SPREAD_{it} is the sovereign spread; DEBT_{it} is the ratio of debt to GDP; GDP_{it} is the real growth rate of GDP; REER_{it} is the real effective exchange rate; VIX_t is the equity volatility index; ε_{it} is the error term. The subscript i=1,2,. . .,N identifies the countries and t=1,2,. . .,N, the time periods, The parameters β_1^j, β_2^j, β_3^j, β_4^j are allowed to change across time, where $j = 1, \ldots, J$ identifies the time of the possible multiple breaks, which are unknown both about the number and the time of their occurrences. The error term is given

by:

$$\varepsilon_{it} = F_t^{'} \gamma_i + u_{it}, \tag{2}$$

where F_t is a vector of unknown factors, which are common across countries and receive a country-specific factor loading γ_i. These common factors allow for co-movements across spreads, not accounted for by the regressors, and can lead to cross-sectionally correlated regression errors.

Since the EMU countries are intrinsically subject to the same monetary policies and share common institutional and political shocks, their business cycles are also expected to be subject to co-movements. Therefore, the real product growth rate is specified to be:

$$\text{GDP}_{it} = F_t^{'} \delta_{\text{GDP},i} + x_{\text{GDP},it} \tag{3}$$

Given equations (2) and (3), the presence of the unobserved factors both in the error term and in the regressors lead to endogenous regressors. Therefore, we include the cross-sectional average of GDP as a proxy for the unobserved factors, as recommended by Karavias et al. (2022).

The quarterly panel data set starts in the first quarter of 2001 and ends in the last quarter of 2013. Therefore, it includes important disruptive financial events: the global financial crisis and the European debt crisis. Assuming that the parameters are constant when they are subject to structural breaks leads to incorrect inference. Also, specifying breakpoints when they do not exist also leads to unreliable estimates. Therefore, we run the sequential test for multiple breaks at unknown breakpoints (Bai and Perron, 1998; Ditzen et al., 2021), applying the asymptotic distributions reported in Ditzen et al. (2021) for panel data.

The sequential test searches for the number and time of breaks that minimize the total sum of squared residuals and is implemented in multiple steps: firstly, it tests the null of no breaks against the alternative of one break. If the null is not rejected, the test ends and concludes there is no break. If the null is rejected, the breakpoint is estimated and the sample is divided in two parts, separated by the breakpoint. In this case, it tests whether there is an additional break in each of the two subsamples. If no evidence of a second break is found, the test is over and concludes there is one breakpoint. Otherwise, it splits the sample at the new breakpoints and test for additional breaks at each new subsample. The test ends only when it cannot reject the number of breaks assumed under the null hypothesis.

In our dataset, we account for heteroskedasticity and autocorrelation by using an HAC robust variance estimator and reject the null of no break or

just one break but cannot reject the presence of two breaks. The estimated breakpoints are the second quarter of 2010 and the third quarter of 2012.

Therefore, we pre-multiply the economic fundamentals and the VIX by the indicator functions I_{2010} and I_{2012}. After estimating the breakpoints, the dynamics of sovereign spreads are:

$$\begin{aligned} \text{SPREAD}_t = \beta_0 &+ \left(\beta_1^0 I_0 + \beta_1^{2010} I_{2010} + \beta_1^{2012} I_{2012}\right) \text{DEBT}_t \\ &+ \left(\beta_2^0 I_0 + \beta_2^{2010} I_{2010} + \beta_2^{2012} I_{2012}\right) \text{GDP}_t \\ &+ \left(\beta_3^0 I_0 + \beta_3^{2010} I_{2010} + \beta_3^{2012} I_{2012}\right) \text{REER}_t \\ &+ \left(\beta_4^0 I_0 + \beta_4^{2010} I_{2010} + \beta_4^{2012} I_{2012}\right) \text{VIX}_t + \varepsilon_t \end{aligned} \tag{4}$$

where I_0 is the indicator function which is equal to 1 from the start of the sample until the second quarter of 2010 and 0 otherwise; I_{2010} is the indicator function which is equal to 1 from the third quarter of 2010 until the second quarter of 2012 and 0 otherwise; I_{2012} is the indicator function which is equal to 1 from the third quarter of 2012 onwards and 0 otherwise; β_i^0 is the impact of the i^{th} variable until the first quarter of 2010; β_i^{2010} is the impact of the i^{th} variable from the third quarter of 2010 until the second quarter of 2012; β_i^{2012} is the impact of the i^{th} variable from the third quarter of 2012 onwards; ε_t is the error term; SPREAD_t is the sovereign spread; DEBT_t is the ratio of debt to GDP; GDP_t is the real growth rate of GDP; REER_t is the real effective exchange rate; VIX_t is the equity volatility index.

4. Results

Table 1 shows the estimated parameters for both central and peripheral economies resulting from five models. Model 1 is a linear model that includes country fixed effects and allowing for no breaks or differences in the parameters across central and peripheral economies. As expected, a higher growth in real GDP is associated with a decrease in sovereign spreads, as it implies higher taxable income and may improve the country's capacity to honor public debt obligations. Also, a higher debt-to-GDP ratio is associated with higher sovereign spreads, since it means that a higher proportion of public income is already compromised to honor past debt obligations and may imply a higher probability of default. The linear model predicts that the real effective exchange rate and the VIX are not associated with changes in the sovereign spreads.

Model 2 also controls for country fixed effects and allows for two optimal breaks estimated by the sequential test for multiple breaks at unknown breakpoints, as proposed by Ditzen et al. (2021). This model uses a heteroskedas-

Table 1
Estimation results

	Model 1	Model 2	Model 3	Model 4		Model 5	
Variables	All Countries	All Countries	All Countries	Central	Periphery	Central	Periphery
gdpreal	–0.14*	–0.03	–0.01	–0.03**	–0.03**	0.00	–0.01
	(0.03)	(0.17)	(0.53)	(0.00)	(0.00)	(0.88)	(0.95)
gdpreal_2010	–0.14*	–0.69***	–0.71***	–0.10	–0.62***	–0.07	–0.77**
	(0.03)	(0.00)	(0.00)	(0.09)	(0.00)	(0.09)	(0.01)
gdpreal_2012	–0.14*	–0.44***	–0.44***	0.00	–0.41***	0.00	–0.21
	(0.03)	(0.00)	(0.00)	(0.82)	(0.00)	(0.79)	(0.59)
debt	0.10***	0.06***	0.06***	0.00	0.06***	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.97)	(0.00)	(0.10)	(0.81)
debt_2010	0.10***	0.08**	0.07***	0.01***	0.04*	0.02***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.92)
debt_2012	0.10***	0.08***	0.07***	0.01	0.04*	0.01***	0.01
	(0.00)	(0.00)	(0.00)	(0.10)	(0.04)	(0.00)	(0.81)
reer	0.11	–0.02					
	(0.06)	(0.67)					
reer_2010	0.11	–0.03					
	(0.06)	(0.41)					
reer_2012	0.11	–0.04					
	(0.06)	(0.33)					
vix	0.00	0.01*	0.02*	0.01***	0.01***	0.01***	0.00
	(0.93)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)	(0.98)
vix_2010	0.00	0.10*	0.08	0.00	0.16*	0.00	0.18*
	(0.93)	(0.02)	(0.10)	(0.52)	(0.05)	(0.85)	(0.05)
vix_2012	0.00	0.10	–0.03	0.00	0.14	0.00	0.24
	(0.93)	(0.07)	(0.56)	(0.96)	(0.24)	(0.70)	(0.42)
N	512	512	512	260	252	260	252
CCE						X	X
R-squared	0.53	0.80	0.80	0.88	0.88	0.70	0.81

Note: p-values in parentheses (*significant at the 5% level., **significant at the 1% level., ***significant at the 0.1% level.). N stands for the number of observations, CCE stands for the common-correlated effects estimator.
Source: Author's estimation using sovereign spreads, real GDP growth (gdpreal), the real effective exchange rate (reer), debt-to-GDP (debt) from Eurostat and VIX (vix) from Bloomberg.

ticity and autocorrelation robust variance estimator. The algorithm rejects the null of no break (against the alternative of one break) and the null of one break (against the alternative of two breaks), but cannot reject the presence of two breaks (against the alternative of three breaks) at the 5% significance level. The estimated breakpoints occur in the second quarter of 2010 and the third quarter of 2012.

In model 2, the estimated parameters show that economic fundamentals, measured by the debt-to-GDP ratio and real GDP growth rate, were always important to price sovereign spreads for both central and peripheral countries. However, their importance increases significantly after the first quarter of 2010, when the ECB and European governments failed to coordinate effectively to address the crisis and financially rescue highly indebted countries.

Since then, an increase of 1% in GDP growth decreases spreads in 0.69 percentage points, a decrease of 73% in relation to the mean sample spread of 0.94 percentage points.

However, spreads became less countercyclical after the ECB announced it would do whatever it would take to financially assist countries, in the third quarter of 2012. After the ECB announcement, an increase of 1% in GDP growth decreases spreads in 0.44 percentage points. Because the real effective exchange rate does not seem to be important to price spreads in models 1 and 2, they are dropped off in model 3 to increase the precision in the estimation of the other parameters. The results of models 2 and 3 are similar, except for the loss of statistical significance for our measure of international risk aversion, the VIX, from 2010. It calls for the possible distinct pricing functions for peripheral and central economies.

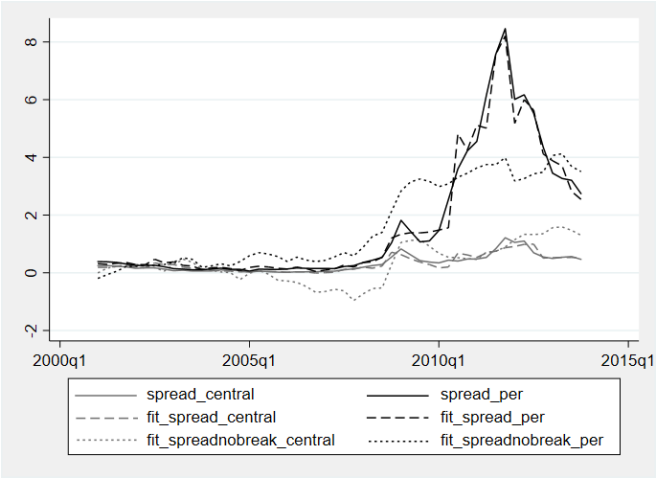
According to Caballero and Krishnamurthy (2008), financial capital flows from riskier or low-quality assets to high-quality assets during international financial crisis, when the degree of international risk aversion increases. In turn, sovereign spreads increase in economies with higher risk of sovereign default. Therefore, it is important to allow for a different pricing function for economies characterized by a higher risk of default.

Model 4 also controls for country fixed effects and relaxes the assumption that central and peripheral European economies have the same debt pricing function, by allowing different parameters for the two groups of economies. It includes a pre-multiplication of all variables by a binary variable that identifies the peripheral economies and is applied in the same sample of 512 observations (260 observations from central and 252 from peripheral economies) used in the first three models.

It is noticeable that spreads became more countercyclical since the first half of 2010, mainly for peripheral economies where a decrease of 1% in GDP growth would increase spreads in 0.62 percentage points, an increase of 40% in relation to the mean sample peripheral spread of 1.57 percentage points. In fact, lower GDP growth implies lower availability of income to repay the cost of debt. For central economies, the impact of a decrease of 1% in GDP growth becomes 0.10 but loses statistical significance.

The findings also highlight the augmented role of market sentiments in pricing sovereign spreads for peripheral European economies during the European debt crisis. Importantly, peripheral sovereign spreads increase by 0.16 or 10.19% in relation of its mean sample value of 1.57 for peripheral economies when the VIX increases by one unit (4.7% in relation to its mean sample value of 21.35) since the first half of 2010.

Figure 2
Actual and fitted sovereign spreads for central and peripheral European economies



Source: Author's estimation using sovereign spreads, real GDP growth (gdpreal), the real effective exchange rate (reer), debt-to-GDP (debt) from Eurostat and VIX (vix) from Bloomberg.

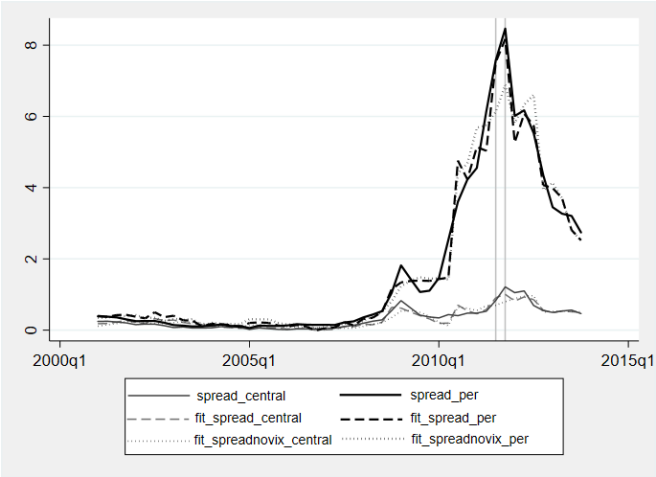
However, the central economies did not experience a significant additional impact of VIX after the first quarter of 2010. The results suggest that financial markets considered peripheral European bonds considerably riskier during the European debt crisis.

Model 5 allows for common-correlated effects, using the cross-sectional average of GDP as a proxy for the unobserved factor, and is estimated separately for central and peripheral economies. The main results of model 4 are unchanged: first, spreads become more countercyclical between the second term of 2010 and Draghi's announcement, mainly for peripheral economies; second, the VIX becomes more important to price peripheral sovereign debt in the same period. However, since the cross-sectional GDP averages are highly correlated with the real GDP, some variables lose statistical significance what lead us to prefer model 4.

Figure 2 shows model 1 and model 4 fitted (coded as fit_spreadnobreak and fit_spread, respectively) and actual spread (spread) for peripheral (per) and central economies (central), separately. It indicates that model 4 improves the model fitting substantially in relation to model 1.

The results also show that market sentiments become more important to price sovereign spreads for peripheral European economies, during the Euro-

Figure 3
Impact of VIX in sovereign spreads



Source: Author's estimation using sovereign spreads, real GDP growth (gdpreal), the real effective exchange rate (reer), debt-to-GDP (debt) from Eurostat and VIX (vix) from Bloomberg.

pean debt crisis. Importantly, peripheral sovereign spreads increase by 0.16 or 10.19% in relation of its mean sample value of 1.57 for peripheral economies when the VIX increases by one unit (4.7% in relation to its mean sample value of 21.35) since the first half of 2010. In contrast, the central economies have not faced a significant increase on the impact of VIX after the first quarter of 2010. The results suggest that financial markets reclassified peripheral European bonds as 'bad quality' assets during the European debt crisis (Caballero and Krishnamurthy, 2008). Financial markets possibly expected that peripheral economies would not have the capacity to adopt the unpopular austere fiscal policies required to reduce the accumulation of public debt. In fact, the agreed EMU partial bailout plan to Greece at that moment was conditioned on the implementation of fiscal austerity that led to public protests across the country. Figure 3 shows model 4 fitting (fit_spread) in comparison to a modification of model 4, by excluding the VIX (fit_spreadnovix), for peripheral (per) and central economies (central).

It is noticeable that the VIX improves the model fitting only for the peripheral economies. Also, the VIX loses importance to price peripheral European bonds after Mario Draghi's 'whatever it takes announcement', what means they were reclassified as safe assets or good quality assets as predicted by Caballero and Krishnamurthy (2008). Moreover, spreads became less coun-

tercyclical after Draghi's announcement.

Figure 3 shows the oscillation of economic fundamentals does a quite good job in explaining sovereign spreads. Market fears, represented by the VIX, is important to price sovereign debt only when there are significant jumps in the VIX, represented by the vertical gray lines in 2011q3-2011q4, and mainly for peripheral economies.

De Grauwe and Ji (2013); de Grauwe and Ji (2015) and Aizenman et al. (2013) argue that most fluctuations in sovereign spreads during the Eurozone debt crisis could be attributed to market sentiments, not related to the economic fundamentals of those countries. However, in this paper, we show that a model of economic fundamentals that incorporates changes in expectations can explain most variations in spreads. In this model, there were two moments of change in expectations: the first half of 2010, when the EMU agreed on a partial bailout plan to Greece conditioned on the implementation of fiscal austerity, and the second, after Draghi's 'whatever it takes' announcement.

Prior to the onset of the sovereign debt crisis, European economies enjoyed low borrow costs in international financial markets. At that moment, financial markets possibly expected that EMU institutions would financially assist member countries.

In 2010, protests in Greece after the EMU agreed on partial bailout plan to Greece conditioned on severe fiscal austerity, and the fear of crisis contagion to other European countries have changed the expectations regarding the probability of sovereign default. At that moment, it was not clear the EMU would be able the to solve the crisis.

However, Mario Draghi's 'whatever it takes' announcement calmed down financial markets. In fact, the estimated second break occurs at this moment, when spreads become also less responsive to changes in domestic economic fundamentals. After this announcement, financial markets could get confident that the EMU institutions would, by any means, solve the crisis.

5. Conclusion

This paper proposes a model to explain European sovereign spreads by oscillations in economic fundamentals in a framework that allows for multiple breaks. The two estimated breakpoints are as follows: the first, when investors realized that fiscal sustainability of the EMU should be understood in a decentralized fashion, by observing the economic fundamentals of each country separately; the second, when the ECB realized the existence of the euro was in check and announced it would be able to financially assist the

countries in trouble.

The European sovereign debt crisis has led to significant variations in central and peripheral sovereign spreads. This paper shows how the financial markets' initial lack of confidence in the EMU's ability to solve the crisis, in the beginning of 2010, and the subsequent regain of confidence, in the third quarter of 2012, impacted the relative costs of sovereign borrowing, measured by sovereign spreads.

We show that while the EMU authorities announced partial financial cooperation among States to deal with the crisis, mainly the infeasibility of fully bailing out highly indebted governments, they were subject to popular and political opposition and have magnified the crisis by increasing the cost of European sovereign borrowing. On the other hand, they have helped to decrease sovereign spreads when Mario Draghi's announced the ECB would save the Euro. The ability of central European countries to control public indebtedness was also questioned, and we show the degree of confidence on the announcements has also led to a change in the cost of central European sovereign borrowing, although to a lower degree than on peripheral European countries. Therefore, the empirical evidence supports an increase in the risk of default, measured by the greater impact of economic fundamentals on the probability of default when there would be no full bailout expectations. The increase was larger for the peripheral countries.

In addition, there was an evident asymmetry on the impact of the announcements. The econometric model shows that the increase in the degree of global risk aversion during the European debt crisis led to a significant increase in the cost of borrowing, which could not be attributed to the worsening of their domestic economic conditions, only for the peripheral countries. In fact, we provide empirical evidence that only peripheral European bonds were subject to severe market sell off in 2011. Therefore, the empirical evidence supports an increase in the price of risk due to escalation on market fears, measured by the impact of the increase in international risk aversion, for the peripheral countries. However, the peripheral bonds became less subject to market fears after Mario Draghi's 'whatever it takes' announcement.

The estimated structural breaks can be understood as changes in expectations regarding the ability of the EMU to solve the crisis. The estimations show the main oscillations in spreads can be explained by economic fundamentals as it would be predicted by the rational expectations theory.

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