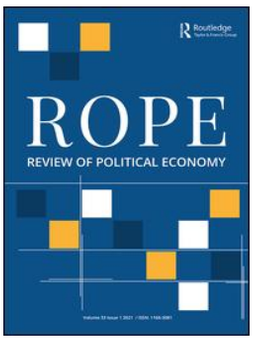

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Timing Does Matter: Institutional Flaws and the European Debt Crisis

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ABSTRACT

Financial crises are complex phenomena. Yet, at the cost of some simplifications, the literature has identified two main elements causing the crises: macroeconomic imbalances and institutional design flaws. Economists recognise that both play some role, but disagree on their strength. Using Bai and Perron's technique and an EGARCH model we contribute to the debate on the European debt crisis by identifying break dates and changes in volatility in daily values of 10-year public bond interest rates for Greece, Italy and Spain. The results are then related to key political and institutional events. The results of our econometric exercise uncover the following facts: the crisis began in May 2010; worsened after summer 2011, as the European authorities hastened to restructure the Greek debt; improved during summer 2012, when the ECB approved the OMTs, a new programme for the purchase of bonds. On the whole, the results are compatible with an interpretation of the crisis that considers the institutional flaws as the main cause.

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1. Introduction

The aim of this paper is to contribute to the debate on the origin of the European debt crisis by combining the use of descriptive statistical methods with the analysis of the news, in particular those regarding the policy decisions of the European monetary union. The study relies on the statistical identification of the breaks occurred in the daily values of 10-year public bonds 'interest rates of Greece, Italy and Spain and on the investigation of their volatility. It covers from 1999 to 2014, i.e., from the birth of the euro to the Five Presidents' Report and the related revision of the procedures of the 'European Semester',[1] which signal the introduction of a new approach to the institutional organisation of policy coordination.[2] The descriptive statistical

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[1]To put the 2015 Five Presidents' Report into action the European Commission introduced the European Semester, which 'enhanced democratic dialogue, and further improved economic governance through the introduction of National Productivity Boards and an advisory European Fiscal Board which is already up and running' (Document of the European Commission titled 'The EU's economic governance explained', p. 7, downloadable at https://ec.europa.eu/info/sites/info/files/eu-economic-governance-explained.pdf).

[2]The analysis of the working of this new approach, which is still a debated issue, goes beyond the scope of this paper.

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analysis provides some significant facts that can be used to discuss their likely causes. The tools utilised are the Bai and Perron's technique and an EGARCH model. The interpretation of the news and policies moves from the theoretical standpoint, which Keynes (1936, 202–204) expounded in the *General Theory*, that the interest rate depends on the operators' expectations on the movements of this variable. The expectations, in turn, depend on the information that the operators have on the past and present choices of the authorities.

Like all economic phenomena, financial crises are caused by a combination of factors regarding the behaviour of supranational institutions, national governments, financial and non-financial firms, workers. The intricacy of these factors has induced the literature to select some elements that more than others influence the occurrence of a crisis. The increased frequency of financial crises over recent decades (see Laeven and Valencia 2018) has fortified this tendency. The literature has thus identified, at the cost of some simplifications, two groups of elements causing financial crises: macroeconomic imbalances and institutional failures.[3] The debate's sides concede that both motives play a role, but question their relative strengths.

The literature on the European debt crisis also acknowledges that macroeconomic imbalances of different kinds[4] and flaws in the institutional organisation can originate the distress. This manifests itself through variations of the interest rates. For this reason, econometric studies on the crisis tend to focus on this variable (see De Grauwe and Ji 2013; Alessandrini et al. 2014).

Interpretations highlighting the role of macroeconomic imbalances can be found in the writings of different schools of thought. Sinn and Wollmershäuser (2011, 2012), Baldwin and Giavazzi (2015), Cesaratto (2017) state that that in Europe was a balance of payments crisis.[5]

The interpretation of Sinn and Wollmershäuser (2011, 2012) can be seen as the closest to that advising the interventions of the European authorities at the beginning of the crisis. For them, the main cause is the mistaken choices of the governments of the countries under attack. Although they acknowledge the existence of nontrivial differences

[3]The literature has proposed three generations of models. The first focussed on the role of external macroeconomic imbalances (Salant and Henderson 1978; Krugman 1979). They provided the theoretical background from which the International Monetary Fund drew its policies for the Latin American debt crises of the 1980s. The second focussed on the possibility that, owing to problems of the institutional organisation, the authorities are unable to control speculative movements (Obstfeld 1994; Kaminsky and Reinhart 1999; Goldfajn and Valdés 1997; Flood and Marion 1999; Chang and Velasco 1999; Sarno and Taylor 2003; Buiter 2007). The events concerning the speculative attacks against the European Monetary System in 1992 and the Mexican and the Asiatic crises in 1994 and 1997 stimulated the elaboration of this generation of models. The third generation of models underlines the role of news that change the views of financial operators on the quality of some assets (Kaminsky and Schmukler 2002; Kaminsky, Reinhart, and Végh 2003; Kaminsky, Mati, and Choueiri 2009).

[4]Alessandrini et al. (2014) include the divide between productivity growth and the fiscal irresponsibility of some governments among the factors causing macroeconomic imbalances. Pérez-Caldentey and Vernengo (2012) and Hein (2013) consider that the export-led growth models adopted by the euro-countries is the main cause of macroeconomic imbalances. For Papadimitriou and Wray (2012), the macroeconomic imbalances are due to the working of the unregulated banking sector, which induced a vast expansion of debt in the peripheral euro-countries. All these authors claim that the imbalances generated deficits in the current accounts of the balance of payments of the peripheral euro-countries. After the crisis of 2007–2008 financial markets did not fund these deficits anymore, causing changes in the interest rates.

[5]For an account of the debate on Cesaratto's position among post Keynesian economists, see Febrero, Uxó, and Bermejo (2018). These authors too oppose two alternative views, one in terms of macroeconomic imbalances and the other in terms of institutional flaws.

among their fundamentals,[6] Sinn and Wollmershäuser maintain that the crisis hit countries where labour unions are strong and governments and central banks are weak. The high wage rates imposed by the unions raised prices and generated deficits in the current account of the balance of payments (see also Rother, Schuknecht, and Stark 2010; Fahrholz and Freytag 2012). Like some authors holding a different interpretation (see Buiter and Rahbari 2010, 3–4; De Grauwe and Ji 2012, 871–872; De Grauwe and Ji 2013, p. 26), these economists claim that the international capital markets were initially unable to price the implicit risks and funded those deficits, but the crisis of 2007–2008 led the markets to correct the mispricing. The interest rates paid by the countries with strong unions and weak governments gradually rose heading to a stop of funds coming from abroad. For these authors, the crisis started in autumn 2009 when the newly elected Greek government revealed that the public deficits were higher than previously announced (Sinn and Wollmershäuser 2011, p. 19; Honkapohja 2014, p. 260). Mistrusting the upright behaviour of the national authorities and confiding in the working of the price mechanism, these authors proposed austerity measures, severe penalties for misaligned national behaviours and labour markets' reforms to come out of the distress.

The alternative interpretation of the crisis considers that the flaws in the institutional organisation are its major cause. The existence of macroeconomic imbalances is not denied. Yet, the crisis began when financial operators realised that the flaws in the institutional organisation would have prevented the European institutions from playing the role for which they had been created, i.e., to defend the economies and the citizens from the instability of the international financial markets. Within the literature proposing this second interpretation there are different views regarding the flaw of the institutional setting that is considered the most important. Before and after the crisis of 2007 the literature identified several related flaws[7] and some gaps and contradictions in the Treaties of the Union,[8] which the European authorities were unable to eliminate.

According to some authors (see De Grauwe 2011, 2012; Kopf 2011; Valiante 2011; Lavoie 2015), the European debt crisis occurred because the European Central Bank (ECB) failed to play the role of lender of last resort in the sovereign bond markets, a role that the central banks of Japan, UK and USA perform. According to De Grauwe (2011, p. 4), the crisis occurred in Spring 2010 when the operators became persuaded that the ECB was not going to stabilise the interest rates on government bonds of peripheral euro-countries. Due to this reaction to the news on the policy decisions of the European authorities, financial markets operated in such a way as to cause rises in the interest rates of the peripheral countries.

For other authors (Wyplosz 2011, 2013; Buiter and Rahbari 2012), the major flaw of the institutional setting was its inability to guarantee a satisfactory solution to the moral hazard problem in the behaviour of the national authorities. This defect generated resistance to let the ECB act as lender of last resort in the sovereign bond markets. This, in turn, led to the speculative reactions that affected the peripheral countries.

[6]They recognise that in the case of Ireland and Spain the problems were generated by a high private debt because public debt had limited dimension.

[7]For a review of the literature on these flaws before 2007, see Panico and Vazquez Suárez (2008).

[8]Art. 105.2, which attributes to the Eurosystem the task of guaranteeing the smooth working of the transmission mechanism of monetary policy, can come in contradiction with Art. 123 that forbids the direct purchase of sovereign bonds and the bailout of national governments. Art. 125.1, which claims that euro countries cannot guarantee the sovereign debt of another member state, can contradict Art. 122.2, which states that countries threatened by severe difficulties can receive assistance by other Union members.

Von Hagen and Mundschenk (2003) further analysed this fault of the institutional setting. For them, policy coordination in the European monetary union eliminated discretion by establishing rigid fiscal rules that ignored differences among the economies. It followed a 'restricted approach', which focused on monitoring the national authorities and used incentives based on punishments of misaligned behaviours. This approach generates non-cooperative attitudes. It has to be replaced by a 'broad one' favouring the involvement of the actors of the process by enhancing the common identification of interests, problems and policies and by using a system of incentives based on prizes and punishments. As had occurred in monetary policy in the 1980s, the rigid rules have to be replaced by an institutional re-organisation able to restore flexibility and the effective use of fiscal policy in the area (see also Von Hagen 2005; Wyplosz 2005; Pisani-Ferry 2007).

Finally, for several writers (De Grauwe 2011, p. 4, 2012, pp. 260–261; Buiter and Rahbari 2012, pp. 6–7 and 18; Mohl and Sondermann 2013, pp. 50–55; Panico and Purificato 2013, pp. 592–602), the flaw of the coordination process and the discrepancies in the Treaties introduced uncertainty as to the mechanisms regulating its working. Under these conditions, conflicting national interests prevailed over those of the whole area in the solution of problems, particularly after the 2007 crisis, which strengthened the German position in the union, by lowering the interest rates on its government bonds, and weakened the position of the other countries by raising their interest rates. For these authors, macroeconomic imbalances and the false declarations denounced by the newly elected Greek government raised the volatility of the interest rates. Yet, the crisis began in May 2010 when market operators realised that, owing to conflicting national interests, the European institutions would not perform the tasks for which they had been designed.

The econometric literature on the European crisis is extensive, but studies dealing with its timing are few and differ from our paper. Gómez-Puig and Sosvilla-Rivero (2014) and Tamakoshi and Hamori (2014) employ a Bai-Perron approach. The former examines contagion effects during the crisis. The latter tests the existence of structural changes but, unlike this paper, uses monthly data, only considers Greece, and finds one break date in April 2010. Inoue, Masuda, and Oshige (2013) check the existence of one structural break in a GARCH model of ten European countries, while our paper searches for multiple structural changes through the approach of Bai and Perron.

The results of the descriptive econometric exercises presented below differ over the two periods, June 1999–May 2009 and June 2009–June 2014. They are the following:

- The first 'break date' in the Greek time series occurred on 10 May 2010, rather than in Autumn 2009, as stated by the first interpretation referenced above.
- Other break dates occurred from October 2011 to August 2012.
- From June 1999 to May 2009, the movements of the interest rates of Germany, Greece, Italy, and Spain were highly synchronised.
- From June 2009 to June 2014, the positive connection between the movements of these rates weakened in size, falling by a factor of two from almost perfect collinearity of 0.95 (p-value = 0.000) to 0.31.
- During this second period, the effects of good news on the bonds' yields became more intense than those of bad news.

The main lines of the interpretation we propose are consistent with these results. They argue that before the crisis, market operators solved the contradictions existing in the Treaties by assuming that in the presence of speculative attacks, the European institutions would have chosen to defend the citizens from the instability of financial markets. These, therefore, priced the sovereign bonds in such a way as to generate small spreads among their yields. The 2007 crisis raised the volatility of the interest rates, but the European debt crisis did not begin until May 2010, when the operators realised that, because of conflicting national interests, the European institutions were not able to perform the tasks for which they were designed. The situation worsened after summer 2011, when the European authorities, under the pressures of national interests and disregarding the warnings of the ECB, hastened to restructure the Greek debt and insisted on proposing austerity measures and punishments for misaligned behaviours. During summer 2012 the situation improved when the ECB President Draghi succeeded in enforcing a new programme for the purchase of securities, amending one of the fallacies of the institutional organisation.

The paper is so organised. Section Two and Three portray the econometric results. Section Four presents a chronology of the crisis compatible with these results. Section Five concludes.

2. Detecting Breaks in the Time Series of Sovereign Bond Yields During the Crisis

The approach of Bai and Perron (1998, 2003)[9] is here utilised to search for 'breaks' in the coefficients of the daily time series of the interest rates of the 10-year government bonds in Greece, Italy and Spain from January 1999 to June 2014.[10] The main part of our analysis focuses on the period June 2009 – June 2014, when the major turbulence in the European sovereign bond markets manifested.

To characterise the time series properties of bond rates (r_t), we test for a unit root in r_t. We use three tests: Augmented Dickey-Fuller test (Dickey and Fuller 1979); GLS Dickey-Fuller test (Elliott, Rothenberg, and Stock 1996); Phillips-Perron Z_τ test (Phillips and Perron 1988). The results presented in Table A1 in appendix say that we cannot reject the null hypothesis of a unit root in the time series of the three countries. These findings confirm those of other empirical studies on interest rates in European countries (Kleimeier and Sander 2000; Sibbertsen, Wegener, and Basse 2014; Gómez-Puig and Sosvilla-Rivero 2014).

We search for breaks in the time series of the first difference of the yield of government bonds, Δr_t, by using the autoregressive equation specified in the Augmented Dickey-Fuller test, and assuming that r_t contains a unit root:

$$\Delta r_t = \mu + \sum_{i=1}^{n} \beta_i \Delta r_{t-i} + \varepsilon_t \tag{1}$$

where t is a time index, $i = 1 \ldots n$ denotes the time lag, μ is a drift coefficient, and ε_t is the error term. Structural changes in Equation (1) mean that the coefficients μ and β_i can

[9]The Appendix presents the details of the methods of this section.
[10]Data were downloaded from the website of Trading Economics on 18 July 2014.

Table 1. Parameter estimates of model (2) for every detected regime.

Country	Regime (Start date – End date)	μ	β_1	β_2	β_3	β_4
Greece	01/06/2009–09/05/2010	0.028	−0.066	0.127	−1.015	
		(1.469)	(−1.152)	(1.119)	(−8.053)	
	10/05/2010–07/11/2011	0.043	0.411	−0.083	−0.080	
		(2.485)	(8.269)	(−1.915)	(−1.981)	
	08/11/2011–10/02/2012	0.120	−0.182	−0.036	0.080	
		(1.535)	(−1.529)	(−0.303)	(0.680)	
	13/02/2012–08/03/2012	1.771	−0.566	−1.613	−3.427	
		(2.194)	(−1.394)	(−4.052)	(−7.812)	
	09/03/2012–10/5/2012	0.208	−0.012	0.041	0.009	
		(2.356)	(−0.558)	(1.928)	(0.448)	
	11/05/2012–23/06/2014	−0.029	0.409	−0.129	−0.016	
		(−2.822)	(10.843)	(−3.183)	(−0.431)	
	Breusch–Godfrey test: 0.012 ($p = 0.913$)					
Italy	01/06/2009–23/10/2011	0.002	0.216	−0.128		
		(0.821)	(5.430)	(−3.211)		
	24/10/2011–08/11/2011	0.080	−0.626	0.73		
		(1.342)	(−2.206)	(2.085)		
	09/11/2011–24/11/2011	0.044	0.373	−0.618		
		(1.479)	(2.826)	(−5.437)		
	25/11/2011–08/01/2012	−0.003	0.164	0.205		
		(−0.091)	(0.937)	(1.192)		
	09/01/2012–02/02/2012	−0.145	−0.164	−0.699		
		(−5.043)	(−0.979)	(−4.043)		
	03/02/2012–29/07/2012	0.003	0.264	−0.179		
		(0.327)	(3.021)	(−2.051)		
	30/07/2012–23/06/2014	−0.007	−0.055	0.007		
		(−2.149)	(−1.220)	(0.146)		
	Breusch–Godfrey test: 0.521 ($p = 0.470$)					
Spain	01/06/2009–13/11/2011	0.003	0.279	−0.124	−0.040	−0.006
		(1.039)	(6.983)	(−2.986)	(−0.960)	(−0.148)
	14/11/2011–01/12/2011	−0.106	0.029	0.685	0.371	0.205
		(−3.162)	(0.142)	(3.444)	(1.378)	(0.752)
	02/12/2011–14/06/2012	0.013	0.192	−0.002	−0.105	−0.080
		(1.411)	(2.372)	(−0.021)	(−1.303)	(−1.034)
	15/06/2012–03/07/2012	−0.074	−0.154	−0.162	−0.387	−0.851
		(−3.411)	(−1.191)	(−1.433)	(−3.627)	(−6.828)
	04/07/2012–01/08/2012	0.003	0.559	0.228	−0.757	0.216
		(0.106)	(2.863)	(1.092)	(−3.361)	(1.003)
	02/08/2012–23/06/2014	−0.008	0.271	−0.155	0.135	−0.173
		(−2.560)	(6.093)	(−3.456)	(3.021)	(−3.975)
	Breusch–Godfrey test: 0.286 ($p = 0.593$)					

vary due to the existence of break points in the series. In this case, the time series of bond yields shows changes in the drift coefficient μ. The passages from one 'regime' to the next occur gradually, as implied by the autoregressive component (β_i).

Our main interest is to identify the changes of the drift coefficient μ that summarises the deterministic component of the long-run dynamics of the interest rate of sovereign bonds. Furthermore, the autoregressive component of Equation (1) also transmits important information on the reaction of financial markets. Indeed, the short-run dynamics of the interest rates can give some indications on how financial operators evaluate new events that change the degree of uncertainty and volatility of the markets.

The estimates of break dates and the coefficients of model (1) in each regime are presented in Table 1.

The results reveal some significant differences in the way the three countries were affected. The analysis of the Greek bond yields detects the first break date on 10 May

2010 when the drift coefficient increased from 0.028 points to 0.043; two other negative breaks occurred in November 2011 and February 2012, and the drift coefficient increased to 1.771.[11] A reversal in the long-term trend happened in May 2012 when the coefficient decreased to –0.029.

The different regimes shown in the series of the Italian bond rates were probably generated by events that changed the drift and the coefficients of the short-run dynamics. In five regimes, the coefficient μ is not statistically different from zero while in two regimes the estimate of μ is significantly negative. In six of the seven regimes, our estimates detect substantial changes in the coefficients of the short-run dynamics. One may interpret these results by deeming that during the periods in which operators were expressing doubts about the credibility of governments' actions, some negative events increased the uncertainty on the sustainability of the Italian public debt. The opposite, which seems more in line with the Italian macroeconomic fundamentals, may have occurred when the trend reverted toward lower interest rates.

The case of Spain seems different from the other two countries. The time series of the Spanish public bond yield shows initially an increasing trend with the interest rate that reaches 5.52 percentage points in December 2010. In November 2011, the drift coefficient μ of the Spanish bond rates became negative. Subsequently, in our estimates, the drift takes nil or negative values. The different regimes of the Spanish bond yields are also characterised by important changes in the short-run dynamics. Favourable events, rather than adverse ones, are thus identified by our analysis of the time series of Spanish sovereign bonds.

3. Volatility in sovereign bonds' yields during the crisis

While the previous section has focussed on the *absolute level* of selected European countries' 10 year public bonds, in this section we investigate the *volatility* of the same rates, i.e., how much observed interest rates fluctuate around their mean values: in general, the larger the interest rates' swings, the riskier the corresponding bond. We study risk by applying an EGARCH model to Greek, Italian, and Spanish 10YR bonds: this methodology directly estimates an equation for rates' volatility, which also allows to compare expected and actually volatility. The gap between these two values is interpreted as reflecting *news*, i.e., unpredictable events not already priced in previous market transactions.

Preliminary, to exclude a source of variability which does not impact on differential risk analysis, we deflate yields using another return rate from a virtually risk-free asset of similar type and maturity. In our case, long before the introduction of the Euro, German public 10YR bonds have been unanimously considered as a valid benchmark for evaluating the performance of other European public bonds given the credibility of the German Central Bank and the strict fiscal discipline of German governments. Nevertheless, while this one-to-one link between yields usually results in close linear relationships between German rates and other European rates during normal times, it is questionable whether also holds during severe financial crises: the issue has been recently

[11] In this context, a negative shock on bond rates means they increase causing higher cost of debt. The opposite meaning applies to the case of a positive shock.

Table 2. EGARCH estimation of volatility, before and after June 2009.

	Greece		Italy		Spain	
	Before	After	Before	After	Before	After
β_1	0.949	0.439	0.941	0.265	0.964	0.266
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_0	−0.000	0.000	−0.000	0.001	0.000	−0.001
	(0.037)	(1.000)	(0.150)	(0.423)	(0.148)	(0.474)
α_1	−0.038	0.139	−0.038	0.111	0.016	0.092
	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	(0.000)
α_2	0.215	0.697	0.275	0.185	0.220	0.180
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_3	0.986	0.953	0.953	0.989	0.964	0.990
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_0	−0.078	−0.031	−0.348	−0.045	−0.272	−0.043
	(0.000)	(0.012)	(0.000)	(0.000)	(0.000)	(0.000)

The dependent variable is the daily change in the level of 10y public bond for each country considered, before and after June 2009; *p*–values in parentheses. Source: Our elaborations on Trading Economics dataset.

tackled by De Grauwe and Ji (2013) using correlations between European countries' bonds yields, whereas we will employ the EGARCH model to investigate the question.

In what follows, we estimate a model of the type:

$$\begin{aligned} \Delta r_t^i &= \beta_0 + \beta_1 \Delta r_t^G + \varepsilon_t, \\ z_t &= \varepsilon_t / \sigma_t, \\ ln\sigma_t^2 &= \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 \left(|z_{t-1}| - \sqrt{2/\pi} \right) + \alpha_3 ln\sigma_{t-1}^2, \end{aligned} \tag{2}$$

where r_t^i is the interest rate for the i-*th* country (Greece, Italy and Spain) and r_t^G is the German rate. Summing α_1 to α_2 provides the overall marginal impact of news on volatility. When α_1's modulus exceeds zero, shocks have asymmetric effects; as $\alpha_1 > 0$, positive shocks generate more volatility than negative ones, and the opposite happens when $\alpha_1 < 0$. Table 2 shows results for the model estimated separately over the June 1999–May 2009 and June 2009–June 2014 periods.

Finding 1. *The international financial crisis disrupted the close link between the Greek, Italian, Spanish and German rates.*

The parameter β_1 is close to 1 for the first period, reflecting an almost perfect one-to-one change in European rates; during the second period, however, this link dropped by more than two thirds. This result corroborates the evidence provided by De Grauwe and Ji (2013) showing high and positive correlations between yields before the crisis and negative correlations between the yields of 'safe-haven' bonds (like Germany, France, and Netherlands') and those of countries in distress during the financial crisis (like Greece, Spain, Portugal, and Italy).

Finding 2. *During the second period, the volatility of Greek bonds increased their sensitivity to unexpected shocks, while Italian and Spanish bonds' volatility remained stable.*

During this period, Greek bonds became extremely sensitive to the absolute size of orthogonal shocks: estimated α_2 increased from 0.215 to 0.697. Italian bonds' sensitivity to orthogonal shocks increased slightly. Also, the unpredictability of Spanish bonds remained fairly stable after June 2009.

We also use 'news impact curves' to check whether positive and negative shocks affect volatility asymmetrically,[12] and obtain the following result:

> **Finding 3.** *During the first period, the shocks' effects are symmetric while during the second period they became asymmetric, with the good news being more destabilizing than bad news. In particular, Greece experienced a substantial increase in responsiveness to news, while Italy and Spain did not.*

The news impact curves for the first period are symmetric around zero: good and bad news have essentially the same effect on volatility. While Greece and Italy displayed a very weak asymmetry toward bad news, Spain's rates were slightly more destabilised by good than bad news. The European crisis increased the responsiveness of the variance to positive news: in all cases, the estimated values for α_1 are of substantive size (0.092–0.139). Greece follows this tendency with the highest values. It also experienced the largest increase of overall responsiveness to volatility in the second period, while Italy and Spain followed in similar but gentler trends. The events of the second period increased Greek rates' volatility, whereas Italy's and Spain's rates, also exposed to the same events, did not change substantially.

Finally, the graphs of EGARCH residuals show remarkable increases during specific periods.[13] Key events for the development of the European crisis, considered in detail in the next section, took place close to the peaks of these increases although they did not always determine a regime change. We confine our analysis to measuring how many key events affect volatility. Also, since these events may extend their influence over long periods, we introduce the following indicator E to translate our daily-based results into a volatility measured over periods of twenty days after the event of interest:

$$E = \frac{\sum_{t=t}^{t+20} \hat{r}_t - r_t}{\sum_{t=t}^{t+20} \hat{\sigma}_t} \tag{3}$$

The numerator is the cumulated error of prediction of the interest rate over a given period of twenty days, starting from the day in which the key event took place. This error amounts to the difference between the expected interest rate ($\hat{r}_t$), as predicted by the EGARCH's first equation, and the actual interest rate (r_t), (i.e., it accounts for the surprises in the interest rate). The denominator is the cumulated expected variance over the same period ($\hat{\sigma}_t$), calculated using the EGARCH's second equation.

The indicator E provides an easily interpretable metric for the error of prediction normalised by the underlying daily variance. The closer the value of E is to zero, the better the model predicted volatility; which can happen either when the predicted interest rate equals the observed interest rate (no error in prediction) or when the prediction error is small compared to the predicted volatility, as often happens during times of financial instability. In sum, the indicator E captures the standard unbiasedness-variance trade-off implicit in every prediction problem. Sudden increases of E indicate that some unexpected events impacted volatility, which calls for an explanation in terms of relevant news. Table 3 gives an account of the timing of some significant changes in the volatility

[12]See Figure A1 in the Appendix.
[13]See Figures A2 and A3 in the Appendix.

Table 3. Error in predicted interest rates.

Event	Date	Greece	Spain	Italy
Staff agreement on the first adjustment programme for Greece	02/05/2010	22.8	435.7	649.5
Formal approval of the first adjustment programme for Greece	09/05/2010	−24.2	−4.9	56.9
Announcement by the ECB of the Securities Market Programme	10/05/2010	325.7	699.7	698.1
Staff agreement on the adjustment programme for Ireland	28/11/2010	132.1	128.1	226.0
Formal approval of the adjustment programme for Ireland	07/12/2010	670.1	16.9	158.2
Staff agreement on the adjustment programme for Portugal	03/05/2011	255.1	186.2	342.7
Formal approval of the adjustment programme for Portugal	17/05/2011	−11.0	−135.5	−11.8
Support by the European institutions to a partial default for Greece	21/07/2011	179.6	450.9	506.1
New restrictive measures requested by EC/ECB/IMF to Greece	02/09/2011	44.9	−217.1	−375.5
Approval of a new round of austerity measures in Greece	12/02/2012	−33.8	−155.0	−150.1
Formal agreement on the Private Sector Involvement	09/03/2012	−3.8	384.5	298.9
Speech of Mario Draghi at the Global Investment Conference	26/07/2012	−24.2	−4.9	56.9

The figures are the ratios between the cumulated error in predicted interest rates from the EGARCH model over the twenty days following a given date and the corresponding predicted variance. Source: Our elaborations on Trading Economics dataset.

of the time series. We will use this metric in the next sections to describe the impact of news and events that have proved relevant for the evolution of the debt crisis.

4. A Chronology of the Evolution of the Sovereign Debt Markets

4.1 Macroeconomic Fundamentals and the Spreads Before the Crisis

The analysis of macroeconomic fundamentals shows the existence of large differences among the countries hit by speculative attacks. Before 2007, the average annual growth rates of Ireland, Greece and Spain were among the highest in the Eurozone; the Italian and Portuguese ones were among the lowest. Ireland enjoyed persistent surpluses in their current account of the balance of payments; Italy showed surpluses and deficits and Greece and Spain, persistent deficits. As to fiscal behaviour, the European authorities celebrated Ireland and Spain as 'virtuous countries'. On the contrary, Greece persistently violated the Stability and Growth Pact (SGP). From 2005, when the European authorities reformed the SGP, Greece increased its deficit and began to pass false information to the authorities.

Despite these differences, the start of EMU generated convergence among the interest rates (Finding 1). Financial operators were trusting that the European authorities would resolve the gaps existing in the Treaties by giving priority to the task for which they had been created, defending the citizens from the instability of financial markets.

Following the collapse of Lehman Brothers in September 2008, financial operators selected the German sovereigns as a safe form of investment. This strengthened the position of Germany within the EMU and affected the equilibrium of power among countries in the monetary union. The interest rates on government bonds began to diverge. The spread between the Greek and German rates moved from a monthly average of 0.79 in September 2008 to 2.85 in March 2009 and then fell to 1.21 in August 2009. Another upward movement began in October 2009 when a centre-left coalition took power in Greece and disclosed the accounting tricks of the previous government: the spread moved from a monthly average of 1.36 in October 2009 to 3.14 in March 2010. Nevertheless, the analysis in Section Two shows that these events did not change the drift

parameter of the interest rates' time series: the first break date in the Greek series is detected on 10 May 2010, when the parameter increases from 0.028 to 0.043 (Table 1).

4.2 The Start of the European Debt Crisis

The identification of the first break date makes a case for setting the start of the European debt crisis in May 2010, as indicated by the literature interpreting it in terms of institutional failures. To further appraise this conclusion, let's consider the events that occurred during the second part of 2009 and the first months of 2010 in greater detail.

In the second half of 2009, the European authorities, in the face of the escalating fiscal imbalances and the improving situation in some countries, asked the national governments to abandon the fiscal stimuli introduced in December 2008 and to adopt restrictive policies.[14] This decision represents an example of the inability of EMU institutional organisation to cope with asymmetric tendencies within the area. In Spain, economic activity was still depressed and the change in fiscal policy amplified the distress of the banking system and collided with the interventions of the national government to restructure it.

The tendency to return to restrictive fiscal policy increased in October 2009, when the newly elected Greek government revealed that the previous one had concealed the true dimension of fiscal deficits. The unearthing of false declarations and the drive towards restrictive policies caused the reaction of the agencies that lowered the rating of the sovereign debts of Greece on 8 and 22 December 2009.

In February 2010, the ECOFIN called on Greece for a report on the measures to be introduced to reduce the deficit and approved these during the meeting held on 15–16 March 2010. Despite that, by the end of March, the interest rate on 10-year sovereign bonds started to rise. On 11 April 2010, the Eurogroup recommended the introduction of a consolidation plan and an extraordinary mechanism for financial support. The lack of support of the German authorities, engaged in an electoral process in Renania-Westfalia,[15] led to a further rise in the interest rates on Greek sovereigns, which increased from 6.7 per cent on 11 April 2010–8.8 per cent on the 22nd, forcing the Greek government to ask for a rescue plan on 23 April. The request was ignored until 2 May 2010 when the Eurogroup proposed that the members of the Union approve the concession of bilateral loans to Greece under the conditions set by an agreed consolidation plan.[16] Despite this proposal, the interest rate kept rising, exceeding 12 per cent. During the weekend of 7–9 May 2010, the ECOFIN eventually held an 'extraordinary' meeting to approve the creation of the European Financial Stability Fund (EFSF) and a rescue package for Greece.[17] The results of the meeting were made public on 9 May after the election in Renania-Westfalia had ended (Panico and Purificato 2013).

When the markets opened on Monday the 10th, the interest rate on the Greek 10-year sovereign bonds was 12.4 per cent. A few hours later it went down to 6.3 per cent, but

[14] In December 2008, the European Council adopted the European Economic Recovery Plan, a programme of national budgetary stimulus packages. In Fall 2009, the ECOFIN approved Excessive Deficit Procedures against eight countries and revised the recommendations and the time schedules for other countries already submitted to these procedures (ECB 2009).

[15] See Ardagna and Caselli (2014, 307–311).

[16] https://www.consilium.europa.eu/media/25673/20100502-eurogroup_statement_greece.pdf accessed on 23 March 2018.

[17] It was 'extraordinary' also because the ECOFIN never meets during weekends because of the high organising costs.

then it rose again and closed at 7.8 per cent. The quick return to 6.3 per cent suggests that the operators had been betting on the European authorities not having reacted to the speculative attack until the elections in Renania-Westfalia had ended. The subsequent rise of the interest rate spelled out that the management of the Greek problems and the results of the ECOFIN meeting were starting to persuade the operators that conflicting national interests were preventing the European institutions from carrying out the tasks for which they had been created.[18]

On 10 May, the ECB also announced the start of the Securities Market Programme (SMP), which allowed the purchase of sovereign debt to stabilise the transmission mechanism of monetary policy disrupted by the speculative attack. The ECB formally deliberated on 14 May, stressing that its institutional role is to secure the smooth working of the transmission mechanism. Nonetheless, some events related to its introduction, namely the criticisms raised by the then President of the Bundesbank in a German newspaper on 11 May and other similar occurrences in subsequent months, further highlighted the existence of national conflicts within the governing bodies of the ECB. These conflicts compelled the SMP to intervene late when the situation had decayed to such a point as to require emergency operations.[19] Moreover, the decision of the authorities to attribute the ECB the position of a privileged creditor made the SMP even more ineffective.

The previous information supports the interpretation of the European debt crisis in terms of defects of the institutional organisations and promotes the view that the operators were gradually persuaded to believe that conflicting national interests had come to dominate, preventing the European authorities from performing the task for which they had been created.

4.3 The Decision to Restructure the Greek Sovereign Debt

The analyses of the previous sections point out that from May 2010 to Fall 2011 there were no other breaks in the parameters of the time series of Greece, Spain and Italy. Nevertheless, the series shows some increases in volatility in connection with specific events.

The indicator E (Table 3) shows an increase up to 128.1 for Spain and to 226.0 for Italy when the staff level agreement on the Irish adjustment programme was reached in December 2010. It further jumped to 186.2 and 342.7, respectively, affected the volatility of sovereign' yields, setting off a period of anxiety and disorder in financial markets.

In July 2011, the Dutch, French and German authorities, motivated by electoral interests,[20] made declarations in favour of an agreement between the government and credit institutions for a partial reduction of the face value of Greek sovereign bonds. The ECB had opposed this solution fearing its negative effects on debt markets.[21] Nonetheless, on

[18]For Ardagna and Caselli (2014), some euro-countries decided to provide financial assistance to Greece to favour their own banks, which had invested in Greek sovereigns. The Treaties' statement that the European authorities must adopt a supranational perspective when making decisions did not play a significant role.

[19]For a description of these events, see Panico and Purificato (2013).

[20]In the Netherlands, general elections had to be held in September. In France, in the face of the presidential elections of July 2012, President Sarkozy, with the support of German Chancellor Merkel, was trying to make up for the loss of consensus by declaring that the private sectors responsible for the crisis had to pay for the damage caused.

[21]President Trichet warned about the consequence of partial default, stating that this event would have disrupted the debt markets (ECB 2011a, 2011b).

July 21 the European Council, composed by the Heads of State or Government of the European Union, decided to support the 'Private Sector Involvement' (PSI) in the second adjustment programme for Greece in the form of a partial write-down of the face value of the Greek sovereign bonds.

As the ECB had dreaded, this resolution raised uncertainty in debt markets.[22] The operators increasingly lost confidence in the idea that the authorities would have operated in such a way as to protect the solvability of government debts. The downfall of this implicit guarantee converted several events to potential sources of tension. The volatility of the Italian and Spanish yields underwent a larger increase than what occurred when the assistance programmes for Greece, Ireland and Portugal were launched: the indicator *E* reached 450.9 for Spain and 506.1 for Italy (Table 3). Moreover, the shares of the Italian and Spanish sovereign debts held by foreign investors fell, the interbank loans to their financial institutions shrank, and the Eurosystem had to step in through the TARGET system to replace the funding of the interbank markets, as had happened after the collapse of Lehman Brothers.[23]

Under these conditions, the deficient results achieved by the restrictive policies proposed by the European authorities and the political instability that they were generating raised further tension in the markets. The discrepancies between the results predicted by the adjustment programme and those actually achieved, the rise of the government debt-GDP ratio of Greece, and the request of a partial reduction of the face value of its sovereign bonds could be seen as evidence of the inadequacy of the policy imposed by the European authorities.[24] Yet, the joint mission of the EC/ECB/IMF did not change positions and left Athens on 2 September, in the context of the fifth review of the first programme, requesting the introduction of new restrictive measures to stabilise the economy. This event again increased the volatility of the Greek sovereign bonds' yields, with the indicator *E* reaching 44.9 (Table 3). Moreover, it led the rating agencies to downgrade the Italian and Spanish sovereign bonds between 4 and 18 October. The first break in the parameters of the Italian interest rate series, a negative change detected on 24 October, can be placed in the context of weak growth perspectives of the austerity measures and the related political uncertainty.

Two days later, on 26 October, the ECOFIN approved a plan that increased the requirements of capital for the major European banks[25] and ratified an agreement for the concession of the sixth instalment of the first assistance programme to Greece. Moreover, it started the negotiation of the second assistance programme, which contained new restrictive measures. This request led the Greek Prime Minister Papandreou on 31 October to call for a referendum on the introduction of measures that were opposed by the population and were causing distress and political uncertainty.

[22]The PSI had a negative impact on banks' balance sheets (ECB 2011c, p. 43) and on the transmission mechanism of monetary policy (ECB 2012a, p. 59).

[23]The share of the Italian sovereign debt held by foreign investors fell from 46.2 per cent in June 2011 to 35.8 in June 2012. Spain's fell from 39.3 per cent to 29.2. In June 2011, the Italian TARGET balance was a positive figure equal to 6 bn. euro. In June 2012, it was -274.3. The Spanish ones were -45.4 and -408.4 bn. Euros, respectively.

[24]Blanchard and Leigh (2013) found that, during the early years of the European debt crisis, fiscal consolidation was negatively related to growth. For them, forecasters underestimated the size of the fiscal multipliers.

[25]The plan raised some capital requirements and imposed a buffer of resources to absorb losses coming from the holding of sovereign debt. Moreover, it allowed the banks to ask the financial support of the EFSF in case of necessity (http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/125644.pdf, accessed on 23 March 2018). The new measures forced five Spanish banks to obtain additional capital.

The new breaks in the parameters of the interest rate series detected in Section Two can be accounted for in this context of high political uncertainty. One break, dated 8 November 2011, a negative shock in the Greek series, was related to the anxiety that Papandreou's referendum generated within the European institutions, increasing pressures on him to call it off. Owing to these pressures, Papandreou withdrew the referendum on 3 November and announced that he was stepping down to let a new government to be formed. The events of the subsequent days, related to the reactions to Papandreou's decisions within his party, further fuelled uncertainty, which was at its highest level on 8 and 9 November when the prospect of a national unity government led by Papademos, a former ECB Vice President, was refused. Uncertainty faded away during the next days when, conforming to the aspirations of European authorities, the national unity government became viable. Papademos took power on 11 November.

Meanwhile, the Italian sovereign bond market was rising. In this context, Prime Minister Berlusconi announced his intention to resign. The analysis presented in Section Two identifies another break date for this country in the form of a positive change on 9 November 2011. The drift parameter of the time series of the Italian bonds' yields decreased from 0.08 to 0.044.

On November 12, Berlusconi resigned, and on the 16th, the former EU commissioner Monti took power as Prime Minister. In this case, too, the choice was conformed to the aspirations of the European authorities. The change of government further reduced the tensions in the markets and two subsequent breaks in the Italian series, two positive changes detected on 25 November 2011 and on 9 January 2012, can be placed in this context of reduced uncertainty.

The changes in the Greek and the Italian governments calmed the financial markets of these countries, but increased the tensions in Spain, where the application of the austerity measures imposed by the European authorities were progressively worsening the conditions of the economy and of the banking system, which was under reconstruction through repeated government interventions.[26] In this contradictory context, which again testifies to the inability of the policy coordination process to take account of the different needs of the EMU economies, we can place the rise in the Spanish coefficients of the lagged variables of the model in Equation (1) and the break in the interest rate series on 14 November 2011, with the drift parameter diminishing from 0.003 to −0.106 (Table 1). The diverging trends of the coefficients of the lagged variables and the drift parameter testify to the high short-run variability of the Spanish bond yields probably countered by a favourable medium term effect on financial operators' expectations due to the prospect of an imminent victory of the centre-right party led by Rajoy in the general elections.

During the subsequent days, new events again generated opposite effects on the financial turmoil. On 20 November, the centre-right party won an absolute majority in the general elections. On the 21st, however, the Fund for Orderly Bank Restructuring, set up by the Spanish government to restructure and recapitalise the banking sector, had to intervene in favour of a savings bank called 'Caja Valencia'. This event led to new

[26]In May 2010, following the ECOFIN's requests, the Spanish government adopted further consolidation measures (ECB 2010). In September, the Parliament approved a reform of the labour market and a pension system in August 2011. On 27 September, it reformed the Constitution to strengthen the sound operation of the government budget.

increases in interest rates, which were not sufficiently neutralised by the concession of the sixth instalment of the financial assistance to Greece on 29 November. A second break in the Spanish interest rate series, a negative shock raising the drift parameter from −0.106 to 0.013 is detected on 2 December (Table 1).

Tensions mounted again at the beginning of 2012 due to the diminishing confidence of the international financial markets in the ability of austerity policies to solve the crisis. On 13 January, in spite of the syntonic proximity between the Italian government and the European authorities and of the implementation of austerity measures, Standard and Poor's again downgraded Greece's sovereign debt, together with those of Spain and other seven euro-countries. The rating agency justified its decision by explicitly referring to the inability of European policies to respond to the crisis. In this context, one can place the break date in the Italian interest rate series, detected on 3 February 2012, when sovereign bond returns went back to a non-decreasing path with the drift parameter rising to zero (0.003).

Something similar occurred in Greece, despite Parliament's approval on 12 February of new austerity measures demanded by European authorities. The analyses of the previous sections detect a break date in the form of an increase in the trend of the interest rates series on 13 February (Table 1), accompanied by a decrease in the volatility of these rates, as shown by the reduction of the indicator E (Table 3).

On 9 March, the Greek Finance Minister announced the good news of a participation rate of 85.5 per cent in the PSI. The majority of private lenders officially agreed to write down 53.5 per cent of the sovereign debt in their hands. The analyses presented in the previous sections detect another break date in the Greek series on the same day: it was a positive shock that reduced the pace at which the interest rates were rising, but did not lead to a downward trend (Table 1). Based on the result of the PSI, the joint mission of the EC/ECB/IMF presented a positive report to the European institutions, which decided to launch the second adjustment programme for Greece.

The Greek sovereign bond yields finally began to decline when, in spite of the outcome of the legislative elections of 6 May 2012, where no party reached the majority of seats, the main political forces declared their will to keep Greece within the EMU. Another break date from Section Two for the Greek interest rate series was on 11 May. From that date, the trend becomes negative, with the drift parameter decreasing from 0.208 to −0.029.

Following the European authorities on the new lines of the economic governance and the requirements to be imposed on the European banks, the Spanish authorities introduced other measures to stabilise the economy.[27] The economic conditions, however, were not improving. On the contrary, the negative growth rates of two successive semesters and the increased deterioration of private debt, particularly in the residential housing sector, was making the support of the banking system more and more necessary.[28]

[27]In November 2011, the ECOFIN had approved new rules on government budget supervision, reinforcing the Stability and Growth Pact, and on 2 March 2012 the Council of Europe signed the Treaty on Stability, Coordination and Governance, known as the Fiscal Compact. As to the banking sector, the ECOFIN had approved on 26 October 2011 a plan to recapitalise the European banks. As a consequence, the Spanish authorities imposed new provisions on the banks (RDL 2/2012), raising their needs for new funding up to 50 billion euros (ECB 2012b).

[28]To facilitate its access to international markets, the Spanish banking system had been restructured in 2010 by reducing the number of small financial institutions from 45 to 18. This process led to the practical disappearance of the 'Cajas de ahorro' (Saving Banks). Moreover, legislation raised capital requirements foreseeing some support from public capital.

At the end of April, an IMF (2012) report on the Spanish banking system clarified that a bank, which the report did not identify but later turned out to be 'Bankia', had to strengthen its balance sheet and that the government had to increase the number of resources devoted to restructuring the sector. On 9 May, 'Bankia' was nationalised[29] and on 12 May, following the recommendations of the IMF, the government approved a Decree (RDL 18/2012), which raised the provisions on the real assets inscribed in the banks' balance sheets and imposed a further increase, amounting to 29 bn. euros, in the funds required for their recapitalisation.[30]

The number of resources that the government had to devote to the rescue of 'Bankia', while respecting the constraints on the budget imposed by the European authorities, pushed the spread further up. Between the end of May and the beginning of June, Standard and Poor's and Moody's downgraded the Spanish debt and the tensions in the markets rose once again.

On 9 June, the Spanish government expressed to the Eurogroup its intention to activate the procedures for the support of the financial sector, but not for full financial assistance. This event reduced the spread and the break date in the interest rate series, a positive change detected on June 15, reflects the markets' pacification it produced. The Spanish government formally asked the procedures for obtaining the support of the financial sector on 25 June.

During the same time, a complex set of new events affected the movements of the interest rates in opposite directions. Cyprus's request for full financial assistance at the end of June and the delays and uncertainty on the approval of the European reforms of the banking union and on the German ratification of the EMS tended to raise the interest rates. The news coming from the ECOFIN meeting and from the Euro area Summit of 28 and 29 June on the EMU's reforms and on the possibility of receiving financial assistance to recapitalise the banks directly even before the EMS started to operate, induced some optimism in the markets and a tendency for falling interest rates. On 3 July, however, the Finnish authorities clarified that the ECOFIN and the Euro area Summit had failed to reach an agreement on these issues, generating disappointment and raising interest rates. Once again, news regarding the functioning of the Euro area's policy coordination can be considered responsible of the new break date in the Spanish interest rates series, detected on 4 July 2012.

4.4 The Changing Role of the ECB in the Debt Markets

By the end of July and the beginning of August 2012, the Italian and Spanish crises evolved towards a positive outcome. The two break dates detected by the analyses of the previous sections, on 30 July for the Italian series and on 2 August for the Spanish one, reflect the turnaround of bond yields, which began to decline. The key events were those leading to the introduction of the Outright Monetary Transactions (OMTs)

[29]Bankia had been set up in 2010 to foster the integration of the 'Cajas de ahorro'. With the support of public capital, it rapidly became the fourth largest Spanish financial institution. In 2011, it had access to the Stock Exchange. The access was, however, based on untrue accounts, which banking supervision failed to uncover. When it was nationalised in May 2012, its 2011 accounts, which had shown a profit of 309 million euros had to be corrected to exhibit a loss of 4,369 million euros (Bergés and Ontiveros 2013, 108).

[30]On May 25, after reformulating its accounts, Bankia asked the government to provide additional 19 bn. euros for the required recapitalisation.

by the ECB. On 26 July, the ECB President Draghi, in the Global Investment Conference held in London, stated: 'within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough' (ECB 2012c). This statement clarified that the ECB President was determined to defeat the conflicting national interests within the governing board and was going to propose new measures to fortify the euro. The ECB announced the guidelines for these measures on 2 August and approved the OMTs on 6 September (ECB 2012d, 2012e). To guarantee the smooth working of the transmission mechanism of monetary policy, the programme cancelled the position of privileged creditor attributed to central banks by the SMP and allowed unlimited purchases in the secondary markets of the bonds issued by the governments fulfilling the fiscal conditions set by the European authorities. The impact on the bond markets was favourable, as the interest rates went rapidly and decidedly down. This corroborates the conclusion that during the crisis, the sensitivity to news became *asymmetric* (Finding 3) especially for Greece, with positive news having a stronger impact than negative on interest rate volatility. This tendency had not manifested itself during the period preceding the sovereign debt crisis (Finding 2). The different impact of positive news during the second period can be interpreted as a tendency of financial operators to consider a continuation of the euro more likely than a breakdown.

5. Conclusions

The analyses presented in the previous pages support the interpretation of the European debt crisis in terms of flaws in the institutional organisation. It points out that the crisis began in May 2010 and that the debt markets were further destabilised by the decision of the European Council in July 2011 to support the involvement of the private sector in the second adjustment programme for Greece, which amounted to the first partial default of an euro-country. The analysis has pointed out that from October 2011 to March 2012, the crisis worsened in spite of the reform of governance approved by the European authorities and of the austerity measures adopted by Greece, Spain, and Italy. In July 2012, the Spanish sovereign bond yields rose again, owing to the failure of the European institutions to achieve an agreement on measures consistent with the restructuring of the banking system. During that summer, the ECB was eventually able to approve the OMTs programme, which stabilised the sovereign bond markets.

These outcomes highlight the need to intervene on the institutional organisation of the coordination process to stabilise the euro area economy and foster its growth. We have to wait for further investigation to know whether the reforms recently introduced, which have set the procedure called 'European Semester', are moving in this direction.

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Appendix A The Bai-Perron (BP) Methodology

We then introduce structural changes in Equation (1) by assuming that the parameters μ and β_i can change because of m breaks:

$$\Delta r_t = \mu_j + \sum_{i=1}^{n} \beta_{i,j} \Delta r_{t-i} + \varepsilon_t,\ t = T_{j-1} + 1,\ \ldots,\ T_j, \tag{A1}$$

where $j = 1, 2, \ldots, m+1$ denotes the regime, and the convention that $T_0 = 0$ and $T_{m+1} = T$ is used. The framework used by Bai and Perron (1998, 2003) for the analysis of multiple structural change is based on the objective of the minimisation of the sum of squared residuals of Equation (A1). Indeed, for each sequence of break dates we have the function of the coefficients (μ_j, $\beta_{i,j}$):

$$\sum_{l=1}^{m+1} \sum_{t=T_{l-1}+1}^{T_l} \left[\Delta r_t - \mu_j - \sum_{i=1}^{n} \beta_{i,l} \Delta r_{t-i} \right]^2. \tag{A2}$$

The minimisation of the sum of squared residuals, Equation (A2), provides the estimates of the coefficients (μ_j, $\beta_{i,j}$), which are function of the particular partition of the period: $\hat{\mu}(\{T_j\})$, $\hat{\beta}_i(\{T_j\})$. Substitution of these estimates in Equation (A2) provides a function of $\{T_j\}$ that we denote $S_T(T_1, \ldots, T_m)$. Among all possible partitions of the period, the optimal break points minimise the sum of squared residuals $S_T(T_1, \ldots, T_m)$:

$$(\hat{T}_1, \ldots, \hat{T}_m) = argmin_{T_1,..,T_m} S_T(T_1, \ldots . T_m) \tag{A3}$$

This problem is constrained by the restriction that the segments between two break points define regimes with a minimum length, h. The constraint has a technical justification (Bai and Perron 1998, 2003) but is also consistent with intuition and econometric practice. In the autoregressive model of Equation (A1), the BP methodology admits different distributions for the random errors across regimes but does not allow for serial correlation.[31]

The procedure to detect multiple structural changes depends on the number of breaks, m. An important part of the contribution of Bai and Perron (1998) is the proposal of some test statistics for the determination of m. The asymptotic distributions of the tests depend on the trimming parameter that defines the minimum distance between two consecutive break dates. Bai and Perron (1998) provide asymptotic critical values via simulations assuming the minimum distance between two break points is the 5 per cent of T, the size of the time series. In our case, $T = 1380$ and the 5 per cent amounts to 69 observations. When we assumed this value of h, some of the estimated break dates occurred at exactly 69 days from the next, meaning that these dates were unreliable. Actually, the period under consideration is characterised by significant turbulence. Accordingly, we chose small minimum distances between consecutive break dates in our implementation of the Bai-Perron methodology. These are 12 days for Italy and Spain and 17 days for Greece. To determine the value of m we proceeded by using an approach based on the assumption made by Bai and Perron (1998) that serial correlation is absent in the error term in Equation (A1). Starting from low values of both the maximum number of breaks, m, and order of the autoregressive model, n, we increased m and n until we chose the model whose residuals display the absence of serial correlation, tested by the Breusch–Godfrey serial correlation LM test. If the

[31]The optimization problem just described implies complex computations that Bai and Perron simplify by proposing a sequential algorithm based on dynamic programming. We performed all computations using the package *strucchange*, version 1.5-0 (Zeileis et al. 2002) that is a component of the *R* system for statistical computing.

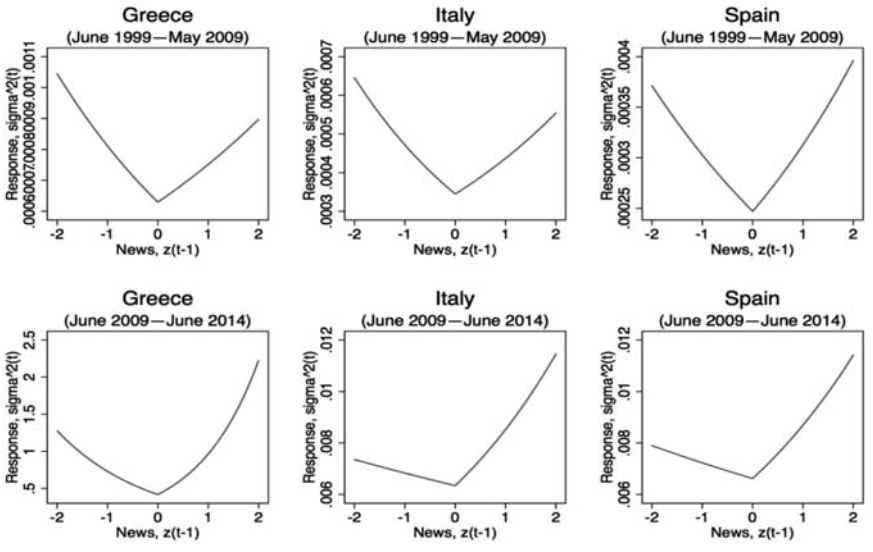

Figure A1. News functions. Source: Our elaborations on Trading Economics dataset.

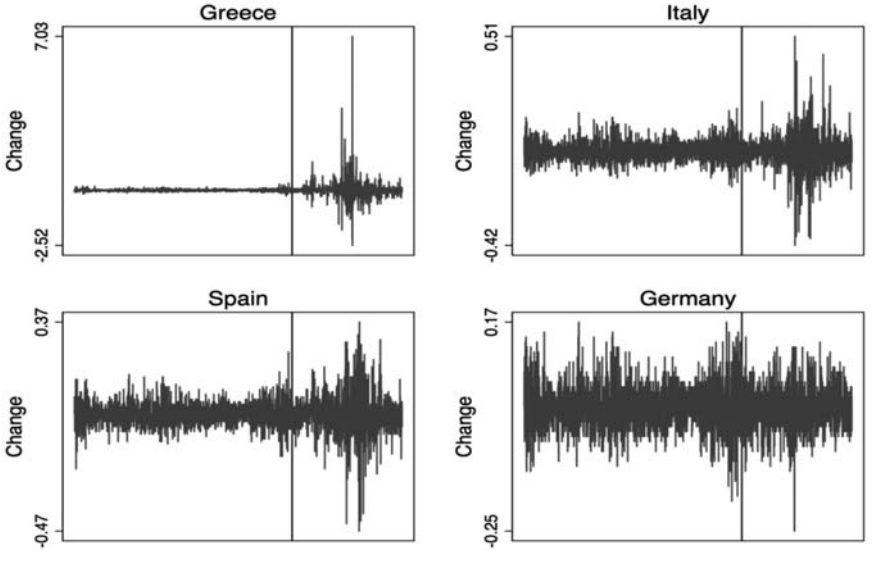

Figure A2. Interest rate changes. Source: Our elaborations on Trading Economics dataset.

number of breaks in the series are greater than the one that we assume, the undetected change would be present in the residuals too, and the latter phenomenon would signal the presence of other breaks by displaying significant autocorrelation.

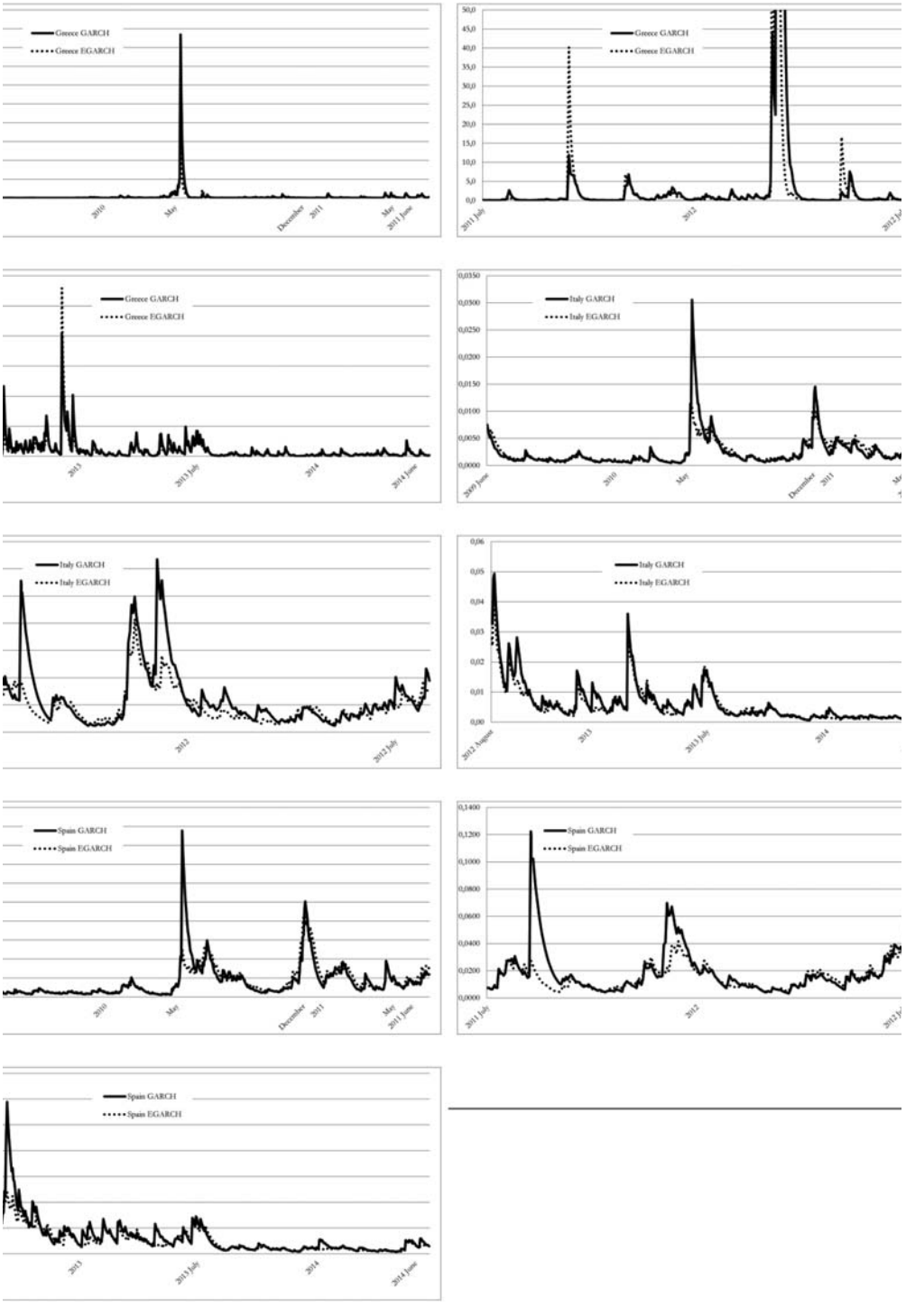

Figure A3. GARCH and EGARCH residuals. Source: Our elaborations on Trading Economics dataset.

Note: Each graph uses a different scale on the *y*-axis in order to allow a clearer visual inspection of the changes in the GARCH and EGARCH residuals.

Table A1. Testing for a unit root in bond rates.

	r_t		Δr_t	
	Test statistic	Critical value, $\alpha = 10\%$	Test statistic	Critical value, $\alpha = 10\%$
Greece				
Augmented Dickey-Fuller	−1.674	−1.282	−16.244	−1.282
GLS Dickey-Fuller	−1.179	−1.634	−12.738	−1.635
Phillips and Perron Z_τ	−1.780	−2.570	−33.227	−2.570
Italy				
Augmented Dickey-Fuller	−1.064	−1.282	−16.280	−1.282
GLS Dickey-Fuller	−1.240	−1.626	−6.537	−1.627
Phillips and Perron Z_τ	−1.301	−2.570	−31.541	−2.570
Spain				
Augmented Dickey-Fuller	−0.956	−1.282	−16.966	−1.282
GLS Dickey-Fuller	−0.946	−1.629	−2.237	−1.627
Phillips and Perron Z_τ	−1.234	−2.570	−26.568	−2.570

The null hypothesis is a unit root with a drift. Time series in the period from 1/6/2009 to 23/6/2014.

Table A2. Break dates.

Country	Break dates	Confidence interval, $\alpha = 5\%$
Greece	10/05/2010	29/04/2010–09/06/2010
	08/11/2011	29/09/2011–15/12/2011
	13/02/2012	08/02/2012–14/02/2012
	09/03/2012	08/03/2012–14/03/2012
	11/05/2012	03/05/2012–15/05/2012
Italy	24/10/2011	10/10/2011–27/10/2011
	09/11/2011	08/11/2011–18/11/2011
	25/11/2011	04/11/2011–29/11/2011
	09/01/2012	02/01/2012–18/01/2012
	03/02/2012	27/01/2012–15/02/2012
	30/07/2012	09/05/2012–04/12/2012
Spain	14/11/2011	08/11/2011–17/11/2011
	02/12/2011	25/11/2011–08/12/2011
	15/06/2012	13/06/2012–25/06/2012
	04/07/2012	28/06/2012–06/07/2012
	02/08/2012	20/07/2012–20/08/2012

Source: Our elaborations on Trading Economics dataset.