Market uncertainty, macroeconomic expectations and the European sovereign bond spreads.

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Abstract

In the present paper we examine the deterministic processes of the European sovereign bond yield spreads under state-dependent specifications, aiming to reveal differences in the information reflected in their movements across time. We begin by examining the persistence characteristics of the dependent variables; finding near-unit-root effects highlights the need for careful econometric specification. Thus, we formulate sovereign bond yield spreads, for eleven EMU countries against the Bund for the period 1992:1-2009:12, as AR(1) processes, while allowing for regime switching effects, specified in a Markovian probabilistic framework. In this context, by taking into account regime switching effects we examine, rather than assume, the effects of the monetary unification on sovereign bond yield spreads, allowing for states of higher and lower interactions to be revealed. Our results indicate that European sovereign bonds achieved only partial integration even before the recent financial turbulence implying that monetary unification is a necessary but not sufficient condition for financial integration in the euro area. Additionally, sovereign bond spreads are found to reflect macroeconomic expectations, as well as risk aversion, while the degree to which the spreads are affected by either macroeconomic or risk perceptions is found to vary both across sovereigns and during the time period examined.

Keywords: financial integration; market conditions; idiosyncratic risk; bond spreads.
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Note: The opinions expressed in this paper do not necessarily reflect the views of the institutions the authors are affiliated with.

1. Introduction

The assessment and promotion of financial integration of European markets constitutes a very interesting research topic that has several policy implications while posing methodological challenges. In examining the state of financial integration in the European bond markets, several empirical works have, until recently, attributed enhanced interactions among EMU sovereign bonds in a great extent to the monetary unification (see among others Baele *et al.*, 2004, ECB, 2005 and European Commission, 2007). In this strand of empirical literature, the differences between yields of European sovereign bonds and the Bund have been one of the most popular proxies for the state of European bond markets' integration. However, during the recent crisis, European sovereign bond spreads widened and reached levels comparable to the ones existing in the pre-EMU period, thus revealing the need to re-assess the determinants of financial integration in the European bond markets and to lift the constancy assumption in the methodological framework.

Previous empirical literature on the determinants of bond spreads has argued that they reflect risk factors, as argued in Cochrane and Piazzesi (2005). Additionally, empirical findings on European bond spreads (e.g. Codogno *et al.*, 2003 and Ehrmann *et al.*, 2010) indicate that these are associated to the degree of financial integration existing in European bond markets. Most frequently, the relevant examinations unfolded by assuming a steady state of integration in the European bond markets; an assumption incorporated in these studies by adopting time-invariant and/or linear examination frameworks. In this context, remaining differences among sovereign bond yields have been attributed mainly to liquidity and credit risk factors (see among others Codogno *et al.*, 2003, Goméz-Puig, 2006 and Manganelli and Wolswijk, 2009). Credit risk variables are used to capture fiscal discipline effects, while liquidity risk variables are interpreted as capturing market infrastructure and institutional divergences.

Furthermore, Bernoth, von Hagen and Schuknecht (2004), note that fiscal imbalances in EMU member-countries are among the major determinants of the European sovereign bond spreads, while Manganelli and Wolswijk (2009), argue that '*even small variations in bond prices may entail significant costs for the tax payer*'. Hence, because the sovereign bond spreads are related to the public debt's cost of borrowing, this topic has important implications for national economic policies exercised by EMU countries,.

The present paper contributes to the relevant literature by reporting several new aspects concerning the dynamics of European sovereign bond yield spreads; most importantly, we adopt the perspective of Neal (1985) on the non-permanent effects of financial integration. To the best of our knowledge this view has not, yet, been incorporated in the relevant empirical research, as works on the topic of determinants of European sovereign bond spreads have not allowed for a changing degree of financial integration. Specifically, the empirical frameworks employed, so far, either ignore changing market and economic conditions or incorporate dummies (e.g. Schuchknecht *et al.*, 2009) in order to separate the sample exogenously, thus allowing for a single, *ex ante* known, break point. However, this perspective relies on the assumption that after the monetary unification the deterministic process of the European sovereign bond spreads has not changed.

On the other hand, under our perspective the effects of shifts, e.g. the European monetary unification, are not permanent; instead they are subject to variations captured by unobserved -state dependent- variables. This way we allow for changes in the effects exercised by the explanatory variables, varying with market or economic conditions, to be reflected. As a result, a changing degree of strength of the interactions can be revealed even in the aftermath of the monetary unification. Overall the results reported herein indicate that monetary unification has enhanced linkages among European sovereign bond markets, although they were not characterized by full financial integration, in line with Hartmann *et al.* (2003). However, this convergence has been reversed, in a great extent, in the aftermath of the credit crisis.

Furthermore, we find that market volatility is negatively related to the European bond markets' integration process, while, in order to achieve financial integration, there is a need for elimination of differences in the pricing processes that are found to exist even in normal periods. Specifically, our results indicate that low volatility characteristics in the period after the monetary unification were associated to the close co-movements of European sovereign bond spreads. Additionally, significant differences exist in the effects exercised by the deterministic variables on spreads of different sovereign issuers, even under low volatility conditions, thus indicating the need for closer institutional integration in euro area economic policies. In our view this last outcome provides a strong motivation for policy-makers to work on the synchronization of fiscal policies or even on fiscal integration, in order to deepen financial integration in Europe.

Finally, we incorporate factors whose deterministic effects on European sovereign bond spreads have not yet been reported in the relevant empirical literature. This way, the categorization of the information incorporated in European sovereign bond spreads according to their driving factors is examined more thoroughly. More informative results are extracted by comparing findings that differ across member-countries, while we categorize the effects according to their origins, as well; be they idiosyncratic or systemic.

The present paper is organized as follows. In section 2 we review a part of the literature that has dealt, so far, with European bond markets and the existing empirical literature on the deterministic factors of sovereign bond spreads. Section 3 discusses the relations explored in the model and section 4 describes the empirical investigation framework and provides a rule for the interpretation of the results. The discussion of empirical results, in section 5, is categorized according to the aim of the investigation. Finally, section 6 discusses potential policy implications of the findings and section 7 concludes.

2. Previous literature

The issue of European bond markets integration has attracted increasing interest in empirical research. Baele *et al.* (2004) provide a formal definition of the financial integration process in European markets. From their perspective in order for a system of financial markets to be integrated, the -exogenous- factors that cause movements of prices in the markets under examination should result to equal and unidirectional effects. In the aforementioned work, sovereign bond markets in the euro area are reported to share an elevated degree of financial integration. Complying with these results, Pagano and von Thadden (2004) argue that homogenizing institutional frameworks and improving efficiency of the market infrastructure in Europe are positively related to the deepening of European bond markets' integration.

However, these results are not accepted unanimously. Hartmann *et al.* (2003) reported findings indicating that European bond markets were only partially integrated in the period after the European monetary unification, while Kiehlborn and Mietzner (2005) argue that European bond markets are segmented. More recently, Abad, Chulia and Goméz-Puig (2010) argue that although the monetary unification has resulted in the enhanced integration of European sovereign bond markets, they still cannot be seen as perfect substitutes. A more complex answer on the effects of financial integration is provided by Schulz and Wolff (2008); using daily data on European sovereign bond yields, they argue that homogenization of trading platforms has increased integration in the ultra-high to high frequency spectrum, whereas in frequencies lower than daily, causal effects stemming from the Bund market are still low, indicating the need for further steps towards full integration.

Furthermore, findings reported in Goméz-Puig (2008) indicate that, in the run-up of the EMU, a lower than expected fall in the cost of borrowing in European sovereign bonds, has been experienced. Specifically, in the first three years after EMU an increase of approximately 12 basis points in sovereign bond spreads, when adjusted for the implied exchange rate risk, is evident. The author attributes these effects to risk factors related to domestic rather than international developments while being associated to core-periphery effects related to market size. As a result, these findings directly challenge the financial integration assumption.

Previous literature examining the deterministic factors of European sovereign bond spreads' movements, has mainly focused on whether these factors are related to systemic, as opposed to idiosyncratic, risk in order to approximate the degree of financial integration in European bond markets. The empirical assessment, to reveal the information incorporated in bond spreads' movements, is mainly performed by decomposing them into deterministic factors; most frequently into credit and liquidity risk premia. More precisely, member countries' fiscal policies and violations of the Stability and Growth Pact have been referred to in the literature as sources of deviations reflected in bond spreads. We refer to previous findings of empirical literature, in more detail, below.

In their work, Codogno *et al.* (2003) have argued that the euro area sovereign bond spreads are mainly driven by international risk factors, while effects stemming from the liquidity component are larger than those stemming from the credit risk one. Arguing that small but significant credit risk components impose market discipline, their results may be interpreted as not questioning the process of financial integration in European bond markets. Similarly, Bernoth *et al.* (2004) find that European sovereign bond spreads incorporate both liquidity and default risk premia, while the latter are shown to be related to fiscal conditions in euro area countries. Their findings, however, indicate that these factors are diminished after the launch of monetary union, thus not affecting the European financial integration process.

In this context a strand of the relevant literature examines the relation between the movements in spreads and fiscal policy. The conclusions drawn in these empirical examinations are interpreted in relation to the degree of discipline imposed by markets on each country's government debt with reference to the limits set by the Stability and Growth Pact. In this aspect, Manganelli and Wolswijk (2009) relate financial integration to fiscal discipline in the euro area; they report results indicating that the higher the credit quality of the (sovereign) issuer, the higher are the effects stemming from the liquidity component. They interpret these findings by stating that although European sovereign bond spreads are driven by a common factor[1], market pricing of credit risk, as subject to countries' fiscal positions, reflects the fact that European bond markets also exercise discipline. Additionally, Schuknecht *et al.* (2009) examine the variation in sovereign bond spreads that can be accounted for by euro area countries' fiscal performance. Their results indicate that the 'no bail-out clause' of the Maastricht Treaty is perceived by markets as a credible one. Consequently, according to their results, the tighter the fiscal policy of an EMU country, the more integrated, financially, its bond market is. In this aspect, the inclusion of Italy, by Pozzi and Wolswijk (2008), in a system characterized by elimination of the idiosyncratic component in bond spreads against the Bund reveals a latent debate over the issue. Of course, including spreads of sovereign bonds issued only by the Netherlands, Italy, Belgium and France against the German benchmark, leaves open the possibility of investigating the remaining euro area, as well.

More recently, Gerlach et al. (2010) have highlighted the link between sovereign and banking risk, as reflected by the movements of euro area sovereign bond spreads. In particular, they argue that although a common risk factor is found in the sovereign bond spreads of euro area countries, after the monetary unification, its effect differs across countries according to the size and capital adequacy of their banking sector. Supporting this argument, Ejsing and Lemke (2011) show that the rescue schemes issued by euro area sovereigns, in order to address, perceived or real, banking sector challenges during the credit crisis have affected sovereign risk indicating a risk transfer from the banking sector to euro area sovereigns.

In our view, existing literature dealing with the causal effects reflected in European sovereign bond spreads' movements, is neither exhaustive, concerning the

[1] A finding existing also in Codogno *et al.* (2003), Geyer *et al.* (2004) and Favero *et al.* (2010).

factors examined, nor has it provided a robust answer to the question of the state of financial integration in European bond markets. Herein, we expand this empirical literature by relating the degree of European sovereign bonds integration to changes in the underlying market and economic conditions and by allowing the system to reflect effects not previously reported in existing empirical literature. Specifically, we incorporate some of the 'omitted variables', in terms used by Manganelli and Wolswijk (2009). Furthermore, we deem that the question is raised, again, on whether monetary union in Europe, on its own, is sufficient to achieve the goal of a single capital market.

Most papers exploring the determinants of European sovereign bond spreads, use panel regressions (see among others, Codogno *et al.* 2003, Manganelli and Woswijk 2009 and Goméz-Puig 2008). Although panel data analysis allows the reflection of cross-sectional differences, enabling i.e. the examination of differences existing in different credit quality segments, it does not allow an efficient picture of the effects produced by time variation, such as regime shifts, to be uncovered. As a result, the effects of regime shifts are ignored, while, in case such effects are examined this is performed by introducing state variables that categorize the system, exogenously, to separate states (e.g. Schuchknecht *et al.*, 2009). However, as noted by Krolzig (1997), this perspective does not allow for timely capturing of changes in the underlying conditions that eventually will be reflected, once the data observations categorized in the new regime will be enough. In order to perform this task we question the steady-state hypothesis of the effects of a monetary union, as far as the sovereign bond spreads are concerned. Thus, we adopt the framework of Georgoutsos and Migiakis (2010), which allows for endogenous shifts to be revealed. Adopting this perspective, we estimate the causal effects incorporated in European sovereign bond spreads as subject to regime shifts

3. Motivation for the empirical investigation

The present paper reports several effects related to the deterministic process of the European sovereign bond spreads for the first time. Our empirical formulation permits existing variations of the degree of financial integration to be revealed. Before laying down the framework employed, it should be noted that, as a criterion for the degree of financial integration, we adopt the thesis of Baele *et al.* (2004)'s that in the event that a system of financial markets is fully integrated, exogenous shocks should produce equal effects on the underlying assets. Furthermore, in this context we denote that, although the monetary unification strengthened interactions among European bond markets, the recent financial and economic conjunction motivates the examination of the relationship between stability conditions in financial markets and the process of European financial integration. In particular, although the credit crisis of 2007-2009 originated from factors exogenous to the monetary union, European bond yields were asymmetrically affected. As a result, we deem it important that the topic should be re-examined by employing an empirical investigation framework that allows for the underlying causal relations to vary between different states even after monetary unification.

Supporting the aforementioned argument, recent empirical findings motivate an examination of the effects of market conditions on European sovereign bond spreads. Specifically, Baele, Bekaert and Inghelbrecht (2009) investigate the factors explaining the dynamics of the correlation between stock and bond returns. They incorporate several factors that capture either risk aversion or economic fundamentals. Their results indicate that fundamental risk aversion exercises the most powerful effects on asset allocation between stocks and bonds. In this context, they show that there exists a relation between the risk exposure investors are willing to take and the capital allocated among holdings in bonds and stocks; investors change their portfolio composition according to market's uncertainty conditions. Thus, this strand of empirical research provides the motivation to examine the effects of risk-aversion and investment uncertainty on the dynamics of sovereign bond spreads.

From the aforementioned perspective, we differentiate our work from the previous literature by introducing unobserved state-dependent variables in the underlying relation; thus we expect to capture non-linearities that would otherwise be ignored. At this point it should be mentioned that introducing a dummy variable that captures the period after the monetary unification, implies that the system has remained in the new state ever since, whereas we allow the system's causal relations to shift across regimes in each observation of our data sample. In brief, the relationships are examined as belonging to different states of the deterministic structure; the state each observation belongs to is specified by probabilities that are distributed ergodically, following Markov ergodic chains. In this way we allow the system to be classified endogenously according to two separate states, while allowing the variance-covariance matrix to be subject to regime shifts, as well, the classification into regimes of high and low volatility is enabled.

In this context, we aim at decomposing the movements of sovereign bond spreads to their determinants without restricting the examination to credit and liquidity risk factors. Specifically, we examine the effects related to capital allocation between different segments of the market and the information that can be retrieved by the relevant variables, while we also incorporate variables reflecting market participants' expectations, European banking liquidity conditions and inflation rates. Equation 1, below, illustrates the relation examined:

$$\begin{aligned}(i_X^{10} - i_{DE}^{10})_t &= a_0 + a_1(i_X^{10} - i_{DE}^{10})_{t-1} + a_2\Delta f_{t-1}^i + a_3(\Delta f_{t-1}^i)^2 + a_4(i_{AAA} - i_{DE}^{10})_{t-1} + \\ & a_5(i_{BBB} - i_{DE}^{10})_{t-1} + a_6(i_X^{10} - i_X^{3m})_{t-1} + a_7(i_{DE}^{10} - i_{DE}^{3m})_{t-1} + a_8(i_{US}^{10} - i_{US}^{3m})_{t-1} + \\ & + a_9 r_{X\ t-1}^S + a_{10} r_{DE\ t-1}^S + a_{11} r_{US\ t-1}^S + a_{12}(i_X^s - MRO)_{t-1} + a_{13}(\pi_X - \pi_{DE})_{t-1} + \\ & + a_{14}(IP_{t-1}^{EU} - \bar{IP}) + a_{15}\Delta ES_{t-1}^{EU}\end{aligned} \quad (1)$$

Let, i_X^T denote the yield on a bond of the sovereign issuer *x* ($x \in$ {*AT, BE, ES, FI, FR, GR, IE, IT NT, PT*}), with a term to maturity (*T*) at issuance. For the dependent variable, following previous literature, *T* is equal to ten years. Relying on tests for unit and near-unit roots, reported in detail in the results section, we formulate the spread as a first order autoregressive process (AR(1)), in order to deal with issues of high persistence. For the rest of the explanatory variables the following paragraphs provide a brief discussion.

First, following Favero et al. (1997), we need to isolate the domestic exchange rate effects prior to the introduction of the common currency, a step that renders comparability to previous research findings. In particular, taking the rate of exchange of the currency of country *i* against the deutsche-mark (or the euro, since 1999, in the case of Greece) we calculate variable Δf_{t-1}^i as the difference of the exchange rate between points of time *t*-1 and time *t*-2. Furthermore, we introduce a second variable related to the volatility of the aforementioned exchange rate, constructed as its 12-month standard deviation. Of course, both measures, by construction, have zero values after the accession of each country in the euro-zone.

Next, we examine the potential effects that stem from the spreads between yields of the Euro area corporate bonds and the Bund. The relevant variables ($(i_{AAA} - i_{DE}^{10})$

and $(i_{BBB} - i_{DE}^{10})$) are estimated by taking differences of the yields of highly liquid, euro-denominated, corporate bond indices (iBoxx) of the respective credit category and the Bund's. By separating the effects of the highest and the lowest credit quality sectors of the investment category, we take separate results for high (AAA) and low (BBB) credit quality bonds. Thus, the coefficient of the first variable can be interpreted as reflecting effects stemming from liquidity conditions in the corporate bond sector, while the second as an indicator of the sensibility to credit risk conditions and fiscal imbalances (see Codogno *et al.*, 2003 and Manganelli and Wolswijk, 2009).

Marsh and Rosenfeld (1983) have argued that bond yields represent the price of 'money sold forward'. Thus, the pricing of a bond issued by a sovereign entity relative to a bond of another sovereign may reflect inflation and growth prospects. In this context, the term spread has been reported to contain information on expectations for growth and inflation[2]. As a result, we examine the effects exercised on sovereign bond spreads by the slope of the yield curve $(i_X^{10} - i_X^{3m})$, that is the difference between long-term (10-year) bond yields and short-term (3-month) rates.

Equity returns (r_X^S) estimated as the sum of the dividend yield and the growth rate of the market's index value (*P*) (that is $r_X^S = \left[\left(d_{t-1}/P_{t-2}\right) + \left((P_{t-1} - P_{t-2})/P_{t-2}\right)\right]$, where *d* stands for the weighted average dividend paid in *X*'s stock market), are also included in the present analysis. Specifically, we intend to examine whether stock market conditions affect sovereign spreads in line with recent literature linking bonds and equities markets developments.[3] In brief, we note that diversification of risks has been a rational explanation of divergences between the returns of bonds and stocks, as it has been related to decoupling effects also known as 'flight-to-quality'. On the other hand co-movements in stock-bond returns' have also been explained by recourse to common pricing factors. Additionally, following Semenov (2009) who argues that the equity premium puzzle reflects investors' divergence from rationality because of either over-optimism or over-pessimism, we deem that effects stemming from the

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[2] For a more thorough analysis of the information content of the term spread, interested readers may refer to, among others, Balfoussia and Wickens (2007) and Hördahl (2008) for the inflation risk premium and Estrella and Hardouvelis (1991) and Estrella and Mishkin (1997) for future economic activity. Finally, Stock and Watson (2003), provide an extended literature review of the relevant literature.

[3] See Baur and Lucey (2008), Baele, Inghelbrecht and Bekaert (2009) and Yang *et al.* (2009).

beliefs of equity market participants about economic prospects and risk aversion will be captured by this variable.

The yield curve slope and the equity return enter the equation as country-specific variables but we also include the relevant variables for Germany and the United States in each equation. In this way effects stemming from the domestic, European and international sectors are captured. Specifically, home-bias effects are captured by examining the explanatory power of domestic variables, while systemic effects are reflected by the incorporation of variables that are common across countries.

Next, the variable $(\pi_X - \pi_{DE})$ captures differences between inflation rates in country X and Germany. Assessing its relation to the sovereign bond spreads aims at examining whether sovereign bond yield spreads' movements reflect realized differences in the inflation rates of euro area countries against those of Germany. In the context of the well known combination of Fisher's equation and the Expectation's hypothesis of the term structure of interest rates, this assessment implies that we do not rely on static expectations.

We also incorporate differences between short term (1-week) interest rates formulated in country's X interbank market (i_X^s) and the central bank's main refinancing operations' rate. Of course after the monetary unification, this variable is the same for all countries (ECB's MRO). The reason behind the introduction of this variable is to capture banking liquidity effects; according to Linzert and Schmidt (2010) in case the interbank rate diverges away from the main refinancing rate this should reflect tighter liquidity conditions in the banking sector.

Finally, we introduce two variables related to economic activity in Europe as a whole; monthly deviations of the industrial production in Europe from its average value and monthly changes in the European Economic Sentiment Indicator. The first variable $(IP_{t-1}^{EU} - \bar{IP})$ is constructed by taking separate averages for the industrial production before and after October 2008. After all, the period after 2008:10, except that it coincides with the aftermath of the collapse of Lehman Brothers, is the first one in which the industrial production in Europe has been reported to experience a prolonged contraction. This variable is expected to capture growth prospects affecting on European sovereign bonds investors' decisions. Specifically, it is reasonable to believe that in case of higher than expected rates of growth bond yields should adjust accordingly. Moreover, in our case we are interested on whether the effects of these variables on the spreads are homogeneous across the countries we examine.

The second euro area variable we introduce is the rate of change of the European Economic Sentiment *(ES)* Indicator. As explained in Gelper and Coux (2009), this indicator reflects expectations[4] on euro area economic activity (ΔES^{EU}); positive (negative) movements of this variable reflect improvement (deterioration) of the economic climate in the euro area. As a result, it will serve, in our case in order to capture the effects of the expectations on the upcoming economic conditions on the dependent variables. Therefore, in case a steady state of full financial integration had been reached in the euro area bonds, there would be no significant effects stemming from the economic sentiment indicator, as movements of this, euro-aggregate, variable would exercise identical effects on the yields of each euro area bond, which would be eliminated in the estimation of spreads.

4. The empirical investigation framework

4.1 Description of the data

Our data set comprises of yields of on-the-run benchmark bonds of the eleven countries –members of the euro area (excluding Luxembourg[5])– at the time of introduction of the common currency, or in the case of Greece, one year latter. Specifically, we examine yields of bonds with a term to maturity of ten years of the countries, Austria (AT), Belgium (BE), Finland (FI), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), Netherlands (NT), Portugal (PT) and Spain (ES). Spreads are derived by differencing bond yields of each country against yields of the Bund. In this way we align our work to previous research and render comparability in our results. This composition is useful in many aspects; mainly because it covers almost the whole of the potential investment grade credit ratings' classifications, thus enabling comparisons both in a cross-country and a cross-rating category perspective.

The source of the data set we use is Thomson Financial-Datastream, except for the foreign exchange rate and foreign exchange rate volatility variables, the European industrial production and the European economic sentiment index, which all have

[4] Currently, the expectations components of the *ES* concentrate, directly, approximately 50% of the total weights. These are taken by surveys of both professionals (services, industrials, retail and construction) and consumers.

[5] Following previous literature Luxembourg is excluded due to the small size of its public debt.

been collected from Eurostat's public database. Our sample covers the period 1992:1-2009:12.[6] At this point we denote that the present paper is the first to report results covering the period that extends from the Maastricht Treaty until after the eruption of the credit crisis in 2007.

4.2 The methodological framework

First we examine the data, focusing on stationarity properties; we deem that this task is crucial for the proper specification of the European sovereign bond spreads. Taking note, first, of previous research (e.g. Lanne, 2000) reporting near-unit-root effects in interest rates and, second, of the low power of conventional Dickey-Fuller and Philips-Perron tests, we also employ the modified tests of Elliott *et al.* (1996) and Ng and Perron (2001), which enable the distinction between unit-roots and near-unit-roots (Table 1, DF-GLS and PP-GLS, respectively).

Moreover, interest rates have also been reported as autoregressive processes governed by unobserved state dependent variables, (e.g. Ang and Bekaert, 2002). As a result, initially we specify the dependent variable as a first-order autoregressive process that is subject to regime switching effects. Equation 2, below, represents the estimated Markov switching AR(1) specification:

$$(i_X^{10} - i_{DE}^{10})_t = c(s) + \theta(s)(i_X^{10} - i_{DE}^{10})_{t-1} + u_t, \text{ with } u_t \sim N\left(0, \sigma(s_t)\right). \qquad (2)$$

In equation (2), s is the unobserved state dependent variable specified as a Markov ergodic probabilistic distribution, θ is the autoregressive coefficient and c is a constant term. We employ the MS-AR technique of Hamilton (1989), in order to estimate the different regimes through the Expectations Maximization *(EM)* algorithm.

In particular, noting that $p_{ij} = \Pr ob[s_{t+1} = j \mid s_t = i], \quad \sum_{j=1}^{M} p_{ij} = 1 \quad \forall i, j$ describes the probability of the event described as "*s* belongs to regime *j*" in each observation, we estimate conditional, filtered and smoothed probabilities by employing the EM algorithm. Thus the (smoothed) probabilities constitute the main criterion in our

[6] The sample's starting point differs for Portugal (1993:5), Finland (1993:5), Spain (1993:5) and Greece (1994:4).

analysis for the specification of the dominant regime for each observation; we demand $p_{ij} > 0.5$ in order to accept that an observation belongs to one of the two regimes.

As a result we estimate relation (1) as subject to the estimated regime switching effects exercised on the coefficients of the explanatory variables and the variance-covariance matrix. Equation (3) illustrates the Markov switching specification, examined herein:

$$\begin{aligned}(i_X^{10} - i_{DE}^{10})_t &= a_0(s) + a_1(s)(i_X^{10} - i_{DE}^{10})_{t-1} + a_2(s)\Delta f_{t-1}^{i} + a_3(s)(\Delta f_{t-1}^{i})^2 + a_4(s)(i_{AAA} - i_{DE}^{10})_{t-1} + \\ &+ a_5(s)(i_{BBB} - i_{DE}^{10})_{t-1} + a_6(s)(i_X^{10} - i_X^{3m})_{t-1} + a_7(s)(i_{DE}^{10} - i_{DE}^{3m})_{t-1} + a_8(s)(i_{US}^{10} - i_{US}^{3m})_{t-1} + \\ &+ a_9(s)r_{X\ t-1}^{S} + a_{10}(s)r_{DE\ t-1}^{S} + a_{11}(s)r_{US\ t-1}^{S} + a_{12}(s)(i_X^{s} - MRO)_{t-1} + a_{13}(s)(\pi_X - \pi_{DE})_{t-1} + \\ &+ a_{14}(s)(IP_{t-1}^{EU} - \bar{IP}) + a_{15}(s)\Delta ES_{t-1}^{EU} + e_t\end{aligned} \tag{3}$$

where $e_t \sim N(0, \sigma(s_t))$.[7]

Behind this technical description, lies the economic reasoning of the variation in the degree of financial integration across time and different economic conditions, which motivates the incorporation of regime switching effects in the econometric specification. As a result, we lift the assumption of linearity in the structure of the deterministic process of European sovereign bond spreads. Foremost, by incorporating regime switching effects in the error term, the different states are allowed to be related to different volatility states in European sovereign bond markets.

To highlight the difference between our specification and those provided by previous literature, we note that the exogenous separation of the sample to pre and post EMU periods carries the assumption that the specification of the sovereign bond spreads is stable since the monetary unification (Manganelli and Woslwijk, 2009),. On the other hand under the probabilistic classification of the sample to two different specifications, each observation, either belonging in the period before or after the EMU, is classified to either of the two specifications. Under this perspective, volatility conditions may be related to different degrees of interactions between European sovereign bonds.

Furthermore, we estimate the relative explanatory power (C) of each variable in (3) by using a slight modification of the following measure (Beber et al., 2008):

[7] Standard errors have been estimated by applying the Newey-West filter.

$$C_i = \left| \hat{a}_i \sum_{t=1}^{T} (x_{it} - \bar{x}) \Big/ T \right| \cdot \left(\sum_{i=0}^{n} \left| \hat{a}_i \sum_{t=1}^{T} (x_{it} - \bar{x}) \Big/ T \right| \right)^{-1} \qquad (4)$$

where, x stands for the explanatory variable examined each time and $\bar{x}(s_t)$ is its (state-dependent) average, $\hat{a}_i$ is the corresponding estimated coefficient of relation (3). In order to take account of the relative effects of each variable, while simultaneously avoiding a bias towards large non-significant coefficients, we modify (4) by substituting the estimated coefficients by their standardized counterparts. Specifically letting $\tilde{a}_i$ denote the estimated coefficients $\hat{a}_i$, standardized on their own standard deviation, we estimate the following measure:

$$C_i = \left| \tilde{a}_i(s) \sum_{t=1}^{T} (x_{it} - \bar{x}(s)) \Big/ T \right| \cdot \left(\sum_{i=0}^{n} \left| \hat{a}_i(s) \sum_{t=1}^{T} (x_{it} - \bar{x}(s)) \Big/ T \right| \right)^{-1} \qquad (5)$$

where, s is the state-dependent variable classifying the system to the different regimes and T stands for the total number of observations. Note that the average and the coefficient are regime-dependent; that is they take the values acquired with the estimation of relation (3) which change according to the regime the observation t belongs to.

Finally, we investigate whether there exist any clusters in the deterministic effects exercised by the variables of (3) that could indicate grouping phenomena in the European bond markets. In order to approximate the power of the domestic, European or systemic effects we classify the respective variables to 'domestic', 'European' and 'systemic'. Thus, with the use of C_i, from equation (4), we distinguish the power of 'domestic' deterministic effects from 'European' and 'systemic'. In particular, we compare the impact of the domestic variables (i.e. $C_2 + C_3 + C_6 + C_9 + C_{13}$) with the sum of the effects stemming from European (i.e. $C_7 + C_{10} + C_{14} + C_{15}$) and other systemic variables (i.e. $C_4 + C_5 + C_8 + C_{11}$). The discretion of effects to domestic and systemic ones follows the reasoning that while domestic variables are country-specific, the 'systemic' variables, be they European or other, are introduced in the specification of each dependent variable, simultaneously. Following the estimation of the analogy between domestic and other explanatory effects, we classify the processes to groups according to the 'minimization of distance' criterion. Next, we repeat this exercise by comparing the effects exercised by the term and the credit spreads. The purpose of these classifications is to find indications of grouping formations related to the European sovereign bond spreads' deterministic processes.

Overall, results are interpreted under the prism of the information contained regarding the process of financial integration. We deem that in case European sovereign bonds have reached the state of full integration, at some point in the period examined, the underlying deterministic process of the dependent variables will, ultimately, remain unchanged through the rest of the sample; thus a steady-state in European bond markets would have been found in line with Hartmann *et al.* (2003). Additionally, in this case, the effects exercised by the explanatory variables should be homogenous for all dependent variables.

5. Empirical results

5.1 The AR(1) and MS-AR(1) process

Unit root test results reported in Table 1 indicate that the autoregressive processes specified here as driving European sovereign bond spreads do not unambiguously comply with the standard stationarity hypothesis; rather they are closer to highly persistent processes with roots near unity. This result may be interpreted along the lines of Lanne (2000) and (2001), arguing that interest rates follow near-unit-root processes. Recalling that the financial integration hypothesis requires parity relations between sovereign bond yields, rejection of stationarity for their one-to-one linear combinations casts doubts on the intuition of an integrated European bond market.

Next, we turn to the results of the specification for the European sovereign bond spreads as MS-AR(1) processes. Table 2 presents the findings, while the figures 1-10 illustrate the periods characterised by the different regime specifications. Note that the two specifications are found to be separated according to the different volatility characteristics of the dependent variable; high and low volatility, respectively. The first shift, from a high to a low volatility state, is found to occur close in time to the creation of the monetary union while the second shift, from a low to a high volatility state, is found to occur during the period of the recent credit crisis. However, in the first case differences exist with respect to the timing of the shifts across countries.

The earliest shift point from the high to the low volatility specification is found in the Austrian sovereign bond market, which had already shifted to a low volatility regime in 1995:3; although a transition to a high volatility regime is found soon after the Mexican peso crisis of 1994-1995, lasting till 1996:6. In the broad majority of cases the determination of spreads is found to belong to a low volatility regime since late 1997; a date coinciding with the adoption of the Stability and Growth Pact. Exceptions include the Italian and Greek cases (shift dates specified at 1999:2 and 2000:1, respectively). These results indicate that monetary policy unification exercised a shift in the European sovereign bond yields structure, although it was not simultaneous across bonds issued by different sovereigns; as a result the accession process is found to be a more natural candidate to justify the close convergence of European sovereign bond yields. By contrast the second –reverse– shift, transiting from the low to the high volatility regime, is found to occur during the 1st semester of 2008, for almost all countries examined, indicating that the deterioration of market conditions had simultaneous effects on all markets.[8]

Furthermore, according to the results reported in Table 2 there exist indications that the regime shifts have impacted the magnitude of the autoregressive coefficients as well, thus motivating a re-estimation of the unit root tests under the estimated regime switching effects. These results are reported in Table 3. In all cases there exists at least one specification in which the spread's process is clearly stationary. On the technical side, these results indicate the significance of taking into account the regime switching properties of the deterministic process governing European sovereign bond spreads. Additionally, the unit root hypothesis is found to be rejected more frequently in the low volatility regime, indicating that a stationary steady-state equilibrium, among European sovereign bonds, is more probable under low volatility conditions; in our view this may indicate that trend behavior of the spreads is found under high volatility conditions while financial stability is related to a high degree of financial integration.

5.2 The effects exercised by the explanatory variables

[8] With the exception of Finland.

Next, we turn to the results of the specification laid out by equation (3); these are contained in Tables 4 (high volatility regime) and 5 (low volatility regime). Overall, it is apparent that the exogenous explanatory variables have higher deterministic power in the high volatility regime. This result is drawn both by the higher coefficients of determination (adjusted R^2), in all cases, and the smaller value of the autoregressive coefficients for AT, BE, FI, IE, NT and PT. The interpretation of the former, in terms of the explanatory power of the specification, is straight-forward. On the other hand the autoregressive coefficients can be seen as indications of higher persistence of the dependent variable in the low volatility regime, that is not captured by the rest of the explanatory variables.

On the other hand, comparing across countries reveals indications of existence of significant differences in the driving factors of different European sovereign bond spreads; a finding that does not sit easily with the hypothesis of fully integrated markets even under the low volatility specification. Recall that, as noted by Baele *et al.* (2004), in fully integrated markets, the same events should have the same impact across markets. In particular, there exist several cases in which the effects exercised by the exogenous variables are not homogenous across the dependent variables. First, the magnitude of the explanatory variables' effects is not the same for all sovereign spreads examined, even if the coefficients carry the same sign; this result, technically, can be attributed to the different volatility of the dependent variables; thus, this may be seen as another indication that the different degrees of uncertainty in the European bond spreads, affect their information reflected by them. Finally, the sign of the coefficients of the 'systemic' explanatory variables differ in several cases, indicating that opposite effects are produced by the same exogenous factors.

For example, in the low volatility regime, if we consider the sign of the coefficients of the credit spreads, AT, FR, IE, IT and NT are found to be positively (negatively) affected by the AAA (BBB) spread while the opposite stands for ES, FI, GR and PT. These results may be showing that the sovereign bonds belonging in the first group are seen as substitutes for the portfolios investing in high quality corporate bonds while being risk averse choices as well. On the other hand, in the second group the co-movement with the low quality bonds may be interpreted as indication of credit risk considerations, even under low volatility conditions.

In the high volatility regime, however, the effects stemming from the credit spreads are highly homogenous across countries; they all are affected negatively (positively) by the AAA (BBB) corporate bond spread, a result that, in our opinion, is quite reasonable under turbulent market conditions. Specifically, we note that in the high volatility regime the effects exercised by the corporate bond spreads are more significant, as the number of coefficients that are significant under the high volatility regime is larger than under the low-volatility ones. As a result, this goes along with the fact that markets are more sensitive in pricing risks under turbulent conditions. The finding that, in the low volatility regime, the coefficients of the two credit spread variables are very close but with different signs in each case, may suggest existence of anchoring effects. Specifically, this finding suggests that, in low volatility conditions, the effects stemming from the movements of the spread of the AAA-rated bonds against the Bund are largely canceled by opposite effects originating from the BBB variable; as a result in low volatility conditions credit risk movements are indicated not to be reflected in sovereign bond spreads' movements. On the other hand, in the high volatility regime the effects stemming from AAA-spread are much larger than the respective effects of the BBB spreads; still, the effects exercised by the BBB-rated corporate bond spread are, almost for every dependent variable examined, strengthened in the high, as compared to the low, volatility regime. This finding may indicate that market credit risk developments exercise stronger effects on spreads under high volatility conditions, whereas in low volatility conditions there may exist anchoring effects. Hence, European sovereign bonds are indicated to be more sensitive to credit risk in periods of high volatility; thus, indicating a significant asymmetry in their pricing process and explaining, in a large extent, the decoupling effects in the European sovereign bonds, in the aftermath of the 2007-2009 credit crisis.

Further support to the argument of asymmetric effects, stemming from the same explanatory variables, across countries can be drawn when examining other systemic variables as well. For example, in the low volatility regime the signs of the coefficients of the German term spread and equity return are equivalently positive or negative across countries; if the German term spread rises it will have positive impact on the sovereign spreads of Belgium, Finland and Greece and negative on the French spread. In the high volatility regime again there exist significant differences across country, but the significance of this variable is decreased. Again, if we consider the deviation of the European industrial production index from its average and the movements of the economic sentiment indicator, there exist mixed signs across countries, in the low volatility regime, whereas under high volatility conditions both variables have more homogenous, largely positive and significant, effects on the dependent variables across countries. Significant and positive coefficients (e.g. the Belgian spread, in the high volatility regime) may be related to inflationary considerations, accompanying expectations on higher euro area growth, from investors, whereas negative effects from the same variables are reasonable if we consider that investors have higher motives to invest in high-yielders under relatively high investment confidence (e.g. the case of the Greek spread under low volatility conditions).

Expectations on domestic growth and inflation, are reflected in the movements of the domestic spread between long and short-term rates; this variable is found to be more significant, in the low volatility regime, while its effects are not homogenous across countries. However, the lack of homogeneity in this case does not necessarily reflect divergences among the European sovereign bond yields, as this explanatory variable reflects expectations on domestic growth and inflation. This finding rather motivates the examination of the homogeneity of the information contained in the European term spreads, a task that is out of scope for the paper at hand.

Additionally, banking liquidity variables are found to have mixed effects on the European sovereign bond spreads, while their significance is increased in the high volatility regime as compared to the low volatility one. These results are related to the fact that these variables mostly reflect domestic effects, in the high volatility regime, as this period largely covers the period before the monetary unification. In more detail, the results indicate that an increase in the spread between the interbank weekly rate and the main refinancing rate of the central bank increases the sovereign bond spreads of Belgium, Ireland and Portugal, while decreases the spreads of Finland, France and Greece, under high volatility conditions.

The variables capturing the difference between domestic and German inflation, are found to exercise, in large, significant positive effects (with the exception of Finland) on the dependent variables; a result indicating that increases in the difference of the domestic inflation against the German equivalent increases the sovereign bond spreads of euro area countries. Although the significance of these coefficients decreases under the low volatility regime, this result is significant in highlighting the inflation considerations incorporated in sovereign bond yields movements.

Finally, the equity return, be it domestic or not, is found to have limited significance for movements in European sovereign bond spreads, concentrated mostly in the high volatility regime. Under the low volatility regime the effects of domestic equity returns are mostly positive; a result that may be interpreted along the lines of Semenov (2009), who argues on the asset allocation implications under different states of confidence. On the other hand, the increase in the presence of negative effects, under high volatility, may be explained as a flight-to-quality effect (i.e. Baur and Lucey, 2009 and Beber *et al.* 2009). As far as the German and the US equity returns are concerned, only limited significant effects (on the Finnish and Italian spreads) are found in the former case, while the latter variable is not significant in either regimes.

5.3 Decomposition of the deterministic components

In Tables 4 and 5, in the bottom line, we report the adjusted *R*-squared coefficients. In every case they are indicated to be very high, exceeding 50%, thus highlighting the efficiency of the formulation (3).[9] Additionally, we find that the proportion of the movement in country-specific spreads captured by the specification examined herein is greater under the high volatility regime. This result, combined with the increased autoregressive coefficients in the low volatility regime, indicates that the deterministic process of European sovereign bond spreads is found to be stronger under high volatility conditions as the number of explanatory variables found to exercise significant effects on the spreads is higher under the high volatility regime.

Table 6 contains the decomposition of the deterministic part of the process driving the country-specific spreads to its determinants, as these are specified under relation (4). The dynamics of the deterministic power of the explanatory variables are illustrated in the figures 11-20. The upper panel of Table 6 contains the average deterministic power of the explanatory variables according to the high volatility

[9] This specification has been found to be the most efficient when compared to alternative ones, which we have run for robustness purposes. Note that if the specification contained only credit risk variables it would capture, on average, only around 10-15% of the spreads' movements, measured by the adjusted R-squared coefficient. Results of additional regressions are not reported in this paper for economy of space reasons, but are available upon request.

regime, while in the lower panel equivalent figures for the low volatility regime are reported.

A first result extracted by Table 6, is that indeed the explanatory power of all the variables, except for the autoregressive factor, is increased in the high volatility regime. Additionally, the credit spreads' deterministic power is also increased under the same regime. In this table, however, there exists an initial indication of grouping formations in the set of Euro area countries, as the impact of the BBB variable is disproportionally larger for several sovereign spreads (e.g. BE, ES, GR, IT, PT), as compared to the AAA one, a result that remains in the low volatility regime as well (with the exception of Spain). On the other hand, for Finland and Ireland the impact of the AAA variable is much larger than that of the BBB variable, in the high volatility regime, indicating that asset allocation effects, in this case, are related mostly to liquidity effects.

Additionally, there exist clear signs that the movements of the sovereign bond spreads cannot be attributed solely to credit conditions. For example, the maximum impact of the BBB-rated credit spread is found in the high volatility regime for Greece (38.26%); that means that 62% of the movements of the Greek sovereign bond spread are not explained in terms of credit risk but rather according to information contained in the rest of the explanatory variables. Furthermore, the finding of high impact of the domestic term spread, in the low volatility specification indicates that expectations on future macroeconomic conditions exercise significant deterministic effects on sovereign bond spreads, when uncertainty conditions are low.

Finally, from figures 11-20, it is made apparent that there exist several cases for which the rest of the explanatory variables have affected the movements of sovereign bond spreads. For example, the finding of increased impact of the exchange rate and exchange rate volatility before the monetary unification is in line with intuition and previous literature. In this context, one can observe a systemic increase in the effects of the exchange rate variables in the final phase of the ERM II.

5.4 Grouping formations

The aforementioned findings highlight the need to examine even further the symmetry of the effects of the deterministic components of relationship 3. Specifically, we ask whether there exist significantly different degrees of similarities in the deterministic processes followed by the Euro area sovereign bond spreads, across countries.

Ultimately, in case financial integration had been achieved, we would expect to find symmetrical effects and lack of segmentations in the underlying markets. As a result, the findings discussed previously, motivate further analysis for grouping formations. Figures 21-24 illustrate the explanatory power of the exogenous variables classified, in section 4.2 above, according to their origination as domestic, systemic and European, while figures 25 and 26 illustrate classifications of the explanatory power of the term and credit spreads. The left column diagrams contain the classifications according to the high volatility and the right column ones according the low volatility regimes.

When examining the systemic (i.e. those stemming from the same explanatory variables for all countries) against the domestic effects, we find that there exist mixed results across countries and regimes; for example the domestic effects contain higher deterministic power for the Finnish and Irish spreads in the high volatility regime, whereas Belgium, France, Greece, Italy and Portugal may be seen as consisting a group for which the systemic factors exercise increased deterministic effects as compared to the domestic ones, in both regimes. Additionally, in the low volatility regime the domestic effects strengthen only for Spain, whereas for Austria, Finland and the Netherlands the systemic and domestic effects exercised, under the low volatility specification, are in large equiponderant.

The European effects are a specification of the ones stemming from the systemic factors. The comparison of these effects to the ones stemming from other systemic variables, shown in figures 23 and 24, serves to better understand the root of the systemic effects on the spreads. As shown in the aforementioned figures, the effects stemming from the credit spreads and the US-related variables are larger than the ones stemming from the European variables. Furthermore, they are all increasing with higher volatility conditions. However, clear evidence of grouping formation in this case does not exist; the comparison reveals that effects stemming from the ‘other systemic variables’ are largely homogenous across countries and regimes.

Finally, figures 25 and 26 report results related to the comparison of effects stemming from the credit and the term spreads; this comparison is meant for extracting conclusions on the credit-risk or expectations related movements incorporated in the sovereign spreads. In this case, there exist indications of grouping formations in both regimes; the effects of credit spreads on the Greek and the Portuguese spreads are much stronger than the ones stemming from the term spreads, in both regimes. On the other hand, the effect of the credit spread for the sovereign bond spread of Finland is rather small. For the rest of the countries the effects are largely homogenous, with the credit and the term spreads having comparable explanatory power, while the credit spreads' deterministic value increases in the high volatility regime.

6. Policy implications

In brief, our results indicate that the monetary unification is not sufficient, by its own, for financial integration to be achieved in the Euro area; even in the state characterized by a high degree of financial integration, there existed differences in the underlying deterministic processes of European sovereign bond spreads. In particular, the results reported herein indicate that European sovereign bonds are more probable to be subject to parity relations under low volatility conditions. Still, the effects originating by exogenous factors on European sovereign bond spreads are not homogenous across countries, while, in several cases, the dependent variables are found to be subject to opposite effects from the same explanatory variables. in this context, our results indicate that market conditions, specifically the degree of uncertainty measured by volatility conditions, play a crucial role for the degree of integration shared among European bond markets.

Additionally, the uncertainty conditions are found to be related to the effects reflected in the spreads' movements; the effects exercised by variables related to credit risk are strengthened under high volatility conditions, while the effects reflecting market's expectations, such as the term spread, are strengthened in the low volatility regime. This finding, implies that, as markets price risk, it is the investment sentiment conditions that lead the focus either to the former (credit risk) or to the latter (macroeconomic expectations). Furthermore, combining this finding with the timing of the first shift, which in large coincides with the adoption of the Stability and Growth Pact, indicates the existence of a link of the spreads dynamics with market participants' perception on prospective, rather than actual, economic fundamentals.

Overall, we deem that this study has shown that monetary unification is not panacea; it is essential for European regulatory authorities and monitoring bodies to ensure not only a level playing field among market participants but stable market conditions as well. Our results show that the process of financial integration in the European bond markets should be viewed as interconnected to financial stability issues. Furthermore, researchers and analysts should be precautious when interpreting spreads' dynamics, solely on the grounds of credit risk. In our opinion, relating spreads' movements to other factors, as well, such as growth expectations and investment sentiment, provides a more complete view.

7. Concluding remarks

Overall, we have illustrated, first, that, when assessing the driving factors of bond spreads, caution is needed in applying the proper econometric framework. In particular, in the case of the European sovereign bond spreads, we have found that high persistence and regime switching effects may have a crucial role for the proper specification of spreads' deterministic processes and they should be taken into account. Additionally, although the effects exercised by credit risk are strengthened under high volatility conditions, the deterministic process of European sovereign bond spreads is subject to the investment sentiment conditions. In this context we have found that expectations on prospective macroeconomic conditions affect the pricing process of European sovereign bonds, as well.

Furthermore, we have found that the co-movements among European sovereign bonds are closer under low volatility conditions, indicating a positive relation among stability in financial markets and financial integration. However, although a higher state of integration is indicated after the monetary unification, significant differences among the spreads' deterministic processes still existed. Furthermore, clustering the exogenous variables contribution in the spreads' movements, points out that there exist groups that differ significantly according to the explanatory power exercised by the systemic or idiosyncratic effects. Thus, full integration has not yet been achieved in European bond markets, motivating, in our view, further efforts for closer European integration.

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Table 1: Sovereign bond spreads' properties						
	Mean	Std. dev.	DF-test	DF-GLS	PP-test	PP-GLS
AT	0.185	0.153	-2.969**	-2.503**	-3.454**	-2.358**
BE	0.351	0.290	-2.249	-1.801*	-2.366	-0.965
ES	1.169	0.157	-1.914	-1.062	-1.584	-1.179
FR	0.199	0.249	-3.106*	-2.283**	-2.841*	-2.177**
FI	0.772	1.161	-2.584*	-0.142	-2.609*	-0.254
GR	4.049	5.379	-3.736**	0.093	-2.592*	0.221
IE	0.580	0.645	-2.199	-2.189**	-2.109	-2.233**
IT	1.553	1.956	-1.692	-0.401	-1.720	-0.363
NT	0.086	0.151	-3.029**	-1.263	-3.000**	-1.224
PT	1.424	1.924	-2.184	-0.107	-2.120	0.307

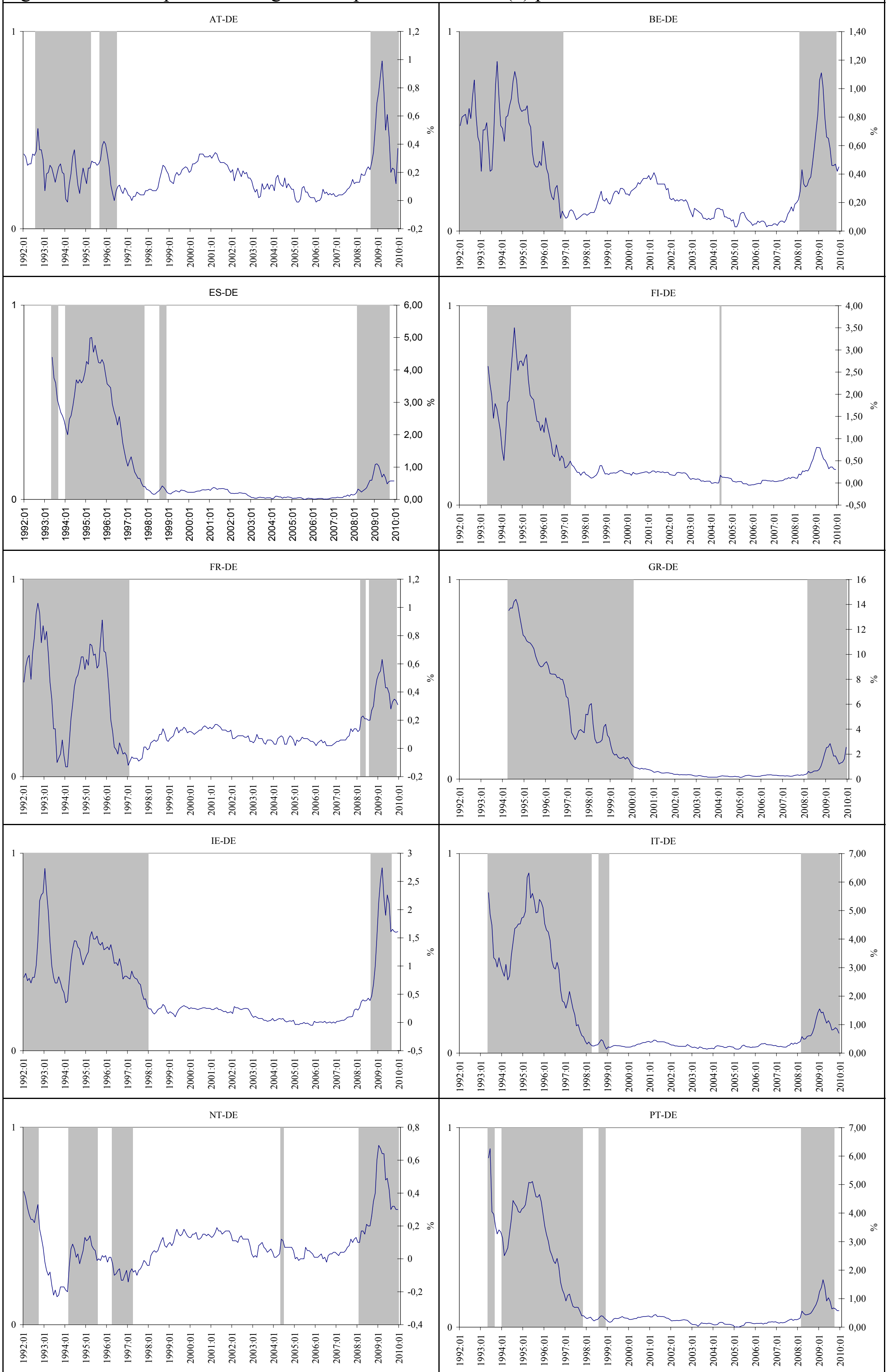
Note: The table presents results of Augmented Dickey Fuller (DF) and standard Philips and Perron (PP) tests, as well as their GLS-modified versions provided by Elliott *et al.* (1996) and Ng and Perron (2001), respectively. Asterisks (*,**) denote rejection of the null of a unit root in the data (in a confidence band of 10% and 5%, respectively).

Table 2: The spreads under the Markov switching AR(1) formulation (eq. 2)				
X	θ		*X*'s std. deviation	
	s= 1	*s*= 2	*s*= 1	*s*= 2
AT	0.953 (0.026)	0.867 (0.067)	0.031	0.106
BE	0.975 (0.020)	0.904 (0.051)	0.023	0.117
ES	0.941 (0.005)	0.992 (0.018)	0.026	0.275
FI	0.895 (0.032)	0.949 (0.031)	0.031	0.362
FR	0.912 (0.029)	0.954 (0.038)	0.019	0.103
GR	0.927 (0.018)	0.987 (0.008)	0.030	0.493
IE	0.992 (0.011)	0.924 (0.043)	0.031	0.226
IT	0.922 (0.011)	0.989 (0.017)	0.028	0.347
NT	0.891 (0.026)	0.972 (0.031)	0.022	0.061
PT	0.904 (0.005)	0.975 (0.026)	0.036	0.439

Note: Figures in parentheses report the estimated standard deviation figures of the autoregressive coeffcients.

Table 3:	Sovereign bond spreads' properties under the regime switching formulation					
	Mean	Std. dev.	DF-test	DF-GLS	PP-test	PP-GLS
High volatility regime						
AT	0.078	0.169	-2.405	-2.087**	-3.191**	-2.382**
BE	0.649	0.259	-2.576*	-2.813**	-2.199	-3.008
ES	1.028	1.623	-1.812	-0.956	-1.897	-1.991**
FR	0.151	0.271	-2.695*	-1.595*	-2.655*	-1.651*
FI	0.644	1.223	-2.169	-0.073	-2.552*	-0.081
GR	3.824	5.444	-3.819**	0.059	-2.745**	0.295
IE	0.231	0.534	-2.651*	-1.837*	-2.531*	-1.937**
IT	1.077	1.715	3.049**	-0.007	-2.681*	0.076
NT	0.052	0.141	-2.579*	-0.992	-2.804**	-0.998
PT	1.162	2.003	-3.033**	-0.070	-3.033**	-0.043
Low volatility regime						
AT	0.106	0.106	-3.511**	-1.372	-3.511**	-1.351
BE	0.110	0.119	-1.591	-0.881	-1.688	-1.869*
ES	0.140	0.367	-4.501**	-4.127**	-4.814**	-4.122**
FR	0.048	0.061	-3.338**	-2.657**	-3.052**	-2.532**
FI	0.130	0.159	-2.394	-1.878*	-2.269	-1.982**
GR	0.168	0.223	-2.501*	-2.128**	-2.449	-2.086**
IE	0.290	0.422	1.629	-1.635*	-1.907	-1.629*
IT	0.149	0.142	-2.339	-1.776*	-2.129	-1.749*
NT	0.035	0.081	-2.747*	-2.591**	-2.801**	-2.517**
PT	0.261	0.546	-4.604**	-4.271**	-4.909**	-3.939**
Note: As in table 1.						

Figures 1-10: European sovereign bond spreads as MS-AR(1) processes



Note: The diagrams illustrate sovereign bond yield spreads during the period 1992-2009; shadowed regions indicate periods belonging in the high-volatility regimes.

Table 4: High volatility regime										
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
a_0	0.006**	0.002	0.018	0.001	0.003	0.007	0.002	0.009	0.001	0.030
	(0.003)	(0.002)	(0.018)	(0.001)	(0.002)	(0.007)	(0.004)	(0.006)	(0.011)	(0.025)
a_1	0.612**	0.662**	0.855**	1.122**	0.902**	0.961**	0.819**	0.959**	0.628**	0.800**
	(0.104)	(0.085)	(0.111)	(0.261)	(0.044)	(0.037)	(0.059)	(0.049)	(0.093)	(0.047)
a_2	-0.002	0.052	0.232	0.117	0.002	-0.023	0.013	0.259**	0.067	0.766**
	(0.057)	(0.052)	(0.171)	(0.057)	(0.033)	(0.068)	(0.041)	(0.060)	(0.059)	(0.255)
a_3	0.229	0.065	-0.013	0.916	-0.157	0.033	3.920	-0.004**	0.088	-0.133**
	(0.269)	(0.086)	(0.061)	(0.802)	(0.535)	(0.026)	(4.424)	(0.002)	(1.052)	(0.64)
a_4	-0.286**	-0.448**	-0.321	-0.039	-0.159*	-1.038**	-0.414	-0.228**	-0.138**	-1.057**
	(0.109)	(0.132)	(0.283)	(0.764)	(0.087)	(0.307)	(0.293)	(0.113)	(0.065)	(0.212)
a_5	0.192**	0.223**	0.176	-0.236	0.089**	0.551**	0.272*	0.059	0.105**	0.594**
	(0.053)	(0.062)	(0.173)	(0.682)	(0.042)	(0.169)	(0.155)	(0.078)	(0.041)	(0.122)
a_6	-0.073	0.067	0.092	-0.234	-0.073**	-0.143**	0.029	-0.015	0.018	0.035
	(0.075)	(0.048)	(0.108)	(0.250)	(0.037)	(0.063)	(0.026)	(0.051)	(0.042)	(0.067)
a_7	0.072	-0.059	-0.038	0.159	0.066*	0.130	-0.026	0.002	-0.035	0.056
	(0.076)	(0.047)	(0.056)	(0.129)	(0.036)	(0.083)	(0.043)	(0.033)	(0.043)	(0.045)
a_8	0.011	0.051**	-0.018	0.037	0.033**	0.173**	0.079**	0.088	0.007	-0.004
	(0.019)	(0.020)	(0.082)	(0.077)	(0.016)	(0.071)	(0.023)	(0.042)	(0.012)	(0.067)
a_9	-0.005*	0.004	0.006	-0.004	-0.002	-0.022**	-0.001	0.018**	0.001	-0.012**
	(0.003)	(0.003)	(0.008)	(0.006)	(0.003)	(0.005)	(0.006)	(0.005)	(0.002)	(0.006)
a_{10}	0.002	-0.004	-0.020	-0.023**	-0.002	-0.014	-0.003	-0.017**	-0.001	-0.018
	(0.005)	(0.003)	(0.016)	(0.009)	(0.003)	(0.010)	(0.007)	(0.008)	(0.002)	(0.014)
a_{11}	0.001	0.002	0.009	0.022	0.004	0.008	0.007	-0.001	-0.002	0.012
	(0.004)	(0.003)	(0.015)	(0.014)	(0.002)	(0.012)	(0.007)	(0.008)	(0.002)	(0.013)
a_{12}	-0.035	0.087**	-0.060	-0.481*	-0.073**	-0.111*	0.011*	0.023	-0.023	0.064*
	(0.047)	(0.038)	(0.167)	(0.278)	(0.036)	(0.066)	(0.006)	(0.126)	(0.024)	(0.039)
a_{13}	-0.026	0.041**	0.174**	-0.244**	-0.006	-0.083	0.119**	0.164**	0.012	0.249**
	(0.050)	(0.017)	(0.089)	(0.091)	(0.026)	(0.057)	(0.039)	(0.038)	(0.019)	(0.065)
a_{14}	0.008	0.019**	0.035**	0.058**	0.018**	0.034**	0.002	0.029**	0.008**	0.073**
	(0.006)	(0.005)	(0.017)	(0.018)	(0.004)	(0.015)	(0.007)	(0.060)	(0.003)	(0.015)
a_{15}	0.002	0.042**	0.056	0.063	-0.009	0.018	-0.030	-0.004	0.011	0.202**
	(0.019)	(0.020)	(0.095)	(0.069)	(0.016)	(0.082)	(0.046)	(0.043)	(0.010)	(0.068)
$\tilde{R}^2$	0.869	0.961	0.963	0.978	0.953	0.995	0.961	0.990	0.950	0.954

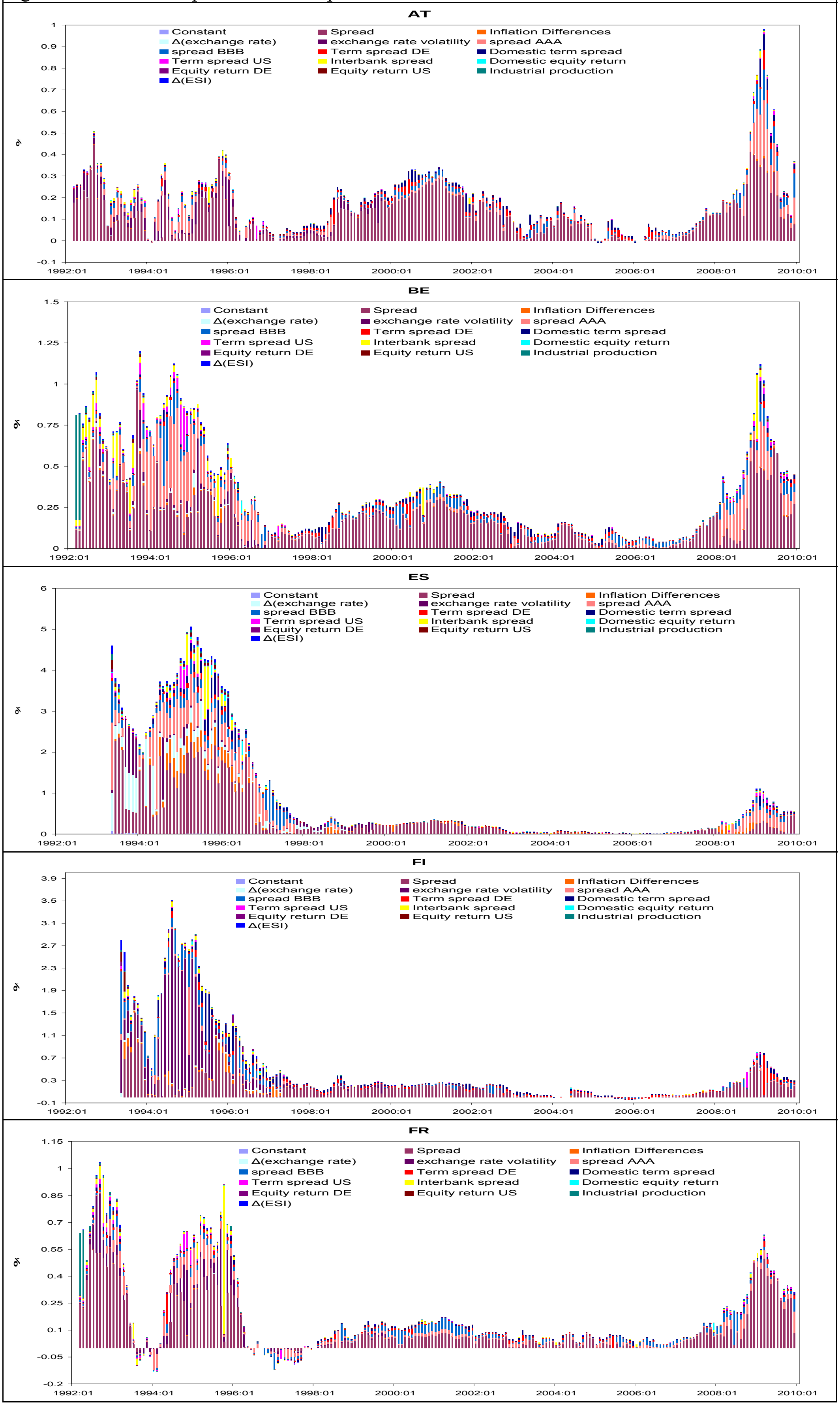
Note: The contents of the first column correspond to the coefficients of the explanatory variables in equation (3). Parentheses contain the respective std. deviations, while asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively.

Table 5: Low volatility regime										
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
a_0	0.006** (0.003)	0.007 (0.005)	0.056 (0.039)	0.011 (0.009)	0.006 (0.005)	0.011 (0.011)	0.023 (0.019)	0.006 (0.004)	0.004 (0.041)	0.72 (0.049)
a_1	0.992** (0.127)	1.062** (0.043)	0.716** (0.179)	1.172** (0.071)	0.645** (0.106)	0.813** (0.085)	0.984** (0.034)	0.717** (0.116)	0.757** (0.056)	0.882** (0.130)
a_2	0.011 (0.068)	0.015 (0.036)	-1.394 (0.941)	0.048 (0.034)	-0.013 (0.037)	-0.116 (0.152)	-0.028 (0.028)	0.182 (0.187)	-0.019 (0.025)	-0.077 (0.561)
a_3	-0.269 (0.192)	-0.058 (0.053)	1.499 (1.035)	0.587** (0.232)	-0.199 (0.362)	-0.024* (0.014)	0.454 (3.101)	1.807 (1.768)	-0.600* (0.344)	-0.041 (0.029)
a_4	0.019 (0.019)	0.022 (0.032)	-0.001 (0.068)	-0.007 (0.010)	0.060** (0.026)	-0.054 (0.041)	0.015 (0.019)	0.041 (0.029)	0.015 (0.013)	-0.083 (0.103)
a_5	-0.009 (0.015)	0.017 (0.022)	0.002 (0.046)	0.008 (0.007)	-0.034** (0.016)	0.047* (0.026)	-0.018 (0.018)	-0.014 (0.019)	-0.009 (0.009)	0.048 (0.094)
a_6	-0.076 (0.130)	-0.079** (0.035)	0.058 (0.085)	-0.263** (0.068)	0.074** (0.036)	0.015 (0.035)	0.005 (0.023)	0.048 (0.038)	0.029 (0.041)	-0.017 (0.045)
a_7	0.081 (0.132)	0.093** (0.039)	-0.018 (0.086)	0.251** (0.067)	-0.087** (0.037)	0.042* (0.023)	-0.001 (0.032)	-0.049 (0.045)	-0.030 (0.042)	0.060 (0.044)
a_8	-0.004 (0.006)	-0.008** (0.004)	-0.023 (0.017)	0.009** (0.003)	0.007* (0.004)	-0.023 (0.019)	-0.001 (0.005)	0.002 (0.007)	-0.001 (0.003)	-0.046 (0.032)
a_9	0.001 (0.001)	0.001 (0.001)	0.004 (0.004)	0.001 (0.001)	0.002** (0.001)	-0.001 (0.001)	0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	0.002 (0.003)
a_{10}	-0.001 (0.001)	-0.001 (0.001)	-0.002 (0.004)	0.001 (0.001)	-0.001 (0.001)	0.002 (0.002)	-0.001 (0.002)	0.002 (0.002)	0.001 (0.001)	-0.001 (0.003)
a_{11}	0.001 (0.001)	0.001 (0.001)	-0.003 (0.004)	-0.001 (0.001)	-0.002 (0.001)	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.002)	0.001 (0.001)	0.003 (0.006)
a_{12}	0.005 (0.014)	-0.018 (0.014)	-0.019 (0.065)	0.018 (0.014)	0.011 (0.014)	-0.015 (0.018)	0.010 (0.025)	0.033 (0.032)	-0.001 (0.012)	-0.057 (0.140)
a_{13}	-0.007 (0.005)	-0.009 (0.008)	-0.027 (0.021)	0.014** (0.004)	-0.004 (0.006)	-0.013 (0.010)	0.001 (0.003)	0.001 (0.008)	0.011** (0.003)	0.006 (0.013)
a_{14}	-0.001 (0.002)	-0.002 (0.002)	-0.009 (0.007)	0.004** (0.001)	0.002 (0.002)	-0.003 (0.004)	0.002 (0.002)	0.002 (0.001)	0.002 (0.002)	-0.021 (0.015)
a_{15}	0.004 (0.006)	-0.001 (0.005)	-0.005 (0.012)	-0.005 (0.005)	0.012* (0.007)	-0.023** (0.010)	0.005 (0.009)	-0.004 (0.009)	-0.001 (0.005)	-0.023 (0.029)
$\tilde{R}^2$	0.823	0.896	0.549	0.933	0.696	0.872	0.733	0.898	0.887	0.500

Note: The contents of the first column correspond to the coefficients of the explanatory variables in equation (3). Parentheses contain the respective std. deviations, while asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively.

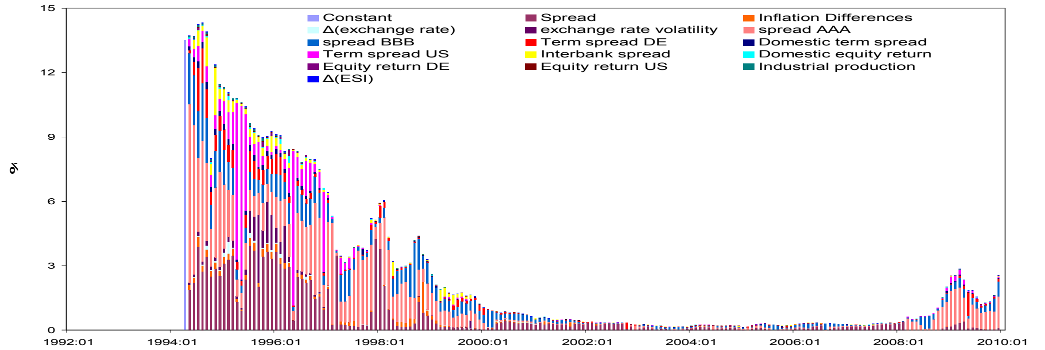
Table 6: Decomposition of the spreads' deterministic component										
High volatility regime										
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
a_1	38.29%	37.31%	24.78%	22.40%	42.72%	16.86%	21.32%	34.95%	33.29%	16.84%
a_2	1.16%	1.49%	8.06%	5.92%	0.18%	2.57%	1.50%	12.79%	0.49%	4.75%
a_3	0.03%	0.58%	6.98%	1.42%	0.03%	0.33%	0.04%	4.13%	2.01%	6.71%
a_4	17.97%	4.48%	1.72%	32.59%	14.47%	2.37%	49.62%	0.29%	7.64%	5.42%
a_5	24.24%	30.30%	23.84%	2.47%	18.68%	38.26%	11.84%	24.06%	29.15%	36.51%
a_6	9.57%	13.27%	14.07%	14.15%	10.36%	20.35%	10.37%	7.24%	17.39%	22.36%
a_7	2.20%	0.99%	1.47%	2.81%	2.32%	4.93%	0.35%	0.11%	3.38%	1.14%
a_8	2.40%	1.39%	4.34%	11.29%	1.55%	1.45%	1.49%	1.37%	1.55%	1.36%
a_9	1.45%	3.17%	1.98%	0.55%	2.62%	7.80%	2.89%	8.66%	1.70%	0.25%
a_{10}	1.96%	4.85%	2.95%	3.00%	5.11%	3.08%	0.08%	3.54%	2.24%	0.79%
a_{11}	0.20%	0.19%	0.29%	0.10%	0.17%	0.93%	0.05%	0.60%	0.12%	0.29%
a_{12}	0.10%	0.55%	1.73%	0.68%	0.12%	0.32%	0.05%	1.37%	0.16%	0.36%
a_{13}	0.08%	0.10%	0.70%	0.94%	0.75%	0.22%	0.14%	0.09%	0.17%	0.42%
a_{14}	0.04%	0.76%	5.24%	1.11%	0.23%	0.17%	0.23%	0.11%	0.41%	1.91%
a_{15}	0.30%	0.58%	1.87%	0.56%	0.69%	0.35%	0.02%	0.69%	0.31%	0.92%
Low volatility regime										
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
a_1	55.32%	55.68%	47.35%	51.90%	41.24%	47.63%	54.67%	65.48%	49.22%	43.45%
a_2	0.36%	0.52%	10.01%	0.65%	0.14%	2.57%	0.17%	0.09%	0.91%	1.41%
a_3	0.10%	0.07%	3.45%	0.10%	0.08%	0.45%	0.05%	0.00%	0.27%	0.23%
a_4	4.80%	0.54%	6.37%	2.36%	2.30%	0.18%	2.41%	3.44%	18.48%	0.31%
a_5	8.56%	7.10%	1.11%	2.93%	14.62%	10.92%	10.40%	8.13%	8.00%	16.17%
a_6	9.98%	16.62%	5.23%	8.45%	24.77%	30.96%	27.04%	10.00%	10.64%	25.72%
a_7	9.63%	8.00%	3.84%	15.78%	7.12%	3.42%	0.18%	3.80%	5.72%	4.16%
a_8	9.18%	9.14%	12.61%	16.06%	6.14%	1.19%	0.92%	5.51%	6.08%	2.37%
a_9	1.03%	0.74%	1.70%	0.81%	0.90%	0.73%	0.07%	0.05%	0.07%	1.15%
a_{10}	0.52%	1.15%	4.95%	0.51%	1.79%	1.20%	3.13%	3.22%	0.07%	3.71%
a_{11}	0.11%	0.14%	1.12%	0.05%	0.13%	0.05%	0.27%	0.04%	0.06%	0.07%
a_{12}	0.10%	0.07%	0.30%	0.05%	0.26%	0.06%	0.10%	0.09%	0.09%	0.04%
a_{13}	0.13%	0.11%	0.58%	0.06%	0.11%	0.06%	0.23%	0.03%	0.25%	0.26%
a_{14}	0.15%	0.04%	0.57%	0.15%	0.32%	0.50%	0.25%	0.07%	0.05%	0.52%
a_{15}	0.04%	0.07%	0.81%	0.14%	0.06%	0.07%	0.11%	0.04%	0.10%	0.46%

Figures 11-20: Decomposition of the spreads to their determinants

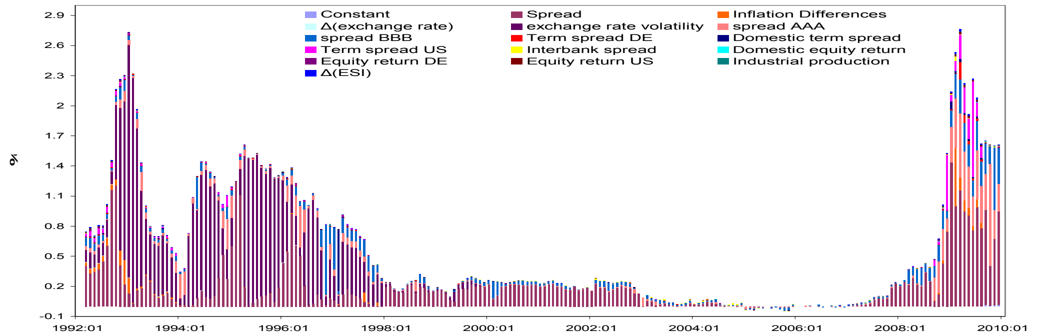


Panel B (continued): Decomposition of the spreads to their determinants

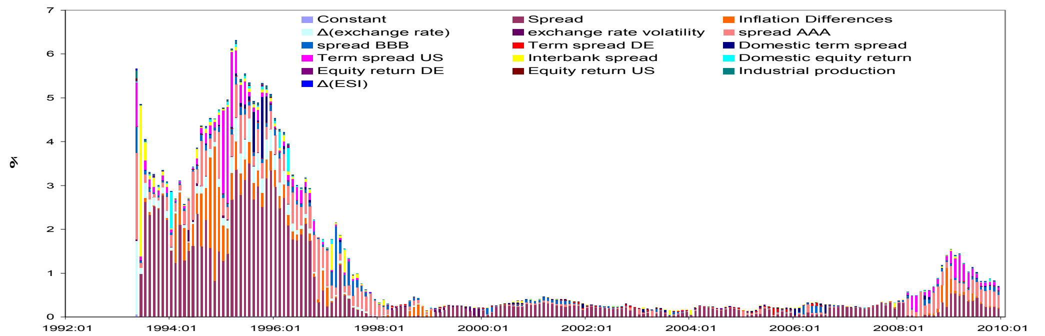
GR



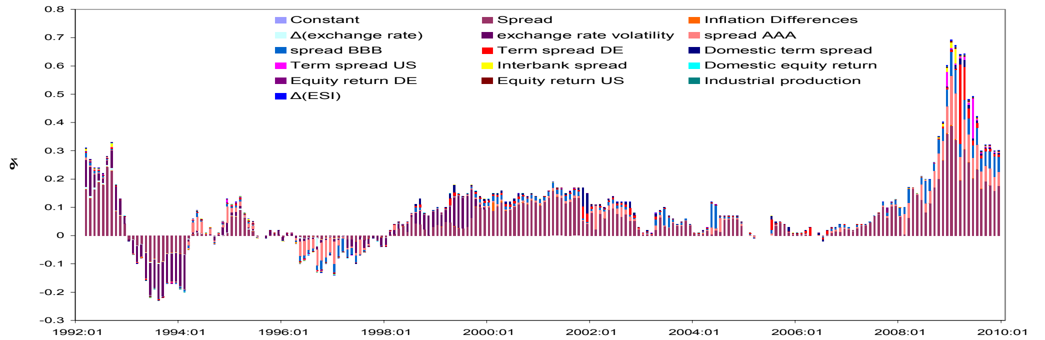
IE



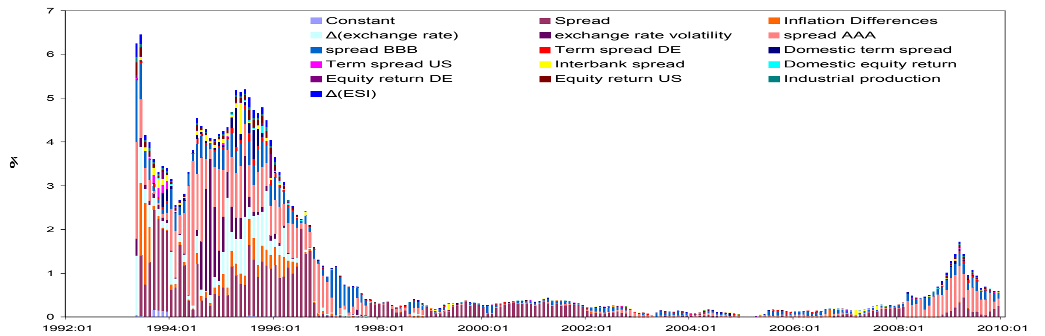
IT



NT

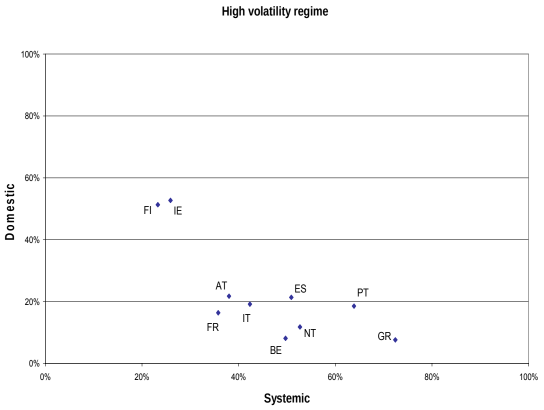


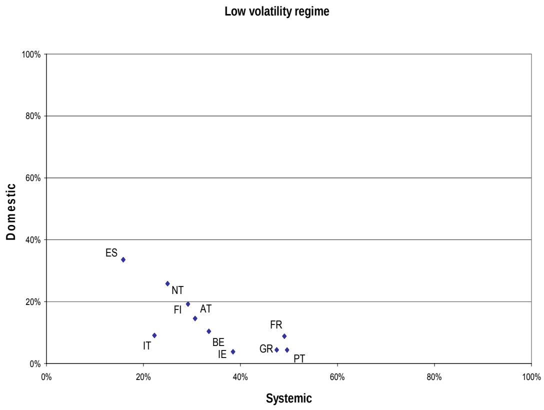
PT



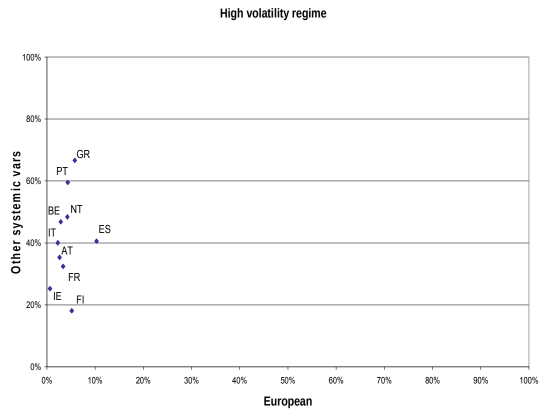
Figures 21-26: Grouping formations

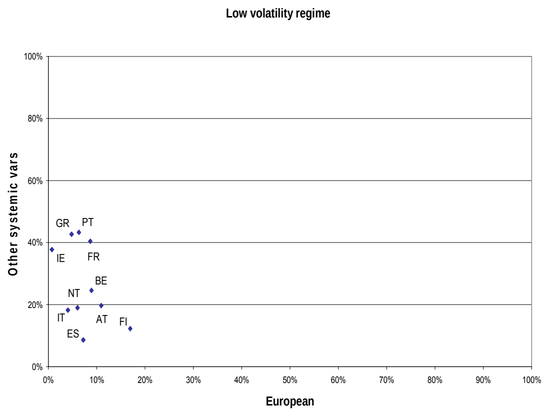
Systemic vs domestic components





European vs other systemic components





Term vs credit spreads