BANK OF GREECE

EUROSYSTEM

Working Paper

European sovereign bond spreads: monetary unification, market conditions and financial integration

Dimitris A. Georgoutsos
Petros M. Migiakis

115

JUNE 2010

WORKINKPAPER WORKINKPAPER WORKINKPAPER WORKINKPAPER WO

BANK OF GREECE
Economic Research Department – Special Studies Division
21, E. Venizelos Avenue
GR-102 50 Athens
Tel: +30210-320 3610
Fax: +30210-320 2432

www.bankofgreece.gr

Printed in Athens, Greece
at the Bank of Greece Printing Works.

ISSN 1109-6691

EUROPEAN SOVEREIGN BOND SPREADS: MONETARY UNIFICATION, MARKET CONDITIONS AND FINANCIAL INTEGRATION.

Dimitris A. Georgoutsos
Athens University of Economics & Business

Petros M. Migiakis
Bank of Greece

ABSTRACT

In this paper we examine the dynamics of European sovereign bond yield spreads focusing on issues related to financial integration and market conditions. The finding of 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, along the lines of a Markovian probabilistic specification. Specifically, by taking into account regime switching effects we examine, rather than assume, that monetary unification affected sovereign bond yield spreads, allowing for states of higher and lower interactions to be revealed. Next, we examine the effects of several exogenous explanatory variables. Our results indicate that European sovereign bonds achieved only partial integration even before the recent financial crisis, while financial integration and financial stability are found to be interconnected. Specifically, we find evidence of different effects exercised by the same deterministic factors on sovereign bond yield spreads even before the recent crisis. Additionally, it appears that a negative relation exists between low-volatility conditions and the magnitude of effects exercised by idiosyncratic risk factors on bond yield spreads.

Keywords: financial integration; sovereign bond spreads; near unit root; regime shifts

JEL classification: F21, 36, G12, G32

Acknowledgements: The authors would like to thank Heather Gibson, an anonymous referee and participants of the 14th Annual Conference on Macroeconomic Analysis and International Finance, for helpful comments and suggestions. The opinions expressed in this paper do not necessarily reflect the views of the institutions they are affiliated with.

Correspondence:
Petros M. Migiakis
Economic Research Department,
Bank of Greece, 21 El. Venizelou Ave.,
10250, Athens, Greece,
Tel.: 0030-210-320 3587
Email: pmigiakis@bankofgreece.gr

1. Introduction

An official aim of the central banking system of the euro area namely the assessment and promotion of financial integration of European markets, constitutes a very interesting research topic. Up until now, reported empirical results have, to a great extent, attributed enhanced interactions among EMU sovereign bond markets to monetary unification (see among others Baele *et al.*, 2004; ECB, 2005 and European Commission, 2007). In this context, differences between yields on European sovereign bonds and the Bund have been one of the most popular proxies for the degree of integration between European bond markets. However, during the recent crisis, European sovereign bond spreads have widened and reached levels comparable to those existing in the pre-EMU period. This development suggests the need to examine further the question of the determinants of financial integration in the European bond markets.

Previous empirical literature on the determinants of bond spreads has argued that they are related to risk factors; a relation explained thoroughly in Cochrane and Piazzesi (2005). Additionally, other empirical findings on bond spreads (e.g. Codogno *et al.*, 2003 and Ehrmann *et al.*, 2005) indicate that they are linked to the degree of financial integration in European bond markets. In this context, taking for granted the hypothesis of the full integration of European bond markets, 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, p. 193), 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 on 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 into the relevant empirical research, as work on the topic of the determinants of European sovereign bond spreads has 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, e.g. 1999. However, this perspective relies on the assumption that in the period after monetary unification the deterministic process of European sovereign bond spreads has not changed.

By contrast, our perspective allows for non-permanence in the effects of shifts as a result of, for example, European monetary unification; instead they are subject to variations captured by unobserved - state dependent - variables. In this way, we allow for changes in the effects exercised by the explanatory variables, which could vary with market or economic conditions. As a result, the strength of the interactions can vary even in the aftermath of the monetary unification. Overall the results indicate that monetary unification has enhanced linkages among European sovereign bond markets, although they are not found to be characterized by full financial integration, in line with Hartmann *et al.* (2003). In the aftermath of the credit crisis, however, this convergence has been reversed in a great extent.

We also find that market volatility is negatively related to the degree of integration of European bond markets, while there is a need to eliminate differences in the pricing processes that are found to exist even in normal periods. More specifically, our results indicate that low volatility characteristics in the period after monetary unification were associated with close co-movements in European sovereign bond spreads. Additionally, significant differences exist between the effects exercised by the deterministic variables on the bond spreads of different sovereign issuers, even under low volatility conditions, thus indicating a 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. In 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 remainder of the paper is organized as follows. In section 2, we review a part of the literature that has dealt 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 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. Similar findings are reported in Pagano and von Thadden (2004) who 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, Hartmann *et al.* (2003) report findings indicating that European bond markets were only partially integrated in the period after European monetary unification, while Kiehlborn and Mietzner (2005) argue that European bond markets are segmented. More recently, Abad, Chulia and Goméz-Puig (2009) argue that although 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 enhanced integration effects 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 room for further financial integration in European bond markets.

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

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' movement is mainly performed by decomposing them into deterministic factors, most frequently into credit and liquidity risk premia. Additionally member countries' fiscal policies and, more precisely, violations of the Stability and Growth Pact have also been referred to in the literature as sources of deviations in bond spreads. We refer to previous findings of empirical literature, in more detail, below.

Codogno *et al.* (2003) argue that 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 that of credit risk. Arguing that small but significant credit risk components impose market discipline, their results may be interpreted as not questioning on 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 process of European financial integration.

In this context a strand of the relevant literature examines the relation between the movement 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. 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, reflecting individual countries' fiscal positions, reflects the fact that European sovereign 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 to be 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 respect, the inclusion of Italy, by Pozzi and Wolswijk (2008), in a system of markets characterized by the elimination of the idiosyncratic component in bond spreads against the Bund, reveals a latent debate over the issue. Of course, the markets in the system, including spreads of sovereign bonds issued by the Netherlands, Italy, Belgium and France against the German benchmark, leaves open the possibility of investigating the remaining euro area countries as well.

In our view, the existing literature dealing with the causal effects reflected in movements in European sovereign bond spreads is neither exhaustive, concerning the factors examined, nor has it provided a robust answer to the question of the state of

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

financial integration in European bond markets. Here, we expand this empirical literature by relating the degree of integration in European sovereign bond markets 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 raise the question as to 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 Codogno *et al.* 2003, Manganelli and Woswijk 2009 and Goméz-Puig 2008, among others). Although, panel data analysis allows cross-sectional differences to be taken into account, 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 the cases where such effects are examined, this is performed by introducing state variables that categorize the system, exogenously, into separate states (e.g. Schuchknecht *et al.*, 2009). However, as noted by Krolzig (1997), this perspective does not allow for capturing changes in the underlying conditions, in a timely manner; in this way, shifts will eventually be reflected, once the data observations categorized in the new regime are enough. In order to perform this task we question the steady-state hypothesis of the effects of a monetary union, as far as 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 determinants of the European sovereign bond spreads for the first time. Our empirical formulation permits existing variations in the degree of financial integration to be revealed. Thus, we adopt the thesis of Baele *et al.* (2004) that, in the event that a system of financial markets is fully integrated, exogenous shocks should produce equal effects on the underlying assets. In this context, although monetary unification strengthened interactions among European bond markets (see among others, Georgoutsos and Migiakis, 2010), 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, by noting that the 2007-2009 crisis, while originating from factors exogenous to monetary union, did not affect all European bond yields equally, we deem it important that the topic should be re-examined. We focus on employing the proper empirical framework; this should allow for relations to vary between different states even after monetary unification.

Supporting the aforementioned argument, recent empirical findings motivate an examination of the effects of equity returns 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 the common pricing factors of stocks and bonds. As a result, they indicate that there exists a relation between the risk exposure investors are willing to take with the capital allocated among holdings in bonds and stocks. Thus, in our opinion, 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; a technique that makes the system efficient by including effects that would be otherwise ignored. Specifically, instead of introducing a dummy variable capturing the period after monetary unification, implying that the system has remained in the new state ever since, we allow the system's causal relations to shift across regimes. Specifically, we formulate the relation between spreads and their determinants as subject to regime shifts that are specified according to a Markov ergodic chain probabilistic distribution, allowing the system to be classified endogenously into separate states. Furthermore, by incorporating regime switching behaviour in the variance-covariance matrix we permit the classification into different regimes to be related to states of high and low volatility. As a result, the system can shift across different volatility regimes associated with stronger or weaker idiosyncratic effects. This specific feature of our methodological framework enables the extraction of results indicating that while monetary union might be a necessary condition for increased financial integration, it is not a sufficient.

Furthermore, we aim at decomposing the information incorporated in sovereign bond spreads by associating their movements not only with credit and liquidity risk factors, but with other explanatory variables, some of which have not yet been examined in the empirical literature. Following previous empirical literature (see among others Codogno *et al.*, 2003 and Manganelli and Woslwijk, 2009), we formulate the dependent variables as functions of several explanatory variables. Most importantly, we examine several factors that have been found, in previous relevant research, to be related to the dynamics of the spreads, such as corporate bond credit spreads, but which have not yet been examined in relation to conditions sovereign bond markets. Specifically, we examine the effects related to capital allocation between different segments of the market, while we also incorporate variables reflecting market participants' expectations, European banking liquidity conditions and inflation rates. Equation 1, below, illustrates the relation examined:

$$\begin{aligned}(i_X^{10}-i_{DE}^{10})_t &= a_0+a_1(i_X^{10}-i_{DE}^{10})_{t-1}+a_2(i_{AAA}-i_{DE}^{10})_{t-1}+a_3(i_{BBB}-i_{DE}^{10})_{t-1}+a_4(i_X^{10}-i_X^{3m})_{t-1}+\\ &+a_5(i_{DE}^{10}-i_{DE}^{3m})_{t-1}+a_6(i_{US}^{10}-i_{US}^{3m})_{t-1}+a_7(i_X^{s}-MRO)_{t-1}+a_8(\pi_X-\pi_{DE})_{t-1}+a_9 r_{X\ t-1}^{S}+\\ &+a_{10} r_{DE\ t-1}^{S}+a_{11} r_{US\ t-1}^{S}\end{aligned} \tag{1}$$

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, as a natural follow up to the findings of the previous literature, we examine the potential effects from the euro-area corporate bond spreads against the Bund. Our analysis takes into account credit conditions in the highest and lowest credit quality , sectors of the investment category. In this way we separate results for high (AAA) and low (BBB) credit quality bonds; the first could be seen as indicating liquidity conditions in the corporate bond sector, while the second as indicator of credit risk. Previous literature on the determinants of European sovereign bond spreads (e.g. Codogno *et al.*, 2003 and Manganelli and Wolswijk, 2009) relates the effects of the credit spreads on the risk originating from fiscal imbalances. The relevant variables ($(i_{AAA} - i_{DE}^{10})$ and $(i_{BBB} - i_{DE}^{10})$, respectively) 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.

Following the argument of Marsh and Rosenfeld (1983, p.683) that bond yields represent the price of 'money sold forward', 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 have significant information content for expected growth and inflation (see among others, Estrella and Hardouvelis, 1991, Estrella and Mishkin, 1997, Stock and Watson, 2003). 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) bill rates. We expect that the yield curve's slope captures market participants' expectations for future economic conditions, in eq. (1).

Additionally, we introduce the variable $(\pi_X - \pi_{DE})$ that captures differences between inflation rates in country *X* and Germany. The reason behind this assessment is that as, according to the combination of Fisher's equation and the Expectation's hypothesis of the term structure of interest rates, bond yields incorporate an inflation risk premium (see among others Balfoussia and Wickens, 2007 and Hördahl, 2008), differences in yields of different sovereign issuers may be related to differences in their inflation rates.

Furthermore, 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 (2008) 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 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). Specifically, we intend to examine whether stock market conditions affect sovereign spreads in line with recent literature reporting common pricing factors in bond and equity markets.[2] Additionally, following Semenov (2009), we deem that investors' beliefs about economic prospects and risk aversion may be reflected in this relation; the author argues that the equity premium puzzle is resolved by appealing to investors' departure from rationality.

The slope of the yield curve and the equity premium enter the equation as country-specific variables,and also include those 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 intra euro area effects are reflected by the incorporation of the German variables; finally, effects stemming from the rest of the world are approximated by incorporating variables stemming from the United States.

[2] See Fama and French (1993), Campbell and Ammer (1993), Baur and Lucey (2008), Baele, Inghelbrecht and Bekaert (2009) and Yang *et al.* (2009). In brief, 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.

4. 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[3]) – at the time of introduction of the common currency, or, in the case of Greece, one year later. 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' categorizations, thus enabling the extraction of comparisons under both a cross-country and a cross-rating category perspective. Source of the data set that we use is Thomson Financial-Datastream, while our sample covers the period 1992:1-2009:12.[4] Thus, 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, with the aim of examining its stationarity properties. This task is crucial in order to specify the proper deterministic formulation for 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, in distinguishing near from exact unit root effects that, 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

[3] Following the previous literature, Luxembourg can be excluded as its public debt is small.
[4] The sample's starting point differs for Portugal (1993:5) and Greece (1994:4) due to data constraints.

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:

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

where, 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. In order to take into account regime switching effects that may distort unit root test results, we employ the MS-AR technique of Hamilton (1989), estimating the different regimes through the Expectations Maximization 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 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) 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:

$$\begin{aligned}(i_X^{10} - i_{DE}^{10})_t = {} & a_0(s) + a_1(s)(i_X^{10} - i_{DE}^{10})_{t-1} + a_2(s)(i_{AAA} - i_{DE}^{10})_{t-1} + a_3(s)(i_{BBB} - i_{DE}^{10})_{t-1} + a_4(s)(i_X^{10} - i_X^{3m})_{t-1} + \\ & + a_5(s)(i_{DE}^{10} - i_{DE}^{3m})_{t-1} + a_6(s)(i_{US}^{10} - i_{US}^{3m})_{t-1} + a_7(s)(i_X^{s} - MRO)_{t-1} + a_8(s)(\pi_X - \pi_{DE})_{t-1} + a_9(s) r_{X\,t-1}^{S} + \\ & + a_{10}(s) r_{DE\,t-1}^{S} + a_{11}(s) r_{US\,t-1}^{S} + e_t\end{aligned} \qquad (3)$$

where $e_t \sim N\big(0, \sigma(s_t)\big)$.[5]

Behind this technical description, exists an economic reasoning supporting the regime switching formulation, namely the variation in the degree of financial integration

[5] Errors have been estimated robustly by applying the Newey-West filter for serial correlation.

across time and different economic conditions. 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.

Furthermore, we estimate the relative deterministic power (C) of the explanatory variables by employing the 'contribution' technique described in Beber *et al.* (2008):

$$C_i = \frac{\left| \hat{a}_i \cdot \frac{\sum_{t=1}^{T} (x_{it} - \bar{x})}{T} \right|}{\sum_{i=1}^{6} \left| \hat{a}_i \cdot \frac{\sum_{t=1}^{T} (x_{it} - \bar{x})}{T} \right|} \qquad (4)$$

where, x stands for the explanatory variable examined each time, $\bar{x}$ is the sample average of the variable, $\hat{a}_i$ is the corresponding coefficient of relation (3) and T stands for the total number of observations. Note that the variable averages and the coefficients are regime-dependent; that is they take the values acquired with the estimation of relation (3) which change accordingly the regime to which observation t belongs.

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, a technique used in Manganelli and Woslwijk (2009), carries the assumption that the specification of the sovereign bond spreads is stable since the monetary unification. 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 monetary unification, 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.

Overall, the results are interpreted under the prism of the information contained regarding the process of financial integration. We deem that in the case that European sovereign bond markets are fully integrated, 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.* (2009). Additionally, in this case, the effects exercised by the explanatory variables should be the same 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.[6] This result may be interpreted along the lines of Lanne (2000) and (2001), arguing for interest rates' processes as having near unit root properties. Recalling that integration characteristics require the parity hypothesis to hold, this result raises the question whether relations between European sovereign bond yields comply with parity if stationarity is rejected for their one-to-one linear combinations.

Next, we turn to the results of the specification for European sovereign bond spreads as MS-AR(1) processes. Table 2 presents the findings, while the figures in panel A 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 in the period close to the creation of the single monetary policy, while the second shift, from a low to a high

[6] Readers interested on the difference between high persistent and stationary processes should refer to Philips *et al.* (2001) and Lima and Xiao (2007).

volatility state, is found to occur during the period of the recent credit crisis. However, in the first case differences exist across countries with resepct to the timing of the shifts.

The earliest shift 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[7], 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 did not have simultaneous effects on all European sovereign bond spreads; 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, the results reported in Table 2 indicate that, in each case, the autoregressive coefficients are smaller than unity, 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, giving support to the intuition that financial integration and financial stability are positively related.

---

[7] Interested readers may refer to Gil-Diaz and Carstens (1996) among others.
[8] With the exception of Finland.

5.2 The effects exercised by the explanatory variables

Next we turn to the results of specification equation (3); these are contained in tables 4 (high volatility regime) and 5 (low volatility regime). They indicate that significant differences in the deterministic specification of European sovereign bond spreads exist, even under the low volatility regime.

More specifically, in every case the effects exercised by the exogenous variables are not homogenous across the dependent variables. Even in the low volatility regime, capturing the period after the monetary unification, there exist significant differences in the direction of the effects of the explanatory variables. In the cases of the German term spread and the German equity return, positive and negative effects are equally distributed across countries; for example, these findings indicate that if the German term spread rises it will impact negatively on the sovereign spread of Spain and positively on Finland and Belgium, under the low volatility specification, or Greece, under the high volatility specification. Furthermore, the magnitude of the deterministic effects is not the same for all sovereign spreads examined, even if the coefficients carry the same sign, while domestic variables are found to exercise more powerful and significant effects than equivalent non-domestic variables. Again, these findings do not sit easily with the hypothesis of fully integrated markets even under the low volatility specification, because, as noted by Baele *et al.* (2004), in fully integrated markets, the same events should have the same impact across all markets.

Next, the regime switching formulation enables conclusions to be drawn about the different effects exercised by credit conditions on the spreads on European sovereign bond yields over the Bund. Specifically, spreads on European corporate bonds with an AAA rating over the Bund have, in the majority of the cases, negative and significant effects on European sovereign bond spreads in the high volatility regime and positive in the low volatility one. By contrast, the spread between BBB European corporate bonds and the Bund have positive effects, in most cases, on the dependent variables, in both the high and low volatility regimes. These results indicate that, in conditions of high volatility, most European sovereign and high credit quality corporate bonds are seen as substitutes, while a deterioration in credit conditions reflected in corporate bond yields for BBB bonds leads to increases in European sovereign bond yields as well. However, the limited significance of these effects in the low volatility regime indicates that corporate credit conditions are not always associated with movements in sovereign bond yields.

Expectations of domestic growth and inflation, reflected by the respective spread between long and short-term rates, are found to exercise significant but not homogenous effects on bond spreads. The sign of this explanatory variable is mostly positive, indicating that European sovereign bond spreads increase with higher inflation and growth expectations; this is especially true for spreads on French and Spanish bonds. By contrast, the effects exercised by the German term spread are not similarly homogenous across countries, in either regime. The finding that this variable is more significant in the low volatility regime is consistent with the notion of higher integration under stable market conditions as it may be argued that it reflects market participants' focus on European aggregates only under the respective specification.

Next, liquidity conditions in the banking sectors have only limited effects on European sovereign bond spreads, under both regimes. The results indicate that the spread between the interbank weekly rate and the main refinancing rate of the ECB exercises mixed effects on country spreads in both regimes, again highlighting the idiosyncratic characteristics of the movement in spreads. However, a finding worth noting is the stability of the effects exercised by the banking liquidity variable, as their signs do not change, while, in most cases, their magnitude is very similar across regimes.

The effects of the difference between domestic and German inflation are found to have limited significance for the dependent variables. Evidently, this variable is more significant under the high volatility regime while the impact on country-specific spreads is again not homogenous.

Finally, the equity return, be it domestic or not, is found to have limited significance for movements in European sovereign bond spreads. 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 for a positive relation between pessimism and movements in the equity premium. However, the increase in the presence of negative effects, under high volatility, may be explained as a flight-to-quality effect in the sense of Baur and Lucey (2009) and Beber *at al.* (2009).

5.3 The spreads' 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, thus highlighting the efficiency of the formulation under relation 3. Additionally, in every case, except for Finland, we find that this specification captures a greater proportion of the movement in country-specific spreads under the high volatility regime. As a result, the deterministic process of European sovereign bond spreads is found to be higher under high volatility conditions.

Additionally, Table 6 contains the decomposition of the deterministic component of the country-specific spreads into to their underlying determinants, while the dynamics of the deterministic power of the explanatory variables are illustrated in the figures in panel B. Overall, these results provide arguments for the idiosyncratic characteristics of the deterministic processes determining spreads, as the distinction between different specifications according to high and low volatility regimes does not generate homogenous changes in country-specific spreads when the explanatory variables change. Furthermore, the shift is found to strengthen the impact of credit risk variables and weaken the impact of equity returns and the term spreads.

A particularly interesting finding is that only spreads for France, Italy and Spain are subject to a lower impact from corporate credit conditions in the high volatility regime, while the difference between Dutch and German bond yields causes a decline in the impact exercised by the AAA corporate bond spread. These results may be indicative of a categorization of European bond markets according to their inherent risk characteristics, as the spreads found to be subject to smaller effects from credit conditions during the high volatility regime are from markets largely complying with those categorized by Dunne *et al.* (2006) as benchmarks.

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. In particular, the results reported herein indicate that the parity relation among European sovereign bonds is more likely to hold under low volatility conditions but still differences have been found in the pricing process of European sovereign bonds relative to the pricing of the Bund. Moreover, even under low volatility, in several cases the dependent variables are found to be subject to opposite effects from the same explanatory variables.

Furthermore, the link between sovereign bond spreads and credit risk is found to vary according to uncertainty conditions and the status of the underlying market. Specifically, we find that sovereign spreads reflect movements in underlying credit risk variables more closely under high volatility conditions. On the other hand, the strengthening of the link among credit risk and sovereign bond spreads' dynamics is not confirmed for markets that have been reported to carry benchmark characteristics; thus indicating segmentation effects in the European bond markets.

Additionally, expectations and idiosyncratic factors are found to exercise significant explanatory power on spreads' movements. In several cases these effects are even larger than those stemming from credit risk variables. This finding, combined 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. As a result, the interpretation of the decline of the sovereign bond spreads, in the aftermath of the EMU, needs precaution.

As a result, we deem that monetary unification is not panacea; regulatory authorities and monitoring bodies should view the process of financial integration in the European bond markets' 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 that caution is needed in applying the proper econometric framework when assessing the driving factors of bond spreads. In particular, in the case of the European sovereign bond spreads, we have found that high persistence and regime switching effects are crucial for the specification of their deterministic processes and they should be taken into account. Additionally, although the effects exercised by credit risk are strengthened under high volatility conditions, European sovereign bond spreads are related to investment sentiment and expectations on prospective macroeconomic conditions, as well.

Furthermore, we have found that the deterministic processes of the spreads are more similar, across countries, 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. Thus, full integration has not yet been achieved in European bond markets. Of course, future research can focus in complementing our results, by investigating more deterministic effects, especially for the low volatility specification.

References

Abad, P., Chulià H., and Goméz-Puig, M., (2009) ‘ EMU and European government bond market integration’, European Central Bank, working paper no. 1079.

Ang A., and Bekaert G., (2002), ‘Regime Switches in Interest Rates’, Journal of Business and Economic Statistics, 20(2), 163-82.

Baele L., Ferrando A., Hördahl P., Krylova E., and Monnet C., (2004), ‘Measuring European financial integration’, Oxford Review of Economic Policy, 20(4), 509-530.

Baele L., Inghelbrecht K., and Bekaert (2009) ‘The determinants of stock and bond return comovements’, National Bureau of Economic Research, working paper series no. 15260.

Balfoussia C., and Wickens M., (2007) ‘Macroeconomic sources of risk in the term structure’, Journal of Money, Credit and Banking 39(1), 205-236.

Baur, D., and Lucey, B., (2009) ‘Flights and contagion- an empirical analysis of stock-bond correlations’, Journal of Financial Stability, 5(4), 339-352.

Beber A., Brandt M., and Kavajecz K. (2008) ‘Flight-to-quality or flight-to-liquidity? Evidence from the Euro-area bond market’, Review of Financial Studies 22(3), 925-957.

Bernoth K., von Hagen J., and Schuknecht l., (2004) ‘Sovereign risk premia in the European government bond market’, European Central Bank, working paper, no. 369.

Campbell J., and Ammer J., (1993) ‘What moves the stock and bond markets? A variance decomposition for long-term asset returns’, Journal of Finance, 48(1), 3-37.

Cochrane, J., and Piazzesi, M., (2005) ‘Bond risk premia’, American Economic Review 95(1), 138-160.

Codogno L., Favero C., and Missale A., (2003), ‘Yield Spreads on EMU Government Bonds’ Economic Policy, 18(7), 503-532.

Commission of the European Communities, (2007) ‘European financial integration report 2007’, Commission staff working document, Brussels, SEC(2007) 1696.

Ehrmann, A., Fratzcher, M., and Rigobon, R., (2005) ‘Stocks, bonds, money markets and exchange rates – measuring international financial transmission’, European Central Bank, working paper series, no. 452.

Elliott G., Rothenberg. T.J., and Stock J.H., (1996) ‘Efficient tests for an autoregressive unit root’, Econometrica, 64, 813-836.

Estrella, A., and Hardouvelis G., (1991) ‘The term structure as a predictor of real economic activity’, Journal of Finance 46(2), 555-76.

Estrella A. and Mishkin F. S. (1997) ‘The predictive power of the term structure of interest rates in Europe and the United States: Implications for the European Central Bank’, European Economic Review 41(7), 1375-1401.

European Central Bank, (2005), ‘Indicators of financial integration in the euro area’, September 2005, Frankfurt.

Fama E., and French, K., (1993), ‘Common risk factors in the returns on stocks and bonds’, Journal of Financial Economics, 33, 3-56.

Favero, C., M. Pagano and E.L. von Thadden, (2010), ‘How does liquidity affect government bond yields?’, Journal of Financial and Quantitative Analysis, *forthcoming* (doi:10.1017/S0022109009990494).

Georgoutsos D., and Migiakis P., (2010) ‘Benchmark bonds interactions under regime shifts’, European Financial Management *forthcoming* (doi: 10.1111/j.1468-036X.2009.00535.x)

Geyer, A., S. Kossmeier, and S. Pichler (2004),’Measuring systematic risk in EMU government yield spreads’, Review of Finance 8, 171-197.

Gil-Diaz, F., and Carstens A., (1996), ‘One Year of Solitude: Some Pilgrim Tales about Mexico's 1994 - 1995 Crisis’, American Economic Review 86(2), 164 - 169.

Goméz-Puig, M., (2006) ‘Size matters for liquidity: evidence from EMU sovereign yield spreads’, Economics Letters 90(2), 156-162.

Gómez-Puig, M., (2008) ‘Monetary integration and the cost of borrowing’, Journal of International Money and Finance, 27(3), 455-479.

Hamilton J.D., (1989), ‘A new approach to the economic analysis of non-stationary time series and the business cycle’, Econometrica 57, 357-384.

Hartmann, P., Maddaloni A., and Manganelli S., (2003) The European financial system: structure, integration and policy initiatives’, Oxford Review of Economic Policy 19, 180-213.

Hördahl, (2008) ‘The inflation risk premium in the term structure of interest rates’, BIS Quarterly Review, (issue September 2008), 23-38.

Kiehlborn T. and Mietzner M. (2005) ‘EU financial integration: is there a ‘core Europe’? Evidence from a cluster based approach’ Johann Wolfgang Goethe-Universität working paper no. 130.

Krolzig H.M., (1997), ‘Markov Switching Vector Autoregressions. Modelling Statistical Inference and Application to Business Cycle Analysis’, *Springer Verlag; 1997*.

Lane P., (2006) ‘Global bond portfolios and EMU’, International Journal of Central Banking 2(2), 1-23.

Lanne, M., (2000) ‘Near unit roots, cointegration, and the term structure of interest rates’, Journal of Applied Econometrics, 15(5), 513-529.

Lanne, M., (2001) ‘Near unit root and the relationship between inflation and interest rates: A reexamination of the Fisher effect’, Empirical Economics, 26(2), 357-366.

Lima L.R., and Xiao Z., (2007) ‘Do shocks last forever? Local persistency in economic time series’, Journal of Macroeconomics 29, 103–122.

Linzert, T., and Schmidt, S., (2008), ‘What explains the spread between the euro overnight rate and the ECB’s policy rate?’, European Central Bank, working paper series, no. 983.

Manganelli S., and Wolswijk G., (2007), 'What drives spreads in the euro area government bond market?', Economic Policy 24(58), 191-240.

Marsh T., and Rosenfeld E., (1983), 'Stochastic Processes for Interest Rates and Equilibrium Bond Prices', Journal of Finance, 38(2), 635-646.

Neal, L., (1985) 'Integration of international capital markets: quantitative evidence from the eighteenth to twentieth centuries', the Journal of Economic History 45(2), 219-226.

Ng, S. and P. Perron (2001) 'Lag length selection and the construction of unit root tests with good size and power', Econometrica, 69, 1519-1554.

Pagano M., and von Thadden L., (2004), 'The European Bond Markets Under EMU', Oxford Review of Economic Policy, 20(4), 531-554.

Philips P.C.B., Moon H. R., and Xiao Z., (2001), 'How to estimate autoregressive roots near unity', Econometric Theory, 17, 29-69.

Pozzi, L., and Wolswijk, G., (2008) 'Have Euro Area Government Bond Risk Premia Converged To Their Common State?', Tinbergen Institute Discussion Papers 08-042/2.

Schuknecht, L., von Hagen J., and G. Wolswijk (2009) 'Government risk premiums in the bond market: EMU and Canada', European Journal of Political Economy 25, 371-384.

Schulz A., and Wolff G., (2008) 'Sovereign bond market integration: the euro, trading platforms and globalization', Deutsche Bundesbnak, Discussion Paper series 1: Economic Studies, no 2008/12.

Semenov, A., (2009) 'Departures from rational expectations and asset pricing anomalies', Journal of Behavioral Finance 10(4), 1542-1579.

Stock J. H., Watson M. (2003), 'Forecasting Output and Inflation: The Role of Asset Prices' Journal of Economic Literature, 41(3), 788-829.

Yang, J., Zhou, Y., and Wang, Z., (2009) 'The stock-bond correlation and macroeconomic conditions: one and a half centuries of evidence', Journal of Banking and Finance, 33, 670-680.

Appendix

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).

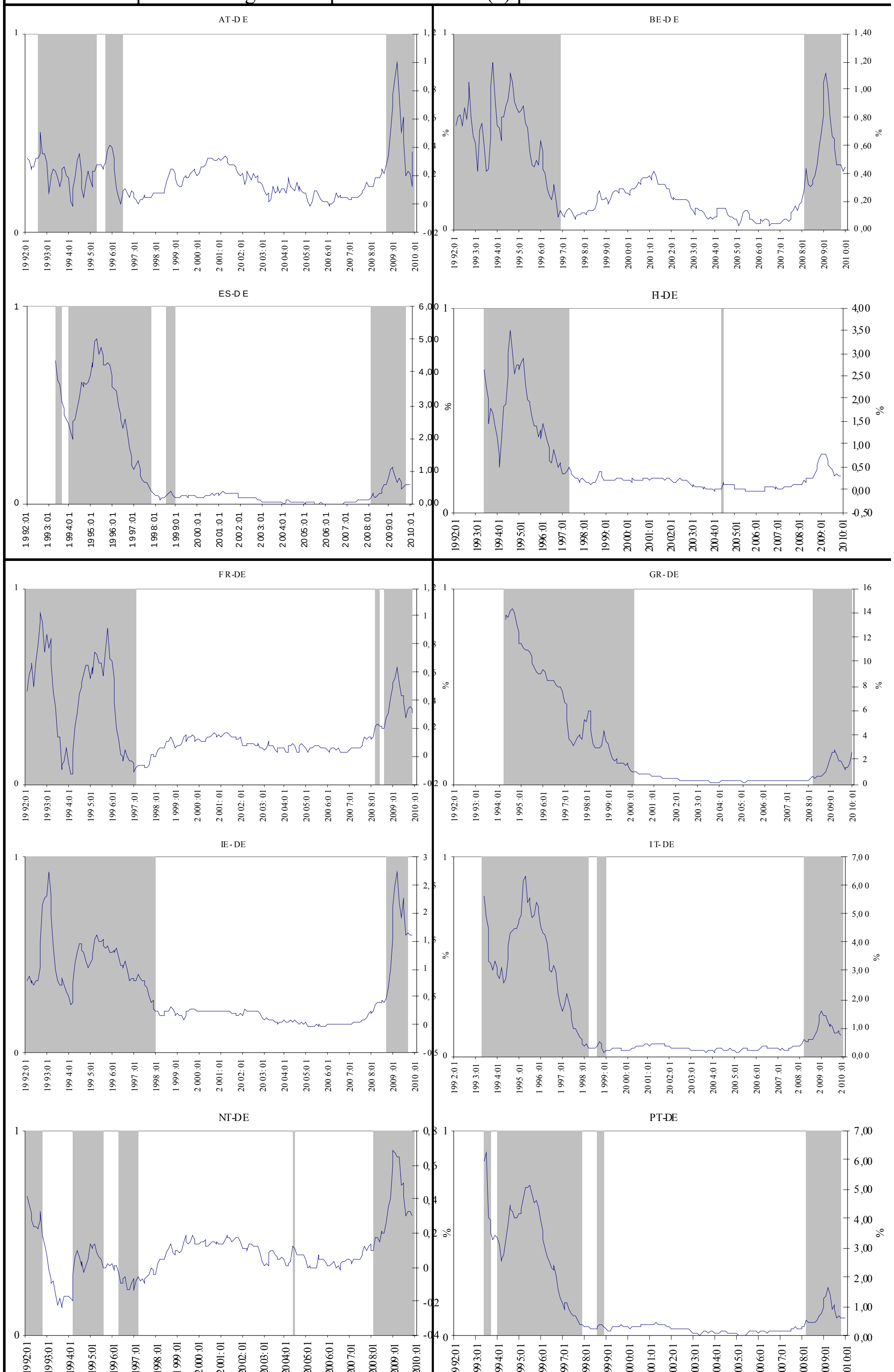
Table 2 The spreads under the Markov switching AR(1) formulation

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

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.						

Panel A: 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** (0.003)	0.002 (0.002)	0.052 (0.038)	0.019 (0.017)	0.004 (0.052)	0.113 (0.109)	0.005 (0.004)	0.053 (0.041)	0.001 (0.002)	0.019 (0.016)
a_1	0.558** (0.096)	0.834** (0.074)	0.799** (0.089)	0.968** (0.239)	0.943** (0.052)	0.955** (0.066)	0.821** (0.055)	0.845** (0.072)	0.618** (0.134)	1.008** (0.178)
a_2	-0.247** (0.104)	-0.195** (0.101)	-0.071 (0.124)	0.820 (0.605)	-0.024 (0.072)	-1.199** (0.399)	-0.400** (0.169)	0.012 (0.102)	-0.105 (0.079)	-0.741* (0.416)
a_3	0.169** (0.049)	0.090** (0.043)	-0.017 (0.056)	-0.977** (0.494)	0.015 (0.030)	0.573** (0.206)	0.274** (0.090)	-0.127** (0.054)	0.087* (0.054)	0.239 (0.191)
a_4	-0.043 (0.074)	0.045 (0.041)	0.247** (0.091)	0.085 (0.021)	0.030** (0.015)	-0.241** (0.102)	0.013 (0.021)	0.206** (0.041)	-0.036 (0.045)	-0.278 (0.291)
a_5	0.050 (0.076)	-0.037 (0.044)	-0.100** (0.040)	0.022 (0.144)	-0.024 (0.016)	0.145** (0.106)	-0.009 (0.041)	-0.043 (0.036)	0.020 (0.051)	0.063 (0.172)
a_6	0.015 (0.017)	0.023 (0.019)	-0.036 (0.054)	0.017 (0.084)	-0.015 (0.020)	0.247** (0.109)	0.098** (0.022)	-0.004 (0.064)	0.009 (0.009)	0.351 (0.222)
a_7	-0.012 (0.035)	-0.056** (0.026)	0.158 (0.128)	-0.205 (0.220)	0.008 (0.018)	-0.108* (0.067)	0.008 (0.006)	0.201 (0.144)	-0.034 (0.036)	0.110 (0.372)
a_8	-0.009 (0.044)	0.027 (0.015)	0.189** (0.081)	-0.293** (0.089)	-0.026 (0.023)	-0.059 (0.089)	0.131** (0.029)	0.082** (0.041)	0.022 (0.021)	-0.079 (0.255)
a_9	-0.007** (0.003)	-0.002 (0.003)	0.005 (0.008)	0.002 (0.006)	0.001 (0.002)	-0.005 (0.005)	-0.001 (0.006)	0.019** (0.007)	-0.001 (0.002)	0.003 (0.028)
a_{10}	0.003 (0.005)	-0.002 (0.003)	-0.005 (0.012)	-0.023** (0.011)	-0.004 (0.003)	-0.022** (0.011)	-0.003 (0.006)	-0.012 (0.013)	0.002 (0.002)	0.027 (0.026)
a_{11}	0.002 (0.004)	0.001 (0.004)	-0.0031 (0.016)	0.011 (0.015)	0.001 (0.004)	0.015 (0.014)	0.005 (0.007)	-0.012 (0.011)	-0.003 (0.002)	-0.026 (0.016)
$\tilde{R}^2$	0.869	0.953	0.909	0.917	0.935	0.919	0.960	0.932	0.942	0.904

Note: Figures report the coefficients of the explanatory variables under the high volatility specification of relation 3, while figures in parenthesis report their std. deviations. 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 (0.005)	0.007 (0.005)	0.055 (0.039)	0.013* (0.008)	0.006 (0.005)	0.011 (0.070)	0.023 (0.019)	0.005 (0.003)	0.003 (0.004)	0.149 (0.101)
a_1	0.924** (0.101)	1.033** (0.052)	0.762** (0.303)	1.125** (0.078)	0.601** (0.131)	0.947** (0.063)	0.987** (0.022)	0.789** (0.105)	0.779** (0.064)	0.852** (0.051)
a_2	0.031 (0.023)	0.022 (0.031)	0.017 (0.044)	-0.006 (0.013)	0.049** (0.022)	-0.001 (0.031)	0.007 (0.020)	0.029 (0.031)	0.008 (0.012)	0.122 (0.086)
a_3	-0.013 (0.016)	-0.016 (0.019)	-0.029 (0.031)	0.009 (0.009)	-0.030** (0.013)	-0.002 (0.022)	-0.014 (0.015)	-0.012 (0.021)	-0.002 (0.009)	-0.122* (0.067)
a_4	0.044 (0.116)	-0.055* (0.033)	0.120** (0.059)	-0.231** (0.072)	0.111** (0.049)	0.021 (0.037)	0.003 (0.008)	0.032 (0.026)	0.008 (0.029)	0.054 (0.031)
a_5	0.043 (0.113)	0.062** (0.033)	-0.095** (0.043)	0.219** (0.071)	-0.118** (0.049)	0.017 (0.014)	0.004 (0.005)	-0.027 (0.029)	-0.006 (0.029)	-0.071 (0.054)
a_6	-0.001 (0.004)	-0.004* (0.002)	-0.011 (0.009)	0.004 (0.003)	0.003 (0.002	-0.014 (0.014)	-0.004 (0.004)	-0.002 (0.004)	-0.004** (0.001)	0.003 (0.013)
a_7	-0.011 (0.017)	-0.026** (0.013)	0.042 (0.059)	-0.006 (0.012)	0.003 (0.016	-0.019 (0.021)	0.003 (0.023)	0.057* (0.032)	-0.014* (0.008)	0.034 (0.031)
a_8	-0.007 (0.005)	-0.006 (0.006)	0.023 (0.019)	0.016** (0.005)	-0.001 (0.004)	-0.008 (0.007)	0.001 (0.003)	0.003 (0.007)	0.011** (0.004)	-0.006 (0.023)
a_9	0.001 (0.001)	0.001 (0.001)	0.007 (0.006)	0.001 (0.001)	0.002** (0.001)	0.001 (0.001)	0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
a_{10}	-0.001 (0.001)	-0.001 (0.001)	-0.004 (0.004)	0.001 (0.001)	-0.001 (0.001)	0.001 (0.001)	-0.001 (0.002)	0.002 (0.002)	0.001 (0.001)	0.002 (0.002)
a_{11}	-0.001 (0.001)	0.001 (0.001)	0.001 (0.002)	-0.001 (0.001)	-0.002** (0.001)	-0.001 (0.002)	-0.001 (0.001)	-0.002 (0.002)	0.001 (0.001)	-0.001 (0.002)
$\tilde{R}^2$	0.822	0.897	0.523	0.929	0.698	0.874	0.738	0.906	0.885	0.646

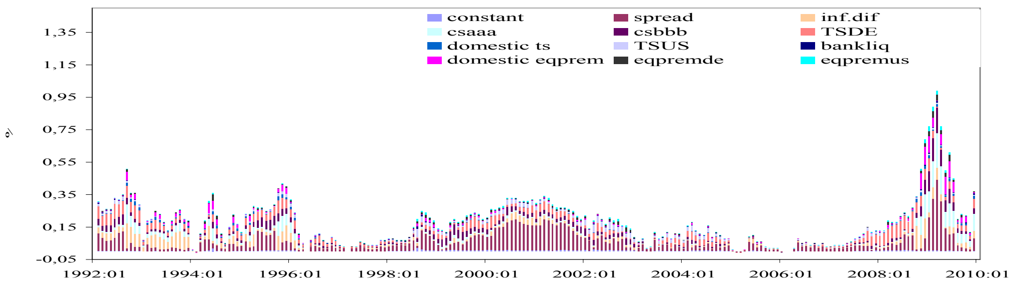
Note: Figures report the coefficients of the explanatory variables under the low volatility specification of relation 3, while figures in parenthesis report their std. deviations. Asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively

Table 6 Decomposition of the spreads' deterministic component

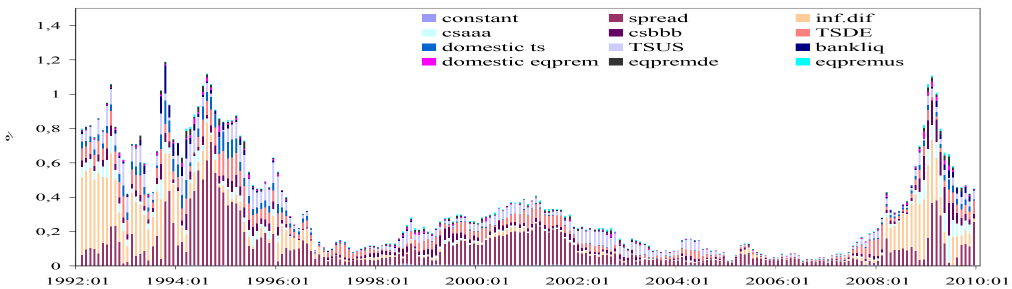
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
High volatility regime										
$(i_X^{10} - i_{DE}^{10})_{t-1}$	14.2%	29.6%	57.4%	37.8%	51.2%	50.5%	30.5%	60.6%	15.1%	48.4%
$(i_{AAA} - i_{DE}^{10})_{t-1}$	23%	14.0%	1.7%	12.9%	3.1%	11.2%	15.6%	0.3%	0.6%	12.3%
$(i_{BBB} - i_{DE}^{10})_{t-1}$	28.7%	13.1%	0.8%	16.5%	3.8%	9.6%	16.6%	5.5%	12.0%	10.4%
$(i_X^{10} - i_X^{3m})_{t-1}$	9.3%	13.3%	13.9%	4.9%	12.2%	9.8%	2.1%	10.3%	30.8%	7.5%
$(i_{DE}^{10} - i_{DE}^{3m})_{t-1}$	11.2%	10.6%	7.8%	1.4%	9.8%	2.9%	1.5%	3.0%	6.8%	2.6%
$(i_{US}^{10} - i_{US}^{3m})_{t-1}$	4.2%	4.2%	1.6%	1.0%	3.7%	3.5%	10.3%	0.2%	0.4%	4.8%
$(i_X^{s} - MRO)_{t-1}$	0.7%	5.9%	2.3%	6.9%	1.3%	4.3%	1.4%	4.1%	8.8%	1.8%
$(\pi_X - \pi_{DE})_{t-1}$	0.7%	4.6%	10.8%	11.9%	6.4%	2.1%	17.6%	3.7%	5.3%	3.4%
$r_{X\,t-1}^{S}$	5.3%	1.4%	1.6%	0.7%	1.2%	0.9%	0.5%	7.0%	8.7%	0.5%
$r_{DE\,t-1}^{S}$	1.8%	1.5%	1.4%	4.7%	4.9%	2.6%	1.3%	3.0%	5.5%	4.4%
$r_{US\,t-1}^{S}$	0.9%	0.5%	0.7%	1.3%	0.9%	1.4%	1.4%	2.4%	4.3%	3.9%
Low volatility regime										
$(i_X^{10} - i_{DE}^{10})_{t-1}$	35.4%	43.9%	30.5%	27.5%	12.6%	57.4%	69.3%	34.8%	31.3%	43.2%
$(i_{AAA} - i_{DE}^{10})_{t-1}$	9.4%	3.6%	1.9%	0.5%	7.6%	0.2%	2.3%	8.0%	8.0%	11.6%
$(i_{BBB} - i_{DE}^{10})_{t-1}$	5.6%	3.2%	3.5%	1.0%	5.7%	0.4%	4.6%	3.4%	3.9%	12.5%
$(i_X^{10} - i_X^{3m})_{t-1}$	18.9%	15.6%	20.3%	31.8%	27.9%	8.2%	2.2%	15.0%	15.2%	9.7%
$(i_{DE}^{10} - i_{DE}^{3m})_{t-1}$	19.1%	17.9%	16.2%	29.8%	30.7%	6.1%	2.2%	12.7%	13.3%	13.2%
$(i_{US}^{10} - i_{US}^{3m})_{t-1}$	0.8%	3.4%	5.4%	1.6%	2.7%	15.7%	5.4%	3.0%	2.4%	1.3%
$(i_X^{s} - MRO)_{t-1}$	1.7%	3.7%	1.4%	0.3%	0.1%	1.2%	0.4%	4.3%	9.5%	1.8%
$(\pi_X - \pi_{DE})_{t-1}$	1.7%	1.5%	4.1%	2.6%	0.3%	2.8%	0.9%	1.3%	2.0%	1.4%
$r_{X\,t-1}^{S}$	2.3%	2.2%	9.7%	2.4%	5.4%	2.9%	4.5%	3.5%	3.2%	1.3%
$r_{DE\,t-1}^{S}$	2.6%	2.9%	6.0%	1.5%	3.2%	3.2%	4.7%	8.6%	7.0%	2.9%
$r_{US\,t-1}^{S}$	1.8%	1.9%	1.0%	1.0%	3.9%	1.9%	3.3%	5.4%	4.3%	1.0%

Panel B: Decomposition of the spreads to their determinants

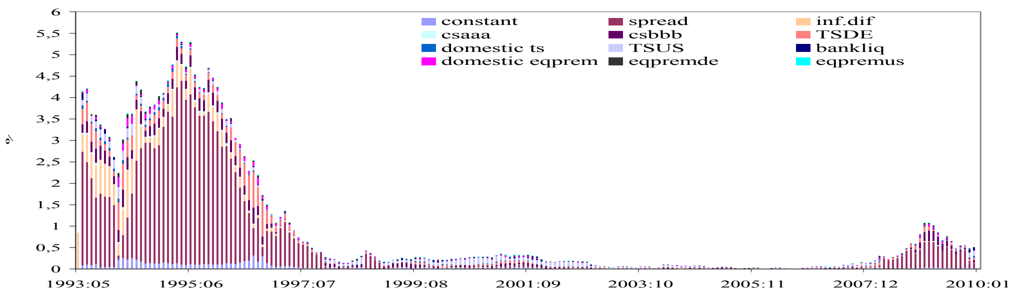
AT



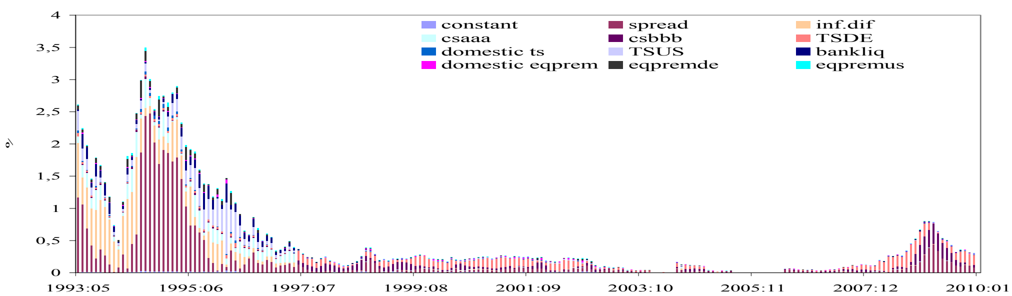
BE



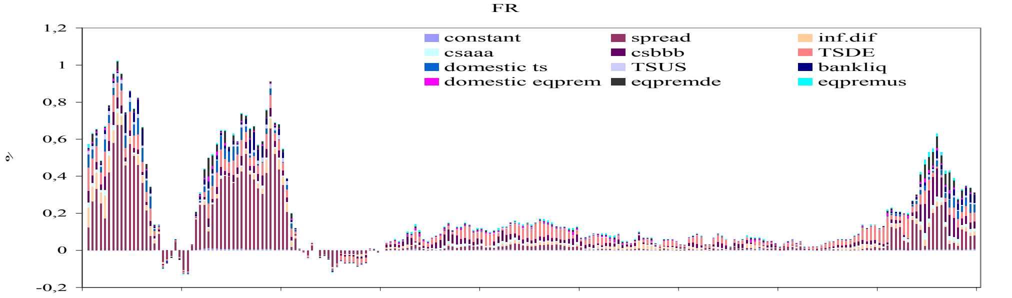
ES



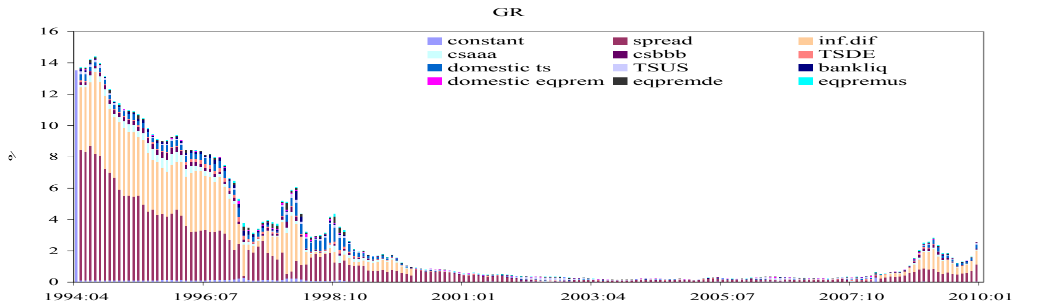
FI

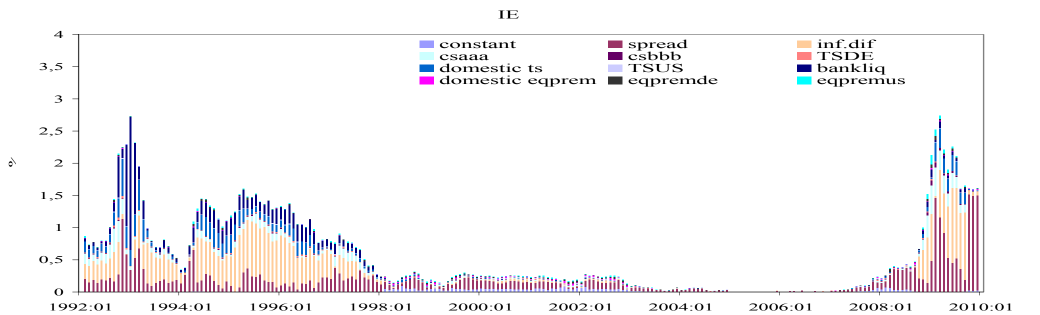


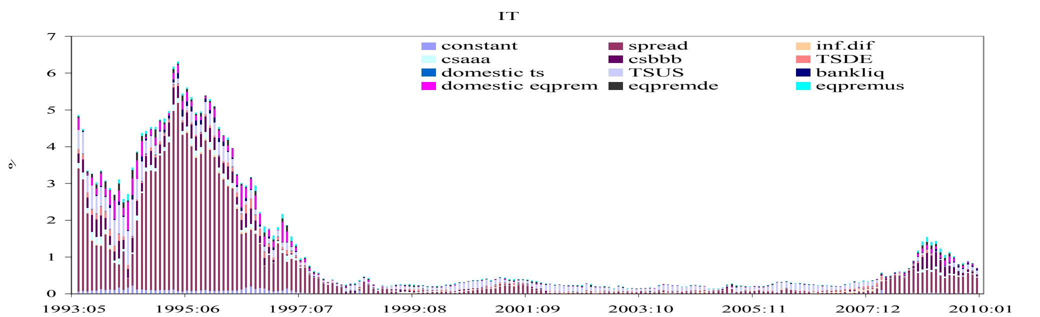
FR

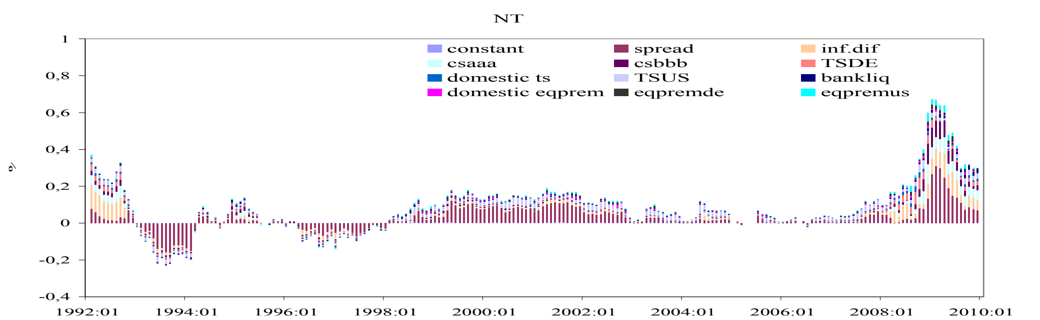


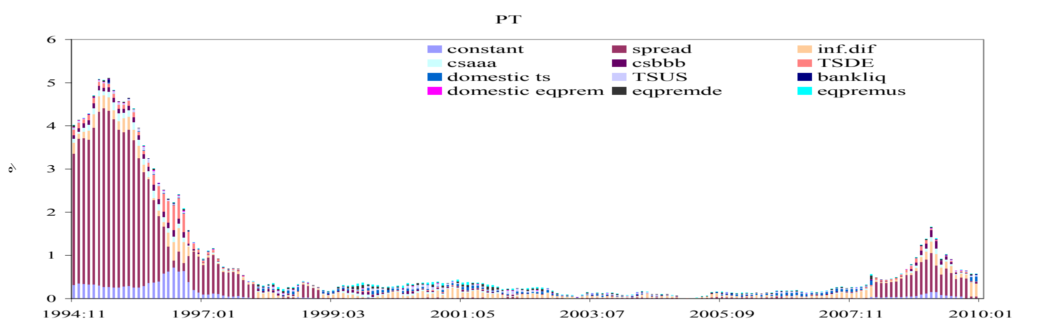
Panel B (continued): Decomposition of the spreads to their determinants











BANK OF GREECE WORKING PAPERS

90. Tavlas, G., H. Dellas and A. Stockman, "The Classification and Performance of Alternative Exchange-Rate Systems", September 2008.
91. Milionis, A. E. and E. Papanagiotou, "A Note on the Use of Moving Average Trading Rules to Test for Weak Form Efficiency in Capital Markets", October 2008.
92. Athanasoglou, P.P. E. A. Georgiou and C. C. Staikouras, "Assessing Output and Productivity Growth in the Banking Industry", November 2008.
93. Brissimis, S. N. and M. D. Delis, "Bank-Level Estimates of Market Power", January 2009.
94. Members of the SEEMHN Data Collection Task Force with a Foreword by Michael Bordo and an introduction by Matthias Morys, "Monetary Time Series of Southeastern Europe from 1870s to 1914", February 2009.
95. Chronis, P., "Modeling Distortionary Taxation", March 2009.
96. Hondroyiannis, G., "Fertility Determinants and Economic Uncertainty: An Assessment using European Panel Data", April 2009
97. Papageorgiou, D., "Macroeconomic Implications of Alternative Tax Regimes: The Case of Greece", May 2009.
98. Zombanakis, G. A., C. Stylianou and A. S. Andreou, "The Greek Current Account Deficit: Is It Sustainable After All?", June 2009.
99. Sideris, D., "Optimum Currency Areas, Structural Changes and the Endogeneity of the OCA Criteria: Evidence from Six New EU Member States", July 2009.
100. Asimakopoulos, I. and P. Athanasoglou, "Revisiting the Merger and Acquisition performance of European Banks", August 2009.
101. Brissimis, N. S. and D. M. Delis, "Bank Heterogeneity and Monetary Policy Transmission", August 2009.
102. Dellas, H. and G. S. Tavlas, "An Optimum-Currency-Area Odyssey", September 2009.
103. Georgoutsos, A. D. and P. M. Migiakis, "Benchmark "Bonds Interactions under Regime Shifts", September 2009.
104. Tagkalakis, A., "Fiscal Adjustments and Asset Price Movements", October 2009.
105. Lazaretou, S., "Money Supply and Greek Historical Monetary Statistics: Definition, Construction, Sources and Data", November 2009.
106. Tagkalakis, A., "The Effect of Asset Price Volatility on Fiscal Policy Outcomes", November 2009.
107. Milionis, E. A and E. Papanagiotou, "An Alternative Methodological Approach to Assess the Predictive Performance of the Moving Average

Trading Rule in Financial Markets: Application to the London Stock Exchange", December 2009.

108. Babecký, J., P. D. Caju, T. Kosma, M. Lawless, J. Messina and T. Rõõm, "The Margins of Labour Cost Adjustment: Survey Evidence from European Firms", December 2009.

109. Droucopoulos, V. and P. Chronis, "Assessing Market Dominance": A Comment and an Extension", January 2010.

110. Babecký, J., P. D. Caju, T. Kosma, M. Lawless, J. Messina and T. Rõõm, "Downward Nominal and Real Wage Rigidity: Survey Evidence from European Firms", February 2010.

111. Mitrakos, T., P. Tsakloglou, "Analyzing and Comparing the Impact of Alternative Concepts of Resources in Distributional Studies: Greece, 2004/5", March 2010.

112. Hall, G. S, G. Hondroyiannis, P.A.V.B. Swamy and G. Tavlas, "Bretton-Woods Systems, Old and New, and the Rotation of Exchange-Rates Regimes", April 2010.

113. Konstantinou, P. and A. Tagkalakis, "Boosting Confidence: Is There a Role for Fiscal Policy?", April 2010.

114. Athanasoglou, P. P, C. Backinezos and E. A. Georgiou, "Export Performance, Competitiveness and Commodity Composition", May 2010.