BANK OF GREECE

EUROSYSTEM

Working Paper

Heterogeneity of the determinants of euro-area sovereign bond spreads; what does it tell us about financial stability?

Dimitris A. Georgoutsos
Petros M. Migiakis

143

MAY 2012

WORKINKPAPER WORKINKPAPER WORKINKPAPER WORKINKPAPER

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

HETEROGENEITY OF THE DETERMINANTS OF EURO-AREA SOVEREIGN BOND SPREADS; WHAT DOES IT TELL US ABOUT FINANCIAL STABILITY?

Dimitris A. Georgoutsos
Athens University of Economics & Business

Petros M. Migiakis
Bank of Greece

ABSTRACT

In this paper we assess the movements of euro area sovereign bond yield spreads vis-à-vis the German Bund as processes specified across different levels of volatility and subject to movements in asset prices and economic conditions. The determinants we use are grouped into domestic and euro-area aggregates, thus allowing us to derive results on their relative explanatory power for movements in spreads and compare them across time and the spectrum of countries. We find that volatility influences the deterministic processes of the euro area sovereign spreads and that identical determinants have effects on spreads that vary considerably across countries. Furthermore, we find that economic sentiment indices are the most important determinants and their significance remains, to a large extent, even when controlling for the debt-to-GDP ratio.

Keywords: bond spreads; euro area; investment confidence; financial stability.
JEL classification: F21; F36; G12; G15; G32.

Acknowledgements: The authors have benefitted from comments and suggestions made by Hiona Balfoussia, Heather Gibson and George Kouretas, as well as participants of the 10th Hellenic Finance and Accounting Association Conference. The views expressed in this paper are those of the authors and do not, necessarily, reflect official stance of their respective institutions.

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

Ever since the European Monetary Union (EMU) was launched, short-term interest rates in the euro-area became *de jure* anchored. Long-term rates were also deemed to be anchored *de facto*, in the first eight years of the EMU, in the sense that they exhibited strong co-movements (see for example, Baele *et al.*, 2004; Manganelli and Wolswijk, 2007; Ehrmann *et al.*, 2011). However, the sovereign debt crisis suggests that the initial policy setting cannot ensure stability of the degree of financial integration in the European monetary union. As a result, a wide literature on European sovereign bond spreads is developing aiming to enhance our understanding of their determinants and to provide concrete proposals to encourage a high degree of integration in the euro-area bond markets. In this paper we focus on how market perceptions and market volatility affect movements in euro-area sovereign bond spreads.

In this respect, our analysis first focuses on the impact of different states of volatility since the monetary unification on the determinants of spreads. This step of our analysis provides information on the determinants of spreads and changes in their underlying specifications arising from changes in the degree of uncertainty. Furthermore, it enables us to focus on the recent crisis and distinguish the specification of spreads for this period; in this context, the empirical evidence that changes in conditions of uncertainty have led to the re-pricing of risks in sovereign markets and that spreads in these markets are significantly explained by domestic economic sentiment indices (ESIs), may be important for ongoing discussions on ways to restore stability in euro-area bond markets.

Additionally, our investigation is concerned with issues related to financial integration. These are addressed by examining the homogeneity of the effects exercised by common, euro-area-wide variables and comparing their strength against the strength of the effects stemming from country-specific variables. Our findings indicate that there are differences in the effects exercised on spreads by their determinants, both in terms of the strength and/or the direction of their responses to movements in euro-area wide variables. Furthermore, in several cases we find that the effects derived by country-specific determinants of movements in spreads are stronger than those that stem from euro-area-wide variables. In this respect, there exists evidence that even before the recent financial crisis there was no uniform pattern of dependence of sovereign bond yields on a common set of explanatory factors.

Finally, we ask whether fiscal consolidation will suffice in order to restore stability and re-establish a high degree of integration in euro-area bond markets. In order to answer this question we introduce the debt-to-GDP ratio into our analysis. In this context, the assumption that fiscal variables cause movements in sovereign bond spreads is rejected, whereas the significance of the economic sentiment variables is confirmed. As a result, we conclude that while fiscal consolidation is a necessary condition to address macroeconomic imbalances and structural malaises, it will not be a sufficient one to restore a high degree of integration and stability in the euro-area bond markets.

The rest of the paper is organized as follows. In section 2 we review the literature that has dealt, so far, with the determinants of sovereign bond spreads and other related issues. Section 3 presents the framework employed and section 4 the findings of the empirical investigation. Finally, section 5 concludes.

2. Discussion of previous literature

Sovereign bond markets have traditionally attracted interest from academia, policy makers and market participants because of their role as benchmarks for defining the cost of capital. Furthermore, bond yields have served to provide investors with the information needed to disentangle the various risk components (see for example Cochrane and Piazzesi, 2005). Recently, interest in euro-area sovereign bonds has increased, initially in order to assess the impact of the EMU on the process of financial integration and, latterly, because of the sovereign debt crisis.

Initially, the literature focused on the effects of EMU on the process of financial integration in European bond markets. Baele *et al.* (2004), in their assessment of financial integration indicators for the euro area, examine European government bond markets and conclude that they share a high degree of financial integration, having benefitted from EMU. In this study, sovereign bond spreads are used to assess the degree of financial integration in the euro-area bond markets. In this respect, studies whose data end before the global financial crisis of 2007-2009 agree that euro-area bond markets share a high degree of financial integration (see among others, Pagano and von Thaddem, 2004; Codogno *et al.*, 2003; Abad *et al.*, 2009).

To this end, several studies have explored the determinants of European sovereign bond spreads, by placing emphasis on assessing the extent to which bond yields co-move, thus reflecting systemic or idiosyncratic risks (e.g. Bernoth *et al.*, 2004; Geyer *et al*., 2004; Pozzi and Wolswijk, 2008; Schuknecht *et al*., 2009); the larger is the impact of the systemic component, the smaller the home-bias effects are. This strand of the literature addresses the topic of the determinants of spreads mainly by focusing on in-sample specifications, linear ever since the EMU. Thus, these studies agree that, euro-area sovereign bond yields share a large systemic component, indicating a high degree of financial integration. More recent studies, though, have shown that the idiosyncratic risk component in the movements in spreads has become stronger than the systemic one (see among others, Gómez-Puig, 2009; Favero and Missale, 2011; Dötz and Fischer, 2010).

In parallel with this research, the literature on sovereign spreads compares the strength of the effects exercised by the credit and liquidity risk factors on sovereign bond spreads in the euro-area. Codogno et al. (2003) argues that effects stemming from the liquidity risk component are stronger than those of the credit risk one. 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. This last outcome is also supported by the findings of Favero and Missale (2011); however, they find that the credit risk component has increased in importance as a determinant of sovereign bond spreads because of the adverse market sentiment conditions after the global financial crisis. Similar arguments can be found in other recent studies using data that extend beyond the 2007-2009 crisis period (see among others, Dötz and Fischer, 2010; Palladini and Portes, 2011). The comparison of the findings of these studies to those with data samples ending before the crisis period constitutes evidence favoring the use of non-linear methodologies, in order to capture changes in the specification of the spreads in-sample.

Furthermore, on the economic meaning of the determinants of the euro-area sovereign bond spreads, movements of the credit risk component are often associated with deviations from or compliance with the limits imposed by the Stability and Growth Pact (SGP). In this respect, the concept of 'market discipline' is used in order to highlight that even a small increase in the credit risk component may entail significant costs for the tax payer (see, Codogno *et al.*, 2003). Following the same rationale, Manganelli and Wolswijk (2009) argue that re-assessments of risks in sovereign bonds by the markets may induce pressure for soundness in fiscal policies. Furthermore, Palladini and Portes (2011) find that the CDS spreads cause movements in sovereign bond spreads and Aizenmann *et al.* (2011)[1] that fiscal-related fundamentals drive the risk of sovereign default as perceived by the CDS market. As a result, the combination of these findings points towards an indirect link between fiscal figures and sovereign bond spreads. Finally, Gibson *et al.* (2011) find that the Greek sovereign bond spread is cointegrated with current account and fiscal deficits, but still a large proportion of its movements remains unexplained; this finding is attributed to under- or over- pricings of risks by markets.

Several studies highlight other determinants such as the dynamic properties of movements in sovereign spreads and uncertainty. For instance Gerlach *et al.* (2010) suggest that sovereign spreads, as a consequence of the global financial crisis of 2007-2009, rose more in countries in which the deficit had persistently exceeded the SGP limit. However, the fact that fiscal data are not significant for explaining movements in spreads in the pre-crisis period and the finding that the banks' capital explains the rise in the spreads lead to the conclusion that the rise in the spreads was associated with expectations that public finances would be burdened by the support required for the banking sector. Under the concept that (forward-looking) asset prices cannot be explained by (backward-looking) economic fundamentals, Arghyrou and Kontonikas (2011) rely on expectations of fiscal outcomes, while with the use of volatility indices, they aim to capture market sentiment. They find that market perceptions of risks in euro-area sovereign bonds shifted after the global financial crisis of 2007-2009. The non-linear

[1] The study suggests that current prices of default risks for peripheral euro-area countries reflect expected rather than actual fiscal figures.

framework of this study, which reveals a re-pricing of risks, is consistent with the concept of Georgoutsos and Migiakis (2010), in which the degree of financial integration is found to be positively linked to financial stability.

All in all, these results suggest that linear formulations are not optimal in the event of changes in investors' preferences. Specifically, if we assume that spreads are indeed good proxies for the degree of bond market integration and take into account time-varying aspects of this process (see Baele and Inghelbrecht, 2010), then this provides a motivation to investigate changes in the structure of the deterministic process of euro-area sovereign bond yields and spreads. Furthermore, time-variation in the degree of financial integration can be treated as a regime-switching process (Georgoutsos and Migiakis, 2009), possibly revealing changes in the underlying determinants of the spreads with permanent shifts arising from monetary unification or higher investors' risk aversion ever since the global financial crisis. In this respect, we examine the degree of homogeneity of the determinants of spreads both across countries and different volatility regimes.

Finally, the findings that stem from empirical examinations of the determinants of spreads may contribute to the ongoing policy discussion of the usefulness of common euro-area wide bonds; an idea originating from a report of the Giovannini Group for the European Commission (Giovannini Group, 2000), which has largely served as the road-map for promoting financial integration in European bond markets. Recently, this concept has been officially adopted by the European Commission, whose proposal is to launch the, so-called, Stability bonds (see, European Commission, 2011). Several aspects of the proposal of common European bonds have already been considered in the literature and, currently, there are mixed views on this issue.[2]

[2] See for example, de Grauwe and Moesen, (2009), Mayordomo *et al.* (2009) and Favero and Missale (2010) for arguments supporting the idea. Counter-arguments are to be found in Issing (2009) and in reports of the press (e.g. the 17th of August 2011 statement of J. Stark, Executive Board member of the European Central Bank at that time, at the German newspaper *Handelsblatt*, available at: http://www.handelsblatt.com/politik/konjunktur/nachrichten/stark-warnt-vor-einfuehrung-von-euro-bonds/4513568.html).

3. The framework for the empirical investigation

3.1 Description of the data set

The dependent variables in our empirical analysis are bond yield spreads, derived as differences between 10-year sovereign bond yields of ten EMU-founding countries[3] and Greece and yields of the equivalent German Bund. Our data frequency is monthly, covering the period 1999:1-2011:1, while for Greece the sample begins at 2001:1, the date of its accession to the EMU; note that, although the initial regressions are performed with data in monthly frequency, some variables (such as the volatility of equity prices), are derived from daily data. Finally, we also perform supplementary analysis with the use of fiscal variables (namely the country-specific ratio of the general government debt to GDP), with the use of data at a quarterly frequency. The sources of the data we have used are Thomson Financial-Datastream and the Statistical Data Warehouse of the European Central Bank. Below we discuss each explanatory variable, leaving a technical description (e.g. data source, estimation process etc.) to the Appendix.

Monthly stock returns (calculated as log-differences of the stock market indices, for each country under consideration, between the last and the first calendar day of each month) are used in order to reflect portfolio allocation effects between stocks and bonds in each country. In this respect, if we resort to the findings for the stock-bond correlation as a proxy for the coefficient of stock returns on the spreads, this relationship is determined, mostly, by behavioral effects related to investors' preferences (see among others, Connoly *et al.*, 2005, Baur and Lucey, 2009 and Semenov, 2009). For instance, periods of financial turmoil and negative stock returns, may be accompanied by rises in sovereign bond spreads because of an increased propensity to hold safer assets, the German Bund in our case. Additionally, during calm periods for the financial markets, investors undertake risks, in order to benefit from excess returns, and this would lead to increases in stocks returns being associated with decreases in sovereign bond spreads. As a result, the respective coefficient is expected to have a negative sign and indicate whether changes in stock returns precede changes in European sovereign bond spreads.

---

[3] Namely, Austria (AT), Belgium (BE), Spain (ES), Finland (FI), France (FR), Ireland (IE), Italy (IT), the Netherlands (NT) and Portugal (PT). Luxembourg is exempted from the present analysis, because of its very low level of outstanding amounts of sovereign bonds.

Next, the standard deviation of equity returns (estimated for each month from daily stock returns) reflects volatility conditions in the stock market. We have chosen to approximate equity market volatility with the use of the standard deviation of returns, instead of implied volatility indices, because the latter were not available for all countries. The increased stock market volatility may be due to, or cause, an increase in other risk components and, thus, lead to increases in bond yield spreads; as a result we expect a positive sign for the respective coefficient (for the US see Jubinski and Lipton, 2011).

Furthermore, we use the Economic Sentiment Indicator (ESI), published monthly by the European Commission (DG ECFIN), in order to assess the business[4] and consumer confidence. According to Rua (2002), the ESI has information content for the GDP growth rate and, thus, it can be used to gauge economic agents' perceptions of future economic activity. In this respect, the domestic ESI may have significant information content for the spreads. For example, the ESI may contribute to the formulation of investors' expectations for sovereign debt sustainability, as a forward-looking indicator for the denominator of the debt-to-GDP ratio, or as a proxy for the future tax-collection capacity of the economy; in this context it is reasonable to expect that an increase (decrease) in the ESI may lead to a decrease (increase) in the spread. Furthermore, the euro-area-wide ESI may also have a significant relationship with the spreads, through, for example, its effect on capital flows across the euro-area.

The term spread between ten and two-year bonds is also used in order to capture the pricing of relative risks in sovereign bonds spreads. Specifically, the yield curve has been the focus of numerous studies, as a sign of investors' expectations about releases of macroeconomic data. In this context, inversions of the yield curve are often related to expected recessions (Estrella, 2005). The rationale behind this well-known stylized fact is that investors expecting weak future economic activity will demand a low return on their longer term investments while in the short run economic uncertainties and / or a tighter monetary policy will lead to higher short-term yields. As a result, the spread between ten

[4]Professionals from the industrial, construction, services and retail trade sectors are surveyed.

and two year bond yields may be useful as a determinant of different sovereign bond yield spreads; we use both the domestic and the German term spread.[5]

Additionally, spreads may be affected by changes in the value of portfolios of domestic Monetary and Financial Institutions' (MFI)[6]; we argue that there are at least two reasons for the introduction of this variable. First, in cases of declines in the value of marketable assets held in trading portfolios, investors tend to resort to bonds as a means of flight-to-safety (see for example, Beber *et al.* 2008). As a result, declines in the value of MFI's portfolios could be negatively related to sovereign bond spreads against the Bund, especially in periods of increased market uncertainty. Second, in times of increased liquidity needs, European banks have an incentive to increase their holdings of European sovereign bonds, as the latter can be used as collateral in the European Central Bank's refinancing operations. In this context, considering that the combination of expected returns and the perceived risks in European sovereign bonds may weigh when MFI portfolio managers select assets, we conclude that this variable may have either a positive or negative impact on spreads.

Theoretical considerations, related to the term structure of interest rates, dictate the inclusion of inflation rates as determinants of the bond yields; in this context, for our purposes, the examination of differences between yields on European sovereigns and those of Germany leads to the use of the differences between the domestic and German inflation rates. An increase in the domestic inflation rate vis-à-vis the German inflation rate, may increase the inflation risk premium on bond yields and lead to an increase in our dependent variable. As a result, the effect exercised by this variable on the spread will be positive.

Next, we also account for the effects of the prevailing credit risk conditions in the European corporate bond market. The indices (iBoxx) of European corporate bonds with a rating of BBB and AAA have been used in order to obtain the spread between their yields; this corporate credit spread is used in order to approximate the effects exercised

[5] The economic sentiment index intends to capture expectations about immediate economic conditions while the term spread captures expectations of more distant economic developments.
[6] Monetary and Financial Institutions, eligible for participating in the monetary policy operations of the European Central Bank.

on the European sovereign bond spreads by changes in credit risk conditions in the European corporate bond market.

Finally, we also ask whether the conditions prevailing in the European money market have significant effects on the sovereign bond spreads. For this reason, we use the spread between the three-month Euribor rate and the main refinancing operations (MRO) rate of the European Central Bank. The three-month Euribor is the benchmark interest rate in the European interbank market, while the MRO rate is charged in the ECB's weekly refinancing operations. It is a stylized fact that in periods of low perceived counterparty risk the cost of borrowing in the European money market is comparable to the central bank's charged interest rate, while during the global financial crisis the three month Euribor rate and the MRO rate diverged because of the stressed conditions prevailing in the interbank market.[7] As a result, the rationale behind using this variable is that the difference between the two rates largely reflects liquidity conditions in the European interbank market. Its effects on sovereign bond spreads may either be positive or negative; the positive sign could be an indication of inter-linkages in conditions in the European money and bond markets, while a negative sign may be the result of changes in the investment portfolios' preferences related to the maturity of their holdings and, as a consequence, changes in the money and bond proportions of their portfolio.

3.2 Specification and methodology

Before specifying the relationships explored in the paper, recall that bond yields are highly persistent processes, falling near the unit-root threshold.[8] In this respect, Georgoutsos and Migiakis (2009) have argued that the properties of sovereign bond spreads also depend on the degree of integration among the underlying markets, which in its turn depends on the prevailing market volatility; thus, bond spreads are better captured by autoregressive processes that also entail Markov switching effects. Thus, the MS-AR(1) formulation for the sovereign bond spreads is illustrated by equation (1) below:

---

[7] The average difference between the two rates was17 b.p. for the period 1999:1-2007:8 and 47 b.p. for the period 2007:9-2009:6.

[8] For a more thorough discussion of the properties of interest rates and bond yields see among others Lanne (2000) and (2001), Ang and Bekaert (2002).

$$(i_X^{10} - i_{DE}^{10})_t = \alpha_0(s) + \alpha_1(s)(i_X^{10} - i_{DE}^{10})_{t-1} + u_t \text{, with } u_t \sim N\left(0, \sigma(s_t)\right). \qquad (1)$$

In equation (1), $(i_X^{10} - i_{DE}^{10})_t$ denotes the spreads as differences between the yield of the ten-year sovereign bond of country *x* from its equivalent Bund yield, at time *t*, *u* is the term used for denoting the errors of the AR(1) specification and s is the unobserved state dependent variable specified as a Markov ergodic probabilistic distribution. The latter enables the estimation of the coefficients (denoted by α's) and the volatility component of the error term, separately across regimes. Thus, the regime classification enables periods under which the effects captured by the coefficients of the specification change to be distinguished; this feature of equation (1) may enable us to distinguish periods differing in the level of persistence of the spreads, for example. Furthermore, as the volatility component of the specification is also subject to regime-switching effects, it enables the classification of the sample across states with different levels of volatility.

We employ the Maximum Likelihood Expectations Maximization algorithm of Hamilton (1989), in order to estimate the probability that event "*s belongs to regime j when in the previous period belonged to regime i*" for each observation, which can be illustrated as $p_{ij} = \Pr ob[s_{t+1} = j \mid s_t = i], \quad \sum_{j=1}^{M} p_{ij} = 1 \quad \forall i, j$. Thus, the probability for each observation belonging to one of the two regimes is estimated conditional only on the regime classification of the previous observation. The smoothed probabilities constitute the main criterion for deciding the regime to which each observation belongs; in case $p_{ij} > 0.5$ the observation concerned is classified as belonging to the respective regime. The identification of the dominant regime, for each observation, depends only on the regime the previous observation belongs to (see, McLachlan and Krishnan, 2008, p. 290-293). In this respect, our analysis has an informative advantage over the alternative of choosing *a priori* a date to separate the sample in sub-periods, as we do not predispose the regime classification of our data sample; instead we allow the properties of our data to generate the regime classification process.

In this context, the MS-AR(1) is extended to incorporate variables that may have informational value for the spreads' determinants; the rationale for choosing the specific variables has been thoroughly analyzed earlier in this section. Thus, equation (1) is transformed into:

$$(i_X^{10} - i_{DE}^{10})_t = \alpha_0(s) + \alpha_1(s)(i_X^{10} - i_{DE}^{10})_{t-1} + \sum_{j=2}^{7} \alpha_j(s) X_{j\,t-1} + \sum_{j=8}^{12} \alpha_j(s) Z_{j\,t-1} + e_t \qquad (2)$$

with $e_t \sim N(0, \sigma(s_t))$.

This specification allows the explanatory variables to have a varying degree of influence on sovereign bond spreads, according to the regime in which they are classified. In equation (2), apart from the notation already used in (1), two vectors, containing exogenous variables, have also been inserted. These vectors contain the potential determinants of the spreads grouped into domestic (vector *X*) and euro-area aggregate variables (vector *Z*); the elements of the two vectors (i.e. the explanatory variables) are, to a large extent, analogous in order to enable the comparison between the strength of country-specific and euro-area wide effects.

In particular, vector *X* contains the following country-specific variables: monthly returns and volatility of the domestic stock market, the domestic economic sentiment index, the domestic term spread between yields of ten and two years of remaining maturity, differences between the domestic and the German inflation rates and monthly percentage changes in the value of assets contained in the balance sheets of domestic MFIs. By contrast, the vector *Z* contains euro-area aggregate variables: the credit spread of yields from euro-area corporate bond indices with a comparable term to maturity, the difference between the Euribor three month rate and the rate charged in ECB's main refinancing operations (MRO), the euro-area economic sentiment index and the German ten to two years term spread. [9]

[9] For a detailed description of vectors *X* and *Z*, see the Appendix.

After estimating the coefficients from equation (2), we employ a technique laid out in Beber *et al.* (2008), which enables us to calculate the percentage of the deterministic component of the dependent variable that is captured by each variables and / or group of variables. However, we have slightly modified this technique, in order to suit the regime-switching nature of our examination. Specifically, the decomposition of the explanatory power of the determinants is performed by estimating the following measure:

$$\overline{C_j} = \frac{\sum_{t=1}^{T(s)} \tilde{a}_j(s_t)(x_{jt} - \bar{x}(s_t))}{T(s)} \tag{3}$$

where, x stands for the explanatory variable examined each time, $\bar{x}(s_t)$ is its (state-dependent) average, $\tilde{a}_i(s_t)$ is the standardized coefficient of variable i as in equation (2), s is the state dependent variable, indicating the regime to which observation t belongs and T stands for the total number of observations for each regime. The fact that the average of the variables and their coefficients are regime-dependent means that their values change according to the regime observation t belongs to, as estimated by the regression of equation (2). Furthermore, we estimate the power of each determinant, or of each group of determinants, in explaining the standardized estimate of the spread as provided by our specification. To do so we use the following measure:

$$\overline{RC_j} = \frac{\overline{C_j}}{\sum_{j=1}^{12} \overline{C_j}} \quad . \tag{4}$$

This measure enables us to investigate whether there are clustering effects in the deterministic processes in (2) and whether the countries under examination can be grouped according to the similarities of the deterministic processes of their spreads. The origination of the deterministic effects, i.e. whether they are country-specific or euro-area wide, is one of the most natural candidates for examination of potential grouping formation; specifically, by this stage of our empirical analysis we ask whether the spreads' movements are mostly explained by (i) domestic as opposed to European effects and (ii) by asset-pricing related variables as opposed to economic sentiment.

4. Empirical results

4.1 Regression results

We begin the discussion of our empirical analysis with the output of the regression of the Markov switching specification described above, in equation (2). Before commenting on the significance of the determinants for each one of the ten EMU countries' spreads, we turn to the regime classification results (see figures 1 to 10, in the Appendix).

These figures, apart from giving a graphical illustration of the time series of the spreads, enable us to distinguish the observations which have been classified as belonging to the 2nd regime of each equation. An important aspect of this classification is that the observations are distributed across the two regimes according to the standard deviation of the equation's residuals; thus, the 2nd regime reflects, in every case, high-volatility conditions. Additionally, note that the shift from the low-volatility to the high-volatility regime occurred during the global financial crisis; the earliest shift is found in the case of Ireland (December of 2007), while the latest one corresponds to the cases of Austria, Belgium and Finland (October 2008). For the rest of the countries, Spain's shift occurs in March 2008, France and the Netherlands are found to experience a shift in April of 2008, Italy in July 2008 and Greece and Portugal in September 2008. These results reveal that the sovereign bond spreads, didn't respond simultaneously to the eruption of the global financial crisis. Moreover, it seems that there exists a relationship between the level of the financial sector, relative to the overall economy, and the timing of shift to the high-volatility specification of the spreads.

Tables 1 and 2 present the output of the regressions for the high- and the low-volatility regimes respectively.

[Insert Tables 1 and 2 around here]

First, we note the findings that are related to the properties of the sovereign bond spreads; the autoregressive coefficients of the specifications are found to be significant and, in several cases, close to unity, indicating that sovereign bond spreads are highly persistent series. This finding is in line with similar findings of previous studies (e.g. Gerlach *et al.*, 2010 and Favero and Missale, 2011). Additionally, it is evident that the specification examined herein has an increased in-sample explanatory power. Specifically, the adjusted R^2 coefficients, reported in the lower panel of Tables 1 and 2, indicate a high level of deterministic power, ranging from about 65% (high-volatility specification of the Belgian bond spread) to approximately 94% (high-volatility specification of the Greek bond spread). Moreover, the explanatory power of the spreads increases in line with the level of their autoregressive coefficients. The deterministic processes of the spreads are illustrated in Figures 11-20, in which we have plotted the estimated series of the spreads against the realized ones, for the period after the collapse of Lehman.

Furthermore, these results indicate that the returns and the volatility of stock markets have enhanced explanatory power for spreads' movements; all dependent variables (except for Finland) are found to be affected by equity market conditions, being related to either the returns or the volatility of prices, in at least one of the two regimes specified. This finding underlines the concept of interlinkages between bond and stock markets. In this context, the finding that spreads in both regimes are negatively related to equity returns, may be seen as an indication that the interlinkages between the two market segments relate to the formulation of investment conditions; sepcifically, spreads decrease (increase) after positive (negative) stock returns. The effects of volatility on spreads confirm the interlinkages of investors' sentiment conditions between the two market segments as it is found that, in all cases where volatility is a significant explanatory variable, an increase in volatility is associated with higher spreads. However, this result is found to hold only under low volatility conditions.

We now turn to an examination of the effects exercised by the domestic economic sentiment conditions, as these are reflected in the Economic Sentiment Index. In this context, it is worth underlying that the Economic Sentiment Indices are forward-looking indices since they are derived by surveys of households and corporations. Our findings indicate that such indices are significant as determinants of the spreads in the spectrum of euro-area countries that we examine, with the exception of Austria and Spain. However, it is evident that the direction of the effects of this determinant changes, when a shift in the underlying volatility regime occurs. Specifically, under the high-volatility regime an improvement in economic agents' beliefs about the outlook of the economy is associated with decreases in spreads for France, Greece and Italy, while under the low-volatility regime the effects exercised by the ESI on spreads in Belgium, Ireland, the Netherlands and Portugal are the opposite. In the low volatility regime, this finding may be an indication that investors are mostly concerned with incoming inflationary conditions and thus an increase in the ESI increases spreads in Belgium, Ireland and the Netherlands. By contrast, under high volatility conditions, the focus turns to a probable deterioration in economic activity, which would amplify macroeconomic instabilities and thus it is a decrease in the ESI that increases the spreads for France, Greece and Italy.

The abovementioned findings can also be commented upon in light of the findings related to the corporate credit risk variable we have included in the specification. In particular an interesting finding is that the credit spread from corporate bond yields with the highest (AAA) and the lowest investment grade rating (BBB) are found to provide only limited information on future movements of the European sovereign bond spreads. More specifically, the difference between the yields of BBB and AAA European corporate bond indices is found to positively affect the spreads of Portugal and France, under low and high volatility conditions, respectively, but not any of the other dependent variables. The reading of this finding could be that credit risk conditions in the corporate bond market are found not to significantly affect conditions in the sovereign bond markets. In this respect, we now turn to commenting on the rest of the deterministic variables contained in equation 2 and their power in explaining spreads movements.

The domestic term spread variables are found to exercise significant effects only in the case of Ireland, in the high volatility regime, while they cause movements, with limited significance, in the spreads of Finland, France and Greece, in their high-volatility regimes, and Ireland and Italy, in their low-volatility regimes. In the abovementioned cases, movements in the term spreads cause opposite effects on sovereign bond yield spreads; however, this does not hold for the case of Greek spreads, in its high-volatility specification and the Irish spread, in its low volatility specification. The last two spreads are positively affected by their respective domestic term spreads.

The inflation differential is found to be a significant determinant of spreads in Belgium and Finland, under low volatility conditions, and Portugal, under high volatility conditions, while it has limited significance for the Dutch spread in the low-volatility regime. Similarly, changes in the value of the assets of monetary and financial institutions and the German term spread are found to exercise only limited effects on sovereign bond spreads. Specifically, the former determinant is found to be significant only in the case of Belgium in the low-volatility regime, while the latter is significant for the Irish spread, again in its low-volatility specification.

Finally, the difference between the three-month Euribor rate from the ECB's main refinancing rate is found to exercise significant effects on the spreads of Finland and France, in their high-volatility specifications, and Austria, Belgium, France and the Netherlands, in their low-volatility specifications. On the other hand, the Economic Sentiment Index for the euro-area is significant for the Greek spread (in both regimes), the French spread (in the high-volatility regime) and the Irish spread (in the low-volatility regime).

However, what is more interesting is that these findings provide clear evidence about the lack of homogeneity of the determinants of sovereign spreads of different euro-area countries; moreover, even where the determinants are similar, their impact differs significantly. Specifically, there are many cases in which the effects exercised by the determinants on the dependent variables differ either in their strength or, even, in their signs.

A narrative example, of this finding, can be given by the difference between the Euribor and the main refinancing operations rate of the ECB, in the low volatility regime, which exercises positive effects with limited significance on the Austrian spread, while its effects on the spreads of Belgium, France and the Netherlands are significant, at the 10% level, but negative. This finding suggests that a deterioration of the conditions in the interbank market increases the Austrian spread one month later, while it decreases spreads in the Netherlands, Belgium and France.

The lack of homogeneity in the determinants of spreads is also supported by the result that the significance of other euro-area wide determinants is not the same across the spreads examined. Euro Area (EA) economic conditions, as reflected in the respective economic sentiment index, exercise significant effects on the spreads of Greece, Ireland (under low volatility conditions) and France (in the high volatility regime). Furthermore, in the case of Greece, the sign of the effects exercised by the EA economic sentiment index moves from negative, under low volatility conditions, to positive. This finding may be interpreted as evidence of a change in investors' preferences; for example it may be indicating that when economic conditions in the euro area improve, investors increase their holdings of Greek sovereign bonds, in low volatility conditions, but become even more risk-averse towards the Greek sovereign bond risk, under high-volatility conditions.

4.2 Grouping formations

In order to examine thoroughly the homogeneity of the spreads' deterministic processes we calculate the relative explanatory power of each determinant, by employing the measure shown in (4), for each of the dependent variables in Table 3, below.

[Insert Table 3 around here]

To begin with, note that the results of the estimation presented in Table 3, mainly permit a comparison of the, standardized, explanatory power of each determinant across the two volatility regimes. The figures in Table 3 report the explanatory power of each variable as a percentage of the deterministic component of the spreads and in this respect allow a comparison across spreads, as well. This comparison enables us to check the degree to which the deterministic processes of the euro-area sovereign bond spreads, across countries, are homogenous.

For example, the equity return variable is found to explain almost one-third of movements in the Greek sovereign bond spread in the high-volatility regime, and more than 25% of the movements of the Spanish sovereign bond spread in the low-volatility regime. On the other hand, it does not explain more than 2% of the movements of spreads of Austria, Belgium, Finland and Portugal, or 4% of Ireland, under low-volatility conditions. Additionally, in the cases mentioned, for which the equity returns have small explanatory power, the volatility effects on movements in spreads are found to be quite large; they explain almost one-fifth of the movements of spreads in Austria, Belgium and the Netherlands under high volatility conditions. Furthermore, it is worth noting that the explanatory power of the volatility of equity prices on spreads' movements increases by almost a half when comparing the overall impact, across countries, in the low and high volatility regimes.

Similarly, the results obtained when examining the effects exercised by the domestic economic sentiment indices on the spreads' movements are found to reveal significant differences across countries. For example, under the high volatility regime, the Portuguese ESI is found to explain almost one-third of movements in the Portuguese spread, whereas the effects of the domestic ESI on spreads in Belgium, Greece and the Netherlands do not exceed a marginal 2%.

Equally revealing, in terms of the homogeneity of the effects exercised by each explanatory variable, is the comparison of the power of the other country-specific determinants of the specification, in explaining the spreads' movements. For example, the domestic term spread is found to explain about 14-16% of the movements in spreads of Austria, Belgium, Greece, Ireland and the Netherlands, in the high-volatility regime, while its explanatory power does not exceed 5% in the rest of the countries; in the low-volatility regime, these differences are not so large, mainly because the explanatory power of the term spread as a determinant of the sovereign bond spread, in each case, decreases. Similar evidence of lack of homogeneity in the deterministic process of the spreads exists also in the cases of the rest of the country-specific variables, namely the inflation differentials and the MFI asset's value.

More importantly, though, the effects exercised by the common, euro-area wide, determinants can, also, be interpreted as indicating lack of homogeneity in the euro-area sovereign bond spreads' deterministic processes. First, we focus on the effects exercised by the corporate credit spread. In this context, note that while a movement in the corporate credit spread explains 25% of movements in the Spanish spread and about 13-14% of movements in French and the Dutch spreads in the high volatility regime, it does not correspond to more than 6% of the deterministic component for the rest of the spreads. In the low volatility regime the credit spread of European corporate bonds explains about 10% of movements in the Portuguese spread and 7% of movements in the French spread, while it does not contribute to more than 5% to movements in the rest of the cases.

Next, we turn to the effects that originate from the euro-area ESI. These are found to have limited explanatory power for most of the sovereign bond spreads. However, in the case of the Greek spread the economic sentiment in the euro-area is found to explain a large part of its movements. This finding accompanied with the negative sign of the respective coefficient (see Table 2) indicates that improvements in conditions in the euro-area economy decrease spreads of the Greek sovereign bonds under low volatility conditions. However, under high volatility conditions, the direction of this relationship reverses, indicating the extreme conditions of risk-aversion for Greek sovereign bonds, during the recent crisis.

Finally, the examination of the explanatory power of the effects of the German yield curve and the interbank spread, are more homogenous across countries. Specifically, the effects exercised by both these explanatory variables are found to have limited power across the spectrum of the dependent variables. This time the exceptions are found in the case of the Austrian spread in its low-volatility specification, and the French spread in its high-volatility specification.

Furthermore, from the above analysis we can also examine whether there are any cases in which evidence of grouping formation exists. In this respect, Figures 21-27 provide a graphical illustration of the explanatory power of each determinant, or group of determinants, on each spread's specifications for the high- and the low-volatility regime.

In these figures three criteria for comparison are reported; first, the autoregressive parameter and the unexplained part of the dependent variable are illustrated, second, the degree to which the spreads reflect country-specific or euro-area wide explanatory variables and, finally, the degree to which the deterministic component reflects economic or market sentiment. It is worth focusing on the last two criteria as we have already commented on the degree to which the specification here explains developments in spreads across regimes.

From the figures in the middle panel, it is shown which country-specific variables have increased strength under the high-volatility regime; as a result, it may be argued that the spreads, under the high-volatility regime are more responsive to country-specific developments. Under this regime, the percentage of spreads explained near or above 50% by country-specific developments are those of Greece, Portugal, the Netherlands and Belgium. Under the low-volatility regime, however, the Portuguese, Italian, Belgian, French and Spanish spreads are 50% or more explained by domestic variables.

Additionally, the bottom panel of figures indicates that the Greek spread is constantly explained in a quite strong manner by economic-sentiment indices, both domestic and euro-area wide, while the same occurs for the Portuguese spread, in the high-volatility regime and the Belgian one in the low-volatility regime. Additionally, these figures illustrate that explanatory effects from the equity-market related variables are worth-noting, in the cases of the Greek spread, under high-volatility conditions, and of the Spanish spread, under low-volatility conditions.

To this end, these findings highlight that there exist both similarities and differences in the deterministic processes of the spreads across countries. For example, the Greek and the Portuguese spreads are found to be subject, to a similar degree, to effects stemming both from their country-specific variables and from the economic sentiment indices. Additionally, in the low-volatility regime, the spreads of France, Greece, Ireland and Portugal are to a similar degree subject to effects stemming from euro-area aggregate variables. On the other hand, the spread of Austria is found to have an idiosyncratic behavior in respect both of the magnitude of its autoregressive effects, under the low volatility regime and to the low explanatory power of both the euro-area wide and domestic variables, in the same regime; in its turn this latter outcome is related to the former one.

4.3 Controlling for effects from the debt-to-GDP ratio

The results presented so far indicate that ESIs and financial market conditions are important, as they are found to have the strongest explanatory power among the explanatory variables of our specification. In this respect, we deem that they deserve proper attention from policy makers in order to resolve the sovereign debt crisis in Europe. In particular, the finding that these variables are significant indicates that the financial stability problems in the euro area, related to the sovereign debt crisis, should be addressed in such a way that one recognizes that market-participants form expectations about economic activity and future returns. At the same time, fiscal consolidation is a necessary condition to address the macroeconomic imbalances among euro-area economies.

Thus, it is interesting to investigate these results in the presence of explanatory variables related to fiscal imbalances; the results of this exercise would indicate whether decisions and actions aiming at solving the macroeconomic imbalances will suffice for restoring stability in the euro-area financial markets. For this reason, we investigate, simultaneously, the relationship of the spreads with fiscal variables and expectations-related determinants. Thus, we examine whether the economic sentiment indices and the equity market variables lose their significance, as determinants of the spreads' movements, when we include fiscal variables in the equations, as well.

The data used, in this exercise, are of quarterly frequency, as this is the highest publicly available frequency for fiscal variables. The equation used for this analysis contains the level and changes of the Debt-to-GDP ratio, the domestic and euro-area wide economic sentiment indices and the equity market returns and volatility. The concept of the exercise does not change: we separate the sample to two sub-periods capturing the observations found, earlier, to belong to the low and the high volatility regimes. For these reasons, the results of this exercise constitute a supplementary analysis to the ones presented in the previous section. The respective results are presented in Table 4.

[Insert Table 4 around here]

The results reveal an interesting picture, regarding the relationship between movements in spreads and the debt-to-GDP ratio; the level and the change in this ratio is not a significant explanatory variable for movements in spreads, in the high volatility regime, with the exception of Portugal. This finding is in line with respective findings in Gerlach *et al.* (2010) and Favero and Missale (2011). By contrast, in the low volatility regime, the results indicate that fiscal variables are more significant as a determinant of spreads in the first eight years of the monetary union.

The domestic ESIs (domestic and euro-area) are found to be significant determinants of spreads in Belgium and Greece, in the high volatility regime, and Austria, Italy and the Netherlands, in the low volatility regime. The euro-area wide ESI is found to move the spreads of Belgium, Spain, Greece and Ireland, in the high volatility regime, and Austria, Belgium, France and Portugal, in the low volatility regime. In this respect, it should be noted that when using quarterly data, there is evidence that the significance of the ESIs increases in several cases as compared to monthly data. This finding sits easily with the stylized fact that economic sentiment exhibits smooth changes through time and as a result its effects may be more significant with lower frequency data.

Equity market returns and volatility variables are found to be significant explanatory variables for several spreads at quarterly frequency. More specifically, in the high volatility regime the spreads of the Netherlands, Portugal and Ireland are found to be negatively affected by their equity market returns, whereas the equity market volatility moves, in the Netherlands, Italy and Greece in the same direction with the respective spreads. In the low volatility regime, equity returns are significant only for the spreads of Belgium and Italy, whereas the volatility significantly affects the spreads of Austria and Portugal.

All in all, focusing on the high volatility regime, it seems that the sovereign debt crisis was not a result of current developments in the level of the debt, or of its dynamics, but rather expectations, as these are reflected in the ESIs and the equity market variables.

As a result, a correct reading of the sovereign debt crisis is that, the deterioration of economic and market expectations, which in a large extent was due to the expected deterioration of the fiscal position in several euro-area countries, has resulted in the widening of the sovereign bond spreads.

5. Concluding remarks

In the present paper we first addressed issues related to the degree of integration and stability of the Eurozone sovereign bonds market. As a yardstick for market integration we use the spreads of 10-year sovereign bond yields against Germany's Bund. Our empirical analysis has shown that even in the pre-2008 crisis period there was no uniform pattern in the determinants of spreads. This evidence intensifies when we examine the post-crisis period since we failed to identify the same determinants with the pre-crisis period, thus validating the argument that the sovereign bonds market lacked a level of stability that would have immunized it from financial market conditions.

We then proceeded to show that movements in the euro-area sovereign bond spreads are often misinterpreted as reflections of fiscal fundamentals; first we find no evidence confirming the link between fiscal variables and the spreads' movements and, second, we find heterogeneity in the determinants of spreads across euro-area countries. We deem that policy makers should draw their attention to this last outcome, incorporating it in the proposed solutions in order to restore financial stability. Furthermore, our findings indicate that spreads are significantly explained by market and economic sentiment conditions. This finding suggests that in the current climate, decisions aiming to support investors' confidence should signal the decisiveness of the policy-makers to (i) deal with the country-specific problems in the euro-area and (ii) improve expectations about economic activity.

References

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

Aizenmann, J., Hutchison, M., and Jinjarak, Y., 2011. What is the risk or European sovereign debt defaults? Fiscal space, CDS spreads and market pricing of risk. National Bureau of Economic Research, working paper no. 17407.

Ang A., and Bekaert G., 2002. Regime switches in interest rates. Journal of Business and Economic Statistics, 20(2), 163-82.

Arghyrou, M., Kontonikas, A., 2011. The EMU sovereign-debt crisis: fundamentals, expectations and contagion. European Commission-Economic Papers No. 436

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., and Inghelbrecht, K., 2010. Time-varying integration interdependence and contagion. Journal of International Money and Finance, 29, 791-818.

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.

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.

Connolly, R., Stivers, S., and Sun, L., 2005. Stock market uncertainty and the stock-bond return relation. Journal of Financial and Quantitative Analysis, 40(1), 161-194.

Dötz, N., and Fischer, C., 2010. What can EMU countries' sovereign bond spreads tell us about market perceptions of default probabilities during the recent financial crisis? Deutsche Bundesbank Discussion Paper series 1: Economic Studies, no. 2010-11.

Ehrmann, M., Fratzscher, M., Gürkaynak, R., and Swanson, E., 2011. Convergence and anchoring of yield curves in the euro area. The Review of Economics and Statistics, 93(1), 350-364.

Estrella, A., 2005. Why Does the Yield Curve Predict Output and Inflation? Economic Journal, 115(505), 722-744.

European Commission, 2011. Green Paper on the feasibility of introducing Stability Bonds. European Commission, Comm(2011) 818, Brussels, *available at:* http://ec.europa.eu/commission_20102014/president/news/documents/pdf/green_en.pdf

De Grauwe, P., and Moesen, W., 2009. Gains for all: a proposal for a common eurobond. Intereconomics, May/June 2009, 132-135.

Favero, C., and Missale, A., 2011. Sovereign spreads in the Euro area: which prospects for a Eurobond? Centre for Economic Policy Research, Discussion Paper no. 8637.

Gerlach, S., Schulz, A., and Wolff, G., 2010, Banking and sovereign risk in the euro area. Centre for Economic Policy Research, discussion paper no. 7833.

Georgoutsos D., and Migiakis P., 2009. Benchmark bonds interactions under regime shifts. *Forthcoming in* European Financial Management (doi: 10.1111/j.1468-036X.2009.00535.x)

Georgoutsos, D., and Migiakis, P., 2010. European sovereign bond spreads: monetary unification, market conditions and financial integration. Bank of Greece, working paper no. 115.

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

Gibson, H., Hall, S., and Tavlas, G., 2011. The Greek financial crisis: growing imbalances and sovereign spreads. *Forthcoming in* Journal of International Money and Finance (doi:10.1016/j.jimonfin.2011.10.009)

Giovannini Group, 2000. Coordinated public debt issuance in the euro area-A Report of the Giovannini Group. *Chapter 4 pages 59-66 in: Public debt and fiscal policy in the EMU*. European Economy no. 2, European Commission: Directorate General of Economic and Financial Affairs Brussels, 2000.

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

Goméz-Puig, M., 2009. Systemic and idiosyncratic risk in EU-15 sovereign yield spreads after seven years of monetary union. European Financial Management, 15(5), 971-1000.

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

Issing, O., 2009. Why a common eurozone bond isn't a good idea. Centre for Financial Studies, white paper III.

Jubinski, D., and Lipton, A., 2011. Equity volatility, bond yields, and yield spreads. *Forthcoming in* Journal of Futures Markets, (doi: 10.1002/fut.20521).

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 re-examination of the Fisher effect. Empirical Economics, 26(2), 357-366.

McLachlan, G., and Krishnan, T., 2006. The EM algorithm and extensions (2nd edition). Wiley Series in Probability and Statistics, John Wiley and Sons, Hoboken, New Jersey.

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

Mayordomo, S., Peña, J., and Schwartz, E., 2009. Towards a common European Monetary Union risk free rate. National Bureau of Economic Research, working paper no. 15353.

Pagano M., and von Thadden L., 2004. The European bond markets under EMU. Oxford Review of Economic Policy, 20(4), 531-554.

Palladini, G., and Portes, R., 2011. Sovereign CDS and bond pricing in the euro area. National Bureau of Economic Research, working paper no. 17586.

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.

Rua, A., 2002. Composite indicators fort he euro area economic activity. Economic Bulletin, Banco de Portugal, September 2002, 87-100.

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.

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

Appendix

1. Description of the variables of vector *X*
   - 'Equity returns' are calculated as differences of logged stock indices' prices of the last and the first day-of-the-month, for each country, (source: Datastream).
   - The 'equity volatility' variable is estimated as the monthly standard deviation of the daily prices of each country's stock market index, (source: Datastream).
   - 'Economic sentiment' refers to the Economic Sentiment Index (ESI) reported every month by the European Commission. The series is calculated as differences of the index from the optimism-threshold (i.e. 100), (source: Datastream).
   - The 'domestic yield curve' variable is estimated as the term spread between ten and two years of domestic sovereign bonds, (source: Datastream)
   - 'Inflation difference' is the difference in time *t* between the inflation rate of country *X* from the German inflation rate. Inflation rates correspond to the year on year percentage changes of the harmonized index of consumer prices (HICP), (source: Datastream).
   - The 'MFI' variable captures monthly percentage changes in the value of assets of the balance sheets of monetary and financial institutions of each country. (the MFI definition follows the official definition from the Eurosystem; source: Statistical Data Warehouse, ECB).

2. Description of the variables of vector *Z*
   - The 'credit spread' series is estimated by using the iBoxx indices for, liquid, corporate bonds with different credit rating, with a residual maturity of 7 to 10 years; specifically, it is the difference between the yields of the iBoxx indices containing BBB-rated European corporate bonds against the yields of the respective iBoxx index of AAA-rated European corporate bonds, (source: Datastream).
   - The 'interbank' variable is the spread of the 3-month Euribor rate over the benchmark rate of the ECB for its main refinancing operations, (source: Datastream).

- The ‘economic sentiment EA’ variable refers to the Economic Sentiment Index (ESI), for the euro-area (changing composition), reported every month by the European Commission. The series is calculated as differences of the index from the optimism-threshold (i.e. 100), (source: Datastream).
- The ‘DE yield curve’ variable is estimated as the term spread between ten and two years of Germany’s sovereign bonds, (source: Datastream).

Table 1: Regression output – the high volatility regime

	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
Constant	0.332	0.395	-0.827	0.186	0.151**	-2.022	0.119	0.108	0.141	0.296
	(0.315)	(0.323)	(0.556)	(0.154)	(0.062)	(2.184)	(0.653)	(0.119)	(0.092)	(0.385)
Spread	0.614**	0.762**	0.697**	0.506**	0.652**	0.479**	1.048**	0.824**	0.323*	0.552**
t-1	(0.199)	(0.136)	(0.208)	(0.155)	(0.136)	(0.154)	(0.121)	(0.136)	(0.189)	(0.233)
Eq. ret	-0.003	-0.010	-0.029**	-0.001	-0.012**	-0.033**	-0.014	-0.016**	-0.008**	-0.014
t-1	(0.003)	(0.009)	(0.011)	(0.002)	(0.002)	(0.013)	(0.011)	(0.005)	(0.002)	(0.025)
Eq. vol.	-0.009**	-0.018	-0.007	0.001	-0.004	-0.004	-0.009	0.003	-0.004	0.009
t-1	(0.004)	(0.012)	(0.005)	(0.002)	(0.003)	(0.011)	(0.021)	(0.016)	(0.003)	(0.063)
Eco. sent.	0.015	-0.007	-0.039	0.005	-0.019**	-0.163**	-0.043	-0.038**	-0.002	-0.051
t-1	(0.013)	(0.023)	(0.050)	(0.010)	(0.007)	(0.055)	(0.029)	(0.015)	(0.006)	(0.042)
Dom. YC	-0.146	-0.059	0.072	-0.211*	-0.220*	0.476*	-0.616**	-0.039	0.064	0.031
t-1	(0.155)	(0.112)	(0.254)	(0.114)	(0.115)	(0.268)	(0.218)	(0.092)	(0.123)	(0.164)
Inf. dif.	0.027	0.103**	0.055	0.054	-0.018	0.406	-0.210	0.067	0.025	0.415**
t-1	(0.119)	(0.044)	(0.110)	(0.046)	(0.049)	(0.381)	(0.143)	(0.081)	(0.018)	(0.200)
MFI t-1	-0.006	0.010	-0.070	-0.001	-0.008	0.047	0.050	-0.015	-0.003	-0.005
	(0.012)	(0.008)	(0.092)	(0.004)	(0.005)	(0.129)	(0.046)	(0.015)	(0.005)	(0.105)
Cr. Spread	-0.043	-0.056	0.201	0.015	0.064**	0.551	-0.222	-0.061	0.032	0.155
t-1	(0.092)	(0.107)	(0.180)	(0.040)	(0.026)	(0.569)	(0.246)	(0.159)	(0.036)	(0.316)
Interbank	0.080	-0.069	0.187	-0.206**	-0.106*	0.851	0.240	0.051	-0.006	-0.344
t-1	(0.141)	(0.116)	(0.227)	(0.082)	(0.059)	(1.237)	(0.268)	(0.123)	(0.065)	(0.411)
Eco. Sent. EA	-0.027	-0.002	0.045	-0.011	0.019**	0.159**	0.010	0.028	-0.003	0.051
t-1	(0.119)	(0.027)	(0.040)	(0.010)	(0.008)	(0.059)	(0.026)	(0.017)	(0.005)	(0.039)
DE YC	0.139	0.013	0.289	0.124	0.186	-0.616	0.428	0.143	-0.086	-0.015
t-1	(0.145)	(0.179)	(0.239)	(0.112)	(0.129)	(0.920)	(0.307)	(0.141)	(0.126)	(0.310)
D. W.	3.010	2.479	2.150	2.124	2.152	2.289	2.755	2.462	2.211	2.582
AIC	-1.213	-0.779	0.159	-1.902	-2.472	2.479	1.196	-1.141	-2.232	1.131
$\tilde{R}^2$	0.759	0.654	0.869	0.749	0.738	0.938	0.931	0.886	0.830	0.895

Note: The figures contained in the cells are the coefficients of each explanatory variable of equation 2, while parentheses contain the respective std. deviations. The regression output has been corrected by applying the Newey-West filter, for controlling serial correlation of the residuals. Asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively.

Table 2: Regression output – the low volatility regime

	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
Constant	0.002 (0.013)	0.004 (0.019)	-0.008 (0.015)	0.021 (0.021)	0.024 (0.015)	0.050 (0.031)	0.028 (0.024)	0.072** (0.023)	-0.004 (0.019)	0.020 (0.029)
Spread t-1	0.895** (.0031)	0.937 (0.056)	0.892** (0.076)	0.748** (0.122)	0.585** (0.158)	0.957** (0.095)	0.678** (0.095)	0.663** (0.107)	0.671** (0.099)	0.464** (0.158)
Eq. ret t-1	-0.002** (0.001)	-0.001 (0.001)	-0.002** (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)	-0.002** (0.001)
Eq. vol. t-1	-0.001 (0.001)	0.003** (0.001)	0.002** (0.001)	0.001 (0.001)	-0.001 (0.001)	0.002** (0.001)	-0.001 (0.001)	0.004** (0.002)	0.002* (0.001)	0.001 (0.001)
Eco. sent. t-1	0.001 (0.001)	0.003** (0.001))	0.001 (0.001)	-0.003* (0.002)	0.001 (0.001)	-0.001 (0.001)	0.003** (0.001)	0.001 (0.001)	0.002** (0.001)	0.004** (0.002)
Dom. YC t-1	0.006 (0.034)	-0.033 (0.038)	0.002 (0.027)	-0.014 (0.034)	0.017 (0.051)	-0.002 (0.045)	0.019* (0.011)	-0.085* (0.045)	0.002 (0.047)	-0.040 (0.033)
Inf. dif. t-1	-0.002 (0.008)	0.017** (0.005)	-0.006 (0.007)	0.010** (0.005)	-0.001 (0.007)	-0.006 (0.007)	0.001 (0.004)	-0.009 (0.008)	0.009* (0.005)	-0.005 (0.005)
MFI t-1	-0.001 (0.004)	-0.003** (0.001)	0.001 (0.001)	0.001 (0.001)	0.002 (0.002)	0.001 (0.002)	-0.001 (0.001)	-0.001 (0.002)	-0.002 (0.002)	-0.003 (0.003)
Cr. Spread t-1	0.009 (0.012)	-0.005 (0.015)	0.008 (0.016)	-0.002 (0.014)	0.012 (0.009)	-0.018 (0.024)	0.019 (0.013)	0.028 (0.019)	-0.010 (0.015)	0.082** (0.030)
Interbank t-1	0.002* (0.012)	-0.062** (0.020)	0.018 (0.016)	0.015 (0.022)	-0.035** (0.014)	0.028 (0.025)	-0.042 (0.026)	0.009 (0.020)	-0.025* (0.015)	-0.019 (0.022)
Eco. Sent. EA t-1	0.001 (0.001)	-0.001 (0.001)	0.001 (0.001)	0.002 (0.001)	-0.001 (0.001)	-0.003** (0.001)	-0.004** (0.002)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
DE YC t-1	-0.004 (0.033)	0.028 (0.039)	-0.001 (0.003)	0.001 (0.034)	-0.034 (0.052)	-0.027 (0.047)	-0.039** (0.015)	0.065 (0.042)	0.016 (0.042)	0.032 (0.036)
D. W.	2.410	2.038	2.411	2.079	2.219	1.929	1.987	2.273	2.187	1.831
AIC	-3.878	-3.723	-3.959	-3.738	-4.447	-3.477	-3.542	-3.681	-3.995	-3.325
$\tilde{R}^2$	0.915	0.917	0.936	0.907	0.716	0.929	0.881	0.829	0.735	0.879

Note: The figures contained in the cells are the coefficients of each explanatory variable of equation 2, while parentheses contain the respective std. deviations. The regression output has been corrected by applying the Newey-West filter, for controlling serial correlation of the residuals. Asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively.

Table 3: Spreads' determinants relative explanatory power

	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
High volatility regime										
Spread	28.70%	42.25%	21.22%	31.13%	35.61%	9.84%	41.67%	40.37%	24.24%	28.22%
Eq. ret	1.69%	1.80%	8.31%	1.28%	6.71%	30.67%	3.64%	8.28%	15.37%	1.74%
Eq. vol.	18.44%	17.80%	8.68%	4.55%	8.11%	3.42%	2.88%	3.24%	19.96%	1.59%
Eco. sent.	4.85%	0.61%	6.34%	3.81%	15.25%	1.08%	12.19%	10.19%	1.93%	29.12%
Dom. YC	15.06%	19.77%	1.30%	4.32%	2.39%	14.05%	13.34%	4.79%	13.94%	2.90%
Inf. dif.	4.54%	7.15%	4.32%	25.44%	0.56%	2.42%	3.69%	8.26%	3.97%	14.81%
MFI	0.95%	2.99%	14.13%	9.61%	10.49%	1.64%	4.53%	1.86%	2.10%	0.31%
Cr. Spread	2.99%	3.06%	25.28%	5.61%	13.43%	0.26%	5.69%	4.37%	13.96%	10.10%
Interbank	1.13%	1.06%	2.31%	5.98%	2.24%	0.68%	1.44%	8.32%	0.41%	3.76%
Eco. Sent. EA	0.45%	0.25%	2.82%	4.69%	3.40%	35.67%	0.79%	6.46%	2.69%	6.23%
DE YC	21.19%	3.27%	5.28%	3.56%	1.81%	0.27%	10.15%	3.86%	1.42%	1.23%
Low volatility regime										
	AT	BE	ES	FI	FR	GR	IE	IT	NT	PT
Spread	75.43%	22.58%	32.71%	34.82%	18.99%	24.54%	26.30%	22.57%	26.99%	12.60%
Eq. ret	9.39%	6.53%	27.49%	7.56%	9.08%	12.82%	7.97%	6.52%	6.10%	13.32%
Eq. vol.	1.72%	5.73%	7.24%	4.69%	4.80%	6.29%	3.77%	8.78%	6.51%	5.11%
Eco. Sent.	6.99%	17.81%	3.33%	5.26%	4.13%	2.50%	13.02%	7.43%	10.49%	11.40%
Dom. YC	0.23%	2.62%	1.85%	7.15%	2.56%	6.05%	7.10%	9.05%	0.27%	6.19%
Inf. dif.	1.64%	7.05%	5.41%	10.97%	2.59%	0.34%	1.18%	11.00%	11.31%	5.98%
MFI	0.37%	19.98%	5.66%	6.11%	5.26%	3.83%	4.54%	7.27%	13.73%	12.15%
Cr. Spread	0.42%	0.57%	3.12%	1.76%	7.39%	4.12%	3.50%	5.08%	1.89%	10.08%
Interbank	0.18%	6.92%	5.01%	3.65%	26.60%	4.66%	12.06%	8.57%	14.18%	10.39%
Eco. Sent. EA	3.44%	7.79%	5.97%	17.32%	9.12%	31.21%	9.85%	8.05%	5.92%	7.40%
DE YC	0.18%	2.40%	2.22%	0.71%	9.47%	3.66%	10.72%	5.69%	2.61%	5.40%

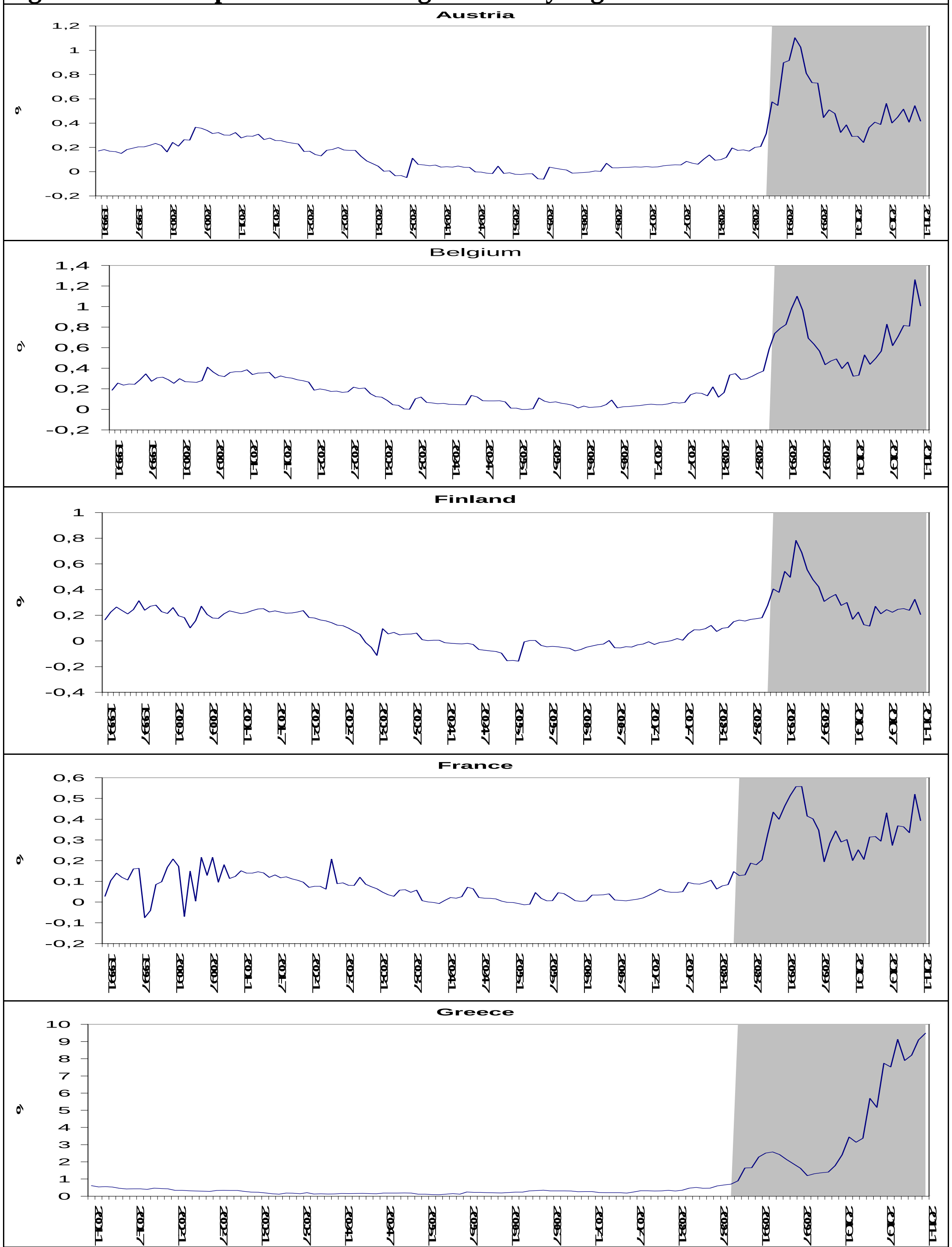
Note: The figures correspond to calculations according to eq. (4).

Table 4: Results for the equity variables and the economic sentiment, in the presence of the Debt-to-GDP ratio

	AT	BE	ES	FR	GR	IE	IT	NT	PT
High volatility regime									
Constant	-2.271	-1.809	-1.406	-0.287	13.367	-1.123	0.454	-0.408	-5.846**
	(1.304)	(1.456)	(1.706)	(0.678)	(8.193)	(0.795)	(4.078)	(0.416)	(2.079)
Spread	0.377**	0.719**	0.608*	-0.091	0.563**	1.093**	1.127**	-0.206	0.522*
t-1	(0.456)	(0.203)	(0.320)	(0.478)	(0.133)	(0.298)	(0.397)	(0.273)	(0.231)
Debt/GDP	0.033	0.018	0.022	0.007	-0.127	0.023	-0.007	0.009	0.074**
t-1	(0.021)	0.015)	(0.042)	(0.009)	(0.072)	(0.015)	(0.038)	(0.006)	(0.029)
Δ(Debt/GDP)	-0.009	0.012	0.029	-0.003	0.301	-0.016	-0.098	-0.003	-0.003
t-1	(0.009)	(0.023)	(0.128)	(0.025)	(0.279)	(0.026)	(0.076)	(0.004)	(0.113)
Eq. ret.	-0.005	0.001	-0.001	-0.003	0.013	-0.025*	-0.004	-0.004**	-0.028**
t-1	(0.004)	(0.003)	(0.007)	(0.003)	(0.015)	(0.012)	(0.007)	(0.001)	(0.012)
Eq. vol.	0.042	0.037	0.118	0.019	0.155*	0.057	0.132**	0.031**	0.114
t-1	(0.029)	(0.022)	(0.073)	(0.014)	(0.079)	(0.086)	(0.057)	(0.013)	(0.077)
Eco. sent.	0.033	0.078**	-0.044	-0.028	-0.248**	0.002	0.103	0.003	-0.023
t-1	(0.039)	(0.031)	(0.055)	(0.019)	(0.092)	(0.035)	(0.116)	(0.010)	(0.047)
Eco. Sent.	-0.047	-0.075**	0.053*	0.020	0.237**	0.026*	-0.048	-0.012	0.037
EA t-1	(0.037)	(0.032)	(0.024)	(0.021)	(0.052)	(0.014)	(0.069)	(0.008)	(0.034)
D. W.	1.774	2.487	2.952	1.496	2.183	3.012	1.965	1.889	2.411
$\tilde{R}^2$	0.667	0.692	0.833	0.622	0.955	0.888	0.573	0.919	0.834
Low volatility regime									
Constant	-0.370	-0.672**	-0.097	0.772**	-0.065	-0.069	-0.638**	-0.288**	0.535**
	(0.295)	(0.119)	(0.101)	(0.190)	(0.561)	(0.049)	(0.288)	(0.086)	(0.105)
Spread	0.737**	0.313**	0.742**	-0.063	0.639**	0.833**	0.454**	0.743**	0.308*
t-1	(0.113)	(0.117)	(0.080)	(0.193)	(0.088)	(0.172)	(0.152)	(0.099)	(0.183)
Debt/GDP	0.005	0.007**	0.001	-0.012**	0.001	0.002	0.007**	0.005**	-0.009**
t-1	(0.004)	(0.001)	(0.002)	(0.003)	(0.006)	(0.002)	(0.003)	(0.002)	(0.002)
Δ(Debt/GDP)	-0.003	-0.002	-0.009	$2.06\text{x}10^{-4}$	0.002	0.006**	0.003	0.004*	0.009*
t-1	(0.002)	(0.002)	(0.007)	(0.004)	(0.006)	(0.003)	(0.004)	(0.002)	(0.005)
Eq. ret.	0.001	-0.002**	0.001	$4.14\text{x}10^{-4}$	$3.7\text{x}10^{-4}$	$3.35\text{x}10^{-5}$	-0.001*	$3.28\ \text{x}10^{-4}$	$2.17\text{x}10^{-4}$
t-1	(0.001)	$(6.62\text{x}10^{-4})$	(0.001)	(0.001)	(0.001)	(0.002)	$(8.03\text{x}10^{-4})$	$(6.76\text{x}10^{-4})$	(0.001)
Eq. vol.	0.009**	-0.002	0.007	0.003	0.005	0.004	0.002	0.006**	0.014**
t-1	(0.004)	(0.004)	(0.004)	(0.002)	(0.006)	(0.005)	(0.003)	(0.002)	(0.005)
Eco. sent.	-0.004	-0.005**	0.007	$7.16\text{x}10^{-4}$	0.001	0.002	0.005**	0.002*	0.001
t-1	(0.004)	(0.002)	(0.004)	(0.002)	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)
Eco. Sent.	0.009*	0.011**	0.002	0.005*	0.002	0.001	$2.89\text{x}10^{-4}$	$6\text{x}10^{-4}$	0.009**
EA t-1	(0.005)	(0.002)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)
D. W.	2.428	2.063	2.160	1.707	2.119	1.904	2.090	2.288	1.716
$\tilde{R}^2$	0.899	0.939	0.937	0.788	0.816	0.743	0.823	0.744	0.859

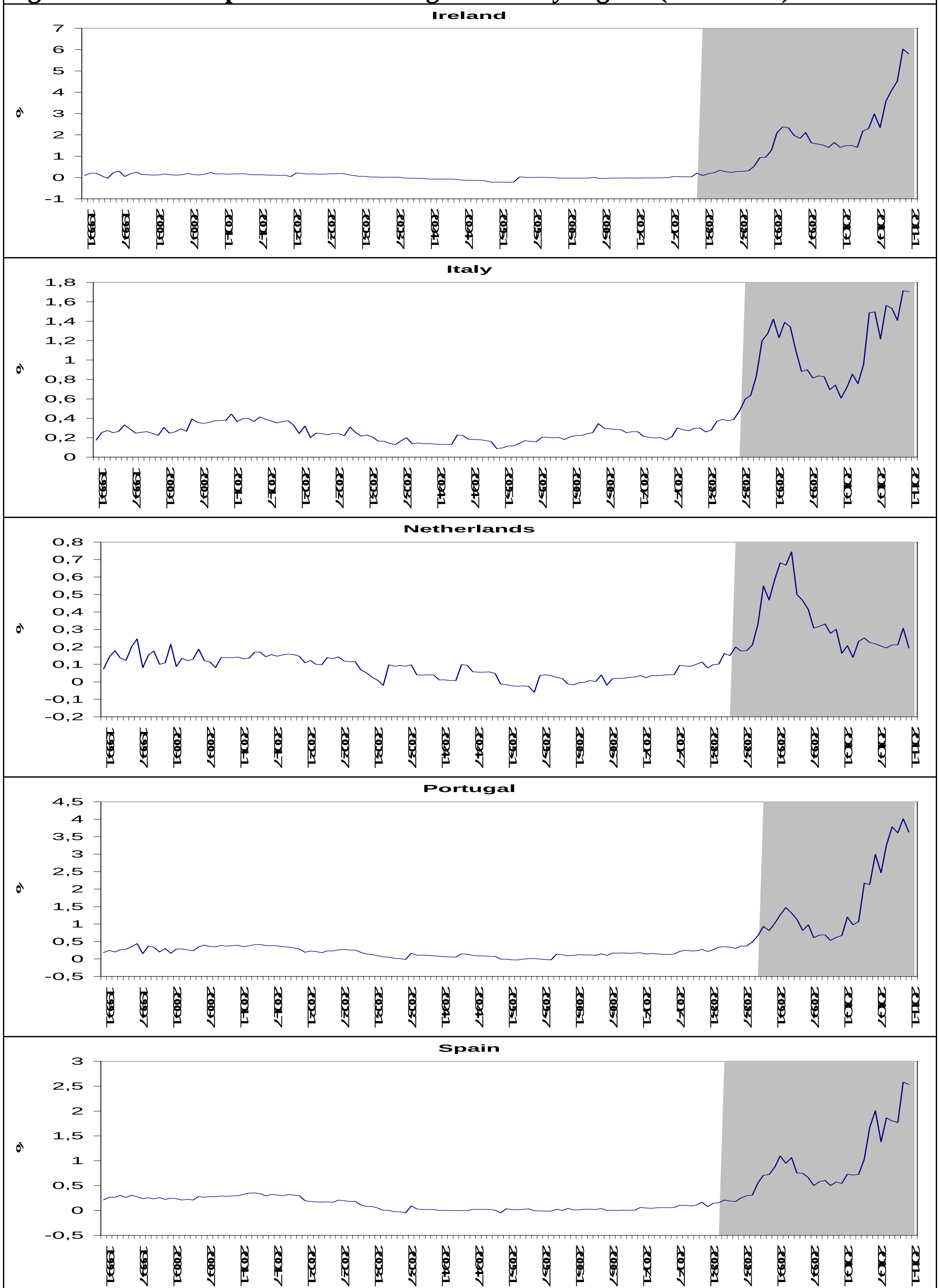
Note: Table 4 contains only the countries for which either the economic sentiment or one of the variables related to the equity market developments was found to be significant in the initial results. In this respect, Finland was omitted, on purpose, from the robustness checks. The figures in the cells are the coefficients of each explanatory variable, while parentheses contain the respective std. deviations. The regression output has been corrected by applying the Newey-West filter, for controlling serial correlation of the residuals. Asterisks * and ** denote significance in a 10% and 5% confidence interval, respectively.

Figures 1-5: The spreads and the high-volatility regime



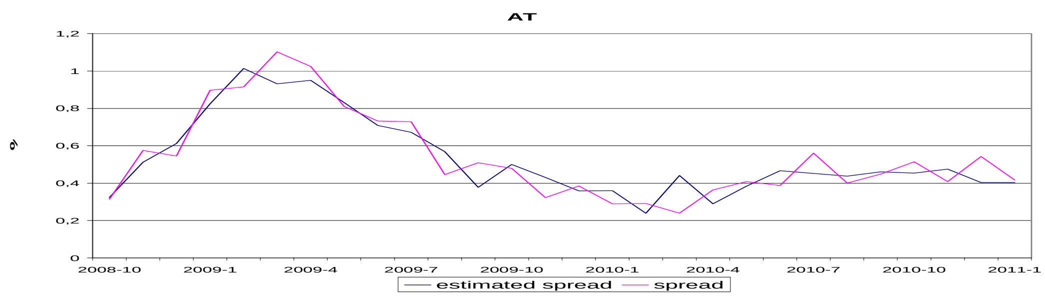
Note: The diagrams illustrate the series of sovereign bond yield spreads during the period under examination, while shadowed regions indicate periods belonging in the high-volatility regimes, specified in each case.

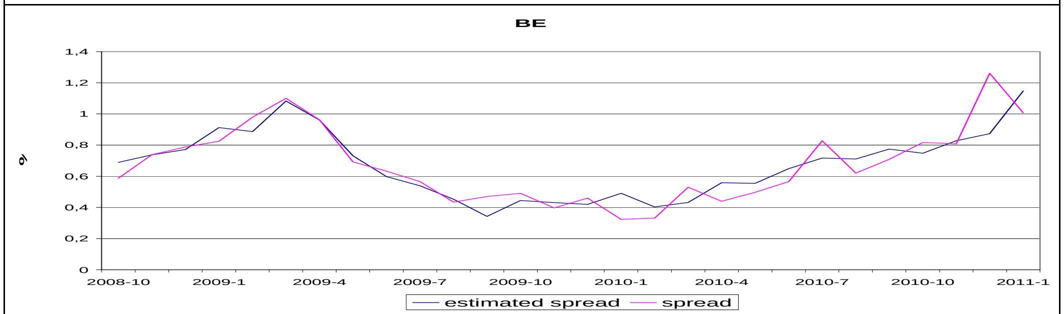
Figures 6-10: The spreads and the high-volatility regime (continued)

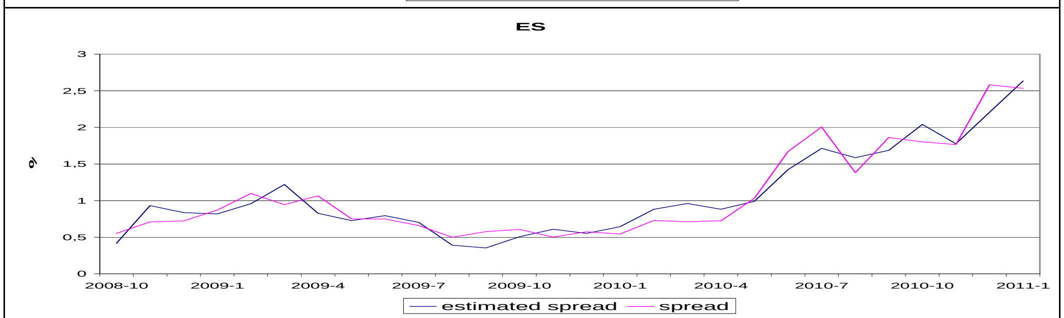


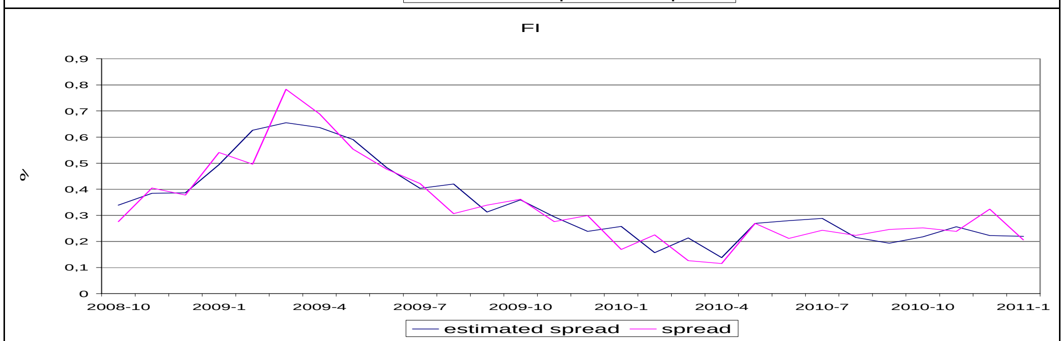
<u>Note:</u> The diagrams illustrate the series of sovereign bond yield spreads during the period under examination, while shadowed regions indicate periods belonging in the high-volatility regimes, specified in each case.

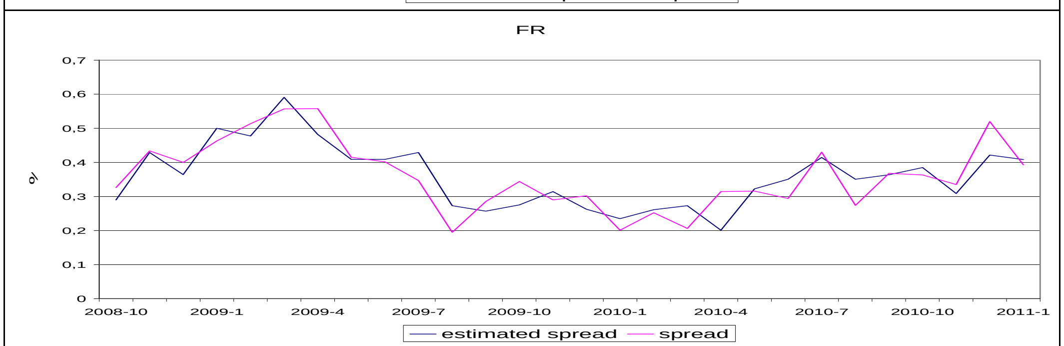
Figures 11-15: Illustration of goodness-of-fit of the estimated spreads



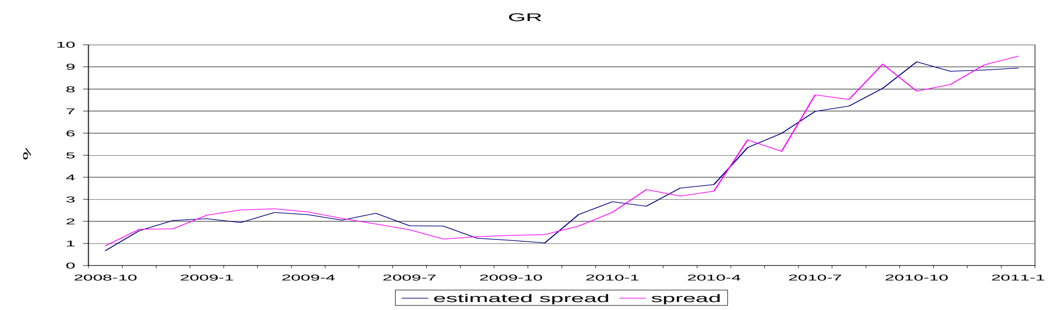


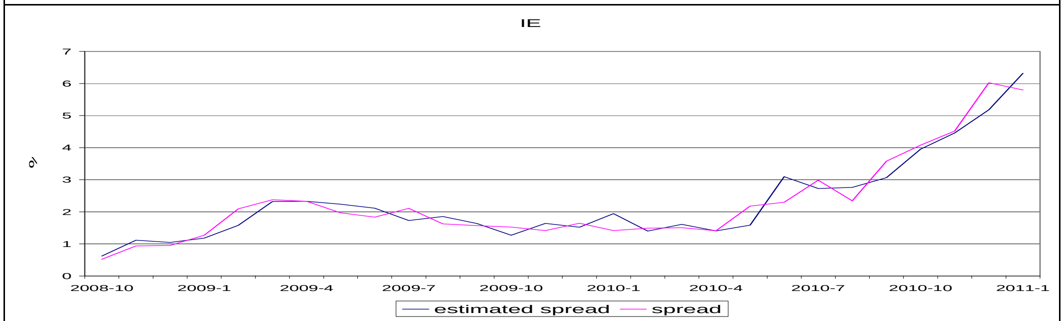


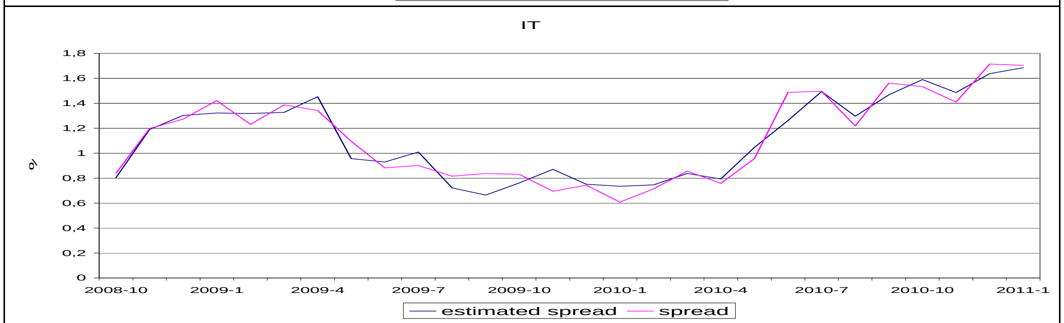


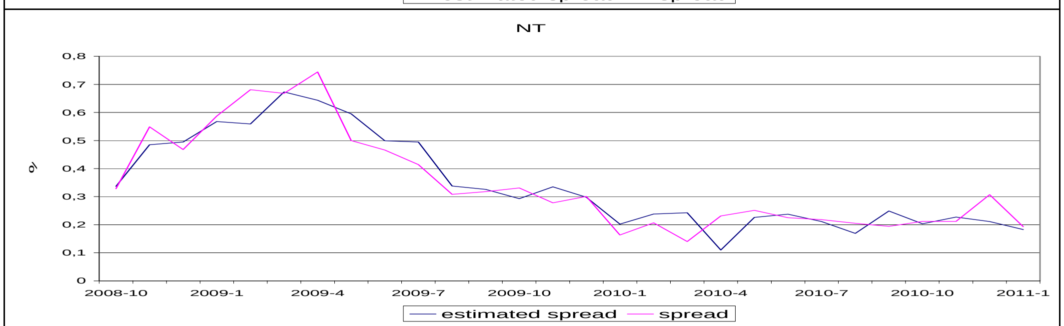


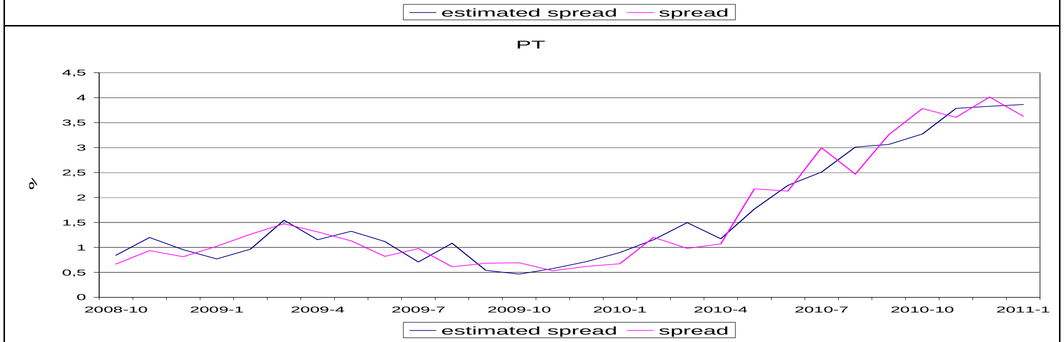
Figures 16-20: Illustration of goodness-of-fit of the estimated spreads (cont'd)





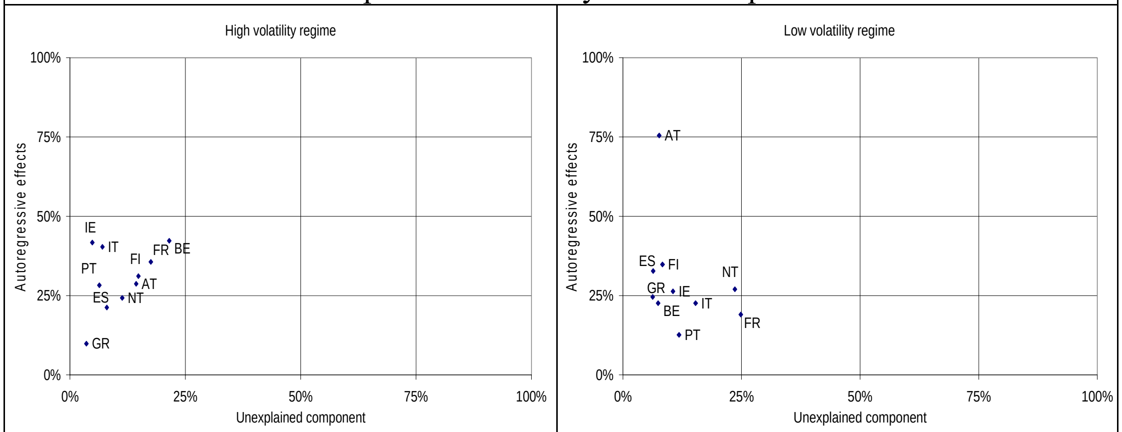




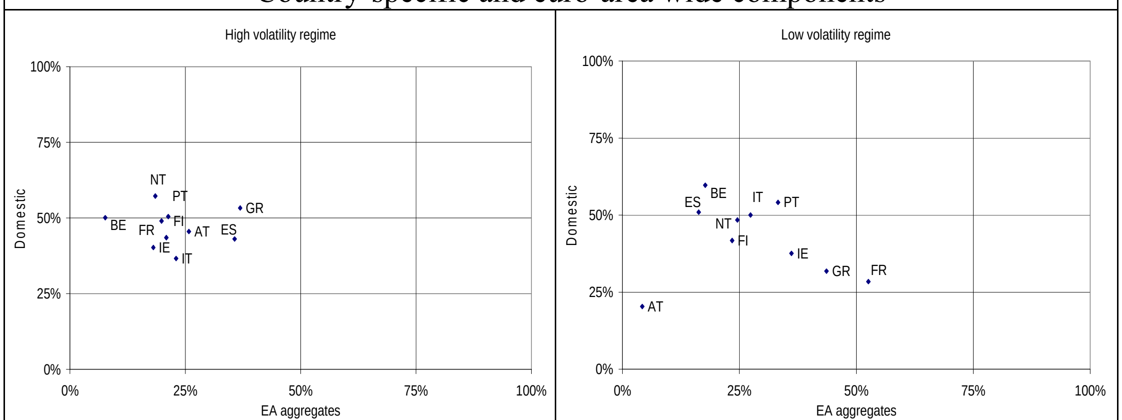


Figures 21-27: Clustering analysis (based on the calculations in Table 4)

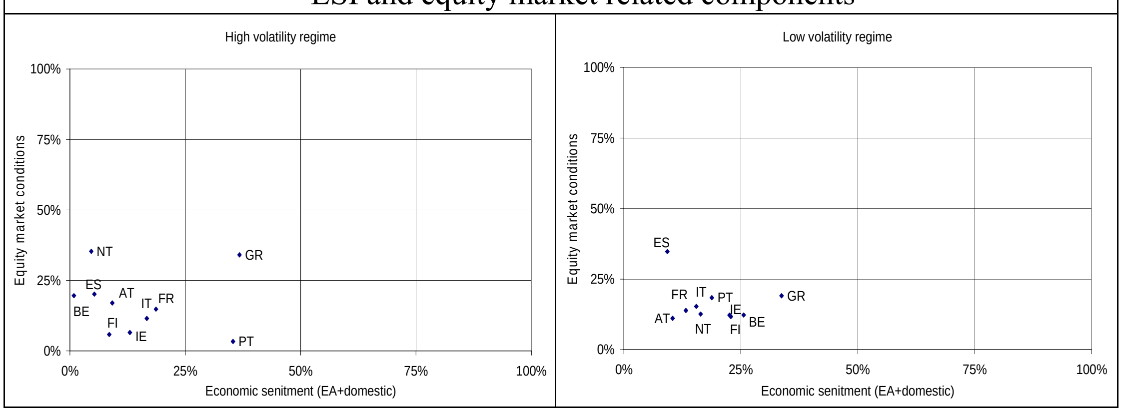
Unexplained and idiosyncratic components



Country-specific and euro-area wide components



ESI and equity market related components



BANK OF GREECE WORKING PAPERS

116. Tagkalakis, A., "Fiscal Policy and Financial Market Movements", July 2010.
117. Brissimis, N. S., G. Hondroyiannis, C. Papazoglou, N. T Tsaveas and M. A. Vasardani, "Current Account Determinants and External Sustainability in Periods of Structural Change", September 2010.
118. Louzis P. D., A. T. Vouldis, and V. L. Metaxas, "Macroeconomic and Bank-Specific Determinants of Non-Performing Loans in Greece: a Comparative Study of Mortgage, Business and Consumer Loan Portfolios", September 2010.
119. Angelopoulos, K., G. Economides, and A. Philippopoulos, "What Is The Best Environmental Policy? Taxes, Permits and Rules Under Economic and Environmental Uncertainty", October 2010.
120. Angelopoulos, K., S. Dimeli, A. Philippopoulos, and V. Vassilatos, "Rent-Seeking Competition From State Coffers In Greece: a Calibrated DSGE Model", November 2010.
121. Du Caju, P.,G. Kátay, A. Lamo, D. Nicolitsas, and S. Poelhekke, "Inter-Industry Wage Differentials in EU Countries: What Do Cross-Country Time Varying Data Add to the Picture?", December 2010.
122. Dellas H. and G. S. Tavlas, "The Fatal Flaw: The Revived Bretton-Woods system, Liquidity Creation, and Commodity-Price Bubbles", January 2011.
123. Christopoulou R., and T. Kosma, "Skills and wage Inequality in Greece: Evidence from Matched Employer-Employee Data, 1995-2002", February 2011.
124. Gibson, D. H., S. G. Hall, and G. S. Tavlas, "The Greek Financial Crisis: Growing Imbalances and Sovereign Spreads", March 2011.
125. Louri, H. and G. Fotopoulos, "On the Geography of International Banking: the Role of Third-Country Effects", March 2011.
126. Michaelides, P. G., A. T. Vouldis, E. G. Tsionas, "Returns to Scale, Productivity and Efficiency in Us Banking (1989-2000): The Neural Distance Function Revisited", March 2011.
127. Gazopoulou, E. "Assessing the Impact of Terrorism on Travel Activity in Greece", April 2011.
128. Athanasoglou, P. "The Role of Product Variety and Quality and of Domestic Supply in Foreign Trade", April 2011.
129. Galuščǻk, K., M. Keeney, D. Nicolitsas, F. Smets, P. Strzelecki and Matija Vodopivec, "The Determination of Wages of Newly Hired Employees: Survey Evidence on Internal Versus External Factors", April 2011.
130. Kazanas, T., and. E. Tzavalis, "Unveiling the Monetary Policy Rule In Euro-Area", May 2011.

131. Milionis, A. E., and D. Patsouri, "A Conditional CAPM; Implications for the Estimation of Systematic Risk", May 2011

132. Christodoulakis, N., and V. Sarantides, "External Asymmetries in the Euro Area and The Role Of Foreign Direct Investment", June 2011.

133. Tagkalakis, A., "Asset Price Volatility and Government Revenue", June 2011.

134. Milionis, E. A., and E. Papanagiotou, "Decomposing the Predictive Performance of The Moving Average Trading Rule of Technical Analysis: The Contribution of Linear and Non Linear Dependencies in Stock Returns", July 2011.

135. Lothian, J. R., and J. Devereux, "Exchange Rates and Prices in the Netherlands and Britain over the Past Four Centuries, July 2011.

136. Kelejian, J., G. S. Tavlas, and P. Petroulas, "In the Neighbourhood: the Trade Effects of the Euro in a Spatial Framework", August 2011.

137. Athanasoglou, P.P., "Bank Capital and Risk in the South Eastern European Region", August 2011.

138. Balfoussia, H., S. N. Brissimis, and M. D. Delis, "The Theoretical Framework of Monetary Policy Revisited", September 2011.

139. Athanasoglou, P. P., and I. Daniilidis, "Procyclicality in the Banking Industry: Causes, Consequences and Response", October 2011.

140. Lazaretou, S., "Financial Crises and Financial Market Regulation: The Long Record of an 'Emerger', October 2011.

141. Papapetrou, E and S. E. G. Lolos, "Housing credit and female labour supply: assessing the evidence from Greece", November 2011.

142. Angelopoulos, K., J. Malley and A. Philippopoulos," Time-consistent fiscal policy under heterogeneity: conflicting or common interests?", December 2011.