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THE GREEK FINANCIAL CRISIS: GROWING IMBALANCES AND SOVEREIGN SPREADS

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ABSTRACT

We discuss the origins of the Greek financial crisis as manifested in the growing fiscal and current-account deficits since euro-area entry in 2001. We then provide an investigation of spreads on Greek relative to German long-term government debt. Using monthly data over the period 2000 to 2010, we estimate a cointegrating relationship between spreads and their long-term fundamental determinants (including a measure of the fiscal situation, competitiveness of the Greek economy, economic activity and oil prices, reflecting the high dependence of the Greek economy on imported energy) and compare the spreads predicted by this estimated relationship with actual spreads. We find that spreads were significantly below what would be predicted by fundamentals from end-2004 up to the middle of 2005; by contrast, since May 2010, actual spreads have exceeded predicted spreads by some 400 basis points.

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1. Introduction

The entry of Greece into the euro area in 2001 provided that country's economy with a huge dividend in terms of sharply-reduced interest rates. The nominal interest rate on 10-year Greek government bonds declined from about 20 per cent in 1994, the time that the then-government announced a goal of bringing Greece into the euro area in 2001, to less than $3^1/_2$ per cent in early 2005. With the eruption of the Greek financial crisis in late 2009, however, interest rates have shot upward, with the 10-year government bond yield increasing to almost 12 per cent at the end of 2010. To what extent have the wide swings in yields reflected economic fundamentals? This paper addresses that issue.

We use the interest-rate spread between 10-year Greek and German government bonds to estimate a cointegrating relationship between those spreads and their long-term fundamental determinants. Recent work on the determinants of spreads uses panel cointegration techniques on high frequency data where spreads are hypothesised to be driven by various financial market variables representing credit, liquidity and market risks (Dotz and Fischer, 2010; Fontana and Scheicher, 2010; Gerlach et al, 2010). By contrast, we focus on one country alone and the macroeconomic determinants of spreads. We argue that during the period 2001-2009 the Greek economy was marked by growing, unsustainable fiscal and external imbalances. We posit that the sharp reduction in interest-rate spreads that occurred during much of this period did not adequately reflect these imbalances. Our empirical results provide some evidence for this view. We also provide evidence that the sharp, upward reversal of spreads following the outbreak of the Greek financial crisis also did not fully reflect fundamental factors. Thus, both undershooting and overshooting of spreads have occurred.

The remainder of this paper consists of six sections. Section 2 describes the origins of the Greek financial crisis, highlighting the crucial role of growing fiscal and external imbalances. Section 3 decomposes the risk premia on Greek sovereign debt into a part which can be explained by the rating given by the standard rating agencies and a part which seems to be idiosyncratic to the markets. Section 4 investigates a more fundamental determination of the spreads by providing a brief overview of the recent literature on the determinants of spreads. Section 5 presents a fundamental modelling

approach. Specifically, we use the methodology proposed by Johansen (1955a) and Pesaran and Shin (2002) to assess the cointegrating rank of a VAR system, and then proceed to identify the structural relationship determining Greek spreads. As fundamental determinants, we include a measure of the fiscal situation, the competitiveness of the Greek economy, economic activity and oil prices (reflecting the high dependence of the Greek economy on imported energy). Section 6 presents the results. In particular, we compare the spreads predicted by the estimated relationship with actual spreads. We find that spreads were significantly below what would be predicted by fundamentals from end-2004 up to the middle of 2005; by contrast, since May 2010, actual spreads have exceeded predicted spreads by some 400 basis points. Section 7 concludes.

2. The Greek financial crisis: origins

2a. The years of growing imbalances: 2001-2008/09

On January 1, 2001, Greece became the twelfth member of the euro area.[1] The motivation for joining the euro area reflected an assessment that the benefits of joining would outweigh the costs. In what follows, we discuss these benefits and costs.

Among the benefits conferred by the euro on its members are the following. (1) For countries with histories of high inflation, such as Greece, it lowers inflation expectations and, therefore, interest rates. (2) It eliminates exchange-rate fluctuations and the possibility of competitive devaluations among participating countries, thereby reducing risk premia and nominal interest rates. (3) With low inflation, economic horizons lengthen, encouraging borrowing and lending at longer maturities. The lengthening of horizons and the reduction in interest rates stimulate private investment and risk-taking, fostering economic growth. The reductions in nominal interest rates under (1) and (2) lower the costs of servicing public-sector debt, facilitating fiscal adjustment and freeing resources for other uses.[2]

[1] At its inception on January 1, 1999, the euro area consisted of eleven countries. Five countries have joined the euro area after Greece's entry, bringing the total number of members in 2011 to seventeen. For a detailed assessment of the euro area, see De Grauwe (2007).

[2] These advantages of a common currency exist so long as the central bank of the monetary union delivers price stability and is credible. In the case of the euro, the European Central Bank quickly established its anti-inflation credentials and became credible.

In the case of Greece, interest-rate spreads between 10-year Greek and German government bonds came down sharply in the years running up to, and the years following, entry into the euro area. These spreads are shown in Figure 1 for the period 1998 through 2010 using monthly data.[3] As shown in the figure, spreads fell steadily, from over 1,100 basis points in early 1998, to about 100 basis points one year prior to euro area entry. Upon entry into the euro area in 2001, spreads had fallen to around 50 basis points and continued to narrow subsequently, declining to a range between 10 to 30 basis points from late 2002 until the end of 2007. During the latter period, the absolute levels of nominal interest rates on the 10-year instrument fluctuated in a range of 3.5 per cent to 4.5 per cent, compared with a range of 5.0 per cent to 6.5 per cent in the year prior to euro-area entry.

The low-interest-rate environment contributed to robust real growth rates. From 2001 through 2008, real GDP rose by an average of 3.9 per cent per year – the second-highest growth rate (after Ireland) in the euro area – underpinned by household spending for consumption, housing investment, and business investment. Inflation, which averaged almost ten per cent in the decade prior to euro area entry, averaged only 3.4 per cent over the period 2001 through 2008.

Although entry into the euro area contributed to a period of prolonged and robust growth, and low (by Greece's historical standards) inflation, two deep-seated problems remained unaddressed; the country continued to run large fiscal imbalances and the country's competitiveness – already a problem upon euro area entry – continued to deteriorate.

Fiscal Policy. Figure 2 reports data on fiscal deficits and government expenditure and revenue as percentages GDP, beginning with 2001. As indicated in the figure, fiscal policy was pro-cyclical throughout the period 2001 through 2009, with deficits consistently exceeding the Stability and Growth Pact's limit of 3 per cent of GDP by

[3] In 1994, the then-Greek government set a goal to enter the euro area on January 1, 2001. The convergence of Greek economic indicators to those of other European Union countries contributed after 1994 to the narrowing of spreads prior to euro area entry. For an analysis of the Greek economy before euro-area entry, see Garganas and Tavlas (2001).

wide margins.[4] Expansionary fiscal policy was mainly expenditure-driven, leading to a rise in the share of government spending (to over 50 per cent of GDP in 2009, from about 45 per cent in 2001). The government debt-to-GDP ratio remained near 100 per cent throughout the period 2001 through 2009.

Competitiveness. Although inflation in Greece during 2001 through 2009 was low by the country's historical standards, inflation was relatively-high by euro-area standards. Inflation was, on average, more than one percentage point higher per year than in the rest of the euro area (Figure 3). Wage increases, adjusted for productivity changes, also exceeded the average increases in the rest of the euro area. With both prices and wages growing at relatively high rates, competitiveness declined (Figure 4). In the period 2001 through 2009, competitiveness, as measured by consumer prices, declined by around twenty per cent; as measured by unit labour costs, competitiveness declined by about 25 per cent. With relatively high real growth rates and declining competitiveness, the current-account deficit, which had already topped 7 per cent of GDP in 2001, rose to about 14.5 per cent of GDP in both 2007 and 2008 (Figure 5).

The large and growing fiscal imbalances were clearly not sustainable. Upon entry into the euro area, Greece gave up the ability to use two key tools to adjust its economy in the case of a country-specific shock. First, it lost the ability to set its own monetary policy. Second, it lost the ability to change the nominal exchange rate of its own currency. To compensate for the loss of these tools, the country needed to have the following: (i) relatively-low fiscal imbalances, so that fiscal policy could be used counter-cyclically in case of a country-specific shock, and (ii) flexible labour and product markets so that the country could be competitive without having to rely on changes in the exchange rate of a domestic currency to achieve and/or maintain competitiveness. As mentioned above, however, competitiveness declined substantially during 2001-2009,

[4] The European Union's Stability and Growth Pact aims to keep members' fiscal deficits below 3 per cent of GDP and their debt-to-GDP ratios below 60 per cent of GDP. Entry into the euro area is, in part, contingent on the satisfaction of these fiscal criteria. In the case of the debt-to-GDP criterion, countries can be allowed to join if the debt ratio is seen to be approaching the 60 per cent critical value at a satisfactory pace. The latter circumstance applied to Greece. In the year 2000, Greece was allowed entry into the euro area with a debt-to-GDP ratio near 100 per cent of GDP (because the ratio was on a declining path) and a fiscal deficit initially reported at 3.0 per cent of GDP; the latter figure was subsequently revised to 3.7 per cent of GDP after Greece became a member of Europe's monetary union.

despite the already large current-account deficits at the time of entry into the union. Moreover, instead of providing the role of an automatic stabilizer, the pro-cyclical stance of fiscal policy acted as a major *source* of shocks.[5] Nevertheless, the low levels of interest-rate spreads during 2001-08 suggest that financial markets paid little attention to the unsustainability of the fiscal and external imbalances during that period.[6]

2b. The wake up call

The global financial crisis that erupted in August 2007, following the collapse of the US subprime mortgage market, initially had little impact on Greek financial markets; spreads on the 10-year instrument, which were in a range of 20 to 30 basis points during January through July of 2007, remained in the vicinity of 30 basis points for the remainder of 2007 and the first few months of 2008 (Figure 1). With the collapse (and sale) of Bear Stearns in March 2008, spreads widened to about 60 basis points, where they remained until the collapse of Lehman Brothers in September. The latter event brought spreads up to around 250 basis points during the first few months of 2009, but they gradually came back down to about 120 basis points in August and September of 2009.

Then came a double shock in the autumn of 2009. Two developments combined to disrupt the relative tranquility of Greek financial markets. First, in October the newly-elected Greek government announced that the 2009 fiscal deficit would be 12.7 per cent of GDP, more than double the previous government's projection of 6.0 per cent.[7] In turn, the 12.7 per cent figure would undergo further upward revisions, bringing it up to 15.4

[5] Given that inflation in Greece during 2001-2009 was higher than the average inflation rate in the rest of the euro area, the ECB's single nominal interest rate meant that real interest rates in Greece were relatively low. Wickens (2010) argues that this situation warranted tighter fiscal policy.

[6] As mentioned in Section 3, however, real time fiscal data understated the severity of the fiscal situation. The real-time data typically indicated that the fiscal imbalances were declining. Subsequent revisions of the data showed that the imbalances were, in fact, increasing.

[7] On its website, the Bank of Greece publishes monthly cash data on the central-government (as opposed to the general-government) fiscal accounts. These data are available with a two-week lag relative to the month for which they apply. The data pointed to a sharp, worsening trend in the central-government fiscal deficit during the course of 2009. In this connection, in early September 2009 (ahead of the general election in October) Bank of Greece Governor, George Provopoulos, alerted the leaders of the two main political parties of the deteriorating fiscal situation and the need of strong corrective actions. See Ziras (2009).

per cent of GDP[8]. Second, in November 2009 Dubai World, the conglomerate owned by the government of the Gulf emirate, asked creditors for a six-month debt moratorium. That news rattled financial markets around the world and led to a sharp increase in risk aversion.

In light of the rapid worsening of the fiscal situation in Greece, financial markets and rating agencies turned their attention to the sustainability of Greece's fiscal and external imbalances. The previously-held notion that membership of the euro area would provide an impenetrable barrier against risk was shaken. It became clear that, while such membership provides protection against exchange-rate risk, it cannot provide protection against credit risk.

The two shocks set-off a sharp and prolonged rise in spreads, which, by-and-large, continued throughout the course of 2010. As shown in Figure 1, spreads on 10-year sovereigns widened from about 130 basis points in October 2009 to around 900 basis points one year later. The widening took place despite an agreement in early May 2010 between the Greek government and the International Monetary Fund, the European Central Bank, and the European Commission, for a three-year, €110 billion adjustment loan under which the Greek government committed to lower its fiscal deficit to 8.1 per cent of GDP in 2010 and to below 3.0 per cent in 2014.[9] Also, the widening occurred amid news that the European Central Bank had embarked on a programme to purchase those government bonds the spreads of which were seen as having risen for reasons unrelated to the fundamentals. To what extent did the rise in Greek spreads during 2010 relate to factors other than the fundamentals? We address this issue in what follows.

[8] Part of the subsequent increase was due to a reclassification of some public enterprises. The enterprises in question, which had previously been excluded from the general government accounts, were brought into those accounts.

[9] The loan also commits the government to undertake wide-ranging structural reforms aimed at making the economy more competitive. The 8.1 per cent deficit target for 2010 does not include the reclassification of public enterprises, mentioned above, which leads to an increase in the 2010 and 2011 fiscal deficits.

3. Spreads and the risk premium

In the 2010 report on *Financial Integration in Europe* (April 2011) from the European Central Bank (2011), a simple model of risk premia for sovereign debt yields is explored. In this section, we extend this model in terms of its specification and estimation methodology, applying the model to the case of Greek sovereign debt. In general, we may think of the relationship between a country's debt yields and that of a risk-free country (say, Germany) as being simply that of equality plus a risk premium, that is:

$$R_t^{gr} = R_t^{ge} + \rho_t + \varepsilon_t$$

where R_t^{gr} is the yield on Greek 10-year bonds, R_t^{ge} is the yield on German government bonds, ρ_t is a time varying risk premium and ε_t is an error term. The risk premium may vary with a number of factors, including the fundamentals of the economy in question. In the ECB report mentioned above, the focus is on the ratings given to a country by the credit rating agencies and we focus on these ratings in this section. (We turn to the fundamental factors in the next section.)

We decompose the risk premium into two components, one of which can be justified on the basis of market information ρ_t^1 and one which is essentially irrational ρ_t^2. Then, parameterising the model slightly differently, we may restate the relationship as:

$$R_t^{gr} = (1+\rho_t^2)R_t^{ge} + \rho_t^1 + \varepsilon_t \qquad (1)$$

We focus on credit rating revisions on Greek sovereign debt during the period and include them in this relationship as dummy variables[10]. These revisions are:

D1	1/1/2000 - 4/11/2002	Moody's upgraded Greek debt from A2 to A1
D2	4/11/2002 - 16/12/2004	Fitch downgraded Greek debt from A+ to A

[10] We do not use all downgrades since some downgrades are simply repeats of what other rating agencies have effectively done.

D3	14/1/2009 - 8/12/2009	Standard and Poor's downgraded Greek bonds from A+ to A
D4	8/12/2009 - end-period	Standard and Poor's downgraded Greek bonds from A to BBB+

Hence, we may restate the relationship as:

$$R_t^{gr} = (1+\rho_t^{\,2})R_t^{ge} + D1 + D2 + D3 + D4 + \varepsilon_t \tag{2}$$

In the ECB study, this relationship is estimated in first differences, using OLS for a rolling window of data. We would argue that the first difference specification is inappropriate for a number of reasons. (1) Differencing the above equation would produce a non-invertible moving average error process which would present estimation problems. (2) The credit rating dummies were not differenced and, hence, the ECB study confuses the relationship between the risk premium and the spread[11]. (3) In addition, with high frequency data, the changes in yields may not be very closely linked and much of the relationship may be lost if sufficient lags are not included. We also argue that the use of OLS as an estimation technique is inherently inappropriate as the underlying assumption of OLS is that the parameters of the model are constant while the risk premium is clearly meant to be time varying. OLS is not therefore a consistent estimator of a true time-varying parameter and will yield biased results.

We, therefore, propose to estimate the following model using the Kalman Filter. The measurement equation is:

$$R_t^{gr} = \beta_t R_t^{ge} + \alpha_1 D1 + \alpha_2 D2 + \alpha_3 D3 + \alpha_4 D4 + \varepsilon_t \tag{3}$$

and the state equation is:

$$\beta_t = \beta_{t-1} + \varpi_t \qquad \omega \sim N(0, e^{\gamma}) \tag{4}$$

We estimate this model by maximum likelihood using daily data on 10-year benchmark yields for both Greek and German government bonds[12]. The results are

[11] The ECB (2011) first difference the interest-rate data, but keep the dummies in levels. Effectively, this procedure leads to the result that a permanent change in ratings leads to a permanently growing spread.
[12] See the Appendix for detailed data sources.

presented in Table 1. The two initial changes in rating are not particularly significant while the latter are important in terms of generating a sizable risk premium. The variance of the state equation is also quite large indicating an important degree of time variation in the total risk premium.

The unexplained risk premium is given by the state variable β_t. This is shown in Figure 6, where values above unity show the excess risk premium. The unexplained risk premium began to rise in late 2008 in advance of the first downgrade of Greek government bonds in early 2009. When this occurred, the unexplained risk premium fell back to normal levels. However, after this, and despite further downgrading in late 2009, the unexplained risk premium continued to rise through 2010, indicating that the spread on Greek bonds became considerably larger than can be explained by the downgrading alone. There are, of course, a range of other factors which may have been influencing the markets that are not captured by the credit rating schemes alone, although the credit ratings aim at capturing the effects of a country's main fundamental variables. Clearly, in the case of Greece, the credit ratings did not capture all of the factors that impacted on spreads. In what follows, we investigate a more structural approach to the risk premium to see if this can offer a better explanation of the unexplained premium.

4. The determinants of spreads: an overview

Much of the earlier work on the determinants of sovereign spreads relates to emerging market economies and covers external debt traded during the 1990s (Min, 1998; Ferrucci, 2003; Grandes, 2007; Baldacci et al., 2008; Alexopoulou et al., 2010). The spread, in line with the idea that it reflects the risk premium required to induce agents to lend to the borrower, is typically modelled as a function of the probability of default and the loss given default. These, in turn, are related to a set of fundamentals that can be grouped into four broad categories: liquidity/solvency risks, macroeconomic fundamentals, external shocks, and market risks. In general, the literature finds support for each of these potential determinants of spreads.

In the literature, solvency risks are usually related (positively) to the overall level of debt (relative to GDP) or the government deficit-to-GDP ratio and the current-account imbalance relative to GDP (which determines the stock of external – usually foreign currency – debt). Liquidity risks relate to the ability of the sovereign to access the foreign currency required to service the debt accumulated; as such these risks are negatively related to export growth and the ratio of international reserves to GDP, and positively related to the debt service ratio (debt servicing/exports).

Macroeconomic fundamentals examined in the literature include inflation, competitiveness (as measured by the real effective exchange rate), the terms of trade, and growth. Spreads are expected to be positively related to inflation, which provides an indication of macroeconomic stability. Competitiveness and the terms of trade affect the build-up of debt and the ability of the country to generate the foreign exchange required to repay. (They are expected to be negatively related to spreads.) Finally, countries that are growing at relatively-fast rates usually find it easier to service a given level of debt.

For emerging market economics, oil prices (or, more generally, commodity prices) and international interest rates tend to be the most important sources of external shocks. The latter are usually proxied by a US dollar-denominated interest rate since the predominance of emerging market external debt is denominated in dollars.

Finally, the level of spreads is sometimes related to market conditions. In this connection, Ferruci (2003) tests whether spreads are positively related to market risk (the risk that secondary market prices might move against the bond holder) and liquidity risks (the risk that bond holders cannot liquidate their holdings without reducing secondary market prices). Ferucci proxies the former with the S&P 500 equity index and the latter with the spread between yields on debt between high and low-rated US companies. Baek et al. (2005) construct a risk appetite index for developed and emerging markets based on the rank correlation coefficient between market returns and volatility. A positive correlation coefficient indicates risk-seeking behaviour whereas a negative one suggests risk-avoiding behaviour. Greater risk appetite is expected to be negatively related to the overall level of spreads. An alternative measure of global risk aversion, used by Grandes (2007), is an index of US corporate bonds rated BB (junk bonds).

An additional factor that is considered to influence spreads in emerging markets is political risk (Baldacci et al., 2008). The potential significance of this variable stems from the seminal work of Eaton and Gersovitz (1981), who draw attention to the importance of willingness-to-pay, and not just ability-to-pay, as a determinant of the probability of default. Baldacci et al. (2008) measure political risk by taking the first principal component of the World Bank's governance index and the Heritage Foundation's economic freedom index. An alternative measure (which also allows sub-indices to be calculated) used by Baldacci et al. (2008) incorporates information from the International Country Risk Guide database. Both measures are found to be significant and positive determinants of spreads (that is, an increase in political risk is associated with a rise in spreads).

Finally, some authors investigate the extent to which contagion is a determinant of spreads for emerging market economies. Grandes (2007), in his study of Latin American countries for the period 1993-01, includes dummies to cover potential contagion from the Mexican, Russian and Brazilian crises. All three dummies are found to be highly significant. In contrast, Min (1998) finds no evidence that the Mexican crisis shifted the level of spreads across developing countries upwards.

As noted, the above literature focuses on emerging market economies. The literature on sovereign spreads in more developed countries (including euro-area countries), in addition to considering macroeconomic fundamentals, also focuses on common trends across countries and global financial conditions more generally. Consequently, panel datasets are typically used to allow cross-country similarities and differences to be exploited in identifying the common international factor[13].

In the light of the ongoing sovereign debt crisis affecting euro-area countries, a number of papers have focused on the determinants of spreads in euro-area countries. Dotz and Fischer (2010) seek to explain spreads by decomposing spreads to generate country-specific default probabilities. A GARCH-in-mean approach allows the authors to extract perceived default probabilities whilst controlling for macroeconomic determinants of spreads along with a measure of financial stability (the movement in the equity index

[13] See, for example, Favero et al., 1997; Codogno et al. 2003; Geyer et al., 2004; Gerlach et al., 2010.

of country x relative to an overall equity index for the euro area) and distress (corporate bond spreads). The sample of daily data runs from February 2002 to end-April 2009. They find strong evidence of a break in March 2008 with the rescue of Bear Stearns. Pre-rescue, the measure of financial distress – corporate bond spreads – is negatively related to sovereign spreads as corporate and sovereign bonds are perceived as substitutes; post-rescue, the coefficient turns positive. At the same time, during the pre-rescue period a real appreciation has a negative impact on spreads as real appreciation is interpreted as evidence of growth and real convergence; post-rescue, the impact is strongly positive.

Fontana and Scheicher (2010) use weekly data on CDS spreads and benchmark bond spreads from January 2006 - June 2010. Their main aim is to examine arbitrage between CDS spreads and bond spreads. However, the authors also examine the determinants of spreads, using various financial market measures as explanatory variables. These measures include the implied volatility of the S&P500 equity index, corporate CDS premia (as a measure of credit market risk), idiosyncratic equity volatility (capturing country-specific factors) and outstanding bonds/GDP. They conclude that credit market factors (corporate bond spreads) are important in explaining sovereign spreads; indeed, they are found to be more important than either the equity market variables or debt. From September 2008, the authors find that country-specific factors are also priced into bonds markets. Gerlach et al. (2010), using euro area country spreads between 2000 and 2009, find strong support for the hypothesis that spreads are driven many by international risk considerations. However, beyond international risk, countries with large banking sectors are found to be more sensitive to changes in aggregate risk. Thus, spreads in such conditions widened more than would be expected following the increase in risk associated with the global financial crisis. The authors also find evidence that spreads vary with country-specific factors, such as government debt and fiscal balances. Georgoutsos and Migiakis (2010) examine the extent to which monetary unification has led to complete financial integration between euro area bond markets by focusing on the determinants of bond spreads, including corporate bond spreads, the slope of the yield curve (containing information on inflation and growth), inflation differentials, equity returns and the difference between the interbank rate and the central bank refinancing rate. The authors use a Markov switching methodology, which allows

for endogenous switching between regimes of low and high volatility. The results suggest that the determinants of spreads vary across regimes and countries, suggesting that financial integration is still incomplete.

5. Data and methodology

In contrast to much of the existing literature, which largely focuses on panels, the purpose of this paper is to focus on the determinants of spreads in one particular country, Greece, using time series cointegration techniques. The data sample is monthly and runs from January 2000 to September 2010. Our aim is to identify the fundamental macroeconomic determinants of government bond spreads. In particular, we seek to identify the fundamental long-run determinants of spreads for the 10-year benchmark Greek bond relative to the German 10-year bond. We then use these determinants to assess whether there is any evidence of market overshooting or undershooting. Thus, we purposely avoid using financial market data to explain movements in spreads. Measures of risk or risk appetite based on financial market data may help in tracking actual spreads, since financial market conditions across countries tend to be highly correlated, but they do not explain the fundamental determinants of spreads at the national level. Thus, our aim is to identify the extent to which the evolution of Greek spreads reflects Greece's economic fundamentals.

We focus on the macroeconomic variables that were found to be significant determinants of spreads in much of the literature and which emerge from the narrative part of this paper. The variables used are as follows.

First, we include a measure of the fiscal situation. Potential explanatory variables are the ratio of government debt-to-GDP and the deficit-to-GDP ratio. Since Greece's entry to the euro area in 2001, Greek fiscal data have been subjected to a number of revisions, sometimes several years after the initial (real-time) release of the data. These revisions have often involved upward revisions of the fiscal imbalances, generating negative surprises. In order to capture the news (or surprise) element that has figured strongly in the Greek experience, we also construct some real time fiscal data. To the best of our knowledge, this is the first time such a variable has been constructed and its impact

on spreads investigated. In particular, using the European Commission Spring and Autumn forecasts[14], we create a series of forecast revisions. For example, the revision in the Spring 2001 forecasts is the 2001 deficit/GDP ratio in the Spring compared to the forecast for 2001 made in the Autumn of 2000. This procedure allows us to generate a series of revisions (see Figure 7), which, when cumulated over time, provides a cumulative fiscal news variable (see Figure 8). Clearly, the variable underestimates the extent of fiscal news which actually emerged during the period. For example, when the newly elected government revised the fiscal data in Autumn 2004, upward revisions of the deficit occurred not only for 2004 (captured in our variable), but also for the years 2000-2003. Another example is given by the revisions to the deficit in 2009. In the Autumn 2009 forecasts, the deficit for 2009 was revised upwards to 12.7 per cent of GDP from the 5.7 per cent forecast in the Spring. This revision, however, does not account for subsequent revisions to the 2009 deficit which occurred in 2010 and brought the figure to 15.4 per cent. To help account for these subsequent revisions, we also include a series of the latest estimate of the fiscal deficit (as a percentage) of GDP in our empirical work.

Second, we seek to capture the decline in competitiveness experienced by the Greek economy since entering monetary union. With the exchange rate fixed, the Greek price level relative to that of Germany provides a measure of real appreciation. We also examine the impact of the trade and current accounts (as percentages of GDP).

Third, economic activity has been found to be an important determinant of the ability of a country to meet its obligations. Given that GDP data are available only on a quarterly basis, we use the rate of change of a monthly coincident indicator of economic activity constructed by the Bank of Greece to provide a measure of growth (Hall and Zonzilos, 2003).

Finally, we assess the effects of several external factors, in particular, the price of oil. The Greek economy is the most oil-dependent economy in the euro area, and macroeconomic aggregates are sensitive to changes in the price of oil. Unlike much of the literature, we do not test for the significance of foreign interest rates given that almost 99 per cent of Greek government debt is denominated in its domestic currency, the euro.

[14] The European Commission publishes forecasts only twice a year.

We initially estimate a co-integrated VAR treating all variables, except for oil prices, as endogenous. This procedure generates a long-run relationship between spreads and the variables discussed above. Along the lines of Ferucci (2003), we use the long-run relationship to generate a series of spreads predicted by the macroeconomic fundamentals. A comparison of predicted with actual spreads allows us to comment on the degree to which the actual spread appears to overshoot and/or undershoot both in the pre-crisis and crisis periods.

The primary objective here is to identify the structural relationship which determines the long-run behaviour of the Greek spread. We therefore need to consider the issue of the formal identification of a cointegrated VAR. The identification problem for non-stationary models can be stated using the structural and reduced form vector equilibrium correction model VEqCM[15], which are as follows.

$$A_0 \Delta \mathbf{z_t} = \sum_{j=1}^{p-1} A_j \Delta \mathbf{z_{t-j}} + \alpha^s \beta^{s\prime} \mathbf{z_{t-1}} + \delta + \varepsilon_t \tag{5}$$

$$\Delta \mathbf{z_t} = \sum_{j=1}^{p-1} \Gamma_j \Delta \mathbf{z_{t-j}} + A_0^{-1} \alpha \beta' \mathbf{z_{t-1}} + A_0^{-1} \delta + A_0^{-1} \varepsilon_t \tag{6}$$

Here z is a vector of N variables (as described above), A and Γ are matrices of suitably dimensioned parameters where $\Gamma_j = A_0^{-1} A_j$, δ is a vector of deterministic components, α^s, β^s are the structural loading weights and cointegrating vectors respectively and have the dimensions $N \times r$ to reflect the reduced rank nature of the system. The term ε_t is a vector of white noise error terms. Using (5) and (6) we can state the identification problem as simply one of being able to uniquely determine the parameters in the structural model (5) from the estimated reduced form model (6). In this sense the problem is formally identical to the Cowles-Commission identification problem. However, the identification problem for the model (5) and (6) is different in a fundamental way to the Cowles-Commission (or standard) identification problem. This is because it now consists of two distinct parts. The first part is the problem of uniquely

[15] See Davidson and Hall (1991), Canova (1995) and Pesaran and Smith (1998).

determining A_0 in (1). Since $\beta' z$ are a set of stationary variables (as they are the cointegrating combinations of the non-stationary variables), in this sense every term in equation (6) is stationary and this leads to the standard identification problem, which is that of uniquely determining A_0. This problem gives rise to the standard rank and order conditions. However, even if this first identification problem is dealt with, this still leaves a second part of the problem unresolved. This second problem arises because even if A_0 is known, we cannot uniquely determine the structural cointegrating vectors from the reduced form estimates.

The problem of identifying the structural cointegrating vectors is well known. Thus it is easily seen that α and β are not identified in general since $\alpha\beta' = \alpha^{+}\beta^{+'} = \alpha\mathbf{P}\mathbf{P}^{-1}\beta'$ for any non-singular (r x r) matrix **P** (rotation). Hence in the reduced rank case the long-run part of the model is not identified. This is true even if A_0 is known, and it is this that leads to the second part of the identification problem. To resolve it, it is necessary to determine r, and identify β with a completely separate procedure. To determine the cointegrating rank, r, we can use standard tests. The next step is more difficult. To achieve full identification of the entire model, both the contemporaneous coefficients $\mathbf{A}_0$ *and* the long-run coefficients β need to be identified. These are logically separate issues, as there are no mathematical links between restrictions on $\mathbf{A}_0$ and those on β. It follows that restrictions are required to identify β *even if* $\mathbf{A}_0$ were known. Conversely, restrictions on β have no mathematical implication for the restrictions on $\mathbf{A}_0$.[16]

The derivation of formal identification criteria of the long-run in a VEqCM is the main subject of Johansen and Juselius (1990) and Pesaran and Shin (2002), where it is demonstrated that a necessary order condition for exact identification is that there are $k = r^2$ restrictions on the β vectors. Johansen (1995a) and Pesaran and Shin (2002) also give a necessary and sufficient rank condition for exact identification, which, for

[16] It remains possible though that the economic interpretation of a restricted set of cointegrating vectors $\beta'\mathbf{z}_t$ may have implications for the nature of restrictions on $\mathbf{A}_0$ that will be economically interesting, particularly when $\mathbf{A}^*$ is restricted via α. Mathematical, and possibly economic, linkages then do exist between restrictions on the adjustment coefficients α and those required to identify β - see Doornik and Hendry (1997).

example, rules out dependence amongst the r^2 restrictions. In general, if the number of available restrictions $k < r^2$ the β system is under-identified, if $k = r^2$ the β system is exactly identified, and when $k > r^2$ the β system is over-identified and, subject to the rank condition being satisfied, the over-identifying restrictions are testable.

The methodology employed in what follows is to begin by assessing the cointegrating rank of our VAR system and then to proceed to identify the structural relationship that determines the Greek spread. We will then present the impulse responses of the VEqCM for completeness, but our main focus will be on the long-run cointegrating vector which determines the spread, as this will allow us to identify the departures from the equilibrium spread.

6. Results

We begin by estimating a standard VAR of order 3 based on the Schwartz/Akaike information criterion, with the objective to minimise the VAR length subject to passing a selection of LM tests for serial correlation. The results of the chosen VAR are presented in Table 2. As usual, the VAR coefficients have very little economic interest as the individual coefficients are not interpretable. All that is important at this stage is that the VAR residuals are generally well-behaved; in this case, the VAR residuals pass a range of LM tests for serial correlation and seem well behaved. Table 3 presents the results for the standard Trace and Maximum Eigenvalue tests for cointegration. Both tests reject the hypothesis of no cointegration, implying there is at least one cointegrating vector. The hypothesis that there is only one vector cannot be rejected at conventional levels of statistical significance. This implies that we have one cointegrating vector. In line with the existing literature, the results provide support for the significance of relative prices, economic activity and oil prices. In addition, our measure of fiscal news is also important in explaining movements in Greek spreads. Other variables – the final (latest) estimates of the fiscal-deficit-to-GDP ratio, the debt-to-GDP ratio, and measures of the trade or current accounts of the balance of payments – were found to be insignificant because their effects were captured by other (significant) variables. Thus, movements in relative

prices best capture the effect of changes in external competitiveness on spreads, whereas real-time news about the fiscal aggregates, as measured by revisions to the Commission's forecasts, best captures the government's fiscal situation.

We then construct a cointegrated VAR, imposing the restriction of one cointegrating vector and given that r=1 we need only one restriction to identify the relationship as a structural one determining the spread (this is to normalise the coefficient on the spread to be -1). The loading weight (the α^s) from the equation for the Greek spread is correctly signed and the cointegrated VAR is stable. In Figure 9, we present the impulse responses of the Greek spread using the standard Cholesky decomposition for the shocks[17] to the other endogenous variables. With the exception of the response of the spread to cumulative fiscal news, the other impulse responses are as expected. Initially, the spread reacts incorrectly to an innovation to fiscal news – that is, good news initially causes the spread to rise, but after some months it falls to negative values, as expected.

In order to assess deviations of spreads from their long-run equilibrium values, we proceed to estimate a simple OLS model of the cointegrating vector. Moving to a simple OLS estimation is consistent with the existence of only one cointegrating vector in the model. The results are presented in Table 4. As is clear from that table, explanatory variables enter the long-run equilibrium regression with the correct sign. The results suggest that an increase in economic activity or cumulative good fiscal news reduce the spread; by contrast, a rise in Greek prices relative to German or a rise in oil prices cause the spread to increase.

The relative economic importance of the variables can be derived by calculating the impact on spreads of a one standard deviation increase in each of the explanatory variables (based on the rationale that a one standard deviation change is actually observed in the data itself). The largest effect comes from relative prices: a one standard deviation increase in Greek prices relative to German prices causes spreads to rise by 225 basis points. This result highlights the importance of the deterioration in competitiveness for the terms on which the government can borrow. By contrast, economic activity has an

[17] Note that since oil prices are assumed to be exogenous, they do not appear in the impulse response functions.

important beneficial effect. A one standard deviation increase in economic activity causes spreads to fall by 138 basis points. The impact of cumulative fiscal news is smaller, but nonetheless significant – a one standard deviation increase in our cumulative fiscal news variable (defined as good news) causes spreads to fall by 54 basis points. It should be recalled, however, that although our fiscal variable aims to capture the effect of fiscal surprises, by construction, it likely understates the magnitude of those surprises. Finally, the effect of oil prices is, not surprisingly, relatively small, with a one standard deviation increase in the price of oil causing spreads to rise by only 17 basis points.

Figure 10 graphs the actual spread along with that predicted by the long-run equilibrium equation in Table 4, allowing us to identify periods of undershooting and overshooting of actual spreads. We define undershooting and overshooting as cases where the difference between actual and predicted spreads lie outside the standard error bands around the residuals plotted in Figure 10.

The first period in which the actual spread deviates significantly from the predicted spread runs from the end of 2004 until the beginning of 2005. This period corresponds to the time (in late 2004) that a newly-elected Greek government revised the fiscal deficits, leading to real larger deficits for the period 2000-2004. It appears, however, that spreads did not respond to these revisions – spreads were significantly lower than predicted. During that period, spreads were in a range of 10 to 25 basis points; on average, they were some 120 basis points below what is predicted by our model.

The second period during which actual spreads significantly deviated from those predicted by the model occurs at the end of our data sample. From mid-2009, predicted spreads rose sharply, mainly in response to the succession of fiscal surprises; from late 2009 through the first quarter of 2010, predicted spreads exceeded actual spreads by significant amounts (usually by over 100 basis points). Subsequently, actual spreads rose sharply and, beginning in May 2010, actual spreads exceeded predicted spreads; the difference became significant in June and remained significant through the end of our sample period (in September 2010). For example, whereas predicted spreads were just over 500 basis points in September 2010, the actual spread, at around 900 basis points, was about 400 basis points higher. Thus, our results suggest that there have been episodes

of both significant undershooting and significant overshooting during the period since Greece joined the euro area.

7. Conclusions

Entry into the euro area provided Greece with the opportunity to benefit from the credibility of the monetary policy of the European Central Bank and the resulting environment of relatively-low inflation rates and low nominal interest rates. In turn, the low interest rates reduced the cost of servicing the public-sector debt, facilitating fiscal adjustment and freeing resources for other uses. Instead of taking advantage of this environment to adjust the economy, during the period 2001-2009 successive Greek governments ran fiscal deficits that averaged over 6 per cent of GDP and they increased the share of government spending in the economy.

In this paper, we first presented evidence on that part of the risk premium unexplained by the credit rating of the Greek sovereign. After rising in late 2008, it returned to normal levels following a downgrade in early 2009. However, thereafter, despite further downgrades, the unexplained risk premium continued to rise.

To understand these results further, we moved on to model spreads as a function of economic fundamentals. The results suggest that, to some extent, the markets may have helped lull the Greek governments into believing that the low interest-rate environment would be a permanent feature of the Greek economy. Our findings strongly support the view that the low-levels of interest-rate spreads reached in the mid-2000s were not justified by the economic fundamentals. In turn, after the crisis erupted in 2009, interest-rate spreads appear to have strongly overshot in an upward direction. The markets' verdict of Greece's fiscal and external imbalances may have come late in the day, but when it came, it came with a vengeance.

Appendix: Data sources

Spread: 10-year benchmark German government bond minus 10-year benchmark Greek government bond - ECB Statistical Data Warehouse – monthly average.

Fiscal data: from Commission forecasts published in *European Economy* and Government Fiscal Statistics published by Eurostat. The forecasts are semi-annual; the actual data, quarterly. All series are interpolated.

Trade and current account data: taken both from Bank of Greece and EL.STAT. Quarterly series were interpolated.

Relative prices: log difference of the monthly seasonally-adjusted harmonised index of consumer prices (HICP) between Greece and Germany – Thomson-Reuters DataStream.

Economic activity: rate of change of coincident indicator of economic activity constructed by Bank of Greece (Hall and Zonzilos 2003).

Oil prices: US dollars per barrel of Brent crude oil (FOB) – Thomson-Reuters DataStream.

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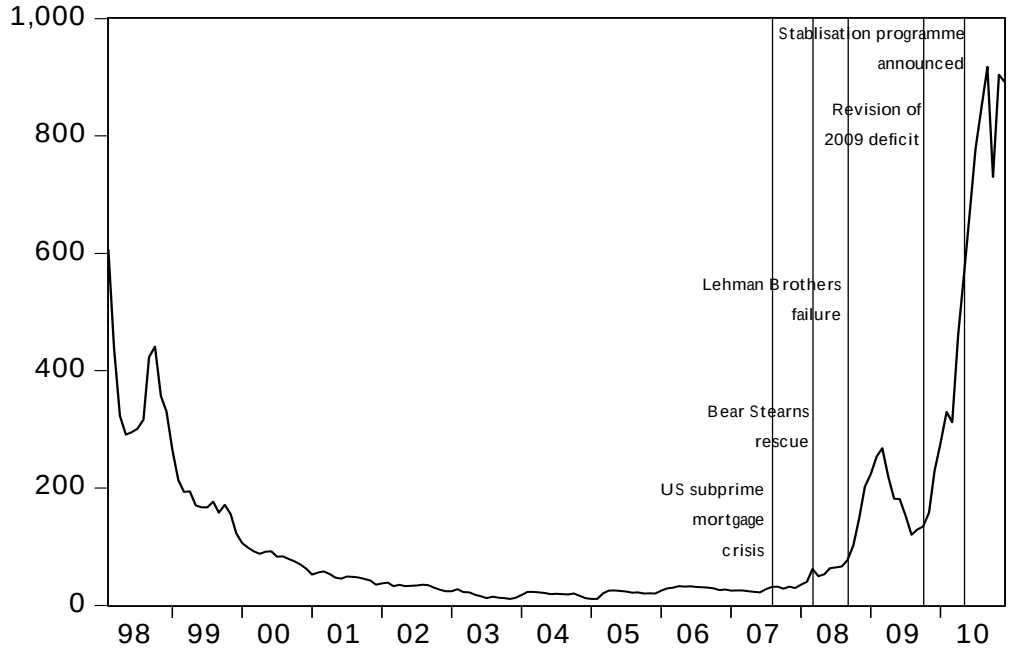
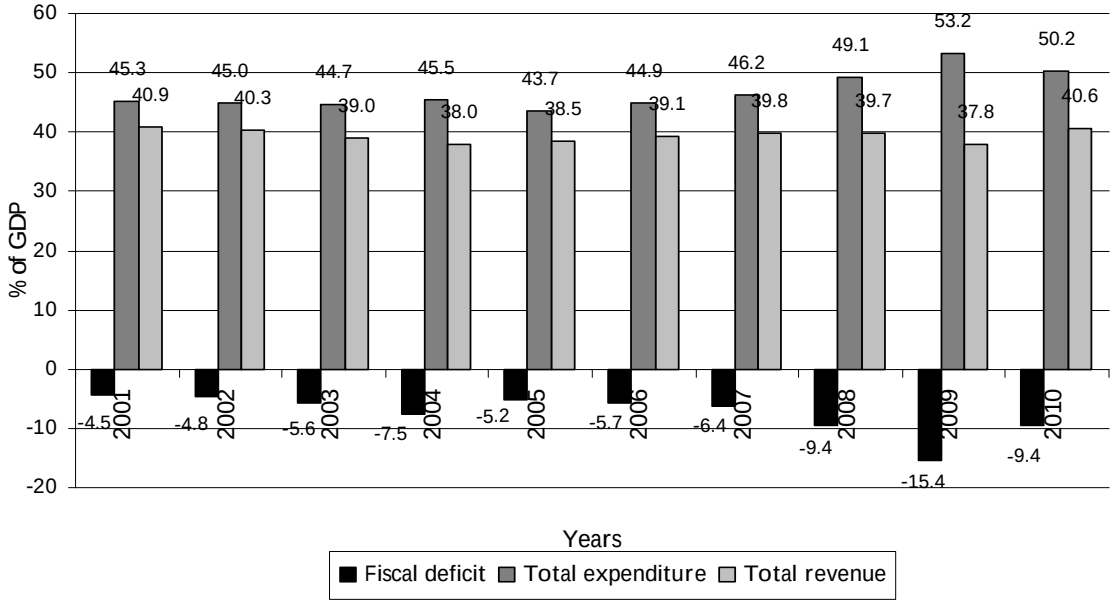
Figure 1: Greek spreads: yields on Greek over German 10-year benchmark bonds
(basis points)



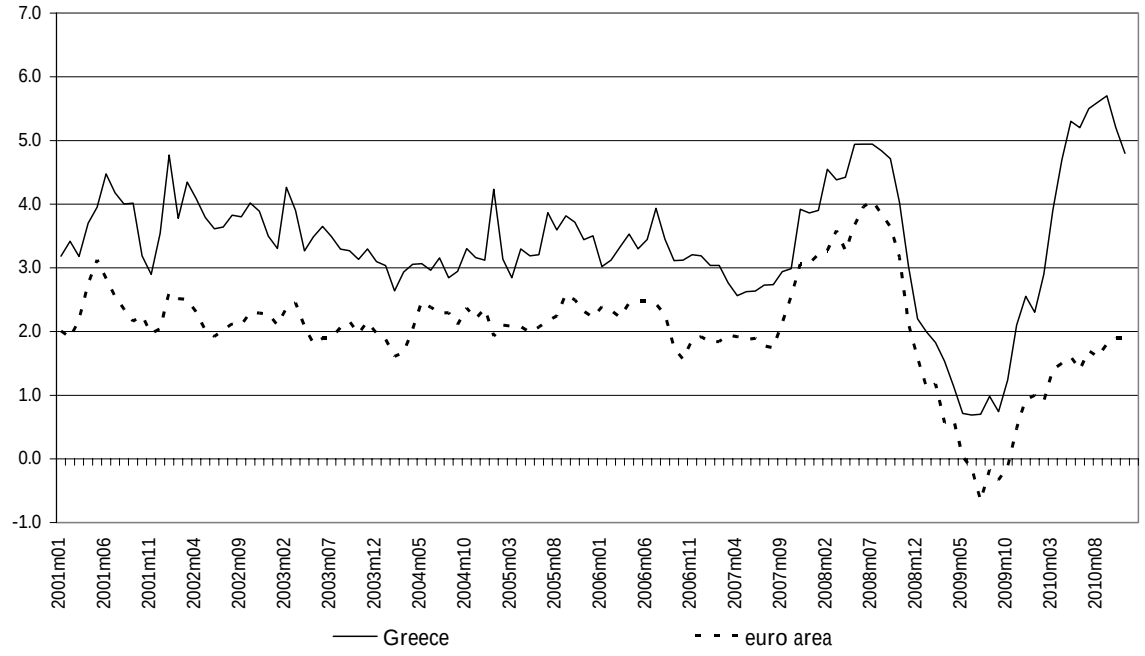
Source: ECB Statistical Data Warehouse

Figure 2: The fiscal deficit, total expenditure and total revenue
(% of GDP)



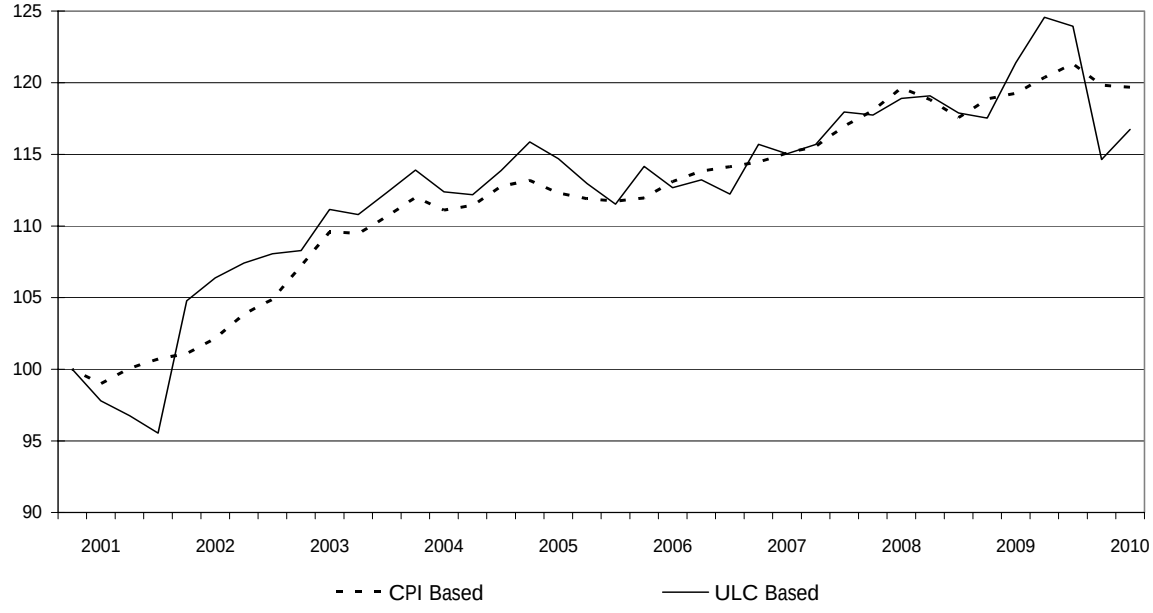
Source: European Commission, Excessive Debt Procedure Notification

Figure 3: Greece and euro area inflation 2001-2010
(based on annual percentage changes in overall Harmonised Idex of Consumer Prices)



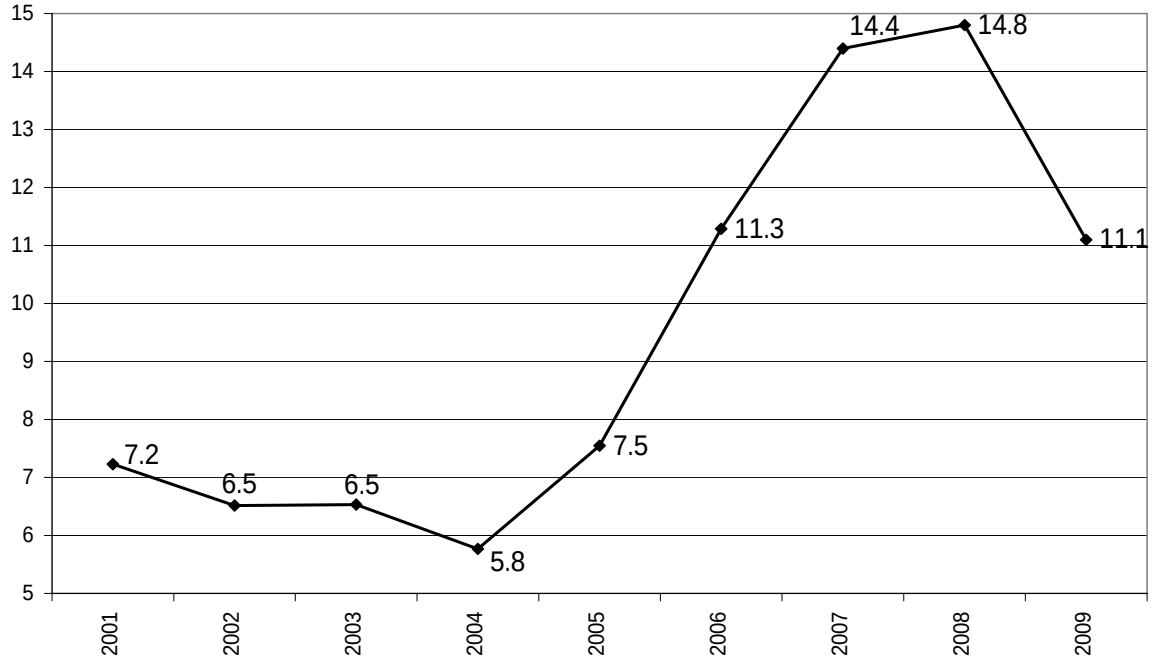
Source: EL.STAT

Figure 4: Real effective exchange rate index (2001q1=100)



Source: Bank of Greece

Figure 5: Greece: current account deficit



Source: Bank of Greece

Figure 6: Unexplained Risk Premium, β_t (SV1)

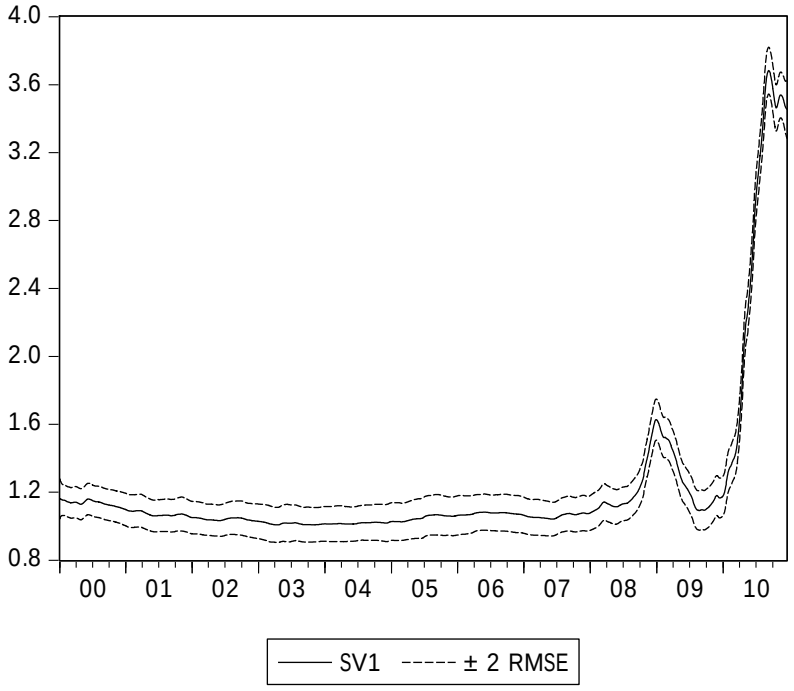
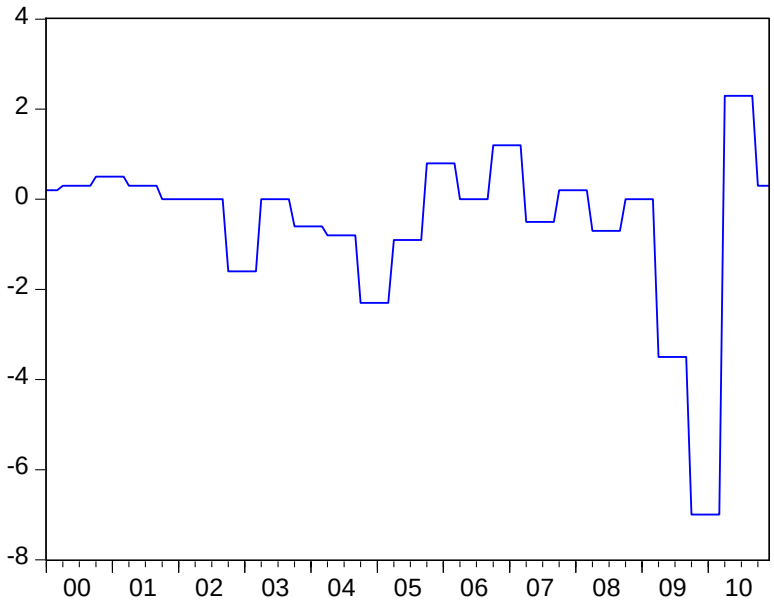
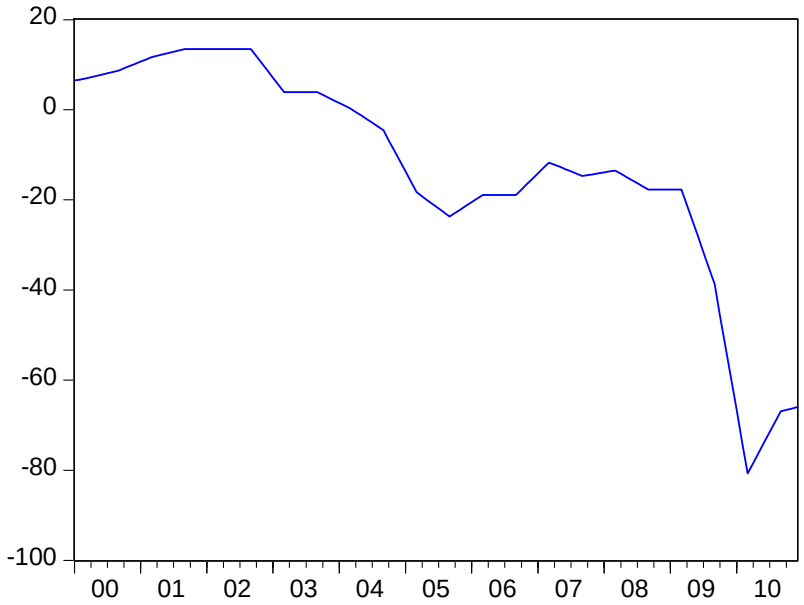


Figure 7: Greek general government balance: revisions to commission spring and autumn forecasts
(percentage points of GDP)



Source: *European Economy*, various volumes

Figure 8: Cumulative fiscal news variable



Source: own calculations (see text)

Figure 9: Impulse response functions

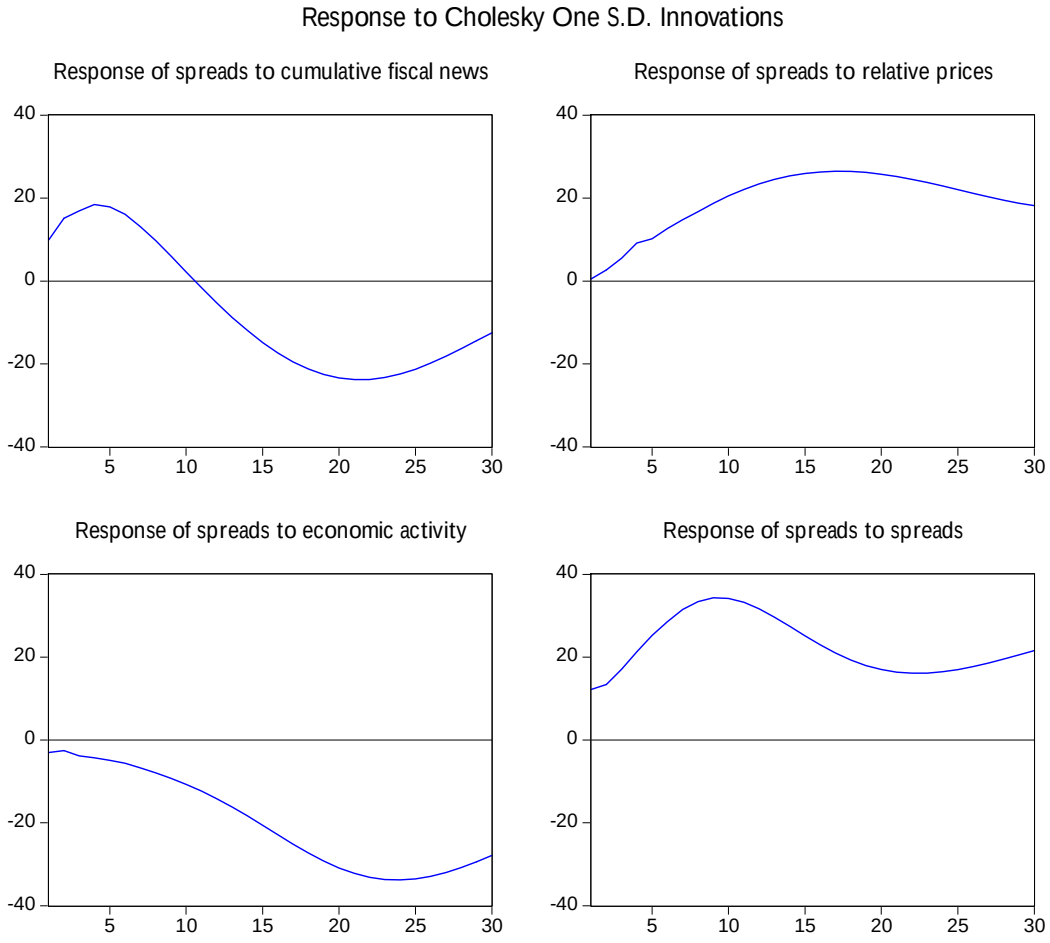


Figure 10: Actual spreads compared to long-run equilibrium spreads
(basis points)

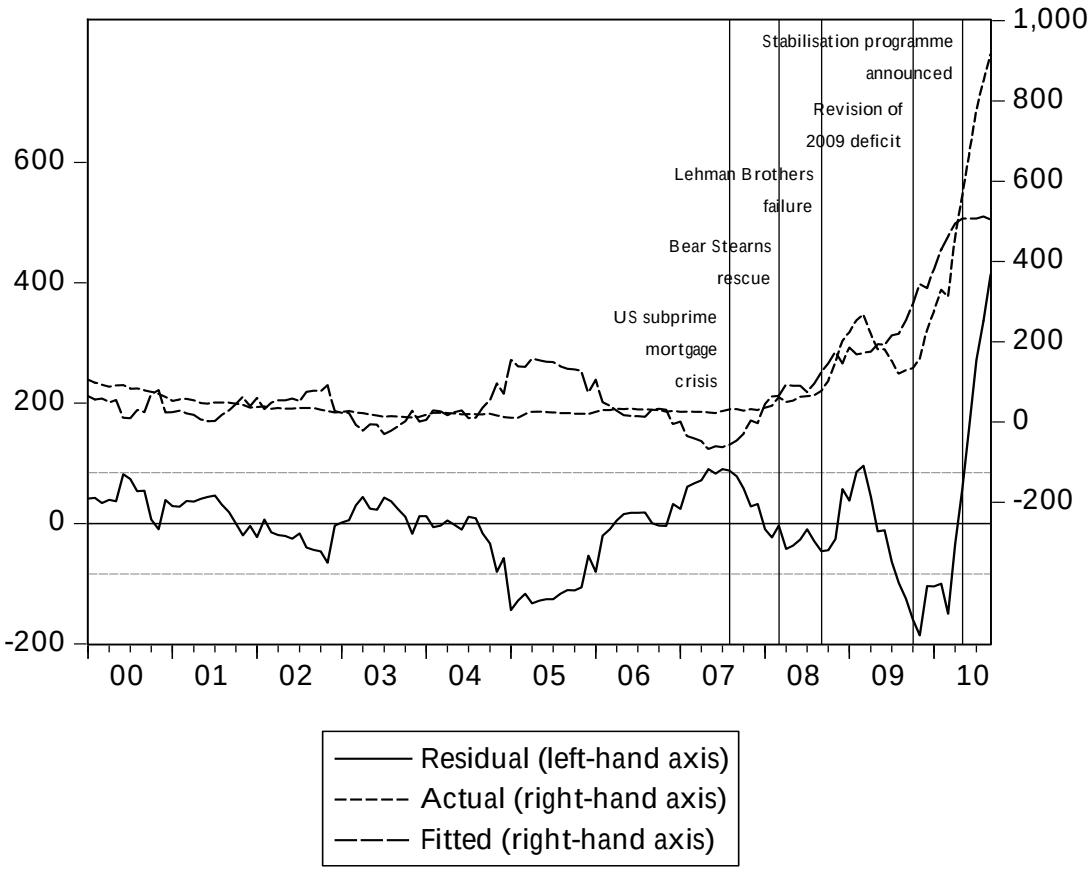


Table 1: Unexplained risk premium (estimating equations (3) and (4))

	Coefficient	Std. Error	z-Statistic	Prob.
α1	0.114225	42.61476	0.002680	0.9979
α 2	0.096184	5.617794	0.017121	0.9863
α 3	0.980321	0.892404	1.098517	0.2720
α 4	2.016643	0.653974	3.083673	0.0020
γ	-7.619053	0.180898	-42.11795	0.0000
	Final State	Root MSE	z-Statistic	Prob.
SV1	3.456468	0.089492	38.62305	0.0000
Log likelihood	-2887.520	Akaike info criterion		2.025574
Parameters	5	Schwarz criterion		2.036004
Diffuse priors	1	Hannan-Quinn criter.		2.029335

Table 2: VAR output

	Fiscal news	Relative prices	Economic Activity	Spread
Fiscal news (-1)	2.131542	0.000155	0.011867	3.396499
	(0.11306)	(0.00054)	(0.01137)	(2.19872)
	[18.8535]	[0.28634]	[1.04347]	[1.54476]
Fiscal news (-2)	-1.599330	-0.000765	-0.003501	-10.07221
	(0.21850)	(0.00105)	(0.02198)	(4.24929)
	[-7.31965]	[-0.72965]	[-0.15927]	[-2.37033]
Fiscal news (-3)	0.438646	0.000584	-0.009580	6.269450
	(0.11905)	(0.00057)	(0.01198)	(2.31534)
	[3.68441]	[1.02319]	[-0.79994]	[2.70779]
Relative prices (-1)	-1.181327	0.472012	1.223908	489.9511
	(19.4452)	(0.09329)	(1.95600)	(378.165)
	[-0.06075]	[5.05949]	[0.62572]	[1.29560]
Relative prices (-2)	24.34149	0.318379	-1.308089	127.3640
	(21.2828)	(0.10211)	(2.14085)	(413.902)
	[1.14371]	[3.11804]	[-0.61101]	[0.30772]
Relative prices (-3)	-18.58019	0.070298	3.276060	-285.0586
	(19.8023)	(0.09501)	(1.99192)	(385.109)
	[-0.93828]	[0.73993]	[1.64468]	[-0.74020]
Economic Activity (-1)	1.429588	-0.000963	1.769862	0.771444
	(0.94130)	(0.00452)	(0.09469)	(18.3061)
	[1.51874]	[-0.21334]	[18.6920]	[0.04214]
Economic Activity (-2)	-3.049898	0.005808	-0.749079	-6.573628
	(1.79107)	(0.00859)	(0.18016)	(34.8321)
	[-1.70284]	[0.67588]	[-4.15776]	[-0.18872]
Economic Activity (-3)	1.858720	-0.004653	-0.056057	5.347972
	(0.94733)	(0.00454)	(0.09529)	(18.4233)
	[1.96207]	[-1.02370]	[-0.58826]	[0.29028]
Spread (-1)	-0.029655	9.15E-06	-0.000252	1.092140
	(0.00604)	(2.9E-05)	(0.00061)	(0.11739)
	[-4.91263]	[0.31585]	[-0.41495]	[9.30318]
Spread (-2)	0.052703	2.90E-05	-0.000824	0.281340
	(0.01049)	(5.0E-05)	(0.00105)	(0.20396)
	[5.02527]	[0.57714]	[-0.78146]	[1.37939]
Spread (-3)	-0.019748	-3.85E-05	0.000720	-0.345149
	(0.00644)	(3.1E-05)	(0.00065)	(0.12531)
	[-3.06473]	[-1.24422]	[1.11021]	[-2.75430]
Constant	0.855250	-0.022153	0.853438	78.40085
	(2.90124)	(0.01392)	(0.29184)	(56.4225)
	[0.29479]	[-1.59152]	[2.92437]	[1.38953]

Table 2: continued

Oil Price (-4)	0.018570	-1.78E-05	-0.001210	0.341134
	(0.00587)	(2.8E-05)	(0.00059)	(0.11406)
	[3.16625]	[-0.63414]	[-2.05128]	[2.99077]
TIME	-0.024947	0.000183	-0.005073	-0.768225
	(0.02139)	(0.00010)	(0.00215)	(0.41599)
	[-1.16626]	[1.78506]	[-2.35794]	[-1.84673]
R-squared	0.998845	0.994490	0.999206	0.990592
Adj. R-squared	0.998703	0.993813	0.999109	0.989437
Sum sq. Resids	76.53309	0.001762	0.774392	28945.80
S.E. equation	0.819355	0.003931	0.082419	15.93457
F-statistic	7039.891	1469.682	10251.13	857.3905
Log likelihood	-149.3683	539.4425	146.9060	-532.2053
Akaike AIC	2.548346	-8.130892	-2.045054	8.483803
Schwarz SC	2.880882	-7.798355	-1.712517	8.816340
Mean dependent	-11.29302	-0.007634	2.729329	90.66958
S.D. dependent	22.74915	0.049978	2.760866	155.0391

LM Test for autocorrelation

Lags	LM-Stat	Prob
1	21.89358	0.1467
2	26.24410	0.0507
3	22.16579	0.1379
4	16.51045	0.4179

Table 3: Cointegration Tests

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.217116	55.81448	47.85613	0.0075
At most 1	0.127939	24.23897	29.79707	0.1905
At most 2	0.043489	6.579412	15.49471	0.6270
At most 3	0.006519	0.843711	3.841466	0.3583

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.217116	31.57551	27.58434	0.0145
At most 1	0.127939	17.65956	21.13162	0.1431
At most 2	0.043489	5.735701	14.26460	0.6473
At most 3	0.006519	0.843711	3.841466	0.3583

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4: The long-run equilibrium relationship

Dependent Variable:
Greek spreads

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1227.195	209.2463	5.864832	0.0000
Economic Activity	-49.58121	5.818096	-8.521897	0.0000
Relative prices	4496.757	1112.390	4.042429	0.0001
Fiscal news (cumulated)	-2.361796	0.858002	-2.752669	0.0068
TIME	-8.212937	1.586209	-5.177715	0.0000
Oil prices (-4)	0.666298	0.509717	1.307194	0.1936

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