On the time-varying relationship between EMU sovereign bond yield spreads and their determinants

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Abstract

We use a varying-coefficients time-series methodology to capture structural instability in the link between euro area sovereign bond yield spreads against Germany and their underlying determinants over the period January 1999 - August 2011. We offer new evidence suggesting that there exists significant heterogeneity across countries, both in terms of the risk factors determining spreads over time as well as in terms of the size of their impact on national spreads. As a general rule, the set of spreads' determinants in the euro area is highly unstable but generally becomes richer and stronger in significance as the crisis evolves.

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1. Introduction

The European sovereign debt crisis which started in Greece in autumn 2009 and subsequently spread across the whole of the EMU periphery has now entered its fourth year. Since the beginning of the crisis policy makers have taken significant measures both at national as well as European level to contain it. These include the implementation of ambitious national adjustment programmes, the creation of the European Financial Stability Fund (EFSF) providing financial assistance to countries whose sovereign bonds have come under intense market pressure and extensive intervention on behalf of the European Central Bank (ECB) at various phases of the crisis in the European sovereign bond markets. These measures, however, have so far achieved only partial success. Four years since its onset the European debt crisis continues to be a source of concern for the European and global economy.

Motivated by these developments, a growing empirical literature has attempted to identify the risk factors affecting EMU government bonds yield spreads against Germany, the variable often used to measure the crisis' severity and extent, using time-series and/or panel estimation approaches. The factors typically considered as spreads' determinants include international financial risk, credit risk and liquidity risk (see e.g. Manganelli and Wolswijk, 2009). The main findings emerging from existing studies can be summarised as follows: First, increased international financial risk has played a major part in the widening of spreads versus Germany, with banking risk being a major channel transforming the global financial crisis of 2007-2009 into a sovereign debt crisis in subsequent years (see e.g. Caceres et al, 2010; Gerlach et al, 2010; Schuknecht et al., 2010; Acharya et al,; 2011). Second, market pricing behaviour has shifted considerably, with fiscal and other macro-imbalances now being more heavily penalised as compared to before the crisis (see e.g. Barrios et al., 2009; Schuknecht et al., 2010; Favero and Missale, 2011; Arghyrou and Kontonikas, 2012; De

Grauwe and Ji, 2012). Third, liquidity risk has played a role, mainly in the periphery economies during the later stages of the crisis (see e.g. De Santis, 2012; Afonso et al., 2012). Finally, there exist significant cross-country contagion/spill-over effects across euro area government bond markets (see e.g. Caceres et al, 2010) as well as a significant response of spreads to changes in credit ratings (see e.g. De Santis, 2012).

The majority of the early studies on the European debt crisis capture structural instability in the relationship between spreads and their determinants by imposing on the data exogenous break points (typically defined within the period summer 2007 to autumn 2008) and estimating sub-sample regressions differentiating between a pre-crisis and a crisis period (see e.g. Barrios et al. (2009), Arghyrou and Kontonikas (2012) and Caggiano and Greco (2012)). More recent studies, have provided evidence that structural instability is not restricted to a simple pre- versus post-crisis differentiation; rather but is a more complex process. Afonso et al (2012), still working with exogenously imposed breaks, identify two rather than one breaks in the process of spreads' determination, respectively occurring in summer 2007 and spring 2009. Bernoth and Erdogan (2012), on the other hand, use a semiparametric time-varying coefficients panel data model to examine whether euro area spreads movements are linked to a shift in macroeconomic fundamentals or to increased risk pricing reflected in a stronger market reaction to shifts in the value of the various risk factors. They provide evidence in favour of time-varying slope coefficients for the panel as a whole and show that since the onset of the global financial crisis the market reaction to fiscal imbalances increased considerably. Similar findings are reached by Aßmann and Boysen-Hogrefe (2012) who use a time-varying coefficients model to capture changes in the weights of spreads' determinants in the euro area over the period 2001-2011.

By highlighting the continuous nature of structural instability characterising the process of spreads' determination the papers by Bernoth and Ergodan (2012) and Aßmann and

Boysen-Hogrefe (2012) have contributed significantly to the study of the European debt crisis. They are, however, subject to an important limitation: Their adopted panel-based econometric framework cannot uncover country-specific heterogeneity in the time-varying relationship between spreads and their underlying determinants. Beyond the innovative feature of endogenous slope time-variation these studies are in line with previous panel-based studies that assume slope homogeneity across countries and common break points in time for all the countries in the panel.[1] is quite probable, though, that the links between sovereign risk and the various risk factors are activated or deactivated at different points in time across different countries. Thus, an econometric approach that allows for this plausible scenario is likely to provide important country-specific information.

In this paper, we deal with country-specific heterogeneity in an explicit manner based on time-series regressions for ten euro area countries. In line with existing literature, we model spreads on proxies of international financial risk, credit risk and liquidity risk. We implement, however, a novel to the studying of government bond spreads dynamic version of the general-to-specific (GETS) model selection methodology (see Hendry, 2000) allowing us to capture changes in the statistical significance and size of the coefficients of spreads' determinants over time. To the best of our knowledge, with the exception of the study by D'Agostino and Ehrmann (2012), our paper is the first to provide information capturing the changing relationship between spreads and their fundamentals on a country-specific basis. D'Agostino and Ehrmann (2012), however model government bond yield spreads against the US and Germany for G7 countries. Therefore, although they provide important insights relating to the French and Italian spread versus Germany, they do not study developments in EMU periphery countries such as Greece, Portugal and Spain, whose role in the European debt crisis has been very prominent. By considering spreads of euro zone members versus

[1] In panel estimations of the determinants of euro area spreads, country-specific heterogeneity is typically allowed for only in the intercept via country fixed effects (see e.g. Attinasi et al., 2009; Manganelli and Wolswijk, 2009).

Germany, we put European developments at the heart of the analysis. Our empirical findings provide new evidence suggesting that there exists significant heterogeneity across countries, both in terms of the risk factors determining spreads over time as well as in terms of the size of their impact on national spreads. As a general rule, the set of spreads' determinants in the euro area is highly unstable but generally becomes richer and stronger in significance as the crisis evolves.

The remainder of the paper is structured as follows. Section 2 describes the dataset. Section 3 explains the econometric methodology. Section 4 presents and discusses our empirical findings. Section 5 concludes.

2. Data description

The dependent variable in our econometric analysis is the monthly 10-year government bond yield spread relative to Germany (*spr*) for ten euro area countries: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portuga and Spain.[2] Our sample covers the period January 1999 - August 2011 (monthly frequency). Following the bulk of existing literature (see e.g. Manganelli and Wolswijk, 2009). We model spreads on variables approximating the international risk factor, liquidity risk and credit risk captured by country-specific fundamentals. More specifically, the set of explanatory variables used in our analysis includes the following:

vix denotes the logarithm of the S&P 500 implied stock market volatility index (VIX). In line with previous studies (see e.g. Beber et al., 2009; Afonso et al., 2012) this variable is

[2] In empirical investigations of euro area spreads, the benchmark 'risk free' interest rate, against which spreads are calculated, is typically approximated by the German government bond yield (see also Bernoth and Erdogan, 2012).

used to measure the international risk factor.[3] We expect a higher value for the international risk factor to cause an increase in government bond spreads.

ba is the bid-ask spread of 10 year government bonds. This variable is extensively used as a proxy for bond market illiquidity (see e.g. Barrios et al., 2009; Favero et al. 2010). A higher value of *ba* indicates a fall in liquidity leading to an increase in government bond yield spreads.

bal and *debt* describe the expected (one-year ahead) government budget balance-to-GDP ratio and government debt-to-GDP ratio, respectively, both measured as differentials versus Germany.[4] The use of expected, as opposed to historical fiscal data, is in line with a number of recent studies on EMU government bond yield spreads including Attinasi et al. (2009) and Sgherri and Zoli (2009). Fiscal conditions are related to credit quality with an expected fiscal deterioration implying higher credit risk. Hence, a higher (lower) value for the expected government budget balance is expected to reduce (reduce) spreads. By contrast, a higher (lower) lever of expected government debt is positively (negatively) associated with spreads values.

gind is the annual growth rate of industrial production, measured as differential versus Germany. This variable is used as a proxy for the state of business cycle and captures the effect of economic growth on spreads according to which sovereign debt becomes riskier during periods of economic slowdown (see Alesina et al., 1992 and Bernoth et al., 2004). Hence an increase (reduction) in *gind* should reduce (increase) spreads by improving (worsening) credit worthiness.

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[3] The VIX is constructed using call- and put-implied volatilities from the S&P 500 index 30-day options. Implied volatility measures are forward-looking, as opposed to historical volatility measures that are backward-looking. The VIX is often called the 'investor fear gauge' since it tends to spike during financial market turmoil periods (Whaley, 2000).

[4] The expected fiscal position data is published bi-annually at the European Commission's Economic Forecasts Database. This semi-annual dataset is transformed into monthly frequency by keeping the expected debt and budget balance observations constant (equal to the last forecast) for the months between a projection announcement and its subsequent revisions, when new information becomes available. This is consistent with the idea that before a new projection arrives, investors can only use the latest available projection to form their expectations.

Finally, q is the log of the real effective exchange rate. An increase (reduction) in q denotes real exchange rate appreciation (depreciation) expected to increase (reduce) spreads as theoretically justified in the analysis of Arghyrou and Tsoukalas (2011) and empirically found by Arghyrou and Kontonikas (2012)

[Figures 1, 2]

Figure 1 presents the movements of the 10-year euro area government bond yield spreads over our sample period. Before the financial crisis erupted in late 2007 spreads against Germany had stabilised at very low levels despite the fact that macroeconomic fundamentals were deteriorating in many euro area countries, especially in the periphery (see Arghyrou and Kontonikas, 2012). During the credit crisis of 2007-2009 spreads versus Germany increased in all euro area economies with German government bonds operating as a 'flight-to-quality' asset. The 'flight-to-quality' characteristic of German bonds is captured in Figure 2, which shows the 10-year German yield against *vix*, our indicator of international financial risk. At the climax of the credit crisis, in the aftermath of the Lehman Brothers bankruptcy in autumn 2008, the VIX increased sharply and at the same time the 10-year German government bond yield plummeted as investors made significant purchases of German bonds.

[Figures 3, 4]

Figure 3 plots the expected government debt-to-GDP ratio. This shows a sharp increase in early 2009 as the global credit crisis started to transform into the European sovereign debt crisis. Fiscal deterioration was accompanied by loss of market confidence for the periphery bond markets, credit rating downgrades and liquidity withdrawals, as indicated by the rising periphery bid-ask spreads in Figure 4.

3. Empirical framework

We capture time variation in the link between spreads and their underlying determinants through a dynamic GETS modelling procedure developed and advocated over time by D. Hendry and his co-authors (see e.g. Hendry, 2000). The GETS methodology is a multipath model selection algorithm similar in spirit to *Autometrics* (see Doornik, 2009), a model selection algorithm embedded in PcGive/OxMetrics (see Hendy and Doornik, 2007).[5] The starting point of the searching process is the definition of a general unrestricted model (GUM). This should be formulated on the basis of theory, encompass competing models and provide sufficient information on the process that is being modelled (see Hendry and Krolzig, 2005; Doornik, 2009). The search algorithm proceeds by reducing the GUM towards one or more terminal models, considering in principle the whole model space. Terminal models are located when all variables in a particular search node are statistically significant.

[Figure 5]

In order to demonstrate how the multipath model selection works, consider for example that the GUM includes four explanatory variables (A, B, C and D) as shown in Figure 5. If all four variables are statistically significant at the 1% level the GUM coincides with the terminal model and the search stops. If, on the other hand, the GUM includes statistically insignificant variables, these are deleted one at a time based on their individual significance. If, for example, only variable A is insignificant, the GUM is reduced to BCD, which becomes the terminal model. If all variables in the GUM are statistically insignificant, the algorithm removes each of them, one at a time, considering four three-variable models BCD, ACD, ABD and ABC. The reduction process is repeated at each of these four nodes. For instance, if all three variables are insignificant at node BCD, the algorithm will move to consider three two-variable models, namely CD, BD, and BC. If any of these two-variable

[5] Autometrics is the second generation model selection algorithm in OxMetrics following PcGets (Hendry and Krolzig, 2001).

models includes two statistically significant variables the search stops and a terminal model is reach. If, on the other hand, at all two-variable nodes both variables are statistically insignificant the algorithm will proceed to one-variable models (two models at each node). The algorithm can consider a maximum of 2^4 potential unique models represented by the solid dots in Figure 5.[6] Note that it is possible that the search algorithm will yield more than one terminal models. If an explanatory variable appears in more than one terminal model its impact on the dependent variable is calculated by averaging the slope coefficients of that variable across all terminal models.

In our setup, the GUM is given by the following equation:

$$spr_t = \alpha + \phi spr_{t-1} + \mathbf{X}_t \boldsymbol{\beta} + \varepsilon_t \qquad (1)$$

where $\mathbf{X}_t = \left[vix_t \quad ba_t \quad bal_t \quad debt_t \quad gind_t \quad q_t \right]$ denotes the matrix of bond market related fundamentals, as defined in Section 3, and $\boldsymbol{\beta}$ is the coefficient vector.[7] The algorithm is applied dynamically using a 60-month rolling window always starting from the GUM shown in Equation (1). In the absence of structural instability in the relationship between spreads and fundamentals, the algorithm should reach the same terminal model(s) across all different sub-samples. In that case, the set of explanatory variables that the algorithm will identify as statistically significant and the size of their coefficients would not change over time. On the other hand, in the presence of shifts in risk pricing the links between sovereign risk and the underlying risk factors may be activated or deactivated at different points in time across different countries. This would give rise to different terminal models across different rolling estimation windows characterised by different statistically significant explanatory variables and/or different estimated coefficients across estimation windows.

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[6] There are 15 unique models with at least one variable and one empty model omitted from Figure 5. Hollow dots reflect duplicated models and can be ignored.

[7] Due to the persistent nature of spreads, studies of their determinants typically include lagged spreads in the set of regressors (see e.g. Attinasi et al., 2009; Gerlach et al., 2010). The algorithm allows fixing variables in the models irrespectively of their statistical significance. In our estimations, a constant and the first lag of the spread are always included in the models.

There are three additional key ingredients in our GETS methodology. First, as suggested by Hendry and Krolzig (2005), we impose theory-consistent sign restrictions on the model space: If a variable is statistically significant but exhibits the 'wrong' sign, then it is deleted. Effectively, the sign restrictions impose priors on the model space to ensure that the terminal model conforms to economic theory, at least in terms of coefficient signs. This aims to safeguard against reaching terminal models that reflect data artefacts as opposed to fundamental economic relationships.[8] In line with the discussion in Section 3, the theoretically appropriate signs for the explanatory variables' coefficients are as follows: *vix* (+), *ba* (+), *bal* (-), *debt* (+), *gind* (-), and *q* (+).

Second, as suggested by Hendry and Santos (2005), the algorithm automatically detects and corrects for any outlying observations (defined by estimated residuals exceeding 3.5 standard deviations) via impulse dummy variables. Outliers may reflect the impact of events which are not captured by our explanatory variables, such as bailout news, or news about country-specific political developments.

Finally, since spreads and the various fundamentals exhibit high persistence, asymptotic inference will tend to over-reject the null hypothesis of no-relationship between them (see e.g. Granger et al., 2001). Therefore we used Monte Carlo simulations to calculate 1% critical values for *t*-tests that account for the observed persistence in the series.[9]

[8] The sign deletion criterion is considered before the individual variable significance criterion, which is ignored if one or more variables are removed as a result of the sign deletion strategy.

[9] We generate seven independent AR (1) processes with autoregressive coefficients calibrated to the empirical first order autocorrelation function parameters of the spreads and the six fundamentals. In turn, a model corresponding to Equation (1) was estimated using the artificial data for each of the countries in our sample using a sample size equal to 60 observations. We generate 50,000 Monte Carlo iterations and collect the *t*-statistics of each fundamental's coefficient for the null hypothesis of zero effect on the dependent variable. Finally, we calculate the 1% critical value using the empirical distribution of the relevant *t*-statistics for each country and regressor (results available upon request).

4. Results

4.1. Models not accounting for structural breaks

We start our empirical investigation by presenting, as a benchmark case, the full-sample results of estimating equation (1) without considering the possibility of structural breaks .The results are presented in Table 1. Panel A presents the estimates of general models including all possible spread determinants specified in the right-hand side of equation (1). Panel B presents parsimonious models obtained by applying a general-to-specific approach on the general models presented in Panel A, eliminating in sequential estimating rounds the least significant variable until a model including only statistically significant variables at the 10 per cent level is obtained.[10]

[Table 1]

The results presented in Table 1 indicate a mixed picture. International risk appears to have been correctly priced in all countries with the (rather implausible) exceptions of Ireland, Portugal and Spain for which the coefficient of vix_t is not significant. Illiquidity is correctly priced in all periphery countries and Belgium. Expected fiscal balance also appears to be correctly priced with the exceptions of Greece, Portugal, Spain and Finland for which it is insignificant. Growth outlook does not appear to be a significant determinant of spreads, with the exceptions of Greece, the Netherlands and Spain, where it is significant with the expected positive sign. For most countries expected public debt is either insignificant or mispriced, as it enters with a negative statistically significant sign (note, however, that expected debt is correctly priced in the cases of Greece and Portugal). Finally, real exchange rates appear with the wrong (negative) sign in all countries where they are statistically significant, the only exception being Greece, where it is significant with the theoretically expected positive sign.

[10] Note that inference regarding statistical significance is based upon the use of heteroskedasticity/autocorrelation-robust standard errors (OLS-HAC; see Newey and West, 1987).

Overall, the results reported in Table 1 suggest heterogeneity across countries regarding the determinants of spreads and yield results whose conformity with theoretical expectations is at best mixed. This may be due to structural change in the relationship between spreads and fundamentals, an issue which we address immediately below.

4.2. Modelling the time-varying link between spreads and fundamentals using GETS

Figure 6, Panels A-E plots the estimated coefficients of the explanatory variables obtained from the application of the GETS searching algorithm when the associated variables enter at least one terminal model at the 1% level of statistical significance.[11]

[Figure 6]

Figure 6 - Panel A indicates that while prior to the credit crisis the link between spreads and international financial risk was not active, it became strongly active following the intensification of the credit crisis in 2008. Ever since the international risk factor has been a statistically significant determinant of spreads in all sample EMU countries. The degree of exposure of spreads to international financial risk, as indicTted by the magnitude of the coefficient of *vix*, tends to be higher in periphery economies. the peak in the values of the *vix* coefficients observed in the immediate aftermath of the Lehman Brother incidence is followed by a stabilisation of the *vix* coefficient at lower levels in all countries. The only exception to this rule is Greece, where the coefficient of vix_t continues to increase throughout the period under consideration. Greece, indeed, provides a good example of the information gains obtained from employing the dynamic GETS methodology relative to models not accounting for structural breaks or time-varying coefficient models such as the one by Bernoth and Erdogan (2012) imposing uniform time-varying coefficients across countries.

[11] The corresponding graph for the real exchange rate is not shown since overall with the exception of very few instances, that variable was statistically insignificant over time across all sample countries, except from Greece for which real exchange rate appreciation was occasionally found to be statistically significant with the expected positive sign

The results presented in Figure 6 - Panel B suggest that liquidity risk has been priced mainly in the periphery EMU countries (Greece, Italy, Ireland, Portugal and Spain) during the sovereign debt crisis period with increasing coefficients over the period 2009 to mid-2010. It is interesting to note that over the same period French bonds also appear to have incorporated a liquidity premium, which they did not incorporate before or after. Since mid-2010 the coefficient of *ba* has declined in all periphery countries and reverted to zero in the case of France. Once again, Greece is an exception to this rule, with the estimated coefficient on illiquidity increasing to the end of our sample period. The timing of the reversal in the estimated values of *ba* approximately matches the creation of the EFSF in May 2010 and the initiation of the Security Markets Programme by the ECB. This indicates that the introduction of a systemic response to the European sovereign debt crisis weakened the relationship between liquidity and sovereign risk. This, combined with the reduction in the values of the estimated *vix* coefficients observed over the same period indicates that with the exception of Greece, the measures taken at a European level since mid-2010 have had a moderating, though not fully offsetting effect on the impact of other spreads determinants.

Panels C and D in Figure 6 present the estimated coefficients of expected fiscal fundamentals. Both panels suggest that the expected fiscal position was not statistically significant in explaining euro area sovereign risk prior to the financial crisis. Panel C suggests that the link between spreads and the expected fiscal balance became active during 2009-2010. We observe, however, significant country-specific heterogeneity in the response of spreads to the expected budget balance both within the core as well as within the periphery group. For example, while the expected budget balance is overall statistically insignificant in explaining spreads in Finland and the Netherlands, French and Austrian spreads are consistently related to the expected fiscal balance since 2009. Moreover, although markets have been penalising higher expected deficits with increasing strength in the case of Portugal, the relationship between spreads and the expected budget balance is not particularly strong in Spain and Ireland.

For Greece and Italy, the expected fiscal balance does not appear to be statistically significant since the end of 2010. Since then fiscal risk for these two countries appears to be priced via the expected debt channel (see Panel D). For Greece, in particular, the estimated coefficient on expected debt has registered a particularly pronounced increase over the last sample year (2011), similar to the increase observed in the value of the *vix* and *ba* coefficients obtained for the same country (see Figure 6, panels A and B respectively). For the remaining countries, our findings do not support the existence of a strong link between EMU spreads and the expected debt-to-GDP ratio; thus, it appears that the credit risk channel mainly operate via the expected budget balance, as opposed to expected debt. Finally, output growth is statistically significant determinant of spreads only in two EMU periphery economies, Greece and Spain and only during the debt crisis period (see Figure 6 - Panel E).

We tested the robustness of our findings with respect to the specification of the dynamic multipath search algorithm in a number of ways. To save space the results are not reported here but are available upon request. First, we repeated the multipath search using a less tight significance level (5% level). Second, we utilised a longer (72-month) rolling window for the estimations. Third, we did not include outliers in the regression models. Fourth, we conducted recursive, as opposed to rolling windows, estimations. Fifth, we did not impose sign restrictions on the model space. Our benchmark results are overall robust to these sensitivity checks.

All in all, in line with previous studies our findings suggest that the relationship between euro area sovereign risk and the underlying fundamentals is strongly time-varying, turning from inactive to active since the onset of the global financial crisis and further intensifying during the sovereign debt crisis.[12] Our results are overall in line with those reported by Bernoth and Erdogan (2012) and Aßmann and Boysen-Hogrefe (2012) who used a varying-coefficients panel approach to capture structural instability in spreads determination within the euro area. The contribution of our approach is to highlight an additional dimension of heterogeneity, namely the differentiation of the coefficients' time variation and impact upon spreads across individual countries. With the partial exception of the study by D'Agostino and Ehrmann (2012) who offer similar findings to ours relating to the French and Italian spreads against Germany in the context of their analysis on G7 economies, this dimension of intra EMU heterogeneity has not been reported in previous literature.

5. Conclusions

In this paper we used a varying-coefficients time-series methodology to capture structural instability in the link between euro area sovereign bond yield spreads against Germany and their underlying determinants over the period January 1999 - August 2011 (monthly frequency). Following the bulk of existing literature we modelled spreads on proxies of international financial risk, liquidity risk and credit risk. We used a dynamic multipath general-to-specific algorithm to capture time-variation in the relationship between spreads and fundamentals on a country-case. We offer new evidence suggesting that there exists significant heterogeneity across countries, both in terms of the risk factors determining spreads over time as well as in terms of the size of their impact on national spreads. As a

[12] Arghyrou and Kontonikas (2012) argue that the finding of non-pricing or mispricing of related fundamentals prior to the crisis is supportive of the 'convergence trading' hypothesis, according to which investors purchased periphery bonds in the hope that these economies would convergence towards Germany. The increased demand for periphery bonds led to lower spreads and the expectation of convergence became self-fulfilling, generating profits for bond market investors and lower borrowing costs for periphery governments, even in the presence of deteriorating fundamentals.

general rule, the set of spreads' determinants in the euro area is highly unstable but generally becomes richer and stronger in significance as the crisis evolves.

Compared to the period preceding the global financial crisis, the significant increase in the importance of fiscal fundamentals, reflected in higher statistical significance and higher size for the estimated coefficients of fiscal variables, indicates higher market sensitivity to idiosyncratic national credit risk. Our findings suggest that intervention measures, in the form of providing distressed countries financial rescue packages and ECB intervention in European government bond markets, have only moderated rather than fully offset the market impact of this heightened market sensitivity. They also indicate that markets now exercise much more binding restrictions on national fiscal policies thus anticipating a restrictive nature for the latter in heavily indebted EMU countries. Overall, the main implication of our empirical findings is that given recent market pricing behaviour the European debt crisis will very likely not be fully resolved as a result of improved global risk conditions or further intervention at the European level. For this purpose, a significant improvement in national fundamentals seems a necessary condition.

References

Aßmann, C., Boyesen-Hogrefe, J. (2012). "Determinants of government bond spreads in the euro area: in good times as in bad". *Empirica*, 39, 341-356.

Acharya, V.V., Drechsler, I., Schnabl, P. (2011). "A Pyrrhic victory? – Bank bailouts and sovereign credit risk". NBER Working Paper 17136.

Arghyrou, M.G., Tsoukalas, J. (2011). "The Greek debt crisis: Likely causes, mechanics and outcomes". *The World Economy*, 34, 173-191.

Arghyrou, M.G., Kontonikas, A. (2012). "The EMU sovereign debt crisis: Fundamentals, expectations and contagion". *Journal of International Financial Markets, Institutions and Money*, 22, 658-677.

Afonso, A., Arghyrou, M.G., Kontonikas, A. (2012). "The determinants of sovereign bond yield spreads in the EMU". University of Glasgow, Adam Smith Business School, Discussion Paper 2012-14.

Alesina, A., De Broeck, M., Prati, A., Tabellini, G. (1992), "Default risk on government debt in OECD countries". *Economic Policy*, 15, 427-451.

Attinasi, M-G., Checherita, C., Nickel, C. (2009). "What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09?". ECB Working Paper 1131.

Barrios, S., Iversen, P., Lewandowska, M., Setzer, R. (2009). "Determinants of intra-euro-area government bond spreads during the financial crisis". European Commission, Economic Papers 388.

Beber, A., Brandt, M., Kavajecz, K. (2009). "Flight-to-quality or flight-to-liquidity? Evidence from the euro-area bond market". *Review of Financial Studies*, 22, 925-957.

Bernoth, K., von Hagen, J., Schuknecht, L. (2004). "Sovereign risk premia in the European government bond market". ECB Working Paper 369.

Bernoth, K., Erdogan, B. (2012). "Sovereign bond yield spreads: A time-varying coefficient approach". *Journal of International Money and Finance*, 31, 639-656.

Caceres, C., Guzzo, V., Segoviano, M., (2010), "Sovereign spreads: Global risk aversion, contagion or fundamentals?". IMF Working Paper 10/120.

Caggiano, G., Greco., L. (2012). "Fiscal and financial determinants of Eurozone sovereign spreads". *Economics Letters*, 117, 774-776.

D'Agostino, A., Ehrmann, M., (2012). "The pricing of G7 sovereign bond spreads – the times they are a-changin", MPRA Paper No 40604.

De Grauwe, P., Ji, Y. (2012). “Mispricing of sovereign risk and macroeconomic stability in the eurozone”. *Journal of Common Market Studies*, 50, 866-880.

De Santis, R. (2012). “The euro area sovereign debt crisis: Safe haven, credit rating agencies and the spread of the fever from Greece, Ireland and Portugal”. ECB Working Paper 1419.

Doornik, J.A., (2009). “Autometrics”. In J. L. Castle and N. Shephard (Eds), *The Methodology and Practice of Econometrics*, 88–21. Oxford: Oxford University Press.

Favero, C.A., Missale, A. (2011). “Sovereign spreads in the euro area. Which prospects for a eurobond?”. CEPR Discussion Paper No. 8637.

Favero, C., Pagano, M., von Thadden, E.-L. (2010). “How does liquidity affect government bond yields?”. *Journal of Financial and Quantitative Analysis*, 45, 107-134

Gerlach, S., Schulz, A., Wolff, G. (2010). “Banking and sovereign risk in the euro-area”. CEPR Discussion Paper No. 7833.

Granger, C.W., Hyung, N., Jeon, Y. (2001). “Spurious regressions with stationary series”. *Applied Economics*, 33, 899-904.

Hendry, D., Krolzig, H. (2001). “Automatic econometric model selection”. London: Timberlake Consultants Press.

Hendry, D., Krolzig, H. (2003). “New developments in automatic general-to-specific modelling”. In B. P. Stigum (Ed.), *Econometrics and the Philosophy of Economics*, 379–419. Princeton: Princeton University Press.

Hendry, D., Krolzig, H. (2004). “Sub-sample model selection procedures in general-to specific modelling”. In R. Becker and S. Hurn (Eds.), *Contemporary Issues in Economics and Econometrics: Theory and Application*, 53–74. Cheltenham: Edward Elgar.

Hendry, D., Krolzig, H. (2005). “The properties of automatic Gets modelling”. *Economic Journal*, 115, 32-61.

Hendry, D., Santos, C. (2005). “Regression models with data-based indicator variables”. *Oxford Bulletin of Economics and Statistics*, 67, 571-595.

Hendry, D. (2000). “*Econometrics: Alchemy or Science?*”. Oxford: Oxford University Press.

Manganelli, S., Wolswijk, G. (2009). “What drives spreads in the euro-area government bond market?”. *Economic Policy*, 24, 191-240.

Newey, W., West, K., 1987. A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica 55, 703-70.

Schuknecht, L., von Hagen, J., Wolswijk, G. (2010). "Government bond risk premiums in the EU revisited: The Impact of the financial crisis". ECB Working Paper 1152.

Sgherri, S., Zoli, E. (2009). "Euro area sovereign risk during the crisis". IMF Working Paper 09/222.

Whaley, R., (2000). "The Investor fear gauge". *Journal of Portfolio Management*, 26, 12-17.

Modelling government bond yield spreads not accounting for structural change

Panel A: General models

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
$spr_{t\text{-}1}$	0.837***	0.908***	0.823***	0.916***	0.809***	0.669***	0.941***	0.875***	0.780***	0.900***
vix_t	0.079***	0.056***	0.074***	0.031***	0.390***	-0.001	0.082**	0.052**	0.061	0.006
ba_t	0.0003	0.0045*	-0.0001	-0.0002	0.004*	0.007***	0.005**	0.0006	0.005***	0.004***
bal_t	-0.015***	-0.010	-0.004	-0.021***	0.007	-0.024	-0.026***	-0.005	0.012	0.003
$debt_t$	-0.004***	-0.003**	-0.002***	-0.003	0.032**	0.005	-0.006**	-0.001	0.022	0.003
$gind_t$	0.016	-0.001	0.000	0.000	-0.013*	0.003	-0.005	-0.001	-0.001	-0.007***
q_t	-0.095	-0.484*	-0.200*	-0.205	2.941*	-0.632	-0.606**	0.018	-0.592	0.380
Adj. R^2	0.945	0.956	0.932	0.944	0.988	0.977	0.971	0.932	0.983	0.976

Panel B: Parsimonious models

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
$spr_{t\text{-}1}$	0.900***	0.905***	0.840***	0.859***	0.811***	0.696***	0.950***	0.897***	0.832***	0.924***
vix_t	0.079***	0.048**	0.071***	0.027**	0.386***		0.071*	0.052***		
ba_t		0.005*			0.004*	0.007***	0.005**		0.004***	0.004***
bal_t	-0.017**	-0.012*		-0.020***		-0.038**	-0.030***	-0.006***		
$debt_t$	-0.004***	-0.003**	-0.003***		0.031**		-0.006**	-0.001*	0.012**	
$gind_t$					-0.012*			-0.001*		-0.006***
q_t		-0.535*	-0.205*	-0.276**	2.709***	-1.179**	-0.613**			
Adj. R^2	0.924	0.956	0.933	0.944	0.988	0.978	0.971	0.932	0.989	0.977

Notes: Sample period: 1999.01 – 2011.08. ***, ** and * denote statistical significance at the 1%, 5% and 10% level respectively. Ordinary Least Squares (OLS) estimates of the parameters with heteroskedasticity and autocorrelation (HAC) consistent estimates of the standard errors are shown.Parsimonious models obtained by applying general-to-specific model reduction.

Figure 1: 10-year government bond yield spreads

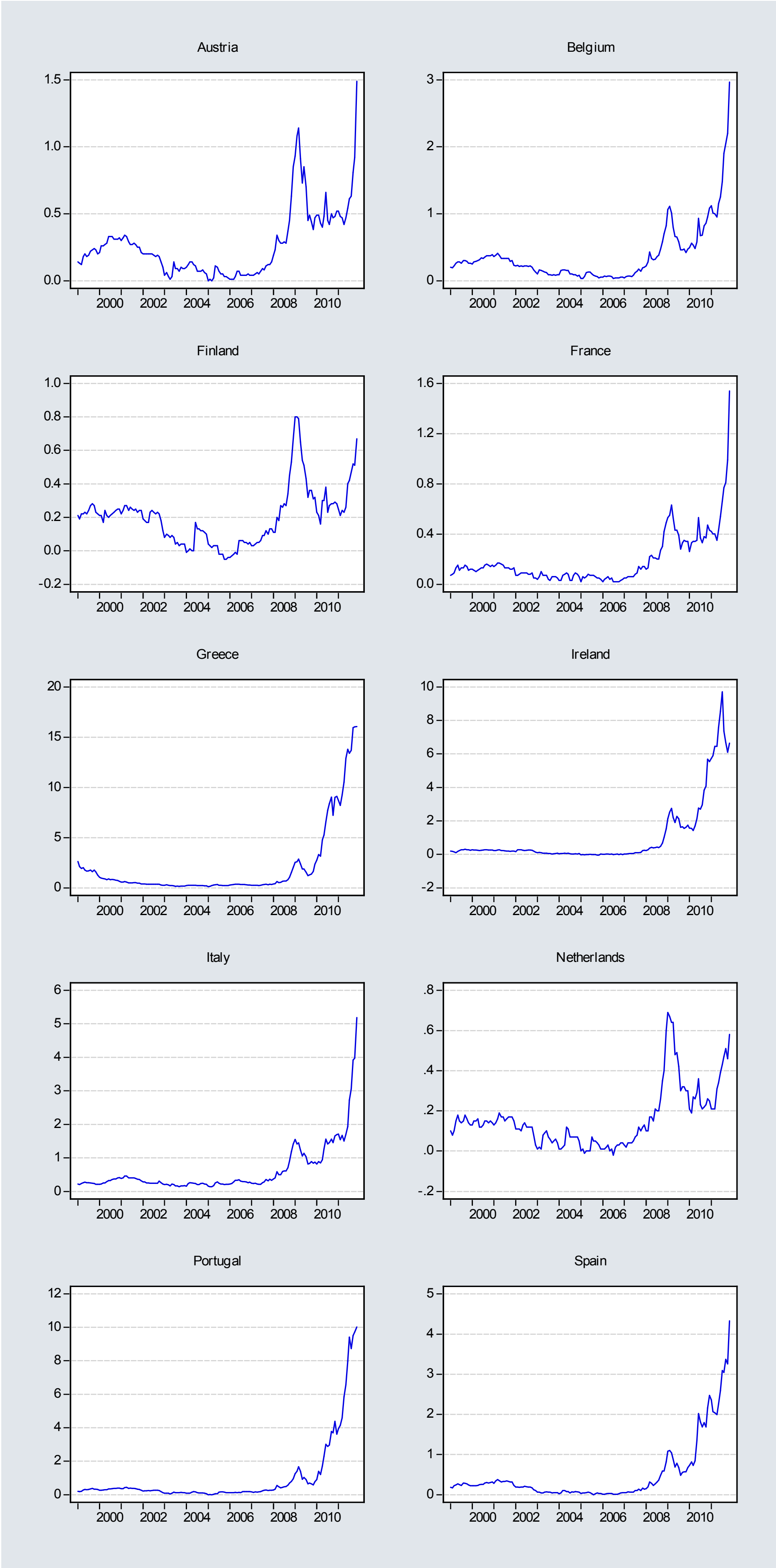


Figure 2: German 10-year government bond yield and VIX

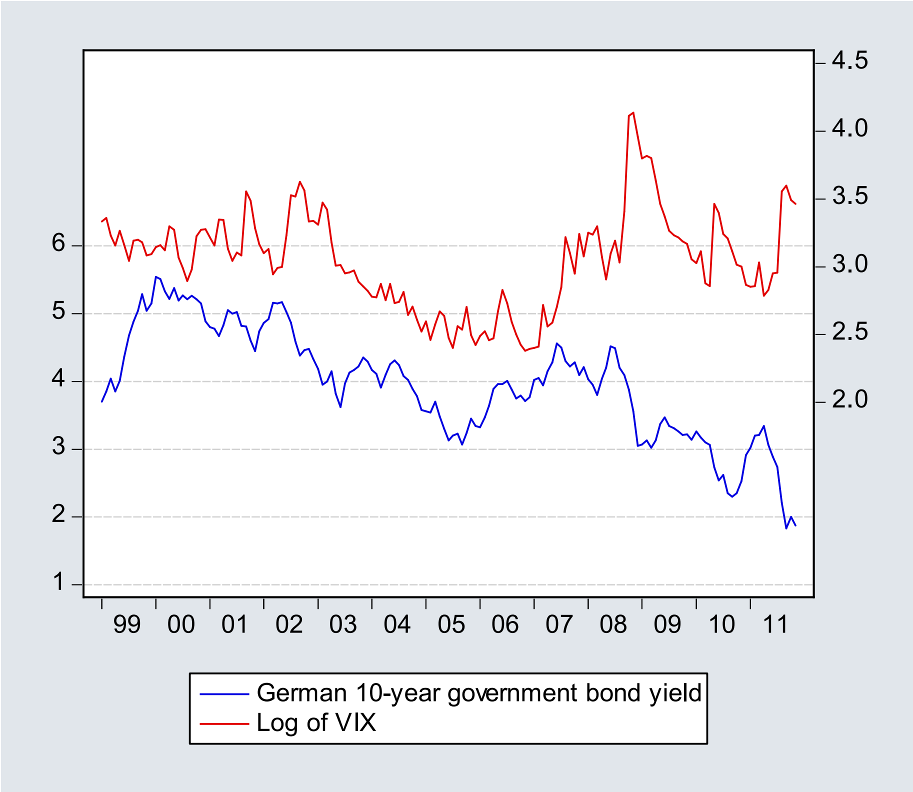


Figure 3: Expected debt as percentage of GDP

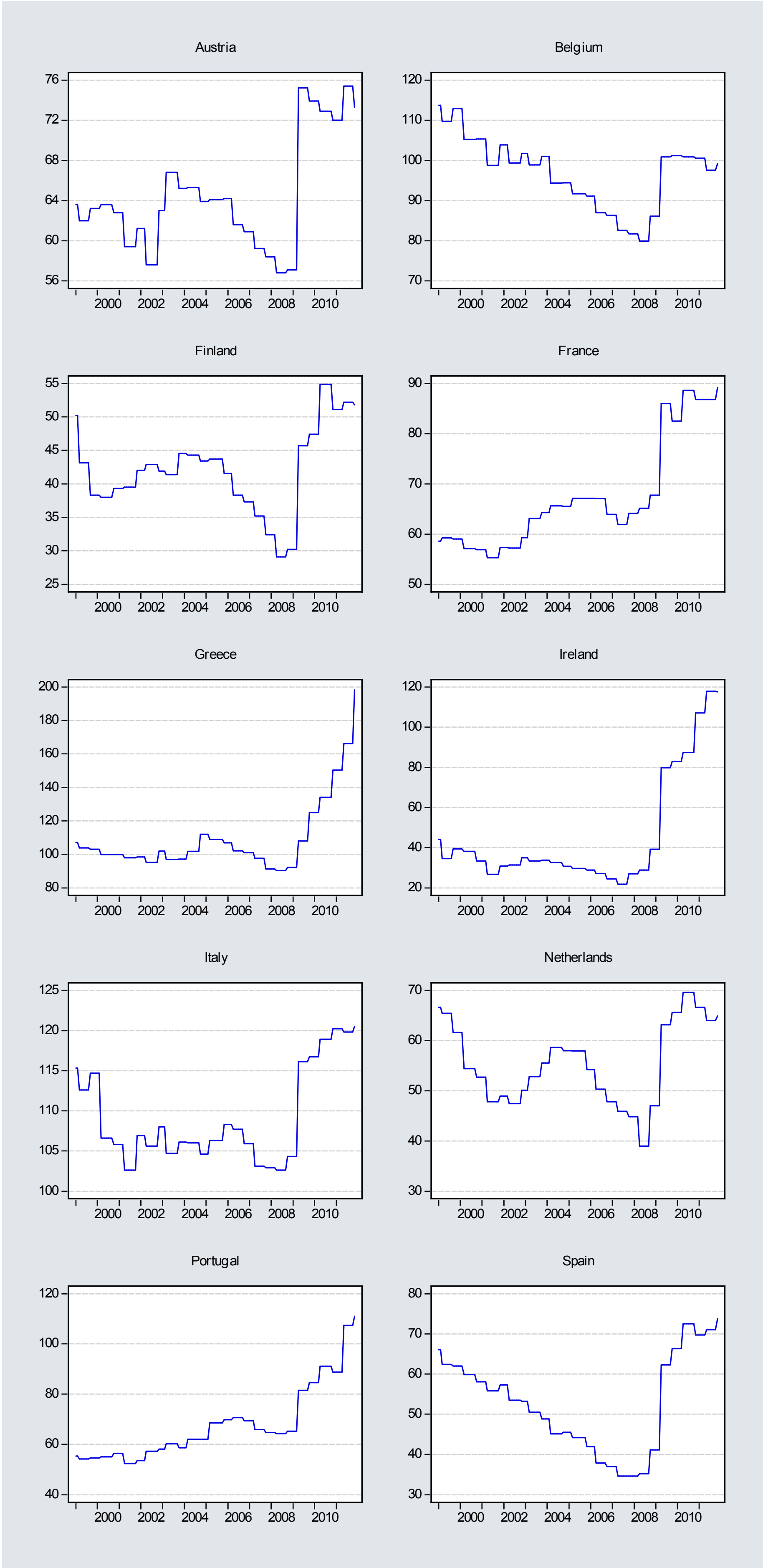
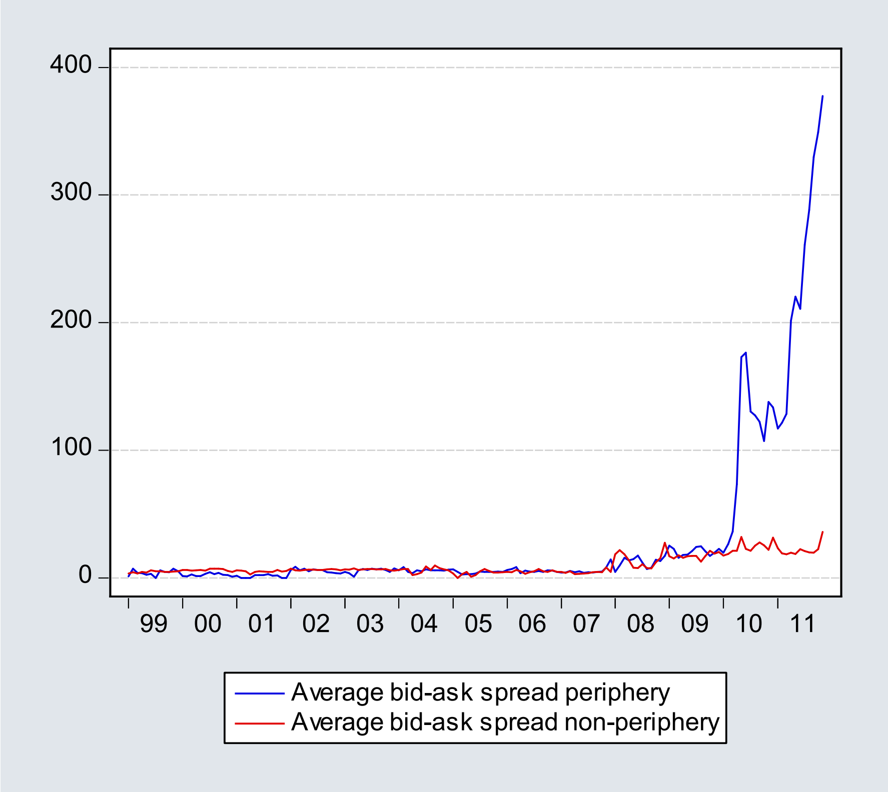
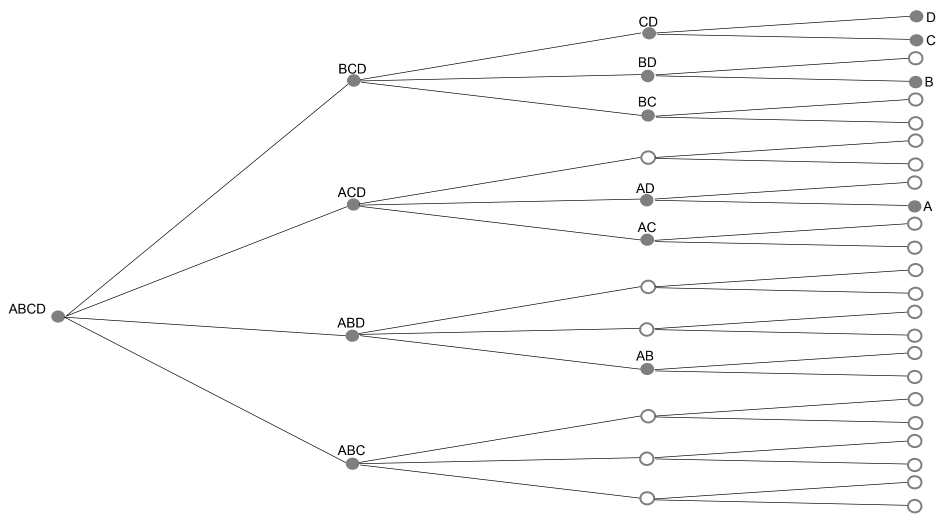


Figure 4: Average bid-ask spread in periphery and non-periphery countries



Note: Periphery countries include Greece, Ireland, Portugal and Spain. Non-periphery countries include Austria, Belgium, Finland, France, Italy and the Netherlands.

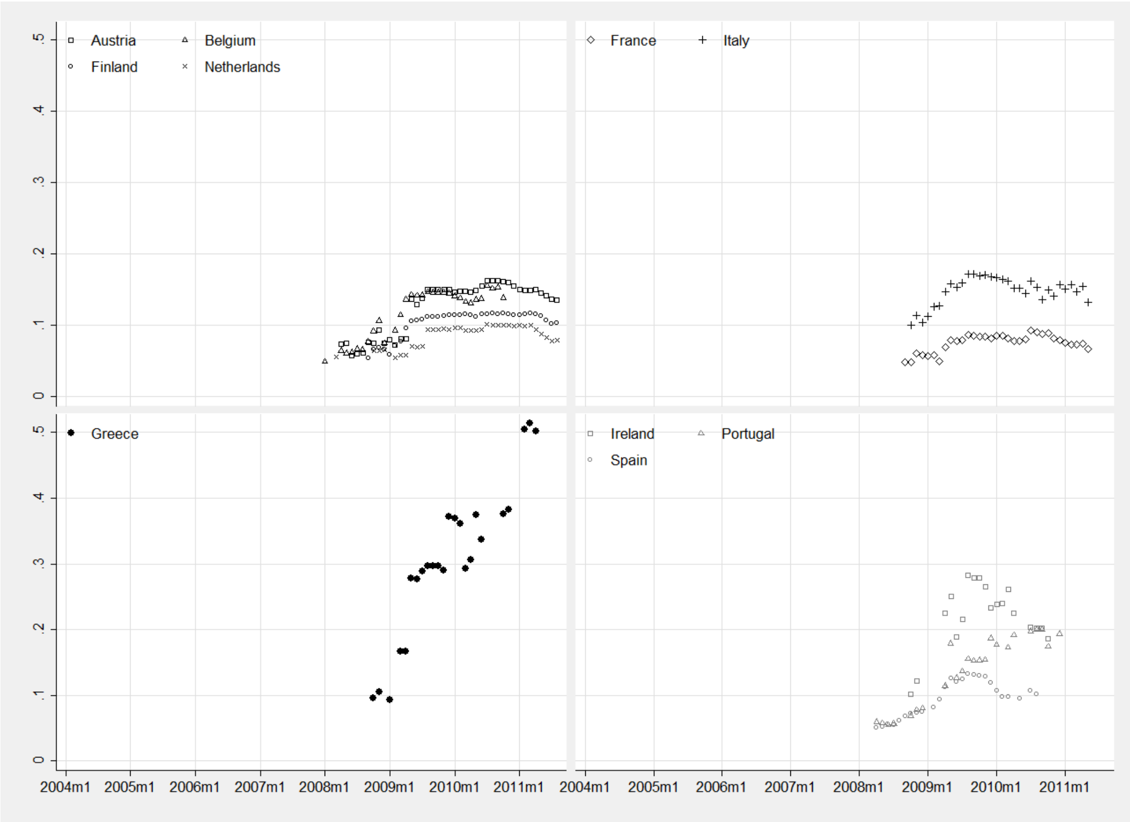
Figure 5: Multipath model space



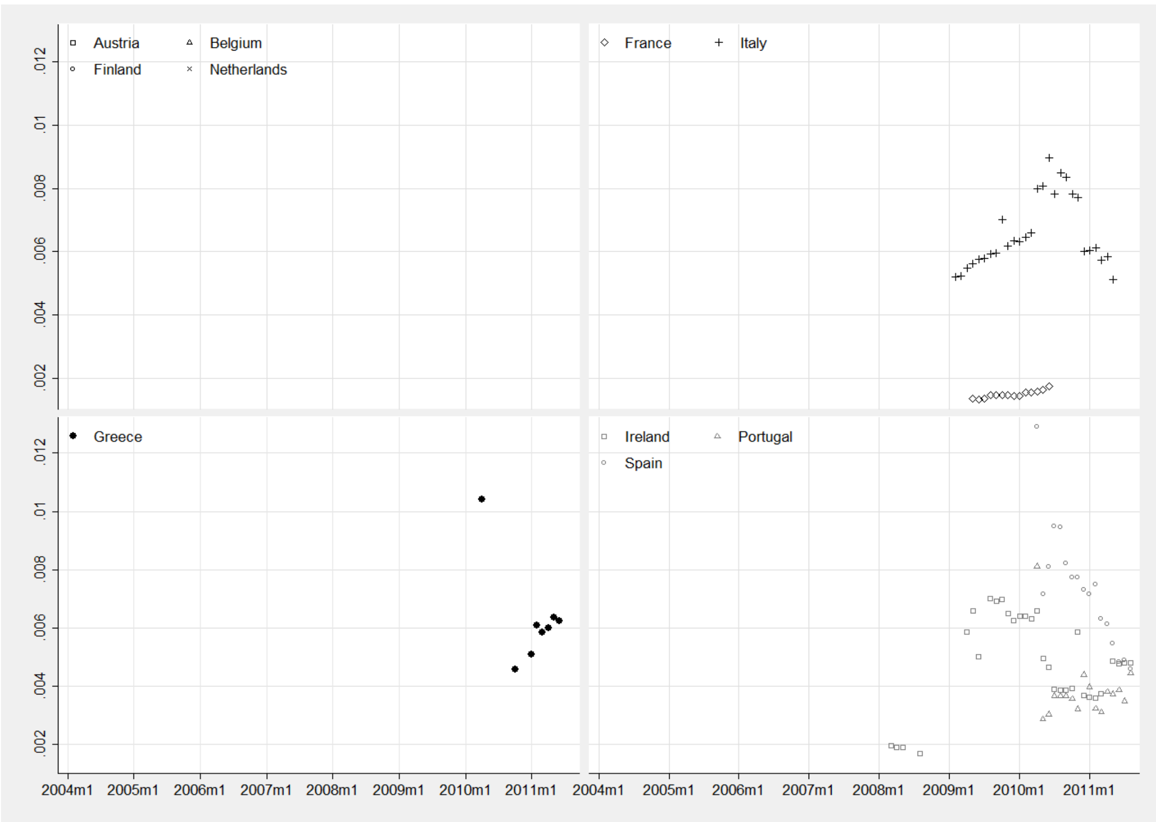
Note: Figure 5 has been reproduced from Doornik (2009). It shows all unique models starting from a GUM with variables ABCD.

Figure 6: Dynamic GETS modelling results

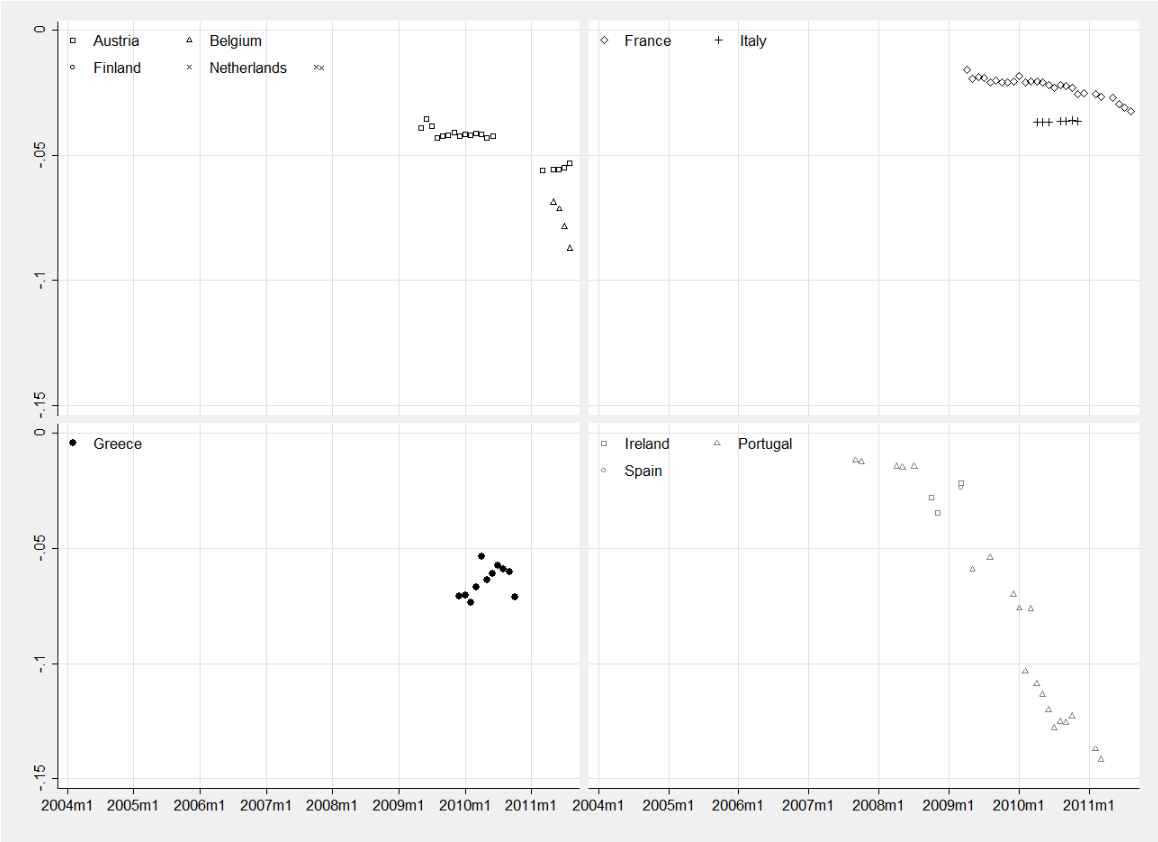
Panel A: *vix*



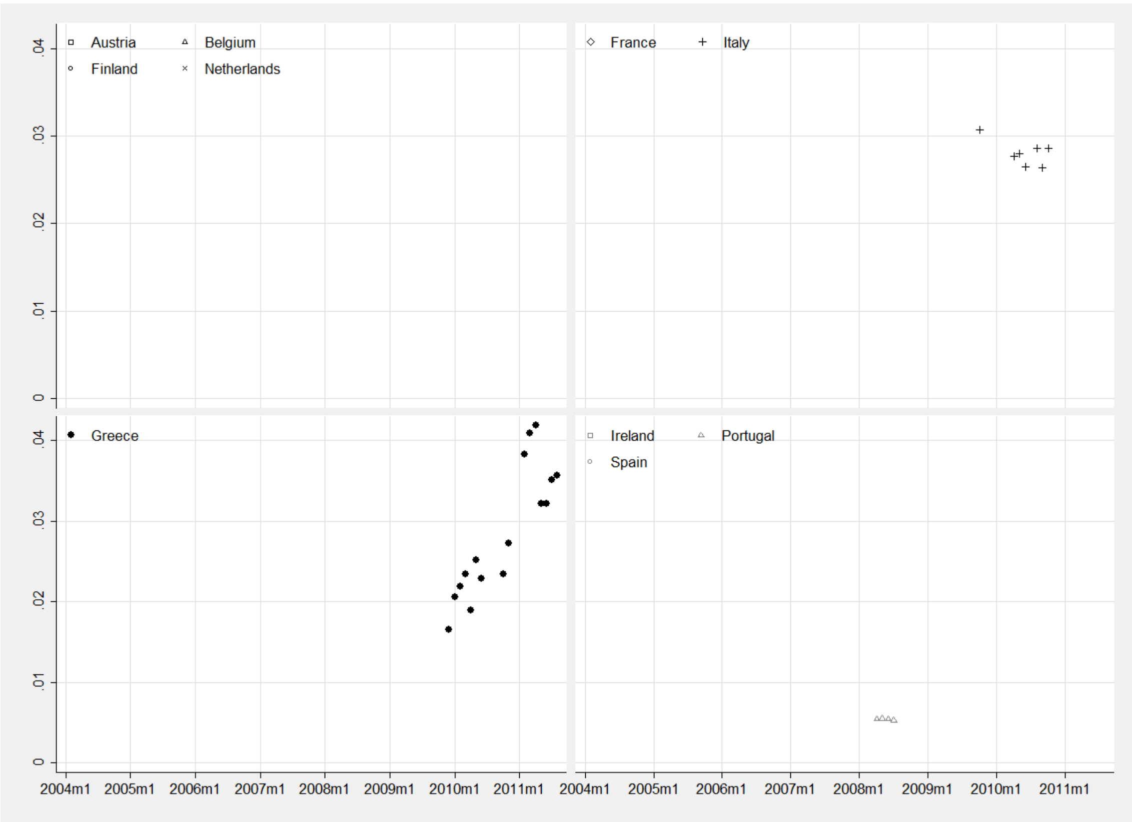
Panel B: *ba*



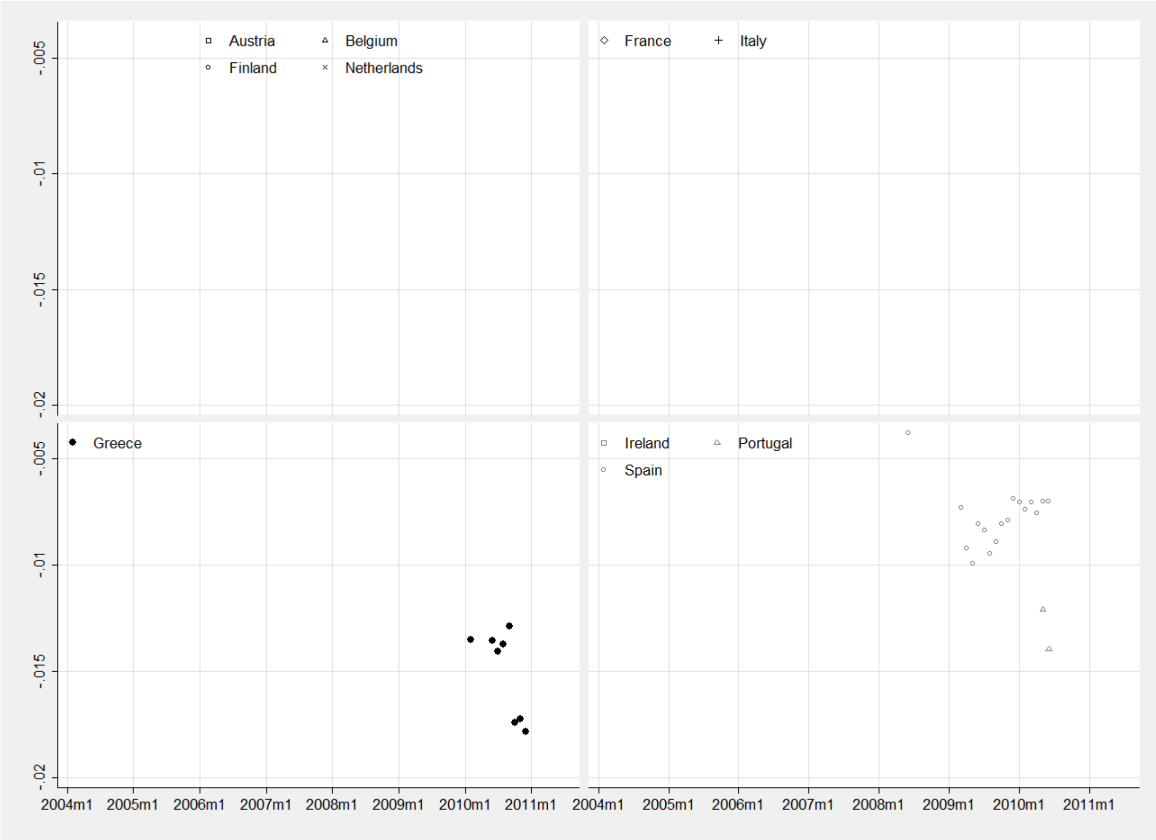
Panel C: *bal*



Panel D: *debt*



Panel E: *gind*



Note: Figure 6 Panels A-E show the coefficients of the spreads-related fundamentals when they are statistically significant at the 1% level in the terminal model(s) after applying the dynamic GETS algorithm using 60-month rolling windows and Equation (1) as the GUM. Monte Carlo based critical values that account for persistence in the series are used in the *t*-tests. The period under investigation is January 1999 - August 2011.