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The Equity-like Behaviour of Sovereign Bonds

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Abstract
Using a rich dataset of high frequency historical information we study the determinants of European sovereign bond returns over calm and crisis periods. We find that the importance of the equity risk factor varies greatly over time and crucially depends on country risk. In low risk countries, government bond returns are negatively related to equity returns, regardless of market conditions. Investors appear to migrate from low risk government bonds to stocks in calm periods and in the opposite direction when markets are under stress. On the other hand, government bonds of high risk countries lose their "safe-asset" status and exhibit more equity-like behaviour during the sovereign debt crisis, with positive and strongly significant co-movements relative to the stock market. Interestingly, this segmentation of the government bond market results in higher diversification benefits for fixed income investors and pension funds in periods of sovereign stress.

Keywords
government bonds, subprime crisis, sovereign debt crisis, credit risk, liquidity risk, asset pricing

JEL Classifications
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1 Introduction

Common distinctions between "safe" and "risky" assets have been called into question following the financial crisis that has affected global markets over the last few years. The abnormally high credit spreads observed for a number of government securities in developed economies, previously considered virtually riskless, marks a paradigm shift in investors' perceptions with profound implications for pricing, hedging and portfolio allocation strategies. The 2010-13 European sovereign debt crisis offers the perfect setting to analyse the determinants of government bond returns and to study how the importance of these determinants changes over time. Specifically, an equity risk factor has long been used in the finance literature to explain government bond returns (see for example, Fama and French, 1993). It is well documented that, in crisis periods, government bonds and stocks exhibit negative co-movements, which result in a negative beta for the equity risk factor. When uncertainty is high, investors migrate away from stock markets and buy government bonds which are perceived to be safer (see, for instance, Connolly, Stivers, and Sun 2005). One of our main contributions is to study how this flight-to-safety phenomenon has been altered by the sovereign debt crisis. Table I gives a stylized description of our findings. We observe that the correlation between stock and government bond returns becomes positive for high risk countries when sovereign default risk increases. This suggests that bonds issued by governments with a poor credit profile are treated more like equities rather than safe assets when economic conditions deteriorate.

[TABLE I around here]

We document a strong segmentation of the European bond market between low and high risk countries that occurs rather abruptly with the onset of the sovereign crisis. This echoes the lower level of market integration observed by Christiansen (2014) in the same period. We find that as the correlation in bond returns between countries with low default probability and countries in distress moves from positive to negative, stronger diversification gains are reaped by investors specialised in government securities as well as diversified funds and investors with a low appetite for risk (e.g. pension funds). This contrasts with equity portfolios which achieve consistently low diversification gains throughout our observation period.

We also explore how the influence of the credit and liquidity determinants of government bond returns varies across Euro-zone countries. To do so, we use an extensive set of government bond data spanning 11 Euro-zone countries from 2003 to 2013. This includes tick-by-tick data that enable us to build daily liquidity measures. We obtain several interesting findings. First, market liquidity risk becomes statistically significant during the subprime and sovereign crisis periods.

However, this factor only affects countries that have run into financial difficulties or are likely to be unable to service their debt. For these, the liquidity risk factor, measured by changes of bond specific bid-ask spreads, is negatively correlated with sovereign bond returns and its significance is not persistent as it dies out in the second half of the sovereign crisis period. This suggests a "flight away from illiquidity" at the beginning of the sovereign crisis which later subsides providing a sign of restored confidence. Second, credit risk does not appear to be priced before the subprime crisis but is important during the sovereign crisis. The credit risk factor, which we proxy with changes in 5-year sovereign CDS prices, is positively related with bond returns when a country is perceived to have a low risk of default. On the other hand, this relationship turns negative as country default risk increases. This is supporting evidence of a strong flight-to-safety from high risk countries to low risk countries. Credit risk affects negatively more and more countries as the financial crisis intensifies.

The rest of the paper is organised as follows. In Section 2 we review the literature. Section 3 is a description of our data. Variables description and model specification are presented in Section 4. In Sections 5 and 6 we discuss our results and robustness tests. Section 7 concludes the paper.

2 Literature review

The unstable relationship between government bond returns and stock returns has been a puzzling feature of these two markets especially over the recent years. Scruggs and Glabanidis (2003) and Baele et al. (2010) report that stock-bond correlation in the US varies from as high as 60% to as low as -60%, but remains mostly positive. Campbell et al (2013) confirm these findings and report negative correlations in the 2000s and especially in the crisis periods of 2000-02 and 2007-09. Campbell and Ammer (1993) and Ilmanen (2003) generally explain stock-bond co-movements through their common exposure to inflation risk. However, Baele et al. (2010) find that inflation and inflation uncertainty are not statistically significant for government bond returns. Thus, after 2000, inflation is unlikely to be the main driver behind the observed correlation pattern. Instead, investors' cyclical search for higher yielding assets in expansionary periods and safe assets in recessions could offer valuable insights. It is conceivable that economic expansion ultimately translates into a negative stock –bond correlation since investors prefer higher yielding stocks over lower yielding government bonds. Similarly, weak economic prospects lead to a "flight-to-safety" from the stock market to the government bond market (Connolly et al. 2005 and Gulko 2002). Other contributions in this area are Andersson et al. (2008) who show that stock-government bond return correlations exhibit similar patterns in the main global economies such as US, UK and Germany. Guidolin and Timmerman (2005) find

negative correlations in the UK when the market is in a "bear" state. Lekkos and Milas (2004) observe a similar negative relationship in the UK market in times of expansion.

With regard to default risk, Fama and French (1993) observe that a common default premium (i.e. the return difference between long term corporate and government bond portfolios) is priced in US government bond returns. According to Liu et al. (2009) such premium disappears during the expansionary period between 2002 and 2006. However, with the start of the financial crisis in the US and the business cycle entering a recession period, Nippani and Smith (2010) provide evidence that more than 60% of the interventions that commit public funds towards diminishing the effects of the subprime crisis have increased the default risk of US Treasury bonds. Substantial credit risk premiums have also characterised the price of government bond issued by some peripheral Euro-zone countries since the start of the subprime debacle. Bai et al. (2012) argue that contagion through fundamental credit shocks is the main driver of government yield spreads during the European debt crisis. Pelizzon et al. (2013) find that, before the ECB intervention in the late 2011, credit risk caused severe loss of liquidity in the Italian sovereign bond market. Among earlier contributions, Prati and Schinasi (1997) consider credit risk as the main determinant to explain Euro cross-country yield spreads and point to the positive difference between the yield of USD denominated debt issues of EMU countries and comparable Treasury securities. Lemmen and Goodhart (1999) view EMU yield spreads as a proxy for credit risk and find a positive relationship with debt-to-GDP ratio changes between 1987 and 1996. This relationship is also documented by Codogno et al. (2003) and Bernoth et al. (2012). Following the monetary unification, the euro bond market has made steps towards more efficient market integration. The emergence and developments of European bond trading platforms have fostered the integration process of the secondary market (Pagano and Thadden, 2004). Codogno et al. (2003), Geyer et al. (2004) and Baele et al. (2004) observe a sharp decrease in EMU yield spreads over the German bund after 1999. These authors also show that sovereign bond yield changes have started to closely follow the changes of the German bund. Codogno et al. (2003), Favero et al. (2010) and Bernoth et al. (2012) provide evidence of an international risk aversion factor affecting European sovereign yields which is related to US corporate bond spreads. Skintzi and Refenes (2006) also find volatility spillovers from the US and aggregate Euro bond markets indexes to individual Euro-zone bond markets. Geyer et al. (2004) conclude that Euro sovereign bond spreads are linked to Euro corporate bond and swap spreads rather than country-specific fundamentals. In emerging markets, Weigel and Gemmill (2006) find that credit risk of Brady bonds from Argentina, Brazil, Mexico and Venezuela is mostly related to regional and global factors. On the other hand, Maltritz and Molchanov (2013) and Martinez et al. (2013) observe that country-specific factors are most important in explaining the

variance of sovereign spreads. Interestingly, all these studies find a negative and statistically significant relationship between changes in credit risk (or bond spreads) and stock market returns. They consider the latter as a good proxy for market sentiment which drives the risk of emerging market bond spreads.

The other determinant of government bond returns that we control for in this study is liquidity risk. Amihud and Mendelson (1991), Kamara (1994), Fleming (2002), Grinblatt and Longstaff (2000), Longstaff (2004), Brandt and Kavajecz (2004) are among those who investigate liquidity effects on US Treasury prices. Li et al. (2009) conclude that half of monthly excess Treasury returns between 1992 and 2002 can be seen as compensation for liquidity risk. Boudoukh and Whitelaw (1991, 1993), Eom et al. (1998) and Singleton (2000) find that benchmark bond prices are more liquid than their non-benchmark counterparts in the Japanese government bond market.

Some evidence of credit and liquidity risks is present in Euro-zone sovereign bond yields before the start of the 2007 subprime financial crisis. Codogno et al. (2003) find liquidity to play only a small role in explaining yield differentials. Beber et al. (2009) observe that credit risk usually accounts for the largest part of sovereign bond spreads but liquidity risk gains importance in times of market uncertainty. Caporale et al. (2012) links market liquidity of Euro-zone sovereign bonds to trading imbalances, macroeconomic announcements, stock market volatility and ECB liquidity provisions. Manganelli and Volswijk (2009) and ECB (2007) decompose the yield spreads over the German bund into credit and liquidity risk premiums since the euro was adopted. Both studies show that the credit risk for high rated Euro-zone sovereigns (AAA and AA+) remained relatively constant throughout the sample, unlike liquidity risk and the credit risk of all other lower rated Euro-zone sovereigns.

3 Data

In this study, we use a comprehensive database of tick-by-tick tradable prices for European government bonds provided by the MTS intra-dealer platform of the London Stock Exchange. MTS comprises bond information from 18 local cash markets and the European Benchmark Market (EBM), or EuroMTS, where only Euro benchmark bonds are traded.[1] Euro benchmark bonds must have an outstanding value of at least € 5 billion (Dufour and Skinner, 2004) and their quotes can be submitted simultaneously to both the local cash platform and on EuroMTS.

[1] As of May 2014, available bond cash markets include Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Portugal, Poland, Slovenia, Spain and United Kingdom.

With an average daily turnover of more than Euro 100 billion as of mid-2014, MTS provides the best data source for the analysis of European government bonds.[2] More information regarding the market microstructure of the MTS platforms is presented in Cheung et al. (2005) and Dunne et al. (2006) whereas the price discovery mechanisms are discussed in Dufour and Nguyen (2011) and Caporale and Girardi (2013).[3]

Starting in 2003, MTS Time Series offers high frequency historical bond data that contain the best three bid and ask prices together with their corresponding tradable size in millions, and complete information regarding executed trades. Quote updates have time stamps with millisecond precision. We consider only the information for the best bid and ask prices throughout the analysis. Our sample covers a period of more than 10 years, from April 2003 to December 2013, and includes 563 government bonds that belong to 11 Euro-zone countries: Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, Netherlands, Portugal and Spain. All selected bonds are fixed-coupon benchmark bonds, have a maximum time to maturity of 51 years and trade on both the local cash market and EuroMTS.[4]

As is the case with any high frequency dataset, some steps are required to clean the data before they can be used in the analysis:

1) We select only quotes and trades registered when the market is open, between 8:15 AM and 5:30 PM Central European Time (CET).

2) All quote updates on each market (local and EuroMTS) that have a bid price higher than or equal to the ask price are eliminated.

3) Quote information from both the local market and EBM is consolidated to form a new order book. We then use the consolidated order book to obtain the bond mid-price available at 5:00 PM CET each day.[5]

[2] For a comparison between MTS and other major electronic platforms on European government bonds see Dunne et al. (2006), Persaud (2006) and ECB (2004, 2007).

[3] Also see Albanesi and Rindi (2000) for the evolution and market microstructure of MTS Italy, the institutional design model for EuroMTS and all other MTS cash markets.

[4] It is worth mentioning that bonds become benchmark bonds when the issue size criterion is met. As a result, a bond need not be a benchmark bond when issued, but can gain the benchmark status at a later date. This happens because some bonds are sold on the primary market in several tranches or tap sales. It is at the time when the bond receives the benchmark status that the bond starts trading on the EBM. Throughout our sample we find 57 such bonds. We include in our analysis only the time period after the bond has received the Euro benchmark flag.

[5] Intra-day spreads of sovereign bond prices have experienced significant increases as a result of the Euro-zone sovereign crisis starting in 2010. Whereas market makers have stopped providing quotes for Greek bonds on the MTS platform at the end of 2011, they have continued to provide quotes for other peripheral Euro-zone countries but at the expense of abnormally high spreads. Portugal however

4) We also address the issue of extremely high intraday bid ask spreads by using a bond specific filter. The filter is applied each year and excludes the top 1% bid-ask spread for each bond. This filter should take care of any extreme and untradeable quote revisions without hindering the informational content of the order book.

4 The model

To study the determinants of bond returns and their time varying behaviour we estimate the following pooled regression model over four distinct time periods: pre-crisis, subprime crisis and the acute and recovery phases of the sovereign crisis:

$$\mathrm{RB_{i,cr,t}} - \mathrm{RECB_t} = \mathrm{c} + \beta_{\mathrm{EQT}}\left(\mathrm{EQT_{i,cr,t}} - \mathrm{RECB_t}\right) + \beta_{\mathrm{CDS}}\Delta\mathrm{CDS_{cr,t}} + \beta_{\mathrm{SPR}}\Delta\mathrm{Spr_{i,cr,t}} + \varepsilon_{\mathrm{i,cr,t}} \quad (1)$$

where $RB_{i,cr,t}$ denotes the mid-price return for bond i issued by country cr at time t, $RECB_t$ represents the 3 month ECB yield,[6] $EQT_{i,cr,t}$ is the country specific stock index return, $\Delta CDS_{cr,t}$ is the change in country specific 5 year CDS spreads, $\Delta Spr_{i,cr,t}$ is the change in bond specific bid-ask spread, and c is the constant.

The above model is in the spirit of Fama and French (1993). We extend their model to include the bid-ask spread variable to control for liquidity effects. However, differently from their original contribution we do not explicitly consider a TERM factor. TERM is a proxy for maturity effects, or unexpected changes in interest rates, and is usually defined as the difference between a long-term government bond return and a short term rate. The reasons for its exclusion are: First, TERM is dominated by its first component, the long-term government bond return, which may raise an endogeneity issue. This is because bond (excess) returns are also the dependent variable of our model and they exhibit high correlation across maturities.[7] Second, maturity effects tend to correlate with credit (and, to some extent, liquidity) effects which are already captured by our explanatory variables. In the robustness Section we also control for maturity effects by interacting the equity factor with maturity dummies. Our main findings remain unaltered.

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presents an exceptional case. Bid prices reach almost 0 and ask prices increase above 300 around 5 PM CET when we sample the daily bond mid-price. Clearly, the value of the MTS mid-price is not informative in this case. To solve this issue, we replace all Portuguese MTS bond mid-prices after 1st Jan 2010 with the Composite Bloomberg Bond Trader (CBBT) mid-prices. It should be noted that the Bloomberg prices are only indicative of the market's consensus regarding the bond's price and, as such, are not tradable as the ones from MTS.

[6] The ECB yield is available only from September 2004 which is used as a starting date for our sample period in all our regressions.

[7] More details on this in the robustness Section.

As a credit risk proxy we use the changes in 5-year CDS prices. Unlike credit ratings, which may be "sticky", CDS contracts are traded daily and represent the creditworthiness of an entity as viewed by the market rather than a rating agency. One problem when using CDS spreads is that these instruments may not be an accurate measure of default risk. Blanco et al. (2005) offer evidence that CDS spreads are considerably larger than credit bond spreads for US and European investment grade bonds. In more recent work, Bongaerts et al. (2011) find significant and robust evidence of a liquidity factor in corporate CDSs. Tang and Yan (2008), Chen et al. (2013), and Corò et al. (2013) reach similar conclusions for the corporate CDS market. Although we are aware of this issue, we assume that the liquidity bias is smallest for the 5 year CDS contract, as it is the most traded maturity.[8]

The liquidity variable ΔSpr represents changes in bond specific proportional bid-ask spreads. Daily bid-ask spreads are estimated as averages of all intraday observations weighted by the time each quote is available in the MTS aggregated order book. Darbha and Dufour (2013) implement a horserace between several liquidity proxies on the MTS database and conclude that the proportional bid-ask spread is the most effective in capturing the variation of bond yields. Although our analysis examines bond returns instead of yields, we also expect the bid-ask spread to provide the best representation of illiquidity throughout our sample.

We are not the first to employ both credit and liquidity proxies within a multifactor model of government bond returns. For instance, Li et al. (2009) implement a similar approach when analysing the effect of market-wide liquidity in the US treasury market. To illustrate how our liquidity and credit variables behave through time, Figure 1 shows the daily 5-year CDS spreads and proportional bid-ask spreads for the 11 countries considered. Key crisis events are accompanied closely by spikes in our daily aggregate measures of credit and liquidity in each country.

[FIGURE 1 around here]

To ensure that no extreme movements bias our results, all returns and changes are winsorized at 1% - 99% when taking into account all observations available, country by country, in each sub-period. We also de-mean our variables, bond by bond in each sub-period, which removes the

[8] Sovereign CDS prices are sourced from Credit Market Analysis (CMA) which operates in New York, London and Tokyo. CMA offers daily term structures of CDS prices for 11 maturities, 6 months and 1 to 10 years, denominated in USD and date back to as early as October 2004 depending on the country. We estimate the 5 year CDS spreads as the average between the New York and London closing prices. We realise this procedure might induce a lead effect in the CDS price but consider this effect to be minimal. Similar to Beber et al. (2009), a complete dataset of CDS prices are obtained using linear interpolation. By eliminating all interpolating data our results remain qualitatively unchanged.

need for cross-sectional fixed effects. All pooled regressions are estimated with daily frequency. For each country, all days where one of the variables is missing are excluded from the analysis. This ensures a consistent number of observations throughout our model specifications.

5 Results

Table II presents the mean and standard deviation for daily bond and stock returns by country. Stock returns are obtained from Datastream. Countries are listed in a way that easily enables us to form groups that share common return characteristics on a consistent basis, as we will show in the rest of the analysis. Finland, Germany and the Netherlands are at the top of the list and we label them as "low risk". Austria, Belgium and France, are "medium risk" sovereigns. Greece, Ireland, Italy, Portugal and Spain are "high risk" countries.

We have identified four main sub-periods in our sample. The first is the pre-crisis, before August 2007, which is characterised by economic expansion and low market volatilities in most of the countries in the sample. The level of interest rates in the Euro-zone increases in this period. As a result, average bond returns are negative for all the 11 countries under analysis. On the other hand, stock returns are generally positive over the same period.

[TABLE II around here]

In August 2007, PNB Paribas closed down three of their hedge funds highly specialized in US mortgage debt. This is one of the early events that signal major problems in the subprime market. Sovereign bond return averages become positive, with the exception of Greece, and may be indicative of a "flight-to-safety" as stock returns turn negative across Europe. We choose January 2010 as the start of the sovereign crisis in Europe as in the previous weeks investors learnt that Greece might have difficulties to repay its debt. We split this period in two parts, each sub-period with a length of two years (from January 2010 to December 2011 and from January 2012 to December 2013), where we observe rather distinct bond and stock price movements.[9]

As shown in Table I, in the first part of the sovereign debt crisis the bond market in the high risk countries become positively correlated with their stock markets. This positive correlation is highly unusual in periods of stress and, as far as we know, has not been documented in the literature. Investors now appear to treat government securities from high risk sovereigns like stocks, that is, as if they were risky assets. On the contrary, the correlation between stocks and bonds in low risk countries remains negative in the first part of the sovereign crisis. This is

[9] As a robustness test we change the cut-off point from 01 January 2012 to 01 July 2012 and the results remain qualitatively the same.

reflected in Table II where low risk bonds have positive mean returns. By contrast, high risk bonds have negative mean returns similar to most stock markets. The only exceptions are the equity markets in Finland and Ireland which are mildly positive, though both exhibit much higher volatility relative to pre-crisis levels.

In the second part of the sovereign debt crisis, a mean reverting process is observed, which may indicate the start of a recovery phase. Indeed, bond returns in low risk countries go back to pre-crisis (negative) levels. On the other hand, returns for all stock markets, and bond markets in high risk economies, become positive. Likely, higher confidence in a recovery encourages investors to move away from low yielding safe assets and toward more risky ones, which represents a "flight to yield". Government bond returns for Greece in this sub-period are not reported due to the scarcity of reliable data. In this phase of the crisis, most Greek bonds were traded a few hours per day or not at all.

We further explore the relationship between bond returns on one end and stock returns as well as credit and liquidity variables on the other, with univariate regressions, before employing the full regression model in equation (1). Table III presents results when the excess equity return is the only explanatory variable. This articulates and confirms the findings previously shown in Table I by providing a breakdown by country.

[TABLE III around here]

Tables IV and V present country specific credit and liquidity effects in bond returns. As expected, there is virtually no indication that either credit or liquidity factors influence sovereign bond prices in the pre-crisis period. Exceptions are represented by Finland and France for which the credit risk factor is statistically significant. However, its explanatory power is negligible (0.49% and 0.68% respectively). We believe these two occurrences are spurious and probably due to the low quality of the CDS data in this period. No results are shown for Ireland in the pre-crisis period because sovereign CDS prices are not available for the country before 2008.

During the subprime crisis, CDS price changes in low risk countries (Germany, Netherlands and Finland) and France are positively and statistically significantly related to bond returns. This suggests that higher credit risk in the local sovereign bond market does not deter investors from buying such securities. The likely implication is that as risk increases in all markets, those that are perceived to be less risky become winners, which is a classic flight-to-safety scenario. Indeed, for countries that later experienced solvency problems, such as Greece and Ireland, higher credit risk is associated with negative bond returns as investors shift to safer assets. The distinction between high and low risk countries becomes clear in the first part of the sovereign debt crisis

when countries with perceived excessive levels of debt have a negative and statistically significant CDS coefficient. These include Italy, Spain, Portugal, Ireland and Greece. Belgium also falls into this group due to its relatively high debt-to-GDP ratio (varying between 80-100% in the pre-crisis period) and expensive bailout programme for two of its largest banks, Fortis and Dexia. Of the countries with a positive relationship between bond returns and CDS price changes during the subprime crisis, only Germany, Netherland and Finland preserve it throughout the ensuing sovereign crisis. Their R-squares also increase substantially, especially in the peak, or first stage, of the sovereign debacle. A similar pattern is seen for high risk countries where the explanatory power of the credit risk factor also increases noticeably. For Spain and Italy, credit risk explains roughly 32.31% of sovereign bond price variation. Surprisingly, credit risk explains only 21.25% of Greek and Irish bond returns which may be the result of the high level of noise that characterises the sovereign bond and CDS markets of these countries over this first part of the sovereign crisis period.

We observe some important changes in the second part of the sovereign crisis period. France and Austria join the group of countries that are negatively affected by credit risk as fear spreads over a possible downturn in both countries. Sensitivity to credit risk increases markedly for Italy and Spain as their CDS coefficients increase in magnitude and R-squares rise above 40%. Lower R-squares are documented for Portugal and Ireland, which have already received a bailout.

Turning to the univariate liquidity analysis, the liquidity coefficient is statistically significant only for high risk countries and is negative. This phenomenon is similar to the one documented by Dick-Nielsen et al. (2012) when observing liquidity flights in the US corporate bond market during the subprime crisis. They find that AAA corporate bonds are not affected by liquidity risk whereas lower-grade corporates are. This result is viewed as indicative of a flight from low to high grade corporates in times of crisis. This explanation would fit with the negative sovereign bond return of high risk countries and positive return of low risk countries in the first phase of the sovereign crisis (see Table II). However, the negative and significant liquidity coefficient for most of the high risk countries in the subprime crisis, when bond returns are mostly positive (with the exception of Greece) would suggest a repositioning of investors from the stock market (where returns are mostly negative) into both high and low risk government bonds. Notably, during the subprime crisis period, Spain, Portugal, Ireland and Greece are the first to be affected by liquidity risk with an average 0.28 basis points decrease in sovereign bond returns for a 1 basis point increase in the bid-ask spread. It is interesting to note that all countries negatively affected by credit risk, as shown in Table III, are also negatively affected by liquidity risk, though the

explanatory power of the latter is lower. Also, during the second part of the sovereign crisis period, i.e. the recovery phase, the liquidity risk effect largely dies out.

[TABLES IV and V around here]

Next, we combine equity, credit and liquidity factors in our regression analysis. Results are reported in Table VI. Although the findings broadly confirm our inference based on the univariate regressions, there are some deviations. For example, the stock market coefficient for high risk countries is statistically significant and negative during the first part of the sovereign debt crisis period. But all high risk countries (i.e. Italy, Spain, Portugal and Ireland) show a positive and highly statistically significant stock market coefficient during that period in the univariate regressions. The counter-intuitive result can be explained by the high negative correlation between the credit risk factor and the stock market in a crisis, which causes the latter to flip sign. As done in previous studies (e.g. Fama and French, 1993 and Petkova, 2006) we control for the interference generated by highly correlated variables through orthogonalization. Specifically, we replace the credit risk factors with its innovations, that is, the residuals obtained by regressing the factor against all the other explanatory variables in equation (1). The results of the new model are reported in Table VII and are now fully consistent with our univariate analysis.

[TABLE VI and VII around here]

5.1 Segmentation in the Euro-zone market

Our regression results reveal a clear segmentation between high and low risk bond returns starting from the beginning of the sovereign crisis. The contrasting sign of the returns between the two types of sovereign debt and their different relationship with key risk factors suggest a radical shift in investors' behaviour. Here, we explore how such phenomenon may affect investors with different risk appetite and asset allocation strategies. Specifically we look at how the crises have altered diversification opportunities across stocks and bonds. To address these points we first group stocks and bonds according to the risk profile of the country of issue. We call "low risk" assets those issued in low risk countries, namely Germany, Finland and Netherlands, while "high risk" assets are issued in Italy, Spain, Portugal, Ireland or Greece. Table VIII presents the descriptive statistics and correlations between the assets classes in each time period. As one would expect, correlations between the high risk and low risk stocks is high throughout the sample period with its peak during the subprime crisis at 91%. On the other hand, while correlation between the high and low risk bond portfolios is high in the pre-crisis and subprime period (99.5% and 87.9% respectively), it drops dramatically and even turns

negative during the two phases of the sovereign crisis (-16% and -0.7% respectively). This is strong evidence of the deep segmentation in the European sovereign bond market between high and low risk countries. The two types of government securities are clearly perceived and traded as if they were different asset classes. One is treated as a safe asset to invest into in a crisis, the other, more like stocks, a higher yield asset to invest into in recovery periods. Indeed the correlations between high risk bonds and the stock markets become substantially positive during the sovereign crisis, while it was markedly negative in previous periods.

[TABLE VIII around here]

Clearly, this sharp change in correlation dynamics has major implications for fund managers and how they can diversify risk. To explore this point we build five equally weighted asset portfolios that differ by asset composition (diversified as opposed to concentrated) and risk profile (low or high risk). The portfolios are (1) a pure bond fund with equally weighted bond indices of low and high risk countries, (2) a pure equity fund with equally weighted equity indices of low and high risk countries, (3) a diversified fund that includes all the above, (4) a pension fund, with low risk stocks and bonds and (5) a hedge fund with positions in high risk stocks and bonds. Next, we look at the diversification gains of each portfolio before and during the crisis periods. Diversification gains are estimated as the risk reduction of a portfolio relative to its constituent assets. Risk is measured with both volatility and a 99% value-at-risk. Results are reported in Table IX (where reductions appear with a positive sign). The findings are fairly consistent across the two risk measures. First, before the crisis and during the subprime crisis the portfolios that enjoy the largest diversification gains are the diversified fund and the high and low risk funds. This is due to the risk reduction achieved through diversification across asset classes. On the other hand, pure stock and pure bond portfolios do not obtain a large gain because of their single asset investment focus. However, during the sovereign crisis, the high risk portfolio is not as effective in reducing risk as high risk bonds and stock become increasingly more volatile and correlated. Instead, the pure bond portfolio becomes the one that reaps the largest diversification benefits (with an average of 31.4% across measures and sub-periods). This is the result of the segmentation in the government bond markets discussed above. For this reason, assuming that the pure bond portfolio is a single-class investment would not be appropriate during the sovereign crisis because of the equity-like behaviour of high risk government bonds.

6 Robustness

We perform several robustness checks to test the validity of our conclusions. We start by considering two additional risk factors, an international risk factor and the LOIS spread. Codogno et al. (2003) and Favero et al. (2010) employ an international risk factor in their analysis of European sovereign bond returns. Constructed as the spread between the 10 year US interest swap rate and the 10 year Treasury bond rate, the factor is typically viewed as a global measure of investors' risk aversion. Ait-Sahalia et al. (2012) and Schwarz (2014) use the LOIS spread given by the difference between the 3 month EURIBOR and EONIA rates, which should capture credit and liquidity shocks in the interbank money market. We add changes of these two variables to our model in Equation (1) and present the results in Table X. The international risk factor is highly statistically significant and negative in the pre-crisis and subprime crisis periods for all countries included in our analysis. However, the effect of this factor disappears altogether in the sovereign debt crisis period. This is suggestive of investors shifting their attention away from the US markets and focusing more on European risk factors. The LOIS spread is highly statistically significant and positive for all countries during all time periods except for high risk countries where it dies out with the start of the sovereign debt crisis. Overall, the combined effect of both factors is substantial during the pre-crisis period (i.e. a 6% increase in the R-squared on average), but becomes negligible as the financial crisis intensifies. Our results are robust to the introduction of these additional factors.

[TABLE X around here]

We have also considered depth as an additional liquidity risk proxy. For each intra-day quote update, depth is defined as the average tradable size available at the best bid and the best ask. Daily observations are obtained as an average of all intra-day depth observations weighted by the time each quote update was available in the order book. This variable proved not to be statistically significant in most regressions.

Fama and French (1993) include a TERM factor as a determinant of government bond returns to capture maturity effects. This is commonly defined as the difference between a long-term government bond return and a short term government bond rate. We build the TERM factor as the return difference between a 10 year bond portfolio[10] specific to each country and the 3

[10] To build the time series of the 10 year bond portfolio we average, each day, all country specific bond returns with a remaining time-to-maturity between 9 and 11 years.

month ECB rate.[11] Although this factor appears to be an appropriate explanatory variable for stocks and corporate bonds, there could be an endogeneity issue when employed to explain government bond returns. We observe that TERM is completely dominated by the long term bond component as the variability and magnitude of the 3 month ECB rate are both relatively much smaller. As a result, including TERM in the regression would be "almost" as if the dependent variable (excess bond returns) was entered on both sides of the equation, given the high correlation of bond returns across maturities. Table XI presents the country specific correlation between the TERM factor and excess bond returns for short, medium and long-term maturity bands. Most countries exhibit very high correlation values especially for medium and long term bonds. To illustrate the negligible impact of the short term government rate in TERM we also report the correlation between the excess bond return and TERM defined simply as the 10 year bond return (that is without subtracting the short term return). Correlations remain virtually unchanged. When using TERM in our regressions (unreported results) several variables exhibit counter-intuitive signs and/or statistical significance. Instead of employing TERM, we control for maturity effects by interacting the equity factor with maturity dummies. As shown in Table XII our results are confirmed and the equity like behaviour of high risk bonds during the sovereign crisis appears to be pervasive across maturities.

[TABLE XI and XII around here]

We perform several other robustness tests. First, we change the cut-off date used to split the sovereign debt crisis in two intervals from 01 January 2012 to 01 July 2012 as there is a clear reduction in both CDS prices and bond bid-ask spreads after this date. Besides some loss in coefficient significance for the medium risk countries, the remaining results are virtually the same. Second, in the main analysis we use clean price returns. We test whether accrued interest has an impact on our results by estimating the dirty price for each bond. We use the following formula to compute bond returns:

$$RB_{i,t} = \frac{\left(P_{i,t} + AI_{i,t} + C_{i,t}\right)}{\left(P_{i,t-1} + AI_{i,t-1}\right)} - 1 \qquad (2)$$

[11] We also consider the 3 month EURIBOR rate instead of the 3 month ECB rate. Results remain unchanged.

where $RB_{i,t}$ represents the bond return of bond i at time t, $P_{i,t}$ is the clean price, $AI_{i,t}$ is the accrued interest at time t and $C_{i,t}$ represents any coupon received in the period $t-1$ to t. Using dirty price return does not changes our conclusions. Finally, to examine the sensitivity of our findings to our credit risk proxy, we replace our CDS data sourced from CMA with 5 year CDS prices, denominated in USD, for our 11 Euro-zone countries with Bloomberg's generic pricing source CBBT. Again our results remain unchanged.

7 Conclusion

The crises of the last decade offer a unique opportunity to study how the return of government bonds and stocks co-move when the market is subject to stress conditions of different degree and type. Using a comprehensive dataset of European sovereign bond prices stretching over a period of 10 years that includes the subprime crisis as well as the European sovereign debt crisis, we find that investors appear to migrate from low risk government bonds to stocks in calm periods and in the opposite direction when markets are in turmoil. On the other hand, government bonds of high risk countries lose their "safe-asset" status during the recent sovereign debt crisis and have exhibited more equity-like behaviour since then, with positive and strongly significant co-movements relative to the stock market as well as abnormally high levels of volatility. The new segmentation of the government bond market appears to generate substantial additional diversification opportunities for investors with low risk appetite, such as pension funds and pure fixed income traders.

Both credit and liquidity risks are important factors in explaining the variation of sovereign bond returns. Credit risk can explain as much as 43% of the variation in bond prices and behaves differently depending on the perceived creditworthiness of the country. If the country has a low probability of default, then credit impacts positively bond returns. For high risk countries the impact is negative which suggests a flight-to-safety. The other main risk factor, liquidity risk, seems to affect only distressed countries.

Over the last two years of our sample period, 2012 and 2013, the European sovereign bond market shows signs of recovery. The 5-year sovereign CDSs and proportional bid-ask spreads for each country in our sample have decreased to levels observed before the start of the sovereign debt crisis. Liquidity risk seems to have largely disappeared probably due to sustained liquidity support offered by the European Central Bank to the banking sector. Italy is the only exception where the proportional bid-ask spread still has an effect, although diminished, on bond returns. On the other hand, although much more contained, the importance of the credit risk factor now

seems to have spread to non-peripheral countries such as Austria, Belgium and France. The picture that emerges is one where sovereign default risk is becoming more pervasive which calls for continued efforts on the part of governments and monetary authorities to keep a watchful eye.

Table I

Correlation of Sovereign Bond Returns and Equity Returns

This table shows the signs of the correlations between sovereign bond returns and local stock returns for low and high risk countries over time. Low risk countries include Germany, Netherlands and Finland. High risk countries comprise Italy, Spain, Portugal Ireland and Greece. Pre-crisis denotes the period from 01 Apr 2003 to 31 Aug 2007, subprime crisis from 01 Sep 2007 to 31 Dec 2009, sovereign debt crisis I from 01 Jan 2010 to 30 Dec 2011 and sovereign debt crisis II from 01 Jan 2012 to 31 Dec 2013.

	Pre-crisis	Subprime crisis	Sovereign Debt Crisis I	Sovereign Debt Crisis II
Low Risk Countries	–	–	–	–
High Risk Countries	–	–	+	+

Table II

Summary Statistics for Sovereign Bond Returns and Equity Returns

The table shows the daily averages and standard deviations of sovereign bond and equity returns for each country in our sample. The pre-crisis covers the time period from 01 Apr 2003 until 31 Aug 2007. The subprime crisis period denotes the time period between 01 Sep 2007 and 31 Dec 2009. The first part of the sovereign debt crisis goes from 01 Jan 2010 to 30 Dec 2011 and the second part between 01 Jan 2012 to 31 Dec 2013. All descriptive statistics are expressed in basis points. The following representative stock market indices are used for each country in our sample: DAX (30 stocks, Germany), AEX (25 stocks, Netherlands), OMX Helsinki (25 stocks, Finland), CAC (40 stocks, France), ATX (20 stocks, Austria), BEL (20 stocks, Belgium), MIB (40 stocks, Italy), IBEX (35 stocks, Spain), PSI (20 stocks, Portugal), ISEQ (20 stocks, Ireland), ATHEX (20 stocks, Greece).

Panel A: Sovereign Bond Returns

	Pre-crisis period		Subprime crisis period		Sovereign crisis period I		Sovereign crisis period II	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Germany	-0.3	21.6	1.0	38.3	1.5	40.0	-0.6	33.9
Netherlands	-0.4	25.3	1.2	39.2	1.6	42.3	-0.4	34.9
Finland	-0.5	18.0	1.1	26.6	0.6	27.6	-0.7	30.8
France	-0.3	25.3	1.3	39.2	0.6	44.6	0.1	34.6
Austria	-0.6	24.2	0.9	41.6	1.1	41.9	0.0	41.9
Belgium	-0.4	26.6	1.2	37.3	-0.1	47.4	1.4	33.8
Italy	-0.4	22.1	1.0	32.2	-2.4	59.5	2.8	51.5
Spain	-0.4	24.4	0.8	40.2	-0.8	65.0	1.6	65.1
Portugal	-0.6	21.3	1.0	38.4	-8.6	109.4	8.9	111.1
Ireland	-0.1	24.1	0.5	40.7	-2.1	113.7	7.3	261.5
Greece	-0.5	22.3	-0.4	45.7	-10.5	192.1	NA	NA

Panel B: Equity Index Returns

	Pre-crisis period		Subprime crisis period		Sovereign crisis period I		Sovereign crisis period II	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Germany	9.6	106.4	-3.2	193.1	-0.3	150.5	8.4	104.8
Netherlands	7.2	97.1	-5.2	209.6	-0.5	134.2	5.2	90.1
Finland	9.8	91.1	-5.0	206.4	0.5	164.7	8.0	123.4
France	7.4	91.5	-4.0	201.0	-2.9	163.8	6.5	115.3
Austria	12.8	98.1	-6.9	246.0	-4.0	165.4	6.4	118.4
Belgium	9.0	78.6	-7.1	184.8	-2.6	140.5	7.0	97.5
Italy	5.8	77.0	-6.7	201.1	-6.6	185.2	5.6	154.2
Spain	8.5	83.0	-1.5	194.2	-4.7	181.4	3.9	148.4
Portugal	8.4	60.4	-6.1	158.4	-7.2	145.6	4.1	116.4
Ireland	6.9	89.4	-13.3	257.5	1.1	143.2	9.1	92.4
Greece	12.2	109.2	-10.6	237.0	-24.2	266.5	10.6	262.5

Table III

Regressions of Excess Sovereign Bond Returns on Excess Stock Market Returns

This table reports excess stock market return betas estimated with the following pooled regression model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{EQT}\left(EQT_{cr,t} - RECB_t\right) + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ represents the return mid-price at time t of bond i issued by country cr, $EQT_{cr,t}$ is the equity index return, and $RECB_t$ represents the 3 month ECB yield. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations, demeaned at the bond level. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. Adjusted-R^2s are presented below each coefficient. For brevity, the coefficients for the constant are not reported.

	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
Germany	−0.023 ***	−0.061 ***	−0.101 ***	−0.078 ***
	1.26%	11.04%	19.20%	7.24%
Netherlands	−0.033 ***	−0.065 ***	−0.120 ***	−0.059 ***
	1.40%	13.05%	17.79%	3.14%
Finland	−0.018 ***	−0.050 ***	−0.068 ***	−0.039 ***
	1.40%	14.77%	16.99%	2.88%
France	−0.034 ***	−0.067 ***	−0.073 ***	0.004
	1.89%	12.76%	8.61%	0.02%
Austria	−0.029 ***	−0.044 ***	−0.059 ***	0.004
	1.74%	6.79%	6.37%	0.02%
Belgium	−0.039 ***	−0.063 ***	0.013	0.030 **
	1.40%	10.26%	0.16%	0.93%
Italy	−0.020 **	−0.027 ***	0.094 ***	0.168 ***
	0.54%	3.17%	12.53%	28.13%
Spain	−0.029 ***	−0.059 ***	0.096 ***	0.180 ***
	1.10%	8.38%	9.44%	18.53%
Portugal	−0.029 ***	−0.063 ***	0.152 ***	0.211 ***
	0.67%	6.44%	5.80%	7.67%
Ireland	−0.027 ***	−0.023 ***	0.090 ***	0.053 ***
	1.17%	2.22%	1.55%	0.86%
Greece	−0.018 ***	0.001	0.190 ***	NA
	0.92%	0.00%	9.67%	NA

Table IV

Regressions of Excess Sovereign Bond Returns on Changes in 5-year CDS Spreads

This table reports the coefficients of changes in 5-year CDS spreads estimated with the following pooled regression model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{CDS}\Delta CDS_{cr,t} + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ represents the mid-price return at time t of bond i issued by country cr, $\Delta CDS_{cr,t}$ refers to the change of the country specific 5 year CDS spread, and $RECB_t$ represents the 3 month ECB yield. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. Adjusted-R^2s are presented below each coefficient. For brevity, the coefficients for the constant are not reported.

	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
Germany	−0.215	3.559 ***	4.626 ***	3.746 ***
	0.00%	2.47%	10.92%	4.51%
Netherlands	−1.775	1.696 ***	3.716 ***	1.576 ***
	0.05%	1.15%	6.99%	1.25%
Finland	5.585 *	1.466 **	3.943 ***	2.582 ***
	0.49%	0.80%	6.63%	1.11%
France	−4.274 **	2.779 ***	0.567	−1.000 ***
	0.68%	1.65%	0.53%	1.73%
Austria	−1.121	0.418	0.616	−1.382 ***
	0.02%	0.22%	0.61%	1.63%
Belgium	−1.480	0.800	−1.551 ***	−1.947 ***
	0.08%	0.36%	9.19%	7.96%
Italy	−0.561	−0.198	−2.004 ***	−2.937 ***
	0.06%	0.05%	32.01%	42.69%
Spain	−0.194	0.472	−2.354 ***	−3.512 ***
	−0.01%	0.17%	32.31%	40.44%
Portugal	−0.218	0.119	−1.772 ***	−2.411 ***
	−0.01%	0.00%	22.03%	34.13%
Ireland	NA	−0.766 ***	−2.587 ***	−1.693 ***
	NA	1.90%	21.13%	5.56%
Greece	0.690	−1.706 ***	−2.048 ***	NA
	0.08%	5.34%	21.25%	NA

Table V

Regressions of Excess Sovereign Bond Returns on Changes in Bid-Ask Spreads

This table reports the coefficients of sovereign bond returns' bid-ask spreads estimated with the following pooled regression model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{SPR}\Delta Spr_{i,cr,t} + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ represents the mid-price return at time t of bond i issued by country cr, $\Delta Spr_{i,cr,t}$ refers to the change of the bond specific proportional bid-ask spread, and $RECB_t$ represents the 3 month ECB yield. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. Adjusted-R^2s are presented below each coefficient. For brevity, the coefficients for the constant are not reported.

	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
Germany	−0.996	0.088	−0.349	0.060
	0.03%	0.01%	0.05%	0.00%
Netherlands	−0.215	−0.195	0.411	0.327
	−0.01%	0.04%	0.17%	0.06%
Finland	1.930	−0.070	0.300	−0.113
	0.08%	0.00%	0.29%	−0.01%
France	−0.871	0.049	0.067	0.197
	0.03%	0.00%	0.00%	0.05%
Austria	−0.722	−0.068	−0.006	−0.082
	0.02%	0.04%	−0.01%	0.05%
Belgium	−0.066	−0.125	**−0.239** **	−0.183
	−0.01%	0.02%	0.85%	0.08%
Italy	−1.404	−0.280	**−0.549** ***	**−0.737** **
	0.05%	0.18%	4.15%	1.02%
Spain	−1.789	**−0.363** **	**−0.222** *	−0.147
	0.10%	0.42%	0.84%	0.19%
Portugal	−0.473	**−0.353** ***	**−0.098** ***	−0.011
	0.00%	0.67%	3.14%	0.20%
Ireland	1.991	**−0.285** **	**−0.184** ***	0.013
	0.11%	1.17%	3.80%	0.08%
Greece	−0.653	**−0.105** **	**−0.059** ***	NA
	0.02%	0.61%	0.76%	NA

Table VI

Determinants of Excess Sovereign Bond Returns by Country Group

This table reports pooled regression coefficients for the following model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{EQT}(EQT_{i,cr,t} - RECB_t) + \beta_{CDS}\Delta CDS_{cr,t} + \beta_{SPR}\Delta Spr_{i,cr,t} + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ denotes the mid-price return for bond i issued by country cr at time t, $RECB_t$ represents the 3 month ECB yield, $EQT_{i,cr,t}$ is the country specific stock index return, $\Delta CDS_{cr,t}$ is the change in country specific 5 year CDS spreads, $\Delta Spr_{i,cr,t}$ is the change in bond specific proportional bid-ask spread. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. For brevity, the coefficients for the constant are not reported.

	Panel A: Low Risk Countries (Germany, Netherlands and Finland)				Panel B: Medium Risk Countries (France, Austria and Belgium)			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**−0.024** ***	**−0.059** ***	**−0.087** ***	**−0.057** ***	**−0.033** ***	**−0.060** ***	**−0.097** ***	**−0.017** *
β_{CDS}	−0.286	0.893	**1.483** ***	**1.513** ***	**−2.389** *	−0.381	**−1.913** ***	**−1.649** ***
β_{SPR}	−0.592	−0.235	−0.265	−0.097	−0.685	−0.130	**−0.170** *	0.018
Adj-R^2	1.29%	12.13%	19.09%	6.14%	1.91%	10.29%	9.78%	3.57%
Per/Cross-sec	*643/73*	*609/84*	*513/98*	*507/111*	*722/68*	*609/75*	*513/86*	*507/108*
#Obs	*30,480*	*35,932*	*36,737*	*43,697*	*33,323*	*37,427*	*36,464*	*42,723*
	Panel C: High Risk Countries (Italy, Ireland, Spain and Portugal)				Panel D: Greece			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**−0.024** ***	**−0.045** ***	**−0.019** *	**0.053** ***	**−0.018** ***	**−0.018** ***	**0.076** ***	NA
β_{CDS}	−0.450	**−0.877** ***	**−2.156** ***	**−2.515** ***	0.669	**−1.970** ***	**−1.780** ***	NA
β_{SPR}	−1.414	**−0.369** ***	**−0.089** ***	0.003	−0.643	**−0.082** **	−0.013	NA
Adj-R^2	0.82%	6.14%	26.98%	36.89%	1.01%	6.55%	22.51%	NA
Per/Cross-sec	*722/81*	*609/105*	*513/119*	*507/140*	*722/26*	*609/26*	*472/24*	*NA*
#Obs	*41,655*	*45,175*	*50,435*	*54,419*	*13,721*	*12,359*	*7,269*	*NA*

Table VII

Determinants of Excess Sovereign Bond Returns with Orthogonalized Credit Factor

This table reports pooled regression coefficients for the following model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{EQT}\left(EQT_{i,cr,t} - RECB_t\right) + \beta_{CDSO}\Delta CDSO_{cr,t} + \beta_{SPR}\Delta Spr_{i,cr,t} + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ denotes the mid-price return for bond i issued by country cr at time t, $RECB_t$ represents the 3 month ECB yield, $EQT_{i,cr,t}$ is the country specific stock index return, $\Delta CDSO_{cr,t}$ is the change in country specific 5 year CDS spreads orthogonalized with respect to the other regressors, $\Delta Spr_{i,cr,t}$ is the change in bond specific proportional bid-ask spread. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. For brevity, the coefficients for the constant are not reported.

	Panel A: Low Risk Countries (Germany, Netherlands and Finland)				Panel B: Medium Risk Countries (France, Austria and Belgium)			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**–0.024** ***	**–0.061** ***	**–0.101** ***	**–0.068** ***	**–0.033** ***	**–0.059** ***	**–0.052** ***	0.010
β_{CDSO}	–0.286	0.893	**1.483** ***	**1.513** ***	**–2.389** *	–0.381	**–1.913** ***	**–1.649** ***
β_{SPR}	–0.600	–0.228	–0.255	–0.064	–0.704	–0.138	**–0.226** **	–0.030
Adj–R^2	1.29%	12.13%	19.09%	6.14%	1.91%	10.29%	9.78%	3.57%
Per/Cross-sec	*643/73*	*609/84*	*513/98*	*507/111*	*722/68*	*609/75*	*513/86*	*507/108*
#Obs	*30,480*	*35,932*	*36,737*	*43,697*	*33,323*	*37,427*	*36,464*	*42,723*
	Panel C: High Risk Countries (Italy, Ireland, Spain and Portugal)				Panel D: Greece			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**–0.024** ***	**–0.039** ***	**0.096** ***	**0.171** ***	**–0.018** ***	0.000	**0.187** ***	NA
β_{CDSO}	–0.450	**–0.877** ***	**–2.156** ***	**–2.515** ***	0.669	**–1.970** ***	**–1.780** ***	NA
β_{SPR}	–1.434	**–0.400** ***	**–0.115** ***	–0.009	–0.642	**–0.105** **	**–0.040** **	NA
Adj-R^2	0.82%	6.14%	26.98%	36.89%	1.01%	6.55%	22.51%	NA
Per/Cross-sec	*722/81*	*609/105*	*513/119*	*507/140*	*722/26*	*609/26*	*472/24*	*NA*
#Obs	*41,655*	*45,175*	*50,435*	*54,419*	*13,721*	*12,359*	*7,269*	*NA*

Table VIII

Descriptive Statistics of Bond and Stock Portfolios

This table presents the mean, standard deviation and correlations between four asset portfolios. LR_Stock and LR_Bond denote low risk stock and bond portfolios that include the stock market indices and average sovereign bond returns, respectively, of Germany, Finland and Netherlands. HR_Stock and HR_Bond are high risk stock and bond portfolios that include the stock market indices and average sovereign bond returns, respectively, of Italy, Spain, Portugal, Ireland and Greece. The mean return and standard deviation measures have been annualised from daily estimates. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013.

Panel A: Pre-crisis period

	Mean Return	Standard Deviation	Correlations		
			LR_Stock	HR_Stock	LR_Bond
LR_Stock	22.7%	16.8%			
HR_Stock	21.5%	12.1%	86.3%		
LR_Bond	−0.6%	3.5%	−25.8%	−19.7%	
HR_Bond	−0.8%	3.6%	−25.3%	−19.4%	99.3%

Panel B: Subprime crisis period

	Mean Return	Standard Deviation	Correlations		
			LR_Stock	HR_Stock	LR_Bond
LR_Stock	−11.8%	36.8%			
HR_Stock	−19.8%	34.8%	91.0%		
LR_Bond	2.7%	5.0%	−45.7%	−44.5%	
HR_Bond	1.4%	5.2%	−30.9%	−28.4%	87.9%

Panel C: Sovereign crisis period I

	Mean Return	Standard Deviation	Correlations		
			LR_Stock	HR_Stock	LR_Bond
LR_Stock	−0.2%	26.8%			
HR_Stock	−21.5%	28.8%	86.6%		
LR_Bond	3.5%	5.1%	−61.0%	−60.1%	
HR_Bond	−12.3%	13.0%	27.6%	45.0%	−19.6%

Panel D: Sovereign crisis period II

	Mean Return	Standard Deviation	Correlations		
			LR_Stock	HR_Stock	LR_Bond
LR_Stock	18.7%	18.7%			
HR_Stock	17.1%	21.5%	77.3%		
LR_Bond	−1.0%	4.3%	−35.6%	−33.5%	
HR_Bond	13.2%	8.9%	40.0%	42.1%	−17.6%

Table IX

Risk Reduction from Diversification

This table shows the reduction in investment funds' volatility and 99% Value-at-Risk relative to the average volatility and Value-at-Risk of the funds' constituent assets. All constituent assets are equally weighted. We build a pure equity fund by including indices from low and high risk countries, the pure bond fund has a combination of low and high risk sovereign bonds, the pension fund comprises low risk bonds and stocks, the aggressive growth/high yield fund holds high risk sovereign bonds and stocks, and the diversified fund is an equally weighted portfolio of high and low risk stocks and bonds. We denote as "low risk" assets issued by Germany, Finland and Netherlands and as "high risk" those issued by Italy, Spain, Portugal, Ireland and Greece. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013.

Panel A: Reduction in portfolio volatility				
	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
Diversified fund	24.7%	18.5%	22.8%	22.9%
Aggressive growth/high yield fund	23.8%	15.8%	12.6%	12.8%
Pension fund	20.0%	16.9%	24.7%	23.3%
Pure equity fund	3.4%	2.3%	3.4%	5.8%
Pure bond fund	0.2%	3.1%	28.2%	30.4%
Panel B: Reduction in portfolio 99% Value-at-Risk				
	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
Diversified fund	24.1%	15.7%	16.9%	22.0%
Aggressive growth/high yield fund	19.5%	13.7%	13.8%	13.9%
Pension fund	16.6%	16.0%	28.8%	19.7%
Pure equity fund	5.7%	2.2%	0.2%	–0.8%
Pure bond fund	–2.1%	7.0%	31.9%	35.0%

Table X

Aggregate Pooled Regressions by Country Group

This table shows pooled regression coefficients for the following model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{EQT}(EQT_{i,cr,t} - RECB_t) + \beta_{CDSO}\Delta CDSO_{cr,t} + \beta_{SPR}\Delta Spr_{i,cr,t} + \beta_{INTR}\Delta IntR_t + \beta_{LOIS}\Delta LOIS_t + \varepsilon_{i,cr,t}$$

where $RB_{i,cr,t}$ denotes the bond mid-price return at time t for bond i issued by country cr, $RECB_t$ represents the 3 month ECB yield, $EQT_{i,cr,t}$ is the country specific stock index return, $\Delta CDSO_{cr,t}$ is the change in country specific 5 year CDS spreads orthogonalized with respect to all the other regressors, $\Delta Spr_{i,c,t}$ is the change in bond specific proportional bid-ask spread, $\Delta IntR_t$ is the change in the international risk factor, and $\Delta LOIS_t$ is the change in the Libor-OIS spread. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level. We employ daily observations. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. For brevity, the coefficients for the constant are not reported.

	Panel A: Low Risk Countries (Germany, Netherlands and Finland)				Panel B: Medium Risk Countries (France, Austria and Belgium)			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**–0.018** ***	**–0.054** ***	**–0.093** ***	**–0.067** ***	**–0.027** ***	**–0.051** ***	**–0.045** ***	0.010
β_{CDSO}	–0.649	0.735	**1.207** **	**1.415** ***	–1.589	–0.439	**–2.010** ***	**–1.694** ***
β_{SPR}	–0.871	–0.252	–0.294	–0.103	–0.872	–0.160	**–0.239** ***	–0.055
β_{INTR}	**–0.966** ***	**–0.566** ***	0.308	–0.129	**–1.311** ***	**–0.711** ***	–0.119	0.329
β_{LOIS}	**3.874** ***	**1.221** ***	**2.241** ***	**4.645** ***	**4.519** ***	**1.420** ***	**2.385** ***	**4.303** **
Adj-R^2	7.16%	14.22%	20.74%	7.00%	8.23%	13.00%	11.94%	4.60%
Per/Cross-sec	*643/73*	*609/84*	*513/98*	*507/111*	*722/68*	*609/75*	*513/86*	*507/108*
#Obs	*30,480*	*35,932*	*36,737*	*43,697*	*33,323*	*37,427*	*36,464*	*42,723*
	Panel C: High Risk Credit Countries (Italy, Ireland, Spain and Portugal)				Panel D: Greece			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT}	**–0.019** **	**–0.033** ***	**0.099** ***	**0.171** ***	**–0.016** ***	0.005	**0.186** ***	NA
β_{CDSO}	–0.047	**–0.951** ***	**–2.178** ***	**–2.516** ***	0.752	**–1.978** ***	**–1.791** ***	NA
β_{SPR}	**–1.444** *	**–0.428** ***	**–0.116** ***	–0.009	–0.723	**–0.104** **	**–0.040** **	NA
β_{INTR}	**–1.121** ***	**–0.669** ***	0.347	0.228	**–1.082** ***	**–0.719** ***	–1.018	NA
β_{LOIS}	**3.970** ***	**1.242** ***	0.825	–2.338	**3.698** ***	**1.146** ***	–0.213	NA
Adj-R^2	6.94%	8.88%	27.36%	36.90%	7.37%	8.50%	22.53%	NA
Per/Cross-sec	*722/81*	*609/105*	*513/119*	*507/140*	*722/26*	*609/26*	*472/24*	*NA*
#Obs	*41,655*	*45,175*	*50,435*	*54,419*	*13,721*	*12,359*	*7,269*	*NA*

Table XI

Correlation of Excess Sovereign Bond Returns and the Term Factor

This table reports the correlation of the term factor, and its long term component, with country specific excess sovereign bond returns. The term factor is the difference between the return of a sovereign bond portfolio with a 10 year average maturity and the 3 month ECB rate. The term factor's long term component is the return of the sovereign bond portfolio with a 10 year average maturity. Short, medium and long denote bonds with a remaining time-to-maturity of less than 3 years, between 3 and 7 years, and above 7 years, respectively.

	Term Factor			Term Factor's Long Term Component		
	Short Maturity	Medium Maturity	Long Maturity	Short Maturity	Medium Maturity	Long Maturity
Germany	57.44%	89.19%	90.79%	57.45%	89.19%	90.78%
Netherlands	55.09%	88.50%	89.44%	55.08%	88.48%	89.42%
Finland	57.40%	85.93%	93.65%	57.36%	85.92%	93.59%
France	57.89%	87.02%	87.54%	57.87%	87.01%	87.51%
Austria	51.27%	83.33%	88.22%	51.26%	83.33%	88.20%
Belgium	56.07%	82.69%	86.53%	56.07%	82.69%	86.53%
Italy	68.14%	90.49%	92.07%	68.12%	90.48%	92.07%
Spain	64.31%	88.94%	91.68%	64.29%	88.94%	91.67%
Portugal	60.47%	83.52%	85.66%	60.46%	83.52%	85.66%
Ireland	48.94%	72.67%	83.81%	48.94%	72.67%	83.81%
Greece	42.81%	65.68%	54.29%	42.92%	65.69%	54.28%

Table XII

Maturity Effects

This table reports pooled regression coefficients for the following model:

$$RB_{i,cr,t} - RECB_t = c + \beta_{EQT_S}(EQT_{i,cr,t} - RECB_t) * DUM_{SML} + \beta_{EQT_M}(EQT_{i,cr,t} - RECB_t) * DUM_{MED} + \beta_{EQT_L}(EQT_{i,cr,t} - RECB_t) * DUM_{LNG} + \beta_{CDSO}\Delta CDSO_{cr,t} + \beta_{SPR}\Delta Spr_{i,cr,t} + \varepsilon_{i,cr,t}$$

where $RB_{i,c,t}$ denotes the mid-price return for bond i issued by country c at time t, $RECB_t$ represents the 3 month ECB yield, $EQT_{i,c,t}$ is the country specific stock index return, $\Delta CDSO_{cr,t}$ is the change in country specific 5 year CDS spreads orthogonalized with respect to all the other regressors, $\Delta Spr_{i,c,t}$ is the change in bond specific percentage bid-ask spread. We employ daily observations. For each sub-period, regressions variables are winsorized at 1% and 99% taking into account all time-series observations demeaned at the bond level. Sub-periods are 09 Sep 2004 to 31 Aug 2007 for the pre-crisis, 01 Sep 2007 and 31 Dec 2009 for the subprime crisis; the sovereign crisis is split into two parts, 01 Jan 2010 to 30 Dec 2011 and between 01 Jan 2012 to 31 Dec 2013. White cross-section standard errors and covariance are used. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. For brevity, the coefficients for the constant are not reported.

	Panel A: Low Risk Countries (Germany, Netherlands and Finland)				Panel B: Medium Risk Countries (France, Austria and Belgium)			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT_S}	**−0.006** ***	**−0.020** ***	**−0.019** ***	**−0.006** ***	**−0.007** ***	**−0.020** ***	**−0.007** *	**0.004** *
β_{EQT_M}	**−0.027** ***	**−0.066** ***	**−0.089** ***	**−0.045** ***	**−0.031** ***	**−0.058** ***	**−0.028** ***	**0.014** *
β_{EQT_L}	**−0.045** ***	**−0.099** ***	**−0.215** ***	**−0.142** ***	**−0.048** ***	**−0.076** ***	**−0.107** ***	0.010
Adj-R^2	1.91%	15.60%	30.94%	10.39%	2.33%	11.60%	12.58%	3.59%
Per/Cross-sec	*643/73*	*609/84*	*513/98*	*507/111*	*722/68*	*609/75*	*513/86*	*507/108*
#Obs	*30,480*	*35,932*	*36,737*	*43,697*	*33,323*	*37,427*	*36,464*	*42,723*
	Panel C: High Risk Countries (Italy, Ireland, Spain and Portugal)				Panel D: Greece			
Coefficient	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II	Pre-crisis period	Subprime crisis period	Sovereign crisis period I	Sovereign crisis period II
β_{EQT_S}	**−0.007** ***	**−0.016** ***	**0.052** ***	**0.068** ***	**−0.005** ***	−0.001	**0.117** ***	NA
β_{EQT_M}	**−0.026** ***	**−0.043** ***	**0.099** ***	**0.176** ***	**−0.016** ***	−0.001	**0.209** ***	NA
β_{EQT_L}	**−0.038** ***	**−0.052** ***	**0.130** ***	**0.260** ***	**−0.031** ***	0.004	**0.218** ***	NA
Adj-R^2	1.03%	6.85%	27.76%	40.77%	1.35%	6.55%	22.99%	NA
Per/Cross-sec	*722/81*	*609/105*	*513/119*	*507/140*	*722/26*	*609/26*	*472/24*	*NA*
#Obs	*41,655*	*45,175*	*50,435*	*54,419*	*13,721*	*12,359*	*7,269*	*NA*

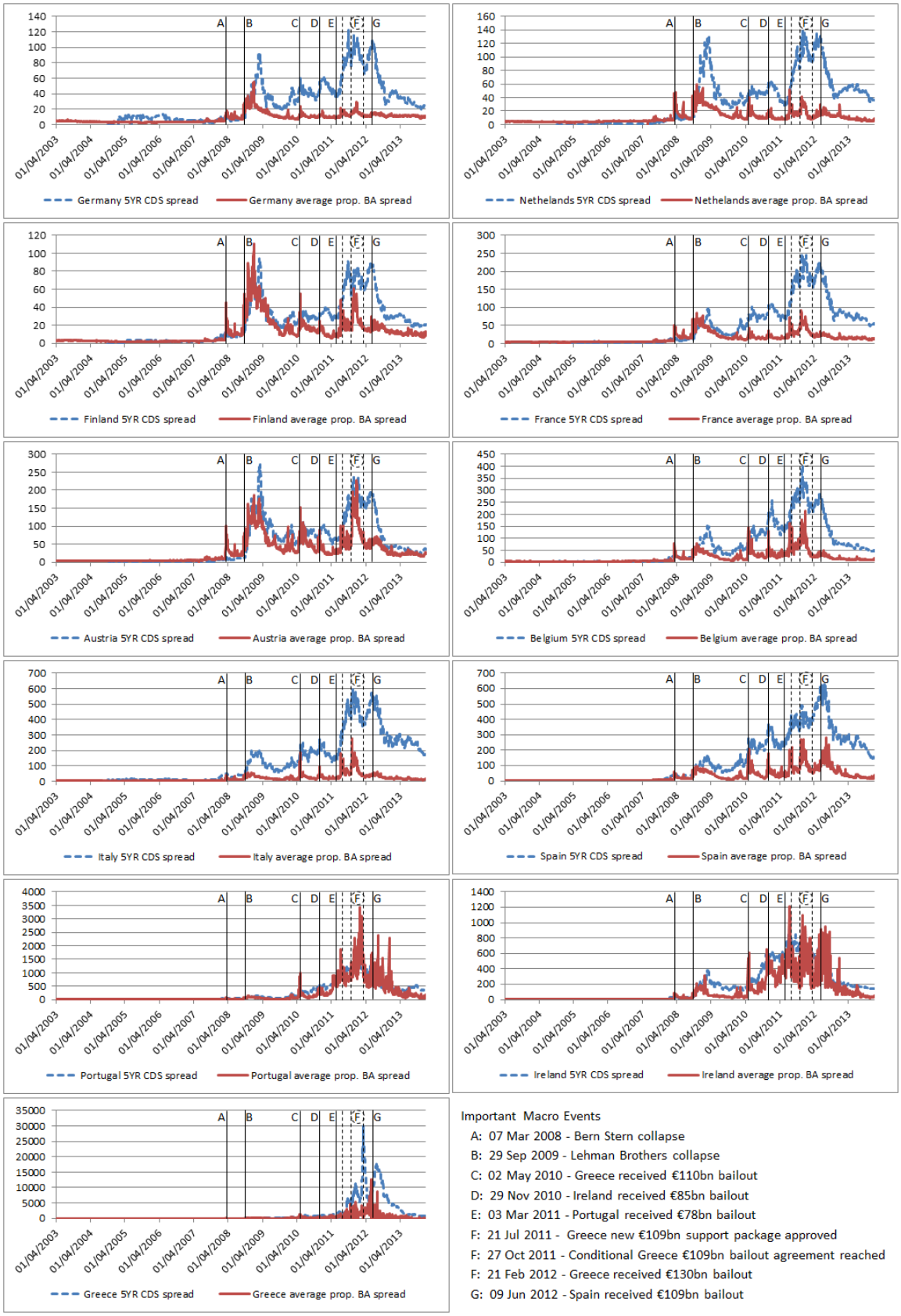

Figure 1. Individual country 5-year CDS spreads and average proportional bid-ask spreads.

This figure shows the daily 5-year CDS spreads and proportional bid-ask spreads for each Eurozone country from Aug 2003 to Dec 2013. All values are expressed in basis points. The vertical lines represent major global events.

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