On the distribution of European government bond returns: Empirical evidence

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Due to recent turbulence in the European debt capital market, one might question the consequences for investors. The benefits of international bond diversification have been extensively researched; however, far less is known about the bond return distributions of debt capital markets that are essential in fixed income management. In this paper we close that literature gap and examine which distribution assumptions hold for European government bond returns in the period from 1999 to 2011. Returns of government bonds of several European countries, inside and outside the EMU, are analysed. We fit the data to the Gaussian, Student's t, skewed Student's t and stable distribution. For sovereign risk free countries we find that the Gaussian distribution is sufficient to fit the data. Since the sovereign risky government bond returns are skewed and heavy tailed, the Gaussian distribution is not sufficiently flexible. Therefore, we suggest the using the skewed Student's t or the stable distribution to model these bonds. The results are robust to a variety of goodness of fit statistics.

Keywords: sovereign bond, government bond, government debt, skewed and heavy-tailed distribution, EMU

JEL–class.: G12, H63, C46

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Abstract

Due to recent turbulences in the European debt capital market, one might ask for consequences for investors. Extensive research has been done on the benefits of international bond diversification. However, far less is known about the bond return distributions of debt capital markets what is essential in fixed income management. We close that literature gap and examine which distribution assumptions hold for European government bond returns in the period from 1999 to 2011. Returns of government bonds of several European countries, inside and outside the EMU, are analysed. We fit the data to Gaussian, Student's t, skewed Student's t and stable distributions. For sovereign risk free countries we find that the Gaussian distribution is sufficient to fit the data. Since the sovereign risky government bond returns are skewed and heavy tailed, the Gaussian distribution is not flexible enough. Therefore, we suggest the use of the skewed Student's t or the stable distribution to model these bonds. The results are robust to a variety of goodness of fit statistics.

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1 Introduction

In the period prior to the establishment of the European Monetary Union (EMU), yields for Euro denominated government bonds converged (see Adam et al., 2002) and prices harmonised. Government bond spreads of EMU countries which had formerly issued sovereign bonds vanished after the introduction of the EMU. Sovereign risk (see Bernoth et al. (2004), Sgherri and Zoli (2009)) was not recognized by investors. In the present Euro crisis, this sovereign risk plays a key role and causes divergence of the yields of non sovereign risk and sovereign risk countries. A second effect of the introduction of the EMU is the significant growth of the Euro bond market (see Pagano and von Thadden, 2004). The ECB (2004) states two reasons for this development. Firstly, improvements in the budgetary balances have led to low net borrowing costs. Secondly, greater transparency in bond issuance has resulted in a highly liquid Euro bond market. The presence of sovereign risk in European government bonds and significant growth of the European bond market has forced investors to improve their risk management for European government bonds.

It is well known that the first two moments are not sufficient to describe investors' utility.[1] Owing to limited positive returns of bonds (in contrast to equities) and a potentially unlimited loss of the nominal value, looking at

[1] 1Higher order moments are important for portfolio selection (see Arditti (1967), Arditti (1971) and Rubinstein (1973)). Empirical studies support the observation that returns are not normally distributed (see Fama (1965) and Arditti (1971)).

skewness in bond returns is intuitive.[2] Although the origin of excess kurtosis in bond returns is less intuitive, it is equally important in risk management (i.e. for VaR calculations). In order to support this intuition, Table 1 shows the skewness and kurtosis for sovereign risky and sovereign risk free European government bond returns. One year sovereign risk free bonds have slightly right skewed and heavy-tailed returns. The sovereign risky bonds of all maturities exhibit significant left skewness and excess kurtosis. This skewness and excess kurtosis in bond returns motivates our choice of tested distributions.

[insert Table 1 about here]

In our study, we empirically test the characteristics of single European government bond returns with maturities of (1,) 3, 5 and 10 years in the period 1999 to 2011. Special attention is paid to skewness and excess kurtosis caused by sovereign risk. The significant rise of spreads in 2008 leads to the conclusion that we have a structural break in the data. Hence, we study the period of the recent Euro crisis (2008-2011) separately. We test the assumption of normal, Student's t, skewed Student's t and stable distributed returns, to match the skewed and heavy-tailed government bond returns. Finally, we perform a variety of goodness of fit statistics to support the statistical significance of our findings.

The first string of literature to which the present paper relates is the vast body of research on security return distributions. This literature is concerned

[2] See Gupton et al. (1997) and Basel Committee (1999, p.27).

mostly with equity returns. Beginning with Mandelbrot (1963), all these papers have in common the fact that they reject the Gaussian distribution assumption as a hypothesis for financial returns. Because of its ability to exhibit heavy tails, there is empirical evidence that the Student's t distribution will provide a reasonable fit for financial returns.[3] The skewed Student's t distribution is often used in modeling financial data, because it is able to handle skewness and excess kurtosis (see Harris and Küçükömzmen, 2001).[4] Since stable distributions can also capture skewness and kurtosis, there exist a significant number of papers that suggest the usage of stable distributions for modeling equity returns. Höchstötter et al. (2005) even find that the stable distribution outperforms the skewed Student's t distribution in fitting returns of German stocks (DAX).[5] Rachev et al. (2003) are the only ones to have studied bond returns. They describe indices of US corporate bond returns with the stable distribution.

The second string of literature, driven by central bank research, is concerned with international bond markets. Cappiello et al. (2003) and Christiansen (2007) find an almost perfect correlation between US and European government bonds. Volatility spillover effects in the period of 1991 to 2002 are reported by Skintzi and Refenes (2006). The focus of our paper is on the

[3]See e.g. Aparicio and Estrada (2001) (European stock markets), Peiró (1994) (stock markets worldwide) or Blattberg and Gonedes (1974) (US stock market).

[4]The skewed Student's t distribution was proposed by Hansen (1994). Further application to stock returns is discussed by Jondeau et al. (2007).

[5]5Further application of the stable distribution is, for instance, provided by Rachev et al. (2005) (US stock market), Kanellopoulou and Panas (2008) (French stock market) and Höchstötter (2006) (German stock market).

Euro government bond market. Côté and Graham (2004) find strong harmonisation of long term government bond yields caused by the introduction of the EMU. Finally, our paper is closely related to the study by Laopodis (2008) in this string of literature. He examines Euro and non-Euro 10 year government bond returns prior to and post EMU integration in the period 1995 to 2006. He also describes their higher order moments but does not offer any application for bond return distributions. The EMU brought risk into government bonds, something which was formerly encountered only in sovereign bonds. Bernoth et al. (2004) and Sgherri and Zoli (2009) study this sovereign risk characteristic of European government bonds prior to the EMU and during the financial crisis, respectively.

The present paper contributes to the existing literature in three essential ways. To the best of our knowledge, we are the first to test a variety of distributions to match skewness and excess kurtosis in government bond returns. Secondly, we differ from other work in this area, by explicitly investing in single government bonds of single maturities instead of using indices. These indices cluster the duration as well as the rating, which produces a blurred view of interest rate and sovereign risk. Thirdly, we perform a variety of goodness of fit statistics in order to test the robustness of our findings.

The remainder of the paper is organized as follows: in section 2 we give an overview of the government bond data under consideration. In section 3 we outline the empirical study. After motivating and defining the distributions in subsection 3.1, we present the results for the period of the European Monetary Union and for the period of the present Euro crisis in subsections 3.2 and 3.3, respectively. Section 4 concludes the paper. The results of non Euro government bond data are provided in the appendix.

2 Data

In an effort to shed some light on Euro government bond characteristics, we investigate several zero coupon bonds of EMU members. The data is provided by each central bank. In order to explain skewness and excess kurtosis, we attempt to identify sovereign and interest rate risk as risk driving factors. Therefore we split the dataset into two dimensions. Firstly, the countries are clustered as either bearing sovereign risk or as being sovereign risk free. Secondly, single bonds with different maturities are tested to report duration[6] as a measure of interest rate risk. Our dataset consists of government bonds from Germany, France, Greece, Italy, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. Germany and, in particular, France, are not totally free of sovereign risk. However, they are close to sovereign risk free. In the following discussion, we consider both countries to be sovereign risk free. Greece, Italy, Portugal and Spain are classified as sovereign risk bearing. This will offer a clearer idea of whether skewness is caused exclusively by sovereign risk. In order to correct for effects that

[6]Since we look at single zero coupon bonds, maturity and duration are equivalent. Therefore, we do not explicitly report the durations.

are caused by EMU membership or the Euro currency we include Sweden, Switzerland and the United Kingdom and the United States.

Secondly, we explicitly study single government bonds of these countries with different maturities. Bonds with different durations will help in identifying the contribution of sovereign risk to skewness and excess kurtosis.

Our dataset consists of government bonds with (1,) 3, 5 and 10 years to maturity.[7] The observations are monthly, starting in January 1999 and continuing to the end of November 2011. The beginning of the period is the moment at which the exchange rates for the EMU were fixed and exchange rate risk de facto no longer existed. This results in an overall dataset of 5364 data points.

In order to fix the $(1,)3,5$ and 10 year maturities over the period under consideration we use synthetic rather than traded bonds. These bond yields are calculated using the Svensson (1994) Model which is standard for EMU countries.[8] The yield curve function is specified by the six parameters $\beta_0, \beta_1, \beta_2, \beta_3, \tau_1$ and τ_2. The spot rate $y(T)$ for a zero coupon bond maturing at T reads:

$$y(T) = \beta_0 + \beta_1 \frac{1 - e^{-\frac{T}{\tau_1}}}{\frac{T}{\tau_1}} + \beta_2 \left(\frac{1 - e^{-\frac{T}{\tau_1}}}{\frac{T}{\tau_1}} - e^{-\frac{T}{\tau_1}}\right) + \beta_3 \left(\frac{1 - e^{-\frac{T}{\tau_2}}}{\frac{T}{\tau_2}} - e^{-\frac{T}{\tau_2}}\right).$$

There are important central banks which use other interpolation methods for yield curve smoothing such as splines (FED). Nevertheless BIS (2005)

[7]Only the government bond data of Germany, France, Spain, Switzerland, UK and US include a bond maturing after one year:

[8]The central banks of Germany, France, Italy, Spain, Sweden and Switzerland fit the yield curve with Svensson (1994). UK uses Variable Roughness Penalty and the US uses smoothing splines (see BIS, 2005). There is no information available on which yield curve fitting method is used by Portugal and Greece.

states that the difference in estimation error are only noticeable for very short (<<1 Year) or very long (>>10 years) maturities. Since we study bonds with $(1,)3,5$ and 10 years to maturity, the yield curve fitting method does not contribute significantly to the estimation error.

3 Empirical Study

Having outlined the government bond data, section 33 presents the results of the empirical study. After motivating the use of more sophisticated distributions than the normal distribution, subsection 3.1 defines the distributions under consideration. Subsection 3.2 presents the results of the empirical study of the period from 1999 to 2011. The results for the period of the Euro crisis are provided in subsection 3.3.

[insert Table 2 about here]

Table 2 shows the mean, variance, skewness and kurtosis of the bond returns of Germany, France, Greece, Italy and Portugal for all analyzed maturities. The mean of all bond returns is close to zero. Generally, bond returns with a longer maturity show a higher variance, which is caused by greater exposure to interest rate and credit risk. We find very little evidence for skewness of returns of sovereign risk free countries in the one year maturity. Returns with a longer maturity are almost symmetrical. Secondly, we study bond returns in countries that are exposed to sovereign risk. Here, we find a strong left skewness. Similar features can be observed for the kurtosis: while the returns of Germany and France in the case of the longer maturities seem almost Gaussian, we find excess kurtosis in the returns with one year to maturity. The return data of sovereign risky countries, particularly Greece and Portugal, display significant excess kurtosis. In summary, there is strong empirical evidence that motivates the use of distributions allowing for excess kurtosis and skewness when describing European government bond returns.

3.1 Distributional Assumptions

Besides the normal and the Student's t distribution we consider the skewed Student's t and the stable distribution as possible candidates for describing government bond data. Normal distributions exhibit neither skewness nor heavy tails. There is empirical evidence (see Table 2) that excess kurtosis is a feature of government bond returns. The Student's t distribution is capable of modeling heavy tails. Let $2 < \eta < \infty$ be the degree of freedom of a Student's t distribution. The normal distribution is a special case of the Student's t distribution as η tends to infinity.

Table 2 illustrates the need to model skewness as well. By adding the parameter $-1 < \lambda < 1$ to the Student's t distribution, we get the skewed Student's t distribution that captures skewness and excess kurtosis. An λ close to the left (right) bound indicates left (right) skewness. The density of a skewed Student's t distribution (see Hansen, 1994) is given by

$$
g(z \mid \eta, \lambda) = \begin{cases} bc\left(1 + \frac{1}{\eta-2}\left(\frac{bz+a}{1-\lambda}\right)^2\right)^{-(\eta+1)/2} & z < -a/b \\ bc\left(1 + \frac{1}{\eta-2}\left(\frac{bz+a}{1+\lambda}\right)^2\right)^{-(\eta+1)/2} & z \geq -a/b \end{cases}
$$

with $a = 4\lambda c(\eta-2)/(\eta-1)$, $b^2 = 1 + 3\lambda^2 - a^2$ and $c = \frac{\Gamma((\eta+1)/2)}{\sqrt{\pi(\eta-2)}\Gamma(\eta/2)}$. The skewed Student's t distribution nests the Student's t distribution by setting $\lambda = 0$. The parameters are estimated with maximum likelihood (ML).

The (α-)stable distribution has four parameters: the index of stability (α), skewness- (β), scale- (γ) and location-parameter (δ). It can exhibit skewness and heavy tails as well. A closed form representation does not exist in general, but it is possible to give the characteristic function. A random variable X is called stable if its characteristic function is given by (e.g., Nolan (2001))

$$
E\exp(\mathrm{i}tX) = \begin{cases} \exp\left(-\gamma^\alpha |t|^\alpha \left[1 + \mathrm{i}\beta\left(\tan\frac{\pi\alpha}{2}\right)(\operatorname{sign} t)\left(|\gamma t|^{1-\alpha} - 1\right)\right] + \mathrm{i}\delta t\right), & \alpha \neq 1 \\ \exp\left(-\gamma |t| \left[1 + \mathrm{i}\beta\frac{2}{\pi}(\operatorname{sign} t)\ln(\gamma |t|)\right] + \mathrm{i}\delta t\right), & \alpha = 1 \end{cases}
$$

with $0 < \alpha \leq 2$, $-1 \leq \beta \leq 1$, $\gamma > 0$ and $\delta \in \mathbb{R}$. As $|\beta|$ gets bigger, so the distribution becomes more skewed. Lower numbers of α indicate heavy tails. As α tends to 2, the distribution becomes Gaussian and β loses its influence. Thus, in contrast to the skewed Student's t distribution, it is not possible to model non heavy-tailed, but skewed, data appropriately. The estimation of the parameters is done by using ML techniques (see DuMouchel (1971) and Nolan (2001)).

3.2 European Monetary Union

Table 3 shows the results of the parameter estimations.[9] We fitted the parameters of the normal, Student's t, skewed Student's t and stable distribution to the bond returns of Germany and France (Greece, Italy and Portugal) for maturities of 1, 3, 5 and 10 (3, 5 and 10) years. For German and French government bond data we find an increasing variance for longer maturities. In the one year maturity returns, the degrees of freedom are lower than in the Gaussian case. We calculate an α of 1.757 for the German data, and 1.722 for France, confirming the assumption of a leptokurtic behaviour from the beginning of this section. The skewness parameters β and λ show slightly right skewed returns. In the case of the longer maturities, α's close to 2 and high degrees of freedom together with λ's close to zero speak for the Gaussian hypothesis.

[insert Table 3 about here]

For the three countries with sovereign risk, the parameters suggest a rejection of the Gaussian hypothesis. In the case of Greece, in particular, low degrees of freedom and low α's indicate heavy tails for all maturities. High negative skewness parameters confirm the presence of left skewed returns. The estimations for Italian and Portuguese return data show similar features; they are less heavy tailed, though.

After calculating the parameters we can now assess the goodness of fit statis-

[9] See Table 9 in the appendix for the estimated parameters of bond returns of Spain, Sweden, Switzerland, UK and USA.

tics. We apply χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests. Owing to the partial lack of tabulation of critical values, we use simulation techniques as proposed in Borak et al. (2005) to calculate p-values and test-statistics for all distributions for the sake of consistency. The calculated p-value gives the probability that the data comes from the supposed distribution. In 4 the p-values of the χ^2-test for normal, Student's t, skewed Student's t and stable distribution are given for the bond returns of Germany, France, Greece, Italy and Portugal for all analyzed maturities.[10] For the one-year bond returns of Germany and France, distributions that exhibit skewness and excess kurtosis offer a better fit than the Gaussian distribution. This confirms our hypothesis that these kinds of returns are leptokurtic. When considering the longer maturities, we find that all distributions give similar fits in terms of goodness. Because there is neither skewness nor excess kurtosis in the data, Gaussian distributions are feasible. The only exception is Germany, where only poor results for ten-year bond returns for all distributions are given.

[insert Table 4 about here]

The goodness of fit results for government bond returns imply that sovereign risk is not as straightforward as in riskless cases. The Gaussian and Student's t distribution fail in describing the Greek and Portuguese data for every maturity. Only in the case of the three year maturity of Italian government bond

[10]We discuss only the results of the χ^2-test here. We get comparable results for KS, CM and AD test. Detailed results for every test and the remaining countries including p-value and test-statistics are provided in Table 11 and 12 in the appendix.

returns do we find evidence for the Gaussian distribution. There is a strong fit of the stable distribution and particularly of the skewed Student's t distribution for Greek bond returns. Both distributions give only a weak fit for the five year maturity exclusively. In the case of Portugal, both distributions, again in particular the skewed Student's t, are able to fit the characteristics of the data in all maturities, in contrast to non skewed distributions. When applied to the Italian data, both fits are sound for three and ten years but slightly weak for the five year maturity.

3.3 Euro Crisis

From an investor's perspective, the Euro crisis highlighted the existence of sovereign risk in Euro government bonds. When market circumstances changed, sovereign risky bond returns began to behave differently. As a consequence, spreads of sovereign risky government bonds rose significantly and yields diverged once again. This fact might lead one to conclude that there is a structural break in the time series under consideration. A graphical analysis suggests using May of 2008 as a possible breaking point, because this is the date on which the spreads began to diverge. We perform a Chow (1960) test for the EMU countries to verify this hypothesis and report the results in Table 5.

[insert Table 5 about here]

In the case of Greek and Portuguese bond returns in particular we find indications of a structural break in all maturities, while for countries without sovereign risk there is only evidence in the short maturity.

In the following, we split time series and study the period after the structural break which corresponds to the time of the Euro crisis. 6 reflects the estimated parameters of German, French, Greek, Italian and Portuguese government bond returns for this period. The one year to maturity bond returns of countries without sovereign risk are again leptokurtic. Considering the sovereign risky bonds, we find a marked negative mean, particularly for Greece. Generally, the return data is still skewed and heavy tailed. When comparing the skewness and tail parameter to the parameters of the original period, we find even greater skewness and excess kurtosis in the data.

[insert Table 6 about here]

Table 7 reports the p-values of the χ^2 test on normal, Student's t, skewed Student's t and stable distributions of the present data. The p-values refer only to the period after the breaking point with the null hypothesis that the empirical distribution equals the distributional assumption. Again, the results are similar to those from the original period. In general, Gaussian distributions cannot describe the features of sovereign risky bonds, whereas stable and skewed Student's t distributions can. The skewed Student's t distribution has a slightly superior fit. The results for KS, CM and AD tests can be found in Table 13 and 14 in the appendix.

[insert Table 7 about here]

We summarise our findings in Table 8. Sovereign risky government bond returns should be modeled with distributions that exhibit skewness and heavy tails. Except in the case of one year maturity, sovereign risk free government bonds can be described with the Gaussian distribution.

[insert Table 8 about here]

4 Conclusion

Prior to the introduction of the EMU, sovereign bond spreads vanished and debt financing costs for EMU countries levelled off. However, during the recent Euro crisis sovereign risk of government bonds of EMU countries once again became a concern for investors and spreads widened significantly.

The present paper is the first step in analyzing how this development might affect investors' government bond investment decisions. Firstly, we test a variety of distribution assumptions to capture the characteristics of government bond returns with and without sovereign risk for the period between 1999 and 2011. Our study shows that the returns of government bonds without sovereign risk and one year maturity is leptokurtic and can be described with distributions that exhibit skewness and excess kurtosis. For bonds with longer maturities, variance increases and returns become Gaussian. For government bond returns with sovereign risk we propose using distributions that can exhibit skewness and heavy tails. The skewed Student's t and the stable distribution fit the data equally well. Our findings are robust for a variety of test statistics. Secondly, we take account of the existence of a structural breaking point in May 2008. This second analysis confirms our results: irrespective of the period under consideration there is still a need to model sovereign risky bond returns with distributions that take skewness and heavy tails into account, while in most cases the Gaussian distribution satisfies non sovereign risky bond returns.

For a better understanding of how much explanatory power the sovereign risk factor in government bonds has, we intend to extract this from government bond yields. Therefore, we plan to look at sovereign spreads separately and (potentially) extract the skewness in government bond returns. This is work in progress. Since there are as yet only a few studies dealing with government bond return distributions, there are some open research topics. One interesting question is which distribution best suits the government returns in a portfolio framework and how co-skewness and co-kortosis affect the distribution assumption.

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		1	3	5	10
		short		long	
sovereign risk free	γ_1	1.06	0.23	0.06	0.13
	γ_2	5.99	3.11	2.52	2.90
sovereign risky	γ_1		-1.09	-1.66	-1.93
	γ_2		16.15	15.21	13.26

Table 1: Skewness and Kurtosis of Bond Returns

The table shows the skewness (γ_1) and kurtosis (γ_2) of European bond returns. As sovereign risk free, we pool German and French government bonds. As sovereign risky, we pool Greek, Portuguese and Italian government bonds. Normally distributed returns have zero skewness ($\gamma_1 = 0$) and a kurtosis of three ($\gamma_2 = 3$).

		Mean	Var	Skew	Kurt
Germany	1	2.61	2.21	1.16	7.45
	3	3.52	7.04	0.20	3.14
	5	4.23	11.07	0.08	2.55
	10	5.07	19.41	0.26	3.01
France	1	2.56	2.15	0.95	4.53
	3	3.36	7.20	0.26	3.08
	5	3.90	11.24	0.03	2.49
	10	4.27	19.20	-0.01	2.79
Greece	3	3.45	28.78	-1.75	13.79
	5	-2.86	32.52	-2.93	17.30
	10	-3.00	41.48	-1.88	11.82
Italy	3	2.98	8.57	-0.91	7.98
	5	3.17	13.04	-0.92	7.22
	10	3.03	22.23	-0.77	7.95
Portugal	3	0.40	20.93	-0.61	26.68
	5	0.30	24.90	-1.13	21.12
	10	-3.41	37.62	-3.13	20.01

Table 2: Descriptive Statistic of Government Bond Returns

The table shows the mean, variance, skewness and kurtosis for German, French, Greek, Italian and Portuguese government bond returns. Figures of the mean and variance are multiplied by 10^3. For comparison, the normal distribution has zero skewness and a kurtosis of three.

		normal		t	skewed t		stable			
	m	μ	σ	dof	dof	λ	α	β	γ	δ
Germany	1	2.606	2.208	11	5	0.237	1.757	0.694	1.278	2.298
	3	3.516	7.036	$\geq 10^2$	$\geq 10^2$	0.123	1.960	1.000	4.855	3.265
	5	4.233	11.067	$\geq 10^2$	$\geq 10^2$	0.059	2.000	0.765	7.800	4.233
	10	5.070	19.413	$\geq 10^2$	$\geq 10^2$	0.115	1.952	1.000	13.355	4.243
France	1	2.563	2.147	15	7	0.305	1.722	1.000	1.277	2.097
	3	3.362	7.203	$\geq 10^2$	$\geq 10^2$	0.164	1.955	1.000	4.949	3.065
	5	3.896	11.237	$\geq 10^2$	$\geq 10^2$	-0.045	2.000	0.332	7.920	3.896
	10	4.265	19.203	$\geq 10^2$	$\geq 10^2$	-0.086	2.000	0.959	13.535	4.266
Greece	3	3.451	28.781	5	2	-0.173	1.185	-0.074	7.256	6.493
	5	-2.858	32.517	5	2	-0.503	1.263	-0.627	7.730	5.812
	10	-2.999	41.483	5	3	-0.372	1.394	-0.560	13.572	6.527
Italy	3	2.984	8.567	10	5	-0.157	1.767	-0.371	4.810	3.659
	5	3.175	13.039	9	4	-0.242	1.702	-0.655	7.080	5.103
	10	3.032	22.235	9	4	-0.279	1.632	-0.583	11.565	6.097
Portugal	3	0.404	20.927	5	2	-0.384	1.390	-0.673	4.893	4.330
	5	0.296	24.898	6	2	-0.403	1.471	-0.891	7.800	5.834
	10	-3.406	37.619	6	3	-0.527	1.466	-0.890	13.517	6.997

Table 3: Parameter Estimation of selected Distributions for European Bond Data

Estimated parameters of the normal, Student's t, skewed Student's t and stable distribution for German and French (sovereign risk free) and Greek, Italian and Portuguese (sovereign risky) bond data. Sovereign risk free (sovereign risky) bond data is reviewed for maturities of 1, 3, 5 and 10 (3, 5 and 10) years. μ, σ, γ and δ are multiplied by 10^3.

	m	normal	Student	skewed Student	stable
Germany	1	0.14	0.06	0.78	0.39
	3	0.53	0.50	0.43	0.38
	5	0.35	0.36	0.19	0.32
	10	0.04	0.04	0.02	0.02
France	1	0.09	0.04	0.37	0.26
	3	0.42	0.45	0.36	0.31
	5	0.27	0.27	0.23	0.23
	10	0.13	0.15	0.15	0.12
Greece	3	0.00	0.00	0.75	0.27
	5	0.00	0.00	0.04	0.07
	10	0.00	0.00	0.83	0.56
Italy	3	0.39	0.13	0.35	0.45
	5	0.18	0.03	0.13	0.15
	10	0.03	0.01	0.53	0.24
Portugal	3	0.00	0.01	0.60	0.24
	5	0.00	0.00	0.63	0.55
	10	0.00	0.00	0.67	0.52

Table 4: P-Values for χ^2-Tests

P-values of χ^2 test on normal, Student's t, skewed Student's t and stable distribution for German and French (Greek, Italian and Portuguese) bond data for maturities of 1, 3, 5 and 10 (3, 5 and 10) years with null hypothesis that the empirical distribution equals the distributional assumption.

	1	3	5	10
Germany	*10.14	2.97	2.08	1.26
France	*14.09	*4.63	2.64	1.47
Greece	-	*13.91	*33.24	*16.02
Italy	-	*5.26	*4.28	*3.49
Portugal	-	*16.40	*16.29	*33.38
Spain	*7.01	*5.02	*3.41	2.82

Table 5: Chow Test for EMU Countries

Chow statistic for the bond return data of Germany, France, Greece, Italy, Portugal and Spain for all maturities under consideration assuming a structural break in May 2008. An * implies significance on a 5% level.

		normal		t	skewed t		stable			
	m	μ	σ	dof	dof	λ	α	β	γ	δ
Germany	1	2.199	3.068	8	3	0.285	1.517	0.580	1.428	1.513
France	1	2.072	2.921	15	5	0.693	1.367	1.000	1.326	0.878
	3	4.255	7.991	33	13	0.096	1.904	1.000	5.278	3.574
Greece	3	-5.941	52.057	15	4	-0.264	1.452	-0.545	26.550	4.030
	5	-22.317	55.673	11	3	-0.490	1.141	-0.824	19.392	-0.601
	10	-24.640	70.651	16	4	-0.352	1.311	-0.782	30.988	-2.947
Italy	3	1.922	12.582	9	3	-0.251	1.397	-0.496	5.602	4.353
	5	2.164	18.494	8	3	-0.327	1.335	-0.716	6.863	7.291
	10	0.711	32.276	7	3	-0.165	1.124	-0.123	10.150	4.565
Portugal	3	-6.360	38.110	6	2	-0.511	0.994	-0.797	8.861	5.135
	5	-8.570	43.797	6	3	-0.510	1.099	-0.858	12.636	4.865
ES	1	1.929	2.279	6	2	0.420	1.432	1.000	0.684	1.168
	3	2.769	5.883	8	3	0.550	1.402	1.000	2.437	0.562
	5	4.876	8.067	21	$\geq 10^2$	0.760	1.658	1.000	4.708	2.892

Table 6: Parameter Estimation of selected Distributions for European Bond Data after structural Break

Estimated parameters of the normal, Student's t, skewed Student's t and stable distribution for German and French (sovereign risk free) and Greek, Italian, Portuguese and Spanish (sovereign risky) bond data for the period after the structural break. The bond data is reviewed for different maturities of 1, 3, 5 and 10 years. μ, σ, γ and δ are multiplied by 10^3.

	m	normal	Student	skewed Student	stable
Germany	1	0.02	0.02	0.80	0.47
France	1	0.06	0.04	0.87	0.58
	3	0.55	0.54	0.38	0.46
Greece	3	0.42	0.39	0.61	0.41
	5	0.00	0.00	0.40	0.33
	10	0.02	0.02	0.72	0.57
Italy	3	0.25	0.23	0.35	0.18
	5	0.00	0.00	0.09	0.08
	10	0.00	0.01	0.69	0.39
Portugal	3	0.01	0.01	0.42	0.38
	5	0.00	0.00	0.75	0.59
	10	0.02	0.01	0.93	0.33
Spain	1	0.00	0.00	0.76	0.29
	3	0.13	0.11	0.49	0.29
	5	0.62	0.63	0.55	0.59

Table 7: P-Values for χ^2-Tests after structural Break

P-values of χ^2 test on normal, Student's t, skewed Student's t and stable distribution for German, French, Greek, Italian, Portuguese and Spanish bond data for different maturities of 1, 3, 5 or 10 years for the period after the structural break with null hypothesis that the empirical distribution equals the distributional assumption.

	sovereign risk free	sovereign risky
1999-2011	normal	skewed t/ stable
2008-2011	normal	skewed t/ stable

Table 8: Concluding links between Returns, Periods and Distributions

A Appendix

	m	normal μ	normal σ	t dof	skewed t dof	skewed t λ	stable α	stable β	stable γ	stable δ
CH	3	3.657	8.889	18	8	0.110	1.874	0.130	5.713	3.522
	5	4.353	12.558	$\geq 10^2$	$\geq 10^2$	0.022	2.000	0.928	8.851	4.353
	10	5.232	22.106	$\geq 10^2$	$\geq 10^2$	-0.053	2.000	0.830	15.581	5.232
ES	1	2.554	2.096	12	6	0.496	1.568	1.000	1.109	1.919
	3	1.864	5.730	18	8	0.221	1.902	1.000	3.734	1.346
	5	2.846	8.756	$\geq 10^2$	$\geq 10^2$	0.106	1.954	1.000	6.012	2.478
	10	4.087	15.077	$\geq 10^2$	$\geq 10^2$	0.191	1.930	1.000	10.278	3.183
SE	1	2.606	3.142	9	3	0.110	1.420	0.264	1.464	2.329
	3	2.982	8.782	10	4	-0.033	1.730	-0.185	4.974	3.304
	5	3.118	13.996	12	5	-0.072	1.763	-0.192	8.292	3.510
	10	3.040	24.180	10	5	-0.121	1.766	-0.221	13.896	3.837
UK	1	3.497	2.468	16	49	0.600	1.791	1.000	1.508	3.077
	3	4.364	7.076	34	14	0.043	1.953	0.471	4.861	4.210
	5	4.749	11.057	$\geq 10^2$	60	-0.082	2.000	0.664	7.793	4.749
	10	4.917	20.571	34	12	0.065	1.958	1.000	14.221	4.163
USA	1	2.770	2.459	46	90	0.592	1.644	1.000	1.473	2.134
	3	4.098	7.240	$\geq 10^2$	$\geq 10^2$	-0.013	2.000	0.844	5.103	4.098
	5	5.023	12.716	$\geq 10^2$	$\geq 10^2$	-0.144	2.000	0.484	8.963	5.023
	10	6.030	23.725	15	6	-0.131	1.789	-0.430	14.628	7.113

Table 9: Parameters of selected Distributions for European Bond Data

Estimated parameters of normal, Student's t, skewed Student's t and stable distribution for Swedish (SE), Spanish (ES), UK, USA and Swiss (CH) bond data. Maturities of 1, 3, 5 and 10 years are reviewed. μ, σ, γ and δ are multiplied by 10^3.

		normal				t				skewed t				stable			
	m	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
Germany	1	**0.14**	**0.00**	**0.00**	**0.00**	**0.06**	**0.01**	**0.00**	**0.00**	**0.78**	**0.66**	**0.15**	**0.13**	**0.39**	**0.37**	**0.09**	**0.09**
		(8.87)	(0.09)	(0.31)	(1.81)	(11.47)	(0.10)	(0.37)	(2.17)	(1.05)	(0.04)	(0.05)	(0.37)	(1.91)	(0.05)	(0.08)	(0.47)
	3	**0.53**	**0.56**	**0.71**	**0.76**	**0.50**	**0.56**	**0.72**	**0.76**	**0.43**	**0.83**	**0.52**	**0.54**	**0.38**	**0.58**	**0.49**	**0.61**
		(4.45)	(0.05)	(0.04)	(0.25)	(4.64)	(0.05)	(0.04)	(0.25)	(4.47)	(0.04)	(0.03)	(0.24)	(4.56)	(0.04)	(0.04)	(0.26)
	5	**0.35**	**0.36**	**0.17**	**0.23**	**0.36**	**0.37**	**0.18**	**0.25**	**0.19**	**0.05**	**0.03**	**0.05**	**0.32**	**0.30**	**0.14**	**0.17**
		(6.00)	(0.05)	(0.08)	(0.49)	(6.00)	(0.05)	(0.08)	(0.49)	(6.47)	(0.06)	(0.09)	(0.51)	(6.00)	(0.05)	(0.09)	(0.50)
	10	**0.04**	**0.02**	**0.08**	**0.07**	**0.04**	**0.02**	**0.09**	**0.07**	**0.02**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.02**	**0.02**
		(12.34)	(0.08)	(0.11)	(0.71)	(12.34)	(0.08)	(0.11)	(0.71)	(13.58)	(0.08)	(0.15)	(0.83)	(12.75)	(0.08)	(0.14)	(0.78)
France	1	**0.09**	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**	**0.37**	**0.00**	**0.01**	**0.02**	**0.26**	**0.01**	**0.04**	**0.07**
		(9.87)	(0.13)	(0.39)	(2.08)	(11.38)	(0.13)	(0.41)	(2.18)	(3.66)	(0.08)	(0.11)	(0.57)	(3.01)	(0.08)	(0.09)	(0.48)
	3	**0.42**	**0.37**	**0.74**	**0.77**	**0.45**	**0.39**	**0.77**	**0.78**	**0.36**	**0.32**	**0.45**	**0.51**	**0.31**	**0.23**	**0.50**	**0.60**
		(5.07)	(0.05)	(0.03)	(0.24)	(5.08)	(0.05)	(0.03)	(0.24)	(5.18)	(0.05)	(0.04)	(0.25)	(4.99)	(0.06)	(0.04)	(0.26)
	5	**0.27**	**0.23**	**0.18**	**0.24**	**0.27**	**0.23**	**0.18**	**0.24**	**0.23**	**0.17**	**0.08**	**0.10**	**0.23**	**0.19**	**0.14**	**0.18**
		(6.67)	(0.06)	(0.08)	(0.47)	(6.67)	(0.06)	(0.08)	(0.47)	(6.09)	(0.05)	(0.07)	(0.43)	(6.69)	(0.06)	(0.08)	(0.48)
	10	**0.13**	**0.15**	**0.05**	**0.07**	**0.15**	**0.16**	**0.06**	**0.08**	**0.15**	**0.23**	**0.04**	**0.05**	**0.12**	**0.13**	**0.03**	**0.05**
		(8.79)	(0.06)	(0.12)	(0.68)	(8.79)	(0.06)	(0.12)	(0.68)	(7.36)	(0.05)	(0.08)	(0.52)	(8.86)	(0.06)	(0.12)	(0.68)

Table 10: Goodness-of-Fit Tests for German and French Bond Data

χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests on normal, Student's t, skewed Student's t and stable distribution for German and French bond data for maturities of 1, 3, 5 and 10 years. The fat values denote p-values with null hypothesis that the empirical distribution equals the distributional assumption. Numbers in brackets represent the test statistics.

	m	normal				t				skewed t				stable			
		χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
Greece	3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.75**	**0.04**	**0.04**	**0.03**	**0.27**	**0.15**	**0.18**	**0.08**
		(48.72)	(0.25)	(2.48)	(12.79)	(56.24)	(0.26)	(2.71)	(13.56)	(0.60)	(0.08)	(0.18)	(1.54)	(0.77)	(0.05)	(0.04)	(0.35)
	5	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.04**	**0.10**	**0.05**	**0.04**	**0.07**	**0.05**	**0.15**	**0.11**
		(89.42)	(0.26)	(3.24)	(17.13)	(101.10)	(0.26)	(3.46)	(17.51)	(7.57)	(0.08)	(0.23)	(1.44)	(2.90)	(0.06)	(0.05)	(0.35)
	10	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.83**	**0.52**	**0.26**	**0.14**	**0.56**	**0.66**	**0.59**	**0.45**
		(64.74)	(0.19)	(1.95)	(11.26)	(77.87)	(0.19)	(2.18)	(11.79)	(0.54)	(0.05)	(0.07)	(0.57)	(0.39)	(0.04)	(0.03)	(0.22)
Italy	3	**0.39**	**0.06**	**0.02**	**0.00**	**0.13**	**0.06**	**0.04**	**0.01**	**0.35**	**0.48**	**0.10**	**0.07**	**0.45**	**0.67**	**0.29**	**0.29**
		(5.35)	(0.07)	(0.16)	(1.46)	(9.58)	(0.08)	(0.24)	(1.96)	(3.05)	(0.04)	(0.06)	(0.44)	(1.48)	(0.04)	(0.05)	(0.33)
	5	**0.18**	**0.01**	**0.00**	**0.00**	**0.03**	**0.02**	**0.01**	**0.00**	**0.13**	**0.05**	**0.18**	**0.27**	**0.15**	**0.11**	**0.21**	**0.35**
		(7.75)	(0.09)	(0.30)	(2.15)	(14.00)	(0.09)	(0.39)	(2.62)	(4.85)	(0.06)	(0.05)	(0.31)	(3.81)	(0.06)	(0.06)	(0.30)
	10	**0.03**	**0.00**	**0.00**	**0.00**	**0.01**	**0.02**	**0.00**	**0.00**	**0.53**	**0.46**	**0.47**	**0.46**	**0.24**	**0.28**	**0.36**	**0.33**
		(12.89)	(0.09)	(0.35)	(2.32)	(18.03)	(0.10)	(0.44)	(2.86)	(1.79)	(0.04)	(0.03)	(0.25)	(1.95)	(0.05)	(0.04)	(0.28)
Portugal	3	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.60**	**0.62**	**0.46**	**0.35**	**0.24**	**0.70**	**0.39**	**0.29**
		(19.33)	(0.23)	(3.36)	(17.88)	(30.84)	(0.24)	(3.63)	(18.80)	(1.28)	(0.05)	(0.06)	(0.52)	(1.36)	(0.04)	(0.03)	(0.28)
	5	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.63**	**0.72**	**0.59**	**0.49**	**0.55**	**0.71**	**0.71**	**0.65**
		(30.32)	(0.18)	(2.03)	(11.88)	(42.49)	(0.19)	(2.29)	(12.89)	(1.13)	(0.04)	(0.04)	(0.34)	(0.63)	(0.04)	(0.02)	(0.20)
	10	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.67**	**0.66**	**0.56**	**0.46**	**0.52**	**0.33**	**0.39**	**0.41**
		(51.40)	(0.18)	(1.52)	(9.15)	(62.68)	(0.18)	(1.72)	(9.90)	(1.22)	(0.04)	(0.04)	(0.34)	(0.70)	(0.05)	(0.04)	(0.26)

Table 11: Goodness-of-Fit Tests for Greek, Italian and Portuguese Bond Data

χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests on normal, Student's t, skewed Student's t and stable distribution for Greek, Italian and Portuguese bond data for different maturities of 3, 5 and 10 years. The fat values denote p-values with null hypothesis that the empirical distribution equals the distributional assumption. Numbers in brackets represent the test statistics.

		normal				t				skewed t				stable			
	m	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
Sweden	1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.62**	**0.28**	**0.20**	**0.15**	**0.14**	**0.23**	**0.20**	**0.20**
		(21.82)	(0.12)	(0.55)	(3.05)	(24.36)	(0.12)	(0.65)	(3.49)	(1.17)	(0.05)	(0.05)	(0.41)	(1.60)	(0.05)	(0.04)	(0.29)
	3	**0.14**	**0.02**	**0.00**	**0.00**	**0.05**	**0.05**	**0.01**	**0.01**	**0.93**	**0.72**	**0.74**	**0.78**	**0.77**	**0.86**	**0.71**	**0.73**
		(8.66)	(0.08)	(0.21)	(1.38)	(12.29)	(0.08)	(0.28)	(1.84)	(0.39)	(0.04)	(0.02)	(0.18)	(0.35)	(0.03)	(0.03)	(0.19)
	5	**0.36**	**0.26**	**0.06**	**0.03**	**0.21**	**0.29**	**0.08**	**0.05**	**0.97**	**1.00**	**0.99**	**1.00**	**0.82**	**0.94**	**0.97**	**0.99**
		(5.62)	(0.06)	(0.12)	(0.86)	(7.96)	(0.06)	(0.18)	(1.20)	(0.26)	(0.02)	(0.01)	(0.09)	(0.28)	(0.03)	(0.01)	(0.09)
	10	**0.05**	**0.05**	**0.02**	**0.00**	**0.01**	**0.05**	**0.05**	**0.02**	**0.02**	**0.05**	**0.10**	**0.09**	**0.02**	**0.28**	**0.17**	**0.19**
		(11.22)	(0.07)	(0.16)	(1.25)	(15.46)	(0.08)	(0.23)	(1.71)	(9.17)	(0.06)	(0.06)	(0.40)	(8.39)	(0.05)	(0.06)	(0.37)
Switzerland	3	**0.99**	**0.36**	**0.18**	**0.17**	**0.92**	**0.45**	**0.19**	**0.15**	**0.75**	**0.07**	**0.13**	**0.19**	**0.89**	**0.37**	**0.15**	**0.25**
		(0.59)	(0.05)	(0.08)	(0.53)	(1.71)	(0.05)	(0.10)	(0.70)	(1.52)	(0.06)	(0.06)	(0.33)	(0.36)	(0.05)	(0.07)	(0.37)
	5	**0.59**	**0.94**	**0.78**	**0.84**	**0.59**	**0.95**	**0.80**	**0.84**	**0.52**	**0.80**	**0.61**	**0.63**	**0.58**	**0.93**	**0.78**	**0.82**
		(3.91)	(0.03)	(0.03)	(0.22)	(3.91)	(0.03)	(0.03)	(0.22)	(3.74)	(0.04)	(0.03)	(0.21)	(3.92)	(0.03)	(0.03)	(0.22)
	10	**0.79**	**0.97**	**0.97**	**0.99**	**0.81**	**0.97**	**0.97**	**0.99**	**0.67**	**0.98**	**0.96**	**0.99**	**0.76**	**0.97**	**0.97**	**0.99**
		(2.61)	(0.03)	(0.02)	(0.12)	(2.61)	(0.03)	(0.02)	(0.12)	(2.70)	(0.03)	(0.02)	(0.11)	(2.64)	(0.03)	(0.02)	(0.12)
Spain	1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.76**	**0.63**	**0.55**	**0.43**	**0.29**	**0.43**	**0.30**	**0.27**
		(21.46)	(0.10)	(0.48)	(2.90)	(22.38)	(0.10)	(0.52)	(3.07)	(1.66)	(0.04)	(0.03)	(0.27)	(2.20)	(0.05)	(0.05)	(0.32)
	3	**0.13**	**0.00**	**0.03**	**0.03**	**0.11**	**0.01**	**0.06**	**0.06**	**0.49**	**0.09**	**0.13**	**0.22**	**0.29**	**0.02**	**0.12**	**0.21**
		(8.96)	(0.09)	(0.14)	(0.82)	(9.54)	(0.09)	(0.16)	(0.96)	(3.01)	(0.06)	(0.06)	(0.32)	(4.45)	(0.07)	(0.08)	(0.40)
	5	**0.62**	**0.77**	**0.80**	**0.74**	**0.63**	**0.80**	**0.82**	**0.75**	**0.55**	**0.16**	**0.30**	**0.30**	**0.59**	**0.34**	**0.47**	**0.52**
		(3.64)	(0.04)	(0.03)	(0.25)	(3.76)	(0.04)	(0.03)	(0.26)	(3.47)	(0.05)	(0.04)	(0.31)	(2.84)	(0.05)	(0.05)	(0.29)
	10	**0.07**	**0.81**	**0.56**	**0.47**	**0.08**	**0.82**	**0.60**	**0.49**	**0.32**	**0.12**	**0.13**	**0.17**	**0.33**	**0.51**	**0.42**	**0.42**
		(10.50)	(0.04)	(0.04)	(0.36)	(10.47)	(0.04)	(0.04)	(0.36)	(5.27)	(0.05)	(0.06)	(0.37)	(4.36)	(0.05)	(0.05)	(0.32)

		normal				t				skewed t				stable			
	m	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
UK	1	**0.60**	**0.37**	**0.05**	**0.01**	**0.40**	**0.24**	**0.10**	**0.02**	**0.61**	**0.02**	**0.01**	**0.01**	**0.50**	**0.02**	**0.05**	**0.02**
		(3.85)	(0.05)	(0.12)	(1.10)	(5.62)	(0.06)	(0.14)	(1.23)	(3.53)	(0.07)	(0.14)	(0.82)	(1.84)	(0.07)	(0.09)	(0.68)
	3	**0.63**	**0.45**	**0.50**	**0.57**	**0.52**	**0.49**	**0.47**	**0.51**	**0.36**	**0.19**	**0.20**	**0.37**	**0.45**	**0.56**	**0.47**	**0.62**
		(3.78)	(0.05)	(0.05)	(0.31)	(4.41)	(0.05)	(0.05)	(0.35)	(4.22)	(0.05)	(0.05)	(0.27)	(3.82)	(0.05)	(0.05)	(0.26)
	5	**0.89**	**0.66**	**0.70**	**0.77**	**0.90**	**0.66**	**0.69**	**0.78**	**0.88**	**0.60**	**0.77**	**0.83**	**0.87**	**0.60**	**0.64**	**0.74**
		(1.80)	(0.04)	(0.04)	(0.24)	(1.81)	(0.04)	(0.04)	(0.24)	(1.43)	(0.04)	(0.02)	(0.17)	(1.78)	(0.04)	(0.04)	(0.24)
	10	**0.72**	**0.86**	**0.73**	**0.72**	**0.77**	**0.86**	**0.67**	**0.68**	**0.87**	**0.99**	**0.99**	**1.00**	**0.71**	**0.94**	**0.93**	**0.93**
		(3.07)	(0.04)	(0.03)	(0.26)	(2.83)	(0.04)	(0.04)	(0.30)	(1.12)	(0.03)	(0.01)	(0.10)	(2.18)	(0.03)	(0.02)	(0.16)
USA	1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.56**	**0.81**	**0.84**	**0.88**	**0.00**	**0.01**	**0.01**	**0.01**
		(24.91)	(0.09)	(0.27)	(1.77)	(25.43)	(0.09)	(0.27)	(1.75)	(3.66)	(0.04)	(0.02)	(0.17)	(14.65)	(0.07)	(0.11)	(0.72)
	3	**0.47**	**0.76**	**0.74**	**0.65**	**0.49**	**0.76**	**0.75**	**0.64**	**0.38**	**0.59**	**0.54**	**0.38**	**0.45**	**0.71**	**0.71**	**0.57**
		(4.77)	(0.04)	(0.03)	(0.29)	(4.77)	(0.04)	(0.03)	(0.29)	(4.64)	(0.04)	(0.03)	(0.28)	(4.79)	(0.04)	(0.03)	(0.29)
	5	**0.48**	**0.40**	**0.20**	**0.22**	**0.49**	**0.42**	**0.20**	**0.22**	**0.45**	**0.34**	**0.34**	**0.31**	**0.45**	**0.37**	**0.16**	**0.18**
		(4.74)	(0.05)	(0.08)	(0.49)	(4.74)	(0.05)	(0.08)	(0.49)	(4.17)	(0.05)	(0.04)	(0.30)	(4.77)	(0.05)	(0.08)	(0.49)
	10	**0.67**	**0.08**	**0.05**	**0.03**	**0.57**	**0.13**	**0.07**	**0.06**	**0.84**	**0.80**	**0.66**	**0.58**	**0.52**	**0.19**	**0.37**	**0.40**
		(3.38)	(0.07)	(0.12)	(0.81)	(4.30)	(0.07)	(0.15)	(1.00)	(0.92)	(0.03)	(0.02)	(0.21)	(1.37)	(0.06)	(0.05)	(0.29)

Table 12: Goodness-of-Fit Tests for Swedish, Swiss, Spanish, UK and US Bond Data

χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests on normal, Student's t, skewed Student's t and stable distribution for Swedish, Swiss, Spanish, UK and US bond data for maturities of 1, 3, 5 and 10 years. The fat values denote p-values with null hypothesis that the empirical distribution equals the distributional assumption. Numbers in brackets represent the test statistics.

		normal				t				skewed t				stable			
	m	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
Germany	1	**0.14**	**0.00**	**0.00**	**0.00**	**0.06**	**0.01**	**0.00**	**0.00**	**0.78**	**0.66**	**0.15**	**0.13**	**0.39**	**0.37**	**0.09**	**0.09**
		(8.87)	(0.09)	(0.31)	(1.81)	(11.47)	(0.10)	(0.37)	(2.17)	(1.05)	(0.04)	(0.05)	(0.37)	(1.91)	(0.05)	(0.08)	(0.47)
France	1	**0.09**	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**	**0.37**	**0.00**	**0.01**	**0.02**	**0.26**	**0.01**	**0.04**	**0.07**
		(9.87)	(0.13)	(0.39)	(2.08)	(11.38)	(0.13)	(0.41)	(2.18)	(3.66)	(0.08)	(0.11)	(0.57)	(3.01)	(0.08)	(0.09)	(0.48)
	3	**0.42**	**0.37**	**0.74**	**0.77**	**0.45**	**0.39**	**0.77**	**0.78**	**0.36**	**0.32**	**0.45**	**0.51**	**0.31**	**0.23**	**0.50**	**0.60**
		(5.07)	(0.05)	(0.03)	(0.24)	(5.08)	(0.05)	(0.03)	(0.24)	(5.18)	(0.05)	(0.04)	(0.25)	(4.99)	(0.06)	(0.04)	(0.26)

Table 13: Goodness-of-Fit Tests for German and French Bond Data after structural Break

χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests on normal, Student's t, skewed Student's t and stable distribution for German (1 year maturity) and French (1 and 3 year maturity) bond data for the period after the structural break. The fat values denote p-values with null hypothesis that the empirical distribution equals the distributional assumption. Numbers in brackets represent the test statistics.

		normal				t				skewed t				stable			
	m	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD	χ^2	KS	CM	AD
Greece	3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.75**	**0.04**	**0.04**	**0.03**	**0.27**	**0.15**	**0.18**	**0.08**
		(48.72)	(0.25)	(2.48)	(12.79)	(56.24)	(0.26)	(2.71)	(13.56)	(0.60)	(0.08)	(0.18)	(1.54)	(0.77)	(0.05)	(0.04)	(0.35)
	5	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.04**	**0.10**	**0.05**	**0.04**	**0.07**	**0.05**	**0.15**	**0.11**
		(89.42)	(0.26)	(3.24)	(17.13)	(101.10)	(0.26)	(3.46)	(17.51)	(7.57)	(0.08)	(0.23)	(1.44)	(2.90)	(0.06)	(0.05)	(0.35)
	10	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.83**	**0.52**	**0.26**	**0.14**	**0.56**	**0.66**	**0.59**	**0.45**
		(64.74)	(0.19)	(1.95)	(11.26)	(77.87)	(0.19)	(2.18)	(11.79)	(0.54)	(0.05)	(0.07)	(0.57)	(0.39)	(0.04)	(0.03)	(0.22)
Italy	3	**0.39**	**0.06**	**0.02**	**0.00**	**0.13**	**0.06**	**0.04**	**0.01**	**0.35**	**0.48**	**0.10**	**0.07**	**0.45**	**0.67**	**0.29**	**0.29**
		(5.35)	(0.07)	(0.16)	(1.46)	(9.58)	(0.08)	(0.24)	(1.96)	(3.05)	(0.04)	(0.06)	(0.44)	(1.48)	(0.04)	(0.05)	(0.33)
	5	**0.18**	**0.01**	**0.00**	**0.00**	**0.03**	**0.02**	**0.01**	**0.00**	**0.13**	**0.05**	**0.18**	**0.27**	**0.15**	**0.11**	**0.21**	**0.35**
		(7.75)	(0.09)	(0.30)	(2.15)	(14.00)	(0.09)	(0.39)	(2.62)	(4.85)	(0.06)	(0.05)	(0.31)	(3.81)	(0.06)	(0.06)	(0.30)
	10	**0.03**	**0.00**	**0.00**	**0.00**	**0.01**	**0.02**	**0.00**	**0.00**	**0.53**	**0.46**	**0.47**	**0.46**	**0.24**	**0.28**	**0.36**	**0.33**
		(12.89)	(0.09)	(0.35)	(2.32)	(18.03)	(0.10)	(0.44)	(2.86)	(1.79)	(0.04)	(0.03)	(0.25)	(1.95)	(0.05)	(0.04)	(0.28)
Portugal	3	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.60**	**0.62**	**0.46**	**0.35**	**0.24**	**0.70**	**0.39**	**0.29**
		(19.33)	(0.23)	(3.36)	(17.88)	(30.84)	(0.24)	(3.63)	(18.80)	(1.28)	(0.05)	(0.06)	(0.52)	(1.36)	(0.04)	(0.03)	(0.28)
	5	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.63**	**0.72**	**0.59**	**0.49**	**0.55**	**0.71**	**0.71**	**0.65**
		(30.32)	(0.18)	(2.03)	(11.88)	(42.49)	(0.19)	(2.29)	(12.89)	(1.13)	(0.04)	(0.04)	(0.34)	(0.63)	(0.04)	(0.02)	(0.20)
	10	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.67**	**0.66**	**0.56**	**0.46**	**0.52**	**0.33**	**0.39**	**0.41**
		(51.40)	(0.18)	(1.52)	(9.15)	(62.68)	(0.18)	(1.72)	(9.90)	(1.22)	(0.04)	(0.04)	(0.34)	(0.70)	(0.05)	(0.04)	(0.26)
Spain	1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.76**	**0.63**	**0.55**	**0.43**	**0.29**	**0.43**	**0.30**	**0.27**
		(21.46)	(0.10)	(0.48)	(2.90)	(22.38)	(0.10)	(0.52)	(3.07)	(1.66)	(0.04)	(0.03)	(0.27)	(2.20)	(0.05)	(0.05)	(0.32)
	3	**0.13**	**0.00**	**0.03**	**0.03**	**0.11**	**0.01**	**0.06**	**0.06**	**0.49**	**0.09**	**0.13**	**0.22**	**0.29**	**0.02**	**0.12**	**0.21**
		(8.96)	(0.09)	(0.14)	(0.82)	(9.54)	(0.09)	(0.16)	(0.96)	(3.01)	(0.06)	(0.06)	(0.32)	(4.45)	(0.07)	(0.08)	(0.40)
	5	**0.62**	**0.77**	**0.80**	**0.74**	**0.63**	**0.80**	**0.82**	**0.75**	**0.55**	**0.16**	**0.30**	**0.30**	**0.59**	**0.34**	**0.47**	**0.52**
		(3.64)	(0.04)	(0.03)	(0.25)	(3.76)	(0.04)	(0.03)	(0.26)	(3.47)	(0.05)	(0.04)	(0.31)	(2.84)	(0.05)	(0.05)	(0.29)

Table 14: Goodness-of-Fit Tests for Greek, Italian, Portuguese and Spanish Bond Data after structural Break

χ^2, Kolmogorov-Smirnov-Lilliefors (KS), Cramer-van-Mieses (CM) and Anderson-Darling (AD) tests on normal, Student's t, skewed Student's t and stable distribution for Greek, Italian, Portuguese and Spanish bond data for different maturities of 1, 3, 5 or 10 years for the period after the structural break. The fat values denote p-values with null hypothesis that the empirical distribution equals the distributional assumption. Numbers in brackets represent the test statistics.