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Abstract

This paper analyzes the existence of flight-to-quality from stocks to bonds and contagion between the two asset classes. Flight-to-quality is present if correlations between stocks and bonds strongly decrease in falling stock markets since this constitutes a movement of the asset classes in opposite directions. A movement in the same direction characterized by strongly increasing correlations in falling stock markets implies contagion across asset classes. We estimate dynamic conditional correlations and analyze normal and extreme changes of these correlations through time without an a priori specification of any crisis period. Daily MSCI stock and government bond returns are analyzed for a selection of European countries and the US. Our findings show that the correlation between the asset classes is characterized by large fluctuations and negative on average for the whole sample period. Extreme negative and positive correlation changes explained with flight-to-quality and contagion are relatively frequent phenomena. Examples of flight-to-quality are in the Asian and Russian crisis 1997 and 1998 and contagion is found after September 11. Controlling for the regime of correlations further shows that stock market volatility contributes to flight-to-quality and bond volatility to contagion.

JEL classification: F36, F37, G11, G14, G15

KEYWORDS: flight-to-quality, contagion, multivariate GARCH

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1 Introduction

This paper examines two phenomena that have evolved in different strands of the literature. The flight-to-quality strand analyzes the stock-bond return relation (Li, 2002, Gulko, 2002, Stivers, Sun and Connolly, 2003 and De Goeij and Marquering, 2004) and the contagion strand investigates stock-stock or bond-bond linkages in crisis times (e.g. Baig and Goldfajn, 1999, Forbes and Rigobon, 2002 and Dungey, Fry, Gonzalez-Hermosillo and Martin, 2004). Empirical findings of the stock-bond return correlations with a focus on crisis periods are rare. The first contributions are Hartmann, Straetmann and Devries (2001) and Gulko (2002).

The motivation to investigate stock-bond correlations in general and in crisis periods in particular is threefold. First, the analysis of stocks and bonds is likely to provide information of investor behavior in normal times and under extreme market conditions and second, this investor behavior can contribute to the stability or instability of the financial system which is why it is important for regulators or policy makers. Finally, the paper attempts to explain the level of stock bond correlations and their changes.

In accordance with the literature, we define contagion as an increase of the correlation coefficient in a crisis period compared to a benchmark period. Flight-to-quality from stocks to bonds is defined as a decrease in the correlation coefficient and simultaneously falling stock markets. Flight-*from*-quality from bonds to stocks is defined as a decrease in the correlation coefficient and simultaneously rising stock markets. Contagion and flight-to-quality are exclusive effects with regard to stock-bond correlations.[1] If there is contagion, there is no flight-to-quality and if there is flight-to-quality there is no contagion. The characteristics of these two phenomena are not similar to positive or negative contagion as

[1]This is only true for stock-bond correlations. There can be contagion among stock markets and flight-to-quality from stocks to bonds.

Table 1: Overview flight-to-quality, flight-from-quality and contagion

	Stock-Bond Correlations are falling	**Stock-Bond Correlations are rising**
Stock Markets Falling	Stock-to-Bond Flight-to-quality	(Negative) Contagion
Stock Markets Rising	Bond-to-Stock Flight-*from*-quality	(Positive) Contagion
Bond Markets Falling	Bond-to-Stock Flight-*from*-quality	(Negative) Contagion
Bond Markets Rising	Bond-to-Stock Flight-to-quality	(Positive) Contagion

discussed in Baur and Frey (2005). Positive contagion is an increase of the correlation caused by positive shocks and negative contagion is an increase of the correlation caused by negative shocks. Therefore, an increase of the correlation coefficient between stocks and bonds could be caused by jointly falling markets or jointly rising markets. In the following, we will only focus on negative contagion since this is the more important and problematic case for investors. Table 1 summarizes the potential phenomena associated with falling and rising stock-bond correlations.

The literature dates back to Keim and Stambaugh (1986) who were the first to investigate the relation of stocks and bonds. Campbell and Ammer (1993) find a low positive correlation between stocks and bonds. The low correlation is surprising to some extent since both asset types depend on common macroeconomic variables which would imply a more pronounced correlation. Despite the contributions cited above, there are papers that analyze the relation of stock and bond market liquidity, the link between corporate bonds and stocks (e.g. Baker and Wurgler, 2005) and momentum spillover effects (Gebhardt, Hvidkjaer and Swaminathan, 2005). Dopfel (2003) and Li (2002) also analyze stock-bond correlations and additionally study the welfare effects of correlation changes for investors. In general there are relatively few papers studying stock-bond correlations.

There are different theoretical arguments that help to determine the level of the stock bond correlations. A positive correlation can be expected due to common macroeconomic variables that drive both stocks and bonds. A negative correlation can be expected if flight-to-quality is present and relatively strong. A correlation around zero could be explained with segmented markets. It is (still) not clear in the literature whether one of these effects dominates the other.

This paper contributes to the literature in several respects. We analyze flight-to-quality and cross-asset contagion in one framework and use a quasi-endogenous test to examine the occurrence of these phenomena for which cumulative abnormal correlation changes (CACC) are introduced. Contemporaneous and predictive regressions reveal the importance of bond and stock market returns and their volatility and also show that there are two regimes of stock-bond correlations. We find that stock-bond correlations fluctuate considerably and change strongly and rather abruptly in several periods constituting flight-to-quality or contagion.

The paper is structured as follows. First, we describe the econometric framework and the endogenous determination of significant correlation changes. Second, we present the data and descriptive statistics. In the fourth section we illustrate and discuss the estimation results and the fifth section concludes.

2 Econometric Framework

We test for the presence of flight-to-quality and contagion by analyzing time-varying correlations between stocks and bonds. We propose a two-stage approach. In the first stage, we estimate time-varying correlations with the dynamic conditional correlation estimator (DCC) of Engle (2002) and analyze the characteristics of these correlations. In particular, we will focus on consecutive and large changes of the estimates.[2] In a second stage, we regress the conditional correlations on stock and bond return characteristics and dummy variables representing different events in the financial markets. In order to test the ro-

[2]The focus on extreme changes only makes a detection of spurious relationships unlikely. However, several specification tests will analyze the robustness of our findings.

bustness of our results with respect to the conditional correlation estimates, we also estimate rolling correlations with different window lengths (see also Andersson, Krylova and Vähämaa, 2004). This additional test shows how volatility can affect the correlation estimates. Our two-stage approach has the main advantage that the test for the presence of flight-to-quality and contagion is not based on a priori defined crisis periods as in Baig and Goldfajn (1998) and Forbes and Rigobon (2002) but on an a posteriori analysis of these phenomena.

First stage:

The first stage estimates the conditional covariance matrices $\boldsymbol{H}_t$ and their corresponding conditional correlation matrices $\boldsymbol{R}_t$ of the bond and stock returns with the DCC model. The DCC model can be formulated as the following statistical specification:

$$r_t|\Omega_{t-1} \sim N(0, D_t R_t D_t) \tag{1}$$

$$D_t^2 = diag(w_i) + diag(k_i) \circ r_{t-1}r'_{t-1} + diag(\lambda_i) \circ D_{t-1}^2 \tag{2}$$

$$\epsilon_t = D_t^{-1} r_t \tag{3}$$

$$H_t = S \circ (\iota\iota' - A - B) + A \circ \epsilon_{t-1}\epsilon'_{t-1} + B \circ H_{t-1} \tag{4}$$

$$R_t = diag(H_t)^{-1} H_t diag(H_t)^{-1} \tag{5}$$

We estimate correlations based on raw returns in order to analyze systematic and idiosyncratic shocks simultaneously. Rolling correlations with relatively large window lengths are also considered as part of a robustness analysis.[3] Large consecutive changes

[3]Since the importance of contemporaneous and lagged volatility decreases with increasing window lengths, this analysis is likely to yield additional information.

within the last K trading days will be computed in order to detect periods of extreme (and relatively abrupt) correlation changes. We compute a time-series of the cumulative abnormal correlation change (CACC) from $t-K$ until t as follows:

$$CACC_t = (\rho_t - \rho_{t-K}) \quad (6)$$

The time-series $CACC_t$ combined with a threshold can reveal abnormal and extreme correlation changes for every time t. The CACC measure serves two purposes. First, it helps detect flight-to-quality and contagion and second, it provides information about the stability of the correlation through time. The second stage analyzes the time-varying correlation estimates as follows.

Second stage:

This stage regresses the conditional correlation estimates[4] $\hat{\rho}_{ij,t}$ for asset markets i and j on a constant, its own lag and lagged shocks of the returns or on contemporaneous shocks only. This implies two regression models. The former is a predictive regression model and the latter a contemporaneous regression model. The model that nests both specifications is written as follows:

$$\hat{\rho}_{ij,t} = \alpha + \beta\hat{\rho}_{ij,t-1} + \gamma\boldsymbol{X}_t + \delta\boldsymbol{X}_{t-1} + \epsilon_t \quad (7)$$

where

$$\boldsymbol{X}_t = [h_{1t} \;\; h_{2t} \;\; r^+_{1t} \;\; r^+_{2t} \;\; r^-_{1t} \;\; r^-_{2t} \;\; \boldsymbol{D}_t] \quad (8)$$

with h_{it} and r^+_{it} (r^-_{it}) denoting the conditional volatility and the positive and negative return shock of asset i, respectively. The predictive regression model is given for $\gamma = 0$ and the contemporaneous model for $\beta = \delta = 0$. The conditional volatilities are estimated with a

[4]Estimates are denoted with a hat.

GARCH(1,1) model. The matrix $\boldsymbol{D}$ contains dummy variables to analyze key financial, economic or political events. The return shocks r_1 and r_2 are included in the regressor matrix in order to obtain information about cross-sectional asymmetries (e.g. whether r_1 is more important than r_2) and information about time-series asymmetries (e.g. whether negative shocks exhibit a larger impact on the conditional correlations than positive shocks). The returns are standardized for this purpose.

3 Data

The data consists of daily continuously compounded MSCI stock and bond index returns of European countries and the US. The European countries are the UK (the only non-EURO country), Belgium, France, Germany, Ireland, Italy and Spain. The MSCI bond indices are sovereign total return indices with maturities longer than 10 years (10year+). All indices are in local currency, that is EURO, US Dollar or British pounds. The data cover a time-period of 10 years from November, 30 1995 until November 30, 2005. The returns are illustrated graphically in figures 10 - 11 and the descriptive statistics are shown in table 2 in the Appendix.

The unconditional correlation coefficient of bonds and stocks is shown in table 3. The upper triangular matrix contains the correlation coefficient between the bond indices and the lower triangular matrix presents the correlation coefficient between the stock indices. On average bond correlations are larger which can be explained by the predominant role of the EURO markets in the sample. An obvious exception is the US for which stock correlations are larger than bond correlations. Average bond return correlations are 0.6967 and 0.5892 for equities.

The unconditional correlation between bond and stock returns is negative without ex-

Table 2: Descriptive statistics of continuously compounded bond and stock index returns

Bond market	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
US	0.0003	0.0056	-0.0312	0.0203	-0.4245	4.4749
UK	0.0003	0.0047	-0.0351	0.0323	-0.1380	5.5756
Belgium	0.0003	0.0076	-0.0341	0.0361	0.0149	4.1830
France	0.0003	0.0079	-0.0355	0.0364	0.0058	4.1805
Germany	0.0003	0.0084	-0.0409	0.0362	-0.0432	4.1799
Ireland	0.0003	0.0076	-0.0429	0.0370	-0.0667	4.4286
Italy	0.0005	0.0084	-0.0459	0.0352	-0.0802	4.2336
Spain	0.0004	0.0079	-0.0391	0.0367	-0.0774	4.1347
Stock market	**Mean**	**Std. Dev.**	**Min**	**Max**	**Skewness**	**Kurtosis**
US	0.0002	0.0109	-0.0601	0.0559	-0.2087	5.9710
UK	0.0003	0.0114	-0.0697	0.0561	-0.1033	6.1231
Belgium	0.0003	0.0119	-0.0561	0.1000	0.2138	8.8693
France	0.0004	0.0137	-0.0723	0.0657	-0.1377	5.6778
Germany	0.0003	0.0154	-0.0867	0.0745	-0.2279	5.8477
Ireland	0.0002	0.0118	-0.0901	0.0617	-0.6744	9.2102
Italy	0.0004	0.0133	-0.0742	0.0704	-0.1486	5.8075
Spain	0.0005	0.0140	-0.0758	0.0653	-0.1617	5.9303

Table 3: Unconditional correlation coefficient of bond-bond returns and stock-stock returns (bonds upper triangular matrix, equity lower triangular matrix)

	US	UK	BB	FRA	GER	IRE	ITA	SPA
US	.	0.4806	0.3201	0.3353	0.3705	0.3234	0.3269	0.3232
UK	0.4126	.	0.4939	0.5255	0.5670	0.4801	0.5312	0.5096
BB	0.6611	0.3750	.	0.9813	0.9741	0.9314	0.8918	0.9527
FRA	0.8026	0.4427	0.7114	.	0.9759	0.9226	0.9026	0.9535
GER	0.7243	0.4893	0.6621	0.8098	.	0.9117	0.8955	0.9453
IRE	0.5430	0.2218	0.4759	0.5096	0.4862	.	0.8575	0.9070
ITA	0.7067	0.3923	0.6216	0.7912	0.7215	0.4594	.	0.9184
SPA	0.7015	0.4079	0.6320	0.7990	0.7238	0.4596	0.7527	.

Table 4: Unconditional correlation between bonds and stocks

		stocks							
		US	UK	BB	FRA	GER	IRE	ITA	SPA
bonds	US	-0.1221	-0.0748	-0.1024	-0.1134	-0.1891	-0.0601	-0.0777	-0.1019
	UK	-0.1345	-0.0487	-0.1250	-0.1540	-0.1671	-0.0971	-0.1013	-0.1351
	BB	-0.2602	-0.1334	-0.2180	-0.3204	-0.2917	-0.2015	-0.2527	-0.2569
	FR	-0.2547	-0.1305	-0.2123	-0.2996	-0.2822	-0.1909	-0.2351	-0.2446
	GER	-0.2421	-0.1159	-0.2034	-0.2936	-0.2698	-0.1808	-0.2262	-0.2352
	IRE	-0.2504	-0.1236	-0.2096	-0.3101	-0.2874	-0.1976	-0.2427	-0.2522
	ITA	-0.2105	-0.0963	-0.1705	-0.2426	-0.2352	-0.1541	-0.1191	-0.1825
	SPA	-0.2455	-0.1286	-0.2082	-0.3017	-0.2815	-0.1891	-0.2183	-0.2173

ception which is in contrast to the findings in Campbell and Ammer (1993).[5] Negative correlations can be explained with an uncertainty about expected inflation or future returns as outlined in Bekaert and Grenadier (2001) and Stivers, Sun and Connolly (2002). Obviously, transitory negative correlations can also be explained with flight-to-quality in certain periods. If these transitory negative correlations are pronounced and of some duration, it is possible that average correlations are influenced by this and slightly negative.

We later examine the correlation estimates around several financial market events in more detail. The events analyzed are the Asian crisis in October 1997, the Russian crisis in June 1998, the EURO introduction in January 1999 and 2002, September 11, the Enron and Worldcom 'news' in October 2001 (16th October) and June 2002 (26th June) and the beginning of the war in Iraq in March 2003 (20th). The analysis is not restricted to these dates due to the computation of extreme and abrupt changes of the correlation coefficient in the preceding K trading days. This is done in the first stage as outlined above.

4 Empirical Results

In this section we first report the results of the estimation of time-varying correlations between stock and bond returns for the US and European stock and bond markets. We also report the correlation estimates of US bonds and EU equities. As a second step we report the regression results of the correlation estimates on the shocks that constitute the level of correlations.

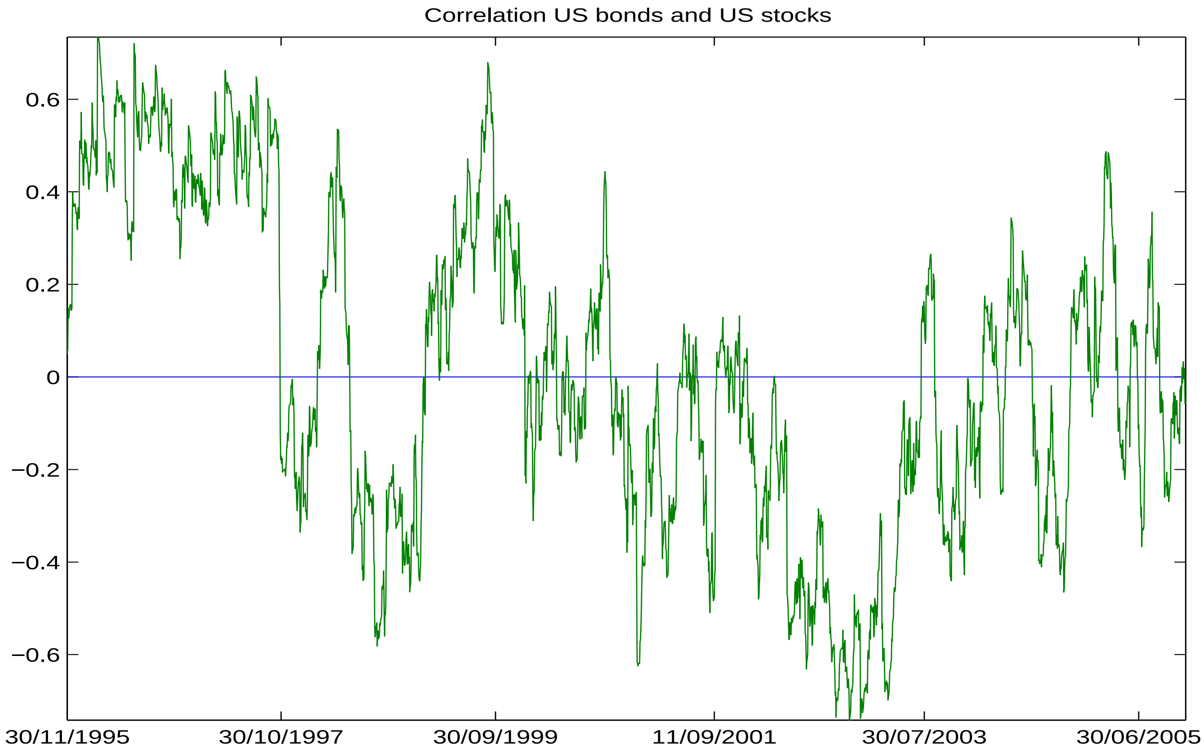

Figure 1: *Time-varying correlations (DCC estimates)*

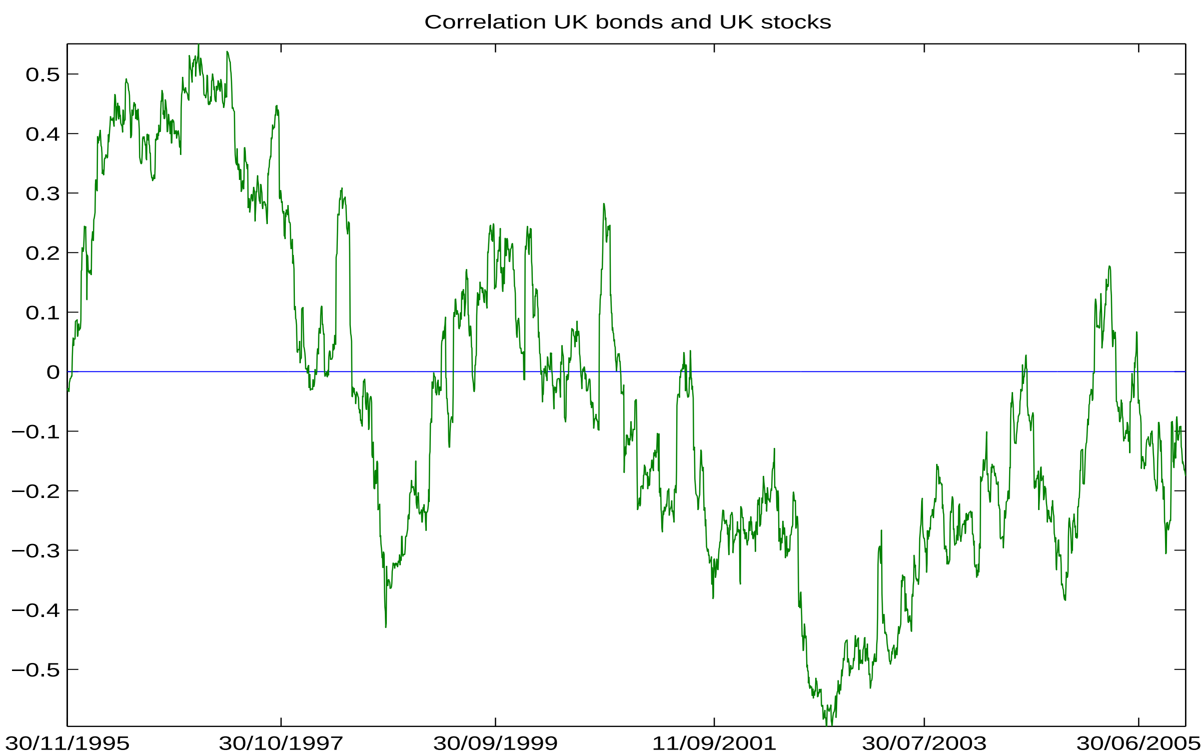

Figure 2: *Time-varying correlations (DCC estimates)*

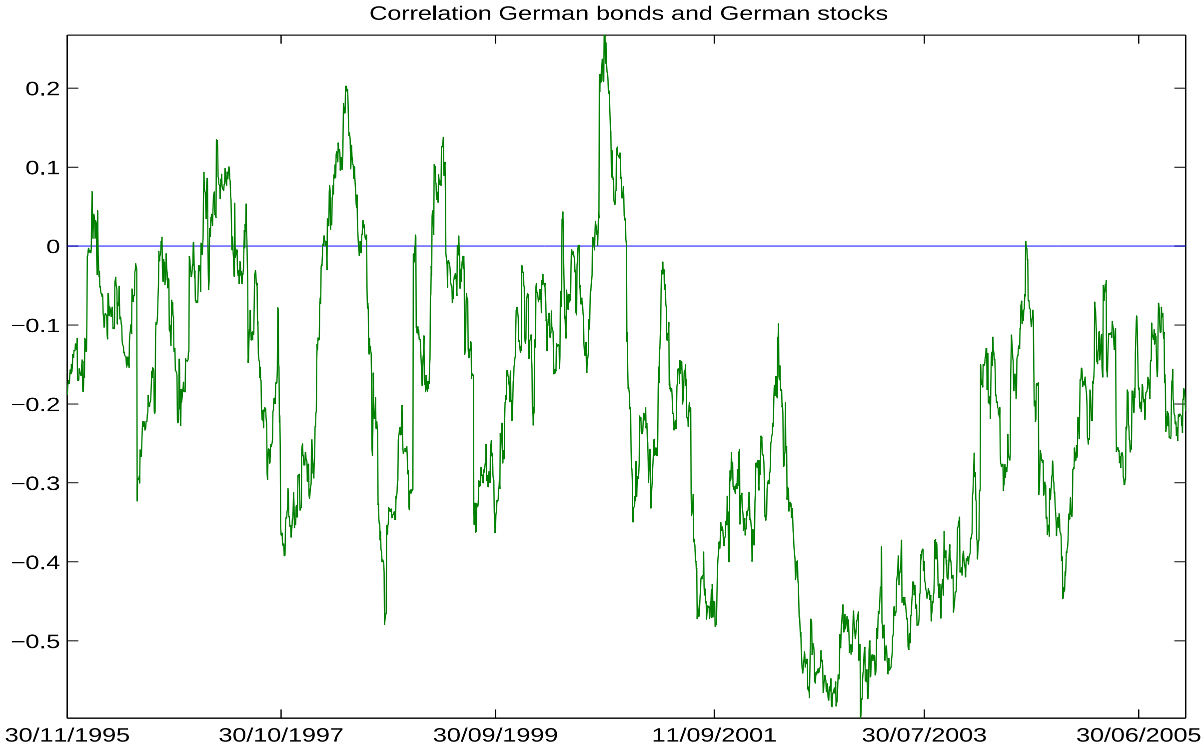

Figure 3: *Time-varying correlations (DCC estimates)*

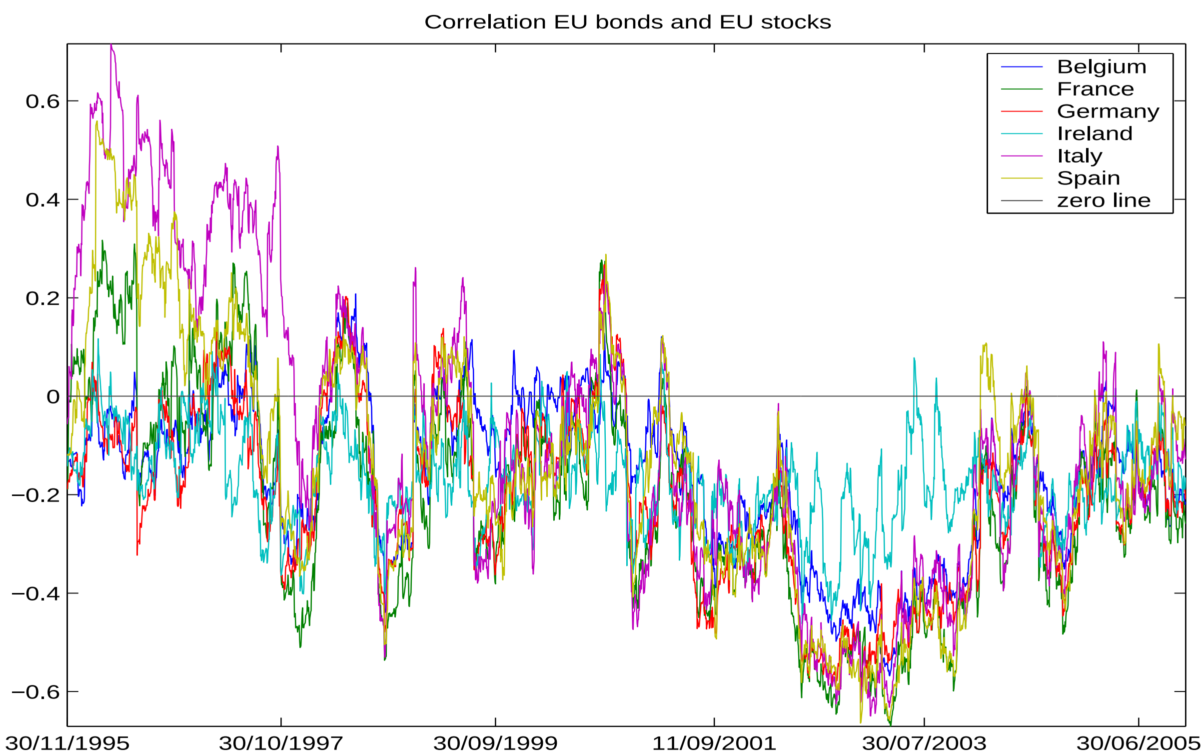

Figure 4: *Time-varying correlations (DCC estimates)*

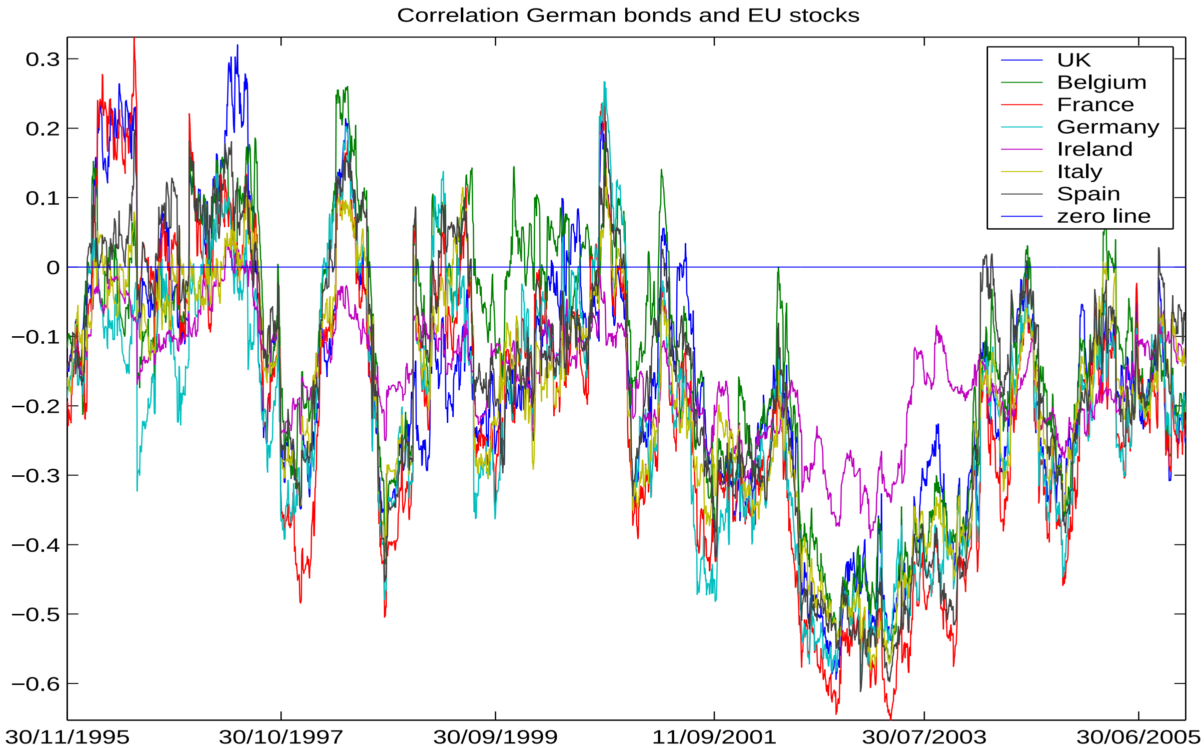

Figure 5: *Time-varying correlations (DCC estimates)*

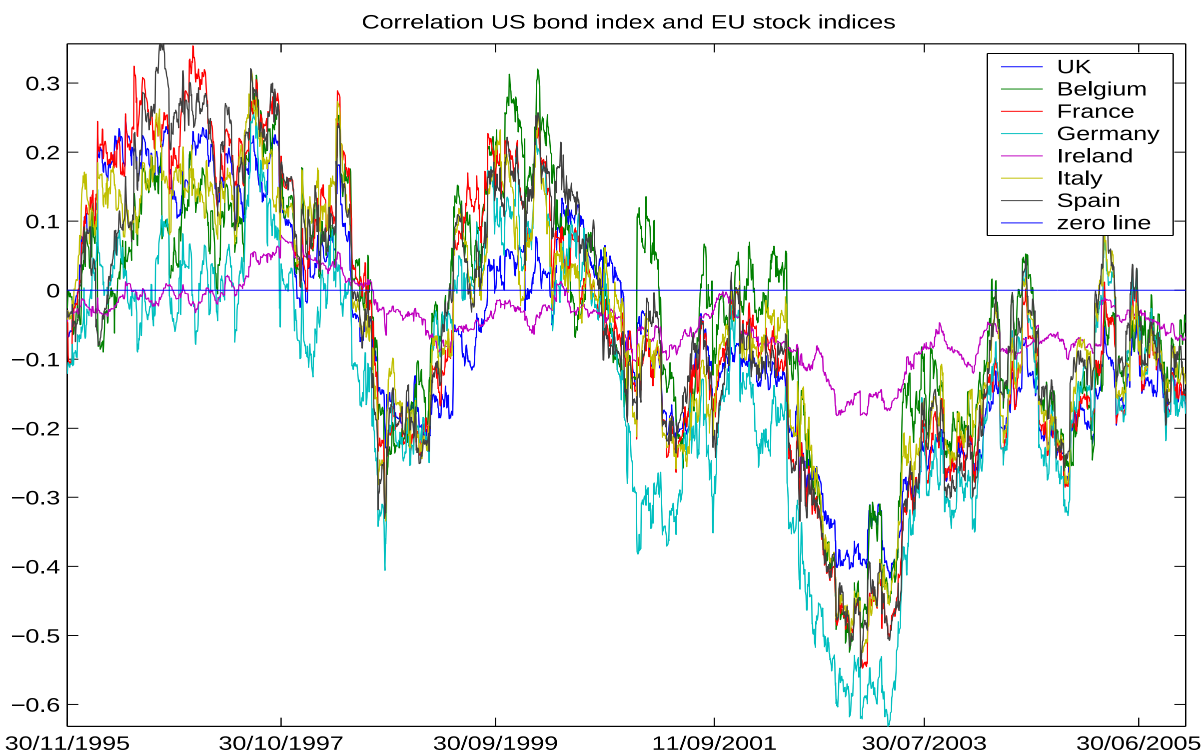

Figure 6: *Time-varying correlations (DCC estimates)*

4.1 Dynamic Correlations - Graphical Analysis

4.1.1 Bond and Stock markets

Figures 1-3 illustrate the time-variation of the correlations between stocks and bonds for the US, the UK and the German stock-bond correlations. Stock-bond correlations for many markets simultaneously are given in figure 4-6. All correlation estimates have two common features. First, they are very volatile and a clear positive or negative stock-bond return linkage for the *entire* sample period can not be determined. Second, all estimates are positive in the beginning of the sample, decline in the subsequent years and increase slightly in the end of the sample period. The first finding is important since it implies that theories predicting the equilibrium correlation different from zero (e.g. positive) cannot be confirmed for the entire sample period.

The range of the correlation estimates is rather large for US bonds and US stocks (figure 1), also for UK bonds and UK stocks (figure 2) and EU bonds and EU stocks (figure 4) but not so for combinations of these. For example, the range of the correlation estimates is significantly lower for US bonds and UK stocks (figure **??**) , German bonds and EU stocks (figure 5) and US bonds and EU stocks (figure 6). The cross-country combinations show how sensitive stocks and bonds react to other country's information. A different evolution of the stock bond correlation represents the German correlation. There is no pronounced positive correlation in the beginning of the sample period and at the end of the sample period the correlation remains negative. This is in stark contrast to the correlations of the other countries.

There are some additional details that are worth mentioning. The EU bond stock market correlations (figure 4) are rather heterogeneous before the Asian crisis and become

[5] Campbell and Ammer (1993) use monthly stock and bond returns in contrast to this study that analyzes daily data.

more homogeneous afterwards. The countries Ireland, Italy and Spain considerably contribute to the heterogeneity. The German bond and EU stock market correlations show that France is most extreme on the downside. Finally, The US bond and EU stock market correlations illustrate that the US bond and Irish stock market linkage is very different from the other markets. It is the most stable correlation for the entire sample period and relatively close to zero. The correlation of the US bonds with the German stock market exhibits the most extreme negative values while the most extreme positive values occur for the Belgian stock market.

Extreme and abrupt changes are presented in the subsequent figures 7 and 8. We compute the cumulative abnormal correlation change (CACC) that contains the information by how much the correlations changed in the last 20 trading days. The CACC measure is important in order to detect contagion and flight-to-quality and also serves in assessing the stability of the stock bond correlations. Frequent changes of this correlation can strongly impact the optimality of portfolios and diversification strategies. The plots show absolute correlation changes in falling stock markets that are larger than one standard deviation of the correlation distribution and illustrate that the correlations fluctuate strongly and that there are numerous periods of flight-to-quality and contagion. The use of large *absolute* changes also provides the information whether extreme negative correlation changes are more frequent and/ or more pronounced than extreme positive correlation changes.[6] Table 8 in the Appendix illustrates that correlations are clearly asymmetric. The most pronounced asymmetries can be observed for stock bond correlations within the EU and of the US bond and EU stock markets. The CACC measure can also be extended to measure only extreme changes that involve a 'jump' from negative correlations to positive correlations or vice versa. The use of this measure would imply that flight-to-quality or contagion

[6]Asymmetric effects of correlations have been analyzed by Ang and Chen (2002) and Longin and Solnik (2001) for example.

is only present if there is a change in the regime (sign) of the correlations. We assume that both phenomena can also occur without a sign change. For example, a correlation change from -0.1 to -0.6 or a change from 0.2 to 0.7 are both extreme correlations movements that are likely to represent contagion or flight-to-quality.

The extreme and abrupt changes for the US bond and stock market correlations can be summarized as follows: There were extreme negative changes of the correlation in falling stock markets end of October 1997 and in the first two weeks of November (values around -0.7), in June 1998 (the maximum value is -0.7588), in October 2000, January 2001, a large drop in correlations before September 11 and a strong increase afterwards. Further large drops were in September 2003, in August 2004 and in April 2005. Large increases were in March and August 2005.

The extreme correlations for the UK bond and stock market are significantly lower than for the US market due to the lower range of the correlation. Extremes are also considerably less frequent. Large absolute changes occur only six times opposed to more than 35 such events for the US stock bond correlations. Large positive changes are in May 1998 and September (13th and 27th) 2000. Large negative changes are in June, July and October 1998.

The extreme correlation changes for Germany are similar to the US and amount to 34 extreme changes. Extreme negative changes are in November 1997, August and September 1998, October, November and December 2000, July 2001, May 2002, July and August 2004 and May 2005. Correlations exhibit extreme positive changes in 1997, 1999, 2000, 2001, 2002 and 2004.

Figure 8 shows the extreme and abrupt changes of the correlations of the EU bonds and the US bonds with the EU markets, respectively. There are several periods where all markets exhibit extreme and abrupt negative changes simultaneously. For the EU stock

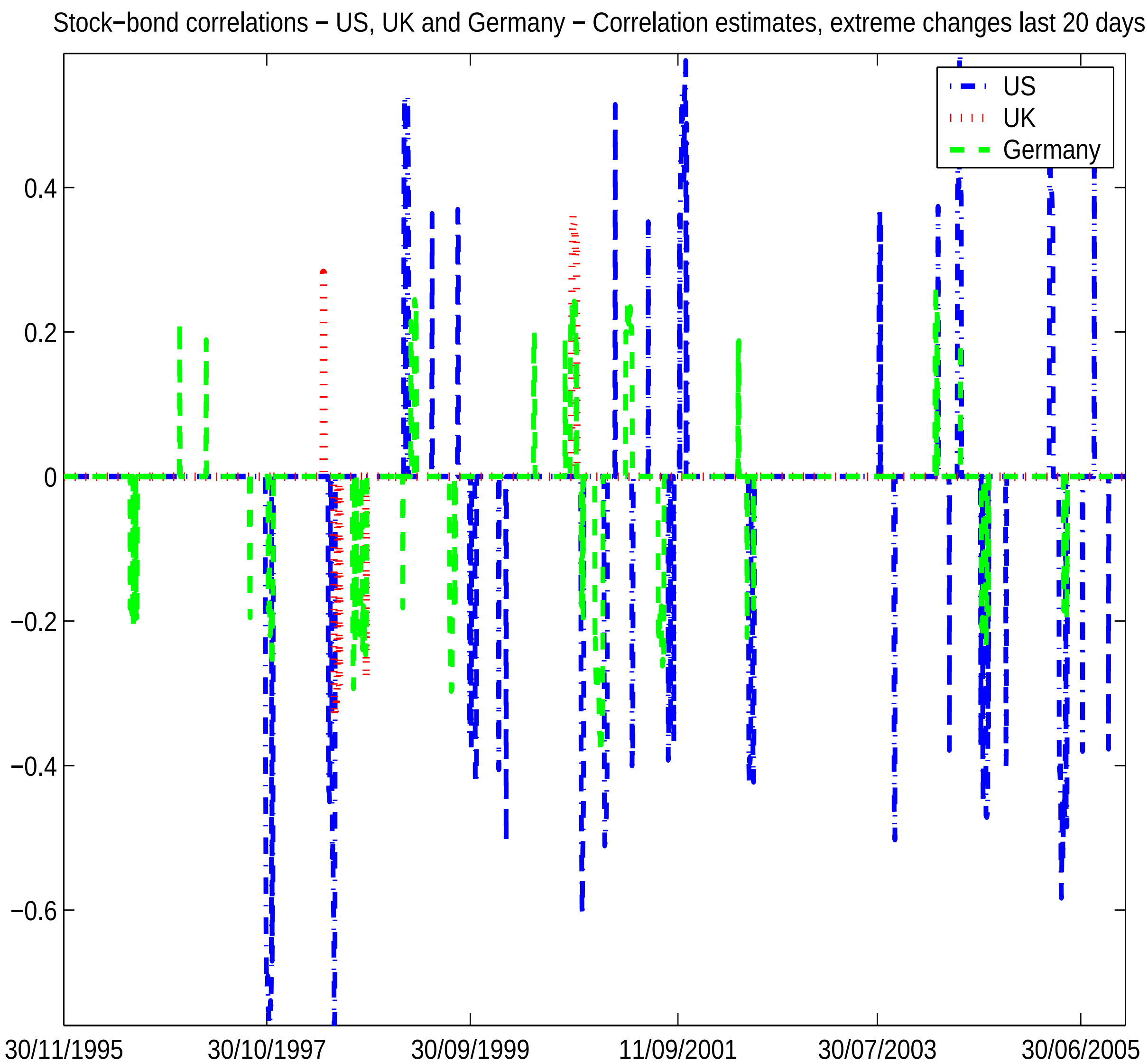

Figure 7: *Extreme changes of time-varying correlations. Positive changes are joint negative return shocks of stocks and bonds and negative changes are associated with negative return shocks only.*

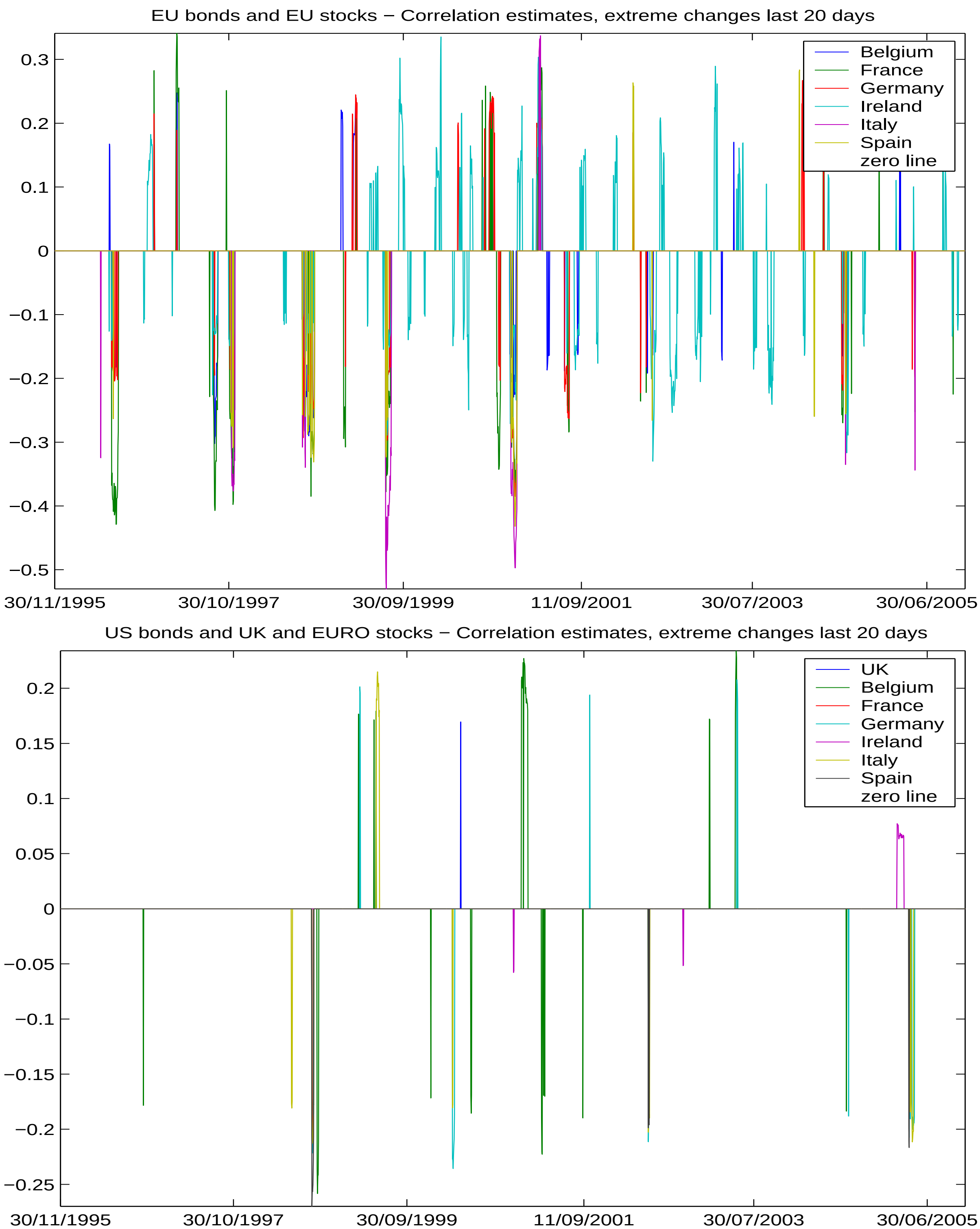

Figure 8: *Extreme changes of time-varying correlations. Positive changes are joint negative return shocks of stocks and bonds and negative changes are associated with negative return shocks only.*

and bond correlations these periods are November 1997, September 1998, July and August 1999, December 2000 and March 2001. For the US bonds with the EU markets these periods are September 1998 where five markets exhibit negative CACC and May 2002 where three markets exhibit negative CACC. There are no other simultaneous extreme correlation movements.

The extreme stock-bond correlations show a considerable degree of heterogeneity. Extremes in one country are often not associated with an extreme in another country. Extremes are very frequent in the US and Germany but not so in the UK. Furthermore, the degree of extreme movements varies significantly. It is most pronounced in the US and less so in the UK and Germany. Finally, there is no clear trend in extreme correlation changes.

4.2 Specification Issues

Rolling correlations are analyzed since longer windows are likely to reduce the impact of volatility as reported by Boyer et al. (1999) and Forbes and Rigobon (2002). Differences can be examined in the Appendix in figures 12-14 for the US, the UK and the German stock bond correlations. The figures show that longer rolling windows imply smoother correlations and shorter rolling windows more volatile correlations. The DCC estimates are in between these extremes but seem to be closer to the shorter rolling windows, i.e. a period of 25 or 50 trading days. The differences for extreme correlations can be analyzed in figure 15 for the US, the UK and the German stock bond correlations, respectively. These figures show that the size of the rolling windows is closest to the DCC estimates for 50 trading days.

The robustness with respect to a different number of past trading days for the computation of the cumulative abnormal correlation changes (CACC) can be analyzed in figure 16 for the US stock bond correlations. Not surprisingly, the larger the number of past trading days K is, the larger the number of abnormal correlation changes that are larger than one standard deviation. The graph also shows that even for only 10 trading days in the past, abnormal correlation changes are relatively frequent and occur once a year on average for the US stock bond correlations. There is also a pronounced asymmetry of positive and negative extremes for this low number of trading days. Negative abnormal changes are more frequent than positive changes. This is not surprising given the large literature on asymmetric effects of negative and positive shocks on volatilities and correlations.

4.3 Regression Model Results

The motivation for this section is twofold. First, it is analyzed whether shocks in the bond market and in the stock market have a different impact on the correlation estimates. Differences of positive and negative shocks are also examined. Second, we investigate several events in the sample period in order to test the existence of flight-to-quality and contagion. This second part is covered to some degree by the analysis above where abrupt changes of the correlation estimates have been plotted and examined. The analysis is based on a regression model and is comparable to tests of contagion as proposed in Baig and Goldfajn (1999) and Forbes and Rigobon (2002).

For the US bond and stock market correlation estimates, the regression results presented in tables 5-6 can be summarized as follows: stock market volatility is three times more important than bond market volatility and explains almost 23 percent of the variation in correlations. Shocks in the stock market are more important than bond market shocks and there is an asymmetric (time-series) effect of the shocks, that is, negative shocks change the correlations by more than positive shocks. Including the lagged correlation estimate in the regression (6) does not qualitatively change this result. The event

Table 5: Contemporaneous regression results: Correlation US bonds and US stocks

regressors	beta	tstat	beta	tstat	beta	tstat	beta	tstat
constant	0.2356	9.6387	0.2358	9.55	0.2487	9.9166	0.2524	10.2413
corr(t)								
hbonds(t)	-506.9874	-0.6634	-492.4363	-0.6435	-619.1903	-0.8004	-695.422	-0.9178
hstocks(t)	-1614.8277	-27.5175	-1618.3777	-26.7543	-1571.5504	-25.1283	-1538.9713	-24.3998
bonds+(t)			-0.0034	-0.3229	0.0001	0.009	0.0003	0.0232
stocks+(t)			0.0032	0.313	-0.0099	-0.8713	-0.0099	-0.8898
bonds-(t)					0.0016	0.1538	0.0014	0.1411
stocks-(t)					0.0313	2.8745	0.0306	2.8576
Dummies Asia							0.2894	4.3987
Russia							-0.2418	-3.7076
EURO intro.							-0.3193	-4.8769
Sep-11							0.1663	2.5373
Enron							0.0761	1.1698
Worldcom							-0.2412	-3.6485
Iraq							-0.4938	-7.3862
R squared	0.2297		0.2298		0.2323		0.2701	

The variables hbonds and hstocks denote the conditional volatilities of bonds and stocks, respectively.
t-statistics larger than 3 (2) are highly significant at the 1% (5%) level.

dummies show the average correlation level conditional on the mean in the specification without the lagged correlation. Including the lagged level of correlation reveals the change in the correlation during the events. Three events are significant. The Asian and the Russian crisis with negative coefficients and September 11 with a positive coefficient which implies that there was flight-to-quality in the Asian and the Russian crisis and contagion after September 11. These events are significant even though the positive and negative bond and stock returns are included in the regression: positive stock returns today decrease correlations tomorrow and negative stock returns also decrease correlations but by a larger amount than positive shocks. The finding that positive stock returns decrease correlations can be explained with a flight-from-quality effect from bonds to stocks. The contemporaneous regression results show that only negative stock market shocks are significant which is additional evidence of flight-to-quality.

Table 6: Predictive regression results: Correlation US bonds and US stocks

regressors	beta	tstat	beta	tstat	beta	tstat	beta	tstat	beta	tstat	beta	tstat	beta	tstat
constant	0.2349	9.5994	0.002	0.4849	0.0029	0.7085	0.2357	9.5361	0.2513	10.0191	0.2556	10.3759	0.0066	1.5701
corr(t-1)			0.9873	306.6589	0.9867	299.664							0.9856	302.5294
hbonds(t-1)	-500.2004	-0.6539	5.7976	0.0462	-17.7655	-0.1413	-481.8626	-0.629	-755.1116	-0.9764	-849.4641	-1.1215	-159.4497	-1.2678
hstocks(t-1)	-1610.908	-27.4214	-16.036	-1.4634	-14.2867	-1.2653	-1612.5764	-26.6313	-1549.658	-24.7847	-1516.547	-24.0521	0.8583	0.0739
bonds+(t-1)							-0.0051	-0.4769	0.0045	0.3789	0.0046	0.401	0.0045	2.337
stocks+(t-1)							0.0022	0.2121	-0.0167	-1.4794	-0.0167	-1.5075	-0.0069	-3.7808
bonds-(t-1)									-0.0082	-0.7828	-0.0083	-0.8089	-0.0097	-5.7394
stocks-(t-1)									0.0425	3.9068	0.0418	3.9057	0.0117	6.5777
Dummies Asia					-0.0321	-2.8974					0.2584	3.9291	-0.0268	-2.4474
Russia					-0.0227	-2.0637					-0.2602	-3.9922	-0.0218	-2.0078
EURO intro.					-0.0088	-0.7929					-0.3271	-4.9979	-0.0124	-1.1363
Sep-11					0.0292	2.6456					0.1958	2.9877	0.0318	2.9244
Enron					-0.0062	-0.567					0.0676	1.0387	-0.0075	-0.6897
Worldcom					-0.0096	-0.8684					-0.2388	-3.615	-0.0011	-0.103
Iraq					-0.0034	-0.299					-0.489	-7.3163	-0.0022	-0.1957
R squared	0.2285		0.9792		0.9794		0.2286		0.2331		0.271		0.9799	

The variables hbonds and hstocks denote the conditional volatilities of bonds and stocks, respectively.

t-statistics larger than 3 (2) are highly significant at the 1% (5%) level.

The results are qualitatively similar for the UK bond and stock market correlations. Exceptions are that lagged bond market volatility is significant, the asymmetry of positive and negative lagged bond and stock market shocks exists but is less pronounced and the EURO introduction is a significant event with a negative coefficient which implies that this event lowered the correlation.

For the correlation of the US bond market and the UK stock market, the findings differ in that there is no asymmetry of positive and negative lagged stock return shocks and the EURO introduction had a significant and positive effect.

The findings for the correlations of EU bond and stock market shocks differ in the following respects from the US bond and stock regression results. For the German correlations, the event dummies are all (except for Enron) significant if the lagged level of correlation is not included. An inclusion of this regressor renders all events insignificant. Interestingly, this effect is not a common feature for the other EURO markets. The Asian crisis is negative and significant for all other countries with the EURO as a currency in the sample. It is important to add that the EURO was not actually introduced at the time of the Asian crisis.

Finally, the stock bond correlations of the US bond market and the EU stock markets replicate the above findings. A special case is Ireland. The event dummies are all significant (except the EURO introduction) in a specification without the lagged level of correlation and explain almost 12 percent of the variation in the bond stock market linkage.

Contagion is more frequent for stock-bond correlations than for stock-stock correlations or bond-bond correlations as reported by Baig and Goldfajn (1999) and Forbes and Rigobon (2002) for stock markets and by Dungey et al. (2004) for bond markets. This result can be due to the different type of asset linkages but can also be explained with the different approach employed in this paper. The computation of the cumulative abnormal correlation change provides a time-series of contagion and flight-to-quality which is not based on a priori defined crisis periods as in the papers cited above. This means that the problem of sample selection bias identified in Pesaran and Pick (2004) is alleviated. In addition, the robustness analysis has shown that the relatively high frequency of extreme correlation changes is also obtained with different time-horizons (last K trading days) and different correlation estimators.

4.4 The Economics of stock bond correlations

This section aims to explain the level of the stock bond correlations from a theoretical perspective. Since there a both arguments for a positive correlation due to common macroeconomic factors and a negative relationship due to flight-to-quality we test the hypothesis that there are two regimes, one positive and the other negative. To distinguish among these two regimes also enables us to analyze whether flight-to-quality involves a change from a positive correlation to a negative or whether it is just an extreme correlation change independent of the regime (the level of correlation). The same is true for contagion. Is contagion associated with a correlation change from a negative regime to a positive or is it just an extreme change of the stock-bond correlation. Moreover, the distinction of positive and negative correlations can also reveal the persistence of the regimes and show whether positive correlations are more frequent than negative correlations or vice versa.

We use a simple model to analyze this hypothesis. We do not attempt to model the regime changes but only the existence of two regimes. Therefore, we estimate the following equation:

$$\hat{\rho}_{ij,t} = \alpha + \beta D(\hat{\rho}_{ij,t-1} < 0) + \delta \boldsymbol{X}_{t-1} + \epsilon_t \tag{9}$$

where $D(\hat{\rho}_{ij,t-1} < 0)$ is a dummy variable that is one if the lagged correlation is negative and zero positive. This regressor captures the mean of the negative regime while the mean of the positive regime is captured by α. Additional regressors in X_{t-1} are the conditional volatilities of bonds and stocks for both regimes and the crisis dummies as used earlier.

Table 7 presents the regression results of this model for the US stock-bond correlations and figure 9 illustrates the existence of two regimes for US, UK and German stock-bond correlations.

The regression results for the US show that stock and bond volatilities have a negative coefficient if we do not account for the two regimes. Hence, higher stock or bond market volatility decrease the stock-market correlation and potentially contribute to flight-to-quality. The goodness of fit is 23 percent. Augmenting the model and including the conditional volatilities for both regimes increases the goodness of fit to 71 percent and also changes the sign of the coefficients. The increase in the goodness of fit is mainly due to bond volatility. Including stock volatility alone increases R^2 to 56 percent while the inclusion of bond volatility in the negative regime increases R^2 to 71 percent. The coefficient estimates can be interpreted as follows. Higher bond volatility increases the correlation in the positive regime and in the negative regime.[7] The stock market volatility decreases the correlations in the positive regime and increases the correlations in the negative regime. The magnitude is similar due to the construction of the dummy variable.[8] These coefficient estimates imply that bond volatility potentially contributes to contagion and stock market volatility to flight-to-quality in the positive regime. Including the dummy variables for the crisis periods does only slightly change the estimates and there is no qualitative difference. The graph contains the correlation estimates and the fitted correlations obtained from a regression with a constant for positive correlations and a constant for negative lagged cor-

[7]Since correlations are negative in the negative regime, negative coefficient estimates imply a positive effect on correlations.

[8]The overall effect is the sum both coefficients.

Table 7: Regression results: Correlation US bonds and US stocks

regressors	beta	tstat	beta	tstat	beta	tstat
constant	0.2368	8.9795	0.09	5.4924	0.0992	6.1155
hbonds(t-1)	-4.5026	-0.538	83.0213	14.7643	77.8525	14.0223
hstocks(t-1)	-16.2663	-27.5063	-5.0331	-5.1514	-4.0326	-3.9353
hbonds (t-1) corr(t-1)<0			-158.604	-37.1179	-155.4622	-35.7781
hstocks (t-1) corr(t-1)<0			-1.934	-1.8348	-2.6177	-2.3832
Asia					0.1465	3.6574
Russia					-0.1625	-4.0921
Euro					-0.0905	-2.2777
Sep-11					-0.0919	-2.186
Enron					-0.1105	-2.7505
Euro					0.1181	2.8939
Worlcom					-0.1807	-4.5253
Iraq					-0.3303	-8.2937
R squared	0.2304		0.7141		0.7292	

The variables hbonds and hstocks denote the conditional volatilities of bonds and stocks, respectively.
t-statistics larger than 3 (2) are highly significant at the 1% (5%) level.

relations. The existence of two regimes is evident but the graph also shows that there is no dominance of one regime with respect to the other and regime changes occur quite frequently.

The regression results for the UK (results are not reported in a table) are qualitatively and quantitatively very different. In a simple regression (without regimes) bond volatility increases the stock-bond correlation and stock volatility decreases the correlation. Both estimates are significant and the goodness of fit measure R^2 is 0.25. Controlling for positive and negative regimes does not change the coefficient estimates in the positive regime as for the US market and the goodness of fit increases considerably to 0.75. In contrast to the US correlations, the coefficient estimates for the negative regime are negative for bond volatility and positive for stock volatility which implies that higher bond volatility increases the correlation and higher stock volatility decreases the stock-bond correlations. This implies that flight-to-quality can even happen when correlations are negative already. The results also illustrate that for the UK the effects are qualitatively the same in both regimes. The graph shows that there are two regimes with a dominance of the negative regime and less fluctuations compared to the US.

The regression results for Germany (again results are not reported in a table) are as follows: bond and stock market volatility have both negative coefficients in the simple regression without controlling for different regimes. Including a negative regime changes the sign of the coefficients. Bond and stock market volatility both have a positive coefficient in the positive regime and a negative coefficient in the negative regime. All estimates are highly significant and the goodness of fit value is 0.56. The coefficient estimates imply that higher volatility increases the correlation in the positive regime and in the negative regime. Therefore, both types of volatilities can cause contagion but none of these contributes to flight-to-quality. The graph illustrates that negative correlations are more frequent than positive correlations and there are considerably less fluctuations than in the US market.

These results have important implications. First, bond volatility significantly increases correlations and can thus contribute to contagion. This is confirmed by the coefficient estimate of the September 11 dummy which is negative in this specification but is positive in the alternative regressions estimated in previous sections. Finally, it could also be argued that there is a positive level of bond stock correlations and a reverting to this positive level is not (never) contagion but only the 'correction' of the flight-to-quality effect.[9] This hypothesis is consistent with the findings for the US market but not so for the UK and the German stock-bond market linkages.

[9]This statement is related to an analysis by Forbes and Rigobon (2002) who conclude for stock-stock correlations that there is no contagion but only interdependence.

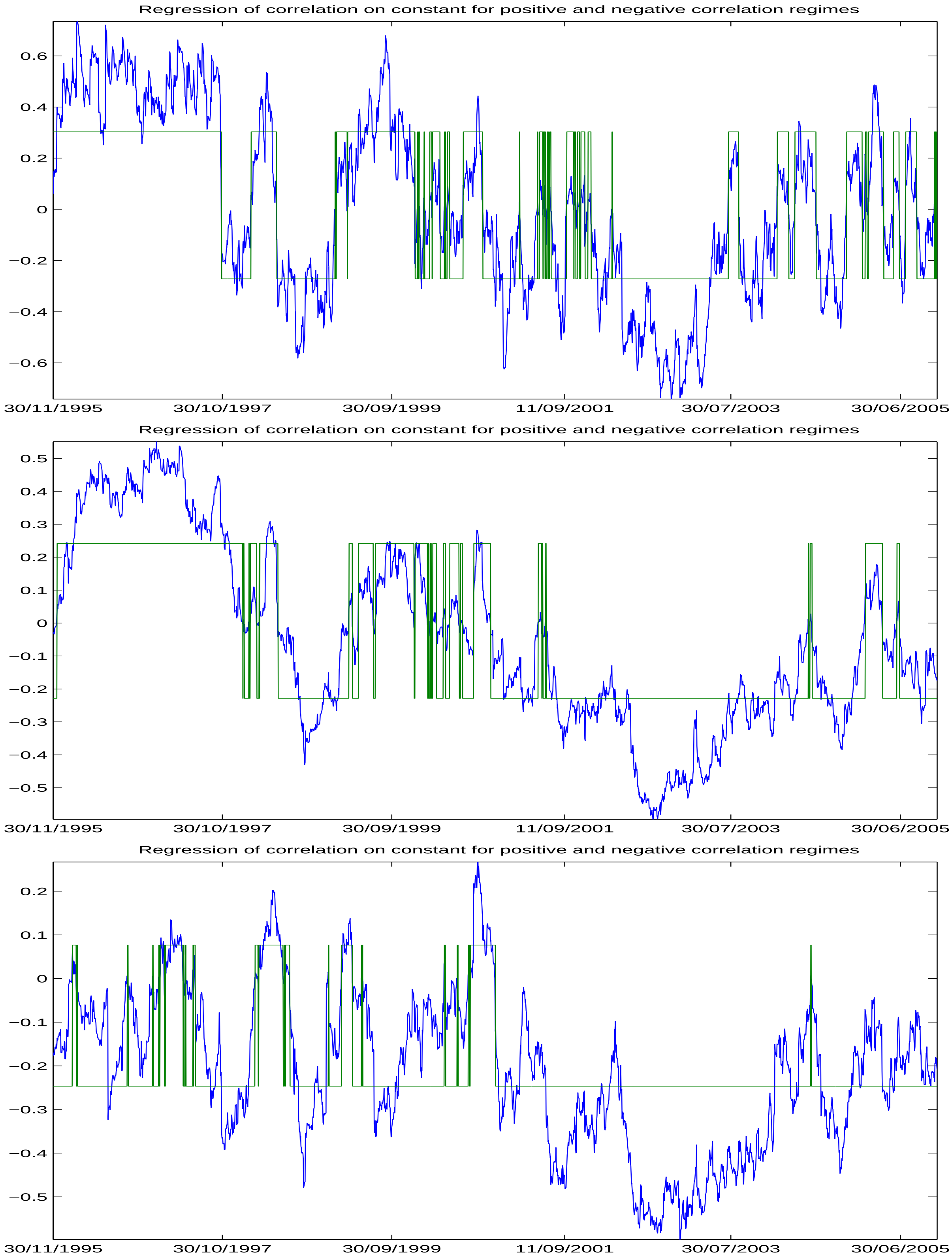

Figure 9: *Results of a simple regression model with a constant for positive correlation and negative correlation levels. Upper graph: US bond stock market correlation, middle graph: UK bond stock market correlation, bottom graph: German bond stock market correlation.*

5 Conclusions

We analyze the existence of flight-to-quality and contagion among stock and bond markets with daily data for a ten year period and use a two stage approach which consists of the estimation of time-varying correlations, the computation of abnormal extreme changes of these correlations and a regression model that analyzes the characteristics and the evolution of the correlations in more detail. We find that the stock-bond correlations are characterized by large fluctuations in the whole sample period and extreme changes in several subperiods. Correlations can change by more than 0.6 points within 20 trading days. We further find that flight-to-quality and cross-asset contagion are relatively frequent phenomena. The most pronounced flight-to-quality effect is in the Asian and Russian crisis in October 1997 and June 1998 and one of the most extreme positive correlation changes defined as (cross-asset) contagion is found after September 11. Our regression results indicate that stock and bond market volatility explain up to 30 percent of stock-bond correlations. Accounting for positive and negative correlation regimes increases this figure to almost 80 percent and reveals that higher stock market volatility decreases correlations and higher bond market volatility increases correlations contributing to flight-to-quality in the former case and contagion in the latter. Bond market volatility is also more important than stock market volatility when the regime (sign) of the correlations is included in the analysis.

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Table 8: Quantiles of DCC estimates between bonds and stocks

Quantiles	1	5	10	25	50	75	90	95	99
USUS	-0.6812	-0.5534	-0.4511	-0.2545	-0.0128	0.2907	0.5027	0.5713	0.6413
UKUK	-0.5647	-0.4844	-0.3700	-0.2511	-0.0751	0.1400	0.3973	0.4520	0.5160
EUEU									
Belgium	-0.5245	-0.4313	-0.3939	-0.2716	-0.1358	-0.0398	0.0325	0.0663	0.1507
France	-0.6289	-0.5604	-0.5088	-0.3805	-0.2148	-0.0683	0.0780	0.1692	0.2611
Germany	-0.5636	-0.5139	-0.4618	-0.3388	-0.1972	-0.0790	0.0157	0.0835	0.1969
Ireland	-0.4021	-0.3354	-0.3063	-0.2327	-0.1734	-0.1068	-0.0423	-0.0156	0.0468
Italy	-0.6126	-0.5347	-0.4540	-0.3152	-0.1370	0.0886	0.3911	0.4835	0.6068
Spain	-0.6065	-0.5490	-0.5025	-0.3174	-0.1432	0.0333	0.1600	0.2923	0.4967
GEREU									
UK	-0.5485	-0.4758	-0.4101	-0.2861	-0.1763	-0.0560	0.0999	0.1856	0.2565
Belgium	-0.5348	-0.4555	-0.3946	-0.2538	-0.1155	0.0029	0.0874	0.1211	0.2159
France	-0.6225	-0.5597	-0.5121	-0.3609	-0.2065	-0.0649	0.0541	0.1349	0.2348
Germany	-0.5636	-0.5139	-0.4618	-0.3388	-0.1972	-0.0790	0.0157	0.0835	0.1969
Ireland	-0.3609	-0.3037	-0.2683	-0.2115	-0.1535	-0.1036	-0.0609	-0.0280	0.0138
Italy	-0.5558	-0.4906	-0.4159	-0.2936	-0.1752	-0.0674	0.0101	0.0473	0.0937
Spain	-0.5607	-0.5155	-0.4735	-0.2820	-0.1400	-0.0201	0.0722	0.1101	0.1589
USEU									
UK	-0.3990	-0.3418	-0.2711	-0.1904	-0.1027	0.0563	0.1793	0.2043	0.2271
Belgium	-0.4827	-0.3876	-0.2381	-0.1449	-0.0266	0.0853	0.1667	0.2226	0.2756
France	-0.4973	-0.4390	-0.2845	-0.1939	-0.0778	0.1281	0.2203	0.2617	0.3114
Germany	-0.6049	-0.5457	-0.3729	-0.2435	-0.1079	0.0089	0.0764	0.1127	0.1988
Ireland	-0.1774	-0.1493	-0.1032	-0.0782	-0.0424	-0.0158	0.0131	0.0449	0.0681
Italy	-0.4810	-0.4124	-0.2472	-0.1755	-0.0631	0.0975	0.1616	0.1882	0.2581
Spain	-0.4924	-0.4259	-0.2924	-0.1728	-0.0613	0.1055	0.2219	0.2613	0.3170

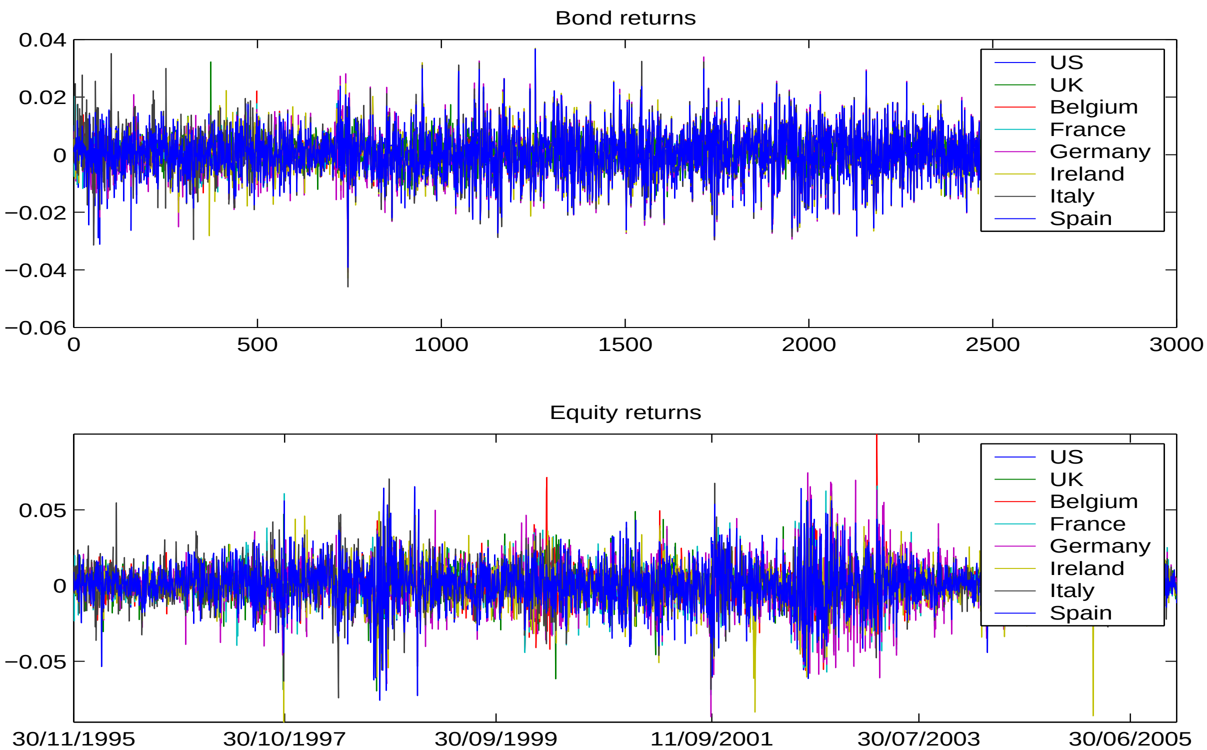

Figure 10: *Plot of Bond and Equity returns*

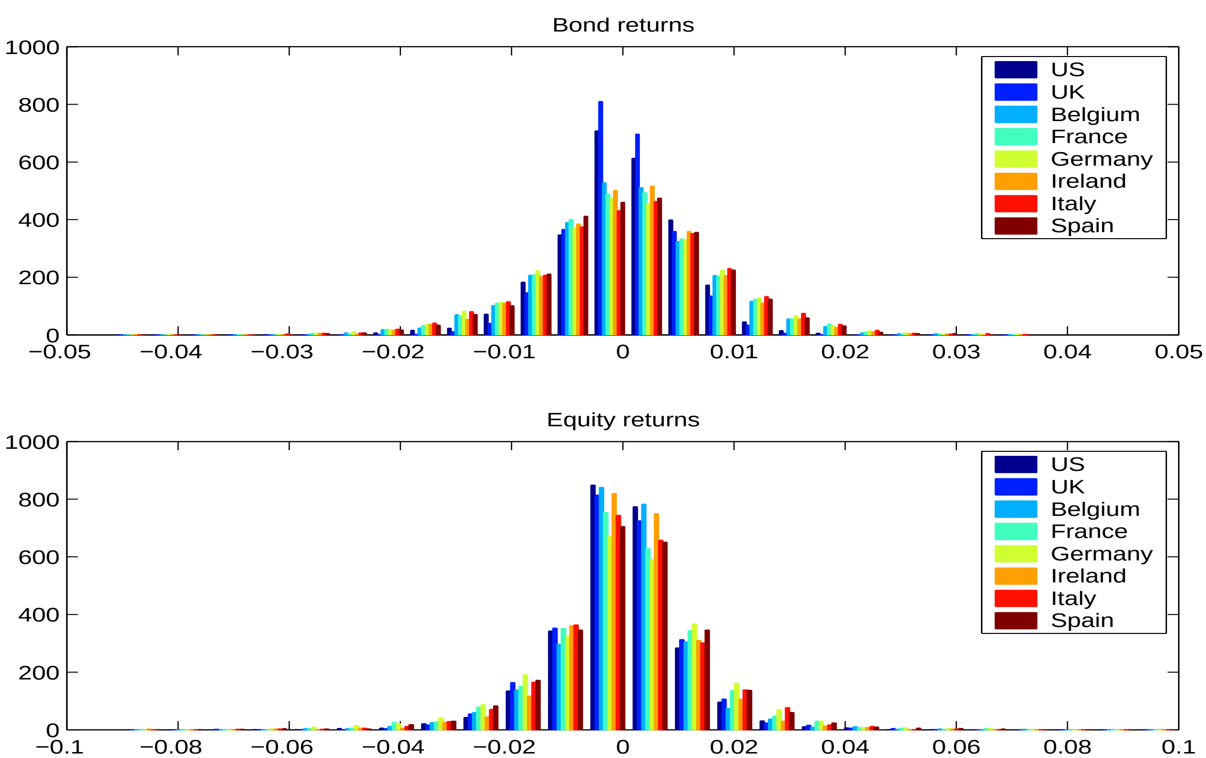

Figure 11: *Histogram of Bond and Equity returns*

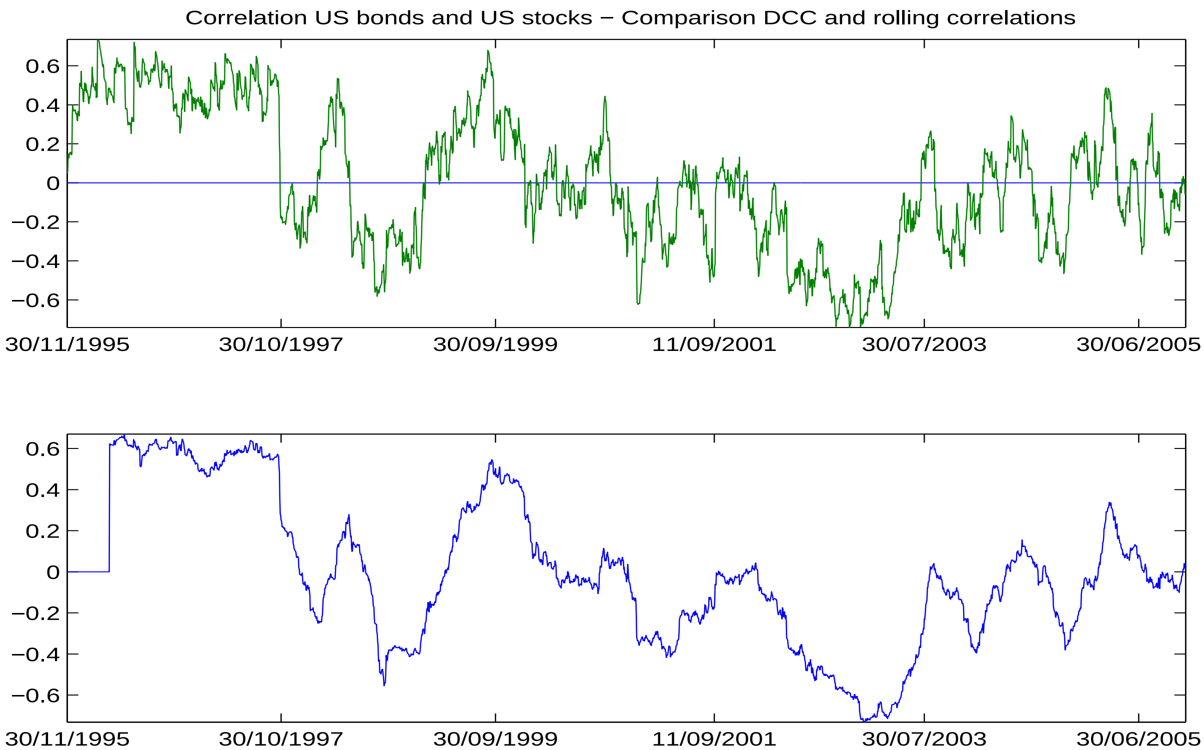

Figure 12: *Comparison DCC estimates and rolling window correlations*

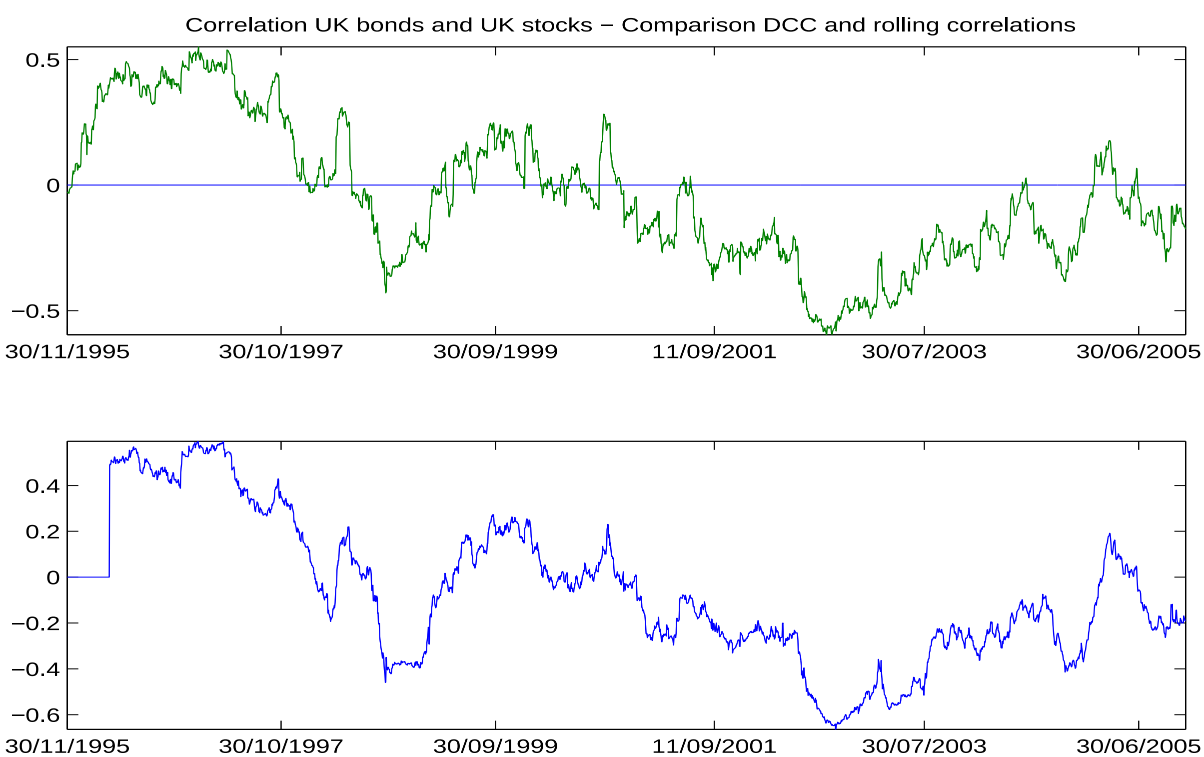

Figure 13: *Comparison DCC estimates and rolling window correlations*

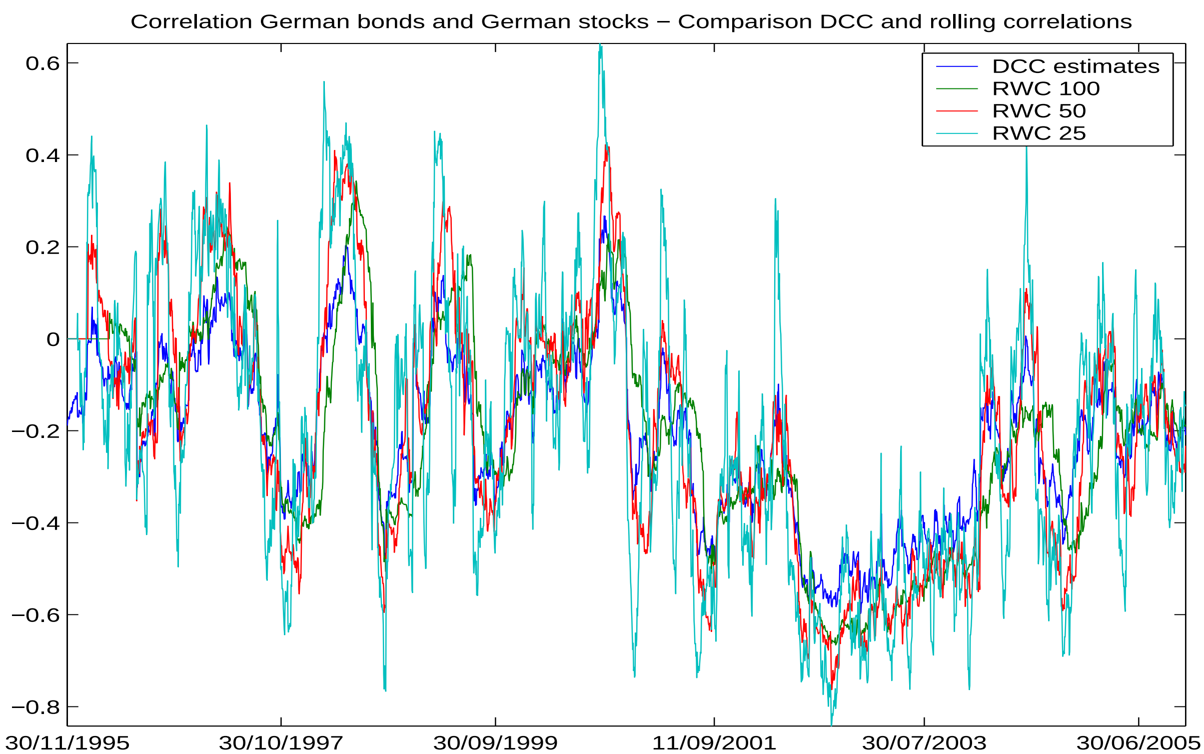

Figure 14: *Comparison DCC estimates and rolling window correlations*

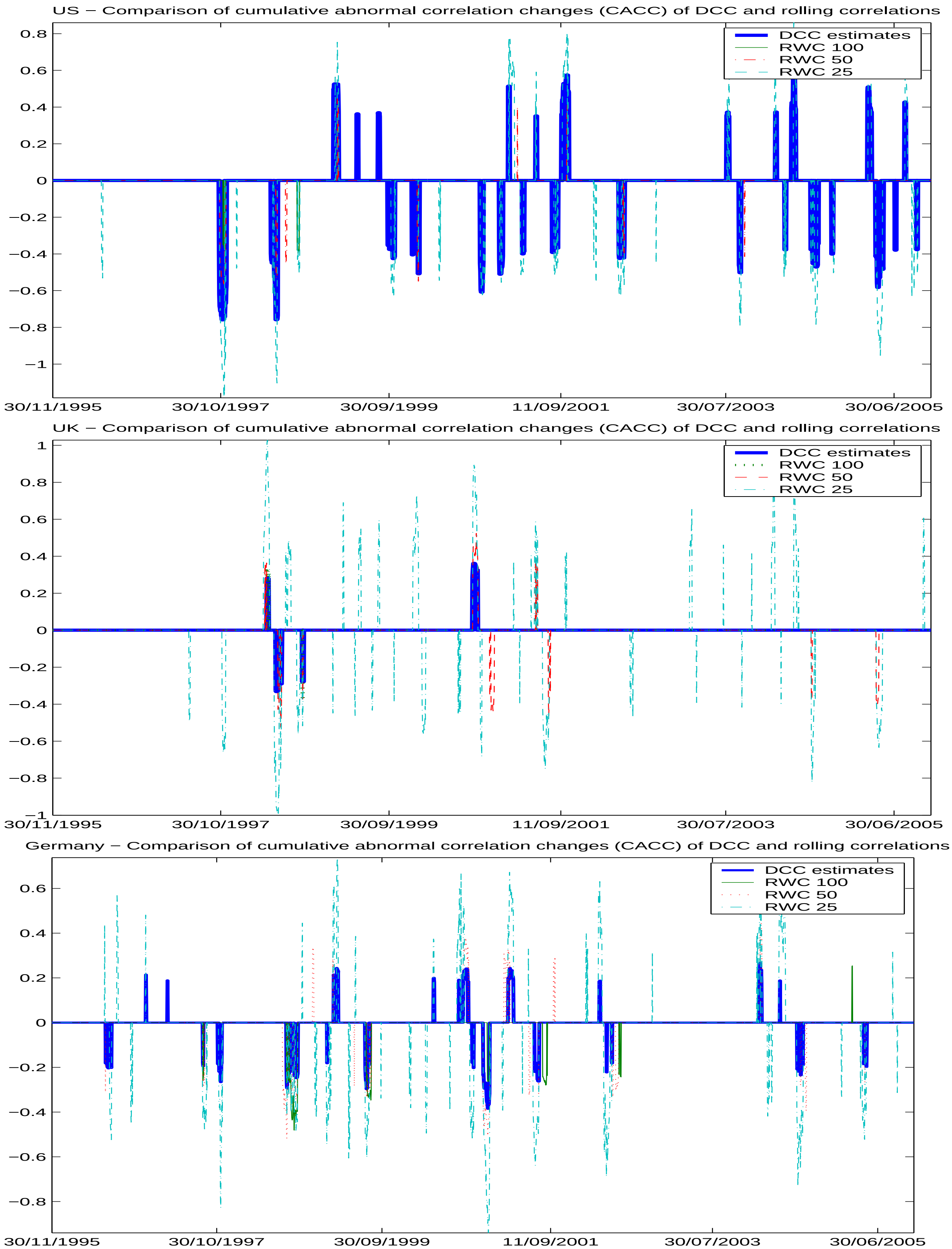

Figure 15: *Comparison extreme changes DCC estimates and rolling window correlations*

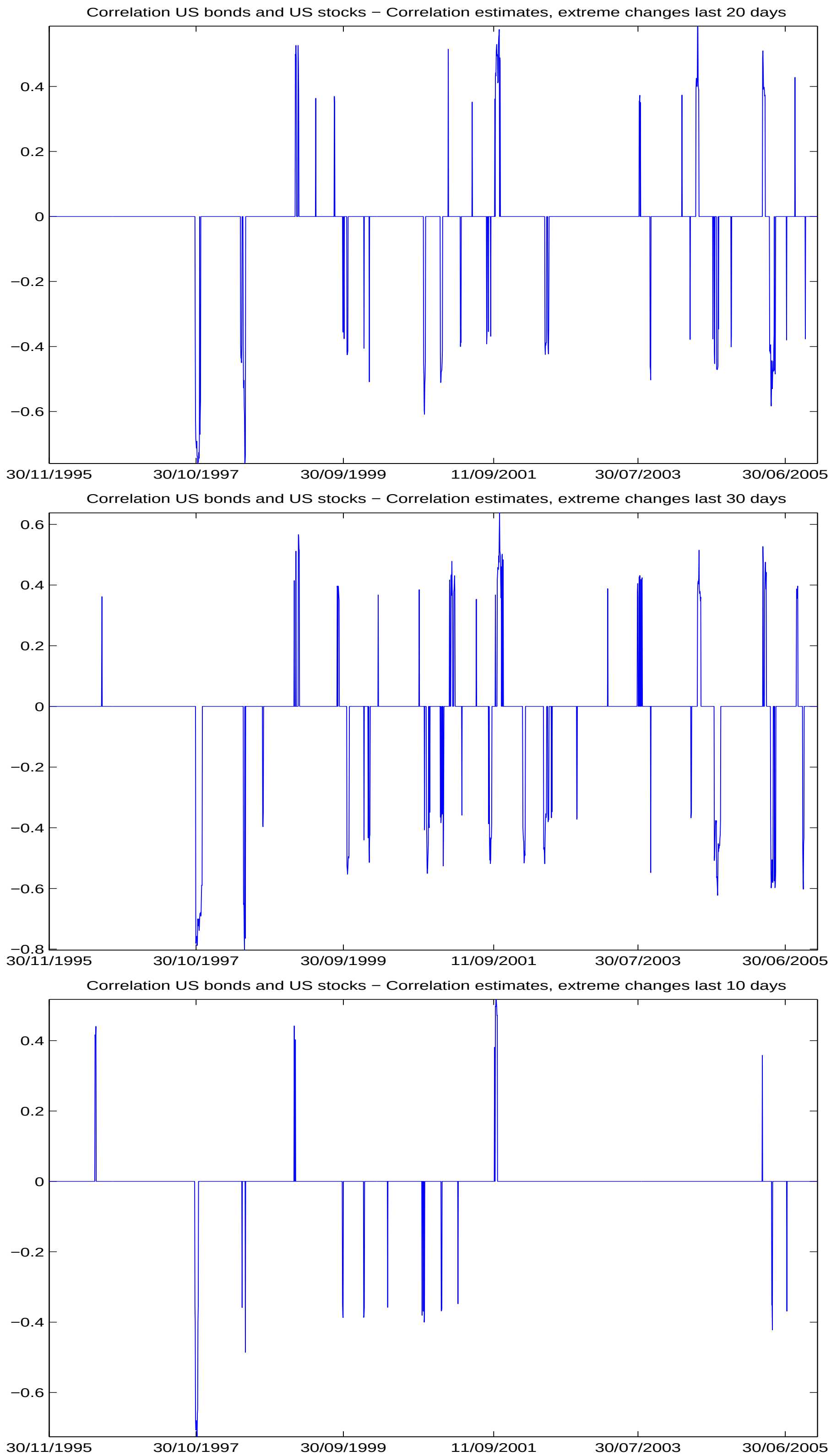

Figure 16: *Robustness analysis of extreme changes for different K (CACC in last K days): Extreme changes of time-varying correlations. Positive changes are joint negative return shocks of stocks and bonds and negative changes are associated with negative return shocks only.*

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