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Abstract

This paper shows empirically that the level of stock-bond correlation depends more on cross-country influences than on stock and bond market interaction. The study examines the relation of cross-country and cross-asset stock and bond market linkages for eight developed countries and finds that (i) stock market returns primarily depend on the US stock market and (ii) bond market returns primarily depend on the US bond market. Recursive Granger causality tests further show that the dominance of the US stock and bond market has increased in recent years and that there is both Granger causality from stocks to bonds and from bonds to stocks in several periods. We argue that the relatively low level of stock-bond correlations is due to an increased cross-country interdependence of financial markets leading to more frequent portfolio reallocations between stocks and bonds in order to compensate for lower cross-country diversification benefits.

JEL classification: **C32; E44; F3; G14; G15**

Keywords: financial market integration, stock market co-movements, bond market co-movements, stock-bond linkages, flight-to-quality, contagion

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Introduction

The integration of financial markets is of key importance for investors and policy makers. This integration can be characterized by an increased cross-country co-movement of stock and bond markets. Portfolio managers invest in both stocks and bonds within countries and among countries. It is therefore not surprising that cross-country co-movements between stocks and between bonds have been analyzed thoroughly. Recently, cross-asset co-movements, that is, stock-bond correlations, have also been analyzed in more detail. It is surprising, however, that there is only one study (see Kim, Moshirian and Wu, 2006) that analyzes the relationship of cross-country stock and bond co-movements and cross-asset stock-bond co-movements.

There is a vast literature on financial market integration in general (e.g. see Baele et al., 2004), stock market integration (e.g. see Bekaert and Harvey, 1995, Bekaert et al., 2002 and Bracker et al., 1999) and stock market co-movements, bond market integration and co-movement (e.g. see Barr and Priestley, 2004) and potential negative effects of this evidenced by the contagion literature (e.g. see Bekaert et al., 2005). Stock-bond correlations are first analyzed by Campbell and Ammer (1993). As noted above, there is only one paper on stock-bond integration (see Kim et al., 2006). Kim et al. find increased cross-market co-movements (stock-stock or bond-bond) and decreased cross-asset co-movements and argue that the latter is evidence for a segmentation of the stock and bond markets due to increased uncertainty associated with the Euro currency and its monetary policy.

The main objective of this paper is to further examine stock-bond co-movements and their relation to cross-country linkages. More specifically, we aim to contribute to the literature in the following ways: First, we develop a simple model that links cross-country and cross-asset co-movements. This model also demonstrates how cross-country contagion and flight to quality from stocks to bonds depend on these co-movements. Second, we analyze whether there is a trend in stock-stock, bond-bond and stock-bond correlations and examine interdependencies between cross-country and cross-asset linkages. Finally, we analyze the hypothesis that stock-bond co-movements are mainly determined by cross-country stock market and bond market movements. The empirical analysis for eight developed countries shows that cross-country stock and bond market linkages are causing

stock-bond co-movements. Granger causality tests based on a VAR for all stock and bond markets in the sample show that the US market causes the other markets. A sub-sample analysis performed with recursive Granger causality tests further shows that stock market returns cause bond market returns and vice versa in several sub-periods. This bidirectional relationship between stock and bond markets indicates that there is a feedback effect potentially reinforcing or correcting phenomena such as flight to quality or flight from quality. However, stock-bond interaction is dominated by cross-country linkages with the US even in sub-samples. Furthermore, in periods in which within-country stock-bond interaction is high the US stock and bond markets exhibit an additional influence on these country's markets.

Stock-bond correlations have declined significantly within the period under study. The average stock-bond linkage has decreased from a level of 0.6 in the beginning of the sample (1994-1996) to values around -0.3 between 2001 and 2005 and values close to zero in the end of the sample (2006). The relatively low stock-bond linkages currently observed among all countries can be explained with the increased cross-country interdependence of stock and bond markets leading to lower diversification benefits and more frequent portfolio reallocations between stocks and bonds.

The paper is structured as follows: The first section proposes a model that links stock-market co-movements, bond-market co-movements and stock-bond co-movements. The second section outlines the econometric framework to assess the validity of this model and the third section presents the empirical results. Finally, section 4 concludes.

1 Theoretical Model

In this section we present a model that illustrates the potential relationship between and among stock and bond markets. The model can be written as follows:

$$\begin{aligned} rs_{1,t} &= \alpha_1 rsm_t + (1-\alpha_1)\epsilon_{1,t} \\ rs_{2,t} &= \alpha_2 rsm_t + (1-\alpha_2)\epsilon_{2,t} \\ rb_{1,t} &= \beta_1 rbm_t + (1-\beta_1)\epsilon_{3,t} \\ rb_{2,t} &= \beta_2 rbm_t + (1-\beta_2)\epsilon_{4,t} \end{aligned}$$

We assume that the stock market returns rs_1 and rs_2 depend on a systemic risk factor (e.g. a broader stock market) rsm with a loading α_1 and α_2 and an idiosyncratic shock ϵ_1 and ϵ_2 with an 'inverse' loading $(1 - \alpha_i)$ for $i = 1, 2$, respectively. Bond market returns are assumed to evolve in a similar fashion. They depend on a broader market return rbm with loading β_1 and β_2 and an idiosyncratic shock ϵ_3 and ϵ_4, respectively. The idiosyncratic shocks $\epsilon_{i,t}$ for all i are normally and independently distributed with mean zero and variance one (N(0,1)).[1] If we further assume that idiosyncratic shocks are uncorrelated with the stock and bond market and that the correlation of rsm and rbm is given by ρ we can derive the following conclusions.

If the correlation of rsm and rbm denoted with ρ is positive, a higher stock market integration (higher α_1 or/ and α_2) leads to a higher stock-bond co-movement ceteris paribus. If, on the other hand, the correlation is negative, the opposite is true, that is, higher stock market integration decreases the level of stock-bond co-movements. The same relationship is true for higher bond market integration. Hence, if the broader stock and bond market indices (the systematic risk factors for stock and bond markets) exhibit a negative correlation then an increased stock or bond market integration leads to a lower stock-bond co-movement.

An alternative to the assumption about the correlation is the inclusion of two factors determining positive and negative co-movement of stocks and bonds. Let's assume the market returns of stocks and bonds depend on two common factors f and g as follows:

$$\begin{aligned} rsm_t &= f_t + g_t \\ rbm_t &= af_t - bg_t \end{aligned}$$

where a and b determine the loadings to the factor f and g. a and b are both non-negative and smaller than one.

The factor f determines the positive co-movement of stock and bond markets and g determines the negative co-movement. The factor g could be viewed as a time-varying risk factor causing stock markets to decline and bond markets to increase. For example, while f could comprise macroeconomic factors such as an economy's growth rates that drive stocks and bonds in the same direction,

[1] Stock and bond returns are generated in a way that the distribution follows the distribution of the idiosyncratic shocks with mean zero and variance one.

g could be a factor capturing stock market uncertainty in some periods decreasing stock market returns and increasing bond market returns implying flight to quality (see Li, 2002 and Connolly et al., 2005).

Both factors f and g lead to a certain correlation between the stock market index and the bond market index yielding the same conclusions as discussed above. If high stock market or bond market integration tends to increase stock-bond co-movements, the common factor f is causing these correlations. If on the other hand high stock or bond market integration tends to lower stock-bond correlations, the common factor g is primarily contributing to the level of stock-bond co-movements.

1.1 Contagion and flight to quality

The model outlined above also provides information about the occurrence of cross-country contagion between stock markets and bond markets and flight to quality from stock to bonds. Contagion can be defined as an increase in correlations between stock markets (cross-country stock market contagion), between bond markets (cross-country bond market contagion) or between stock and bond markets (cross-asset contagion) in crisis periods or in falling stock markets.[2] Flight to quality can be defined as a decrease of stock-bond correlations toward minus one in a crisis period or a falling stock market (see Baur and Lucey, 2006).

Cross-country stock-stock or bond-bond contagion and flight to quality can be caused (i) by changing factor loadings α, β, a and b or (ii) by a temporary change in the correlation of the idiosyncratic shocks[3]. Both assumptions have different implications. If contagion and flight to quality is caused by the common factors f and g, the occurrence of these phenomena tends to be more frequent or more severe the higher the stock or bond market integration is. This also implies that a lower degree of stock or bond market integration lowers the likelihood that contagion or flight to quality occur since f and g play a minor role and idiosyncratic shocks are more important. If on the other hand contagion or flight to quality is exclusively caused by idiosyncratic shocks their occurrence is less likely the more integrated stock markets and bond markets are because of the lower weights attributed to the idiosyncratic shocks.

[2] e.g. see Forbes and Rigobon (2002) for cross-country stock market contagion, Dungey et al. (2004) for cross-country bond market contagion and Gonzalo and Olmo (2005) and Baur and Lucey (2006) for cross-asset contagion.

[3] This is the common idea of contagion in the literature (e.g. see Forbes and Rigobon (2002))

2 Econometric Model

In this section we describe the econometric model to test the hypothesis that cross-country stock or bond market linkages dominate cross-asset stock-bond co-movements.

We proceed in two steps. The first step assesses the dynamics of cross-country and cross-asset stock and bond market correlation estimates obtained with a Multivariate GARCH model and the second step analyzes cross-country and cross-asset linkages with a VAR model for all stock and bond markets. Granger causality tests based on this model will further show the direction and strength of spillovers from one market to another. The first step involves the estimation of time-varying correlations and a subsequent estimation of a trend in order to compare our results with those of Kim et al. (2006). The time-varying correlations are estimated with the DCC model of Engle (2002) which can be formulated as the following statistical specification:

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

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

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

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

where r_t is a vector of stock and/ or bond market returns, D_t is a diagonal matrix of their variances, ϵ_t is a vector of standardized residuals and H_t is the covariance matrix modeled in a ARMA-type fashion where S is the unconditional covariance matrix and A and B are parameter matrices to be estimated.

The time-varying correlations are then given by the ratio of the covariance between two markets and the square root of the product of the variances of the two markets. The existence of a positive or negative trend will be analyzed on a second stage in which the estimated correlation is regressed on a constant and a trend. The two-stage procedure is necessary since the inclusion of a trend in

the DCC Model would risk an indefinite covariance matrix.[4]

The second part of the analysis involves the estimation of a vector autoregressive (VAR) model for all stock and bond markets.

$$\boldsymbol{rs}_t = \boldsymbol{c} + \sum_{i=1}^{p} \boldsymbol{rs}_{t-i} + \sum_{i=1}^{p} \boldsymbol{rb}_{t-i} + \boldsymbol{\epsilon}_t \quad (1)$$

$$\boldsymbol{rb}_t = \boldsymbol{d} + \sum_{i=1}^{p} \boldsymbol{rs}_{t-i} + \sum_{i=1}^{p} \boldsymbol{rb}_{t-i} + \boldsymbol{\nu}_t \quad (2)$$

where $\boldsymbol{rs}_t$ and $\boldsymbol{rb}_t$ are vectors comprising all stock and bond market returns, respectively. The number of lags is determined by p and the vectors of errors are given by $\boldsymbol{\epsilon}_t$ and $\boldsymbol{\nu}_t$.[5] The VAR is the basis for Granger causality tests among and between stock and bond market returns.

Granger causality tests will be performed based on the VAR specified above. A time series variable x is said to fail to Granger-cause another variable y if the mean squared error (MSE) of a forecast of y_{t+s} based on $F_{xy,t} = \{x_t, x_{t-1}, ..., y_t, y_{t-1}, ...\}$ is equal to the MSE of a forecast based on $F_{y,t} = \{y_t, y_{t-1}, ...\}$, $s > 0$. Under the null hypothesis of 'no Granger causality', the test statistic S is given as follows:

$$S = \frac{T(RSS_0 - RSS_1)}{RSS_1}$$

where RSS_0 denotes the residual sum of squares under the null hypothesis, RSS_1 are the residual sum of squares under the alternative hypothesis and T denotes the sample size. The model under the alternative hypothesis is given by $y_t = a_0 + \sum_{i=1}^{p} a_i x_{t-i} + \sum_{i=1}^{p} b_i y_{t-i} + \epsilon_{1,t}$ and the model under the null hypothesis is given by $y_t = c_0 + \sum_{i=1}^{p} c_i y_{t-i} + \epsilon_{0,t}$. The residual sum of squares is then given by $RSS_i = \sum_{t=1}^{T} \hat{\epsilon}_{i,t}^2$. The larger the difference between the sum of squared residuals the higher is the test statistic S. In other words, the more important x is for the prediction of y the larger is the test statistic.

Since it is likely that phenomena such as cross-country contagion or flight to quality only happen in certain sub-sample periods we also test Granger causality in sub-samples. Therefore, we will

[4] A trend (denoted by tr) can only be specified for the whole covariance matrix either for A or for B or for both: $H_t = S \circ (\iota\iota' - A^\star - B^\star) + A^\star \circ \epsilon_{t-1}\epsilon_{t-1}' + B^\star \circ H_{t-1}$ where $A^\star = A + a\text{tr}$ and $B^\star = B + b\text{tr}$.

[5] The VAR could also be formulated as follows $\boldsymbol{y}_t = \boldsymbol{c} + \sum_{i=1}^{p} \boldsymbol{y}_{t-i} + \boldsymbol{\epsilon}_t$ where $\boldsymbol{y}$ comprises all stock and bond market returns.

perform a dynamic Granger causality test based on a recursively estimated VAR which provides a set or time-series of test statistics S_n where n is the number of recursively estimated sub-samples. This methodology is related to dynamic co-integration (see Hansen and Johansen, 1999) where co-integration is recursively estimated leading to a time-series of trace statistics revealing the time-variation in the co-integration relationships. In the case of dynamic Granger causality, the time-series $\boldsymbol{S}$ will provide information about the time-variation of causality between stock and bond markets.

3 Empirical Analysis

This section contains an introduction of the data set, descriptive statistics, a graphical analysis of the time-varying evolution of cross-country and cross-asset co-movements and the results of Granger causality tests.

3.1 Data

The data consists of daily continuously compounded MSCI stock and bond index returns of the US, the UK, Germany, France, Italy, Australia, Canada and Japan. The MSCI bond indices are sovereign total return indices with maturities longer than 10 years (10year+). All indices are in local currencies. The data cover a time-period of more than 12 years from January 1994 until September 2006 leading to a sample size of $T = 3291$ observations. The descriptive statistics are shown in table 1.

The upper triangular matrix in table 2 contains the correlation coefficient between the bond indices and the lower triangular matrix presents the correlation coefficient between the stock indices. The main diagonal contains the unconditional stock-bond correlations. Stock-stock and bond-bond correlations have a comparable magnitude for the same pairs of markets. For example, the bond-bond correlation of the US and the UK is 0.4617 and the stock-stock correlation for the same markets is 0.4117. The similarity is even more pronounced for the stock-stock and bond-bond correlations of Germany and the UK. It is 0.7355 for bonds and 0.7094 for stocks. Finally, the correlations of the US and German markets for stocks (0.4725) and bonds (0.4617) are lower than for the UK-German

pairs and even more similar. Cross-country stock and bond correlations are relatively low for Australia and Japan which can be explained with the different time zone. Note also that the sample contains stock and bond market returns in local currencies. This yields intra-country stock-bond correlations that are independent of exchange rate changes. In contrast, cross-country stock and bond market return correlations are affected by exchange rate changes. Stock-bond co-movements are tabulated on the main diagonal of the matrix and are close to zero (in most cases negative) for many countries except Italy, Australia and Japan. Italy and Australia have positive stock-bond correlations of 0.1852 and 0.1132 and Japan exhibits a negative correlation of -0.2056.

Table 3 presents the unconditional stock-bond correlations for four sub samples, namely 1994-1997, 1997-2001, 2001-2005 and 2005-2006. There are two main features. First, there is significant variation of the correlations through time and second, there is less variation in the cross-section of the sample for each sub period. The standard deviation among all countries averaged over the four sub periods is 0.1324. On the other hand, the standard deviation among all sub sample periods averaged over the eight countries is 0.2918. Obviously, Japan exhibits a very different stock-bond correlation level than the other countries. The main insight from this table is the co-movement of stock-bond linkages among most countries. High correlations are a common feature in the first sub sample, low (around zero) and negative correlations are a common feature in the second and third sub sample period and the fourth sub sample exhibits low correlations around zero for all markets except Japan.

3.2 Dynamic Correlations - Graphical Analysis

In this section we first report the graphical presentation of the time-varying stock-stock, bond-bond and stock-bond estimates. Stock-stock and bond-bond correlations are reported with respect to the US stock and bond market because of the prominent role of the US financial market for the markets in the sample. Stock-bond correlation estimates are shown in figure 1, stock-stock correlations in figure 2 and bond-bond correlations in figure 3. Note that the objective of this section is to obtain a picture of the average evolution of cross-country and cross-asset (stock-bond) correlations. Hence, we examine obvious similarities and disparities among the correlations and do not focus on specific countries.

The stock-bond correlation estimates show a downward trend until 2003 followed by an upward trend in the end of the sample from 2003 until 2006. This behavior of stock-bond correlations is similar for all countries except Japan. The stock-bond co-movement of Japan is negative and relatively constant around a value of -0.2. A regression model with a constant, a trend and a squared trend confirms the above statement. Both trend terms are significant and indicate a u-shape evolution through time for all countries except Japan.[6] Results are not reported due to space considerations.

The stock-stock and bond-bond correlations exhibit an upward trend for the European countries and relatively constant correlations for Canada, Australia and Japan. Analyzing the evolution of cross-country co-movements in more details reveals that cross-country stock market co-movements are inversely related to stock-bond co-movements. To some degree this is also true for cross-country bond market co-movements but this relation is less pronounced.

3.3 Granger causality tests

This section presents the results of the Granger causality tests based on vector autoregressions (VAR) as described in the econometric section. The VAR estimates are not reported due to space considerations. The optimal lag lengths varies between one and three lags for different information criteria. The Akaike information criterion (AIC) selects three lags for restricted VARs (not involving all stock and bond markets) and the Schwartz's Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC) select a unit lag length for all VARs (restricted and unrestricted). Therefore, we choose a unit lag length for all models assuming that the Schwartz and Hannan and Quinn information criteria dominate Akaike's information criterion. Since it was shown that Granger causality tests with auxiliary variables in the information set (higher order VARs) can yield different results for horizons larger than one there is an additional argument for the choice of a unit lag length (e.g. see Giles, 2000 and Lütkepohl, 1993).

Tables 4-7 present the result of the Granger causality tests based on an estimated VAR comprising all stock and bond markets of the sample. Table 4 shows the influence of all stock and bond

[6]This finding is in contrast to Kim et al. (2006) who report a downward trend of stock-bond correlations through time and explain this with the introduction of the Euro and associated monetary policy uncertainty. The reason why we cannot replicate their findings is due to an extended sample period used in this study.

markets on the US stock and bond market (top panel) and the UK stock and bond market (bottom panel). The influence on the stock market is shown in the left part of the table and the influence on the bond market is shown in the right part of the table. Table 5 contains the same information for Germany and France, table 6 for Italy and Australia and table 7 for Canada and Japan. The results for the US show that other stock markets or bond markets have no significant influence on the US stock market since no test statistic exceeds a critical value for any commonly used level of significance. For example, the Chi squared test statistic for the hypothesis that the UK stock market does not cause the US stock market is 0.2842 which is below the 10 percent critical value that would lead to a rejection of the null hypothesis. The Chi squared test statistic for the hypothesis that all stock and bond markets do not Granger cause the US stock market is also not rejected. The test statistic is 20.1510 which is below the 10 percent critical value. The same result is obtained for Granger causality tests examining the influence of other stock and bond markets on the US bond market. The null hypothesis of no Granger causality is not rejected in any case.

The picture is very different for the UK stock and bond market. The US, the Australian and the Japanese stock market cause the UK stock market in the Granger sense. The US bond market also influences the UK stock market. The test statistic is 262 for the Granger causality test with the US stock market and below 10 for the other markets. The UK bond market is mainly influenced by the US (41). The Granger causality tests excluding all markets but the UK stock or bond market leads to test statistics of 435 and 110, respectively.

The pattern is similar for Germany and France (table 5). The US stock market significantly influences the German and the French stock markets (test statistics around 200). The same is true for the US bond market but the test statistic is only a quarter of the value for the stock market (around 50). Other markets also have an impact but the magnitude is small compared to the US. The results for the Italian stock and bond market (table 6) are essentially similar to Germany and France. The main difference is that the influence of the US market is not as pronounced as for Germany and France and the influence of the US stock and bond market on the Italian markets is relatively similar.

The results for Australia (table 6 bottom panel) show that other countries exhibit a strong influence on the Australian stock and bond markets. Again, the US dominates all other countries'

influence but the UK and Canada also have a significant impact. According to the last row that presents the influence of all markets together shows that the bond market is more dependent on other markets than the stock market. However, both test statistics are very large and both greater than 1000 which well exceeds the largest number for all other countries in the sample.

Canada (table 7) is also influenced by the US but to a lower degree than other countries. There is no significant impact of other countries' stock or bond markets on Canada's stock or bond markets. The results for Japan are more similar to the majority of countries. The US stock market exhibits a significant influence on the Japanese stock market. The same is true for the US and Japanese bond markets. The influence is stronger on the stock market than on the bond market. This is also represented by the last row of the table that contains the test statistic for a test excluding all markets. The test statistic for the stock market is larger than 500 and that for the bond market around 80.

These tables show that the US market is relatively independent. Other countries' stock or bond markets do not influence the US stock or bond markets in the Granger sense. The opposite is true for all other markets. They are all significantly influenced by the US stock or bond markets. Finally, there is no significant influence of a country's stock market on its bond market or vice versa. Exceptions are Canada, Italy and the UK but the test statistics are very small compared to the test statistics associated with the US markets.

The next step is to analyze causality dynamically by estimating a restricted VAR in which not all countries and markets are modeled simultaneously but only a subset. Dynamically means that we estimate the VAR and perform the Granger causality test recursively by adding a fixed number of observations (125 trading days). The objective of this methodology is to obtain information about changes in cross-country and cross-asset linkages through time.

Tables 8-10 further investigate the relationship of the US stock and bond market with the UK markets, the German markets and the Japanese markets. The tables present the Chi squared test statistics based on a restricted VAR for the US and the other country's stock and bond markets. The first column contains all 26 sub-samples. The following four columns show the influence of the US bond market on the US stock market, the foreign country's stock market on the US stock market, the foreign country's bond market on the US stock market and the influence of all variables (ALL)

on the US stock market. The last four columns present the test statistics for the US bond market. The 10 (5, 1) percent critical values are 2.7055, 3.8415 and 6.6349, respectively. Table 8 shows that the UK stock market exhibits some influence on the US stock market beginning in the end of 1998. The US bond market does not have such an influence on the US stock market. The opposite is true for the inverse direction. The US stock market, the UK stock market and also the UK bond market exhibit a significant influence on the US bond market. The strongest impact is in 2001. The German stock and bond markets (table 9) do also exhibit some influence on the US market but mainly on the US bond market and only in 1995 and 1996 and around 2001. Finally, the Japanese bond market (table 10) has a statistically significant impact on the US stock market but no impact on the bond market. The test statistics representing the influence of the Japanese stock market on the US markets all indicate that the US market is not linked to the Japanese stock market. Figures 4 and 5 present the test statistics presented in the tables graphically.

Tables 11-17 present dynamic Granger causality tests for the remaining countries. The tables show the influence of a country's stock market on its bond market, the influence of the bond market on its stock market and the influence of the US stock and bond markets on the country's stock and bond markets under investigation.

All tables confirm the results obtained from the full sample tests that the US stock and bond markets exhibit a strong influence on the other markets. The tables also show that the influence has increased in recent years. More precisely, the US stock market's influence on other stock markets has increased and the same is true for the influence of the US bond market on other bond markets. In addition, the US stock market (bond market) also exhibits an effect on other country's bond markets (stock markets). The US stock market causes all other country's bond markets except for Australia. However, there is no increasing influence but rather an inverted u-shape influence over all sub-sample periods. The US bond market also causes all other country's stock markets. Here the exception is the Canadian stock market that is not affected by the US stock market. Again, there is no increasing influence of the US bond market on the other country's stock markets. Furthermore, the cross-country cross-asset effects (US stock - bond market and US bond - stock market) are significantly weaker than the cross-country effects for the same types of assets (US stock - stock market and US bond - bond market).

On average, that is, for the full sample, there is no causality from the stock market to the bond market or from the bond market to the stock market. Notable exceptions are Italy and Canada. The recursive Granger causality tests show a different picture. The estimates reveal that there is both causality from stock markets to bond markets and vice versa in several subperiods. The UK, Australia and Japan stock markets are not influenced by their bond markets in most periods. The same is true for the inverse relationship for Australia and Japan. The UK stock market exhibits a significant influence on its bond market in most periods until the end of 2002. The German, French and Italian markets can be characterized by a decreasing influence of the bond market on their stock markets (especially for Germany) and an increasing influence of the stock markets on their bond markets.

Figure 6 presents the chi squared test statistics for of Granger causality tests running from bonds to stocks (top graph) and from stocks to bonds (bottom graph) for the UK, Germany, France, Italy, Australia, Canada and Japan. The top graph shows that bonds influence stocks in the Granger sense only in Germany in the beginning of the sample (until 1997) and in Canada from 1997 until the end of the sample. The bottom graph presenting the test statistics of Granger causality tests running from stocks to bonds reveal considerable fluctuations and an increasing trend in the end of the sample period for Germany, France and Italy.

Figure 7 shows the influence of the US stock market on the other countries' stock markets (top graph) and on the other countries bond markets (bottom graph). There is a strong positive trend of the influence of the US stock market on the other countries' stock markets for all countries. The picture is very different regarding the influence on the bond markets. Here, only Australia, Canada and Japan are significantly influenced by the US stock market.

Finally, figure 8 presents the time-varying influence of the US bond market on the other countries' stock markets (top graph) and the other countries' bond markets (bottom graph). The UK and Germany are significantly influenced in several sub periods and Australia is influenced in the entire sample period and the US influence has increased in recent years. The bottom graph shows that all bond markets are significantly affected by the US bond market except Canada. There is also a clear positive trend for all countries except Canada.

3.4 Specification Issues

The role of the US stock and bond markets can also be analyzed by comparing two different VAR specifications. The first one comprises a country's stock and bond markets plus the US stock and bond market and the second specification is a restricted version of the first one excluding the US markets. Granger causality tests based on these specifications show that the restricted model indicates causality that does not exist if the US markets are included. This is true for the German and the Australian market. For the other markets we find that the inclusion of the US markets renders more pronounced test statistics, that is, if the test statistic is low in the restricted model, the statistic is even lower in the unrestricted model. The same effect holds for the opposite case. The test statistic is significantly larger in the full model if the hypothesis of 'no Granger causality' is rejected in the restricted model. A similar effect that was found for the German and the Australian markets for the full sample can also be obtained for certain sub-sample period for the other markets. For example, in the years 2000 and 2001 a restricted model indicates causality running from bonds to stocks in all markets except Canada and Japan that disappears if US markets are included in the VAR. This finding is additional evidence that cross-country influences significantly affect stock-bond co-movements.

The results are based on VARs with a unit lag length. Using alternative lag lengths of two and three lags does not change the Granger causality tests qualitatively for the UK, Germany and France but for Italy, Australia, Canada and Japan. For the latter four countries an augmentation of the lag length generally leads to a lower number of rejections of the null hypothesis of no Granger causality. However, the role of the US markets for these countries is not altered qualitatively and the changes in the test statistics and associated probabilities are negligible.

Moreover, it could be argued that the window length (number of observations in sub-sample periods) is too long to detect significant stock-bond interaction being responsible for the importance of the cross-country linkages. However, an examination of the test statistics for different time periods and different countries reveals that there is significant stock-bond causality in several sub-sample periods. Furthermore, there is no systematic trend which suggested that the results are due to the recursively augmented sample size or the window length.

Finally, we also considered the possibility of spurious Granger causality due to non-stationarity of the variables, time-aggregation or small samples (e.g. see He and Maekawa, 2001). Obviously, non of the aforementioned applies to our data sample.

3.5 Summary

The results can be summarized as follows: (i) there is no causality from bond to stock markets or from stock to bond markets on average but in several sub-periods, (ii) the US stock and bond markets are affecting both foreign stock and bond markets and (iii) the influence of the US stock and bond markets has increased for all countries (the influence of the stock market is considerably stronger) and dominates other influences, e.g. the effects of a country's own stock or bond markets.

These findings imply that cross-country linkages with the US govern and dominate stock-bond co-movements. In addition, if there is causality from stock to bond markets or from bond markets to stock markets there is also a feedback effect in many cases. In other words, in times in which stock markets cause bond markets, bond markets cause stock markets and vice versa. Moreover, in times of stock-bond or bond-stock market causality there is often an additional effect of the US stock or bond market on the foreign country's bond or stock market.

Regarding the relatively low stock-bond linkages and the high cross-country linkages recently observed compared to the past suggests that stock-bond market interaction, including phenomena such as flight to quality or flight from quality, is not the primary cause of lower stock-bond correlations. It is rather cross-country stock-stock and bond-bond linkages that cause stock-bond correlations to change significantly. The low correlations can be explained with decreased cross-country diversification benefits leading to an increased frequency of portfolio reallocations between stocks and bonds.

This has important implications regarding the theoretical model presented in the first part of this study. Given that cross-country co-movements have increased and govern stock-bond relations lower stock-bond co-movements can be described adequately with the factor g in the theoretical model. This factor drives stocks and bonds in opposite directions (leads to low or negative stock-bond co-movements) and depends on the integration of stock and bond markets or on cross-country

linkages.[7]

4 Conclusions

This paper analyzes the relationship of cross-country and cross-asset linkages. We show empirically that the level of stock-bond correlation depends more on cross-country influences than on stock and bond market interaction. A recursively estimated VAR further reveals that there is a bidirectional causality among stock and bond markets in several periods. We argue that the relatively low level of stock-bond co-movements recently observed among all countries is due to lower diversification benefits of cross-country stock or bond market investments leading to a higher frequency of portfolio reallocations between stocks and bonds.

[7] An interesting issue related to this findings is the question whether increased cross-country market integration changes the likelihood of contagion and flight-to-quality. The number of contagious incidences and occurrences of flight-to-quality is too small and the sample period too short to answer this question empirically in this paper. However, one could argue that higher cross-country linkages reduce the potential for extreme positive correlation changes potentially associated with contagion. The same is true for low or negative stock-bond correlations. Large negative changes are less likely the lower the stock-bond correlation is. Bringing both conditions together, that is, high cross-country and low cross-asset co-movements implies that the severity of contagion and flight-to-quality decreases.

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Appendix

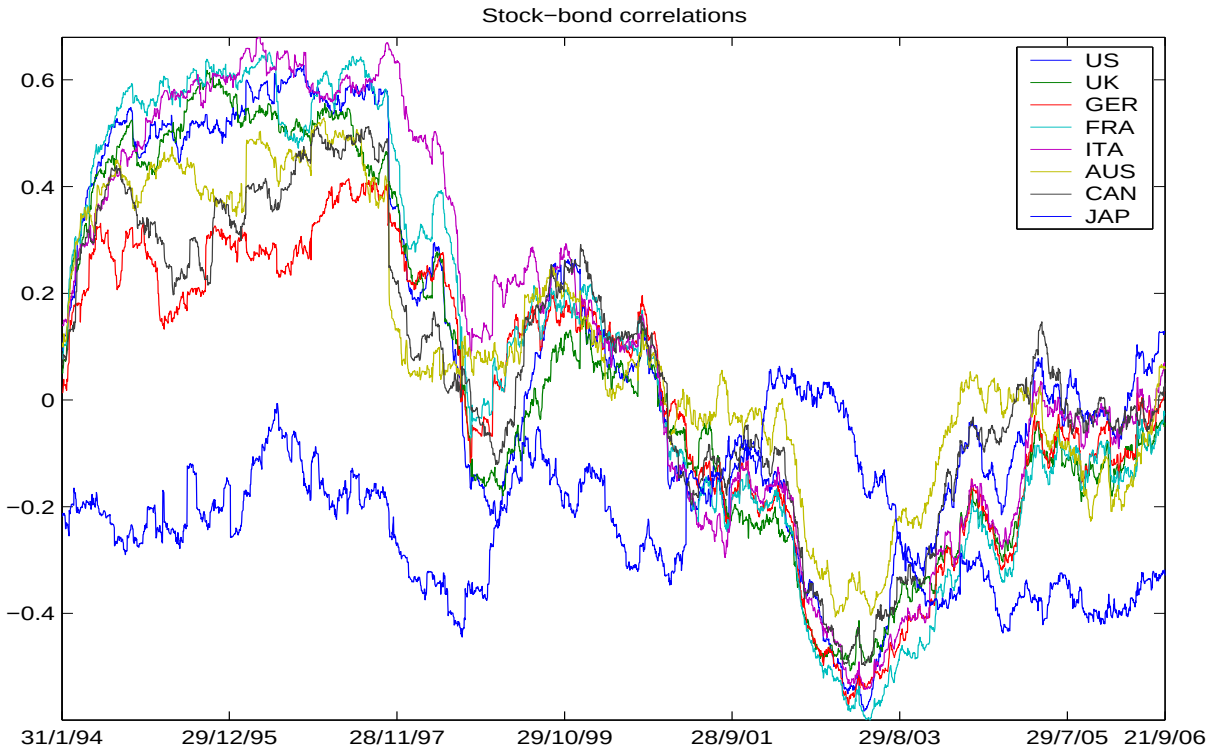

Figure 1: *Stock-bond correlations (DCC estimates)*

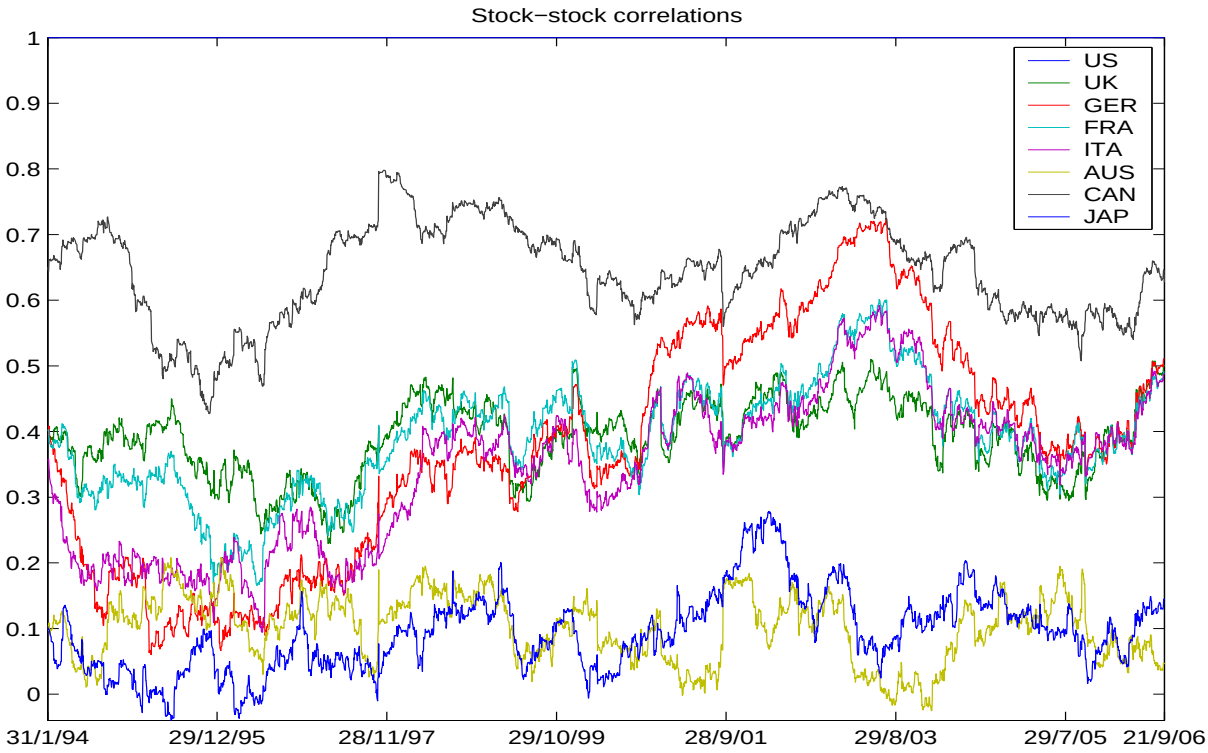

Figure 2: *Stock-stock correlations (DCC estimates)*

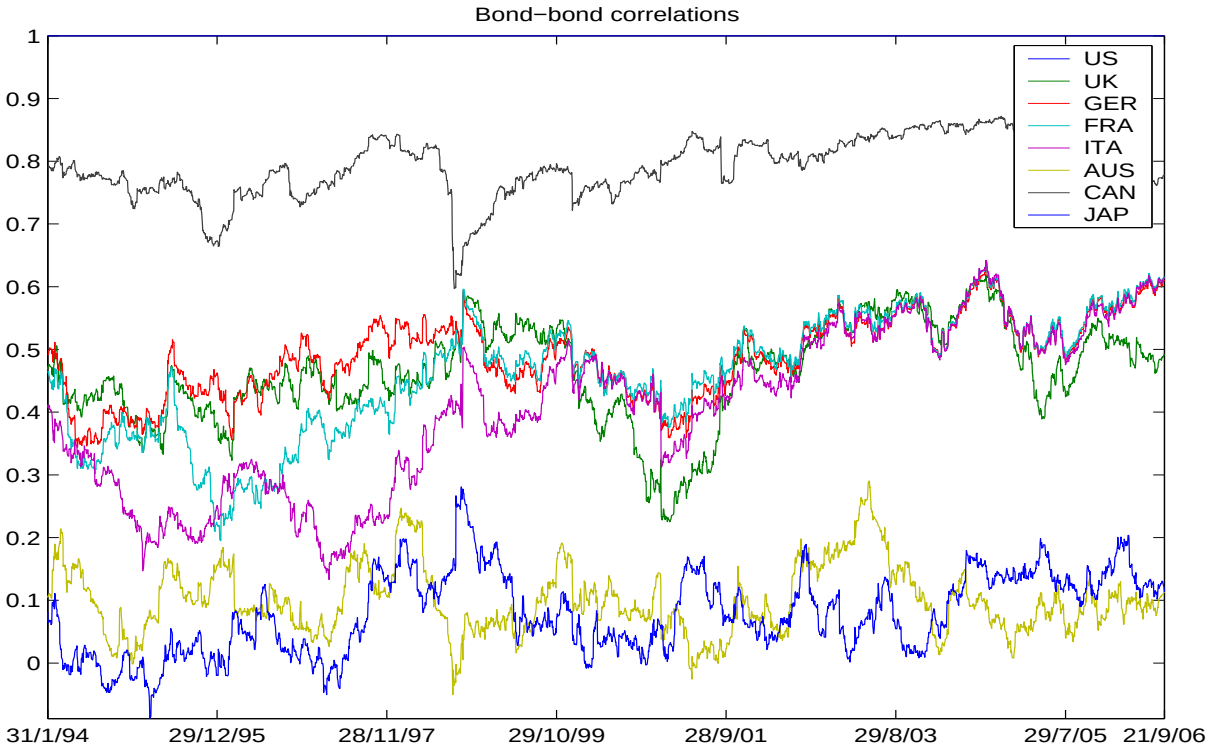

Figure 3: *Bond-bond correlations (DCC estimates)*

Table 1: **Descriptive statistics of continuously compounded bond and stock index returns**

Stock market	**Mean**	**Std. Dev.**	**Min**	**Max**	**Skewness**	**Kurtosis**
US	0.0003	0.0105	-0.0697	0.0561	-0.1130	6.8322
UK	0.0002	0.0103	-0.0601	0.0559	-0.2220	6.1867
GER	0.0002	0.0143	-0.0867	0.0745	-0.2432	6.3459
FRA	0.0003	0.0130	-0.0723	0.0657	-0.1246	5.8114
ITA	0.0003	0.0131	-0.0742	0.0704	-0.1111	5.5210
AUS	0.0002	0.0083	-0.0676	0.0522	-0.3663	6.4578
CAN	0.0003	0.0103	-0.0926	0.0532	-0.5460	9.5272
JAP	0.0000	0.0120	-0.0651	0.0681	-0.0215	5.2950
Bond market	**Mean**	**Std. Dev.**	**Min**	**Max**	**Skewness**	**Kurtosis**
US	0.0003	0.0055	-0.0312	0.0203	-0.3562	4.4412
UK	0.0003	0.0049	-0.0351	0.0323	-0.2210	5.3951
GER	0.0003	0.0052	-0.0343	0.0253	-0.4321	5.2498
FRA	0.0003	0.0046	-0.0233	0.0212	-0.2813	4.6562
ITA	0.0004	0.0057	-0.0418	0.0296	-0.4568	6.8303
AUS	0.0003	0.0054	-0.0328	0.0282	-0.2341	5.6024
CAN	0.0003	0.0049	-0.0299	0.0247	-0.1813	5.2381
JAP	0.0002	0.0043	-0.0320	0.0247	-0.5438	8.7837

The table presents the descriptive statistics of the stock and bond markets for the US, the UK, Germany, France, Italy, Australia, Canada and Japan.

Table 2: **Unconditional correlation coefficient of stock and bond market returns.**

	US	**UK**	**GER**	**FRA**	**ITA**	**AUS**	**CAN**	**JAP**
US	**-0.0149**	0.4617	0.4753	0.4400	0.3670	0.0907	0.7806	0.0558
UK	0.4117	**-0.0321**	0.7355	0.7236	0.6038	0.1642	0.4320	0.0797
GER	0.4725	0.7094	**-0.0564**	0.8986	0.7257	0.1870	0.4521	0.0849
FRA	0.4336	0.7967	0.7868	**0.0102**	0.7467	0.1957	0.4220	0.0846
ITA	0.3648	0.6727	0.6750	0.7427	**0.1852**	0.1664	0.3743	0.0507
AUS	0.0834	0.2484	0.2593	0.2407	0.2162	**0.1132**	0.1695	0.1472
CAN	0.6651	0.4070	0.4505	0.4311	0.3597	0.1577	**0.0348**	0.0375
JAP	0.1003	0.2292	0.2177	0.2349	0.1872	0.4078	0.1505	**-0.2056**

The table shows the unconditional correlation coefficients of cross-country and cross-asset stock and bond market returns. The upper triangular matrix contains cross-country bond market returns, the lower triangular matrix contains cross-country stock market returns and the main diagonal of the matrix contains (cross-asset) stock-bond correlations for each country.

Table 3: **Unconditional stock-bond correlations for four sub-samples**

	1994-1997	**1997-2001**	**2001-2005**	**2005-2006**
US	0.4843	-0.0691	-0.2898	0.0532
UK	0.5020	-0.0932	-0.3577	-0.0809
GER	0.3029	0.0194	-0.3678	-0.0536
FRA	0.5676	-0.0022	-0.4083	-0.0728
ITA	0.5893	0.0805	-0.3486	0.0023
AUS	0.3788	0.0431	-0.2003	-0.0336
CAN	0.3788	-0.0121	-0.2217	-0.0070
JAP	-0.1942	-0.1602	-0.2407	-0.3531

The table shows the unconditional correlation coefficients of cross-asset stock and bond market returns.

Table 4: **Results of Granger causality tests for US market (top panel) and UK market (bottom panel)**

Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
US stocks	stocks	UK	0.2842	1	0.594	**US bonds**	stocks	US	0.5814	1	0.446
US		GER	0.2305	1	0.631	US		UK	0.5619	1	0.454
US		FRA	0.1742	1	0.676	US		GER	0.2008	1	0.654
US		ITA	1.7890	1	0.181	US		FRA	0.1168	1	0.733
US		AUS	0.5158	1	0.473	US		ITA	0.1783	1	0.673
US		CAN	2.0209	1	0.155	US		AUS	0.8755	1	0.349
US		JAP	0.3463	1	0.556	US		CAN	0.8293	1	0.362
US	bonds	US	0.0046	1	0.946	US		JAP	0.3258	1	0.568
US		UK	0.0888	1	0.766	US	bonds	UK	1.5024	1	0.220
US		GER	0.0593	1	0.808	US		GER	0.0041	1	0.949
US		FRA	0.1358	1	0.713	US		FRA	0.0367	1	0.848
US		ITA	0.0001	1	0.992	US		ITA	0.1579	1	0.691
US		AUS	4.6506	1	0.031	US		AUS	0.0036	1	0.952
US		CAN	0.7101	1	0.399	US		CAN	0.5509	1	0.458
US		JAP	1.9995	1	0.157	US		JAP	0.0012	1	0.973
US		ALL	20.1510	15	0.166	US		ALL	6.9151	15	0.960
Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
UK stocks	stocks	US	261.7600	1	0.000	**UK bonds**	stocks	US	0.0420	1	0.838
UK		GER	0.7075	1	0.400	UK		UK	4.4764	1	0.034
UK		FRA	0.9332	1	0.334	UK		GER	1.0827	1	0.298
UK		ITA	1.6609	1	0.197	UK		FRA	1.0009	1	0.317
UK		AUS	3.7249	1	0.054	UK		ITA	1.2749	1	0.259
UK		CAN	0.0025	1	0.960	UK		AUS	1.9901	1	0.158
UK		JAP	7.4983	1	0.006	UK		CAN	4.0978	1	0.043
UK	bonds	US	4.0323	1	0.045	UK		JAP	0.0395	1	0.843
UK		UK	0.0052	1	0.943	UK	bonds	US	41.2170	1	0.000
UK		GER	0.4045	1	0.525	UK		GER	0.7364	1	0.391
UK		FRA	0.8512	1	0.356	UK		FRA	3.4994	1	0.061
UK		ITA	0.0006	1	0.980	UK		ITA	1.2882	1	0.256
UK		AUS	0.8692	1	0.351	UK		AUS	2.2314	1	0.135
UK		CAN	1.1574	1	0.282	UK		CAN	0.0092	1	0.924
UK		JAP	0.0428	1	0.836	UK		JAP	0.8590	1	0.354
UK		ALL	434.9200	15	0.000	UK		ALL	110.0200	15	0.000

The table contains the results of Granger causality tests based on an estimated VAR including all stock and bond market returns with 1 lag. The first column contains the stock market under investigation, the second column the market that is excluded from the regression in order to test for causality of the excluded market, the third column contains the Wald test statistic, the fourth column the degrees of freedom and the fifth column the level of significance with which the null hypothesis of "no causality" can be rejected. Columns six to ten present the results of Granger causality tests in the same order for the bond market.

Table 5: **Granger causality tests for German (GER) market (top panel) and French (FRA) market (bottom panel)**

Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
GER stocks	stocks	US	184.0400	1	0.000	**GER bonds**	stocks	US	0.2355	1	0.627
GER		UK	0.0929	1	0.760	GER		UK	2.1637	1	0.141
GER		FRA	3.2361	1	0.072	GER		GER	1.4381	1	0.230
GER		ITA	1.9911	1	0.158	GER		FRA	1.9937	1	0.158
GER		AUS	1.2065	1	0.272	GER		ITA	0.8149	1	0.367
GER		CAN	0.7910	1	0.374	GER		AUS	0.7631	1	0.382
GER		JAP	3.5778	1	0.059	GER		CAN	4.8296	1	0.028
GER	bonds	US	0.1866	1	0.666	GER		JAP	0.6170	1	0.432
GER		UK	2.3835	1	0.123	GER	bonds	US	50.4760	1	0.000
GER		GER	0.1304	1	0.718	GER		UK	2.6013	1	0.107
GER		FRA	0.0000	1	0.997	GER		FRA	0.3884	1	0.533
GER		ITA	0.0527	1	0.818	GER		ITA	0.0607	1	0.805
GER		AUS	1.9639	1	0.161	GER		AUS	4.0342	1	0.045
GER		CAN	0.8511	1	0.356	GER		CAN	2.6107	1	0.106
GER		JAP	0.0010	1	0.975	GER		JAP	3.2244	1	0.073
GER		ALL	346.8700	15	0.000	GER		ALL	180.9100	15	0.000
Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
FRA stocks	stocks	US	216.2300	1	0.000	**FRA bonds**	stocks	US	0.0625	1	0.803
FRA		UK	3.4267	1	0.064	FRA		UK	3.3695	1	0.066
FRA		GER	0.5166	1	0.472	FRA		GER	0.3252	1	0.568
FRA		ITA	1.0749	1	0.300	FRA		FRA	2.0900	1	0.148
FRA		AUS	2.4193	1	0.120	FRA		ITA	6.2126	1	0.013
FRA		CAN	1.4380	1	0.230	FRA		AUS	0.9730	1	0.324
FRA		JAP	4.8986	1	0.027	FRA		CAN	4.7894	1	0.029
FRA	bonds	US	5.6542	1	0.017	FRA		JAP	1.9983	1	0.157
FRA		UK	2.1124	1	0.146	FRA	bonds	US	41.2300	1	0.000
FRA		GER	0.4073	1	0.523	FRA		UK	2.7392	1	0.098
FRA		FRA	0.0997	1	0.752	FRA		GER	5.1364	1	0.023
FRA		ITA	0.1961	1	0.658	FRA		ITA	0.0855	1	0.770
FRA		AUS	0.1202	1	0.729	FRA		AUS	6.2629	1	0.012
FRA		CAN	1.6786	1	0.195	FRA		CAN	2.5116	1	0.113
FRA		JAP	0.0008	1	0.977	FRA		JAP	4.2725	1	0.039
FRA		ALL	399.4000	15	0.000	FRA		ALL	201.6400	15	0.000

The table contains the results of Granger causality tests based on an estimated VAR including all stock and bond market returns with 1 lag. The first column contains the stock market under investigation, the second column the market that is excluded from the regression in order to test for causality of the excluded market, the third column contains the Wald test statistic, the fourth column the degrees of freedom and the fifth column the level of significance with which the null hypothesis of "no causality" can be rejected. Columns six to ten present the results of Granger causality tests in the same order for the bond market.

Table 6: **Granger causality tests for Italian (ITA) market (top panel) and Australian (AUS) market (bottom panel)**

Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
ITA stocks	stocks	US	107.7900	1	0.000	**ITA bonds**	stocks	US	0.0159	1	0.900
ITA		UK	3.3385	1	0.068	ITA		UK	6.7427	1	0.009
ITA		GER	1.4303	1	0.232	ITA		GER	0.0738	1	0.786
ITA		FRA	0.0031	1	0.956	ITA		FRA	4.0767	1	0.043
ITA		AUS	0.0044	1	0.947	ITA		ITA	8.2748	1	0.004
ITA		CAN	0.0561	1	0.813	ITA		AUS	0.9952	1	0.318
ITA		JAP	6.3781	1	0.012	ITA		CAN	0.9287	1	0.335
ITA	bonds	US	0.4003	1	0.527	ITA		JAP	3.1415	1	0.076
ITA		UK	1.6178	1	0.203	ITA	bonds	US	27.8120	1	0.000
ITA		GER	0.0604	1	0.806	ITA		UK	0.8543	1	0.355
ITA		FRA	6.1402	1	0.013	ITA		GER	0.0040	1	0.950
ITA		ITA	4.8890	1	0.027	ITA		FRA	3.7693	1	0.052
ITA		AUS	2.0314	1	0.154	ITA		AUS	0.2205	1	0.639
ITA		CAN	0.1689	1	0.681	ITA		CAN	1.8247	1	0.177
ITA		JAP	0.2984	1	0.585	ITA		JAP	1.8529	1	0.173
ITA		ALL	190.9600	15	0.000	ITA		ALL	119.9700	15	0.000
Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
AUS stocks	stocks	US	293.4200	1	0.000	**AUS bonds**	stocks	US	18.2240	1	0.000
AUS		UK	30.0290	1	0.000	AUS		UK	3.3689	1	0.066
AUS		GER	0.5857	1	0.444	AUS		GER	0.8651	1	0.352
AUS		FRA	1.8792	1	0.170	AUS		FRA	0.0108	1	0.917
AUS		ITA	2.6580	1	0.103	AUS		ITA	0.4287	1	0.513
AUS		CAN	44.4860	1	0.000	AUS		AUS	2.3007	1	0.129
AUS		JAP	14.6250	1	0.000	AUS		CAN	3.1862	1	0.074
AUS	bonds	US	10.1500	1	0.001	AUS		JAP	0.0259	1	0.872
AUS		UK	0.1780	1	0.673	AUS	bonds	US	370.9300	1	0.000
AUS		GER	5.6326	1	0.018	AUS		UK	5.9045	1	0.015
AUS		FRA	6.8271	1	0.009	AUS		GER	0.3541	1	0.552
AUS		ITA	0.0901	1	0.764	AUS		FRA	0.3824	1	0.536
AUS		AUS	0.3571	1	0.550	AUS		ITA	1.2057	1	0.272
AUS		CAN	2.3077	1	0.129	AUS		CAN	58.4070	1	0.000
AUS		JAP	0.2318	1	0.630	AUS		JAP	0.9115	1	0.340
AUS		ALL	1491.2000	15	0.000	AUS		ALL	2086.1000	15	0.000

The table contains the results of Granger causality tests based on an estimated VAR including all stock and bond market returns with 1 lag. The first column contains the stock market under investigation, the second column the market that is excluded from the regression in order to test for causality of the excluded market, the third column contains the Wald test statistic, the fourth column the degrees of freedom and the fifth column the level of significance with which the null hypothesis of "no causality" can be rejected. Columns six to ten present the results of Granger causality tests in the same order for the bond market.

Table 7: **Granger causality tests for Canadian (CAN) market (top panel) and Japanese (JAP) market (bottom panel)**

Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
CAN stocks	stocks	US	27.1180	1	0.000	**CAN bonds**	stocks	US	6.2409	1	0.012
CAN		UK	0.1087	1	0.742	CAN		UK	1.9466	1	0.163
CAN		GER	4.7910	1	0.029	CAN		GER	0.3079	1	0.579
CAN		FRA	1.0596	1	0.303	CAN		FRA	0.6494	1	0.420
CAN		ITA	1.8110	1	0.178	CAN		ITA	0.4583	1	0.498
CAN		AUS	0.0453	1	0.831	CAN		AUS	1.1479	1	0.284
CAN		JAP	0.3483	1	0.555	CAN		CAN	2.5725	1	0.109
CAN	bonds	US	0.1266	1	0.722	CAN		JAP	0.5442	1	0.461
CAN		UK	0.8139	1	0.367	CAN	bonds	US	1.2178	1	0.270
CAN		GER	0.0008	1	0.978	CAN		UK	1.1020	1	0.294
CAN		FRA	0.4240	1	0.515	CAN		GER	0.2710	1	0.603
CAN		ITA	0.0025	1	0.960	CAN		FRA	0.1008	1	0.751
CAN		AUS	0.4736	1	0.491	CAN		ITA	0.1703	1	0.680
CAN		CAN	7.9189	1	0.005	CAN		AUS	0.0345	1	0.853
CAN		JAP	0.2581	1	0.611	CAN		JAP	0.8572	1	0.355
CAN		ALL	58.8060	15	0.000	CAN		ALL	16.6240	15	0.342
Dependent		**Excluded**	**chi2**	**df**	**Prob**	**Dependent**		**Excluded**	**chi2**	**df**	**Prob**
JAP stocks	stocks	US	92.1670	1	0.000	**JAP bonds**	stocks	US	4.9374	1	0.026
JAP		UK	9.7840	1	0.002	JAP		UK	1.6643	1	0.197
JAP		GER	1.7235	1	0.189	JAP		GER	0.7689	1	0.381
JAP		FRA	9.5326	1	0.002	JAP		FRA	0.0470	1	0.828
JAP		ITA	1.9952	1	0.158	JAP		ITA	0.0513	1	0.821
JAP		AUS	2.4563	1	0.117	JAP		AUS	0.2240	1	0.636
JAP		CAN	5.8634	1	0.015	JAP		CAN	1.0534	1	0.305
JAP	bonds	US	0.0032	1	0.955	JAP		JAP	0.2791	1	0.597
JAP		UK	1.4489	1	0.229	JAP	bonds	US	15.4560	1	0.000
JAP		GER	0.0783	1	0.780	JAP		UK	0.0056	1	0.940
JAP		FRA	1.1556	1	0.282	JAP		GER	1.5896	1	0.207
JAP		ITA	1.1507	1	0.283	JAP		FRA	0.1765	1	0.674
JAP		AUS	0.1203	1	0.729	JAP		ITA	0.0801	1	0.777
JAP		CAN	0.0691	1	0.793	JAP		AUS	0.0501	1	0.823
JAP		JAP	0.4457	1	0.504	JAP		CAN	0.2075	1	0.649
JAP		ALL	545.6000	15	0.000	JAP		ALL	83.8040	15	0.000

The table contains the results of Granger causality tests based on an estimated VAR including all stock and bond market returns with 1 lag. The first column contains the stock market under investigation, the second column the market that is excluded from the regression in order to test for causality of the excluded market, the third column contains the Wald test statistic, the fourth column the degrees of freedom and the fifth column the level of significance with which the null hypothesis of "no causality" can be rejected. Columns six to ten present the results of Granger causality tests in the same order for the bond market.

Table 8: **Sub-sample Granger causality tests for the US market with the UK market**

	b -> s	**UK s -> s**	**UK b -> s**	**ALL**	**s -> b**	**UK s -> b**	**UK b -> b**	**ALL**
22/07/1994	0.0354	0.0362	0.0735	0.2714	2.3227	0.1148	0.1630	3.2714
13/01/1995	0.4438	0.1348	0.0046	0.8269	2.1760	0.0904	0.2246	3.3995
07/07/1995	0.0003	0.0150	0.0075	0.0156	0.6186	0.0089	0.0334	0.8632
29/12/1995	0.0414	0.5344	0.0772	0.6290	0.6474	0.1190	0.3618	0.9176
21/06/1996	0.2420	0.0140	0.5548	0.7261	0.6521	0.0050	0.0063	0.7514
13/12/1996	0.0156	0.0058	0.1446	0.1670	0.6109	0.1477	0.0875	1.3498
06/06/1997	0.0553	0.1344	0.0325	0.1860	0.1109	0.3817	0.0016	0.7902
28/11/1997	1.1183	0.0327	0.0012	1.4040	0.1308	1.8562	0.2609	1.8729
22/05/1998	0.7340	0.4715	0.0501	1.2439	0.3488	2.2881	0.2851	2.3097
13/11/1998	0.0297	4.9104	0.1299	4.9684	0.6680	3.1386	0.6942	3.3074
07/05/1999	0.3075	6.3744	0.1807	6.5554	0.5602	4.2525	0.5674	4.3333
29/10/1999	0.0576	5.7280	0.0735	6.5845	1.4029	4.1831	0.9370	4.6576
21/04/2000	0.2312	1.4074	0.1114	2.2128	2.6335	3.5737	0.5865	4.8401
13/10/2000	0.5135	4.7348	0.0078	5.7033	3.9990	3.3596	1.3369	6.2462
06/04/2001	0.6815	1.9847	0.4107	4.2119	5.8894	3.1109	0.7982	7.2496
28/09/2001	1.2469	4.3935	0.2261	7.0656	7.4976	4.0554	1.2908	9.4772
22/03/2002	0.9160	3.3922	0.1928	5.3866	4.1309	4.4565	1.9553	7.6410
13/09/2002	0.7609	3.3626	0.2270	4.9906	1.7213	2.8948	2.0424	5.2042
07/03/2003	1.3027	2.6198	0.0272	4.2971	1.6767	1.4883	1.8468	4.0111
29/08/2003	1.4816	1.7182	0.0993	3.9147	0.3318	0.5448	2.2049	2.8007
20/02/2004	1.6422	2.0824	0.1349	4.5832	0.9979	1.0213	2.0691	3.4575
13/08/2004	1.8618	1.9301	0.0556	4.4448	0.4645	0.7513	2.9652	3.8047
04/02/2005	1.7844	2.1007	0.1163	4.7164	0.1872	0.5122	2.5025	3.0137
29/07/2005	1.6146	2.1852	0.1431	4.6364	0.1613	0.5444	3.2744	3.8000
20/01/2006	1.7014	2.0346	0.2484	4.9320	0.1507	0.5679	3.7954	4.3409
14/07/2006	1.4810	2.1564	0.1224	4.3758	0.1559	0.4413	3.1282	3.5702

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 9: **Sub-sample Granger causality tests for the US market with the German market**

	b -> s	**GER s -> s**	**GER b -> s**	**ALL**	**s -> b**	**GER s -> b**	**GER b -> b**	**ALL**
22/07/1994	0.1537	0.1640	1.4636	1.5296	3.4750	5.3507	6.7821	10.8170
13/01/1995	0.3988	0.0809	0.0512	0.6744	3.4562	3.1296	2.1363	6.4406
07/07/1995	0.0260	0.8884	0.1076	0.8886	1.0962	3.2803	1.6150	4.5101
29/12/1995	0.0000	1.9918	0.4430	2.0910	0.6992	2.2621	2.0410	3.7416
21/06/1996	0.0506	0.2887	0.0035	0.4064	0.7976	0.6753	0.4912	1.6080
13/12/1996	0.0069	0.0098	0.0902	0.1346	0.9468	0.4547	0.3870	1.4863
06/06/1997	0.0000	0.0863	0.3372	0.3978	0.2655	0.1249	0.0503	0.3713
28/11/1997	0.3236	3.7086	1.4897	5.5095	0.0001	0.0189	0.0004	0.0235
22/05/1998	0.1214	2.1385	0.9646	3.2434	0.0129	0.0035	0.0002	0.0150
13/11/1998	0.0416	0.3033	0.2407	0.4537	0.0343	0.0103	0.4605	0.4880
07/05/1999	0.0057	0.0357	0.4835	0.7577	0.0502	0.6379	0.3244	0.8035
29/10/1999	0.1603	0.0008	3.0278	3.3357	0.3756	0.4343	1.4023	1.7897
21/04/2000	0.0197	0.0223	1.3046	1.7983	1.6357	1.3599	0.9470	3.0456
13/10/2000	0.1751	0.0463	0.7465	1.6223	3.4709	3.1873	2.2605	6.8299
06/04/2001	0.2701	0.1148	1.6803	3.1736	5.1074	2.1570	1.4350	6.8535
28/09/2001	1.1497	0.8723	0.4795	3.6545	6.3446	2.6166	2.2533	8.9299
22/03/2002	0.6858	0.6033	0.6520	2.9949	3.4784	3.3035	2.1960	6.7487
13/09/2002	0.5658	0.8027	0.6413	2.8469	1.1463	1.2865	2.5059	4.0741
07/03/2003	1.3108	1.0044	0.0778	2.7362	1.0860	0.4323	2.1879	3.3299
29/08/2003	1.3401	0.4030	0.2040	2.7017	0.2124	0.2391	1.8554	2.1532
20/02/2004	1.4806	0.6517	0.3085	3.3293	0.6510	0.3234	1.3923	2.0941
13/08/2004	1.7193	0.7716	0.1750	3.4110	0.2436	0.1980	2.0323	2.3306
04/02/2005	1.6161	0.7632	0.2788	3.5447	0.0446	0.0502	1.6477	1.7112
29/07/2005	1.4757	0.7862	0.2861	3.3834	0.0304	0.0562	2.1631	2.2179
20/01/2006	1.6230	0.7755	0.3527	3.7809	0.0203	0.0463	1.9812	2.0228
14/07/2006	1.4201	1.0448	0.2233	3.3722	0.0205	0.0167	1.7851	1.8115

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 10: **Sub-sample Granger causality tests for the US market with the Japanese market**

	b -> s	**JAP s -> s**	**JAP b -> s**	**ALL**	**s -> b**	**JAP s -> b**	**JAP b -> b**	**ALL**
22/07/1994	0.0096	0.0023	0.1323	0.1367	2.4052	0.0954	1.1608	4.0595
13/01/1995	0.6570	0.4589	0.0087	1.0440	2.5744	0.0090	1.3324	4.0681
07/07/1995	0.0000	0.0459	0.1661	0.2527	0.8153	0.4720	0.0012	1.2523
29/12/1995	0.0483	0.1670	0.4631	0.6034	0.6281	0.7490	0.4431	1.5493
21/06/1996	0.0437	0.7955	2.4477	2.8694	0.7841	1.3742	1.7050	3.3216
13/12/1996	0.0033	1.0640	0.8469	1.6195	0.9719	0.6475	0.6594	1.9597
06/06/1997	0.0528	1.3633	0.3637	1.5790	0.2707	0.8007	0.7850	1.5850
28/11/1997	1.3497	0.9250	0.0988	2.5437	0.0034	0.3121	0.6810	0.8447
22/05/1998	0.6785	1.2467	0.4185	2.8586	0.0056	0.0870	0.1864	0.2385
13/11/1998	0.0006	0.0023	0.3653	0.3797	0.0439	0.1328	0.2313	0.5070
07/05/1999	0.1196	0.0001	0.8647	1.0480	0.0010	0.0034	0.9422	0.9942
29/10/1999	0.0961	0.0372	1.3379	1.6413	0.2397	0.0927	0.0322	0.3610
21/04/2000	0.3769	0.0623	2.8748	3.6805	1.1540	0.1819	0.0724	1.3875
13/10/2000	0.6285	0.0668	2.9472	3.6906	2.3227	0.4471	0.2055	2.9535
06/04/2001	1.2359	0.2921	4.4165	5.9255	3.9041	0.3782	0.0251	4.1855
28/09/2001	1.7820	0.0059	3.8399	6.0029	4.8578	0.4349	0.0016	5.0970
22/03/2002	1.2938	0.0009	4.6700	6.3388	1.9929	0.5785	0.0149	2.3862
13/09/2002	1.0502	0.2439	2.7348	4.5815	0.5700	0.2226	0.0284	0.7500
07/03/2003	1.2966	0.9638	3.9390	7.1953	0.7746	0.0043	0.1509	0.9451
29/08/2003	1.7325	0.8001	3.4769	7.0109	0.0831	0.0001	0.0455	0.1354
20/02/2004	2.0310	0.4160	4.0178	7.4109	0.4796	0.2135	0.2050	0.9145
13/08/2004	2.0902	0.3981	3.3668	6.7872	0.1610	0.2108	0.0195	0.3864
04/02/2005	2.1414	0.3501	2.9681	6.3291	0.0416	0.2559	0.0302	0.3530
29/07/2005	1.9461	0.4232	2.8491	6.1262	0.0270	0.3572	0.0393	0.4678
20/01/2006	2.2256	0.3732	3.4272	7.0525	0.0166	0.2554	0.0363	0.3482
14/07/2006	1.7392	0.4082	2.7880	5.8700	0.0274	0.1888	0.0049	0.2289

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 11: **Sub-sample Granger causality tests for the UK market with the US market**

	b -> s	**US s -> s**	**US b -> s**	**ALL**	**s -> b**	**US s -> b**	**US b -> b**	**ALL**
22/07/1994	0.0518	5.8027	0.8284	7.1807	3.0828	0.0014	0.4172	3.7572
13/01/1995	1.0731	24.5780	2.8235	29.8700	1.1929	0.0085	0.9683	2.6510
07/07/1995	1.0525	26.3820	0.7980	34.4880	1.6316	0.0451	3.4598	7.5792
29/12/1995	2.3090	31.8150	0.2108	44.8200	1.3556	0.2264	5.3231	10.8680
21/06/1996	1.6711	30.3180	0.0687	42.5310	2.3975	0.1252	6.4197	12.7470
13/12/1996	0.7909	43.2320	0.1876	58.3760	2.8586	0.3328	8.4189	17.3910
06/06/1997	0.3769	67.7810	2.5159	78.4180	6.0218	4.5109	5.2653	24.2530
28/11/1997	0.0000	99.9750	6.7268	103.9500	5.8453	4.2055	8.7218	25.6690
22/05/1998	0.1491	105.1400	6.2007	108.9400	5.4200	3.2881	14.1700	30.2030
13/11/1998	0.0635	147.4600	12.0320	151.1600	4.3236	1.7857	27.1970	38.5070
07/05/1999	0.2009	169.1900	10.6460	172.3900	4.0161	1.8448	33.9190	45.2970
29/10/1999	0.2170	178.5900	8.3191	181.0500	4.1295	1.6480	33.2360	44.7980
21/04/2000	0.2956	219.6200	6.1343	220.6200	3.1310	1.0050	39.5610	47.3840
13/10/2000	0.5102	208.7800	3.3904	210.4000	3.7780	2.2245	38.7290	48.4690
06/04/2001	0.3677	210.6400	2.3545	211.4600	3.1955	2.4565	43.1000	51.3120
28/09/2001	0.0183	208.9200	0.6039	210.2200	3.7211	2.0363	46.8260	54.7950
22/03/2002	0.0022	231.6600	1.6980	231.8900	2.8407	0.8044	53.0410	58.4830
13/09/2002	0.0141	271.9300	2.8239	272.3100	0.5170	0.0183	58.8830	60.2430
07/03/2003	0.0233	294.5200	2.2937	295.9900	0.2469	0.0246	60.4530	61.4140
29/08/2003	0.0182	304.5100	2.6001	306.4900	0.0121	0.3604	67.6620	68.3100
20/02/2004	0.0009	311.7700	1.9274	313.7100	0.0004	0.2503	67.6660	68.4600
13/08/2004	0.0004	330.0400	1.9748	331.9500	0.0039	0.3503	70.3420	71.1880
04/02/2005	0.0003	345.9400	1.9198	347.7300	0.0166	0.6145	74.0960	75.2250
29/07/2005	0.0052	362.8100	2.1349	364.5600	0.0242	0.8469	81.8730	83.2450
20/01/2006	0.0217	377.5000	2.0434	379.0900	0.0305	1.1773	81.3530	83.1070
14/07/2006	0.0055	393.9500	2.6463	396.1700	0.0041	0.9785	82.1570	84.1250

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 12: **Sub-sample Granger causality tests for the German market with the US market**

	b -> s	**US s -> s**	**US b -> s**	**ALL**	**s -> b**	**US s -> b**	**US b -> b**	**ALL**
22/07/1994	6.1782	9.5823	2.1824	55.1350	0.3713	0.4513	6.2242	9.9832
13/01/1995	6.6516	42.4580	5.5181	142.5400	1.4953	1.1983	12.5190	14.6930
07/07/1995	5.9179	70.1770	5.8337	192.1400	7.9281	0.5321	23.3710	33.5900
29/12/1995	9.5423	85.3780	8.3058	237.2200	9.0257	0.1568	28.0590	43.0620
21/06/1996	14.9880	85.2320	13.1310	277.4700	8.9130	0.1187	27.1810	42.3470
13/12/1996	21.2700	105.9800	14.9350	348.8500	6.3866	0.4336	30.4470	42.2650
06/06/1997	20.2970	157.8400	8.2851	393.2800	3.5769	0.5711	22.2570	38.9830
28/11/1997	24.8070	312.7300	1.2114	517.5800	1.2022	0.9573	25.9950	39.9590
22/05/1998	22.3110	349.5600	0.4839	520.1600	1.4765	0.8546	34.1800	48.3340
13/11/1998	2.1121	360.3800	0.7552	418.1200	3.5419	1.3616	50.0660	64.0720
07/05/1999	1.1703	353.8300	0.9505	399.0200	3.2692	1.5211	59.0080	71.5740
29/10/1999	1.5044	353.6100	0.3316	399.2500	2.2607	1.5042	58.6340	71.6280
21/04/2000	0.4128	344.3300	1.5696	385.1100	0.9238	1.3246	68.1690	77.4070
13/10/2000	0.3149	339.0100	2.9341	381.1800	0.3056	2.8391	64.9540	76.4870
06/04/2001	0.8789	306.3000	5.7196	347.5200	0.3473	3.0800	73.0480	83.1910
28/09/2001	1.0996	276.2400	8.2417	319.5400	0.6573	3.4097	81.1260	91.7690
22/03/2002	1.0056	290.3800	4.6662	321.7400	1.0776	1.3696	92.1350	98.5560
13/09/2002	1.0266	286.9600	2.6107	306.2300	2.5474	0.0346	99.0410	100.8100
07/03/2003	0.3739	245.8300	3.7164	260.4700	3.2534	0.0004	106.6500	107.3100
29/08/2003	0.7367	241.5900	1.9029	253.1200	5.1217	0.2842	121.0500	121.3600
20/02/2004	0.4192	244.3400	2.4417	255.2800	5.5264	0.2132	126.5600	126.9500
13/08/2004	0.3298	259.6500	2.3169	270.1500	5.7480	0.2866	131.0000	131.3700
04/02/2005	0.5967	272.0000	1.8436	282.4800	6.3696	0.4688	138.9300	139.3100
29/07/2005	0.6917	285.6000	1.6242	295.8900	6.7321	0.6377	151.0200	151.3700
20/01/2006	0.8103	297.9300	1.4530	308.0900	7.0981	0.6936	152.1400	152.5800
14/07/2006	0.8874	309.2700	0.9058	318.3500	7.0737	0.7710	151.2800	151.7700

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 13: **Sub-sample Granger causality tests for the French market with the US market**

	b -> s	**US s -> s**	**US b -> s**	**ALL**	**s -> b**	**US s -> b**	**US b -> b**	**ALL**
22/07/1994	0.0349	3.1889	0.0268	7.6107	0.6014	0.2618	4.5063	6.7727
13/01/1995	0.0001	9.3519	0.0000	14.9920	0.3479	0.7566	7.4303	8.5611
07/07/1995	2.2013	11.5400	0.8327	26.1680	0.0242	0.2640	14.3630	18.9640
29/12/1995	2.2734	15.6840	0.2678	29.3810	0.0449	0.0163	15.9220	23.2780
21/06/1996	2.6932	22.3090	0.1013	38.1980	0.0021	0.1452	14.5870	24.6830
13/12/1996	2.2747	33.2350	0.0258	52.5150	0.0031	0.0086	19.8110	30.2970
06/06/1997	2.1325	40.9000	0.2648	55.6180	0.2068	1.4047	15.3630	31.2710
28/11/1997	0.0850	110.0500	3.8754	120.5500	0.0705	1.9757	20.8420	36.5470
22/05/1998	0.2023	124.3200	4.5730	133.1700	0.2353	2.2535	26.4490	42.4970
13/11/1998	2.1498	137.1300	5.4358	148.8100	0.1566	3.3434	39.9130	55.7860
07/05/1999	2.1275	145.8600	4.7791	155.2500	0.8632	2.6192	48.6740	63.0430
29/10/1999	0.8965	162.0900	5.3366	168.3700	0.3668	2.7442	48.9770	63.7510
21/04/2000	1.2125	188.5700	4.1101	192.0900	0.3319	1.8931	58.2770	68.8710
13/10/2000	1.2003	190.9600	2.7727	194.5100	0.1281	3.6924	57.2690	70.5520
06/04/2001	0.3059	206.4200	2.0646	208.1100	0.2596	3.6013	65.5810	76.8050
28/09/2001	0.0443	200.1700	0.6887	201.4800	0.1613	4.2730	73.3710	84.9800
22/03/2002	0.0136	222.1900	1.3027	222.7400	0.5334	1.8922	84.5780	91.9760
13/09/2002	0.0330	271.8400	2.6736	273.0300	2.6434	0.0789	91.4460	94.7050
07/03/2003	0.2205	274.5200	1.9289	277.3600	3.7794	0.0067	98.8020	101.1200
29/08/2003	0.0123	278.5600	2.4375	281.0700	6.5178	0.3247	113.4100	116.6100
20/02/2004	0.0420	284.2600	1.9324	286.8600	6.7755	0.2291	120.0600	123.3900
13/08/2004	0.0587	303.2900	1.8720	305.8600	7.2157	0.3251	124.9100	128.3000
04/02/2005	0.0078	318.9400	2.1559	321.3600	7.7936	0.5224	132.8900	136.4000
29/07/2005	0.0007	335.6900	2.4230	338.1800	7.4715	0.6076	144.5800	147.6600
20/01/2006	0.0075	352.0400	2.6783	354.5800	7.7384	0.6719	145.1900	148.3900
14/07/2006	0.0272	368.2200	3.4975	371.3000	7.9781	0.7872	144.8700	148.3600

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 14: **Sub-sample Granger causality tests for the Italian market with the US market**

	b -> s	**US s -> s**	**US b -> s**	**ALL**	**s -> b**	**US s -> b**	**US b -> b**	**ALL**
22/07/1994	3.4611	2.8079	2.0936	7.7599	0.1278	1.0636	0.8971	1.2392
13/01/1995	1.4059	1.5664	0.2311	3.1555	0.1148	0.0459	0.2220	0.3546
07/07/1995	0.0453	1.2799	0.0315	2.5792	0.0567	0.2903	4.3742	5.2039
29/12/1995	0.1174	0.9423	0.0387	2.0996	0.1591	0.2483	4.1742	5.0308
21/06/1996	0.3463	1.3222	0.4376	4.9438	0.0879	0.6999	6.7569	7.4756
13/12/1996	0.5298	3.0933	0.4371	8.7117	0.6689	0.2163	8.1582	10.9550
06/06/1997	1.1368	8.0566	0.0038	13.6010	0.4057	0.0077	6.0852	9.6637
28/11/1997	2.2374	41.6390	1.5572	49.4430	0.0766	1.2901	5.8830	12.5990
22/05/1998	2.1523	42.8770	0.8487	49.9240	0.0427	1.0939	8.5526	15.0650
13/11/1998	1.0696	81.8960	3.7342	82.4330	1.1505	1.9555	15.1500	23.6920
07/05/1999	0.4615	83.3430	2.7521	83.7120	1.8010	1.8608	20.4400	29.3000
29/10/1999	0.5967	85.8130	2.8196	86.5150	1.3458	1.6999	22.4640	31.2750
21/04/2000	0.4803	95.7240	1.6237	96.9670	1.7573	1.1584	26.7930	34.0100
13/10/2000	0.4595	92.1230	0.7937	93.8480	1.4155	2.1158	27.4440	36.0700
06/04/2001	0.7581	96.2550	0.3499	97.8210	2.0592	1.7956	33.2660	40.8870
28/09/2001	0.6015	94.2040	0.0033	96.8790	2.8600	1.8997	38.4600	46.9710
22/03/2002	0.7785	102.0400	0.3653	103.0000	4.1646	0.7194	46.3940	53.3800
13/09/2002	0.4354	116.7800	0.5557	116.8400	7.3307	0.0037	50.7900	56.6520
07/03/2003	0.3136	114.0000	0.1326	114.0100	8.3695	0.0001	55.0860	60.4320
29/08/2003	0.9386	118.0400	0.2349	118.2200	12.7450	0.2921	64.2880	71.8700
20/02/2004	0.9002	122.0200	0.1432	122.1500	13.7290	0.2185	67.5020	75.7470
13/08/2004	0.8994	128.2300	0.1507	128.3500	14.6600	0.3013	70.2810	78.9180
04/02/2005	1.0950	134.1900	0.1618	134.3800	15.7330	0.4594	75.5150	84.6060
29/07/2005	1.2849	141.5200	0.2381	141.7600	15.3180	0.5018	83.7230	92.0730
20/01/2006	1.4031	147.5900	0.2006	147.8700	16.4150	0.5845	84.7730	93.8130
14/07/2006	1.4544	153.7500	0.4135	154.1000	16.9550	0.6877	85.0990	94.5380

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 15: **Sub-sample Granger causality tests for the Australian market with the US market**

	b -> s	US s -> s	US b -> s	ALL	s -> b	US s -> b	US b -> b	ALL
22/07/1994	0.0000	1.0571	0.3817	4.9973	0.0000	0.0195	3.1265	7.4065
13/01/1995	0.0010	3.0870	1.0476	10.9500	0.0520	0.0002	6.9814	11.9160
07/07/1995	0.0209	4.2930	1.0043	12.6140	0.1398	0.0093	12.3220	19.3490
29/12/1995	0.0221	6.0844	1.3045	16.7370	0.2309	0.0001	14.9810	23.6050
21/06/1996	0.0062	5.9384	2.3543	19.8640	0.2237	0.2993	18.3310	33.6260
13/12/1996	0.0321	7.8841	3.0086	26.0850	0.3122	0.1596	22.9090	39.9620
06/06/1997	0.0450	9.4971	3.6586	29.7890	0.2716	0.1873	27.6370	45.8240
28/11/1997	0.0319	24.0020	1.3998	40.6050	0.3699	0.0004	39.5220	51.9350
22/05/1998	0.0185	29.0500	1.2570	44.5310	0.3449	0.0052	45.8220	57.0350
13/11/1998	0.0104	37.6740	1.3421	46.8800	0.4521	0.0651	50.9350	57.2000
07/05/1999	0.0043	42.7540	2.1165	52.9110	0.3660	0.0003	61.7640	66.3810
29/10/1999	0.0013	46.0630	2.2487	57.9930	0.3114	0.0021	71.8680	77.7890
21/04/2000	0.0024	53.1360	2.3571	64.2680	0.2442	0.0553	79.1440	83.1700
13/10/2000	0.0003	58.1210	2.6311	69.5510	0.2091	0.1001	87.2570	90.7470
06/04/2001	0.0001	62.8070	3.1503	72.4390	0.3237	0.1431	95.1090	96.9440
28/09/2001	0.0336	62.0000	2.9881	70.4230	0.3537	0.2310	104.3800	105.8200
22/03/2002	0.0054	65.1660	3.6076	73.8410	0.2805	0.3972	117.5300	118.6600
13/09/2002	0.0083	74.1830	4.1652	81.0510	0.1824	0.8019	124.1500	124.7600
07/03/2003	0.0021	81.3670	4.5686	86.1880	0.1158	0.9099	133.1100	134.5100
29/08/2003	0.0066	87.9420	4.2699	92.0120	0.0944	1.0158	138.2500	140.0900
20/02/2004	0.0128	93.0610	4.1586	96.6520	0.0822	1.0408	145.2700	147.3400
13/08/2004	0.0268	97.0200	4.4301	100.8600	0.0782	1.1073	156.0500	158.2600
04/02/2005	0.0289	101.3300	4.5864	105.2900	0.0573	1.1661	161.5300	163.8400
29/07/2005	0.0269	104.3700	4.5982	108.4200	0.0612	1.2618	169.2500	171.6800
20/01/2006	0.0318	108.4600	4.4830	112.3400	0.0525	1.4090	178.3000	180.9800
14/07/2006	0.0405	113.9200	4.5372	117.9400	0.0771	1.4564	187.5300	190.3300

All values in the table have to be multiplied by 1.0e+001 to obtain the true values.
The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 16: **Sub-sample Granger causality tests for the Canadian market with the US market**

	b -> s	US s -> s	US b -> s	ALL	s -> b	US s -> b	US b -> b	ALL
22/07/1994	0.0017	0.0229	1.2282	3.3548	0.0250	0.9093	4.3936	4.8007
13/01/1995	0.0102	2.9598	0.4637	7.6432	0.1031	0.3528	0.5434	0.6460
07/07/1995	0.0051	3.0070	0.4229	7.4750	0.1155	0.0007	0.3481	0.6018
29/12/1995	0.3357	3.4995	0.0022	6.0598	0.0927	0.1986	0.0731	0.4470
21/06/1996	0.5242	1.9216	0.0046	4.9334	0.3806	0.7168	0.3970	1.8347
13/12/1996	2.1850	4.9205	0.1586	11.0150	0.4643	1.5076	0.1307	2.3624
06/06/1997	2.4593	2.6643	0.1049	8.2352	0.8982	5.2151	0.0133	6.4495
28/11/1997	3.5339	5.9805	0.1563	14.0150	0.6785	4.5221	0.1897	6.4117
22/05/1998	2.6610	6.3054	0.4193	11.1420	1.0799	4.4948	0.6550	6.8976
13/11/1998	9.8129	4.3596	1.8121	17.3370	1.6697	2.4206	3.0664	6.9984
07/05/1999	6.1631	2.1454	0.4368	12.2850	2.3097	2.5532	4.2845	8.7225
29/10/1999	7.6577	5.4549	1.1048	16.8740	5.5372	6.5771	1.5724	10.2640
21/04/2000	13.0810	11.4770	1.7658	31.6540	6.1479	8.7391	1.4920	12.1720
13/10/2000	11.9050	18.0610	1.5124	37.9800	6.3679	9.3341	2.4968	13.9760
06/04/2001	12.4080	11.7290	0.6584	35.1880	3.8221	8.4522	2.9237	12.6290
28/09/2001	6.9654	14.3200	0.0120	35.1260	4.1223	10.0600	4.1540	15.6310
22/03/2002	7.2159	19.8660	0.0950	37.2300	4.4451	6.9999	4.6095	13.0350
13/09/2002	8.3544	26.0430	0.1687	43.6910	2.5579	4.9056	4.6397	10.1750
07/03/2003	7.9618	20.3450	0.0322	38.2430	2.2651	6.0755	4.1025	10.3050
29/08/2003	8.4672	21.4710	0.0152	41.0600	1.2683	3.8588	2.7853	6.7551
20/02/2004	9.1792	21.7750	0.0347	42.5240	2.0490	5.6551	2.2435	7.9605
13/08/2004	9.1085	22.7960	0.0288	43.6940	2.1673	5.1622	2.2321	7.4359
04/02/2005	9.4765	23.3750	0.0156	45.7020	2.3277	4.8349	2.1613	7.0625
29/07/2005	8.8612	23.1610	0.0008	45.2130	2.3342	4.7374	2.2298	7.0655
20/01/2006	9.6134	24.2890	0.0034	47.7930	2.2541	4.6412	2.5158	7.2575
14/07/2006	9.0685	27.1280	0.0024	49.3780	2.6514	5.2465	2.2792	7.6412

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

Table 17: **Sub-sample Granger causality tests for the Japanese market with the US market**

	b -> s	**US s -> s**	**US b -> s**	**ALL**	**s -> b**	**US s -> b**	**US b -> b**	**ALL**
22/07/1994	8.0355	0.7990	0.8434	13.6780	0.8222	0.8380	1.0298	2.3585
13/01/1995	8.0395	8.8050	0.0165	23.4150	0.3557	1.6187	2.4577	3.0991
07/07/1995	0.6841	5.3135	3.3712	22.7670	0.5374	1.8094	6.5517	6.9018
29/12/1995	0.6804	8.4669	3.0021	27.7020	0.1695	1.5442	8.3151	8.7507
21/06/1996	0.1651	8.4067	4.3857	31.2750	1.3468	1.1996	8.0517	9.8150
13/12/1996	0.0154	13.2370	4.3955	41.5360	0.5424	2.1829	12.9630	14.0920
06/06/1997	0.0093	17.7770	4.0170	46.9990	0.0503	4.0572	13.2430	13.3070
28/11/1997	1.1544	70.6350	0.1928	97.6950	1.1006	11.5380	20.1230	23.0310
22/05/1998	2.3927	79.6860	0.4143	94.6290	2.5487	11.5280	23.4340	27.2080
13/11/1998	0.7390	106.5700	1.4502	110.8300	2.5955	15.4850	37.8410	44.5250
07/05/1999	0.3963	121.6800	0.5930	126.2400	0.6299	15.0390	33.6010	40.1440
29/10/1999	0.0951	148.9600	1.8342	153.1700	0.0444	18.8130	38.7020	46.3770
21/04/2000	0.0775	174.7700	1.1721	179.3600	0.2008	22.3230	42.9920	53.7380
13/10/2000	0.0106	190.6000	0.9365	195.1900	0.2784	24.2160	40.5070	53.5330
06/04/2001	0.0647	192.7000	0.2592	196.2300	0.0165	27.9200	38.1670	56.9250
28/09/2001	0.2163	206.0700	0.1859	209.6600	0.1298	26.7630	33.9860	53.0690
22/03/2002	0.0511	227.3100	1.0801	228.5400	0.2758	24.1980	32.3360	50.1370
13/09/2002	0.0770	251.0600	0.5496	251.7000	0.4055	18.9530	27.6910	43.6960
07/03/2003	0.7519	263.1300	0.2511	264.6800	0.0018	13.7650	25.1780	38.8840
29/08/2003	1.5375	294.0200	1.2632	297.7300	0.8422	16.1290	29.0120	47.6220
20/02/2004	0.4533	312.9200	2.3761	317.0100	0.8482	15.7850	28.8300	47.4610
13/08/2004	0.2827	332.1700	1.7885	335.3400	1.0106	17.5760	34.0340	54.9870
04/02/2005	0.3956	350.5300	2.2785	354.4300	1.0411	19.3160	39.0030	61.9830
29/07/2005	0.4345	369.4100	2.3012	373.3300	1.1308	20.3810	42.9140	67.1380
20/01/2006	0.7178	377.3900	2.2994	381.8200	0.7649	21.5970	44.3080	69.2620
14/07/2006	0.7889	402.5400	2.9096	407.9300	0.6595	20.4670	49.2520	72.7430

The table contains the results of Granger causality tests based on a VAR estimated with 1 lag comprising all stock and bond market returns of the above sample. The full sample is divided into 26 sub samples, each comprising 125 observations. The columns contain the Wald test statistic of the Granger causality test based on a recursive procedure including all previous observations. Column two reports the test statistics for bonds causing stocks within the market under investigation. Column three shows the test statistics for the US stock market causing a country's stock market. Column four contains the same information for the US bond market causing a country's stock market in the Granger sense. Column five reports the Granger test statistic for all variables of the system. Columns six to nine contain the same information for the bond market. The 10, 5 and 1 percent critical values of the Chi squared distribution ($df = 1$) are 2.7055, 3.8415 and 6.6349, respectively.

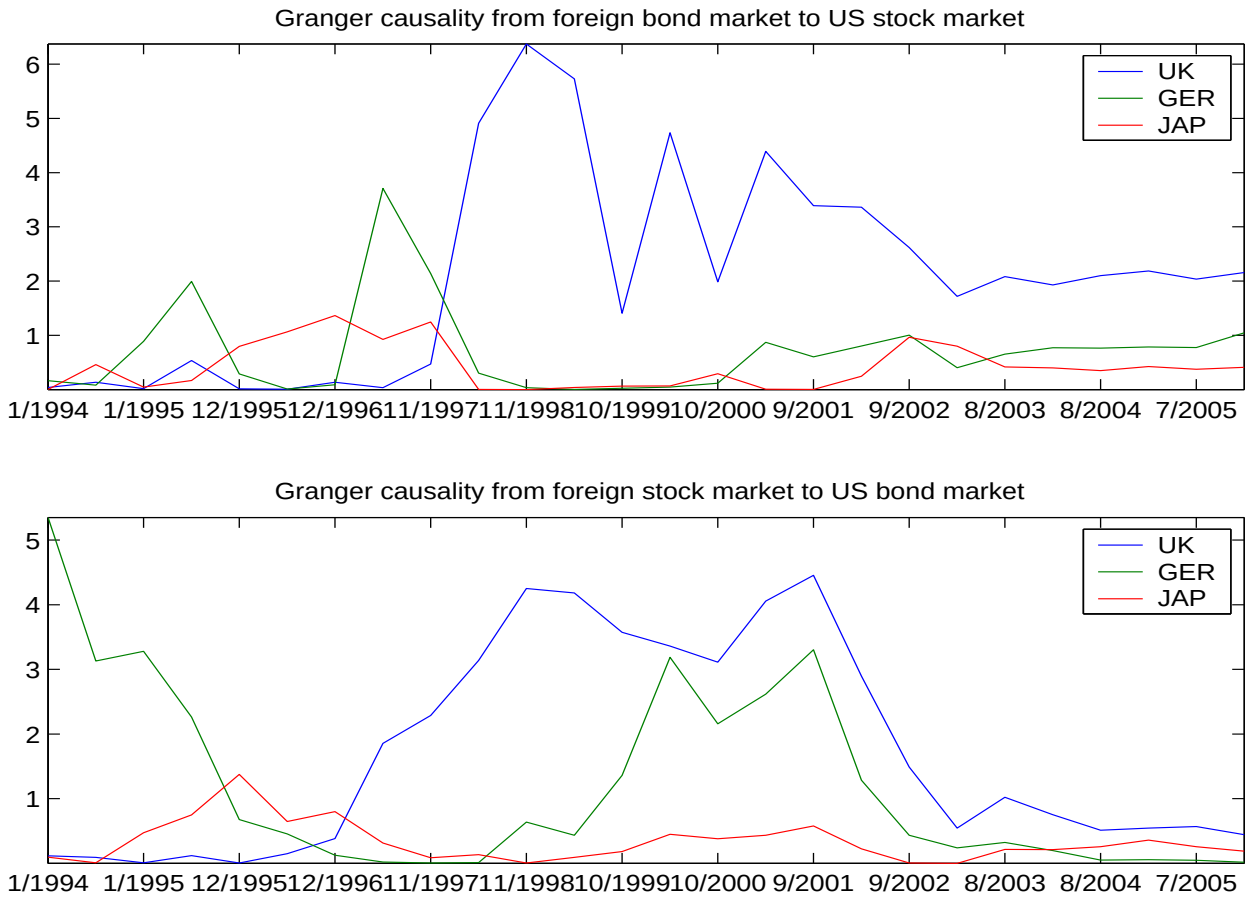

Figure 4: *Granger causality test from UK, GER, JAP bond market to the stock market (top panel) and from the stock market to the bond market (bottom panel). The graphs show Wald test statistics based on recursive Granger causality tests comprising 26 sub-samples. The test statistics are based on a VAR with 1 lag including the country under investigation and the US stock and bond market. The* 10, 5 *and* 1 *percent critical values of the Chi squared distribution* ($df = 1$) *are* 2.7055, 3.8415 *and* 6.6349, *respectively.*

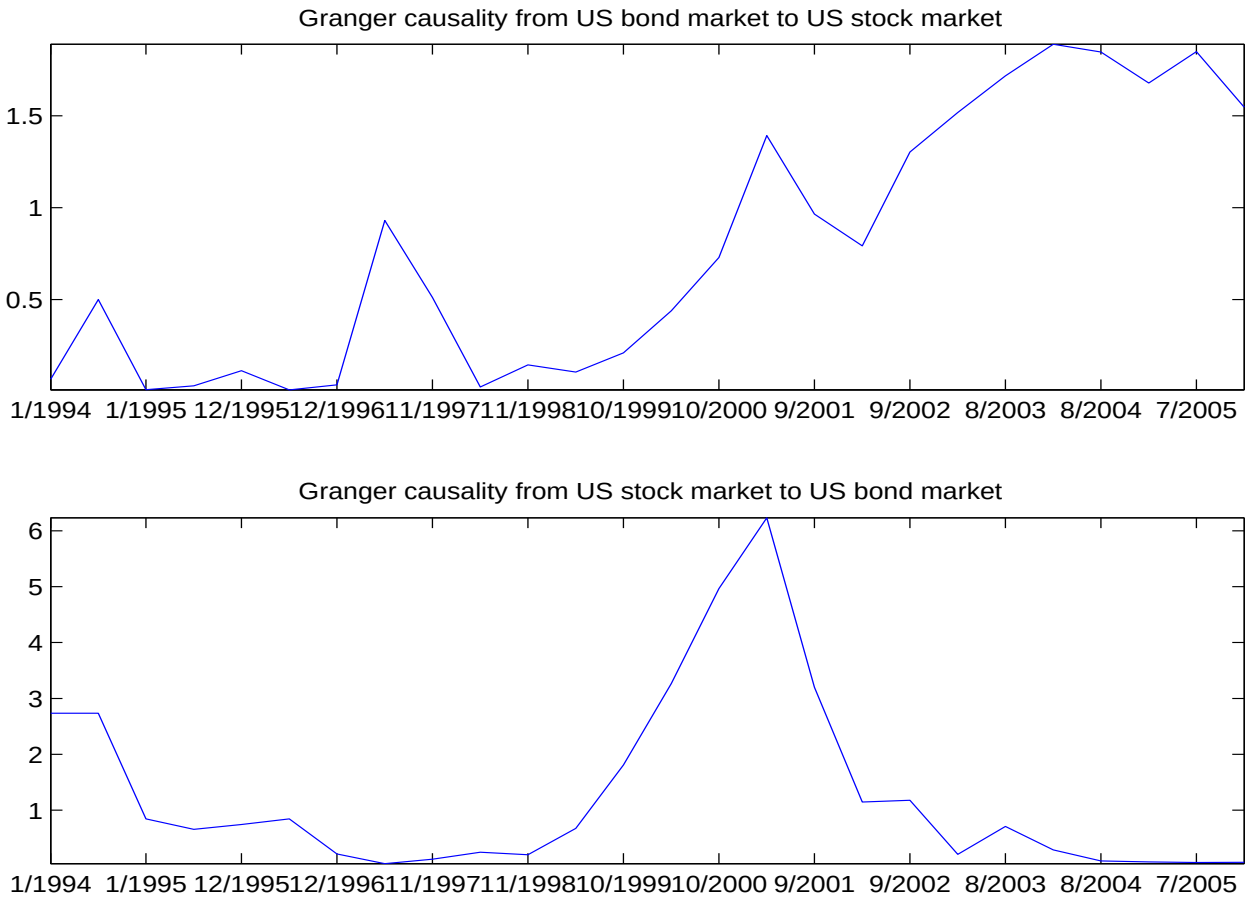

Figure 5: *Granger causality test from the bond market to the stock market (top panel) and from the stock market to the bond market (bottom panel). The graphs show Wald test statistics based on recursive Granger causality tests comprising 26 sub-samples. The test statistics are based on a VAR with 1 lag including the country under investigation and the US stock and bond market. The* 10*,* 5 *and* 1 *percent critical values of the Chi squared distribution (*$df = 1$*) are* 2.7055*,* 3.8415 *and* 6.6349*, respectively.*

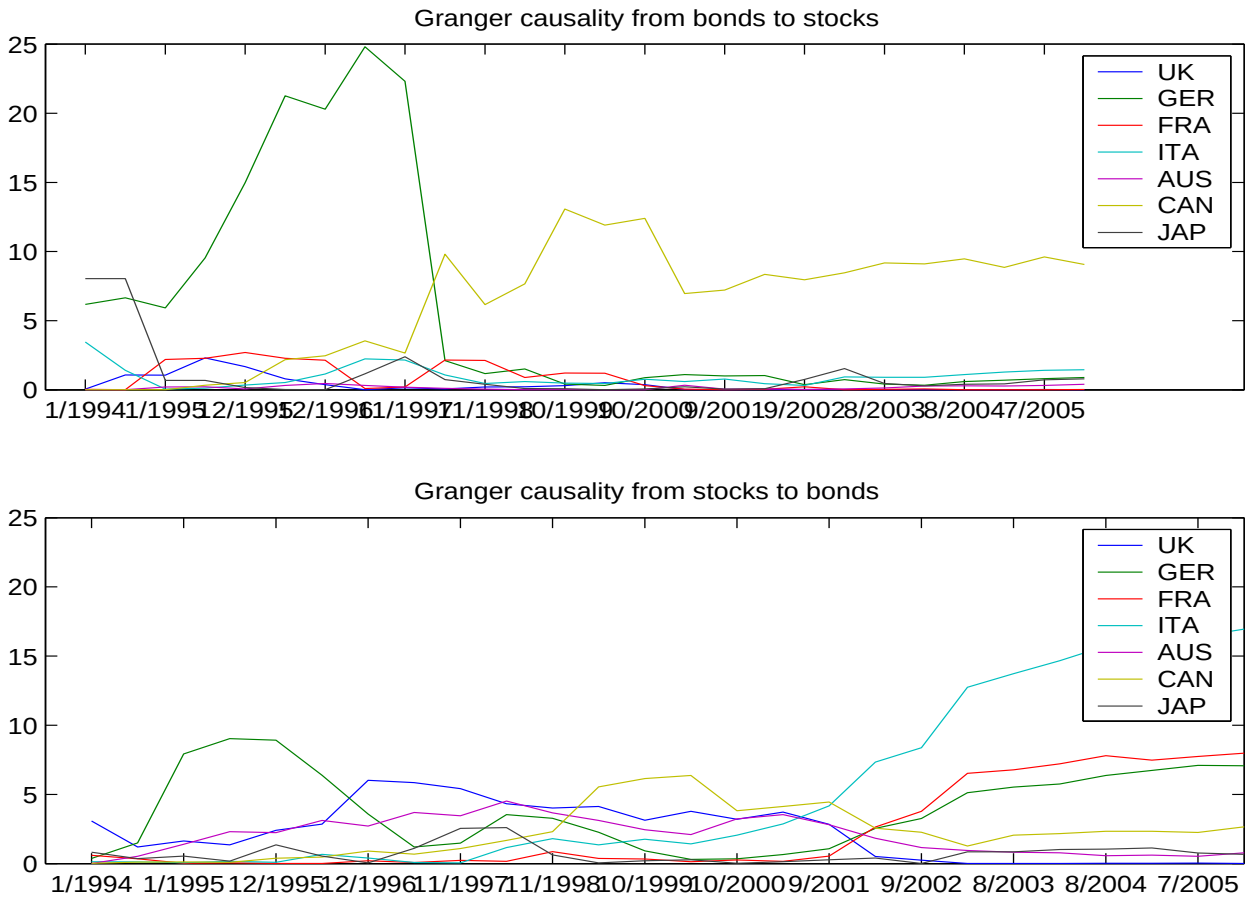

Figure 6: *Granger causality test from the bond market to the stock market (top panel) and from the stock market to the bond market (bottom panel). The graphs show Wald test statistics based on recursive Granger causality tests comprising 26 sub-samples. The test statistics are based on a VAR with 1 lag including the country under investigation and the US stock and bond market. The* 10, 5 *and* 1 *percent critical values of the Chi squared distribution* ($df = 1$) *are* 2.7055, 3.8415 *and* 6.6349, *respectively.*

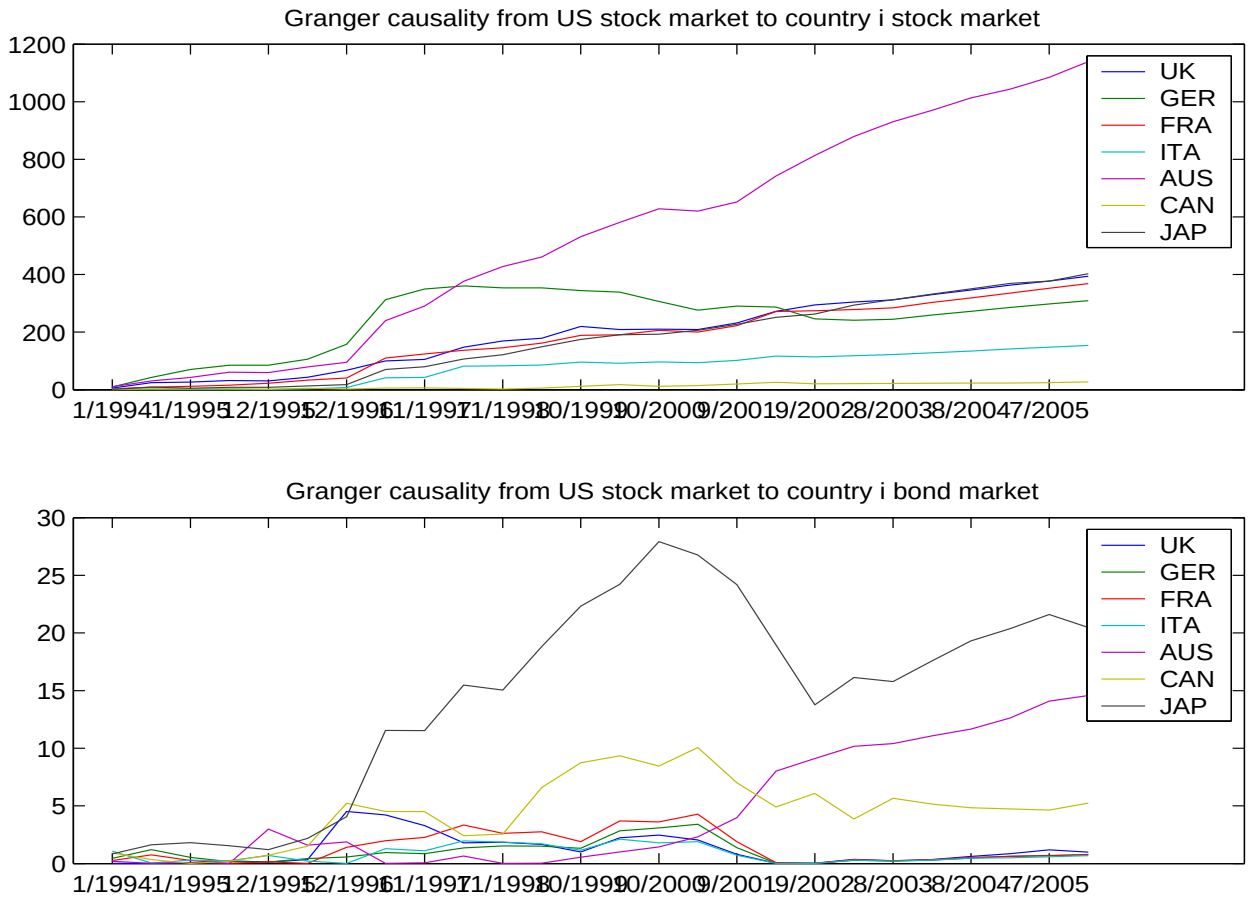

Figure 7: *Granger causality test from US stock market on a country's stock (top panel) and bond market (bottom panel). The graphs show Wald test statistics based on recursive Granger causality tests comprising 26 sub-samples. The test statistics are based on a VAR with 1 lag including the country under investigation and the US stock and bond market. The* 10, 5 *and* 1 *percent critical values of the Chi squared distribution (*$df = 1$*) are* 2.7055, 3.8415 *and* 6.6349, *respectively.*

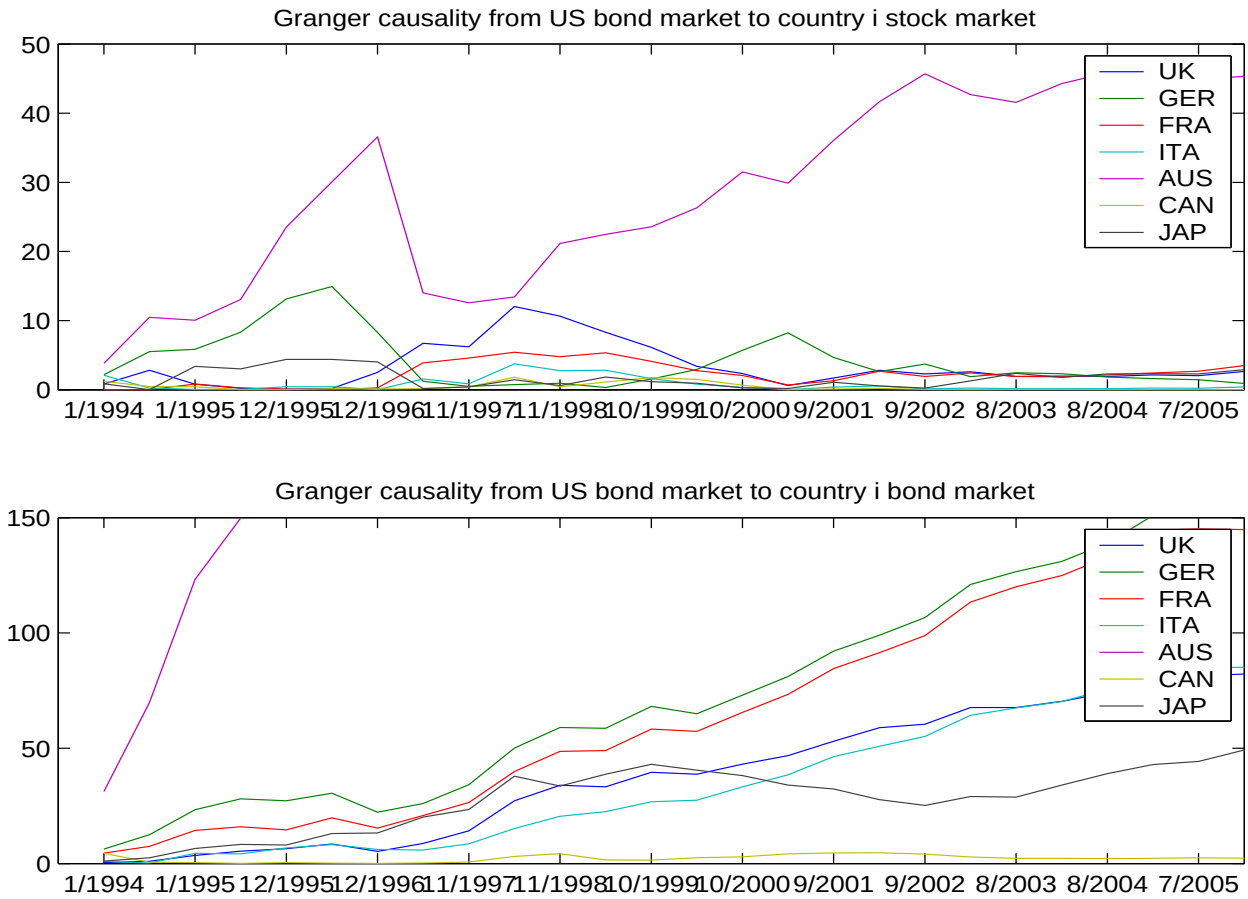

Figure 8: *Granger causality test from US bond market on a country's stock (top panel) and bond market (bottom panel). The graphs show Wald test statistics based on recursive Granger causality tests comprising 26 sub-samples. The test statistics are based on a VAR with 1 lag including the country under investigation and the US stock and bond market. The* 10, 5 *and* 1 *percent critical values of the Chi squared distribution (*$df = 1$*) are* 2.7055, 3.8415 *and* 6.6349, *respectively.*

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