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## Symposium: Advances in the Study of the Economics of Terrorism

# Does Terrorism Affect the Stock-Bond Covariance? Evidence from European Countries

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Using daily stock and bond returns data from four European countries—France, Germany, Spain, and Great Britain—that have been the victims of significant terrorist activity, this study addresses the issue of whether transnational and/or domestic terrorist attacks have affected in any significant manner the time-varying stock–bond covariance, their returns, and their variances. Stock and bond markets can be influenced and determined not only by the usual array of macroeconomic factors but also by security shocks, such as a terrorist incident, that have the potential to affect investors' sentiment and portfolio allocation decisions. The issue at hand is addressed using a VAR(p)-GARCH(1,1)-in-mean model, and the results reported herein indicate that terrorist attacks trigger a flight-to-safety effect primarily in France and Germany and to a smaller degree in Great Britain and Spain.

**JEL Classification: H56, G1, G15**

## 1. Introduction

As has been documented by a plethora of empirical studies, markets and market agents react to exogenous events, such as natural or anthropogenic catastrophes, social unrest, political upheavals, and violent events such as conflict and war (Asteriou and Siriopoulos 2003; Schneider and Troeger 2006; Capelle-Blancard and Laguna 2009; Wisniewski 2009; Guidolin and La Ferrara 2010; Kaplanski and Levy 2010). Although the probability of their occurrence is omnipresent, events like these are largely unanticipated and have the potential to generate uncertainty, adversely influence risk perceptions, and exert a negative effect on investors' sentiment and their concomitant assessment of markets. Hence, markets' volatility and portfolio allocation decisions are influenced.

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A growing strand of the aforementioned literature has focused on how markets react to terrorist attacks (Arin, Ciferri, and Spagnolo 2008; Nikkinen et al. 2008; Brounrn and Derwall 2010; Nikkinen and Vahamaa 2010; Ramiah et al. 2010; Chesney, Reshetar, and Karaman 2011). Given that terrorist incidents are unforeseen even in terrorism-prone countries, these incidents represent exogenous shocks that rattle and upset the daily social and economic routine (i.e., market anticipations) and on occasions can have serious political repercussions on the domestic as well as international level. As it has been shown, markets' reaction to terrorist events can significantly vary. The size of this response depends on a number of factors including the severity of the attack in terms of victims and damages, the target(s) hit, and the size and maturity of the markets (Gulley and Sultan 2006; Kollias et al. 2011; Kollias, Papadamou, and Stagiannis 2011). Although terrorist attacks negatively impact markets, this effect is often not particularly pronounced and is generally short lived (Chen and Siems 2004; Eldor and Melnick 2004; Gulley and Sultan 2006). Following the thematic focus of this growing corpus of empirical studies, the purpose of this article is to examine the impact of transnational and domestic terrorist attacks on the stock-bond covariance, their returns, and their variances for four major European capital markets.

The time-varying covariance between stocks and bonds has received considerable and growing attention in the relevant theoretical and empirical literature since it has many implications ranging from portfolio selection and asset allocation to risk management strategies for investors and portfolio managers (Shiller and Beltratti 1992; Campbell and Ammer 1993; Li 2002; Kim, Moshirian, and Wu 2006; Connolly, Stivers, and Sun 2007; Andersson, Krylova, and Vahamaa 2008; Yang, Zhou, and Wang 2009). As noted by Connolly, Stivers, and Sun (2005), the covariance between stock and bond returns is positive over the long term and is mainly, but not exclusively, driven by inflation expectations. More specifically, an increase in inflation expectations may be a signal of a more restrictive monetary policy, implying a higher interest rate used in order to discount cash flows in bond and stock price valuations. However, the covariance between the two assets does present significant variation over time with a number of recent studies reporting findings that point to a negative covariance over sustained periods of time (Fleming, Kirby, and Ostdiek 2003; Ilmanen 2003; Li 2002; Connolly, Stivers, and Sun 2005; Guidolin and Timmermann 2005; Cappiello, Engle, and Sheppard 2006). Gulko (2002) in particular argues that periods of negative stock-bond covariance are present around stock market crashes, while results by Connolly, Stivers, and Sun (2005) indicate that bond returns tend to be high relative to stock returns during the periods of high stock market implied volatility, a finding that is reinforced by those reported in Kim, Moshirian, and Wu (2006). If a broad generalization is attempted, it appears that periods of market uncertainty and, hence, high volatility, can trigger a flight-to-quality effect with investors fleeing from stocks to bonds since the latter are generally considered to be a more secure and less risky investment (Gulko 2002; Baur and Lucey 2009). The reverse flow, that is, a flight-from-quality, is observed once market uncertainty is reduced. Both flows negatively affect the stock-bond covariance and bring about a decrease in the covariance coefficient.

Apart from the usual cohort of economic factors that can influence this relationship over the long run, exogenous events can also exert an impact on the stock-bond covariance over the short run. Using daily data from four major European markets, this study examines whether, and to what extent, this relationship is affected by terrorist incidents. As already pointed out and has been shown in a number of other articles, terrorist attacks are, from the equity markets' perspective, security shocks that can affect investor psychology and sentiment, risk perceptions and tolerance, and market uncertainty with the concomitant impact on stock market volatility and portfolio allocation decisions (Amelie and Darne 2006; Gulley and Sultan 2006; Drakos 2010a, b, 2011). Hence, a flight-to-quality/safety effect might be caused, thus affecting the stock-bond covariance. Chesney, Reshetar, and Karaman (2011) examine the impact that terrorism has on the behavior of stocks, bonds, and commodities, focusing on issues of portfolio diversification strategies to counter the uncertainty posed by terrorism. However, to the best of our knowledge, the question of how terrorist activity affects the stock-bond covariance has not been addressed before in a multivariate Generalised Autoregressive Conditional Heteroskedasticity (GARCH) framework,[1] as done here. An unrestricted Vector Autoregressive (VAR)–GARCH model is employed herein for two main reasons. First, the VAR representation permits the identification of the causality direction between two or more variables without explicitly assuming a specific direction. Second, financial time series, like the stock and bond series used here, frequently present time-varying variances affecting the validity of the estimated parameters. For this reason, modelling time-varying conditional variances and covariance is regarded as the suitable approach in such cases. In the ensuing section, the data and methodology are presented. The findings are indicated and discussed in section 3, followed by conclusions in section 4.

## 2. Data and Methodology

Four European Union countries are selected to explore the question at hand: Spain, Germany, France, and Great Britain. They are four of the largest and most important economies in the European Union (EU), with large and mature bond and stock markets. All have been the victims of systematic terrorist campaigns from domestic as well as transnational terrorist groups. In the past, almost all have been the venue of mass-casualty terrorist attacks (Enders and Sandler 2012).

The financial data set used in our empirical estimations consists of daily data on German, French, British, and Spanish bond and stock returns. The German stock returns are calculated from the DAX index, the British returns from the FTSE100 index, the French returns from the CAC index, and the Spanish returns from the Madrid stock index. The bond returns for Germany, Britain, and France are extracted from the benchmark All-Maturity government bond price indices available by J.P. Morgan. In the case of the Spanish bond data, the All-Maturity government bond index provided by Reuters Ecowin financial database was used. The sample covers the period from January 4, 1988, to March 11, 2008, for Britain, France, and Germany. Bond data availability in the case of Spain restricts the sample from December 30, 1997, to October 24, 2007.[2]

The data on terrorism used in the empirical investigation are drawn from the Enders, Sandler, and Gaibulloev (2011) decomposition of terrorist incidents into domestic (NTer) and transnational (TTer) in order to allow for possible differences in market agents' reaction depending on the perpetrators of attack.[3] From all the events contained in that data set, only the ones that have caused casualties—fatalities and/or injuries—are selected in each of the two

[1] Multivariate GARCH models have been widely used to study covariance (Longin and Solnik 1995; Kim, Moshirian, and Wu 2006; Li and Zou 2008).

[2] The sample data selection in every country is based on bond data availability.

classification groups. Terrorist attacks that cause casualties are more serious and hence more likely to affect and shake markets and the stock-bond covariance. As can be seen in Table 1, Spain is by far the country that has suffered the most attacks during the sample period, with the greatest number of casualties. Germany, Great Britain, and France follow Spain in sheer number of attacks. However, in terms of victims, it is Britain that has suffered the second largest number of casualties after Spain, with Germany and France being the two countries where terrorism has claimed appreciably fewer injuries and fatalities. The systematic and prolonged operation of Euskadi Ta Askatasuna (ETA) and the Provisional Irish Republican Army (IRA), as well as smaller but just as deadly organisations such as the Irish National Liberation Army (INLA) in Spain and Britain, respectively, explains to a large extent their first and second place in terms of victims.

In order to examine the impact of these events on the stock-bond covariance, their returns, and their variances, a variable quantifying terrorist activity is constructed. The use of a zero-one dummy variable treats all events equally in terms of importance and does not allow for the significance of each incident, as this is reflected in the number of casualties caused. So, instead of the usual zero-one dummy variable, a terror index was calculated following the methodology introduced by Eckstein and Tsiddon (2004). The daily index is defined as the natural logarithm of ($e$ + number of fatalities + number of injuries) that occurred each day. The terror events that took place during the weekend are summed up to the previous Friday's figure. This index is then introduced in the multivariate GARCH analysis that follows. Finally, given the time issue associated with when each event has taken place vis-à-vis the markets' trading hours, we look at the events contemporaneously, at time $t$, and lagged, at time $t - 1$.

The issue at hand is examined using a multivariate GARCH framework. Such models are in spirit very similar to their univariate counterparts that have extensively been used to examine markets' volatility (Bollerslev 1990; Hamao, Masulis, and Ng 1990; Ilmanen 1995; Longin and Solnik 1995; Skintzi and Refenes 2006). The multivariate GARCH models specify equations for how the covariances move over time. Several different multivariate GARCH formulations have been proposed in the literature, including the Half-vectorization (VECH),[4] the diagonal VECH, and the BEKK (Baba, Engle, Kraft, and Kroner)[5] models.[6] In our case, the bivariate unrestricted BEKK-GARCH(1,1) model, proposed by Engle and Kroner (1995), is used to address the question of how terrorist attacks have affected the stock-bond covariance in the four countries used. This class of models is not used frequently in empirical studies due to their complexity that often leads to severe convergence problems (Bauwens, Laurent, and Rombouts 2006). However, the bivariate version of the general BEKK($p$, $q$) model with $p = q = 1$ in general provide a good compromise between conducting a multivariate analysis and still achieving robust convergence. Moreover, the BEKK model (Engle and Kroner 1995) addresses the difficulty with VECH of ensuring that the conditional variance-covariance matrix is always

[3] The incidents that could not be classified by Enders, Sandler, and Gaibulloev (2011) into transnational or domestic were not used.

[4] Its name is taken by the vectorized representation of the model, where VECH( ) denotes the operator that stacks the lower triangular portion of a symmetric $N \times N$ matrix into an $N(N + 1)/2 \times 1$ vector of the corresponding unique elements.

[5] The BEKK acronym refers to a specific parameteriztion of the multivariate GARCH model developed in Engle and Kroner (1995).

[6] For a more detailed discussion and survey see, among others, Bauwens, Laurent, and Rombouts (2006).

**Table 1.** The Attacks

| Event Type | Number of Attacks | Fatalities | Injuries | Total Casualties | Total Casualties in All Categories |
|---|---|---|---|---|---|
| France | | | | | |
| Transnational | 52 | 18 | 5 | 23 | 284 |
| Domestic | 256 | 19 | 193 | 212 | |
| Uncertain | 17 | 5 | 44 | 49 | |
| Germany | | | | | |
| Transnational | 324 | 28 | 190 | 218 | 524 |
| Domestic | 195 | 13 | 277 | 290 | |
| Uncertain | 20 | 1 | 15 | 16 | |
| Spain | | | | | |
| Transnational | 84 | 194 | 1839 | 2033 | 3123 |
| Domestic | 867 | 174 | 863 | 1037 | |
| Uncertain | 40 | 17 | 36 | 53 | |
| Great Britain | | | | | |
| Transnational | 41 | 275 | 34 | 309 | 1893 |
| Domestic | 285 | 71 | 1502 | 1573 | |
| Uncertain | 16 | 2 | 9 | 11 | |
| Totals | 2197 | 817 | 5007 | 5824 | |

Source: Enders, Sandler, and Gaibulloev (2011).

positive definite. The joint process governing the two variables is modeled with the bivariate VAR unrestricted BEKK-GARCH(1,1)-in-mean model including the terrorism index in the construction of the mean, variances, and covariance matrices. More specifically, Equation 1 gives the expression for the conditional mean

$$\mathbf{x_t} = \boldsymbol{\gamma} + \boldsymbol{\delta} \sum_{j=1}^{p} \mathbf{x_{t-1}} + \boldsymbol{\lambda} \mathbf{d_t} + \boldsymbol{\zeta} \mathbf{h_t} + \boldsymbol{\varepsilon_t}, \tag{1}$$

where vector $\mathbf{x}$ = (RB, RS) includes the returns of the bond (RB) and stock (RS) markets, respectively, in the country examined.

The lag length, defined as $p$, is based on Akaike (AIC) criterion in each country. Vector $\mathbf{d}$ = (TTer, NTer) includes the transnational and domestic terrorism indices in each country based on the Enders, Sandler, and Gaibulloev (2011) decomposition and classification. The terrorism index is an exogenous variable presented in both equations. $\mathbf{h} = (h_{11}, h_{22}, h_{21})$ is the GARCH-in-mean vector. The residual vector $\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2)$ is bivariate and generalized distributed with $\boldsymbol{\varepsilon}_t | \Phi_{t-1} \sim \text{GED}(0, \mathbf{H}_t)$, and the corresponding conditional variance covariance matrix is given by

$$\mathbf{H_t} = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix}.$$

The second moment will take the following form:

$$\mathbf{H_t} = \mathbf{C_0 C_0'} + \mathbf{A'} \boldsymbol{\varepsilon_{t-1}} \boldsymbol{\varepsilon_{t-1}'} \mathbf{A} + \mathbf{B'} \mathbf{H_{t-1}} \mathbf{B} + \mathbf{K} \bullet TTer_t + \boldsymbol{\theta} \bullet NTer_t, \tag{2}$$

where the conditional variance-covariance matrix depends on its past values and on past values of error terms defined on matrix $\boldsymbol{\varepsilon}_{t-1}$. $C_0$ is a $2 \times 2$ matrix, the elements of which are zero above the main diagonal; **A**, **B** are $2 \times 2$ matrices. **K**, $\boldsymbol{\theta}$ are the coefficient matrices for the transnational and domestic terrorism index, respectively, and the operator "•" is the element-by-element (Hadamard product). More analytically,

$$\mathbf{H_t} = \begin{pmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{pmatrix} \begin{pmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{pmatrix}' + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix}' \boldsymbol{\varepsilon}_{t-1} \boldsymbol{\varepsilon}'_{t-1} \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}' + \mathbf{H_{t-1}} \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} + \mathrm{K} \bullet TTer_t + \theta \bullet NTer_t. \quad (3)$$

The main advantage of the BEKK-GARCH versus VECH-GARCH model is that it guarantees by construction that the covariance matrices in the system are positive definite. The maximum likelihood is used to jointly estimate the parameters of the mean and the variance equations. In a single equation format, the model may be written as follows:

$$h_{11,t} = c_{11}^2 + \alpha_{11}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{11}\alpha_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}^2\varepsilon_{2,t-1}^2 + \beta_{11}^2 h_{11,t-1} + 2\beta_{11}\beta_{21}h_{12,t-1} + \beta_{21}^2 h_{22,t-1} + \kappa_{11} TTer_t + \theta_{11} NTer_t, \quad (4)$$

$$h_{12,t} = c_{11}c_{21} + \alpha_{11}\alpha_{12}\varepsilon_{1,t-1}^2 + (\alpha_{21}\alpha_{12} + \alpha_{11}\alpha_{22})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}\alpha_{22}\varepsilon_{2,t-1}^2 + \beta_{11}\beta_{12}h_{11,t-1} + (\beta_{21}\beta_{12} + \beta_{11}\beta_{22})h_{12,t-1} + \beta_{21}\beta_{22}h_{22,t-1} + \kappa_{12} TTer_t + \theta_{12} NTer_t \quad (5)$$

$$h_{22,t} = c_{21}^2 + c_{22}^2 + \alpha_{12}^2\varepsilon_{1,t-1}^2 + 2\alpha_{12}\alpha_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{22}^2\varepsilon_{2,t-1}^2 + \beta_{12}^2 h_{11,t-1} + 2\beta_{12}\beta_{22}h_{12,t-1} + \beta_{22}^2 h_{22,t-1} + \kappa_{22} TTer_t + \theta_{22} NTer_t. \quad (6)$$

## 3. The Findings

The analysis is based on bond and stock market returns given that their prices are characterized as $I(1)$ processes. Table 2 presents the descriptive statistics for the return series in both markets in each of the four countries examined here. As can be seen, stock and bond mean returns are positive and statistically significant. As intuitively expected, the bond market volatility is smaller compared to the stock market volatility. Broadly speaking, the Jarque-Bera values are high and statistically significant. In the bond markets, the degree of skewness measured in absolute terms is higher compared to stock markets. Most return series have some auto covariances, as indicated by Ljung–Box statistics, and all of them present autoregressive conditional heteroskedasticity (ARCH) effect, as implied by ARCH Lagrange Multiplier Test. Moreover, the distribution of these is fat-tailed because excess kurtosis is greater than zero. As a result, adopting the VAR($p$)-BEKK-GARCH(1,1)-in-mean model in our analysis seems an appropriate choice in order to take into account any time-varying volatility in clusters.

**Table 2.** Descriptive Statistics

| | Observations | Sample Mean | $t$-Statistic (Mean = 0) | Sample St. Deviation | Skewness | Kurtosis (Excess) | Jarque-Bera | Minimum Value/Date | Maximum Value/Date | Ljung-Box Test $Q(16)$ $p$ value | ARCH(16) LM Test $p$ value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spanish bond | 2562 | 0.00021 | 5.070 | 0.002 | −0.281 | 0.982 | 136.687 | −0.008 | 0.008 | | |
| returns | | | <0.01*** | | <0.01*** | <0.01*** | <0.01*** | 2007:07:17 | 1999:02:26 | (0.09)* | <0.01*** |
| Spanish stock | 2562 | 0.00044 | 1.823 | 0.012 | −0.195 | 2.671 | 778.037 | −0.065 | 0.059 | | |
| returns | | | (0.06)* | | <0.01*** | <0.01*** | <0.01*** | 1999:01:05 | 1998:12:25 | <0.01*** | <0.01*** |
| French bond | 5267 | 0.00029 | 8.942 | 0.002 | −0.119 | 1.786 | 712.374 | −0.011 | 0.012 | | |
| returns | | | <0.01*** | | <0.01*** | <0.01*** | <0.01*** | 1995:09:21 | 1993:07:30 | (0.04)** | <0.01*** |
| French stock | 5267 | 0.00032 | 1.672 | 0.014 | 0.089 | 5.516 | 6685.252 | −0.090 | 0.112 | | |
| returns | | | (0.09)* | | <0.01*** | <0.01*** | <0.01*** | 2007:12:27 | 2008:01:03 | <0.01*** | <0.01*** |
| German bond | 5267 | 0.00023 | 8.196 | 0.002 | −0.433 | 3.128 | 2311.979 | −0.016 | 0.012 | | |
| returns | | | <0.01*** | | <0.01*** | <0.01*** | <0.01*** | 1994:03:01 | 1988:06:03 | (0.01)*** | <0.01*** |
| German stock | 5267 | 0.00040 | 2.013 | 0.014 | −0.014 | 6.600 | 9558.370 | −0.128 | 0.114 | | |
| returns | | | (0.04)** | | (0.68) | <0.01*** | <0.01*** | 1989:09:14 | 2008:01:02 | <0.01*** | <0.01*** |
| British bond | 5267 | 0.00032 | 6.969 | 0.003 | 0.120 | 4.435 | 4328.560 | −0.022 | 0.028 | | |
| returns | | | <0.01*** | | <0.01*** | <0.01*** | <0.01*** | 1997:11:25 | 1992:04:09 | (0.50) | <0.01*** |
| British stock | 5267 | 0.00023 | 1.522 | 0.011 | −0.067 | 6.385 | 8951.104 | −0.088 | 0.088 | | |
| returns | | | (0.12) | | (0.04)** | <0.01*** | <0.01*** | 2008:02:20 | 2008:01:30 | <0.01*** | <0.01*** |

The estimation results for the VAR-unrestricted BEKK-GARCH(1,1)-in-mean model are presented in Table 3. The diagnostic tests in the lower part of the table in some cases of VAR models still provide evidence for autocorrelation. Therefore, in order to ensure correct inference Newey and West (1987) standard errors are computed. Looking at the mean equation of stock returns, we see that stock volatility coexists with high stock returns pointing to the well-known risk-return result that investors require high return for the risk undertaken (see coefficients *H*(2,2) in the stock equation). Overall, the results for the stock markets in question point to a negative effect from terrorist attacks (see the TTer and NTer coefficients in the stock equation), but this is not uniformed across all four bourses. The least affected appears to be the Madrid stock exchange, followed by London, where a negative but weak effect on mean returns is present in the case of domestic terrorist attacks with no effect on market volatility. Both countries share a common characteristic when it comes to terrorism. They have both been the victims of prolonged terrorist activity mainly by domestic terrorist groups, as already noted. Hence, it is possible that terrorist action is discounted by markets and their agents, suggesting market efficiency when it comes to absorbing and incorporating exogenous shocks of relative regular occurrence. The most affected stock markets are Paris and Frankfurt. Terrorist attacks, transnational as well as domestic, appear exerting a negative and significant impact both on mean returns as well as volatility ($\kappa_{22}$, $\theta_{22}$) in the case of the former with an indirect negative effect on returns via the volatility channel (see *H*(2,2) combined with $\kappa_{22}$, $\theta_{22}$) also being present. When it comes to the German stock market, the volatility is significantly affected only in the case of transnational terrorist incidents (see $\kappa_{22}$ coefficient), with the volatility channel also transmitting a negative effect on mean returns (see *H*(2,2) combined with $\kappa_{22}$).

Let us now turn to the four bond markets (Table 3). As a general observation, the findings indicate that transnational and domestic terrorism do not have any direct impact on mean bond returns in the four sample countries. Although not universal across all four markets, terrorist activity is associated with a reduction in bond variance (negative and statistically significant $\kappa_{11}$ and/or $\theta_{11}$ coefficients). The exception is the British bond market, where no impact on volatility is traced. A reduction in bond volatility can be tentatively interpreted as evidence suggesting a flight-to-quality effect. This is the case in France and Germany, where both domestic and transnational terrorist events reduce bond volatility (see $\kappa_{11}$ and $\theta_{11}$ coefficients). For the latter, an indirect weak positive effect on bond returns via the volatility channel is also evident, providing further evidence in support of a flight to reduced uncertainty effect (see the sign of the *h*(1,1) coefficient in the bond equation). In the case of Spain, volatility is reduced only by domestic attacks (negative and statistically significant coefficient $\theta_{11}$), while the indirect weak positive effect on bond returns, via the volatility channel, is also present here (combine the coefficient $\theta_{11}$ the *h*(1,1) in the mean equation for bonds). Hence, a flight to reduced uncertainty/greater safety effect appears to be present in the case of Spain as well.

When we turn to the direct effects of terrorist activity on the bond-stock returns and variance–covariance, the results are similar in three out of the four markets examined. There is no significant effect, with the exception of France, where the variance–covariance between stock and bond markets is significantly reduced by both domestic and transnational terrorist incidents (see $\kappa_{12}$ and $\theta_{12}$). This result may be interpreted as implying diversification benefits between stock and bond assets as a result of terrorist activity. Moreover, given the negative and significant variance–covariance between bond market returns and bond-stock variance–covariance, we can deduce a positive indirect effect on bond returns. This finding can be treated as a further indication of a flight-to-bonds and the uncertainty-reducing aspect of it in days

**Table 3.** VAR-BEKK-GARCH(1,1)-in-Mean Model Estimation Results

| | France | | Germany | | UK | | Spain | |
|---|---|---|---|---|---|---|---|---|
| | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | |
| Variable | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. |
| Bond Mean Return Equation | | | | | | | | |
| Const. | 0.00050 | 0.60 | 0.00040 | 0.36 | 0.00085 | 0.12 | −0.00001 | 0.95 |
| $RB_{t-1}$ | **0.05755** | **<0.01** | 0.02009 | 0.17 | 0.02742 | 0.08 | 0.00238 | 0.92 |
| $RB_{t-2}$ | **0.03763** | **0.02** | **0.02890** | **0.03** | **0.03573** | **0.03** | **0.05066** | **0.02** |
| $RB_{t-3}$ | 0.00466 | 0.72 | 0.02977 | 0.12 | **0.04141** | **0.02** | −0.02674 | 0.15 |
| $RB_{t-4}$ | −0.00861 | 0.48 | 0.00201 | 0.90 | −0.00257 | 0.89 | −0.04131 | 0.16 |
| $RB_{t-5}$ | **−0.02617** | 0.09 | 0.02215 | 0.09 | −0.00751 | 0.70 | | |
| $RB_{t-6}$ | | | −0.02112 | 0.11 | −0.01262 | 0.53 | | |
| $RS_{t-1}$ | **−0.00628** | **0.01** | **0.00370** | **0.04** | −0.00148 | 0.80 | −0.00858 | 0.07 |
| $RS_{t-2}$ | 0.00258 | 0.32 | −0.00085 | 0.62 | −0.00959 | 0.06 | −0.00199 | 0.67 |
| $RS_{t-3}$ | 0.00333 | 0.19 | −0.00143 | 0.38 | 0.00727 | 0.10 | 0.00107 | 0.80 |
| $RS_{t-4}$ | −0.00235 | 0.35 | **−0.00425** | **0.01** | 0.00043 | 0.90 | −0.00789 | 0.08 |
| $RS_{t-5}$ | 0.00061 | 0.77 | −0.00305 | 0.26 | **0.01310** | **0.02** | | |
| $RS_{t-6}$ | | | **−0.00351** | **0.04** | 0.00673 | 0.11 | | |
| TTer | −0.00090 | 0.65 | −0.00038 | 0.40 | −0.00074 | 0.46 | 0.00031 | 0.31 |
| NTer | 0.00008 | 0.90 | 0.00042 | 0.64 | 0.00009 | 0.88 | 0.00047 | 0.11 |
| $H(1,1)$ | 19.17321 | 0.24 | −35.09725 | 0.07 | −10.75380 | 0.33 | −56.50128 | 0.08 |
| $H(1,2)$ | **−17.65938** | **0.01** | 1.39808 | 0.78 | −14.25180 | 0.25 | −12.62610 | 0.35 |
| $H(2,2)$ | −0.17513 | 0.31 | −0.06131 | 0.58 | −0.07593 | 0.83 | 0.19577 | 0.43 |
| Stock Mean Return Equation | | | | | | | | |
| Const. | **0.01692** | **<0.01** | 0.01920 | 0.16 | −0.00030 | 0.78 | −0.00040 | 0.77 |
| $RB_{t-1}$ | 0.09569 | 0.12 | 0.00614 | 0.96 | 0.04048 | 0.14 | 0.20476 | **0.01** |
| $RB_{t-2}$ | −0.03497 | 0.61 | 0.00937 | 0.89 | 0.05067 | 0.12 | −0.24672 | **<0.01** |
| $RB_{t-3}$ | −0.01202 | 0.85 | 0.08337 | 0.16 | 0.04050 | 0.17 | −0.11712 | 0.16 |
| $RB_{t-4}$ | −0.10126 | 0.21 | 0.03929 | 0.57 | −0.03165 | 0.29 | −0.07606 | 0.41 |
| $RB_{t-5}$ | −0.04705 | 0.54 | 0.14044 | 0.07 | 0.01497 | 0.59 | | |
| $RB_{t-6}$ | | | −0.05307 | 0.51 | **0.06730** | **0.01** | | |
| $RS_{t-1}$ | 0.00309 | 0.89 | 0.02858 | 0.24 | 0.00101 | 0.95 | −0.00185 | 0.90 |

**Table 3.** Continued

| Variable | France | | Germany | | UK | | Spain | |
|---|---|---|---|---|---|---|---|---|
| | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | |
| | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. |
| $RS_{t-2}$ | −0.01852 | 0.27 | −0.03237 | 0.35 | −0.00393 | 0.74 | **0.03796** | **0.01** |
| $RS_{t-3}$ | −0.01742 | 0.41 | −0.02798 | 0.22 | **−0.03306** | **0.01** | −0.02139 | 0.15 |
| $RS_{t-4}$ | 0.01980 | 0.21 | 0.01795 | 0.42 | 0.03104 | 0.09 | **−0.03646** | **0.01** |
| $RS_{t-5}$ | **−0.03654** | **0.04** | 0.00079 | 0.96 | **−0.02760** | **0.04** | | |
| $RS_{t-6}$ | | | −0.00064 | 0.97 | −0.00053 | 0.96 | | |
| TTer | −0.03892 | **<0.01** | 0.00289 | 0.24 | 0.00241 | 0.30 | −0.00027 | 0.88 |
| NTer | −0.00338 | 0.21 | −0.04614 | 0.16 | **−0.00179** | **0.03** | 0.00033 | 0.75 |
| $H(1,1)$ | 69.35558 | 0.47 | −45.30973 | 0.80 | −12.32294 | 0.51 | −35.24616 | 0.81 |
| $H(2,1)$ | 69.59162 | 0.26 | 65.29979 | 0.20 | 24.34511 | 0.28 | 31.77627 | 0.77 |
| $H(2,2)$ | **8.19650** | **<0.01** | **4.31563** | **0.01** | **5.55352** | **0.02** | **4.98112** | **<0.01** |
| Variances-Covariance Equations | | | | | | | | |
| $c_{11}$ | **0.00216** | **<0.01** | 0.00122 | **<0.01** | **0.00038** | 0.23 | **0.00029** | **0.01** |
| $c_{21}$ | **0.01524** | **0.01** | 0.00018 | 0.95 | 0.00086 | 0.20 | 0.00089 | 0.27 |
| $c_{22}$ | **0.00772** | **<0.01** | −0.00572 | 0.42 | **0.00264** | **<0.01** | 0.00139 | 0.25 |
| $\alpha_{11}$ | **0.19601** | **<0.01** | **0.20391** | **<0.01** | **0.18827** | **<0.01** | **0.12483** | **0.01** |
| $\alpha_{12}$ | −0.11485 | 0.42 | **0.31708** | **0.03** | **0.06724** | **0.04** | −0.01207 | 0.95 |
| $\alpha_{21}$ | **−0.00503** | **0.04** | −0.00192 | 0.47 | 0.00931 | 0.09 | **0.00792** | **<0.01** |
| $\alpha_{22}$ | **0.40593** | **<0.01** | **0.48302** | **<0.01** | **0.32423** | **<0.01** | **0.31991** | **<0.01** |
| $\beta_{11}$ | **0.97623** | **<0.01** | **0.97528** | **<0.01** | **0.98055** | **<0.01** | **0.98951** | **<0.01** |
| $\beta_{12}$ | −0.01650 | 0.60 | −0.02811 | 0.27 | −0.00940 | 0.43 | −0.02367 | 0.41 |
| $\beta_{21}$ | **0.00298** | **0.01** | −0.00035 | 0.76 | −0.00411 | 0.15 | **−0.00266** | **<0.01** |
| $\beta_{22}$ | **0.90472** | **<0.01** | **0.87407** | **<0.01** | **0.94330** | **<0.01** | **0.95289** | **<0.01** |
| $\kappa_{11}$ | **−0.00292** | **<0.01** | **−0.00098** | **<0.01** | −0.00018 | 0.31 | **0.00015** | 0.04 |
| $\kappa_{12}$ | **−0.03149** | **0.01** | −0.00133 | 0.42 | −0.00077 | 0.47 | **0.00143** | **<0.01** |
| $\kappa_{22}$ | **−0.00623** | **<0.01** | **−0.01014** | **<0.01** | −0.00201 | 0.15 | −0.00032 | 0.71 |
| $\theta_{11}$ | **−0.00134** | **<0.01** | **−0.00126** | **<0.01** | 0.00025 | 0.59 | **−0.00039** | **<0.01** |
| $\theta_{12}$ | **−0.00387** | **0.02** | 0.00124 | 0.87 | −0.00037 | 0.38 | −0.00141 | 0.11 |
| $\theta_{22}$ | **−0.00439** | **0.01** | **0.03104** | **0.04** | **−0.00096** | **<0.01** | −0.00110 | 0.25 |

**Table 3.** Continued

| Variable | France | | Germany | | UK | | Spain | |
|---|---|---|---|---|---|---|---|---|
| | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | | $R_{Bonds}$-$R_{Stocks}$ | |
| | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. | Coeff | *T*-Stat. |
| Diagnostics | | | | | | | | |
| GED Parameter | **0.55535** | **<0.01** | **0.64531** | **<0.01** | **0.60317** | **<0.01** | **0.45807** | **<0.01** |
| Usable Observations | 5262 | | 5261 | | 5261 | | 2558 | |
| Log Likelihood | 41,833.03 | | 41,968.66 | | 41,126.19 | | 21,225.86 | |
| | Res. Bond eqn. | Res. Stock eqn. | Res. Bond eqn. | Res. Stock eqn. | Res. Bond eqn. | Res. Stock eqn. | Res. Bond eqn. | Res. Stock eqn. |
| Ljung-Box $Q(60)$ *p* value | 0.02 | 0.01 | 0.27 | 0.01 | 0.07 | 0.14 | 0.14 | 0.22 |
| McLeod-Li(60) *p* value | 0.06 | 0.12 | 0.31 | 0.79 | 0.47 | 0.04 | 0.55 | 0.06 |
| ARCH(4) Test *p* value | 0.07 | 0.11 | 0.33 | 0.79 | 0.55 | 0.04 | 0.63 | 0.06 |

with terrorist events in France. In a slightly different context and methodological approach, Drakos (2004) also showed that a flight-to-quality effect within stock markets and across sectors is possible as some sectors appear to be more terrorist-prone, that is, they are affected in a more pronounced way by terrorist incidents. In the case of Germany, indirect influences are found through the effects on the residuals of the bond market (see $\alpha_{11}$ $\alpha_{12}$). Terrorism lowers bond volatility and reduces the effect of a residual shock on the covariance between stock and bonds. Finally, for Spain, stock market uncertainty reduces the stock-bond covariance through the negative and significant cross term $\beta_{21}\beta_{22}$ in Equation 4. Nevertheless, terrorism does not seem to directly affect in any significant and statistically meaningful manner stock market volatility.

As far as the other coefficients in the variance equations are concerned, it can be observed that the bond markets present a higher volatility persistence compared to the stock markets in all the countries examined (compare the $\beta_{11}$ to the $\beta_{22}$ coefficients). Moreover, the $\alpha_{11}$ coefficients can in broad terms be characterized as being more uniform across the bond markets compared to the $\alpha_{22}$ coefficients in the stock markets. This implies that the impact of news on bond variability is quite similar across all four bond markets (see $\alpha_{11}$). In the case of the stock markets, the arrival of news seems to have similar effects on stock market variability in the Paris and Frankfurt markets ($\alpha_{22}$) and a different influence in the other two markets.

A further step in the analysis is to use the estimated mean, variance, and covariance equations to simulate the effects of a typical transnational or domestic terrorist attack.[7] Using impulse response analysis, we can simulate and quantify the possible effect of terrorism on the bond and stock markets. More specifically, apart from the direct effect of terrorist attacks on returns, volatility, and covariance, indirect effects stemming from volatility and covariance on mean returns can also be examined. An interesting finding is that the variance response estimates ($h_{11}$, $h_{12}$, $h_{22}$) inform the bounds on the mean responses in the bond and stock returns' reactions to changes in the TTer and NTer variables. Therefore, uncertainty shocks can provide useful information on bond and stock returns over terrorist events. Figures 1a and 1b show the impulse response functions for a one unit change in the log-scaled TTer and NTer variables.

Looking at the terrorist effects on the French markets, we observe a flight-to-quality/safety effect in the case of transnational attacks. In particular, the covariance between the two markets is affected in a negative and significant manner. Bond returns increase, while stock returns are significantly reduced. These effects last for almost 20 days. In the case of Germany, domestic attacks have a noticeable impact on stock market mean returns and their volatility. Transnational attacks seem to have a negative effect on stock returns, a positive effect on bond returns, and a common reaction as far as stock volatility is concerned. In the case of both transnational and domestic attacks, bond returns exhibit a small positive effect lasting for more than 20 days.

Turning to Britain (Figure 1b), a flight-to-quality response appears present in the case of transnational attacks. Bond returns increase while stock returns are reduced. The covariance between bond and stock returns decreases in both domestic and transnational attacks. However, in terms of magnitudes, these effects are, in comparative terms, substantially lower. Notably, through volatility and covariance, there are indirect effects on stock returns implied in the case of Britain. For Spain (Figure 1b), a movement from stocks to bond markets is evident

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[7] We thank Walter Enders for suggesting this step.

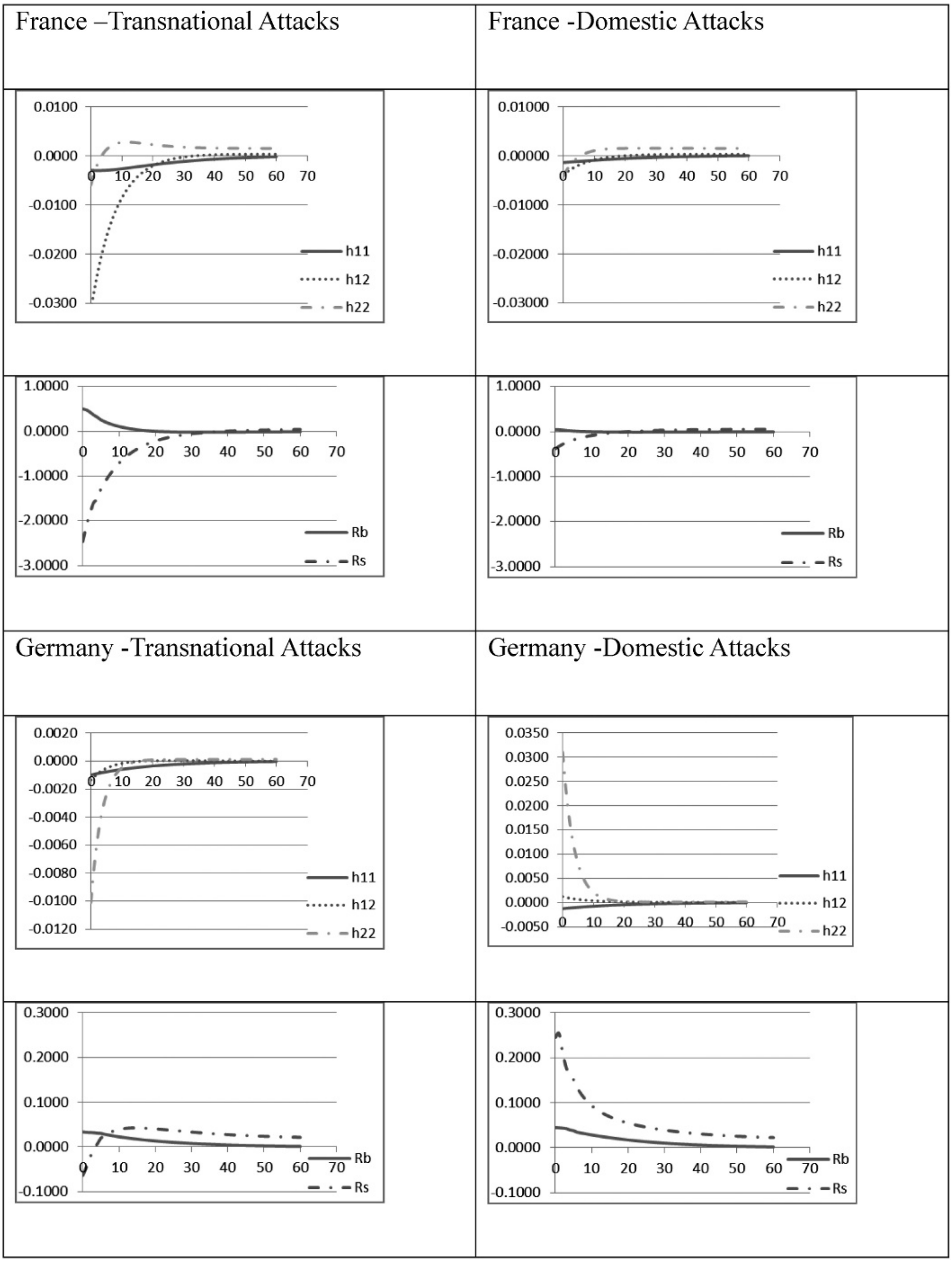


**Figure 1.** (a) Impulse responses of conditional variances, covariances, and returns to transnational versus domestic attacks in France and Germany

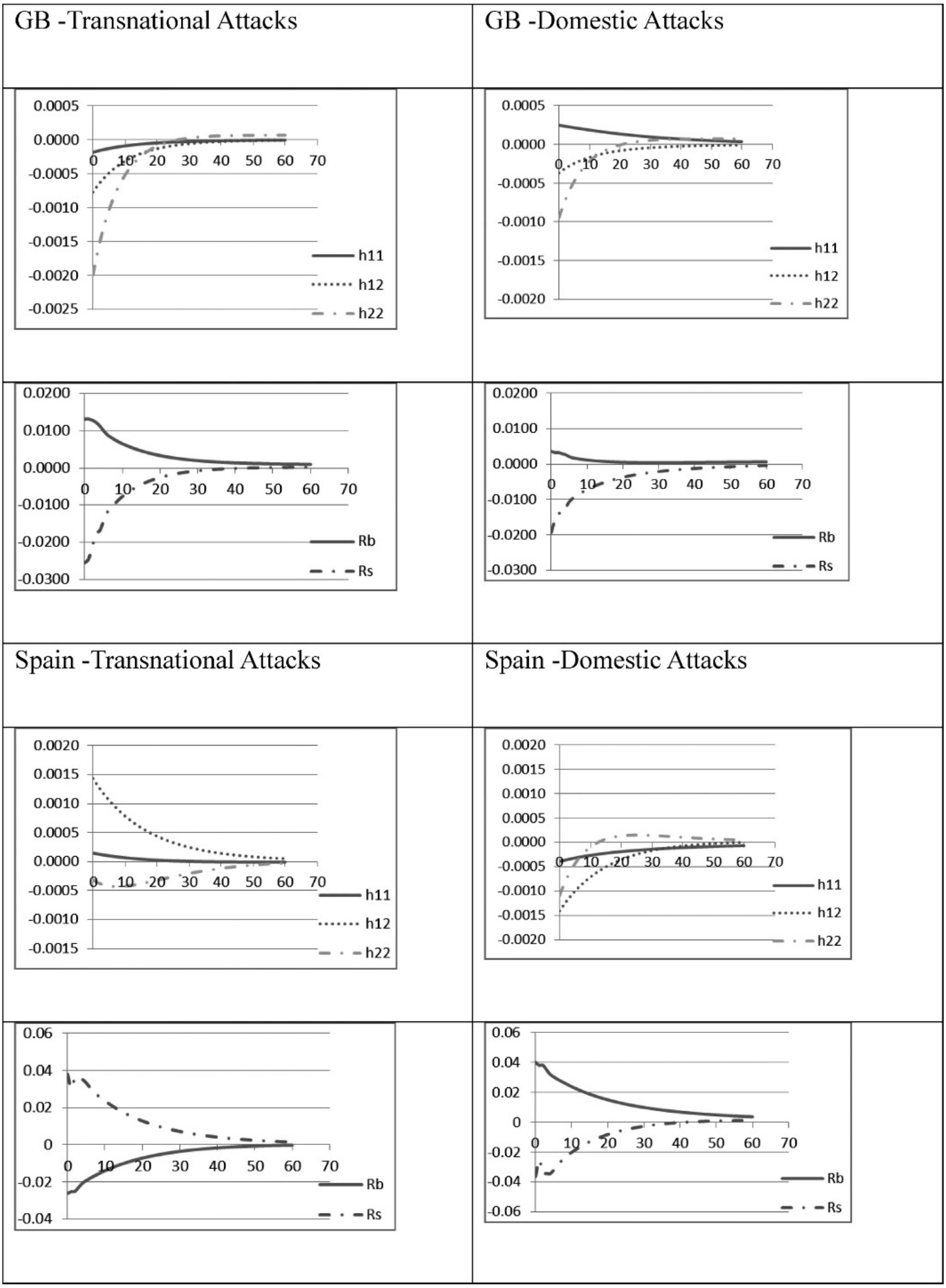


**Figure 1 continued.** (b) Impulse responses of conditional variances, covariances, and returns to transnational versus domestic attacks in Great Britain and Spain only in the case of domestic attacks. In particular, the covariance between the stock and bond markets is reduced for almost 20 days, and bond returns are affected positively, while stock returns are affected negatively by these attacks.

Finally, by looking at Figures 1a and 1b and comparing the effects of transnational versus domestic terrorism on bonds and stocks, we uncover interesting information. More specifically, bonds returns increase, while stock returns are reduced in Germany, France, and Great Britain. In these countries, bond variability is also reduced. This empirical evidence is more clearly present in the case of transnational vis-à-vis domestic attacks. Additionally, the reduction in covariance is higher in transnational attacks in the cases of France and Great Britain. The same applies for the cases of variances reductions in Germany and Great Britain. Hence, one may conclude that the transnational attacks seem to produce a more clear effect across markets and countries. The exception is Spain, where domestic attacks yield a reduction in the covariance among markets, suggesting a flight from the stock to the bond market.

## 4. Concluding Remarks

The effects of terrorism on the stock-bond covariance, their returns, and their variances are the focus of the article. This relationship can be influenced and determined not only by the usual cohort of economic factors but also by exogenous shocks, such as terrorist attacks. These attacks may trigger a flight-to-quality/safety reaction as they negatively affect sentiment and risk perceptions. Using VAR methodology and a multivariate GARCH-in-mean framework that allows the modelling of the variance with the covariance, we investigate this issue for Germany, France, Spain, and Great Britain. Unlike previous studies, we concentrate not on the reaction of a single market—stock or bond—to transnational or domestic terrorism but rather on how the relationship between these two markets is affected. If a broad generalization is attempted based on our findings, then we highlight a mild division between the four countries of the study. Compared to Spain and Great Britain, markets in France and Germany emerge as the countries more affected by terrorist incidents. Great Britain is the country where both financial markets are least affected, with only mild evidence of a flight-to-quality effect that is more traceable to transnational than to domestic attacks. A similar, but appreciably more pronounced, flight-to-quality reaction is also detected in France and Germany for transnational attacks. For Spain, such evidence is present only in the case of domestic terrorist events. This mild division between the four countries may stem from Britain and Spain being the victims of long-term systematic terrorist campaigns, mainly by domestic groups such as the provisional IRA and ETA, respectively. Since terrorism was, for many years, an embedded feature of the political scene, market agents and investors were presumably more accustomed to such incidents in these two countries. As such, their occurrence was discounted, thereby suggesting market efficiency when it comes to absorbing and incorporating exogenous shocks of relative regular occurrence. Indeed, of the two markets, the London one emerges as the more efficient in these terms, since it is the least rattled by terrorist episodes.

Another division uncovered in this study is the different impact between domestic and transnational terrorist attacks. Markets are more likely unsettled by the domestic terrorism, which reflects political problems, such as ethnic or minority divisions, economic-based frictions, and general unrest within countries. These, in turn, may generate political and/or government instability. On the other hand, transnational terrorism was invariably a spillover problem from issues and conflicts in other regions of the world. This was particularly true in our four sample countries and could explain why markets were found to be more sensitive to domestic terrorist incidents.

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