Terrorism and Stock Markets: An Empirical Study

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Focus of the Paper

To study empirically the effect of terrorist attacks on stock markets at global, regional, local and industry levels.

Why do we care about terrorism risk?

- Change in nature of terrorism risk
- Economic consequences: global and local
- Implications for financial markets
Motivation

Terrorism risk is a new area of research in finance field

- the nature of this extreme risk and its impact on financial markets have to be studied;
- ways to model this risk and new hedging instruments have to be developed.

Who is interested in the management of terrorism risk?

- Investors, insurance and reinsurance companies, banks, government agencies
Contributions

- empirical analysis of the impact of wide range of terrorism events on stock markets at different levels (global, European, local and industry)

- comparison of impact of terrorism events and the impact of other extreme events such as natural hazards and financial crashes

- construction of original database of terrorism events with financial component

- methodology: event-study, non-parametric methodology, filtered GARCH-EVT approach
What are the Key Findings?

- Around two thirds out of 77 considered terrorist attacks led to significant negative impact on at least one stock market under consideration.

- The Swiss market was affected by the highest number of attacks while the S&P500 by the lowest number.

- The insurance sector and airline industry exhibited the highest susceptibility to terrorism. The FTSE Global Banks was affected by the least number of attacks.

- The analysis of the post-event window response based on the 30-day cumulative abnormal returns show significant positive impact of terrorism events on the aero/defense and pharma/biotech sectors.
What are the Key Findings?

- The American stock market was affected by the lowest number of natural hazards, which is similar to the impact of terrorist attacks and in contrast to the effect of financial crashes.

- At the industry level, the insurance and airline industries showed high sensitivity to all three categories of extreme events. Similarly to terrorist attacks and in contrast to financial crashes, the banking industry experienced little negative impact of natural hazards.

- We did not find any evidence suggesting a significant positive impact of natural catastrophes on the pharmaceutical/biotechnology sectors as it was in the case of terrorist attacks.

- Similarly to terrorism events, the event-day negative returns associated with financial crashes had an extreme nature. The sensitivity of the stock markets to financial crashes was declining in the post event window. As to natural catastrophes, the negative impact was more often observed in the post-event period.
Empirical Analysis

- Research Questions
- Data
- Methodology
- Empirical Results
Research Questions

- Research Question 1: Do terrorist attacks have a significant negative impact on global, European, American and Swiss stock markets?

- Research Question 2: Do terrorist attacks have a significant negative effect on such industry indexes as insurance, travel/pleasure, airline?

- Research Question 3: Do terrorist attacks have a significant positive effect on such industry indexes as defense and pharmaceutical/biotechnology?

- Research Question 4: How strong is an event-day and post-event window reaction associated with terrorist attacks?

- Research Question 5: How does the impact of terrorist attacks compare to that of natural catastrophes and financial crashes?
Data

Time Period: 04/01/1994 - 31/08/2005

Daily prices:
  - Global, European, American and Swiss stock indexes
  - 9 industry indexes

77 terrorism events

Geographical coverage: 25 countries


19 natural catastrophes
Methodology

- Classical Event Study Approach
- Non-Parametric Conditional Distribution Approach
- Filtered GARCH-EVT Approach
Filtered GARCH with EVT Approach

- We assume the following dynamics of returns:

\[ X_t = \mu_t + \sigma_t Z_t, \]  \hspace{1cm} (1)

where \( X_t \) is a strictly stationary time series, innovations \( Z_t \) are white noise process and have a marginal distribution function \( F_Z(z) \).

- We chose AR(1) model for the dynamics of the conditional mean:

\[ \mu_t = \varphi X_{t-1} \]  \hspace{1cm} (2)

and GARCH(1,1) process for the conditional volatility:

\[ \sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2, \]  \hspace{1cm} (3)

where \( \alpha_0 > 0, \alpha_1 > 0 \) and \( \beta > 0 \), \( \varepsilon_t = X_t - \mu_t \) and \( \alpha_1 + \beta < 1 \).
Filtered GARCH with EVT Approach

- This model allows to obtain filtered residuals

\[
(z_{t-n+1}, \ldots, z_t) = \left(\frac{x_{t-n+1} - \hat{\mu}_{t-n+1}}{\hat{\sigma}_{t-n+1}}, \ldots, \frac{x_t - \hat{\mu}_t}{\hat{\sigma}_t}\right)
\]  

that are approximately iid, which is an important requirement for the EVT approach applied next.

- EVT: The Peak-Over-Threshold Method

  - The Generalized Pareto distribution \( \Rightarrow \) the quantile estimate \( \hat{z}_q \) for \( q > 1 - k/n \) is

\[
\hat{z}_q = z_{k+1} + \frac{\beta_k}{\xi_k} \left( \left( \frac{1 - q}{k/n} \right)^{-\xi_k} - 1 \right)
\]  

- VaR Estimate:

\[
\widehat{VaR}_q^t = \hat{\mu}_{t+1} + \hat{\sigma}_{t+1}\hat{z}_q.
\]  

- Backtesting (McNeil and Frey, 2000)
Filtered GARCH with EVT Approach

Example: the impact of the bombing in Peru (20.03.2002) on the FTSE All World stock index

- the quality of the fit of AR(1)-GARCH(1,1) model
- the quality of the fit of EVT model
- VaR computations
- backtesting

Event Day Return: \(-0.0131**\)

Estimates of VaR: \(VaR_{0.01} = -0.0152, \ VaR_{0.05} = -0.0109, \ VaR_{0.10} = -0.0085\)

\(\Rightarrow\) there is a negative impact of the bombing in Peru on the global index (event-day impact)
Figure 1: EVT conditional quantile estimates $\hat{x}_{0.99}$ superimposed on the negative log returns, $n=500$
Filtered GARCH with EVT Approach

Two indexes: the S&P500 and the FTSE All World Non-Life Insurance:

- 22 attacks (19 in the event-study and 23 in the non-parametric approach) led to the significant negative impact on the S&P500. 16 attacks caused negative event-day returns that are less than the $VaR_{1\%}$ and $VaR_{5\%}$.

- 21 attacks (23 in the event-study and 24 in the non-parametric approach) caused a significant negative impact on the FTSE All World Non-Life Insurance. 15 attacks have caused negative event-day returns that are less than the $VaR_{1\%}$ and $VaR_{5\%}$. 
### Different Methods

<table>
<thead>
<tr>
<th>Event Day</th>
<th>Extreme Event</th>
<th>Filtered GARCH-EVT</th>
<th>S&amp;P500</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Event-Day Return</td>
<td>( VAR_{0.01} )</td>
<td>( VAR_{0.05} )</td>
</tr>
<tr>
<td>19.05.2003</td>
<td>Suicide Bombing in Israel</td>
<td>-0.0252***</td>
<td>-0.0222</td>
</tr>
<tr>
<td>05.08.2003</td>
<td>Bombing in Indonesia</td>
<td>-0.0178**</td>
<td>-0.0205</td>
</tr>
<tr>
<td>11.03.2004</td>
<td>Bombing in Madrid</td>
<td>-0.0153**</td>
<td>-0.0183</td>
</tr>
<tr>
<td>09.05.2004</td>
<td>Bombing in Russia</td>
<td>-0.0106</td>
<td>-0.0204</td>
</tr>
<tr>
<td>22.09.2004</td>
<td>Armed Assault in India</td>
<td>-0.0140**</td>
<td>-0.0146</td>
</tr>
<tr>
<td>07.10.2004</td>
<td>Bombing in Egypt</td>
<td>-0.0100*</td>
<td>-0.0162</td>
</tr>
<tr>
<td>15.04.2005</td>
<td>Armed Assault in Colombia</td>
<td>-0.0169**</td>
<td>-0.0175</td>
</tr>
<tr>
<td>23.06.2005</td>
<td>Failed Attack in Australia</td>
<td>-0.0109***</td>
<td>-0.0101</td>
</tr>
<tr>
<td>29.07.2005</td>
<td>Bombing in Spain</td>
<td>-0.0077</td>
<td>-0.0122</td>
</tr>
<tr>
<td>27.10.1997</td>
<td>Mini-crash due to Asian crisis</td>
<td>-0.0711***</td>
<td>-0.0220</td>
</tr>
<tr>
<td>31.08.1998</td>
<td>Russian financial crisis</td>
<td>-0.0704***</td>
<td>-0.0346</td>
</tr>
</tbody>
</table>
Empirical Results

- Research Question 1: Do terrorist attacks have a significant negative impact on global, European, American and Swiss stock markets?

- The obtained results show significant negative impact of terrorism events on the above mentioned markets.

- 55 out of 77 terrorist attacks (56 in the non-parametric case) had a significant negative impact on the behavior of at least one of these markets.

- The Swiss market was affected by the highest number of attacks while the American market was affected by the lowest number of events.
Empirical Results

- Research Question 2: Do terrorist attacks have a significant negative effect on such industry indexes as insurance, travel/pleasure, airline, banking and financials?

- The empirical evidence suggests a significant negative impact of terrorism events on the above mentioned industries. 61 terrorist attacks (55 in the non-parametric case) led to significant negative return movements in at least one industry index.

- Insurance sector exhibited the highest susceptibility to terrorism (the MSCI Europe Insurance was affected by the highest number of attacks).

- The FTSE Global Banks was affected by the lowest number of attacks.

- The MSCI Europe Airlines demonstrated high susceptibility to terrorism events.
Empirical Results

- Research Question 3: Do terrorist attacks have a significant positive effect on such industry indexes as defense and pharmaceutical/biotechnology?

- The analysis of the event-day reaction and of the post-event window response based on the 6-day cumulative abnormal returns (CARs) did not shown any significant positive impact of terrorism events on the above mentioned industries.

- However, when the post-event impact is examined for a longer time window, we found a significant positive response of these markets to terrorist attacks.
Empirical Results

- Research Question 4: How strong is an event-day and post-event window reaction associated with terrorist attacks?

- The event-day return movements had an extreme nature: abnormal returns are significant at 0.01 and 0.05 levels (in the non-parametric case, the cumulative probabilities are in the interval [0.00; 0.05]).

- However, while the even-study suggests extreme character of CARs, the non-parametric methodology indicates that the strength of the impact was declining in the post-event period.
Empirical Results

- Research Question 5: How does the impact of terrorist attacks compare to that of natural catastrophes and financial crashes?

- Similarly to terrorist attacks, natural hazards and financial crashes had a negative impact on global, European, American and Swiss stock markets.

- While the European and Swiss markets showed high susceptibility to terrorist attacks and natural catastrophes, these markets demonstrated less of a negative impact associated with financial crashes.

- The American stock market was affected by the lowest number of natural hazards, which is similar to the impact of terrorist attacks and in contrast to the effect of financial crashes.
Empirical Results

- At the industry level, the insurance and airline industries showed high sensitivity to all three categories of extreme events.

- Similarly to terrorist attacks and in contrast to financial crashes, the banking industry experienced little negative impact of natural hazards.

- We did not find any evidence suggesting a significant positive impact of natural catastrophes on the pharmaceutical/biotechnology sectors as was in the case with terrorist attacks.

- The event-day reaction of stock markets to natural catastrophes can be characterized by both extreme or abnormal negative return movements.

- As to the post-event reaction, the CARs have been more often extreme than abnormal. Similarly to terrorism events, the event-day negative returns associated with financial crashes had an extreme nature. The sensitivity of the stock markets to financial crashes was declining in the post event window.
Conclusions

- This study reveals results in regard to global, regional, country and industry effects of terrorism events on stock markets. Also, it compares the impact of these events on the stock markets with the effect of natural catastrophes and financial crashes.

- Terrorism events do have a negative impact on stock markets. Insurance, travel/tourism, airlines, financials sectors are those that are particularly sensitive to terrorism events.

- For some industry stock markets, such as aero/defense and pharam/biotech, the impact of terrorist attacks are found to be positive (new business opportunities).

- There are both similarities and differences between the impact of terrorism on stock markets considered and the effect of natural catastrophes and financial crashes.
Work in progress and Future Research

- Filtered GARCH-EVT Approach
- Modelling of terrorism risk