# Catastrophe Bonds. From Structure to Strategy – A Cluster Analysis at European Level

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**ABSTRACT**

*As a core activity and discipline of corporate management and corporate governance, risk management is, especially nowadays, a central part in pursuing the sustainable development desiderates, both from the perspective of the firm and of the society as a whole. Considering the negative impact natural catastrophes have on the companies' and countries' competitiveness, the development of sustainable financial products that make a contribution to transferring the risk and allocating the capital in case of disasters stands for a continual preoccupation, especially for the (re)insurance industry, while the study of catastrophe bonds – insurance-linked securities – is of interest in the specialized literature. In this context, the scope of the present research is to expand the empirical studies within this field while examining the link between the structure of the catastrophe bonds and the risk management approach employed while accessing the capital markets through this transactions. The methodology entailed clustering a selection of transactions developed by European cedents based on the size of each issue and correlating the results with an innovative score, developed to encompass several important catastrophe bonds structural components. The findings reflect that the general structural elements of the financial transactions reflect closely the corporate approach regarding the innovative risk intermediation instruments for the examined catastrophe bonds deals. The outcomes also emphasize, as expected, that companies with a stronger presence on this market seem to have a more sophisticated risk management approach.*

**KEYWORDS:** *catastrophe (cat) bond, cluster analysis, risk management, sustainable development*

**JEL CLASSIFICATION:** *C38, G32, G22, Q1*

## 1. INTRODUCTION

### 1.1. Research premises

Sustainable development and catastrophe risk management practices stand, nowadays, for interrelated concepts that, from an economic and environmental perspective, are more and more associated to corporate competitiveness, as well as to the general welfare of the society.

Considering the social and economic implications natural disaster have on the E.U. member states, the financing of the natural catastrophes stand for one of the major concerns at E.U. level, as also reflected by the most recent initiatives regarding the insurance of natural and

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man-made disasters (EC, 2013a; Maccaferri et al., 2012), as well as by those connected to the adaptation to climate change (EC, 2013b).

From a managerial perspective, the natural hazard risks, among which we can identify natural disasters risks, are one of the essential preoccupations in business continuity planning at operational level. (Hopkin, 2010, 39). For the specific case of (re)insurance companies they stand for the core concerns regarding the profitability of the organization, especially in a more and more competitive market considering the ongoing changes within this industry (e.g. the lowering of the entry barriers) (Adena et al., 2009, 21).

Within this context, the development of sound and sustainable financial instruments addressing the natural disasters is one of the solutions the (re)insurance industry advanced in order to tackle the economic effects this ones have on corporate economic performance. This is the case of the catastrophe bonds – alternative risk transfer tools defined as "a fully collateralized instrument that pays off on the occurrence of a defined catastrophic event" (Cummins, 2008, 23-24) that were developed in order to address the excessive losses suffered by the (re)insurance industry after mega-catastrophes (Cummins et al., 2002, 558-559).

### 1.2. Literature review – selective studies

From a managerial perspective, the innovative financial products examined within this research relate, at a first glance, to two key corporate areas: on the one hand, as hedging instruments, they are a part of the broad risk management and corporate governance sphere and, on the other hand, as tools addressing the economic dimension of natural catastrophes, they are mentioned as pertaining to the corporate social responsibility preoccupations of the (re)insurance companies.

In line with the first mentioned area, as a risk management instrument, the objective of the present paper is to examine the market of catastrophe bonds issued by European based cedents from the perspective of the risk management strategy adopted while developing the catastrophe bonds transactions by using a set of deals that publicly reveal their main characteristics. In this sense, the research will focus on several structural features of these deals in order to reveal the link structure-risk management approach.

In terms of ***the structural aspects*** related to cat bonds, the specialized literature focuses generally on two aspects:

(1) Detailing the mechanism an the participants involved within the securitization process: the ceding company – generally an insurance or an reinsurance company, the special purpose vehicle through which the cat bonds are issued, the investors, the rating agencies and other parties (Mocklow et. al., 2002, 48-50; Cummins & Weiss, 2009, 522-524; Nguyen & Lindenmeier, 2014, 82-83).

(2) Examining and/or describing the various features of the structure, among which we mention those relevant for the current research: the tenor, the trigger mechanism, the covered perils and the geographical zones. (Mocklow et. al., 2002, 50-58; Cummins, 2008, 26-28).

With respect to the tenor of the cat bonds, the studies generally emphasize the evolution of the established term and the advantages regarding the spanning of these deals over a multi-year period (3-4 years) as a reflection of the strategic choice of securing the price, while

also not incurring the fixed costs associated to annual issues (Cummins, 2008, 26; Krutov, 2010, 35).

Regarding the trigger mechanism, the literature focuses on stressing the main features with respect to the main five types (parametric – pure or index, modelled loss, industry loss – pure or modelled, indemnity and hybrid), while also describing their advantages and disadvantages in terms of basis risk, transparency and moral hazard (Mocklow et. al., 2002, 50-54; Cummins, 2008, 27-28; Hagedorn et al., 2009, 46-47; Krutov, 2010, 34).

In terms of the perils and locations, the studies notice the evolution towards covering multiple natural disasters from various geographical zones as a reflection of the diversification desiderate. (Krutov, 2010, 35)

Regarding ***the risk management*** aspects, the literature encompasses a series of studies that focus on the main advantages associated to sharing the natural disaster risk while accessing the capital markets through catastrophe bonds, of which we mention:

(1) Additional capacity for the (re)insurance companies in managing the insurance-linked risks and, consequently, more capital for pursuing other corporate strategic investment objectives while considering a more efficient capital allocation (Adena et al., 2009, 22-23; Krutov, 2010, 24). In addition, they offer the opportunity to transfer rather non-peak risks in Europe and Asia (Besson, 2009, 36).

(2) Providing coverage over a multi-year period (Adena et al., 2009, 23; Besson, 2009, 36).

(3) Decreasing the credit risk as a consequence of their structural feature regarding the fully collateralization, a major advantage especially in times of great losses on the (re)insurance markets (Adena, 2009, 23; Krutov, 2010, 24).

Considering the overall size/volume of the catastrophe bonds transactions developed during 2007, McGhee et al. (2008, 13-14) notice a change from regarding the capital markets as a merely tactical solution (used as a protective measure in times of traditional capital shortage) to a strategic measure (as a reflection of repositioning the business model by using alternative capital sources to face the growing risk from natural disasters and the insured losses).

### 1.3. Research objectives and hypothesis

Considering the current state of the research, in terms of advancing the knowledge within the alternative risk transfer instruments, the present analysis will approach the following aspects:

(a) Analyzing the cat bonds market from a unitary perspective by focusing on European companies (mainly reinsurance companies).

(b) Examining the link structure-risk management approach (tactical vs. strategic) by developing an innovative score containing several important catastrophe bonds' structural components while also employing cluster analysis in order to expand the applicative researches within this field.

(c) Focusing on the tactical/strategic approach at the level of individual transactions.

In detail, the research objective is to examine whether there is a link between the risk management approach (tactical or strategic) and the structure of the cat bonds transactions developed by European sponsors present on this market. The three hypotheses investigated through this research are as follows:

H1. There is a link between the risk management approach regarding the catastrophe bonds and the structure of the transactions.

H2. The approaches are rather homogeneous at the level of the analysed sample (the strategic approach being adopted mostly by larger sponsors, while the tactical one by smaller sponsors).

H3: The strategic approach is represented through transactions developed during and after 2007, considered a crucial year for the CAT bond market (see Bouriaux & MacMinn, 2009, 11, citing McGhee et al., 2008, 13).

## 2. ANALYSIS OF THE CAT BOND ISSUANCE STRATEGIES OF THE EUROPEAN COMPANIES

### 2.1. Data and research methodology

The research is developed on three levels: (1) the applied examination of the catastrophe bonds issued by E.U. based companies, especially from the reinsurance sector, (2) the emphasising of a series of structural aspects at the level of the selected cat bonds transactions sample and (3) the highlighting of several risk management strategies, developed on cat bonds issuance at European level.

The analysis stands in discriminating between similar groups of cat bonds transactions settled mainly by (re)insurance groups based on the E.U. market based on the volume of each issue as a reflection of the companies' inclination of including the cat bonds in their global risk management strategy, while determining a pattern of the risk management approaches through developing an innovative structure-related score, based on the most important features of these financial instruments. The analyses within this research were developed by employing the SPSS software package.

#### *2.1.1. Sample selection*

The initial analysed sample consisted in 80 cat bonds transactions (considered at the level of each class) developed during the 1999-2014 period by European based firms, mainly the most important insurance companies and reinsurance groups (Munich Re, SCOR, AXA, Allianz, Hannover Re, Assicurazioni Generali, Groupama, Brit Insurance, Achmea, Sorema, AGF), as well as other companies that are present on the cat bond market, like Electricite de France.

In order to substantiate the analysis, while also accounting for the specificity each class brings to the overall sample, the cat bond transactions are considered either as volume consolidated transactions when the various classes have similar characteristics, either as separate transactions when they have different structural features (e.g. the covered perils). In addition, as generally required, there were eliminated from the analysis the transactions identified as unusual/outliers in terms of volume. Therefore, the overall sample comprises 60 cat bonds transactions. The data was collected from a well-known alternative risk transfer solutions blog – www.artemis.bm, while also corroborating the information with the annual reports regarding the insurance-linked securities or the cat bonds market issued by prestigious companies like Aon Benfield, Guy Carpenter & Company, Lane Financial, Munich Re (Münchener Rückversicherungs-Gesellschaft) or Swiss Re.

### *2.1.2. Cat bonds structure and risk management strategy proxies*

Firstly, the research involved forming statistically homogenous groups in terms of the issuance volume as a proxy of companies' propensity to use cat bonds as risk transfer instruments incorporated in their general risk management approach (Bouriaux & MacMinn, 2009, 11; McGhee et al., 2008, 13).

In Table 1 there are displayed the descriptive statistics (mean, standard deviations, skewness and kurtosis) for the volume variable that will be used within the clustering procedures employed within the research. The skewness value reflects a slight asymmetry, while the kurtosis coefficient is negative. As one can notice, when applying the general rule of thumb of assessing the normality condition, both the skewness and kurtosis have absolute values lower than three times the values of theirs standard errors. Therefore, it seems that the volume variable comes from a normal distribution.

**Table 1. Volume – descriptive statistics**

| | **Statistic** | **Standard Error** |
|---|---|---|
| Mean | 142.787 | 10.422 |
| Std. Deviation | 80.732 | |
| Minimum | 10.000 | |
| Maximum | 300.000 | |
| Skewness | 0.218 | 0.309 |
| Kurtosis | -0.928 | 0.608 |

*Source:* author's contribution (developed in SPSS IBM)

**Table 2. Volume – tests of normality**

| | **Kolmogorov-Smirnov[a]** | | | **Shapiro-Wilk** | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Volume | .085 | 60 | .200* | .962 | 60 | .062 |
| *. This is a lower bound of the true significance. | | | | | | |
| a. Lilliefors Significance Correction | | | | | | |

*Source:* author's contribution (developed in SPSS IBM)

In order to strengthen this conclusion, there was also performed both the Kolmogorov-Smirnovand the Shapiro-Wilk tests of normality (see Table 2). As the probability is higher than 0.05 for both of them (0.2 and, respectively, 0.062) and the tests are not statistically significant, we conclude that the volume variable is approximately normally distributed (Gamst et al., 2008, 67-68).

Secondly, the analysis consisted in developing, for each cat bond transaction, an innovative structure-based score – the CatBondStrat Score – on three structural characteristics (tenor, peril and, trigger). From the perspective of this research, the score's components reflect three main risk management strategic aspects in relation with the cat bond market, as follows:

(a) the commitment of the companies towards using the cat bond market on a rather longer term – *the tenor*. The scores attributed to this component are integers from 1 to 5 corresponding to the maturity of the bonds included within the analysis. Within the analysis, the scores higher than 1 will stand for a stronger attachment towards using innovative risk transfer mechanism (considering that from the tenor perspective a maturity lower than 1 could be assimilated to that of a traditional insurance contract). In addition, through applying longer maturities, there is also reflected the strategic choice of securing the spread (McGhee et al., 2008, 25). Taking into account that in our sample there are not transactions with tenors longer than 5 years – considered within the specialized literature as "not favoured by the market" due to the re-pricing risk inconvenient (Cummins, 2008, 34) we do not apply a maturity penalty.

(b) the diversification and broadening of the risks portfolio managed through innovative risk transfer instruments – *the covered geographic areas and perils*. In order to account for the sophistication of the portfolio of the chosen perils to be transferred to the capital markets, there were considered four categories each receiving a corresponding score (1-4), as follows:

- single peril/geographic area – peak peril – 1 (reflecting the focus only on the US area and only on earthquakes or hurricanes);
- single-non peak – 2 (indicating the centring on a single peril/geographic area, but on non-peak catastrophes, generally European storms in our sample);
- multiple-peak & multiple-only non-peak – 3 (representing the inclusion of multiple geographical areas or perils with only peak perils – e.g. both U.S. hurricane and U.S. earthquake or multiple geographical areas or perils with only non-peak perils – e.g. European windstorm, Japanese earthquake);
- multiple-at least one peak – 4 (reflecting the concentration on multiple geographical areas or perils and at least one non-peak risk).

(c) the sponsor companies' strategic choice towards more transparent trigger mechanisms as a form of rise the investors' appetite towards these assets, especially during periods of time when their risk profile is more difficult to evaluate (e.g. turbulent time on the financial markets) – *the trigger mechanism.*

Following well-known taxonomies within the specialized literature, there were considered the following 6 trigger classes and their corresponding scores: indemnity – 1, hybrid – 2, industry loss index – 3, modelled loss – 4, parametric index – 5, pure parametric – 6.

In table 3 there are displayed the descriptive statistics from the perspective of the CatBondStrat Score. It is impressive that at the level of this sample the highest score is of 13 out of 15, while the majority of the transactions (65%) lay in the middle range (8-10), considering the 5-13 sample's scores spectrum. Additionally, considering the span 5-13, and the scores of over 8 of pertaining to the higher range, approximately 75% of the analysed transactions lay within this segment.

**Table 3.CatBondStrat Score– descriptive statistics – frequency analysis**

| Variable | | Frequency | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| **CatBondStrat Score** | 5 | 3.00 | 5.00 | 5.00 |
| | 6 | 3.00 | 5.00 | 10.00 |
| | 7 | 2.00 | 3.33 | 13.33 |
| | 8 | 7.00 | 11.67 | 25.00 |
| | 9 | 13.00 | 21.67 | 46.67 |
| | 10 | 19.00 | 31.67 | 78.33 |
| | 11 | 5.00 | 8.33 | 86.67 |
| | 12 | 6.00 | 10.00 | 96.67 |
| | 13 | 2.00 | 3.33 | 100.00 |
| | Total | 60 | 100.0 | |

*Source:* author's contribution (developed in SPSS IBM)

### *2.1.3. Cluster analysis*

For the purpose of identifying cat bonds groups that are homogeneous within themselves while also heterogeneous between each other based on the volume of each transactions, there were employed several cluster analyses and their respective methods (Lloyd, 1982; MacQueen, 1967; Steinhaus, 1957; Everitt, Landau, & Leese, 2001; Ward, 1963; Gamst et al., 2008; Mooi & Sarstedt, 2011).

In order to assess the link between the volume and the CatBondStart Score as a confirmation of the strategic purpose of using the cat bonds market, at the level of each identified cluster there was assessed the statistical dependence, while employing parametric, as well as nonparametric measures of association (Pearson correlation coefficient, respectively Kendall's tau and Spearman's rho coefficients). In addition, the examination of this link involved the comparison, between clusters, of the CatBondStart Score in terms of the frequency of the values, as well as from the point of view of the main central tendency indicators (average and mode).

Therefore, in order to determine the optimal number of clusters based on the volume variable, there was employed a hierarchical cluster analysis while considering as amalgamation rule the Ward's method and as distance measure Block (city block, Manhattan), as they are specified within the SPSS software package. The data was standardized, having a standard deviation of 1.

The research was complemented by developing a partitioning method, mainly the k-means cluster analysis, while using as number of groups the one determined through the hierarchical grouping methodology. In order to check for the appropriateness of grouping the transactions, there were employed several tests and analysis (the test of homogeneity of variances and one-way ANOVA).

**2.2. Results and discussion of findings**

After running the hierarchical cluster analysis, there were examined the linkage points within the hierarchical tree diagram (displayed in Figure 1) in order to identify the suitable number of clusters formed based on the volume variable.

As can be noticed, the appropriate number of clusters seems to be two. To further confirm this assumption, the investigation was complemented by analysing the agglomeration schedule and the scree plot of the coefficients' changes. Following this result, the k-means clustering analysis was performed considering two clusters. The first step was to investigate the clusters' centres with respect to the volume (see Table 4). The analysis confirmed that in terms of the cat bonds volume there is a cluster that comprises transaction with lower volume (Cluster 1 – reflecting a more tactical approach) and a cluster including cat bonds transactions with higher volume (Cluster 2 – reflecting a more strategic approach).

The picture of the volume clusters reveals that the majority of the transactions are within the lower volume cluster (39 out of 60) considering our sample (Table 5). As expected, in the second cluster we identify a lower number of transactions with higher volume – suggesting the strategic approach, while in the first cluster a large number of transactions with lower volume – suggesting the tactical approach.

Furthermore, as expected, the majority of the transactions in the second cluster (except for one from SCOR and one from EDF) were developed after 2007, a year considered to be of major importance in confirming the crisis resilience and the consolidation of the cat bond market.

In addition, almost all sponsors are found with transactions in both clusters, except for two cases: (1) when the sponsor is a rather major player within the reinsurance industry and enters the market for the first time, after 2006, it can be found in the higher volume cluster and (2) when the sponsor is a rather smaller reinsurance company or entered only circumstantially (before 2007) it can be identified in the lower volume cluster.

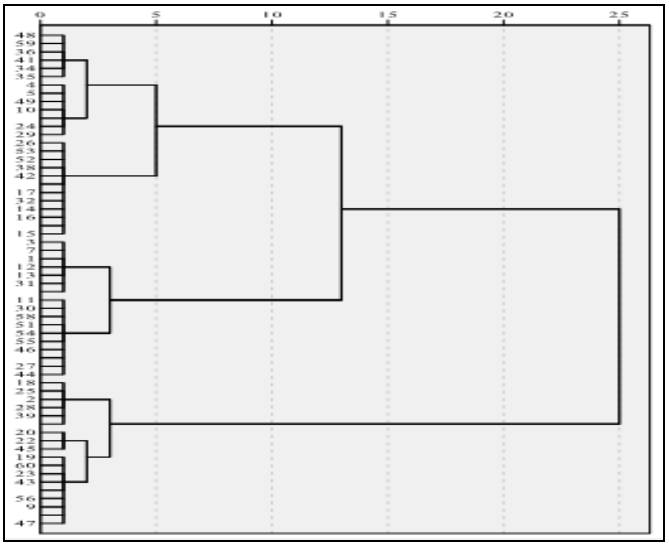


**Figure 1. Dendogram – based on volume**
*Source:* author's contribution (developed in SPSS IBM)

**Table 4. Cluster centres – based on volume**

| | | |
|---|---|---|
| Cluster | 1 | 93.5186 |
| | 2 | 234.2857 |

*Source:* author's contribution (developed in SPSS IBM)

**Table 5. Volume based clusters**

| Cat Bonds included in: **Cluster 1 – Lower volume** | Cat Bonds included in: **Cluster 2 – Higher volume** |
|---|---|
| ✓ Halyard Re I-Sorema-1999 | ✓ Atlas Re Class A&B&C-SCOR-2000 |
| ✓ Halyard Re 2000-Sorema-2000 | ✓ Pylon Class A&B-Electricite de France-2003 |
| ✓ Mediterranean Re Class A&B-AGF-2000 | ✓ Fremantle - A&B&C-Brit Insurance-2007 |
| ✓ PRIME Capital CalQuake & Euro Wind-Munich Re-2001 | ✓ Midori-Munich Re-2007 |
| ✓ PRIME Capital Hurricane-Munich Re-2001 | ✓ Blue Fin A&B-Allianz -2007 |
| ✓ Halyard Re II -Sorema -2001 | ✓ Atlas Re IV-SCOR Global -2007 |
| ✓ Atlas Re II Class A&B-SCOR-2001 | ✓ Green Valley-Groupama-2007 |
| ✓ Aiolos Limited-Munich Re-2005 | ✓ Queen Street - A&B-Munich Re-2008 |
| ✓ Carillon Ltd Class A – I-Munich Re-2006 | ✓ Atlas V Ltd. Series 1&2&3-SCOR Global -2009 |
| ✓ Carillon Ltd Class B-Munich Re-2006 | ✓ Blue Fin II Ltd.-Allianz -2009 |
| ✓ Carillon Ltd Class A – II-Munich Re-2006 | ✓ Eurus II Ltd.-Hannover Re-2009 |
| ✓ Eurus Ltd.-Hannover Re-2006 | ✓ Pylon II Capital Ltd. - Class A&B-EDF (via Natixis)-2011 |
| ✓ Atlas Re III-SCOR-2006 | ✓ Calypso Capital Ltd. (Series 2011-1)-AXA Global-2011 |
| ✓ Blue Wings-Allianz -2007 | ✓ Atlas VI Capital Ltd. (Series 2011-1) - Class A&B-SCOR Global-2011 |
| ✓ Carillon Ltd. - Class E - II-Munich Re-2007 | ✓ Kibou Ltd. (Series 2012-1)-Hannover Re for Zenkyoren-2012 |
| ✓ Blue Coast - Class A&B&C-Allianz -2008 | ✓ Blue Danube Ltd. (Series 2012-1) - Class A&B-Allianz -2012 |
| ✓ Ianus Capital Ltd.-Munich Re-2009 | ✓ Atlas Reinsurance VII Limited - Class B-SCOR Global-2012 |
| ✓ Atlas VI Capital Ltd. (Series 2009-1)-SCOR Global -2009 | ✓ Blue Danube II Ltd. (Series 2013-1)-Allianz -2013 |
| ✓ Eos Wind Ltd. Class A-Munich Re-2010 | ✓ Calypso Capital II Ltd. |
| ✓ Eos Wind Ltd. Class B-Munich Re-2010 | |
| ✓ Blue Fin Ltd. Series 3 Class A&B-Allianz -2010 | |
| ✓ Green Valley Ltd. Class A Series 2-Groupama -2010 | |
| ✓ Atlas VI Capital Ltd.Series 2010-1-SCOR Global-2010 | |
| ✓ Green Fields Capital Ltd. Series 2011-1 Class A-Groupama-2010 | |
| ✓ Queen Street II Capital Ltd.-Munich Re-2011 | |
| ✓ Blue Fin Ltd. Series 4 Class B-Allianz -2011 | |
| ✓ Queen Street III Capital Ltd.-Munich Re-2011 | |
| ✓ Queen Street IV Capital Ltd.-Munich Re-2011 | |
| ✓ Tramline Re Ltd. (Series 2011-1)-Amlin AG-2011 | |
| ✓ Atlas VI Capital Ltd. (Series 2011-2) - Class A-SCOR Global-2011 | |
| ✓ Queen Street V Re Ltd.-Munich Re-2012 | |
| ✓ Queen Street VI Re Ltd.-Munich Re-2012 | |
| ✓ Eurus III Ltd.-Hannover Re-2012 | |

| Cat Bonds included in: **Cluster 1 – Lower volume** | Cat Bonds included in: **Cluster 2 – Higher volume** |
|---|---|
| ✓ Queen Street VII Re Ltd.-Munich Re-2012<br>✓ Atlas Reinsurance VII Limited - Class A-SCOR Global-2012<br>✓ Tramline Re II Ltd. (Series 2013-1)-Amlin AG-2013<br>✓ Queen Street VIII Re Ltd.-Munich Re-2013<br>✓ Windmill I Re Ltd. (Series 2013-1)-Achmea-2013<br>✓ Queen Street IX Re Ltd.-Munich Re-2014 | (Series 2013-1) - Class A-AXA Global-2013<br>✓ Calypso Capital II Ltd. (Series 2013-1) - Class B-AXA Global-2013<br>✓ Lion I Re Ltd.-Assicurazioni Generali-2014 |
| Note: The names of the cat bond transactions are formed as follows: the name of the transaction/SPV, the name of the cedent/sponsor company and the issuance year | |

*Source:* author's contribution (developed in SPSS IBM)

As far as the diagnostic analysis is concerned, there was performed a One-Way ANOVA analysis in order to investigate whether the two volume based clusters are statistically different. Therefore, firstly, the homogeneity of variances was verified by employing the Levene test statistics. As one can observe in Table 6, the hypothesis of equal variance is not violated (Sig.>0.05).

Following Gamst, Meyers, & Guarino (2008, 101) the null hypothesis regarding the equality in variances of the two clusters cannot be rejected and, consequently, the ANOVA investigation within the One-Way ANOVA was developed. As is displayed in Table 7, the means of the two clusters seem to be significantly dissimilar, as for the Fisher F test the Sig. is lower than 0.05.

**Table 6. Diagnostic analysis – test of homogeneity of variances**

| Levene Statistic | df1 | df2 | Significance |
|---|---|---|---|
| 1.631 | 1 | 58 | 0.207 |

*Source:* author's contribution (developed in SPSS IBM)

**Table 7. Diagnostic analysis – one way ANOVA**

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 270479.800 | 1 | 270479.800 | 137.537 | 0.000 |
| Within Groups | 114062.224 | 58 | 1966.590 | | |
| Total | 384542.023 | 59 | | | |

*Source:* author's contribution (developed in SPSS IBM)

In order to account for the relation volume-CatBondStrat Score at the level of each identified cluster, the statistical dependence coefficients displayed in Table 8 revealed, as expected, that there is a positive association between the two indicators, however this is statistically significant only for the first cluster.

**Table 8. Correlation coefficients**

| **Coefficient** | | **Cluster 1 – Lower volume** | | **Cluster 2 – Higher volume** | |
|---|---|---|---|---|---|
| | | *Volume* | *CatBondStrat Score* | *Volume* | *CatBondStrat Score* |
| *Pearson Correlation* | *Volume* | 1 | **0.595**** | 1 | 0.252 |
| | *Sig. (2-tailed)* | | 0.000 | | 0.270 |
| *Kendall's tau_b* | *Volume* | 1.000 | **0.395**** | 1.000 | 0.211 |
| | *Sig (2-tailed)* | | 0.001 | | 0.223 |
| *Spearman's rho* | *Volume* | 1.000 | **0.507**** | 1.000 | 0.275 |
| | *Sig (2-tailed)* | . | 0.001 | | 0.227 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | |

*Source:* author's contribution (developed in SPSS IBM)

When corroborating the volume pattern identified through the cluster analysis with the CatBondStrat Score, at the level of each group as well as through a comparative approach (see Table 9), the investigation reveals that in terms of the central tendency indicators, as expected, the average CatBondStrat Score is higher for the second cluster (9.67, compared to 9.23). Though the mode is equal for both clusters (10.00), the percent of this value is also higher for the second cluster that displays a higher volume pattern.

Furthermore, the percent of transactions with a score equal or higher than 10 is higher in the second cluster (57.2, compared to 51.3 in the first cluster). In addition, while in both clusters the majority of the transactions have scores higher than 8 (considered within the analysis as a lower average score with reference to our sample), the percent of these transactions is higher within the second cluster (86%, compared to 69% in the first cluster).

**Table 9.Clusters' CatBondStrat Score– descriptive statistics**

| **CatBondStrat_Score Cluster 1 – Lower volume** | | | | **CatBondStrat_Score Cluster 2 – Higher volume** | | | |
|---|---|---|---|---|---|---|---|
| | **Mean** | **Median** | **Mode** | | **Mean** | **Median** | **Mode** |
| | 9.23 | 10.00 | 10.00 | | 9.67 | 10.00 | 10.00 |
| **Value** | **Frequency** | **Percent** | **Cumulative Percent** | **Value** | **Frequency** | **Percent** | **Cumulative Percent** |
| 5 | 3 | 7.7 | 7.7 | | | | |
| 6 | 2 | 5.1 | 12.8 | 6 | 1 | 4.8 | 4.8 |
| 7 | 2 | 5.1 | 17.9 | | | | |
| 8 | 5 | 12.8 | 30.8 | 8 | 2 | 9.5 | 14.3 |
| 9 | 7 | 17.9 | 48.7 | 9 | 6 | 28.6 | 42.9 |

| **CatBondStrat_Score Cluster 1 – Lower volume** | | | | **CatBondStrat_Score Cluster 2 – Higher volume** | | | |
|---|---|---|---|---|---|---|---|
| 10 | 10 | 25.6 | 74.4 | 10 | 9 | 42.9 | 85.7 |
| 11 | 5 | 12.8 | 87.2 | | | | |
| 12 | 4 | 10.3 | 97.4 | 12 | 2 | 9.5 | 95.2 |
| 13 | 1 | 2.6 | 100.0 | 13 | 1 | 4.8 | 100.0 |
| Total | 39 | 100.0 | | Total | 21 | 100.0 | |

*Source:* author's contribution (developed in SPSS IBM)

## 3. CONCLUSIONS AND FURTHER RESEARCH

At the level of the original contribution, the present paper broadens the empirical studies regarding the cat bonds market by focusing on European based companies, mainly from the insurance and reinsurance sector, while also developing a structure score that proxies the risk management approach at the level of each transaction. The findings of the present research reflect that the general structural elements of the financial transactions reflect closely the corporate approach regarding (catastrophe) risk financing through capital markets.

In detail, a confirmed hypothesis referred to the presence of a link between the risk management approach and the structure of the analysed transactions. This assumption was validated from two perspectives. Firstly, at the level of each cluster, generally, a higher volume was also associated with a higher CatBondStrat Score, an aspect confirmed partially by the correlation analysis. Secondly, the transactions included in the higher volume cluster had also a higher average CatBondStrat Score (complementary, the transactions with a CatBondStrat Score higher than the average were more numerous than those in the lower volume cluster).

This aspect suggests that the tactical/strategic approach in terms of managing the risks through cat bonds based on the volume is also, on average, mirrored at the level of the structure of the transaction.

The hypothesis regarding the homogeneity of the risk management approaches at the level of the analysed sample was partially confirmed. As noted, the second cluster (with, strategically oriented transactions, based on their volume) was mostly composed by those developed by large companies, while the smaller ones tend to cluster within the tactical approach group. One aspect that should be noted is the presence of the large players in the cluster with a rather tactical approach, fact that reflects a more elaborated risk management strategy for those companies that are more experienced on the cat bond market.

The assumption stating that the strategic approach is represented through transactions developed during and after 2007, even though partially, was also confirmed (the majority of the transactions in the higher volume cluster were accomplished within the stated period). Connected to this aspect, another fact noticed during the research was that within the tactical cluster, there were also transactions developed during and after 2007 by large companies which could also come as a confirmation of the above mentioned elaborated risk management approach that could be further reflected in a consolidation of the corporate competitiveness, in general.

As further research, the present research could be extended at two levels: (1) considering within the analysis transactions developed by other companies (not only European based) and (2) developing the research through analysing at the level of each structural element by employing other clustering procedures.

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