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Analysis of risk premium determinants on cat bonds

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Abstract

This paper presents an analysis of the risk premium determinants on catastrophe bonds (cat bonds). Firstly, from a theoretical point of view, the existing models used for determining the level of risk premiums will be presented through a comparative analysis. Then, through an empirical approach we'll present our results by taking into consideration cat bonds covering earthquake risk issued during 1999-2012. The first model shows the existing relationship between the expected losses of the company that requires coverage through an alternative risk transfer instrument such as cat bonds and the level of risk premium. By estimating our model in different conditions, taking as parameters the location and the frequency of the events, the fluctuations of risk premiums can be observed. In case of cat bonds covering USA earthquakes the risk premium is greater than those covering Japan earthquakes. Through the second model we aim to observe the determinants that influence risk premium. The explanatory variables taken into consideration are: the issuing amount, the probability of event occurrence, conditional expected loss, the probability of exhaustion, maturity, the rating and the trigger type of each bond. The results show that the probability of event occurrence and credit rating of the bond are significant determinants of risk premium, being considered by the investors when they decide to diversify their portfolio through financial instruments that are not affected by the volatility from financial markets. These results are mostly consistent with existing theoretical models but can also be observed certain differences which will be discussed. The moment when investors start to lose money is perceived more serious than the amount they will lose. As regards the rating, it offers information about the quality of the bond. Given the importance of this risk premium determinant we'll also present the main factors considered by the rating agencies in the moment of setting a certain rating for a cat bond.

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1. Introduction

Cat bonds are financial instruments that transfer catastrophic risk to capital markets. These appeared as a result of the need for development, the financial capacity of traditional market being limited, and often, those events characterized by an occurrence probability of 1% are not covered through reinsurance contracts because of high prices that such coverage involves and due to the uncertainty of insurance company regarding the reinsurer's financial capability in case of event occurrence. (Cummins, 2008)

These fixed income financial instruments are attractive for investors who receive a coupon rate that is composed of two parts (Bodoff, 2009):

- a recompense generated by their choice to invest an amount of money, respectively the value of the bond, for a certain period of time, usually between 1 and 5 years. This is based on LIBOR.
- a risk premium, expressed as a percentage of the bond amount, which investors receive as a result of taking cat risk. So, if the defined cat event causes the release of the funds, the bond amount is made available to issuer, in this case the investors may lose the entire investment or only a part of it, depending on the event severity. The optimistic scenario is when the defined event doesn't occur, the investors receiving at the end of the period the full amount originally invested and all the coupons.

$$Coupon\ rate\ (\%) = LIBOR\ (\%) + Risk\ premium\ (\%) \tag{1}$$

The risk premium presents a special importance both from a theoretical and practical point of view. Thus, models that captures its behavior in different conditions presented a permanent interest for development, for researches such as: Kreps (1999), Lane (2000), Kozik et al(2001), Lane and Mahul (2008), Gatumel and Guégan (2008), Wang et.al (2008), Bodoff (2009).

The basis of risk premium models on cat bonds were established before the ART market development, Kreps being one of the first researchers that tried to create a relationship between the reinsurance contracts pricing and capital markets, by comparing underwriting activity and investments. The conclusion he reached is that the risk premium should incorporate a margin expressed as a function of standard deviation, this being a measure of the risk of the bond or tranche:

$$Risk\ premium\ (\%) = Expected\ loss\ (\%) + Margin\ (\%) \tag{2}$$

However, none of the issuances realized in 1999 didn't take into account the standard deviation as a risk measure but rather the expected loss and the frequency of events. For series characterized by a high skewness, standard deviation isn't seen as an appropriate measure of extreme risk, this being defined as the loss of the entire capital invested. In these circumstances the alternative was to consider the margin as a function of conditional expected loss, which is an expression of the intensity of an event. Also, nor this measure hasn't been considered enough robust, then being introduced a second risk measure, the probability of first dollar loss which express the frequency of events.

Also, Kozik (2001) argues the necessity of incorporating in the risk premium of a skewness cost in case of insurance products that covers catastrophic risk, in these situations standard deviation of the rate of return can't be considered an appropriate measure of the risk that investors are exposed to.

A model that takes into account the risk of losing the full invested capital is:

$$Risk\ premium\ (\%) = Expected\ loss\ (\%) + \frac{Capital\ at\ risk \times rate\ of\ return\ (\%)}{Bond\ amount} \tag{3}$$

Given the high intensity that characterizes catastrophes, the event occurrence may lead to loss of full capital invested, and in these circumstances the capital at risk equals the amount of the bond, the relation above becomes:

$$Risk\ premium\ (\%) = Expected\ loss (\%) + Rate\ of\ return\ (\%) \tag{4}$$

Staring from the above relation Bodoff (2009) has developed a new model for risk premium on cat bonds:

$$Risk\ premium\ (\%) = Constant\ (\%) + Loss\ multiplier * Expected\ loss\ (\%) \tag{5}$$

The risk premium, the constant and the expected loss are expressed as percentage of the bond amount. The constant is in fact that rate of return requested by investors and the loss multiplier must be introduced in model because of the uncertainty related to expected loss, the data series of this variable isn't known, but rather the result of simulations realized by companies specialized in risk modeling.

Another argument behind this decision is about the differences noticed regarding the value of expected loss based on assessments of risk modeling company.

The utility of such model is represented by the fact that it allows companies interested in issuing cat bonds to have an image on the price behavior in the past and at the same time is an indication of their future evolution, a number of parameters can be introduced into the model: the type of the risk covered, the location considered or the frequency of events in time.

Once the companies observe prices behavior the next question that arises is related to their high level. In order to find the answer to this question the starting point was represented by the analysis of reinsurance contracts that covers cat risks, so, being observed that during 1989-1998 the level of premiums paid have exceeded the expected loss with a value that have fluctuated between 1,5% and 7,5%. Froot (2001) explains this volatility by losses distribution, insufficient capital of traditional market, in these circumstances reinsurers holding the market power. Cat bonds, being an alternative solution removes these drawbacks but also the high cost is explained by: the high risks investors are exposed to.

2. Data and methodology

2.1. Data

We considered only those cat bonds issued during 1999-2012 that cover earthquake risks, the data being obtained from studies and reports of Lane Financial LLC, GC Securities and AON Benfield Securities. For each tranche of cat bond the data collected were as follows: expected loss, amount of the bond, trigger type, rating by Standard and Poor's or by Moody's or Fitch in case of missing, maturity, spread but also a series of information specific for cat bonds: EL –expected loss, PFL-probability of first dollar loss, POE-probability of exhaustion, CEL-conditional expected loss equal to the ratio between expected loss and the probability of first dollar loss which represents the expected loss of one dollar invested in case the defined event occurs triggering the release of funds.

Table 1. Descriptive statistics of the variables considered

	Mean	Maximum	Minimum	Standard deviation
Risk premium	5.63%	14.5%	1.5%	2.70%
Expected loss	1.44%	7.94%	0.19%	1.48%
Conditional expected loss	56.07%	100%	0.08%	36.8%
Probability of first dollar loss	1.94%	10.64%	0.24%	2.08%
Probability of exhaustion	1.12%	6.2%	0.11%	1.17%
Amount of the bond (million USD)	114.27	350	3	91.4
Maturity (months)	29.47	60	12	14.93

As a fist aspect that can be noticed from the table above is the high level of risk premium compared to expected loss, the difference between the average values of the two variable being 4.19%. If the event occurs, on average, 56.07% of the invested amount is lost. The average value of the probability of first dollar loss is relative small, only 1.94%. This low value of the probability of first dollar loss is a proof that cat bonds are issued for high level of reinsurance protection. The probability of exhaustion is 1.12% and the average value of a tranche is 114.27 million USD. However we can observe a significant fluctuation on the value of a tranche, from 3 million USD to 350 million USD. The maturity of these bonds is around 2 years, the maximum maturity of such a bonds being 5 years. It has not been considered the cat risk coverage for more than 5 years because market participants are interested in a reevaluation of risk at a given time, so the price paid incorporate the new information regarding the frequency and severity of cat events as well the existing conditions regarding underwriting. Given the evolution of extreme events worldwide, respectively the ascending trend, a cat bond that offers coverage for a long period would be an advantage for the company that requires coverage, but not for investors who would be more likely to lose a part or the full amount invested.

2.2. Methodology

- The relationship risk premium-expected loss:

In the first model we aim to capture the linear relationship existing between the risk premium and the expected loss and to observe how the location covered and the events frequency influence the level of risk premium.

$$Risk\ premium\ (\%) = Constant\ (\%) + Loss\ multiplier{*}Expected\ Loss\ (\%) \tag{6}$$

Considering studies realized in the past, it was demonstrated that for the same covered risk the value of risk premium doesn’t vary significantly, the difference appears when the model is estimated for different risks. Also, we’ll observe that the value of the rate of return requested by investors varies depending on the capital accumulation at risk. The hypotheses that will be tested are: H0: the location covered directly influences the level of risk premium; H1: the frequency of events is directly correlated with the risk premium. In order to accomplish our objective, firstly we’ll estimate the model globally, considering all cat bonds covering earthquake risk over time. A second step consists of considering the location, aiming to estimate the model for Japan and USA. Then we’ll take into account the influence of the period, respectively before and after 2006, the model being estimated only for the period 2006-2012 for reasons of data availability.

- Risk premium- determinants

In order to understand the reason why investors require a high level of risk premium on cat bonds and the issuers offer it, we'll identify what factors are significant for both parties. The model that we'll estimate is:

$$Risk\ premium_i = a_0 + a_1 * Amount_i + a_2 * PFL_i + a_3 * CEL_i + a_4 * POE_i + a_5 * Maturity_i + a_6 * Rating_i + a_7 * Trigger_i + \varepsilon_i \quad (7)$$

Risk $premium_i$- is the dependent variable, natural logarithm of risk premium on tranche i of cat bond;

$Amount_i$- natural logarithm of bond amount expressed in million USD on tranche i;

PFL_i- probability of first dollar loss on tranche i of cat bond, which is equivalent to the probability of event occurrence that generates the release of funds;

CEL_i- conditional expected loss associated to tranche i, equal to the ratio of the expected loss and probability of first dollar loss;

POE_i- probability of exhaustion on tranche i; the probability to lose the full amount invested;

$Maurity_i$- number of years for which tranche i has been issued, during which the issuer receives the necessary funds to cover the losses generated by the occurrence of the event in specified conditions;

$Rating_i$- takes the value of 1 if the rating associated to tranche i is BB or another lower value, 0 otherwise;

$Trigger_i$ – takes the value of 1 in case of indemnity trigger on tranche i, 0 otherwise;

According to existing theoretical models we expect to obtain a direct relationship for rating, relationship that is confirmed in case of corporate bonds, as it provides a signal to investors regarding the quality of the bond. Another aspect we'll observe is the influence of the trigger type on the risk premium, according to theory an indemnity trigger is less favorable to investors due to the lack of transparency, the determination of issuer company' losses being influenced by its practices, so there is a high moral hazard.

3. Empirical results

3.1. The relationship risk premium-expected loss

The results of the first model, respectively the estimation realized at a global level, all cat bonds issued to cover earthquake risk being included:

Table 2. The results of the model risk premium – expected loss at a global level

Variable	Coefficient	Standard deviation	t-Statistic	Prob.
Constant%	3.35%	0.27%	12.0099	0.0000
Loss multiplier	1.4817	0.1390	10.6569	0.0000

R-squared=0.6468
Source: Authors' processing
Risk premium %= 3.35%+1.48*Expected loss%

Table 3. The results of the model risk premium – expected loss when the location is considered

Location	Variable	Coefficient	Standard deviation	t-Statistic	Prob.
Japan	Constant%	2.50%	0.25%	9.7816	0.0000
	Loss multiplier	1.7427	0.1410	12.3535	0.0000
USA	Constant%	3.58%	0.32%	10.9970	0.0000
	Loss multiplier	1.4834	0.1603	9.2515	0.0000

$R\text{-squared}_{Japonia}$=0.9327

R-squared$_{USA}$=0.6455
Source: Authors' processing
Risk premium %$_{Japonia}$= 2.50%+1.74*Expected Loss%
Risk premium %$_{USA}$= 3.58%+1.48*Expected Loss%

Table 4. The results of the model risk premium-expected loss when the issuance period is considered

Period	Variable	Coefficient	Standard deviation	t-Statistic	Prob.
2006-2012	Constant%	3.72%	0.38%	9.6197	0.0000
	Loss multiplier	1.3906	0.1620	8.5807	0.0000

R-squared=0.6423
Source: Authors' processing
Risk premium%2006-2012= 3.72%+1.39*Expected Loss%

The assumption about the direct relationship between the rate of return on capital requested by investors and the risk premium on cat bonds is confirmed in all three cases. The differences between models appear regarding its value. So, the highest value, of 3.72% was obtained when only cat bonds issued after 2006 were considered, a possible explanation for this result being the occurrence of the biggest natural catastrophe in terms of losses that struck USA in 2005, respectively Hurricane Katrina and the ascending trend observed at a global level of natural catastrophes, both as frequency and intensity. Also, although both USA and Japan are known as areas exposed to earthquake risk considering that USA has a greater exposure also the rate of return requested by investors is higher, respectively 3.58% compared to 2.5% in case of a cat bond covering Japan earthquake risk. The highest value registered by the loss multiplier can be observed in case of Japan when it reaches 1.74 which indicates a greater impact of uncertainty regarding the estimation of expected loss.

3.2. Risk premium -determinants

Table 5. The results of the model regarding risk premium determinants on cat bonds

Dependent variable	Independent variable	Coefficient	Standard deviation	t-Statistic	Prob.
Risk premium	Constant	0.4366	0.2754	1.5848	0.1193
	Amount	0.0849	0.0472	1.7962	0.0785*
	Probability of first dollar loss	0.1910	0.0472	4.0421	0.0002**
	Conditional expected loss	0.0010	0.0013	0.7940	0.4309
	Probability of exhaustion	-0.0553	0.0800	-0.6918	0.4922
	Maturity (years)	-0.0096	0.0387	-0.2499	0.8037
	Rating	0.4954	0.1880	2.6345	0.011**
	Trigger	0.0535	0.1382	0.3870	0.7000

R-squared=0.6088

Note: **Significance at the 5% level; * Significance at the 10% level

The significant variables are the probability of first dollar loss, that represents the probability of the event occurrence that triggers the bond, and the rating of the bond, and if we consider the significance level of 10% also the amount of the bond. Therefore, investors are the most concerned by the moment when they begin to lose invested amounts and not by the probability of losing the full amount invested. In these circumstances the location covered through the cat bond has a special importance.

4. Conclusions

As in the theoretical approach, the rating is a sign that shows the investors the bonds' quality, as it is a significant variable in the model. Considering its importance we'll present a series of elements regarding the factors taken into account by the rating agency Moody's when determining the rating of a cat bond. The central element is represented by the expected loss, but determination of the rating involves a whole quantitative process. (Moody's, 2013):

- The assessment of the promise made to investors: this refers to the payment of the full capital and the interests associated invested in case the event doesn't occur. Not only totals are taken into consideration but also the moment when these are transferred to investors, the frequency of coupons payment. So, the assessment of the promise to investors is done based on both values: the principal and the interests because the event occurrence at the beginning of covered period affect both amounts.
- Running potential losses scenarios and their associated probabilities: at this stage particularly important are the models developed by companies specialized in risk assessment. The results are expressed as annual exceedance probability of loss for a certain risk. Since the data series are low, uncertainty evaluation is critical, so the rating agency performs different stress tests in order to observe the robustness of the model. These tests are performed for different triggers, number and types of risks covered. For example in case of a indemnity trigger the median value of stress factor has the highest value, of 1.2 compared with parametric triggers or modeled loss triggers when it takes a value of 1.05. This difference is due to disadvantages for investor of indemnity triggers.
- Determination of expected loss: the expected loss is established as percentage of bond amount being determined as weighted average of losses, adjusted in function of stress factors considered. The average is calculated after each scenario has assigned an occurrence probability, so the expected loss equals the sum of investors' losses for each scenario weighted with its occurrence probability.
- Comparison of cat bonds expected loss with a series of benchmarks: this is the last step and it consists of a comparison of cat bond expected loss with one of a conventional bond having the same maturity as the cat bond.

These presented steps can be complemented by additional information taken into account, these being always public. Sometimes is required even a rating update based on new information available. A different result to what theoretical models sustain is obtained for trigger, this is not a significant variable, so choosing a indemnity trigger, less favorable to investors doesn't involve a higher risk premium in comparison with the other trigger types.

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