Explaining the Spread Premiums on Catastrophe Bonds

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Abstract

Since cat event losses are uncorrelated with aggregate risks in financial markets, the spread premium for such catastrophic protection should be approximately equal to the expected loss under perfect market. On the other hand, most CAT bonds offer 200-1300 bps for interest spreads, far higher than expected losses of CAT bonds and interest spreads offered by BB-rated corporate bonds. Past research explores little the causes of exceptional high spreads of CAT bonds but focuses more on the theoretical pricing of them. This article tries to explain the spread premiums of CAT bonds, the risk premiums investors ask for investing in CAT bonds, from an empirical viewpoint, verifying whether these significant factors are consistent with those proposed in theoretical pricing models.

Analyzing issuing data of nonlife CAT bonds from 1997 to 2007, we find that, for catastrophe-event risk, investors care the probability of exhaustion and probability of first dollar loss but not the conditional expected losses. In other words, investors perceive how likely they would begin to lose and lose all the money more serious than how much they would lose. Moreover, issuers also pay a lower price for CAT bonds with non-investment grade ratings or those covering multiple perils. This outcome is similar to that obtained from the empirical issuing price of IPOs, as investors recognize the ratings as the signals of the qualities of the bonds. Besides, though there is no theoretical pricing model to support lower price for CAT bonds covering multiple perils, the result still seems reasonable since multiple-peril bonds are perceived highly structured and opaque and constrain investors' discretion to construct their portfolio of risks. However, indemnity-trigger CAT bonds seem not to offer significantly higher spreads than those of the trigger types unfavorable to investors, such as industry-loss index, modeled-loss index, and parametric triggers. It may be evidence confirming the result of Cummins et al. (2004) that insurers can hedge almost as effectively using the intrastate-loss index and parametric index as they can using perfect hedge. As a result, they may not like to offer significantly higher spreads when using an indemnity trigger.

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I. Introduction

CAT bonds have become a more and more important and popular tool for property insurance companies to manage their catastrophe risks, including hurricane, earthquake, windstorm, typhoon, terrorism risk, and so forth. The total risk capital outstanding of CAT bonds, measured in bond principal outstanding, reached $8.48 billion at the end of 2006, a 74 percent increase over the 2005 year-end total of $4.90 billion. Given the extraordinary large volume and high growing speed, it is expected that the technique of securitization becomes mature and investors are more and more familiar with this kind of investing tool.

Since cat event losses are uncorrelated with aggregate risks in financial markets, the spread premium for such catastrophic protection should be approximately equal to the expected loss under perfect market. In other words, the theoretical spread over LIBOR for the cat-event risk should be equal to the expected loss. On the other hand, the ratio of premium to estimated expected loss across cat-event reinsurance contracts ranges from 1.5 to 7.5 during 1989-1998, indicating that prices are considerably greater than the expected loss. Moreover, much of the high premium-to-expected loss ratio comes from the riskier upper tails of the loss distribution (Froot, 2001). To explain the exceptional high premium for reinsurance contracts, Froot (2001) advances two plausible supply-side hypotheses that there is insufficient capital in reinsurance and reinsurers have market power.

CAT bonds, an alternative catastrophe risk hedging instrument for insurance companies, seem free of the problems of financing imperfection and market powers possessing by reinsurers. Thus, arguably they make the cat-event risk reinsurance market more competitive. Nevertheless, most CAT bonds offer 200-1300 bps for interest spreads, typically far higher than those of BB-rated corporate bonds. How can investors charge for such a high premium? There must be some disliked risks for risk-averse investors to bear. As a result of that, issuers need to accommodate to investors' concerns when pricing.

Past research explores little the causes of exceptional high spreads offered by CAT bonds but focuses more on the theoretical pricing of them. Lee and Yu (2002) point out that, besides related parameters of a catastrophe event such as the mean and the standard deviation of the logarithm of the amount of catastrophe losses, occurrence intensities, and CAT loss variance, both moral hazard and basis risk are significant factors driving down the bond prices, that is, pushing up the spread premiums of cat bonds. The authors derive their result under the assumption that CAT bondholders are repaid only part of the principal if the insurer is insolvent. Constructing a model with parameter uncertainty, Froot et al. (2002) analyze whether the high yields of CAT bonds can result from the uncertainty associated with actuarial probabilities. They find that parameter uncertainty does not tend to increase spreads much and hence does not appear to be a satisfactory explanation for high yields of CAT bonds.

This paper explores the spread premiums of CAT bonds from an empirical viewpoint. We observe the issuing prices of CAT bonds during 1997-2007 and attempt to understand which factors issuers and investors care for so that investors require and issuers are bound to offer higher premiums for CAT bonds. Moreover, we try to verify whether these significant factors are consistent with those proposed in the theoretical pricing models.

The rest of the paper is organized as follows: Section II details our data, study design, and model. The results of the empirical analysis are presented in Section III. Section IV concludes.

II. Data and Methodology

A. Data

Our data are collected from researches and publications provided by professional financial institutions. Only nonlife CAT bonds are investigated. The data set contains descriptive data on general bonds, such as issuing spreads, credit ratings, issuing amounts, and bond maturities. Besides, the data contain some characteristic information on CAT bonds, including expected losses (EL), the probability of first dollar loss (PFL; the probability the event is triggered), the probability of exhaustion (POE; the probability investors loss all principals), and conditional expected losses (CEL; the expected loss of $1 invested dollar on condition that the event is triggered), which is also equal to the quotient of expected loss to PFL.

Each tranche, instead of each bond, is viewed as a single observation. We eliminate 43 tranches with incomplete data. Most of eliminated samples are drawn from the first few years after the application of CAT bonds. S&P ratings are used for the ratings of the bonds in this study. If an observation only possesses a rating of other rating agencies, appropriate transfer is adopted. In total, 177 observations between 1997 and 2007 meet our criteria for analyses.

To investigate compositions of the risk premium, spreads to LIBORs are used, we thus eliminating the impact of the variations in the LIBOR, proxy of the risk-free rate. As the values of the spread premiums range from 0 to 1, we take natural log of them to induce their range more covering the whole real numbers and put the results in our regression model as the dependent variable. By doing so, we make our dependant variable more conforming to normal distribution.

The summary statistics is presented in Table 1. The table shows that the average issuing spread premium of CAT bonds is high compared to the average expected loss. The difference between average spread premium and average expected loss is 5.44%, about 2% to 3% higher than the average risk premium of BB-rated corporate bonds. Moreover, the maximum of the spread premium reaches 32.60% for bond Successor Hurr Ind E-1 in 2006, a quite incredible and attractive figure. Besides, the range and the standard deviation of spreads are large.

The table also displays that if the event is triggered, on average 73.53% of the amount will lose. Generally, the average PFL of CAT bonds is low (a probability of occurrence of 0.0297), reflecting the fact that CAT bonds are often issued to cover the so-called high layers of reinsurance protection. The average POE of 1.13% means that investors would loss all principals with probability of one-hundredth on average. Although the average size of a tranche is only $66.7 million, nearly $8.5 billion of risk capital was outstanding by the end of 2006 as mentioned before, quite a large market size. The average maturity of CAT bonds is around three years and the maximum of maturity does not exceed 5 years, supporting the reasoning that bonds longer than 5 years are not favored by the market because market participants would like to reprice risk periodically to reflect new information on the frequency and severity of catastrophes and to recognize changes in the underwriting risk profile of the sponsor (Cummins, 2008).

Table 1

Summary Statistics: CAT bonds issued during 1997-2007

The table summarizes CAT bonds issued, total 177 observations, during 1997-2007. Each tranche, instead of each bond, is viewed as a single observation. Spread premium is the issuing spread to LIBOR. PFL represents the probability of first dollar loss, POE stands for the probability of exhaustion, and CEL is conditional expected losses, which is also equal to the quotient of expected loss to PFL.

Variable	Mean	Std. Dev.	Minimum	Maximum
Spread Premium (over LIBOR)	7.07%	4.79%	0.76%	32.60%
Expected loss	1.63%	1.77%	0.01%	11.38%
CEL	73.53%	16.38%	0.92%	100.00%
PFL	2.97%	7.16%	0.01%	60.65%
POE	1.13%	1.12%	0.00%	4.89%
Amount ($mil)	67.90	62.00	1.80	313.00
Maturity (months)	31.30	14.00	7.00	60.00

B. Explanatory Variables

Our data concerning parameters of cat-event risk include expected losses, CEL, PFL, and POE. Since expected losses equal to the product of CEL and PFL, we abandon the variable expected losses but put both CEL and PFL as explanatory variables to grasp their individual explaining power for expected losses. Besides related parameters of cat-event occurrence, moral hazard and basis risk are important factors in CAT bonds for both investors and issuers since they influence the efficiency of the hedging and the monitoring cost incurred. According to Lee and Yu (2002), both moral hazard and basis risk are positively correlated to spread premiums of CAT bonds. Though, this result is based on the assumption that CAT bonds may be insolvent when insurers or reinsurers go bankruptcy. However, nowadays almost all securitization products are organized with the bankrupt-remote mechanism so the argument may not sustain. On other grounds, it is expected that moral hazard would be positively correlated with but basis risk be inversely correlated with the spread premiums offered: For a CAT bond with high basis risk, insurers will be reluctant to offer high spreads; for a CAT bond with high moral hazard, investors will claim for high spreads to compensate their higher expected losses or high monitoring costs. Moreover, moral hazard and basis risk are flip sides to each other (Doherty, 1997). Accordingly, we need to care for only one of them.

Trigger types are used as the proxy of basis risk in this paper. There are four broad trigger types: (1) *indemnity triggers*, where payouts are based on the size of the sponsoring insurer’s actual losses; (2) *industry-loss index triggers*, where payoff on the bond is triggered when industry-wide losses from an event exceed a specified threshold; (3) *modeled-loss index triggers*, where an actual event’s physical parameters are used in simulating the model provided by one of the major catastrophe-modeling firms to estimate the loss index; (4) *parametric triggers*, where the payoff on the bond is triggered by specified physical measures of the catastrophic event such as the magnitude and location of an earthquake or the wind speed and location of a hurricane. Securities based on insurer-specific (or hedger-specific) losses have no basis risk but expose investors to moral hazard, whereas securities based on industry loss indices or parametric triggers greatly reduce or eliminate moral hazard but expose hedgers to basis risk. Though our data are classified as four different trigger types—indemnity, industry loss index, modeled loss, and parametric, to obtain a more significant and clearer result, we only differentiate them between indemnity and non-indemnity type.

Multiple-peril bonds cover more than one peril at the same time. For example, earthquake risk and hurricane risk may be bundled together to form a single issuance.

It is generally agreed that multiple-peril bonds are usually priced higher than other single-peril catastrophe bonds. These bonds appeal to sponsors because they cover multiple perils for broader protection, reducing transaction costs. Investors, on the other hand, generally prefer to construct their own portfolio of risks, but buying multiple-peril bonds limits this possibility. Moreover, these products are usually highly structured and opaque (Cummins, 2007). Thus, investors may require higher yields for multiple-peril bonds to compensate for the investing limitation and information barrier imposed. Accordingly, we put the dummy variable PERILS to investigate the effect of the number of perils on spread premiums.

Table 2

Description of Our Sample: CAT bonds issued during 1997-2007

The table presents more detailed information of our data. Each tranche, instead of each bond, is viewed as a single observation. Panel A describes the ratings possessed by our sample bonds. S&P ratings are adopted for the ratings of the bonds in this study. If the observations only possess the ratings of other rating agencies, then appropriate transfer would proceed. Panel B displays trigger types of our observations. Panel C shows the number of perils our sample bonds cover.

Variable	Number of Observations	Percent of Observations
Panel A: S&P Rating		
AAA	3	1.69
AA	0	0.00
A	3	1.69
BBB	19	10.73
BB	114	64.41
B	31	17.51
NR	7	3.95
Panel B: Trigger Types		
Indemnity	40	22.60
Industry-Loss Index	23	12.99
Modeled-Loss Index	33	18.64
Parametric	81	45.76
Panel C: Number of Perils		
Single peril	115	65.17
Multiple perils	62	34.83

As the goal of this paper is to investigate the "issuing prices" of CAT bonds—the initial spread premiums—we also refer to the research about the IPOs of corporate bonds. Fung et al., 1997 show that the rating of a bond is inversely correlated to the degree of underwriting pricing for bond IPO, that is, spreads increase as the quality of the bonds decreases. Analogously, we expect that the ratings of CAT bonds are negatively correlated to the spread offered. Furthermore, Cai et al. (2007) claim that the amount of bond offering—a variable correlated with information problem—is positively correlated to the return offered. Since the amount of bond offering is highly correlated with firm size, larger offering size might have greater underpricing if large firms are more difficult to understand. Thus, the variable the amount of CAT bonds issued is put in our regression model.

Year dummies and location dummies are also added in the model to control the factors of macroeconomic environment, such as reinsurance cycles and the occurrence of catastrophe events.

Table 2 describes our sample. Panel A shows that the vast majority (more than 80 percent) of CAT bonds are below investment grade (ratings below BB), while only few bonds (3.95 percent) do not own ratings. Moreover, according to Panel B, nearly half of CAT bonds are of parametric triggers, and only 23 percent CAT bonds choose indemnity triggers, the trigger type most favored by issuers because of less basis risk born. Panel C reports the number of perils that CAT bonds cover. Nearly two-thirds of the sample bonds (65 percent) cover single peril.

III. Empirical Results

The following regression model is performed to analyze the impact factors in spread premiums on CAT bonds.

$$SP_i = \beta_0 + \beta_1 Amount_i + \beta_2 Maturity_i + \beta_3 CEL_i + \beta_4 PFL_i + \beta_5 POE_i + \beta_6 Rating_i + \beta_7 Perils_i + \beta_8 Trigger_i + \sum_{j=9}^{18} \beta_j Year_{ji} + \sum_{k=19}^{34} \beta_k Location_{ki} + \varepsilon_i \quad (1)$$

where

SP_i: is natural log of the spread premium on tranche i of CAT bonds,

$Amount_i$: is natural log of the amount of issue on tranche i of CAT bonds in U.S. million dollars,

$Maturity_i$: is the number of years to maturity on tranche i of CAT bonds,

CEL_i: represents conditional expected losses of \$1 on tranche i of CAT bonds,

PFL_i: represents the probability of first dollar loss on tranche *i* of CAT bonds,

POE_i: stands for the probability of exhaustion on tranche *i* of CAT bonds,

$Rating_i$: takes a value of 1 if the tranche *i* is rated BB or lower (non-investment grade) and 0 otherwise,

$Perils_i$: takes a value of 1 if multiple perils are covered by tranche *i* and 0 otherwise,

$Trigger_i$: takes a value of 1 if the trigger type of tranche *i* is indemnity trigger and 0 otherwise,

$Year_{ji}$: are dummy variables corresponding to year 1997 to 2007,

$Location_{ki}$: are dummy variables corresponding to respective risk locations, and

ε_i : is the random error term for tranche *i*.

The regression results relating to model (1) are presented in Table 3. From the model 1 of Table 3, both PFL and POE are significant factors related to the spread premium. With 1% increases of PFL, spread premiums would be one fortieth higher ($e^{(2.4371*0.01)} - 1$). The impact of POE on the spread premium is more significant; with 1% increases of POE, spread premiums would be approximately three tenth higher ($e^{(27.6206*0.01)} - 1$). To fix the idea, considering a tranche with 1% POE and offering 10% spread premium, the issuer needs to raise its spread to 13% if the issuer wants to issue a tranche with 2% POE, everything else being equal. The result that investors ask higher risk premium for higher CAT-event risk is intuitive and consistent with existent pricing models of catastrophe bonds. However, in our empirical result, investors care for probability of exhaustion (POE) and the probability of first dollar loss (PFL) more than expected losses they would suffer when the bond is triggered (CEL). In other words, investors worry that they lose any money and that they loss all their principals and get nothing back, just as Hurricane Katrina claims leading to the pay out of the entire principal of KAMP Re 2005 Ltd. in 2005. They perceive how likely they would begin to lose and lose all the money more serious than how much they would lose.

Moreover, the dummy variables RATING and PERIL are significant. If the CAT bonds are of non-investment grade, the issuer would price 1.8 times ($e^{0.5799}$) more spread premiums than those of investment grade. This outcome is similar to that obtained from the empirical issuing price of IPOs, as investors recognize the ratings as the signals of the qualities of the bonds. In addition, according to Cummins (2008), the ratings of the CAT bonds indicate the layer of catastrophic-risk coverage provided by the bonds, that is, the qualities of the CAT bonds. While there have been fewer CAT bonds issued with investment grade after 2005, our data indicates that the issuing spread premiums of CAT bonds tend to be higher on average in recent years.

Besides, for CAT bonds covering multiple perils, their spread premiums would on average be one fifth ($e^{0.1699} – 1$) higher than those covering a single peril. Though there is no theoretical pricing model to support the result, the result still seems reasonable since multiple-peril bonds are perceived highly structured and opaque and constrain investors' discretion to construct their portfolio of risks.

Surprisingly, indemnity-trigger CAT bonds seem not to offer significantly higher spreads than those of the trigger types unfavorable to investors, such as industry-loss index, modeled-loss index, and parametric triggers. This finding does not agree with what we expect: higher moral hazard and low basis risk would result in higher return for investors. On the other hand, it may be evidence confirming the result of Cummins et al. (2004) that the basis risk with intrastate-loss index trigger is not very large (especially so for large insurers) and might be worth incurring to avoid the moral hazard inherent in the perfect hedge, i.e., using indemnity triggers. Moreover, insurers can hedge almost as effectively using the parametric index as using the actual state and regional loss indices. As a result, since it is not more costly for issuers to use a loss-index trigger and parametric trigger, they may not need to offer significantly higher spreads when using an indemnity trigger.

In addition, the constant term is significantly negative. Since through natural log conversion, in all samples the dependant variables are negative, the negative intercept just shifts our data to their "real" positive values. Nevertheless, the variable AMOUNT is not significant as predicted for bond IPOs. Unlike bond IPOs, CAT bonds with large offering size would not have significantly more serious information problems though it may be more difficult for investors to investigate the quality of underwriting. If the bonds are not of indemnity trigger, investors do not need to bear every dollar loss to contracts when the event is triggered but bear the loss according to the total industry loss or the intensity of physical measures of the catastrophic event. Moreover, only one-third of our data is of indemnity trigger, so we may not be able to see the consequence that investors ask higher spreads for large offering bonds.

To check the robustness of our results, we transfer our original dependent variables to the inverse of normal distribution to fit them as the normal distribution. By doing so, we can satisfy the assumption under OLS regression model that the residual terms follow normal distribution. The regression results are presented in model 2 of Table 3. From the model 2, we find that the results agree with those in model 1; the significant variables are the same in both models, and the relative magnitude of coefficients of significant variables is similar.

Table 3

Empirical Regression Results on Spread Premiums of CAT Bonds

AMOUNT represents natural log of the amount of issue, MATURITY denotes the number of years to maturity, CEL represents conditional expected losses of $1, PFL stands for the probability of first dollar loss, POE denotes the probability of exhaustion, RATING takes a value of 1 if the tranche of CAT bonds is rated BB or lower (non-investment grade) and 0 if it possesses an investment grade rating, PERILS takes a value of 1 if multiple perils are covered by the tranche and 0 if only a single peril is covered, TRIGGER takes a value of 1 if the trigger type of the tranche is an indemnity trigger and 0 otherwise, dummies for YEAR all take a value of 0 if the tranche was issued in 1997 and 1 if it was issued during 1998 to 2007 respectively, and dummies for LOCATION all take a value of 0 if the risk covered is located throughout U.S. and 1 if it is located in California, Florida, East/Gulf Coast, Northwestern U.S., Central U.S., North Atlantic, Japan, Euro, Euro and Japan at the same time, U.S. and Euro at the same time, U.S. and Japan at the same time, U.S., Euro, and Japan at the same time, Switzerland, Taiwan, Mexico, and worldwide respectively. The dependent variable is the natural log of the spread premium in model 1. For model 2, the dependant variable is the inverse of normal distribution of the spread premium.

	Using LOG(spread) as the dependent variable	Using NORMINV(spread) as the dependant variable
Independent Variable	Model 1	Model 2
CONSTANT	-3.6557***	-1.9305***
	(-19.49)	(-19.80)
AMOUNT	0.0096	0.0071
	(0.49)	(0.69)
MATURITY	-0.0007	-0.0004
	(-0.33)	(-0.43)
CEL	-0.0128	-0.0357
	(-0.07)	(-0.38)
PFL	2.4371***	1.2587***
	(4.20)	(4.18)
POE	27.6206***	15.8351***
	(10.55)	(11.64)
RATING	0.5799***	0.2456***
	(7.72)	(6.29)
PERILS	0.1699**	0.0793**
	(2.19)	(1.97)
TRIGGER	-0.1329	-0.0673
	(-1.69)	(-1.65)
DUMMIES for YEARS:	(Control Variables)	

YEAR98	-0.5109	-0.2434
	(-1.81)	(-1.66)
YEAR99	-0.1641	-0.0669
	(-1.15)	(-0.90)
YEAR00	-0.0319	-0.0094
	(-0.22)	(-0.12)
YEAR01	0.0012	0.0101
	(0.01)	(0.14)
YEAR02	0.0190	0.0112
	(0.14)	(0.16)
YEAR03	-0.0235	-0.0076
	(-0.17)	(-0.11)
YEAR04	-0.2102	-0.1032
	(-1.50)	(-1.41)
YEAR05	-0.1460	-0.0786
	(-0.95)	(-0.98)
YEAR06	0.1940	0.1091
	(1.52)	(1.65)
YEAR07	0.2697	0.1468
	(1.37)	(1.43)
DUMMIES for LOCATIONS: (Control Variables)		
CA	-0.0457	-0.0284
	(-0.56)	(-0.67)
FL	0.1966	0.0911
	(0.94)	(0.84)
EAST/GULF COAST	0.1375	0.0606
	(1.03)	(0.87)
NW US	-0.4417	-0.1964
	(-1.64)	(-1.40)
CENTRAL US	-0.6108***	-0.2807***
	(-4.28)	(-3.79)
N ATLANTIC	0.0945	0.0764
	(1.05)	(1.63)
JAPAN	-0.2767***	-0.1455***
	(-3.23)	(-3.26)
EURO	-0.2398***	-0.1280***
	(-3.05)	(-3.14)
EURO_JAPAN	0.0281	0.0139
	(0.23)	(0.22)
US_EURO	0.0453	0.0353
	(0.41)	(0.61)
US_JAPAN	-0.0518	-0.0256
	(-0.19)	(-0.18)

US_EURO_JAPAN	-0.1755	-0.0850
	(-1.75)	(-1.63)
SWITZERLAND	-2.5104***	-1.1777***
	(-6.36)	(-5.74)
TAIWAN	-0.1865	-0.0852
	(-0.69)	(-0.60)
MEXICO	-1.1623***	-0.5508***
	(-6.10)	(-5.57)
WORLDWIDE	0.1493	0.0847
	(0.78)	(0.85)
R^2	0.8722	0.8700
Adjusted R^2	0.8416	0.8389

** significant at the 0.05 level

*** significant at the 0.01 level

IV. Conclusion

CAT bond market has grown and thrived since 1997. CAT bonds solve the problem of limited capital in reinsurance market and offer a competitive price (Cummins, 2008). However, compared to BB-rated corporate bonds, the spread premiums offered by CAT bonds are strictly and significantly higher. To examine the factors investors care for and thus yield extra premiums and check them against the factors in existent theoretical pricing models of CAT bonds, we use issuing prices of CAT bonds during 1997-2007 to make empirical analyses.

The results are interesting. Probability of exhaustion (POE) and probability of first dollar loss (PFL) are the factors investors care for catastrophe-event risk; but the conditional expected losses (CEL) are not. In other words, investors worry that they may lose all their principals and get nothing back and perceive how likely they would lose money more serious than how much they would lose.

Moreover, CAT bonds with investment-grade rating or covering multiple perils yield extra spread premium. The first result is similar to that obtained from the empirical issuing price of bonds IPOs: Investors recognize the ratings as the signals of the qualities of the bonds. Though we don't find theoretical pricing models that predict higher spread for multiple-peril bonds, the second result is also acceptable: Multiple-peril bonds are perceived highly structured and opaque and constrain investors' discretion to construct their portfolio of risks.

However, different trigger types seem not to have a significant impact on spread premiums on CAT bonds. CAT bonds with indemnity triggers do not yield higher spreads in our analysis. Our explanation is that since insurers can hedge almost as effectively using the intrastate-loss index and parametric index as they can using perfect hedge (Cummins, 2004), they may not like to offer significantly higher spreads when using an indemnity trigger.

Besides, the variable AMOUNT is not significant as predicted for bond IPOs. Unlike bond IPOs, CAT bonds with large offering size would not have significantly more serious information problem since investors do not need to bear every dollar loss to contracts when the event is triggered but bear the loss according to the total industry loss or the intensity of the cat-event parameter if the bonds are not of indemnity trigger.

The results are sustained after we do the robustness test by transferring the dependant variables through the inverse of normal distribution. If the result is a continuing phenomenon, it will be favorable to issuers. They can issue indemnity-trigger bonds to prevent any basis risks without offering significantly higher compensation to investors. Moreover, it may be worthy for the issuers to pursue higher ratings. They should make the trade-off between issuing a multiple-peril bonds and offering a lower spread premium.

Some of our results do not conform to existent pricing models of CAT bonds. For example, CAT bonds with basis risk do not have significantly smaller issuing spreads but CAT bonds covering multiple perils do yield extra return for investors. Furthermore, there is some inconformity between the theoretical pricing model and our empirical result for significant cat-event risk factors. Theoretically, all the mean and the standard deviation of the logarithm of the amount of catastrophe losses for the insurer, the occurrence of catastrophes, and trigger levels are important variables to determine the cat-event risk premium. However, in our analyses, the amount and the standard deviation of catastrophe losses only matter to determine the possibility of CAT bonds being triggered and debt being fully forgiven but not the exactly losses investors will suffer. Further research for these disparities need to be undertaken, especially if there is more detailed information about the characteristics of CAT bonds.

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