Catastrophe Securitization: A Multi-Factor Event Study on the Corporate Demand for Risk Management

by

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(Under the direction of Robert E. Hoyt)

ABSTRACT

This paper examines the market response to the issuance of catastrophe securities by public companies. We test for market responses to catastrophe security issuances in order to determine whether they reflect the theoretical predictions of the corporate demand for insurance literature. A multi-factor world market event methodology and a single-factor event methodology are used to test Cumulative Average Abnormal Returns for significance. Empirical results suggest that catastrophe bond issuance is perceived as a value added project by investors, reflected in positive abnormal returns about the issue date. Furthermore, cross-sectional analysis suggests that abnormal returns are higher for non-insurance companies, are decreasing in firm size, and are higher issues that utilize modeled loss triggers.

INDEX WORDS: Catastrophe Bond, Catastrophe Securitization, Catastrophe Securities, CAT Bond, Corporate Demand for Insurance

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1. Introduction

The catastrophe securitization market has grown dramatically since 2004 in all measurable areas: especially the number of issuances, total risk capital issued, and diversity of trigger types and offering structures. As shown in Figure 1, transaction volume grew from 10 transactions in 2005 to 20 in 2006 and 31 in 2007, with a combined $7.3 billion in new transactions in 2007, a 56% increase over 2006 and a 268% increase over 2005 (Hartwig (2008).

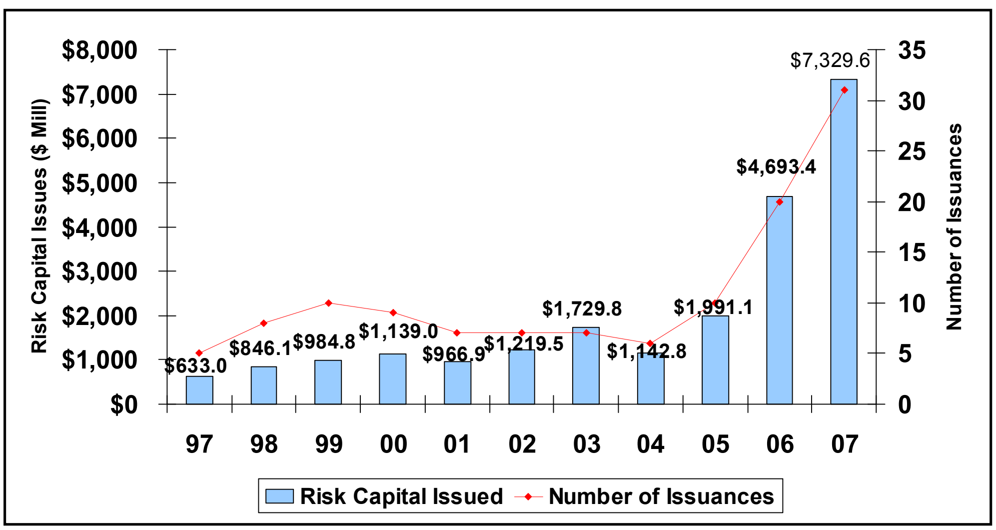

Figure 1. Catastrophe Bond Market (non-life)

Source: MMC Securities/Guy Carpenter, A.M. Best; Insurance Information Institute.

Indeed, almost 50% of the total issuance volume in the market was placed in the 3–year period from 2005 to 2007. Cummins (2008) claims that catastrophe bond issuances have reached a critical mass, evidenced by the market's growth in popularity from 2004 to 2007, and the fact that the market now compares in size with the property-catastrophe reinsurance market.

With few exceptions, the catastrophe bond triggers have moved beyond the traditional indemnity triggers common in the 1990's to include more complex parametric, modeled loss, and hybrid triggers by year end 2006. This dramatic movement in complexity impacts basis risk and also the transaction costs inherent in these catastrophe securities. It is too early to determine whether the increase in indemnity-based triggers in 2007 reflects attempts to mitigate basis risk (and investors' perception of it), or market forces that favor sponsors (McGhee et al. (2008)).

The emergence and growth of this new risk management technique, and a liquid market for catastrophe securities, provides a new opportunity to empirically test predictions of the corporate demand for insurance and risk management theory, and the effect of risk management on firm value. Specifically, event study methodology is utilized to empirically test abnormal returns around the announcement of a catastrophe bond transaction. Furthermore, to test the impact of transaction characteristics on firm value, the paper examines the effect of a series of characteristics on stock returns. These characteristics include the issue market cycle, firm size, geographic market (U.S. vs. global/international), bond rating, leverage, sponsor industry (insurance vs. non-insurance), relative issue size, trigger type, and perils included, on stock returns.

Prior literature suggests that since nonsystematic risks are diversifiable in the market, other factors must provide an incentive for a public company to purchase insurance or engage in risk management. Mayers and Smith (1982, 1990) hypothesize that the corporate demand for insurance is a non-linear function of the tax code, expected costs of bankruptcy and financial distress, the firm's ownership structure, investment incentives, information asymmetry, and the comparative advantage in real services.

Several articles build on this literature, including the examination of the corporate demand for insurance from a capital structure perspective (Garven (2003) and Berger (1992)) and from an asymmetric information perspective (Jean-Baptiste and Santomero (2000); Fazzari, Hubbard and Petersen (1988)). However, the authors are not aware of studies linking catastrophe securitization and the corporate demand for insurance and risk management.

The paper begins with an introduction to the current catastrophe bond market, a prior literature review and a general definition of catastrophe bonds. Summarizing prior literature, the paper explains the structure and triggers of catastrophe bonds before relating catastrophe bonds to the corporate demand for insurance. After developing hypotheses related to catastrophe bond issuances, the paper describes the data and methodology. Empirical results are presented prior to conclusions.

2. Literature Review

Articles that discuss catastrophe securitization fall into four broad categories: 1) The Market and History, 2) Design and Structure, 3) Technical Discussion, and 4) Valuation and Pricing.

Cummins (2007, 2008) and McGhee et al. (2007, 2008) provide catastrophe bond market reviews and historical updates. Other research, such as Cummins (1999) describes the characteristics of a securities market that would be directly accessible to the investor, improving the availability because it would resolve the issue of financing catastrophic risk financing. Froot (2001) also examines the market for catastrophe event risk and focuses on examining transactions that look to capital markets, rather than traditional reinsurance markets, for risk-bearing capacity.

Other articles spotlight the design and structure of catastrophe securitizations (Etherington (2004); Tynes (2000); Ali (2000); and Borden and Sarkar (1996)). The technical discussions include assessments of the risk financing techniques employed and the different ways of combining risk pooling capacity of insurance with the diversification of the securities market (Chichilnisky and Heal (1998)) and an analysis of the basis risk of catastrophic loss index derivatives (Cummins (2004)). Yang (2008) examines the correlation between catastrophe risk securities and portfolios of other equities by analyzing abnormal returns in the Japanese stock market using event study methodology.

The final area of research has been in the valuation and pricing of catastrophe securitization. Lee and Yu (2002) calculate default risk free and default risk catastrophe bond prices using Monte Carlo simulation, while showing that higher degrees of moral hazard and basis risk included in an issuance significantly drive down catastrophe bond prices. Vaugirard (2003) develops an arbitrage pricing approach to value catastrophe securitizations, while Lee and Yu (2007) demonstrate that the value of a reinsurance contract can be increased by issuing catastrophe bonds.[1]

While these studies represent important advances in understanding the development of the current market, none tested the empirical relationship between the issuances and firm value. In fact, because of current securities regulations that do not require public release of information regarding private catastrophe bond transactions, academic inquiry has been limited to date (Cummins (2008)). Specifically, current regulation dictates that the distribution of prospectuses for privately placed bonds can be limited to accredited investors (e.g. institutional investors and high net worth individuals) under Securities and Exchange Commission Regulation D. Our access to unique data about catastrophe security issuances allows us to overcome these limitations and contribute to the limited empirical research on catastrophe securitization and the prior literature on the corporate demand for insurance and risk management.

2.1. Catastrophe Bond Definition

Catastrophe bonds (henceforth CAT Bonds) are high-yield, risk-linked securities used to explicitly transfer major catastrophe exposures (such as low probability disastrous losses due to hurricanes and earthquakes) to the capital markets. Common definitions in the literature include: 1) fully collateralized instruments that pay off on the occurrence of a defined catastrophic event (Cummins (2008)) and 2) debt securities that link coupon and principal payments to the performance of a natural catastrophe insurance portfolio (Pennay (2007)).

[1] Some other research of interest in regards to different catastrophe bond pricing methodologies includes Jarrow (1995), Duffie (1999), Kau (1996), and Burnecki (2005).

2.2. CAT Bond Design and Structure

CAT bonds are issued by a Special Purpose Vehicle (SPV) that has been established by the bonds' sponsors. These vehicles are generally established offshore in locations such as Bermuda and the Cayman Islands because of their favorable regulatory, accounting, tax, and capital requirements (Wattman and Jones (2007)). The SPV's only purpose is to issue the CAT bonds and provide catastrophe coverage for the sponsor. The entity is usually owned by a charitable trust, so it is protected from credit and insolvency risk (Wattman and Jones (2007)). Cummins (2008), McGhee et al. (2007), and Wattman and Jones (2007) illustrate the basic structure for a CAT bond issuance. A brief history of the CAT bond market is provided in Appendix A.

Generally, CAT bonds provide coverage for very high layers of loss exposure, where the attachment of coverage is at the 1% probability of loss (1 in 100 year loss potential) and exhausts at the .4% probability of loss (1 in 250 year loss potential) (McGhee et al. (2007)). The bonds can also be issued as single-peril or multi-peril bonds with sponsors preferring multi-peril and investors preferring single-peril (McGhee et al. (2007)). This particular structure and attachment point provide reasonable alternatives to insurance because: 1) reinsurance pricing tends to be high for coverage at these levels due to minimum pricing constraints and transaction costs; 2) counterparty credit risk tends to be high at these levels because reinsurance companies generally take a net position and insolvency is a possibility if a major catastrophe were to occur; 3) coverage terms may not be favorable for the sponsor at this level; and 4) the catastrophe capacity may simply not be available[2].

Once the CAT bonds are issued to the investors by the SPV, the sponsor enters a reinsurance or derivative contract with the SPV for which it pays a premium. Then, the bond proceeds from

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[2] Specific capacity (supply) designated for certain regions or for certain perils may have been exhausted by market demand.

the issuance are deposited into a trust account to collateralize the transaction where the funds are then invested in low risk short-term investments and swapped with a highly-rated counterparty with returns based on the London Interbank Offered Rate (LIBOR) or another acceptable index. This process creates floating rate bonds that are virtually interest rate risk-free.

During the CAT bond's contract term (typically 3 years but as long as 6 years[3]), the interest payments made to investors include the premium paid by the sponsor plus returns earned on the bond proceeds. Wattman and Jones (2007) note that several issuances actually guarantee the interest payment for the inaugural year even if an event occurs that wipes out the entire principal. The bond proceeds can potentially be wiped out or diminished because the call option embedded in the bond is triggered by an occurrence with known parameters linked to the potential catastrophic event covered (Cummins (2008)). If an event occurs that triggers the coverage, the bond proceeds become available to the sponsor in total, or in part, and are released from the SPV to assist in the payment of covered claims. If the occurrence triggers only a partial loss to the bond proceeds, then the CAT bond face value is reduced and the interest payment to investors is recalculated based on the reduction in bond proceeds. Most CAT bond contracts provide for the principal to be entirely at risk: the investors bear the risk that they could lose the entire principal amount and interest payments.

CAT bonds are characterized by three distinct trigger types: 1) Indemnity Triggers; 2) Index Triggers; and 3) Hybrid Triggers. Indemnity Triggers are peril-specific triggers where the payout is dependent on the firm's actual loss. This trigger most resembles traditional insurance and provides sponsors with the smallest basis risk. Like an insurance policy, the indemnity trigger is susceptible to moral hazard and requires a significant amount of disclosure on the part of the sponsor, which increases information costs. Index triggers are broken into three categories:

[3] Puma Capital (Limited, 2008).

1) Parametric Trigger – claims are triggered by specific physical characteristics defined in the CAT bond contract such as wind speed of a hurricane, category of a hurricane, and magnitude of an earthquake, in combination with a specific location or locations.
2) Industry Loss Trigger – claims are triggered by an estimate generated by an industry loss calculation derived by a reporting service such as the Property Claim Service (PCS)[4].
3) Modeled Loss Trigger – claims are triggered by simulation of an actual event's physical characteristics defined in the CAT bond contract in order to determine the exposure. The modeling firms that generally perform the simulation are EQECAT, Applied Insurance Research Worldwide (AIR), or Risk Management Solutions (RMS) (Cummins (2008)). The Modeled Loss Trigger type likely provides the lowest basis risk of the index triggers (McGhee et al. (2007)).

Investors tend to favor index-linked triggers because they reduce moral hazard; however, their complexity (higher level specialized analysis required), drives up transaction costs and may impact liquidity. Sponsors also enjoy some cost benefits and increased investor demand for index triggers, at the expense of increased basis risk. Hybrid trigger contracts, in which multiple trigger types exist within a single CAT bond contract, may include a multiple peril indemnity trigger along with a parametric index. One example of a hybrid trigger contract is when the CAT bond contract includes both an indemnity trigger on Gulf Coast hurricane combined with a modeled loss index trigger on California earthquake within the same contract.[5] Investors appreciate the reduced moral hazard offered by hybrid triggers, relative to indemnity based triggers (even complex hybrid triggers with an indemnity sub-trigger offer lower moral hazard

[4] PCS, a unit of Insurance Service Offices (ISO), investigates reported disasters and determines the extent and type of damage, dates of occurrence, and geographic areas affected. PCS assigns serial numbers to each catastrophe of a certain magnitude and for each catastrophe; the PCS loss estimate (the "PCS Index") represents anticipated industry-wide insurance payments for property lines of insurance.
[5] For more examples of hybrid triggers, including contracts with dual triggers, see McGhee et al. (2007).

than a straight indemnity trigger). Sponsors utilizing hybrid triggers are marginally able to customize their basis risk; although this benefit comes at the cost of transaction costs and reduced investor demand. For more information on the trigger types see Cummins (2008), McGhee et al. (2007), Wattman and Jones (2007), and Canabarro (2007) .

Early in their history, CAT bonds were priced primarily on supply and demand with the sponsor setting an initial issue price based on standard derivative pricing models, allowing the secondary market to discover the price equilibrium based on the investor demand. More recently, however, financial experts rely less on the standard derivative pricing model, which is inadequate since the Black-Scholes and related models do not provide for the impact of the stochastic nature of the underlying events. Since the pricing model of defaultable bonds does contain a mechanism for the potential partial or complete loss of principal value, generating higher yields, some experts believe it is more appropriate.[6] While CAT bonds have historically been thought to have high spreads relative to equivalent corporate bonds, the private nature of the CAT bond market provides little data to verify the actual yields.

In general, pricing is most impacted by modeling results, followed by historical market precedence, spreads on the secondary market securities, current reinsurance rates, and concentration of exposure. Cummins (2008) and McGhee et al. (2008) suggest that the market for CAT bonds is more competitive with reinsurance pricing than many first thought and CAT bond premiums are declining.[7]

In summary, several reasons for the increasing popularity of CAT bonds include: 1) unlike reinsurance, CAT bonds are 100% collateralized and counterparty credit risk is removed; 2)

[6] Some research of interest in regards to different catastrophe bond pricing methodologies includes Jarrow (1995), Duffie (1999), Kau (1996), and Burnecki (2005).

[7] For specifics on catastrophe bond pricing, the reader is referred to Cummins (2008), McGhee et al. (2007,2008), Froot (2001), Canabarro (2007), and Lane (2007).

sponsors are able to lock in multi-year contracts which make budgeting and placement less time consuming; 3) capacity is locked in for multiple years which shields sponsors from insurance market fluctuations; 4) new catastrophic capacity is opened up, diversifying a firm's risk management tools; and 5) investors enjoy additional diversification opportunities.

3. Corporate Demand for Insurance & Hypotheses Development

The theory of corporate demand for insurance was first described by Mayers and Smith (1982, 1990). In their research, they propose hypotheses about the demand for insurance and test them using data from the insurance industry. One of their primary assumptions, that the purchase of reinsurance by an insurance company is comparable to the purchase of insurance by firms in other industries, has been widely accepted and empirically tested in different forms in the succeeding literature. The theory of the corporate demand for insurance suggests that firms enhance shareholder value by purchasing insurance to obtain favorable tax benefits, reduced costs of financial distress and reduced probability of bankruptcy, reduced costs associated with ownership structure, improved investment incentives, reduced costs associated with information asymmetry, and benefits of comparative advantage in real services.

Among the studies contributing to the theory of the corporate demand for insurance, Powell and Sommer (2007) examined the demand for internal and external reinsurance using traditional corporate demand theory and internal markets theory. Garven and Lamm-Tennant (2003) examine the corporate demand for insurance from a capital-structure perspective. Jean-Baptiste and Santomero (2000) examine the effect of asymmetric information on the transfer of underwriting risk between insurers and reinsurers. There are also many other articles that study the corporate demand for insurance,[8] but like the above, none of them examine empirically the theory of the corporate demand for risk management in the context of a firm's decision to utilize catastrophe securitization.

[8] For example, see Main (2000), Hoyt and Khang (2000), and Yamori (1999).

Following Mayers and Smith (1982, 1990) and other studies on the corporate demand for insurance we expect several benefits to impact the demand for catastrophe securitization:

3.1. Tax Benefits

Historically, many uncertainties regarding the tax benefits of CAT bond issuances have accompanied the growth of the CAT bond market.[9] Most importantly, the economic viability of an issue relies on substantial care necessary to verify that the SPV is not subject to U.S. corporate tax law (Davidson (1998)).[10] However, today, there are a few factors that influence why CAT bond issuances benefit from tax laws: 1) Cummins (2008) notes that offshore CAT bonds may not pose taxation problems for their sponsors, and, furthermore, given the ambiguity of the tax treatment for CAT bonds by the Tax Code and the Internal Revenue Service, the premium payments by the sponsors are actually being deducted for income tax purposes just like insurance premiums; 2) Harrington and Niehaus (2003) argue that SPVs are beneficial because corporate tax costs are lower than financing with equity, and, furthermore, the bonds are not as risky as insurance because they are insensitive to insurer financial ratings[11]; and 3) similar to traditional corporate insurance demand theory, the issuance of CAT bonds can reduce a firm's expected tax burden by reducing the volatility of pre-tax income (Mayers and Smith (1990)). Given these findings, the tax benefits of CAT bonds should cause their issuance to have a positive impact on firm value.

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[9]Cummins (2005) states that uncertainties about the regulatory, accounting, and tax treatment (RAT) of ILS also has been a factor in impeding the development of the market. If the resolution of these issues levels the RATs playing field for ILS, the market can be expected to grow more rapidly.

[10] Cummins (2008), states that the bond's SPV's are also not taxable for U.S. federal income tax purposes, provided that they are not held to be "engaged in a U.S. trade or business."

[11] Harrington and Niehaus (2003), state that one important advantage of CAT bonds as a financing mechanism is that corporate tax costs are lower than for financing through equity and that the bond poses less risk in terms of potential future degradations of insurer financial ratings and capital structure than financing through subordinated debt.

3.2. Reduced Costs of Financial Distress and Reduced Probability of Bankruptcy

CAT bonds reduce the probability and associated costs of financial distress in a similar way to insurance, with some additional advantages. These unique advantages include: a) 100% collateralization and resulting elimination of counterparty credit risk relative to traditional insurance; b) the capacity and price are locked in for multiple periods and relatively resistant to insurance-related market cycles which results in risk transfer stability (McGhee et al. (2007)); c) claims payouts are likely to be faster compared to traditional insurance, especially with index-based triggers, because the available funds are more liquid and easier to access than traditional reinsurance; and d) the loss adjustment process is minimized (McGhee et al. (2007)). Given these characteristics, the reduction in financial distress costs and the probability of bankruptcy by the issuance of CAT bonds should result in a positive impact on firm value.

3.3. Ownership Structure

Given that event study methodology relies on trading data and is thus necessarily limited to publicly traded firms, this study is limited in its ability to draw inference about the effect of CAT bonds on all firms. With this limitation, the prediction as it relates to organizational structure is uncertain and should be addressed in future research. However, as noted earlier, current securities regulations do not favor the release of information regarding private CAT bond transactions, which discourages research by both academics and other third parties who may have interest (Cummins (2008)).

3.4. Investment Incentives

As shown in the capital structure literature of Myers (1977) and articles on the corporate demand for insurance such as Powell and Sommer (2007), the risk of catastrophic losses could cause equity-holders in a firm to reject certain positive net present value (NPV) projects because any potential benefits would primarily accrue to debt holders. Therefore, transferring this potential catastrophic risk to investors by way of fully collateralized CAT bonds reduces the expected cost of bypassing such projects and increases shareholder value.[12] Furthermore, the risk transfer provided by CAT bonds reduces the need for costly external capital after a catastrophic loss, when funds are likely to be most expensive. Considering these arguments, this study predicts that investment incentives from the issuance of CAT bonds will result in a positive impact on firm value.

3.5. Information Asymmetry

Since this study analyzes only publicly traded firms, information asymmetry between equity-holders, investors and the sponsors should be relatively low because of the disclosure requirements and the work done by analysts who track the firms (Pottier (1999)). However, according to Cummins (2008), current securities regulations do not favor the release of information regarding private CAT bond transactions, which would increase information costs related to private issuances. With these two theories counterbalancing one another, we cannot predict the impact on firm value with the information available.

3.6. Comparative Advantages in Real Services

The real services efficiencies theory suggests that insurance firms develop a comparative advantage in claims administration,[13] as well as offering loss control at cost levels not generally attainable on a stand-alone basis. Furthermore, insurers often purchase reinsurance because

[12] Mayers and Smith (1987) demonstrate that in certain cases, the purchase of insurance controls the underinvestment incentive.
[13] Mayers and Smith (1990), state that insurance firms develop a comparative advantage in processing claims because of scale economies and gains from specialization.

reinsurers typically have greater experience with low probability catastrophic events and subsequently provide insurers with critical information regarding proper pricing and claims processing procedures for such potential occurrences (Mayers and Smith (1990)). These comparative advantages are also relevant in CAT bond issuances, albeit from a different perspective. CAT bond issuances, which rely heavily on their financial ratings for pricing, are dependent on expert modeling of catastrophic perils by firms such as AIR Worldwide Corporation; EQECAT Inc.; and Risk Management Solutions, Inc. These firms provide real services that not only provide the investors with valuable information, but also add value for the equity-holders. The information provided by the modeling firms often include data on:

- The specific peril(s) included in the contract (e.g., U.S. Earthquake, U.S. Hurricane, European Windstorm, Japanese Earthquake);
- Specific details regarding the exposure data gathered for the risk model;
- Results of the models developed;
- Potential outcomes from stress testing of the peril model; and
- The existence and effect of multiple event triggers (e.g., 2nd or 3rd event triggers).[14]

Considering comparative advantages in real services also exist in CAT bond issuances, this study predicts that there will be a positive impact on firm value as a result of the expert modeling provided to the sponsor.

[14] Araya, Rodrigo, 2004, Moody’s Approach to Rating Catastrophe Bonds Updated, (Moody's Investors Services).

4. Data

The data for this study include 44 combined catastrophe securitization transactions between 1997 and 2007 – combined because some transactions included multiple tranches announced on the same announcement date. The 44 combined transactions under analysis were issued by 20 different firms across three industries (financial services, energy, and entertainment). Our data, gathered using multiple sources as discussed below, include the sponsor name, the special purpose vehicle (SPV) name, the catastrophe issuance date or news release date, the issuance size in U.S. dollars, the issuance rating, the trigger type, and the perils covered. Removed from the sample were obvious events that would compromise the integrity of the empirical analysis such as: 1) mergers and acquisitions that occurred prior to an event resulting in the delisting of the stock; 2) takedowns, because by nature they are meant to be issued over a period of time and are difficult to link to a single event date; 3) events with conflicting data in relation to dates or issuers involved in the issuance; and 4) non-catastrophe property and casualty issuances such as credit or auto insurance securitizations. Table 1 on the following page provides firm-specific and summary statistics about the sample.

Since dividend return data are not readily available for foreign firms and indices in our sample, we use daily returns excluding dividends for both firm returns and corresponding local market returns. For the multi-factor world market model described below, the local market returns for each firm are defined as daily local stock price returns excluding dividends for each firm from the home exchange of each firm (the stock returns are from Switzerland, the United States, Germany, the United Kingdom, and France). Furthermore, the domestic market indices used to control for country specific effects are as follows: Switzerland (SMI), the United States (S&P 500), Germany (DAX), the United Kingdom (FTSE), and France (CAC). Lastly, to capture world market effects, we use the Morgan Stanley Capital International World Index (MSCI) and the U.S. dollar price of foreign currencies for each country to index the change in exchange rates.

Table 1. Univariate Company Statistics

Company	Industry	Sales USD m	Employees	Market Cap USD m
AXA	Insurance	$160,392	96,009	$72,727
Allianz SE	Insurance	$152,196	N/A	$81,005
Lehman Brothers Holdings Inc.	Investment	$59,003	28,600	$30,159
The Allstate Corporation	Insurance	$36,769	36,800	$27,486
Swiss Reinsurance Company	Insurance	$34,775	10,891	$28,500
Vivendi Universal	Entertainment	$29,293	37,014	$48,224
Travelers Companies Inc.	Insurance	$26,017	33,300	$31,035
The Hartford Financial Services Group Inc.	Insurance	$25,916	31,000	$23,513
Dominion Resources, Inc.	Energy	$15,674	17,500	$24,600
The Chubb Corporation	Insurance	$13,568	10,800	$20,333
Hannover Re	Insurance	$12,157	1,988	$5,738
XL Capital Ltd.	Insurance	$9,136	3,772	$6,956
Brit Insurance Holdings Plc.	Insurance	$2,309	751	$1,479
Converium Ltd. (SCOR Re)	Insurance	$2,091	514	$2,427
Aspen Insurance Holdings Ltd.	Insurance	$2,008	444	$2,561
Hiscox Ltd.	Insurance	$1,980	637	$2,176
Endurance Specialty Holdings Ltd.	Insurance	$1,850	484	$2,460
Catlin Group Ltd.	Insurance	$1,456	185	$1,910
PXRE (Argo Group International Holdings Inc.)	Insurance	$1,000	N/A	$1,153
Montpelier Re Holdings Ltd.	Insurance	$736	N/A	$1,626
n		20	17	20
Mean		$29,416	18,276	$20,803
Standard Error		$10,326	5,976	$5,293
Median		$12,863	10,800	$13,645
Standard Deviation		$46,179	24,639	$23,672
Minimum		$736	185	$1,153
Maximum		$160,392	96,009	$81,005

Source: Factiva Current Financials (12/31)

As a proxy for the foreign exchange value of the U.S. dollar, the Major Currencies Index is used. Our data sources are the Center for Research in Securities Pricing (CRSP), Global Insight, and corporate websites. CRSP provided stock price information on available stocks and market indices such as U.S. stocks and the S&P 500 index. Global Insight provided global domestic indices, where available, and exchange data, where available. Global Insight also provided partial data on the MSCI World Market Index. MSCI was contacted directly for missing data. Global stock price data was gathered from corporate websites when no other source provided such data. Event dates and other issuance data were taken from: CAT bond market reports (McGhee et al. 2006, 2007), Moody's Investor Service, Factiva, LexisNexis, Business Source Complete, and corporate websites.

5. Methodology & Hypotheses

Event study methodology is based on the semi-strong form of the Efficient Market Hypothesis, which says that capital markets efficiently impound new information upon its public release, inducing abnormal returns to the extent that expected future cash flows would be impacted by the news. We employ both a multi-factor world market model event study methodology as presented by Park (2004) and a market model event study methodology as presented by MacKinlay (1997). MacKinlay's (1997) work provides the foundation of the event study empirical analysis in many studies such as Wilcox, Kuo-Chung and Grover (2001), Subramani and Walden (2001), and Park (2004).

5.1. Multi-factor World Market Model

The first stage of this study will employ a multi-factor world market model of Henderson (1990) and Park (2004) as the foundation for the analysis such that:

$$R_{ijt} = \alpha + \beta_i R_{mjt} + \gamma_i R_{wmt} + \delta_i X_{jt} + \varepsilon_{ijt}$$

where R_{ijt} is firm i 's stock return in its home country on day t , R_{mjt} is the domestic market index return in country j on day t, R_{wmt} is the world market index return on day t , and X_{jt} is the change in the foreign currency exchange rates in country j on day t . α , β_i , γ_i , and δ_i are firm specific parameters, and ε_{ijt} is a normally-distributed random-error term with $E[\varepsilon_{ijt}] = 0$ and $Var[\varepsilon_{ijt}] = \sigma_{ij}{}^2$. The multi-factor world market model is used for several reasons. Primarily, it provides a more robust analysis for a multi-national sample, allowing for the inclusion of factors beyond the domestic market. While the event study literature has shown that a multi-factor world market model provides only marginal explanatory power, it is most useful when the sample firms primarily come from a single industry and numerous markets, as in this study (MacKinlay (1997)). Furthermore, the market model may over-estimate changes in firm value, relative to the world market model, when applied to a multi-country event study and increase the probability of a Type I error (Park (2004)).

Once Equation (1) is estimated across the sample for the estimation period, the daily abnormal returns for the event period are calculated as follows:

$$A_{ijt} = R_{ijt} - (a_i + b_i R_{mjt} + g_i R_{wmt} + d_i X_{jt})$$

where A_{ijt} are the daily abnormal returns for firm i in country j on day t, and a_i, b_i, g_i, and d_i are the firm-specific multiple regression parameter estimates from Equation (1). Therefore, the abnormal returns for firm i in country j on day t are attuned for domestic market changes, world market changes, and movements in foreign currency exchange rates.

The event day t utilized in the study is the earliest of the announcement date, the close date, or the first press reference to the issue. The estimation window is day $t-175$ to day $t-20$ and event windows assessed in this study are day $t-10$ to day $t+10$ and day $t-1$ to day t.

To assess the aggregated events for the multi-factor world market model we test the calendar-time portfolio excess returns which are estimated with equation (3):

$$R_{pt} - R_{ft} = \alpha_p + b_p (R_{mt} - R_{ft}) + b_{1p} R_{wmt} + b_{2p} X_t + \varepsilon_t$$

In equation (3), the intercept α_p measures the daily average excess return of the firms after controlling for the three factors. The dependent variable $R_{pt} - R_{ft}$ is the daily average excess return of the calendar-time portfolio of firms; $R_{mt} - R_{ft}$ is the excess return of the market portfolio of firms; R_{wmt} is the excess return of the world market portfolio of firms; and X_t is the excess return of the exchange rate portfolio of firms. The standard errors are adjusted for possible heteroscedasticity caused by the variation in the number of firms in daily portfolios. To control for heteroscedasticity, the weighted regression method is applied. The weights are the reciprocal of the square root of the number of sample firms on each day.

The intent of the first stage is to utilize the Fama-French Multi-factor Test to determine whether the intercept, estimating the proportion of the mean daily abnormal return over the specified event window not explained by the three explanatory factors in the multi-factor world market model, has a statistically significant coefficient. Given that all factors discussed in section 3 are expected to lead to non-negative abnormal returns from issuing CAT bonds, the first proposed hypothesis is:

> *I) As a result of the theory on the corporate demand for insurance, a firm's market value will increase upon issuance of a CAT bond, while controlling for domestic market factors, world market factors, and exchange rate factors.*

This study will also test whether the multi-factor world market model, as presented in Park (2004), should be used for further empirical testing in this study. If the world market index return factor and the change in the foreign currency exchange rate factor are significant at the 5% level or better, the cross-sectional analysis study will include specifications that use abnormal returns from both the multi-factor world market model and the market model as dependent variables.

5.2. Market Model

The second stage of this study will employ a market model approach as presented by authors such as MacKinlay (1997). This is a simple version of the multi-factor world market model used in section 5.1. The market model utilized is as follows:

$$R_{ijt} = \alpha + \beta_i R_{mjt} + \varepsilon_{ijt}$$

where R_{ijt} is firm i 's stock return in its home country on day t and R_{mjt} is the domestic market index return in country j on day t. α and β_i are firm specific parameters and ε_{ijt} is a random-error term with $E[\varepsilon_{ijt}] = 0$ and $Var[\varepsilon_{ijt}] = \sigma_{ij}^{2}$.

Once Equation (4) is estimated, the daily abnormal returns for a market model event study are calculated as follows:

$$A_{ijt} = R_{ijt} - (a_i + b_i R_{mjt})$$

where A_{ijt} are the daily abnormal returns for firm i in country j on day t, and a_i and b_i are the firm-specific multiple regression parameter estimates from Equation (4). Therefore, the abnormal returns for firm i in country j on day t are adjusted for domestic market changes.

To assess significance of the aggregated events for the market model, this study utilized the Patell z Test as developed by Patell (1976).[15]

As stated in the hypothesis for the multi-factor world market model, all factors provided in section 3 suggest the value of risk management is expected to lead to increased firm value from issuing CAT bonds, which leads to the second proposed hypothesis:

[15] The Standardized Cross-sectional z Test and the Generalized Sign z Test were also completed for robustness. The tests are discussed in Appendix B.

II) As a result of the theory on the corporate demand for insurance, a firm's market value will increase upon issuance of a CAT bond, while controlling for domestic market factors.

5.3. Cross-sectional Model

In order to analyze the effect of a CAT bond issuance on firm value, the empirical approach utilized is ordinary least squares regression (OLS) as follows:

$$CAR_{i,T_1,T_2} = \alpha + BX_i + \varepsilon_i$$

where CAR_{i,T_1,T_2} represents the dependent variable for the cumulative abnormal return for event i during the event window (T_1, T_2). X_i is a vector of independent variables that are anticipated to have an effect on the dependent variable. α and B are intercept coefficients and ε_i is a random error term.

The CAR_{i,T_1,T_2} for event i during the event window (T_1, T_2) is calculated as follows:

$$CAR_{i,T_1,T_2} = \sum_{t=T_1 i}^{T_2 i} AR_{it}$$

where T_1, T_2 are the two event dates specific to event i. The dependent variable captures the cumulative change in firm value during a specific event window.

Market Cycle. A dummy variable is used for the catastrophic property and casualty loss years of 1998, 2001, and 2005 in order to compare CAT bond issuances for those years to issuances in non-catastrophe years (base case = 0). With insurance market capacity being challenged (decreasing supply) in catastrophe years, we expect CAT bond prices to increase in catastrophe years because of a surge of interest (increasing supply) in the market. The resulting price increase leads to the prediction that a reduction in firm value will follow the announcement of a CAT bond issuance in catastrophe years compared to non-catastrophe years.

Leverage. In order to test for leverage effects upon CAT bond issuance, the ratio of total liabilities to net worth at year end for each firm was used.[16] The impact of leverage is difficult to predict, since one would expect that firm value is decreasing in leverage. However, if CAT bonds' role as insurance dominates their role as debt, they may reduce the probability of bankruptcy and financial distress costs, resulting in a positive correlation between firm value and leverage. Considering these two points counterbalance one another, we do not have a prediction for leverage.

Bond Rating. Since bond rating is difficult to test in a setting where multiple tranches are often announced on the same date, with each tranche having a different rating, a dummy variable was used to compare investment grade issuances to non-investment grade issuances (base case = 0). An investment grade issuance is defined as an issuance where greater than 50% of the limits issued are rated BBB or better and a non-investment grade issuance encompasses the remainder. Since the CAT bond market has historically been driven by non-investment grade CAT bond issuances, we predict that bond rating, i.e., investment grade issuances compared to non-investment grade issuances, will not be a significant predictor of firm value.

Firm Size. The natural logarithm of firm total assets is used to proxy for experience and ability to issue CAT bonds. A CAT bond issuance requires the use of investment bankers, legal counsel, actuarial science professionals, risk management practitioners, and other professional resources for a successful issuance. Abnormal returns should be smaller for large firms because investments in them are less risky. Furthermore, since larger firms generally retain more risk,

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[16] Leverage may be difficult to measure consistently across firms due to the global nature of the sample used in the study and also the diverse accounting standards applied in different countries.

their CAT bond issuances should be higher rated, providing lower risk premiums to investors. Since larger firms can retain more risk at lower cost, we expect abnormal returns to be decreasing in firm size, signaling a lower effect on firm value resulting from CAT bond issuance. This study predicts a negative coefficient for firm size.

U.S. Issuer. U.S. Issuer is a dummy variable used to test the effect of U.S. firms issuing CAT bonds compared to non-U.S. firms (base case = 0). With globalization so prominent in the world today, and the firms in this study being large public companies, the expectation is that U.S. Issuer will not be significant.

Non-insurer Issuer. Non-insurer Issuer is a dummy variable used to test whether non-insurers compared to insurers (base case = 0) provide any abnormal return benefits surrounding a CAT bond issuance. The expectation is that non-insurers will receive greater increases in firm value around the announcement compared to insurers because of three reasons: 1) historical studies indicate that bond issuances increase firm value while equity issuances decrease firm value for both insurers and non-insurers; 2) the issuance will be perceived by non-insurance investors as innovative and value added while the issuance by insurers will be perceived as routine business much like the purchase of reinsurance; and 3) the issuance of CAT bonds by insurers does not provide the transparency of risk holdings desired by their investors because they are off-balance sheet transactions. If this expectation is correct, the prediction is that firm value will increase when investors perceive innovation and are provided proper transparency when investing in a firm.

Relative Issue Size. In order to proxy for relative issue size, the firm's cumulative CAT bond issuance on the event date is divided by the firm's total assets at year end of the event year in U.S. dollars. The sign on this variable is difficult to predict because very small ratios will likely have no impact on firm value, but as the ratio increases the sign will become positive to a neutral level which would encompass the range of investor favorable debt levels. However, once the ratio becomes very large it may be perceived as increasing leverage beyond investor favorable debt levels, which may lead to possible financial distress costs and a higher probability of bankruptcy, and a neutral to negative impact on firm value. The prediction is that relative issue size will likely be positive to some point and turn negative when the ratio reaches some significance; for this reason, there is no prediction for relative issue size.

Trigger Type. This study uses dummy variables to analyze whether or not diverse trigger types affect firm value differently. The analysis compares modeled loss triggers (base case = 0) to indemnity triggers, industry index triggers, and parametric index triggers.[17]

In general, there are three primary drivers regarding the effect of trigger type on firm value. First, CAT bond triggers with higher information costs compared to those with lower information costs, will have a lower positive impact on firm value at the close date of the bond issuance.[18] Furthermore, nonsystematic risks are diversifiable by shareholders, so firm-specific risk is of little concern to well diversified equity-holders in a widely-held public firm. Secondly, indemnity triggers, compared to non-indemnity triggers, require a greater risk spread premium[19], which, consequently, allows for greater positive abnormal returns for non-indemnity based triggers such as parametric index triggers, industry index triggers, and modeled loss triggers; with modeled loss triggers having the lowest basis risk of the index based triggers. Thirdly, basis

[17] With limited data available e.g. catastrophe bond prospectuses and other valuable information, it was impossible to breakout a hybrid based trigger dummy variable. This should be considered for future research.
[18] McGhee et al. (2007), states that indemnity triggers have the lowest basis risk of the triggers for sponsors; however, they have high information costs related to disclosure requirements and moral hazard costs. Also, hybrid triggers tend to have high information costs related to their complex development. Basis risk is highest for the triggers that use an underlying index to compute payouts i.e. parametric triggers, index triggers, and modeled loss triggers.
[19] Risk spread premium is a function of the form of business covered, the related modeling credibility issuance, the sponsor's ability to underwrite, risk management in place, and the loss and claims adjustment ability of the firm (McGhee et al. (2008)).

risk is inherent in the index based trigger types and moral hazard is intrinsic to the indemnity based trigger type, so, for example, if moral hazard is viewed as more (*less*) value depleting by the investor versus basis risk, then firm value will decrease (*increase*) when compared to index based trigger types with greater basis risk and lower moral hazard.

These three drivers lead us to our predictions. We predict that higher information cost triggers, such as indemnity triggers, will provide less positive results compared to non-indemnity triggers. Also, as discussed in the second paragraph above, if the risk spread premium is high for indemnity based triggers compared to non-indemnity triggers, the non-indemnity triggers will see greater positive abnormal returns compared to indemnity triggers. Finally, with modeled loss triggers providing the lowest basis risk, and arguably the lowest moral hazard of the triggers, we expect the greatest increase in firm value from this trigger type, compared to the other index based triggers and indemnity based triggers. Given these predictions, the sign of the parametric index trigger and the industry index trigger dummy variables are predicted to be negative when compared to the modeled loss trigger because of their greater inherent basis risk. Also, if risk spread premiums and information costs are high for indemnity triggers; then we would predict indemnity triggers to be negative when compared to the modeled loss trigger type. Lastly, we predict that the extra costs associated with the removal of moral hazard and firm specific risk, which is diversifiable at little or no cost by investors, will not be viewed as value increasing and result in a negative result for indemnity based triggers compared to modeled loss triggers.

Single Peril. Single Peril uses a dummy variable to assess whether or not single peril CAT bonds compared to multi-peril CAT bonds affect firm value differently. This study compares multi-peril bonds (base case = 0) to single peril bonds. As investors are able to diversify on their own, the prediction is that single peril will not be significant and not add to firm value.

6. Empirical Results

This section discusses the empirical findings on whether or not CAT bond issuances have an effect on firm value and what, if any, characteristics are significant predictors of firm value changes. We begin with a discussion on the multi-factor model results, followed by the market model results. Lastly, we conclude the empirical results section with a discussion regarding the cross-sectional model results.

6.1. Multi-factor Model Results

Alpha, or the intercept, estimates the element of the mean daily abnormal return over the event window that is not explained by the three explanatory factors in the multi-factor world market model. Given this, the results presented in Table 2 support the prediction that from the day before the CAT bond issuance through the actual issuance, firms receive a significant and positive excess return of 0.21% at the 5% level of significance using both the standard OLS test and the heteroskedasticity-consistent t-test.

Furthermore, during the 21-days surrounding the CAT bond issuance announcement, the firms receive a significant and positive excess return of 0.12% at the 5% level of significance. The result for the 21-day window is positive and significant at the 1% level using the heteroskedasticity-consistent t-test. This result is as predicted in hypothesis I, showing that the announcement of a CAT bond issuance induces a positive abnormal return, consistent with the corporate demand for insurance and risk management theory.

Table 2. Multi-factor World Market Model Results

Custom Factor Calendar-Time Portfolio Regressions						
Coefficients	**Average Day in (-1,0)**			**Average Day in (-10,10)**		
	Estimate	**OLS t**	**HS t**	**Estimate**	**OLS t**	**HS t**
Intercept	0.0021	1.97**	2.04**	0.0012	2.29**	2.35***
Domestic Market	0.8050	5.57***	3.48***	0.8975	11.83***	8.12***
World Market	0.0123	0.05	0.03	0.0946	0.89	0.88
Foreign Exchange	-0.0029	-0.89	-1.15	-0.0000	-0.05	-0.18
R-squared		43.41%			30.90%	

Notes: Day 0 is the earliest of the announcement date, the close date, or the first press reference to the issue. HS t - heteroskedasticity-consistent t-test. N=44.

*Significant at the 10% level

**Significant at the 5% level

***Significant at the 1% level

6.2. Market Model Results

As indicated in the methodology section, and for robustness, it was necessary to empirically test the data with both the multi-factor world market event study methodology as well as the market model event study methodology. Table 3 presents the results of the market model.

The findings in Table 3 provide strong support for hypotheses II. In particular, the Patell z Test is positive and significant at the 10% level for the window (-1, 0).[20] These results reinforce

[20] Also supporting Hypothesis II, the Standardized Cross-sectional z Test (cross sectional variance correction) and the Generalized Sign z Test (non-parametric test) results are positive and significant at the 5% level.

the findings of the multi-factor world market model that around the announcement of a CAT bond issuance, a positive and significant abnormal return is present, consistent with the theory of the corporate demand for risk management and insurance.[21]

Table 3. Market Model Results

Market Model, Equally Weighted Index Excluding Dividends				
Days	**Cumulative Average Abnormal Return**	**Patell z**	**StdCsect z**	**Generalized Sign z**
(-10,+10)	2.60%	0.950	1.075	1.597*
(-1,0)	0.52%	1.594*	2.110**	2.071**
(-1,+1)	0.49%	1.143	1.482*	1.156

Notes: Day 0 is the earliest of the announcement date, the close date, or the first press reference to the issue. N=44.

*Significant at the 10% level

**Significant at the 5% level

***Significant at the 1% level

[21] With Swiss Re representing 19 of the 44 events studied, empirical analyses were performed to test whether or not Swiss Re had a significant impact on the results by testing for an increase in firm value around the catastrophe bond announcement with and without Swiss Re events. The findings provided evidence that Swiss Re events were not driving the positive and significant results in the multi-factor world market model or the market model results. However, when the OLS regression was performed, a Swiss Re dummy variable was added and it was negative and significant at the 10% level for the (-1, 0) window, which would actually mitigate a positive and significant return.

6.3. Cross-sectional Model Results

The results from the OLS regression are presented in Table 4. Thirty-six events were utilized in the OLS regression because 6 of the events did not contain pertinent trigger details in order to complete the regression and 2 of the events contained stand alone perils which were not U.S. exposures, unlike the other 36 events. The 2 removed events contained the stand alone perils of Germany wind and Mediterranean earthquake. Since these two perils are, for CAT bond modeling and pricing purposes, quantitatively different from U.S. exposure issuances due to their geographic demand, market demand, and exposure demand, their inclusion in the OLS model would jeopardize the interpretation of the results. The Adjusted R-squared for the models range from 23.28% to 41.31%.

Market Cycle. On the one hand, the high catastrophe market cycle dummy variable was negative for the (-10, 10) window, although the result is not significant. This finding does not support the prediction that supply and demand (i.e., market cycle), impact CAT bond issuances in a similar manner as compared to traditional insurance.

On the other hand, but not as predicted, the high catastrophe market cycle dummy variable was positive and highly significant for the (-1, 0) window. Upon reflection, this is likely a result of market specific effects. In other words, the (-10, +10) window is impacted by broader market reactions to an issuance; more of a true market capacity supply and demand response. However, the smaller event window picks up firm specific effects such as the need, and then the ability to attain catastrophe capacity in a hardening market, which protects a firm from possible financial distress costs related to future catastrophic losses. This would result in a positive and significant response for the (-1, 0) event window.

Firm Size. The firm size variable is negative and significant at the 5% level for the (-10, +10) window and negative and significant at the 10% level for the (-1, 0) window. This result is as predicted and supports the assertion that larger firms generally have greater resources, experience, and are able to retain more risk. Historically, CAT bonds have been seen as providing sizeable returns to investors because of high risk premiums, and investors have sought riskier issuances for higher returns. This point further reinforces that CAT bond issuances by less risky firms result in smaller increases in firm value, i.e., investors in large low risk firms prefer risk retention over risk transfer.

Non-insurer Issuer. Another variable of significant interest is the non-insurer issuer dummy variable. This variable was significant and positive at the 5% level for both windows assessed. As predicted, non-insurance firms realized larger increases in firm value around the issuance of CAT bonds than insurance firms. This result supports the prediction that investors in non-insurance firms, compared to insurance firms, find CAT bond issuances as innovative, while issuances by insurance firms are considered more routine. Furthermore, and as discussed earlier, since the issuance of CAT bonds by insurers are off-balance sheet transactions, investors may not respond as positively due to reduced transparency, resulting in a greater increase in firm value for non-insurance firms compared to insurance firms.[22]

Relative Issue Size. As predicted, the relative issue size variable is not significant for the (-10, +10) window. This finding reinforces the suggestion that small ratios may have no impact on firm value, while very large ratios could be perceived as increasing leverage and possible financial distress costs, which would result in a reduction in firm value, i.e., the relationship is likely unimodal.

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[22] Note, there are 4 non-insurers in the sample studied which should be considered when interpreting the results of this study.

However, the (-1, 0) window is significant and negative at the 5% level, which was not predicted. This would mean the relationship is not unimodal and provides more of a negative linear trend than anticipated. This result can also be explained by market versus firm specific responses as well. In other words, the market responds to CAT bond issuances, in general, in a more unimodal relationship to relative issue size, however, larger firms are penalized for not retaining risk, as evidenced by the negative and significant result for this window. This finding is further reinforced by the addition of the Swiss Re dummy variable which is significant at the 10% level for the (-1, 0) window and not significant for the (-10, +10) window.

Trigger Type. The trigger type dummy variables, in particular, provided some compelling results. When comparing the parametric index trigger type and the industry index trigger type to the base case modeled loss trigger type, the variables are significant and negative at the 5% level and the 1% level respectively for the (-10, +10) window. This result is as predicted because both the parametric index trigger type and the industry index trigger type provide greater basis risk for investors, compared to the modeled loss trigger type, which increases possible financial distress costs and the probability of bankruptcy due to a catastrophic loss. This finding supports the prediction that investors prefer low basis risk, compared to high basis risk, which results in an increase in firm value.[23] Lastly, the indemnity trigger type is significant and negative at the 5% level when compared to the modeled loss trigger type. Not surprisingly, this finding supports the hypothesis that investors prefer low information costs, low risk spread premiums, low moral hazard, and low basis risk, as provided by the modeled loss trigger type compared to the indemnity based trigger type.

[23] It is important to note that few indemnity based trigger types were tested due to the historical low frequency of usage during the sample period. Also, as suggested earlier, with limited data available e.g. catastrophe bond prospectuses and other valuable information, it was impossible to breakout a hybrid based trigger dummy variable. This should be considered for future research.

Single Peril. Lastly, the single peril dummy variable, compared with the multi-perils dummy base case, provided no significant predictive power with respect to firm value when controlling for other factors for either window tested. This result is as predicted and is due to the fact that investors are able to diversify investment portfolios on their own at virtually no cost, so a firm managing firm specific risks adds no firm value.

Table 4. Cross-sectional Model Results

Variable	**CAR (-1,0)**		**CAR (-10,+10)**		**Predicted Sign**
Intercept	0.031	0.026	0.315***	0.308***	+/-
	(0.021)	*(0.021)*	*(0.098)*	*(0.010)*	
Market Cycle	0.018***	0.022***	-0.048	-0.041	-
	(0.005)	*(0.006)*	*(0.030)*	*(0.031)*	
Firm Size	-0.003*	-0.022	-0.019**	-0.017**	-
	(0.002)	*(0.006)*	*(0.008)*	*(0.008)*	
U.S. Issuer	0.007	-0.000	-0.026	-0.037	+/-
	(0.005)	*(0.006)*	*(0.029)*	*(0.036)*	
Non-insurer Issuer	0.023**	0.017**	0.123**	0.113**	+
	(0.009)	*(0.007)*	*(0.057)*	*(0.055)*	
Relative Issue Size	-0.214**	-0.217**	-0.393	-0.400	+/-
	(0.084)	*(0.081)*	*(0.621)*	*(0.615)*	
Parametric Index Trigger	0.001	0.003	-0.083**	-0.080**	-
	(0.007)	*(0.006)*	*(0.036)*	*(0.035)*	
Industry Index Trigger	0.009	0.010**	-0.099***	-0.097***	-
	(0.006)	*(0.005)*	*(0.033)*	*(0.032)*	
Indemnity Trigger	0.003	0.002	-0.107**	-0.109**	-
	(0.006)	*(0.005)*	*(0.051)*	*(0.050)*	
Single Peril	-0.008	-0.005	0.027	0.031	+/-
	(0.006)	*(0.006)*	*(0.020)*	*(0.021)*	
Swiss Re		-0.014*		-0.020	
		(0.007)		*(0.027)*	
Adjusted R^2	23.28%	27.13%	41.31%	39.50%	

Notes: The CARs used as dependent variables are from the market model. Heteroskedasticity-consistent standard errors are reported in parentheses. N=36.[24,25,26,].

*Significant at the 10% level

**Significant at the 5% level

***Significant at the 1% level

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[24] Research found that diverse accounting methods were used across global companies in the sample, which made the Leverage variable suspect in the model. Leverage was also highly correlated with Firm Size at the <.0001 level of significance, so it was not included in the final model.

[25] Bond Rating was not included in the final model because of its weak power and lack of significance. The vast majority of catastrophe bond issuances in our sample are below investment grade.

[26] Variance Inflation Factors were calculated to test for multicollinearity and the results provided VIFs between 0 and 2.43 for the window (-10, +10) and between 0 and 2.56 for the window (-1, 0) for the independent variables. These results provided evidence of low multicollinearity.

7. Conclusions

Catastrophe securitization issuances have increased dramatically since 2004. This new momentum has created a CAT bond market that compares to the catastrophe-property reinsurance market in capitalization. Furthermore, the increasing volume of transactions has created greater interest from non-traditional CAT bond investors such as non-institutional investors and academics.

This study uses both a multi-factor market model and a market model event study methodology to empirically test 44 CAT bond issuance events over a 10-year period between 1997 and 2007. As predicted, the event window $t-1$ to day t was positive and significant at the 5% level of significance around the announcement of a CAT bond issuance. Quantitatively similar results emerge from both the multi-factor market model and the standard market model, suggesting robust results.

Lastly, the cross-sectional empirics also provided interesting results. As predicted, firm size was significant and negative at the 5% level of significance. This finding reinforces the fact that CAT bond issuances by less risky firms result in smaller increases in firm value due to investors' desire for risk retention by low risk firms. Furthermore, non-insurer issuer was significant and positive at the 5% level of significance. This finding reinforces our assertion that investors view CAT bonds issued by non-insurance firms as innovative and that insurance firm issuers receive less value due to transparency issues when compared to non-insurer issuers. Our findings with regard to trigger type support the hypothesis that investors prefer low information costs, low risk spread premiums, low moral hazard, and low basis risk, as provided by the modeled loss trigger type compared to the indemnity, parametric index, and industry index triggers.

Catastrophe securitization is a fast and growing tool of risk management. As more data becomes available, future empirical research will be possible, unless government regulation continues to suppress curious minds by regulating the relatively private catastrophe securitization process.

References

American Academy of Actuaries, 1999, Evaluating the Effectiveness of Index-Based Insurance Derivatives in Hedging Property/Casualty Insurance Transactions, *Report of the Index Securitization Task Force* (Washington, DC), 1-42.

Ali, Paul Usman, 2000, GIO, Earthquakes and Hurricanes: An Overview of Catastrophe-Linked Securities and Other Innovations, *Company and Securities Law Journal,* 18: 62-66.

Araya, Rodrigo, 2004, Moody's Approach to Rating Catastrophe Bonds Updated, (Moody's Investors Services).

Berger, Lawrence A., J. David Cummins, and Sharon Tennyson, 1992, Reinsurance and the Liability Crisis, *Journal of Risk and Uncertainty,* 5: 253-272.

Boehmer, Ekkehart, Jim Musumeci, and Annette B. Poulsen, 1991, Event-study methodology under conditions of event-induced variance, *Journal of Financial Economics,* 30: 253-272.

Borden, Sara, and Asani Sarkar, 1996, Securitizing property catastrophe risk, *Current Issues in Economics & Finance,* 2: 1-6.

Brown, Stephen J., and Jerold B. Warner, 1985, Using Daily Stock Returns: The Case of Event Studies, *Journal of Financial Economics,* 14: 3-31.

Burnecki, Krzysztof, Kukla Grzegorz, and David Taylor, 2005, Pricing of Catastrophe Bonds, *Statistical Tools in Finance & Insurance*, 93-114.

Canabarro, Eduardo, Markus Finkemeier, Richard R. Anderson, and Fouad Bendimerad, 2007, Analyzing Insurance-Linked Securities, *The Journal of Risk Finance,* 1-27.

Chichilnisky, Graciela, and Geoffrey Heal, 1998, Managing Unknown Risks, *Journal of Portfolio Management,* 24: 85-91.

Cowan, Arnold Richard, 1992, Nonparametric Event Study Tests, *Review of Quantitative Finance & Accounting,* 2: 343-358.

Cowan, Arnold R., 2005, Eventus Software, (Cowan Research LC, Ames, Iowa).

Cummins, J. D., D. Lalonde, and R. D. Phillips, 2004, The Basis Risk of Index-Linked Catastrophic Loss Securities, *Journal of Financial Economics,* 71: 77-111.

Cummins, J. David, 1999, The Insurance Link to Securities, *Risk Management,* 46: 17-21.

Cummins, J. David, 2005, Convergence in Wholesale Financial Services: Reinsurance and Investment Banking, *Geneva Papers on Risk & Insurance - Issues & Practice,* 30: 187-222.

Cummins, J. David, 2007, CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments, (Temple University), 1-43.

Cummins, J. David, 2008, CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments, *Risk Management & Insurance Review,* 11: 23-47.

Davidson Jr, Ross J., 1998, Working Toward a Comprehensive National Strategy for Funding Catastrophe Exposures[a], *Journal of Insurance Regulation,* 17: 134-170.

Duffie, D. and Singleton, K.J., 1999, Modeling Term Structures of Defaultable Bonds, *The Review of Financial Studies,* 12(4): 687-720.

Etherington, Geoffrey and Marc S. Voses, 2004, Cat Bonds & Risk Modeling, *Risk Management,* 51, 44.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen, 1988, Financing Constraints and Corporate Investment, *Brookings Papers on Economic Activity,* 141-206.

Froot, Kenneth A., 2001, The market for catastrophe risk: a clinical examination, *Journal of Financial Economics,* 60: 529-571.

Garven, James R. and Joan Lamm-Tennant, 2003, Demand for Reinsurance: Theory and Empirical Tests, *Assurances,* 7: 217-238.

Harrington, Scott E., and Greg Niehaus, 2003, Capital, corporate income taxes, and catastrophe insurance, *Journal of Financial Intermediation,* 12: 365-389.

Hartwig, Robert P., 2008, Catastrophes, the Credit Crisis & Insurance Cycle Impacts & Implications for the P/C Insurance Industry, (Institute, Insurance Information).

Haw, In-Mu, and Victor S. Pastena, 1990, Market Manifestation of Nonpublic Information Prior to Mergers: The Effect of Ownership Structures, *Accounting Review,* 65: 432-451.

Henderson Jr, Glenn V., 1990, Problems and Solutions in Conducting Event Studies, *Journal of Risk & Insurance,* 57: 282-306.

Hoyt, R. E. and H. Khang, 2000, On the Demand for Corporate Property Insurance, *Journal of Risk and Insurance,* 67: 91-107.

Hoyt, Robert E. and Kathleen A. McCullough, 1999, Catastrophe Insurance Options: Are They Zero-Beta Assets?, *Journal of Insurance Issues,* 22: 147-163.

Hoyt, R.E. and R.D. Williams, 1995, The Effectiveness of Catastrophe Futures as a Hedging Mechanism for Insurers, *Journal of Insurance Regulation,* 13: 27-64.

Jarrow, R.A. and Turnbull, S., 1995, Pricing Options on Financial Securities Subject to Default Risk, *Journal of Finance,* 50: 53-86.

Jean-Baptiste, Eslyn L., and Anthony M. Santomero, 2000, The Design of Private Reinsurance Contracts, *Journal of Financial Intermediation,* 9: 274-297.

Kau, J.B. and Keenan, D.C., 1996, An Option-Theoretic Model of Catastrophes Applied to Mortgage Insurance, *Journal of Risk and Insurance*, 63(4): 639-656.

Lane, M., and R. Beckwith, 2006, How High Is Up: The 2006 Review of the Insurance Securitization Market, (Lane Financial LLC).

Lane, M., and R. Beckwith, 2007, That Was the Year that Was! The 2007 Review of the Insurance Securitization Market, (Lane Financial LLC).

Laster, David S., 2001, Capital Market Innovation in the Insurance Industry Sigma, (Swiss Reinsurance Company).

Lee, Jin-Ping and Min-Teh Yu, 2007, Valuation of Catastrophe Reinsurance with Catastrophe Bonds, *Insurance: Mathematics & Economics,* 41: 264-278.

Lee, Jin-Ping and Min-Teh Yu, 2002, Pricing Default-Risky Cat Bonds with Moral Hazard and Basis Risk, *Journal of Risk & Insurance,* 69: 25-44.

Linn, Scott C., and John J. McConnell, 1983, An Empirical Investigation of the Impact of 'Antitakeover' Amendments on Common Stock Prices, *Journal of Financial Economics,* 11: 361-399.

MacKinlay, A. Craig, 1997, Event Studies in Economics and Finance, *Journal of Economic Literature,* 35: 13-39.

Main, B. G. M., 2000. Large Companies and Insurance Purchases: Some Survey Evidence. *The Geneva Papers on Risk and Insurance,* 25: 235-250.

Mayers, David, and Clifford W. Smith Jr, 1982, On the Corporate Demand for Insurance, *Journal of Business,* 55: 281-296.

Mayers, David, and Clifford W. Smith Jr, 1990, On the Corporate Demand for Insurance: Evidence from the Reinsurance Market, *Journal of Business,* 63: 19-40.

McGhee, Christopher, Justin Faust and Ryan Clarke, 2006, The Catastrophe Bond Market at Year-End 2005: Ripple Effects from Record Storms, (Guy Carpenter & Company, LLC and MMC Securities Corp.).

McGhee, Christopher, Ryan Clarke and Joseph Collura, 2007, The Catastrophe Bond Market at Year-End 2006, (Guy Carpenter & Company, LLC and MMC Securities Corp.).

McGhee, Christopher, Ryan Clarke, John Fugit and Jeffrey Hathaway, 2008, The Catastrophe Bond Market at Year-End 2007, (Guy Carpenter & Company, LLC and MMC Securities Corp.).

McWilliams, Abagail, and Donald Siegel, 1997, Event Studies in Management Research: Theoretical and Empirical Issues, *Academy of Management Journal,* 40: 626-657.

Myers, Stewart C., 1977, Determinants of Corporate Borrowing, *Journal of Financial Economics,* 5: 147-175.

Park, Namgyoo K., 2004, A Guide to Using Event Study Methods in Multi-Country Settings, *Strategic Management Journal,* 25: 655-668.

Patell, James M., 1976, Corporate Forecasts of Earnings per Share and Stock Price Behavior: Empirical Tests, *Journal of Accounting Research,* 14: 246-276.

Pennay, Richard, 2007, Market loss index for Europe – Expanding capital market capacity, (Swiss Reinsurance Company).

Pottier, Steven W., and David W. Sommer, 1999, Property-Liability Insurer Financial Strength Ratings: Differences Across Agencies, *Journal of Risk and Insurance,* 66: 621-642.

Powell, Lawrence, and David Sommer, 2007, Internal Versus External Capital Markets in the Insurance Industry: The Role of Reinsurance, *Journal of Financial Services Research,* 31: 173-188.

Rieck, Olaf and Canh Thang Doan, 2007, Shareholder Wealth Effects of Mergers & Acquisitions in the Telecoms Industry, (Nanyang Technological University, Singapore).

Schipper, Katherine, and Abbie Smith, 1986, A Comparison of Equity Carve-outs and Seasoned Equity Offerings: Share Price Effects and Corporate Restricting, *Journal of Financial Economics,* 15: 153-186.

Subramani, Mani, and Eric Walden, 2001, The Impact of E-Commerce Announcements on the Market Value of Firms, *Information Systems Research,* 12: 135-154.

Tynes, Johannes Skylstad, 2000, Catastrophe Risk Securitization, *Journal of Insurance Regulation,* 19: 3-27.

Vaugirard, Victor E., 2003, Pricing Catastrophe Bonds by an Arbitrage Approach, *Quarterly Review of Economics & Finance,* 43: 119-133.

Wattman, Malcolm P., and Kimberly Jones, 2007, Insurance Risk Securitization, *Journal of Structured Finance,* 12: 49-54.

Wilcox, H. Dixon, Chang Kuo-Chung, and Varun Grover, 2001, Valuation of mergers and acquisitions in the telecommunications industry: a study on diversification and firm size, *Information & Management,* 38: 459-471.

Yamori, N., 1999. An Empirical Investigation of the Japanese Corporate Demand for Insurance. *Journal of Risk and Insurance*, 66: 239-252.

Appendices

A. CAT Bond Market and History

CAT bonds were first introduced as a solution to problems resulting from traditional insurance market capacity constraints, excessive insurance premia, and insolvency risk due to catastrophic losses. Hurricane Andrew in 1992 first triggered attempts to utilize the securities markets as a risk transfer mechanism for potential low probability catastrophic events. Cummins (2008) says that the first CAT bond transactions were initiated by the Chicago Board of Trade (CBOT), originally as futures contracts and later as put and call options.[27] In 1997, the Bermuda Commodities Exchange (BCE) made another attempt at developing a catastrophe options market. Both of these attempts failed because the limited market size did not allow sufficient diversification of counterparty credit risk, reinsurance relationships, and significant basis risk. A study completed by the American Academy of Actuaries in 1999 confirmed that basis risk was a real concern for insurers seeking these contracts and that unacceptable basis risk was the primary driver mitigating the development of the CAT-loss securities market (Cummins (2004)). In 2007, the Chicago Mercantile Exchange (CME) and the New York Mercantile Exchange (NYMEX) each offered CAT bonds to provide additional risk transfer capacity in the wake of approximately $80 billion in losses from 7 of the 10 most expensive hurricanes in U.S. history

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[27] See also Hoyt and Williams (1995) for a discussion of estimating hedge ratios using CBOT insurance options and Hoyt and McCullough (1999) for an evaluation of whether catastrophe options are zero-beta assets.

between August 2004 and October 2005 (Hartwig (2008)). However, the underlying geographic parameters were so broad that substantial basis risk remained.

Hannover Re sold the first successful over-the-counter CAT bond, an $85 million issuance, in 1994 (Laster (2001)) and the first non-financial firm to issue a CAT bond was Oriental Land Company, which transferred some of its earthquake exposure to the securities markets in 1999. While few non-financial firms have issued such securities since, public utility company Dominion Resources placed a $50 million issuance in 2006 (McGhee et al. (2007)).

The increase in activity from 2005-2007 noted in figure 1 was not a surprise, resulting in part from the estimated $142 billion capital shortfall in the property insurance and reinsurance market caused by the 2004-2005 hurricane seasons (McGhee et al. (2008))[28].

The successful placements of 2006 increased knowledge, market liquidity, and demand for CAT bonds, which continued into 2007. This increase in market size, combined with the relative lack of correlation with other asset classes, made CAT bonds increasingly attractive diversification tools (McGhee et al. (2008)). The success of the market was made more prominent when KAMP Re 2005 Ltd. acknowledged a quick and relatively painless $190 million settlement on a CAT bond tied to losses from Hurricane Katrina (McGhee et al. (2006)). Lane (2006) acknowledges that CAT bond losses had been paid out prior to the KAMP Re bond, but they are not on public record.

Figure 2 highlights the significant growth of the CAT bond market, showing the relative contribution of cat bond limits to the total market capacity by year (McGhee et al. (2008)). For example, in 1997 cat bonds only contributed 3% of total market capacity, while in 2007 the

[28] As McGhee et al. (2008) said, "The capital shortfall estimate was provided in June 2006 by Risk Management Solutions, Inc. and is composed of USD60 billion of losses related to Hurricanes Katrina, Wilma and Rita and an additional USD82 billion to reflect the increased perception of hurricane activity rates and required capital levels. Record profits elsewhere in the industry helped to offset capital shortfalls."

market contributed 32% of total market capacity, which is almost a 1000% increase in relative utilization[29].

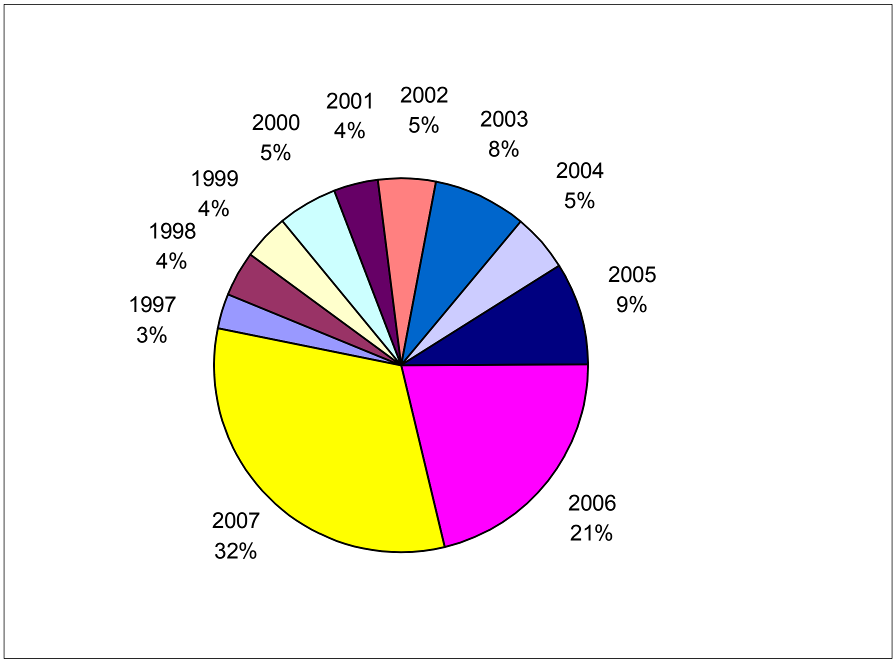

Figure 2. Contribution of Cat Bond Limits to Total by Year

Proportion of total CAT bond market generated by year.

Source: GC Securities

[29] For more historical details and data see McGhee et al. (2007, 2008), Cummins (2005, (2008), Laster (2001), Pennay (2007), and Lane (2006).

B. Other Tests for Robustness

The Standardized Cross-sectional z Test: The Standardized Cross-sectional z Test is very similar to the Patell z test but there is an empirical cross-sectional variance correction that is applied (Boehmer, Musumeci and Poulsen (1991)). Boehmer, Musumeci and Poulsen (1991) provide evidence that this test is more robust than the Cross-sectional Standard Deviation test utilized by such authors as Brown and Warner (1985). The firm portfolio test statistic for event day t is:

$$t = \frac{AAR_t}{s_{AAR_t} \big/ \sqrt{N}}$$

where

$$s^2_{AAR_t} = \frac{1}{N-1}\sum_{i=1}^{N}\left(A_{it} - \frac{1}{N}\sum_{j=1}^{N} A_{jt}\right)^2 .$$

This provides the estimated variance for $CAAR_{T_1,T_2}$:

$$s^2_{CAAR_{T_1,T_2}} = \frac{1}{N-1}\sum_{i=1}^{N}\left(CAR_{i,T_1,T_2} - \frac{1}{N}\sum_{j=1}^{N} CAR_{j,T_1,T_2}\right)^2 .$$

Finally, the Standard Cross-sectional z test statistic is calculated as follows:

$$t_{CAAR} = \frac{CAAR_{T_1,T_2}}{s_{CAAR_{T_1,T_2}} \big/ \sqrt{N}} .$$

All factors provided in section 6 suggest the value of risk management is expected to lead to increased (or neutral) firm value from issuing CAT bonds.

Generalized Sign z Test: Considering daily stock returns may not necessarily follow the normal distribution for all firms in this study, a non-parametric test can be used in combination with the parametric tests to assess the prior results for robustness. This test avoids the dependence on normality of stock return distributions (Cowan (1992)). The main concern with failing to reject results from the parametric tests alone is that the study's results can be dominated by outliers (Rieck (2007)). The Generalized Sign Test uses the normal approximation to the binomial distribution to compare the percentage of positive abnormal returns around the event day to the proportion of abnormal returns from the estimation period. The null hypothesis in this test is that the percent of positive returns in the estimation period is the same as around the event day. Rieck (2007) provides the example, if 50% of returns are positive during the estimation period, and 70% of firms have a positive return on day t, the test checks for whether or not the difference between 50% and 70% is statistically significant. Again, all factors provided in section 6 suggest the value of risk management is expected to lead to increased (or neutral) firm value from issuing CAT bonds.