2007

Risk Management through Derivatives Securitization

Stefan Filip '07
Illinois Wesleyan University

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Stefan Filip
Research Honors 2007
Dr. Jin Park

Abstract: With the fluctuations in the financial markets reaching tens of billions of dollars in just one day, using complex financial instruments instead of typical insurance could be more effective and cheaper to finance high-severity and low frequency risk exposures. Insurance-linked derivatives such as catastrophes bonds and weather bonds have been used for some time in the United States and European Union. The risks that they cover vary from property catastrophes, weather, general liability, and extreme mortality risks. As the number of issuers for these securities increases and new over-the-counter (OTC) products appear on the secondary markets there is a growing need to understand how they should be priced and considered by law. I intend to analyze the methods of pricing as well as creating a model for a weather derivative for the Illinois corn production and test its impact based on past statistical data

Introduction

The capital and insurance market have been converging in sectors that benefit both investors and insurance companies. The insurance market can be an option to investors since the insurance industry's performance is uncorrelated with the performance of the capital market. At the same time the capital market can provide additional capital that will help expand and strengthen the insurance and reinsurance market's financial condition. According to the Insurance Information Institute (2006), the U.S. Property/Casualty insurance industry has total surplus, "the broadest measure of claims-paying capacity," was $427.1 billion at the end of 2005. Hurricanes Katrina and Rita resulted in over $66 billion insured loss, which is about 15.5% of the surplus. Table 1 shows the ten most costly catastrophic events in the world. We can see how vulnerable the insurance market is to a catastrophic event and we can easily justify the need of an additional source for capital to maintain its financial stability after an extreme loss.

Investment Company Institute (2006) reports that the value of total worldwide assets invested in mutual funds is about $17.8 trillion, and the U.S. alone accounts for $8.9 trillion. Some 3,000 companies listed on the NYSE have a combined market capitalization of over $15 trillion, and the market value produced by DOW Jones Industrial average or SP500 changes by a percent is about $150 billion, two times more than the loss caused by Hurricane Katrina and Rita combined in 2005. Compared to the reactions from two hurricanes, a decrease in one percent of the value of the capital appears ordinary as economical news. Therefore, insurance securitization using capital market could offer a more efficient and diversified mechanism for financing catastrophic events (Vaugirard, 2003).

Figure 1: Top 10 most costly world catastrophes

Rank	Date	Type	Insured loss ($ MM)
1	Aug-05	Hurricane Katrina	[illegible]
2	Aug-92	Hurricane Andrew	$22,987
3	Sep-01	Terrorist attack on WTC	[illegible]
4	Jan-94	Earthquake Northridge	$19,040
5	Sep-04	Hurricane Ivan	[illegible]
6	Oct-05	Hurricane Wilma	$12,953
7	Sep-05	Hurricane Rita	[illegible]
8	Aug-04	Hurricane Charley	$8,590
9	Sep-91	Typhoon Mireille	[illegible]
10	Sep-89	Hurricane Hugo	$7,434

(Source: Swiss Re, sigma, No. 2/2007)

The capital market got involved in the insurance industry providing additional capital through different approaches: traditional insurance, contingent financing and securitization. Traditional insurance and contingent financing provide typical insurer/reinsurer agreements and credit lines for reinsurance. Insurance securitization brings a new perspective to the reinsurance industry. There are three major types of securitizations for catastrophe risk: credit-risk securitizations, synthetic reinsurance and weather derivatives. These types of financial instruments are also referred to as insurance-linked securities. Insurance securitization provides investors new investment opportunity that is not correlated to other capital markets. Thus, investors can create more diversified portfolio.

One of the most important reasons why these new type of securities are popular is because of the additional reinsurance capacity it brings to the market. For major insurance companies it can be difficult to obtain enough reinsurance to cover major events that have the potential to wipe out much of its surplus. Due to the extra need of capital that has developed in the last decade, insurance-linked securities are now needed to provide adequate protection. This seems only as a natural step after the Bermuda market began in the late 80s to provide reinsurance options, thus bringing capital into the industry that now appears insufficient.

Credit quality is also an important factor when deciding between catbonds and reinsurance. Since for catbonds, the party issuing the bonds is already in possession of the principal invested in liquid treasury securities, there is no risk of access. However, for reinsurance, companies sometimes need to purchase reinsurance from several companies simultaneously to ensure that they will have access to the funds. Therefore, a properly designed insurance-linked security will have a greater credit quality than conventional reinsurance. Ultimately, companies risk mangers could feel that they do not have enough coverage for a specific peril. In many cases like this, an additional layer above the reinsurance, covered by a catbond will provide the extra margin of safety required by the company.

Credit Risk Securitization and Synthetic Reinsurance

The credit-risk securitization involved the creation of a special purpose vehicle (SPV) or trust that will issue the bonds, and manages the raised capital. The bonds are sold to investors, capital markets, to raise the targeted amount, to which the insurance company has a collateral accession right. The SPV will invest the raised capital in a highly secure portfolio composed mainly of U.S. treasury bills. If no catastrophic event occurs, the investors will receive their initial investment plus promised returns from the SPV. If a catastrophic event occurs, then the insurance company has access to the fund raised by the SPV from the sale of the bonds, but needs to issue surplus notes or other securities to the investors. The investors will then receive returns on the surplus notes. However, this type of securitization is similar to a credit line since the insurance company has to ultimately pay its losses and not be reimbursed. This type of structure is presented in Figure 2.

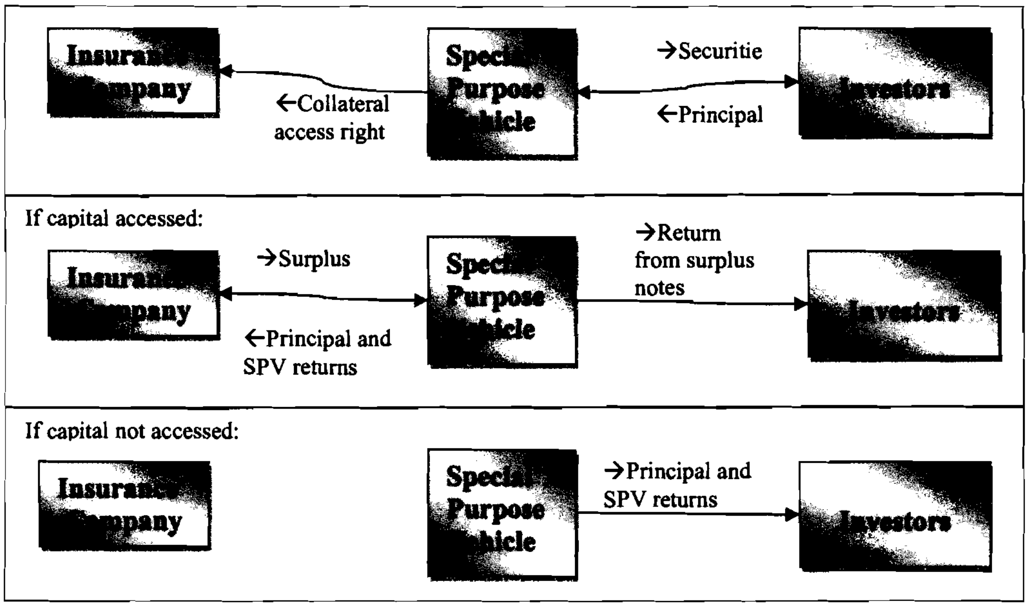
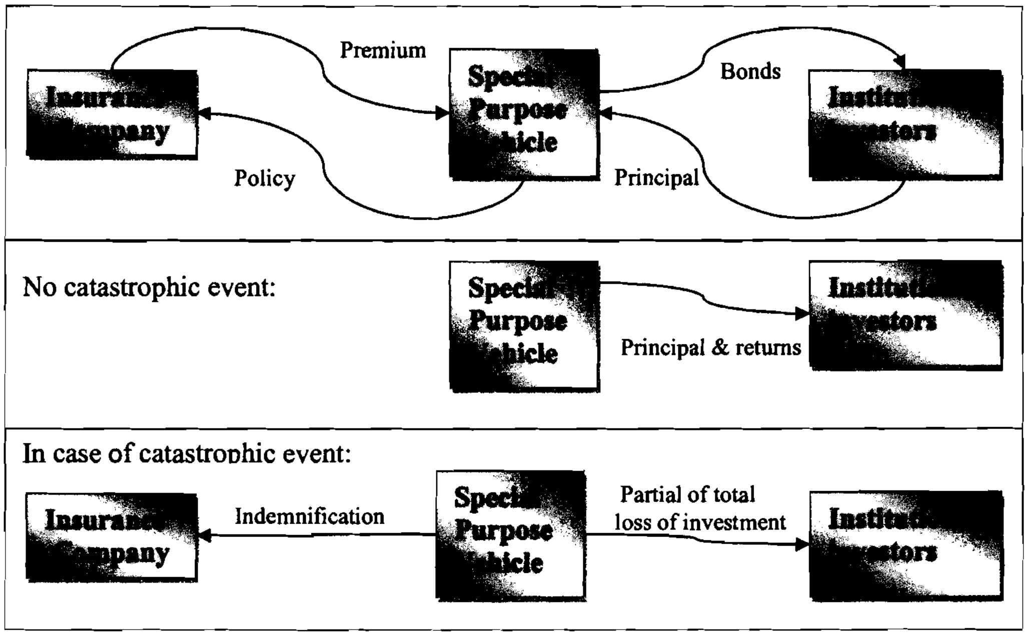


Figure 2: Credit-risk Securitization

The second type of securitization is synthetic reinsurance. This is the more commonly used method since it is more flexible and easier to implement. It is more commonly referred to as a "cat bond" or "Acts of God bonds" since it has a certain trigger event that allows the insurance company to access the funds raised and held by the SPV from the sale of the bond. Its structure is similar to the credit-risk securitization but is much simpler after a defined event occurs. The collateral right under the credit-risk securitization is replaced with the right to directly access funds if a defined event occurs. In this case, the SPV will act as reinsurance for the insurance company. The structure of the synthetic reinsurance is composed of the insurance company, the SPV and the investors. The insurer pays a certain premium or fee to the SPV, while the SPV agrees to pay a certain amount if a defined event occurs. If this happens, the investors will lose their principal and future returns. If the defined event does not occur, then the investor will receive the principal and the promised returns on the SPV investment, while the insurance company receives any remaining profits. Since the investors face a pure-risk situation, the yield on the synthetic reinsurance securities is often high, between 15%-20%. The structure of synthetic reinsurance is shown in Figure 3.

Figure 3: Synthetic reinsurance



Purpose and design of insurance-linked securities

The main types of insurance-linked securities are catastrophe bonds (catbonds) and weather bonds. The tread for this type of securities was stated in 1992 with the introduction of the index-linked catastrophic loss future contracts on the Chicago Board of Trade. However, these were not as popular and were de-listed due to low volume of trading. The first catbond was issued by Swiss Re in 1997, and it covered earthquake losses. Soon after that, in 1999, the first catbond issued by a non-financial company covered earthquake losses for the Oriental Land Company Ltd, the owner of Tokyo Disneyland. One of the recent large scale catbonds was issued by Swiss Re, worth at $260 million dollars, which covered the risk of cancellation the FIFA World Cup 2006 in Germany. The bond was designed to cover the marketing revenue that would be refunded if the matches were to be cancelled due to a natural catastrophe or terrorism. The largest underwriters for catbonds are Goldman Sachs, Swiss Re Capital Markets and Lehman Brothers; however, there are many other actors in the market such as UBS, Barclays, BNP Paribas and AON Capital Markets. The cumulative annual trading in 2004 was over $1.4 billion jumping to $2.10 billion in 2005 and reached $4.6 billion in 2006. The main reason for this jump is considered to be Katrina and the expectancy of losses due to the hurricane within the next decade.

The purpose of the insurance-linked securities is to hedge insurance risks by transferring the costs to the capital markets from the insurance market, and also to increase capital efficiency by "drawing on alternative sources of financing" (Swiss Re Media briefing, 2005). The catbonds are similar in their design to the high-yield corporate bonds. The main differences are: (1) the type of underlying risk, natural peril as opposed to credit risk, and (2) the rating of the bonds. For typical risk with low severity and high frequency, insurers were able to diversify their losses through a large number of policies. In this case, the insurer will charge a premium that is equal to the expected annual loss and has a large number of policies. Based on the law of large numbers, the proper amount of premiums can be determined statistically, creating a stable investment income profit. However for events with high severity and low frequency, the law of large numbers is not valid, and it is more difficult to set a certain rate. In order to value the bonds, external agencies are hired that have created statistical models and are able to provide a framework for their pricing. Generally, catbonds are traded with high margins; the price is based on expected value plus a function corresponding to the probability of the event happening following a sample of historical observations. The coupon is usually priced as the LIBOR index plus a certain percentage that ranges from 4 to 10 percent. If a catastrophic event occurs that will trigger the bond, then, in the case credit-risk securitization type catbonds, the coupon yield will become LIBOR minus a fixed percentage. LIBOR (London Interbank Offered Rate) is determined by the rate that banks participating in the London money market will charge each other for short-tem loans.

Another important aspect of the catastrophic bonds is the trigger function. The issuer of the bonds needs to choose how the collateral access or indemnification right is triggered. There are four types of triggers, which are indemnity, modeled loss, indexed to industry loss, and parametric. The last two are the most used since they provide the most flexibility and are easiest to define. When index to industry loss is used as a trigger for the bond, then the insurance company own claims are not the ones taken into consideration, but it is the whole industry instead. When the overall industry suffers a general loss due to a single event that will reach a certain threshold, then the insurance company will have access to the SPV funds. The bond will define in its structure how the industry losses will be determined. This will usually be done by third-party agencies.

The most used type of event trigger is the parametric one. In this case there is no specific claim amount, but rather the trigger is indexed to a certain natural phenomena. The factor could be wind speed, earthquake scale, ground movement, rainfall, drought time, etc. Data is collected from previously specified stations and then entered in a formula. There are usually several bounds that will generate, using a formula, a certain percentage of principal loss. For example, the first catbonds issued by Swiss Re used a natural index as triggers. It was designed to cover earthquake loss exposures in the Boso

Figure 4: Geographical design

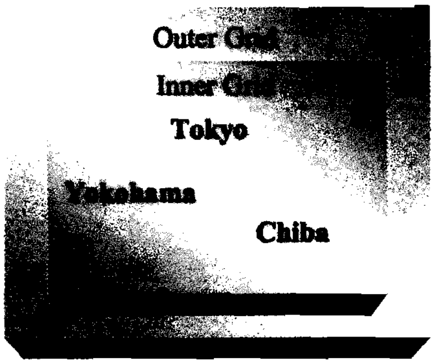


Figure 5: Earthquake cat bond repayment table

Earthquake level Richer Scale	7.1	7.2	7.3	7.4	7.5	7.6	7.7
	25%	40%	55%	70%	85%	100%	
			25%	44%	63%	81%	100%

(Source: Swiss Re Media Briefing)

Peninsula. An inner grid and outside grid were drawn and if an earthquake would have occurred; depending on the intensity there would have been a certain deduction from the principal paid by the institutional investor.

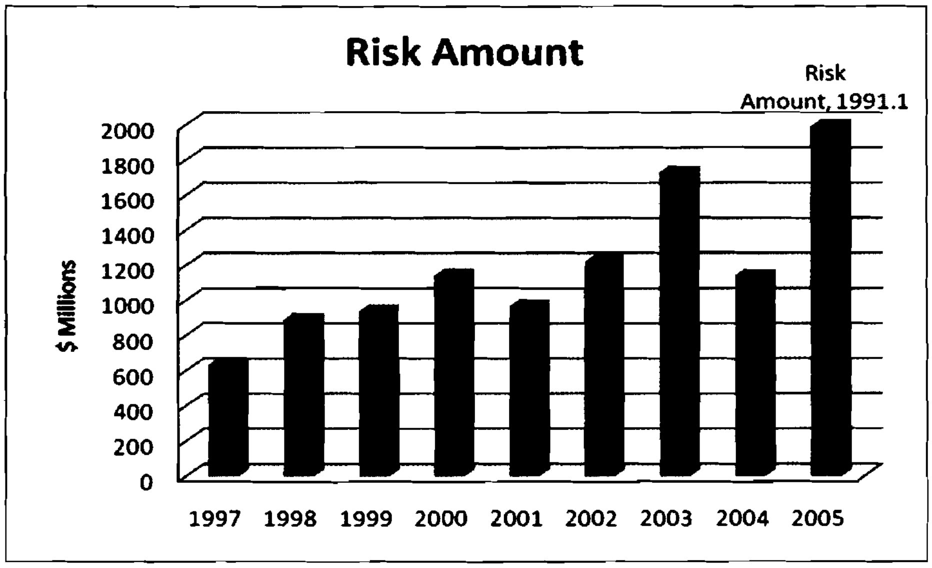
Cost/Benefit in using Securitization

Using cat bonds instead of typical reinsurance could reduce costs for most insurance companies if the structure of the bonds is properly designed, and the investors are not risk averse. If a certain catastrophic event is calculated to have a probability of ten percent, a typical reinsurance company will charge up to 14-15 percent of what. However, if a cat bond is used instead, for such an even the investors would demand up to 17 percent. This represents the ten percent pure risk, five percent risk-free interest and an additional two percent as risk premium. Yet, the SPV will invest the principal in treasury bonds that will yield a five percent which brings the total charge for the cat bond to 12 percent, significantly lower than typical reinsurance.

The negative side of these types of insurance-linked derivatives is the fact that the insurance industry is getting highly regulated, and the creation of such a bond sometimes requires obtaining various approvals from regulators. This will keep the price the same but will create a gap of capital that insurance companies will need to fill. Pricing will vary however, based on the underwriting cycle. After a catastrophe, the supply will be low, which will force issuers and reinsurers to increase their premiums in order to rebuild capital. When there is excess capital on the market, the issuers will reduce their rates. The "tighter the market for a particular line of reinsurance business becomes, the more compelling will be the case for securitization in that line of business"

(Belonsky Laster Durbin, 1999). Also, as the number of transaction increases, there is an increase in standardization. As we can see in Figure 6, the risk amount that catbonds are insuring has increased since 1997, with the highest amount reaching $1.9 billion in 2005. The more the contracts become standardized, the easier it is to use them and reduce transaction costs. As investors become more accustomed to a specific structure and the contract is more transparent, the lower the premium will be. In time, this type of securities will follow the pattern of other financial instruments such as mortgage-backed securities and their price will get closer and closer to the Treasury securities. However, the typical reinsurance business is also expanding. Issuers of catbonds are now opening their own reinsurance subsidiaries in order to take hold of a greater market share. The supply for hurricane catbonds has gone down in the last year by 25 percent, while the demand has increased by 25 percent. This way, other forms of insurance-linked securities are being explored, such as swaps, weather derivatives, and reinsurance sidecars.

Figure 6: Risk amount insured through catbonds



Weather derivatives and other instruments

As previously mentioned there are other type of securities that insurance companies are turning to, such as the catastrophe swaps and weather derivatives. Catastrophe swaps (henceforth swaps) started to be sold on the Catex (electronic insurance exchange) between insurance and reinsurance companies. In a typical swap contract, a group of policies (insurance portfolio) along with its liability is being exchanged for a security along with its cash flow. The insurer takes the responsibility to pay an investor the periodic payments for the security while the investor is liable for any claims that come out of the insurance portfolio that was exchanged. However, the payment only occurs when a catastrophic event occurs that reached a certain agreed measure of magnitude. From the insurer view, the payment for the investor's security is equivalent to a reinsurance premium. Initially, these types of contracts were developed so that insurers can exchange insurance portfolio in order to diversify their current policies. Since this did not bring any new players into the market and thus no new capital, it was abandoned and other non-insurance companies, such as hedge funds, were allowed to participate in Catex. There has not been an increase in this type of securities but they are thought to be successful when the insurance industry is going trough a soft period.

Weather derivatives have been available on the market since 1997. Their purpose is to hedge the weather risk by a corporation. According to the US Department of Commerce, "weather impacts businesses contributing $1 trillion of the $9 trillion US GDP." The initial use was for the US energy sector after deregulation of the energy industry. One of the major players in weather derivatives was Enron, which was among the first group of companies to offer and trade these securities. The weather derivatives are contracts against weather change. The main difference from normal derivatives is that their underlying asset (rain, temperature, wind, precipitation and other indexes that are composed on several weather factors) has no direct impact on the price of the derivative. When certain weather conditions are reached, the derivative is triggered, this provides payments to the beneficiary of the weather derivative (the insured) for a specific amount of days. Their main usage is for the energy sector in US and Europe and for the agricultural sector in Africa, Asia, and Australia. Farmers can benefit from this by purchasing weather derivatives, which will provide them with payments if the temperature goes below a certain point for a number of days. The market for these financial instruments has increased, and the aggregate national value is at $4.6 billion. The main players are the insurance and reinsurance companies, banks, energy traders, and hedge funds. Therefore, there is access to a lot of capital, and the potential for growth is great. The Chicago Mercantile Exchange introduced the weather futures and options in 1999 and is now trading weather derivatives in US, Canada, Europe and Japan. However, since the investors earn the premium income if no trigger is evoked, there has been a lot of speculation on the market, which only increased the price of the derivatives. This will only affect the players that truly benefit from them: the farmers and the energy companies.

Pricing model for a weather derivative

A pure weather derivative instrument has an underlying weather index such as accumulated snowfall, rainfall, or "degrees days" over a period of time. They are used to cover damage from infrequent, high-loss events. Since weather derivatives are only triggered by a rigid index, they are out of the subject of moral hazard. A typical weather derivative is priced based on five elements: (i) the underlying weather index, (ii) the time period, (iii) location of weather data collection center, (iv) the dollar increments for each index point and (v) the "strike" point on the weather index. For example, if the index point value is one dollar, when the accumulated weather index rises over the strike value the reimbursement will be equal to the difference between the accumulated value and the strike time one dollar. Using this concept we can define a weather index for the beneficiaries of corn production.

Index creation

Illinois is one of the top corn producing states in the US. Roughly 20% of it was used by ethanol plants. The price of the corn per bushel is usually fixed though futures contracts. However, in order to protect both the farmers and the consumers (such as ethanol plants) from the risk of loosing part of the crop, weather derivative are an option. The most frequently used index for weather derivatives for crops is the "growing degrees days" (henceforth GDD). Corn in US grows only at temperatures between 50 and 86 degrees Fahrenheit. GDD is calculated from the start of the season in mid May to the end in mid September. Each day, the average temperature is found by dividing the sum of the maximum and minimum temperature by two. Then the 50 is subtracted from the average temperature and added to the GDD. The corn can be tracked in its growth by the number of GDD. Corn is mature when it reaches 2400 GDD and usually has equal monthly increments.

$$GDD = \frac{MaxTemp + MinTemp}{2} - 50$$

If Min Temp<50 then Min Temp=50;
If Max Temp>86 then Max Temp=86.

However, this type of weather index has limitations since during one month the temperatures could be are extremely low while during the next month they could be extremely high, then the GDD would be within normal conditions, but the corn production might be significantly affected. Also, this type of index only takes into consideration the temperature, while other factors such precipitation as are ignored. Therefore, a new index should be created that will take into account other factors and leave room for further development.

To test a new hypothesis data will be required. We create a database that contains the monthly average temperature and precipitation for Illinois, as well as the actual corn crop yield for Illinois for the last 100 years. This data is gathered from the National Climatic Data Center and the U.S. Census Bureau (The National Data Book). July and August are the most important months for the growth of corn regarding precipitation and that temperature has a strong effect on corn development from seeding to maturity, we can predict that that:

$$Yield = f(Temp, Precipitation, Time)$$

Time will represent a factor since we can assume that every year there is a difference in capital, workers and technology used by the farmers. After several tests we find that the best regression model to explain corn yield is:

$$Yield = \beta_1 + \beta_2 Mean\_Temp + \beta_3 Ln\ (MeanJuly\text{-}Aug\_Precipitation) + \beta_4 Time.$$

As suggested from the GDD paradigm in which temperature is the only factor for the corn, we find that the mean temperature s the most impact on the corn yield, or index. We can predict that as the temperature increase, the corn yield will decrease. The reason behind this assumption is the fact that corn is a plant that grows best in temperate climate, with a stable moderate summer temperature and high precipitation. The next variable is the mean of the precipitation for July and August is significant as well since after testing a variety of precipitation formulas, we find that the precipitation for July and August are the most important for the crop yield. Also, we discover that yield is correlated logarithmically to the mean precipitation for July and August. As for the year variable we set the base year of 1906 to be 1 and 2006 to be year 100.

Therefore, we can explain 89.9% of the corn yield for Illinois using these factors. Also, all the factors are statistically significant on our model. As the average temperature increases, the yield decreases. Also, since July and August are the hottest months of the year, the higher the precipitation levels, the higher the yield. We will use this new regression as our index for the future weather derivative model.

$$SF_{Wesleyan} = -2194.218 + 1.287*Year - 3.549*MeanT + 13.434*LnMeanP\_july\_aug$$

Our results are as follows:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.950(a)	.902	.899	13.34444

a Predictors: (Constant), LnMeanP_july_aug, Year, MeanT

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	-2194.218	112.333		-19.533	.000
	Year	1.287	.047	.896	27.553	.000
	MeanT	-3.549	.862	-.147	-4.116	.000
	LnMeanP_july_aug	13.434	5.918	.083	2.270	.025

a Dependent Variable: Yield

Figure 7: Statistical results

Pricing model

There are several methods for the pricing of a derivative. Weather derivatives are based on an index that is not controlled by the market and sometimes difficult to calculate its volatility. However, using $SF_{Wesleyan}$ as an index would make it easier for the pricing model, since it will allow for an easy calculation of volatility. The mathematical model used for pricing the derivative is the Black-Scholes model. This is usually used for derivatives having as underlying assets stocks. We will test how successful the Black-Scholes model can be using a weather based index as the underlying value. We will create a call option when the farmer sells the derivative to an investor. The investor then buys the call options hopping that the weather conditions will make the yield increase. Next, we will create a put option that the farmer will buy which will protect him/her in case of weather conditions deteriorating. The formula for the pricing of a call option is:

$$C = SN(x) - Kr^{-t}N(x - \sigma\sqrt{t}),$$

,where

$$x \equiv \frac{\log\left(\frac{S}{Kr^{-t}}\right)}{\sigma\sqrt{t}} + \frac{1}{2}\sigma\sqrt{t}$$

The formula for pricing a put option is:

$$P = Kr^{-t}N(y - \sigma\sqrt{t}) - SN(y)$$

,where

$$y \equiv \frac{\log\left(\frac{Kr^{-t}}{S}\right)}{\sigma\sqrt{t}} - \frac{1}{2}\sigma\sqrt{t}$$

The S represents the starting value of the index at the starting point of the contract. We calculate S using the same formula that we deduced for the $SF_{Wesleyan}$. For the temperature and precipitation we use the average temperature and precipitation for the last 100 years from our data. Since we want to calculate the value of a call option for 2007, for time variable we set time equals 2007. K represents the strike value if the option is exercised. In order to find K we need to calculate when a farmer would need to exercise an option. This will be the case when unfavorable temperature and precipitation cause a decrease in crop yield below a certain limit. This limit can be calculated based on finding the optimal temperature and precipitation for corn and use these values in the index formula.

The σ variable represents the value of volatility in the $SF_{Wesleyan}$ index yield. For this calculation we need to pursue a few steps. The first method would be a simple calculation of the mean or standard deviation. However, the index value tends to be loganormally distributed, which means that the natural logarithm of the value relative have a normal distribution. Therefore, a truer variable of volatility would be the variance. The table below shows our calculation, but only for the last five years. The final result would be the variance of the whole 100 years of data.

$SF_{Wesleyan}$	Relative=Si/Si-1	log Ri	log Ri - μ	(log Ri - μ)^2	$\sigma^2/5$
142.801225					
134.824402	0.944140376	-0.05748	-0.03584	0.0012842	
155.550469	1.153726376	0.142997	0.164642	0.0271069	
144.121205	0.926523758	-0.07632	-0.05467	0.0029889	
130.957765	0.908664099	-0.09578	-0.07414	0.005496	
Total:		-0.08658		0.036876	0.0073752

μ (average)=	-0.02164	Volatility = $(\sigma 2/5)^{0.5}$	=	0.085879

Figure 8: Volatility calculation for 2006-2002

The final result for volatility taking into consideration 100 years will be 0.316105187.

The interest rate, r, is the risk free interest rate (T-Bill rate). From the time of the seeding to the time of the harvest roughly six months pass, we use the r as the yield of a six month T-bill (currently at 4.8%). The time t is the duration of the contract and it is defined at the number of days till expiration over 365, thus t is equal to 0.5. The N(x) and N(x-α√t) represents the standard normal distribution functions. We can calculate these with most statistical programs and also using statistical tables.

When all the variables are defined and calculated we test the output for a variety of interest rates. The results are shown in the tables below.

S	**158.321789**		
K	**150.9841618**		
σ	0.316105187		
t	**0.5 (6 months)**	**C**	**S-K**
r	3.5	**19.168067**	7.337627
	4.86	**19.724378**	**7.337627**
	5.5	**19.986192**	7.337627

Figure 9: Price observations for call option

S	**158.321789**		
K	**150.9841618**		
σ	0.3161		
t	**0.5** (6 months)	**P**	**K-S**
r	3.5	**9.240012797**	-7.337627
	4.8	**8.846160977**	-7.337627
	5.5	**8.660072987**	-7.337627

Figure 10: Price observations for a put option

We will analyze the put options that would be purchased by a farmer. The farmer has an expected yield of S, however, he/she would like to lock the value of K. This means, that if weather factors are not favorable and the index yield falls under K then the farmer could exercise the weather derivative and get reimbursed for its loss. This would be beneficial for the farmers since it will provide a layer of protection against the negative effects of weather on its crop. For example, the estimated price of corn per bushel for 2007 is between $2.25 and $2.55. We can test the impact of the previous put option for a farmer with a locked price of $2.45 per bushel.

	Bushels/acre	**Price(2.45)**				
Expected	158.321	387.8865				
Strike	150.984	369.9108	Difference			
			bushels/acre	Price	Total cost	
Actual	180	441	29.016	**-71.089**	**419.783**	not exercised
	160	392	9.016	**-22.0892**	**370.783**	not exercised
	145	355.25	-9.016	**14.6608**	**334.033**	EXERCISED
	140	343	10.984	**26.9108**	**321.783**	**EXERCISED**
	130	318.5	20.984	**51.4108**	**297.283**	EXERCISED

Figure 11: Practical results

We can observe from the Figure 11 that the total cost of the yield for a year will include the price of the put option, P, times the price of corn per bushel. Also, when the yield is over the strike price, the derivative will not be exercise, but if the price is below the exercise price, it will be. This will then act as an insurance contract for the farmer for an adverse weather conditions. That is, if the actual yield due to unfavorable weather condition is worse than expected, the farmer with the put option will exercise his/her right to sell the crop at the strike price. Thus, the proceeds from the put option will offset loss from the actual yield.

Conclusion

The financial market has been giving insurance companies a pathway to access a potentially unlimited capital. The catastrophic bonds are used mainly by insurance companies to cover their top layer of risk which otherwise would have been open to either no protection or expensive reinsurance. With the structure and design of the present catbonds, only insurance companies or large corporations can truly use them for their benefit, since they are still expensive and difficult to manage. However, there is still potential to develop securities that could be used by smaller companies against catastrophic or high severity events. As more banks and hedge funds start issuing cat bonds, we could observe that the insurance industry will merge with the financial markets. This type of insurance will be unregulated in order to satisfy the investors need for flexibility and speculators could negatively affect the growth.

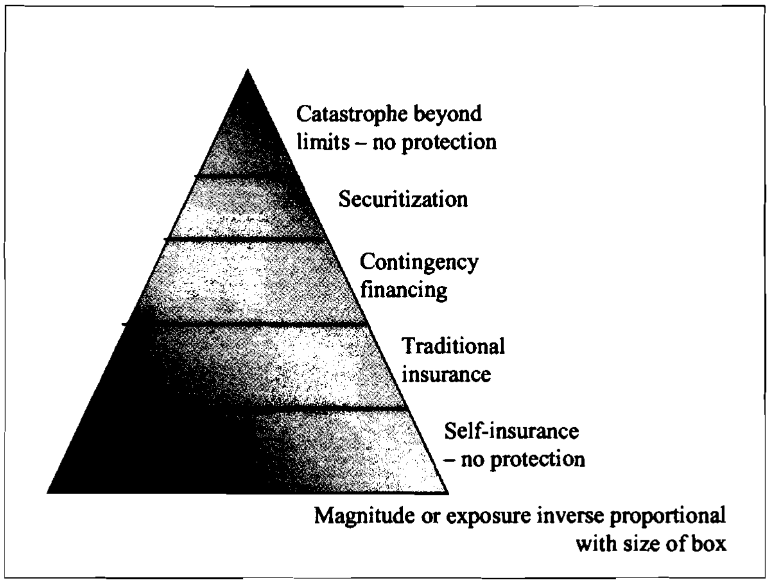


Figure 12: Risk Layers

As for insurance companies this type of reinsurance will only create more efficiency and the ability to underwrite more risks. For catastrophic events, the catbonds could be used in order to avoid bankruptcy or to significantly lower own capital. Reinsurance companies can also benefit by transferring their own risk and eliminating credit risk from their traditional reinsurance. For the investors, these bonds only provide new means of diversification that is highly uncorrelated with other market variations and could be used to balance an investment portfolio. Furthermore, the catastrophic bonds provide a high return that will satisfy most risk takers. Thus, the bridge between the insurance and capital markets will only continue to develop, so that both can benefit from the exchange.

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