Direct Your Learning

10

Catastrophe Reinsurance

Educational Objectives

After learning the content of this assignment, you should be able to:

- Describe the operation, functions, and use of catastrophe treaties.
- Describe the purpose of each of the following clauses designed or adapted for catastrophe treaties:
  - Term clause
  - Retention and limits clause
  - Ultimate net loss clause
  - Loss occurrence clause
  - Other reinsurance clause
  - Reinstatement clause
- Explain how catastrophe treaty pricing is affected by attachment points, layers and limits, underlying insurance analysis, inuring reinsurance, pay-back of prior losses, and reinsurance limits.
- Summarize the key components and outputs of a catastrophe model.
- Given the results of a catastrophe modeling analysis, determine options that a primary insurer can employ to manage its catastrophe exposures.
- Describe the following alternatives to traditional catastrophe reinsurance:
  - Lines of credit
  - Catastrophe bonds
  - Catastrophe options
  - Catastrophe risk exchanges
  - Industry loss warranties
  - Reinsurance sidecars

Outline

Catastrophe Reinsurance

10

OVERVIEW OF CATASTROPHE TREATIES

Catastrophe excess of loss reinsurance, usually called catastrophe reinsurance or catastrophe excess, provides primary insurers with protection from the financial consequences of an accumulation of losses arising from a catastrophic event. Catastrophic events occur infrequently, yet the severity of the loss they produce can threaten a primary insurer's solvency. Primary insurers use catastrophe treaties to safeguard their policyholders' surplus (net worth) should a catastrophic event occur.

Most primary insurers that sell property insurance purchase catastrophe reinsurance. The demand for catastrophe reinsurance results from natural and manmade disasters to which property loss exposures are subjected. Examples include tornadoes, hurricanes, acts of terrorism, earthquakes, and winter storms. See the exhibit "Inflation-Adjusted U.S. Catastrophe Losses by Cause of Loss, 1991–2010*."

The operation of catastrophe treaties allows all or most of a primary insurer's property losses to be reimbursed after reaching a specified attachment point. This supports its function of stabilizing underwriting results and helping ensure a predictable loss experience. Catastrophe treaty reinsurance may be used in layers, with the primary insurer's financial co-participation, as part of an entire reinsurance program.

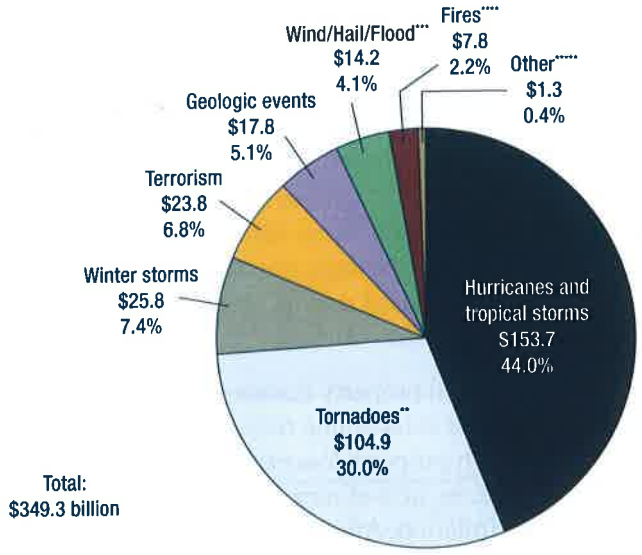
Operation of Catastrophe Treaties

Coverage under a catastrophe treaty is triggered when accumulated losses arising out of a single event exceed the attachment point. Once losses exceed the attachment point, the reinsurer reimburses the primary insurer for losses until the reinsurance limit is reached. Unlike property per risk excess of loss, catastrophe reinsurance usually applies to all of the primary insurer's property business (such as all personal and commercial insurance covering property loss exposures) or a large subset of it (such as all property loss exposures in the states of Alabama, Mississippi, and Louisiana), rather than to losses sustained by individual loss exposures.

Catastrophe treaties often specify that they will not respond to a loss arising out of a single loss exposure, no matter how large the loss may be. In practice, most catastrophe treaties have a sufficiently high attachment point that many of the primary insurer's policies would have to be involved in a loss for the catastrophe treaty to respond. For example, if the largest property policy

Inflation-Adjusted U.S. Catastrophe Losses by Cause of Loss, 1991–2010*

(2010 $ billions)



* Adjusted for inflation by ISO using the GDP implicit price deflator. Excludes catastrophes causing direct insured losses less than $25 million in 1997 dollars.

** Excludes snow.

*** Does not include flood damage covered by the federally administered National Flood Insurance Program.

**** Includes wildland fires.

***** Includes civil disorders, water damage, and non-property losses such as those covered by workers compensation.

Used with permission from The I.I.I. Insurance Fact Book 2012 (Insurance Information Institute, 2012), p.129. [DA09177]

the primary insurer is willing to insure has a $1 million limit, the attachment point of the catastrophe treaty may be set at $10 million. As with other types of excess of loss reinsurance, catastrophe treaties typically contain a co-participation provision.

For primary insurers that have geographically diversified loss exposures and a limited exposure to catastrophe-related causes of loss, the price of catastrophe reinsurance is probably relatively low. However, for primary insurers that sell insurance almost exclusively in catastrophe-prone areas, catastrophe reinsurance is likely to be expensive and available only with a high attachment point relative to the size of the catastrophic exposure.

Functions of Catastrophe Treaties

Primary insurers use catastrophe treaties to provide catastrophe protection—that is, to limit the financial consequences of catastrophic events. At a minimum, losses arising from a catastrophic event will destabilize underwriting results (increase the loss ratio and therefore increase the combined ratio), and they may even lead to insurer insolvency.

Hurricane Andrew, a Category 5 hurricane on the Saffir-Simpson Hurricane Scale, made landfall on August 24, 1992, and led to seven insurer insolvencies in Florida. Although the terrorist attacks of September 11, 2001, and Hurricane Katrina in 2005 caused higher paid losses in insured property losses than Hurricane Andrew, no insurer declared insolvency as the result of the terrorist attacks, and only one insurer did so after the devastating hurricane season in 2004, which included hurricanes Charley, Frances, Ivan, and Jeanne.[1] It is also expected primary insurers will continue to face challenges of large catastrophic loss exposures because of population shifts in hurricane-prone areas, higher property values, and weather and climate changes. Catastrophes such as these have a widespread effect on the property-casualty industry because they reduce policyholders' surplus and thereby limit underwriting capacity.

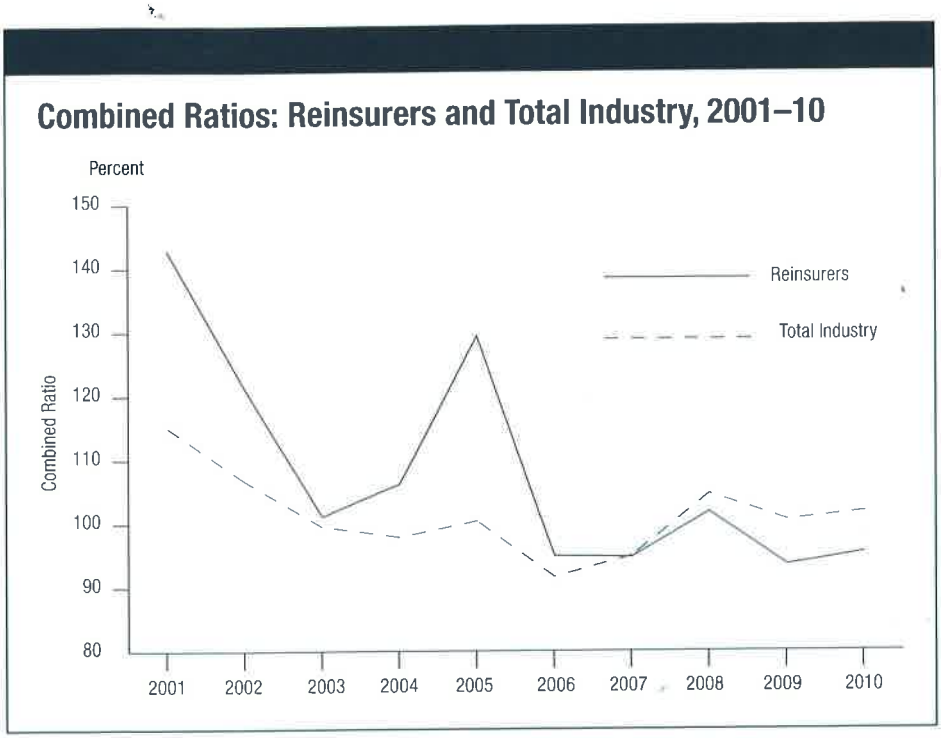
With catastrophe treaties, a primary insurer can limit its losses to a predetermined retention per loss occurrence. This stabilizes loss experience results because losses in excess of the retention are passed on to reinsurers. The primary insurer's current and future reinsurance premium payments can spread the financial effects of catastrophe losses over several years.

Catastrophe treaties also help primary insurers avoid large fluctuations in earnings per share and wide swings in profits and losses that can cause adverse financial market reactions. By purchasing catastrophe treaties, primary insurers achieve loss experiences that are more statistically predictable.

Although catastrophe treaties do not guarantee that primary insurers will have constant loss ratios, they do flatten some of their loss ratio peaks. The exhibit shows the combined ratios of reinsurers relative to the total property-casualty insurance industry. See the exhibit "Combined Ratios: Reinsurers and Total Industry, 2001–10."

Catastrophe Treaties as Part of a Reinsurance Program

As with other forms of reinsurance, catastrophe reinsurance may be provided in layers. Lower layers have lower limits, higher loss frequency, and higher premiums than higher layers. The primary insurer may also have a percentage co-participation in losses that exceed the attachment point, which encourages the primary insurer to exercise sound claim handling practices even after the attachment point has been exceeded.



Used with permission from The I.I.I. Insurance Fact Book 2012 (Insurance Information Institute, 2012), pp. 43, 48. [DA09178]

The primary insurer typically has other reinsurance that applies before the catastrophe treaty. This is known as inuring reinsurance because it inures to the benefit of (reduces the loss to) the catastrophe treaty. For example, the primary insurer might have purchased facultative, surplus share, quota share, or per risk excess of loss reinsurance to reduce the amount of loss covered by the catastrophe treaty. The catastrophe treaty only applies when the primary insurer's net retention (after the inuring reinsurance) exceeds the attachment point.

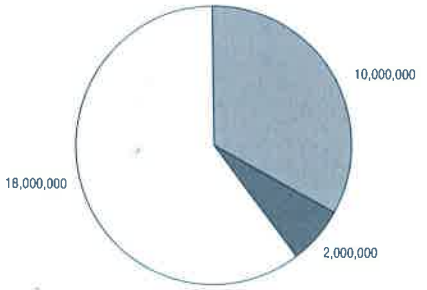
The exhibit illustrates how inuring reinsurance can benefit the catastrophe treaty. See the exhibit "Effect of Inuring Reinsurance."

Effect of Inuring Reinsurance

The primary insurer has a 60% quota share treaty and a $20 million xs $10 million catastrophe treaty. A policy covered by the treaties experiences a $30 million loss.

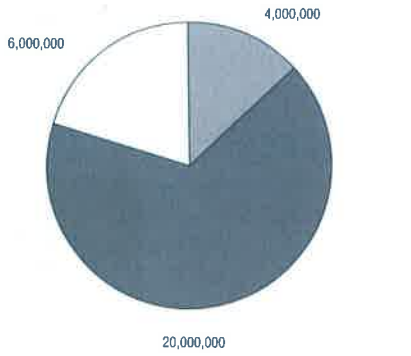
If the quota share treaty inures to the benefit of the catastrophe treaty, the loss exposures are as follows:

Loss	$30,000,000
Minus 60% quota share	(18,000,000)
Loss subject to catastrophe treaty	$12,000,000
Minus primary insurer's retention	(10,000,000)
Catastrophe coverage	$ 2,000,000



If the quota share treaty does not inure to the benefit of the catastrophe treaty, the loss exposures are as follows:

Loss	$30,000,000
Minus primary insurer's retention	(10,000,000)
Catastrophe coverage	$20,000,000
60% quota share of $10,000,000 retention	$ 6,000,000
40% primary insurer's net retention	$ 4,000,000



[DA05424]

CLAUSES DESIGNED OR ADAPTED FOR CATASTROPHE TREATIES

Catastrophe treaties typically contain the common clauses that appear in other excess of loss treaties.

These are among the common clauses designed or adapted for use in catastrophe treaties:

- Term clause
- Retention and limits clause
- Ultimate net loss clause
- Loss occurrence clause
- Other reinsurance clause
- Reinstatement clause

The sample clauses in this discussion are for illustrative purposes only and should not be relied on to construct an actual treaty.

Term Clause

The term clause defines the term of the reinsurance treaty. Catastrophe treaties usually have a one-year term, but they can be provided on a multiple-year term or on a continuous basis with annual termination provisions.

Because many catastrophic events are seasonal, such as hurricanes and tornadoes, treaty terms that allow the primary insurer or reinsurer to terminate a catastrophe treaty before the end of an annual term are unusual. The term clause prevents one of the parties from canceling the agreement just before or after a catastrophe season.

Catastrophe treaties typically apply only to losses occurring during the treaty's term, so run-off coverage is not provided. However, they often include an extended expiration provision, which provides that, if the treaty expires while a loss occurrence is in progress, the reinsurer will indemnify the primary insurer as if the entire loss occurrence had occurred during the treaty's term. Therefore, the primary insurer has one retention under its expiring catastrophe treaty and does not have a second retention for the same loss occurrence under its renewal catastrophe treaty.

The term clause shown in the exhibit contains an extended expiration provision. See the exhibit "Sample Term Clause."

Sample Term Clause

A. This Contract shall become effective on January 1, 20X4, with respect to losses arising out of loss occurrences commencing on or after that date, and shall remain in force until December 31, 20X4, both days inclusive.

B. If this Contract expires while a loss occurrence covered hereunder is in progress, the Reinsurer's liability hereunder shall, subject to the other terms and conditions of this Contract, be determined as if the entire loss occurrence had occurred prior to the expiration of this Contract, provided that no part of such loss occurrence is claimed against any renewal or replacement of this contract.

[DA05425]

Retention and Limits Clause

The retention and limits clause in a catastrophe treaty should include these features:

- Net retention stated as the ultimate net loss per loss occurrence
- Co-participation provision
- Per loss occurrence limit

The ultimate net loss and loss occurrence clauses define ultimate net loss and loss occurrence, both of which affect net retention. Those clauses provide that only the portion of each individual loss that is retained net by the primary insurer (not reinsured in any way) can be included in the amount of loss subject to the catastrophe treaty.

The primary insurer's retention under a catastrophe treaty must be greater than its retention for a single loss exposure. For example, if the primary insurer has a maximum net retention of $1 million per loss exposure, the retention on its catastrophe treaty must be more than $1 million. Generally, a catastrophe treaty that attaches just above the maximum loss exposure retention is expensive, so primary insurers usually have a catastrophe treaty retention equal to several per loss exposure retentions.

In addition to the retention, catastrophe treaties generally require the primary insurer to retain a co-participation percentage of the excess loss to encourage primary insurers to properly handle losses after the retention has been exceeded.

The retention and limits clause in the exhibit contains a co-participation provision. See the exhibit "Sample Retention and Limits Clause."

Sample Retention and Limits Clause

A. The Company shall retain and be liable for the first __$1,000,000__ of ultimate net loss arising out of each loss occurrence. The Reinsurer shall then be liable for __95%__ of the amount by which such ultimate net loss exceeds the Company's retention, but the liability of the Reinsurer shall not exceed __95%__ of __$4,000,000__ as respects any one loss occurrence.

B. In addition to its initial retention each loss occurrence, the Company shall retain __5%__ of the excess ultimate net loss to which this Contract applies.

[DA05426]

The reinsurer's limit of liability is also stated in the retention and limits clause. The "Sample Retention and Limits Clause" exhibit states that the reinsurer's limit of liability "shall not exceed 95% of $4,000,000."

Ultimate Net Loss Clause

The ultimate net loss clause in a catastrophe treaty defines what constitutes a loss. Because of the importance of catastrophe reinsurance in protecting the primary insurer's assets, the definition of ultimate net loss should be clearly worded. This clause should reflect how the primary insurer and reinsurer intend for the primary insurer's various treaties to operate. For example, defining ultimate net loss on a gross loss basis means that the reinsurer does not benefit from the primary insurer's other reinsurance.

To illustrate, a catastrophic event may trigger a recovery from facultative reinsurance agreements on specific loss exposures that are also subject to the catastrophe treaty. If the catastrophe treaty were on a gross loss basis, then the facultative reinsurance recoveries would not reduce the amount of the primary insurer's loss in determining whether the catastrophe treaty's attachment point had been met. Consequently, catastrophe losses would possibly accumulate more quickly. The ultimate net loss clause shown in the exhibit would not produce such a result. It specifies that ultimate net loss means actual loss retained by the primary insurer, so all other reinsurance inures to the benefit of the catastrophe treaty. See the exhibit "Sample Ultimate Net Loss Clause."

Sample Ultimate Net Loss Clause

54 A
ULTIMATE NET LOSS

The term "Ultimate Net Loss" means the actual loss, including loss adjustment expense, paid or to be paid by the Company on its net retained liability after making deductions for all recoveries, salvages, subrogations and all claims on inuring reinsurance, whether collectible or not; provided, however, that in the event of the insolvency of the Company, payment by the Reinsurer shall be made in accordance with the provisions of the Insolvency Article. Nothing herein shall be construed to mean that losses under this Contract are not recoverable until the Company's ultimate net loss has been ascertained.

Source: Brokers & Reinsurance Markets Association (BRMA), www.brma.org/frommembers/contractword/Ultimate%20Net%20Loss%20BRMA%2054A-L.doc (accessed November 13, 2012). [DA05427]

Generally, the ultimate net loss definition in a catastrophe treaty includes loss adjustment expenses incurred for catastrophe losses. Loss adjustment expenses do not include regular office expenses and salaries of the primary insurer's employees. However, expenses of regular employees who are temporarily diverted from their normal and customary duties and assigned to the field to adjust a catastrophe loss can be specifically included. Only those expenses actually incurred when settling claims are covered. Any salvage or recoveries that reduce the loss are deducted from ultimate net loss and applied when they are realized, without time limit. Consequently, reinsurers can benefit from salvage recoveries after loss payment.

To calculate ultimate net loss, reinsurers deduct losses on other applicable reinsurance from the actual loss sustained, whether those losses are recovered or not. Therefore, the loss to catastrophe reinsurers is not increased if the primary insurer cannot collect amounts due from other reinsurers under inuring reinsurance.

Loss Occurrence Clause

The loss occurrence clause defines what constitutes a catastrophic occurrence. The loss occurrence definition for a catastrophe treaty could be identical or very similar to the loss occurrence definition in a property per risk excess of loss treaty with a per occurrence limitation. The similarity exists because property per risk excess of loss reinsurers want to limit their losses from catastrophes.

The exhibit shows a loss occurrence clause that could be found in a catastrophe treaty. In the clause, losses from causes of loss not specifically described are limited to those occurring within 168 consecutive hours. The final paragraph addresses the possibility of a catastrophe involving more than one cause of loss with different hour limitations. For example, a hurricane could involve windstorm losses subject to the 72-hour limitation and flood losses subject to the 168-hour limitation. The primary insurer could consider all losses arising out of the hurricane as a single loss occurrence, subject to the hour limitations indicated. See the exhibit "Sample Loss Occurrence Clause."

Other Reinsurance Clause

The other reinsurance clause specifies whether the retention applies only to the primary insurer's net retention or to both the primary insurer's net retention and the underlying reinsurance. If the stated retention does not apply to underlying reinsurance, the primary insurer is left with a gap in reinsurance coverage.

For example, if the stated retention for a second layer $5 million xs $5 million catastrophe treaty that overlies a first layer $4 million xs $1 million catastrophe treaty does not include the first layer's retention, the primary insurer would have a $1 million net retention on the first layer and would then have an additional $4 million retention before the second layer would operate. The exhibit illustrates this. See the exhibit "Effect of Underlying Reinsurance Included."

The problem illustrated in the "Effect of Underlying Reinsurance Included" exhibit is overcome by simply acknowledging the underlying reinsurance layer. An example of another reinsurance clause that acknowledges both a property per risk excess of loss and an underlying catastrophe treaty is shown in this exhibit. See the exhibit "Sample Other Reinsurance Clause."

Reinstatement Clause

The reinstatement clause of a catastrophe treaty is drafted to reflect the possibility that multiple catastrophic occurrences can occur in a single year. Because of this possibility, the treaty, through the reinstatement clause, usually provides for an automatic reinstatement of the reinsurance limit. The reinstated reinsurance limit is usually provided for an additional premium.

Sample Loss Occurrence Clause

27 E
LOSS OCCURRENCE

The term "Loss Occurrence" shall mean the sum of all individual losses directly occasioned by any one disaster, accident or loss or series of disasters, accidents or losses arising out of one event which occurs within the area of one state of the United States or province of Canada and states or provinces contiguous thereto and to one another. However, the duration and extent of any one "Loss Occurrence" shall be limited to all individual losses sustained by the Company occurring during any period of 168 consecutive hours arising out of and directly occasioned by the same event except that the term "Loss Occurrence" shall be further defined as follows:

(i) As regards windstorm, hail, tornado, hurricane, cyclone, including ensuing collapse and water damage, all individual losses sustained by the Company occurring during any period of 72 consecutive hours arising out of and directly occasioned by the same event. However, the event need not be limited to one state or province or states or provinces contiguous thereto.

(ii) As regards riot, riot attending a strike, civil commotion, vandalism and malicious mischief, all individual losses sustained by the Company occurring during any period of 72 consecutive hours within the area of one municipality or county and the municipalities or counties contiguous thereto arising out of and directly occasioned by the same event. The maximum duration of 72 consecutive hours may be extended in respect of individual losses which occur beyond such 72 consecutive hours during the continued occupation of an assured's premises by strikers, provided such occupation commenced during the aforesaid period.

(iii) As regards earthquake (the epicenter of which need not necessarily be within the territorial confines referred to in the opening paragraph of this Article) and fire following directly occasioned by the earthquake, only those individual fire losses which commence during the period of 168 consecutive hours may be included in the Company's "Loss Occurrence."

(iv) As regards "Freeze," only individual losses directly occasioned by collapse, breakage of glass and water damage (caused by bursting of frozen pipes and tanks) may be included in the Company's "Loss Occurrence."

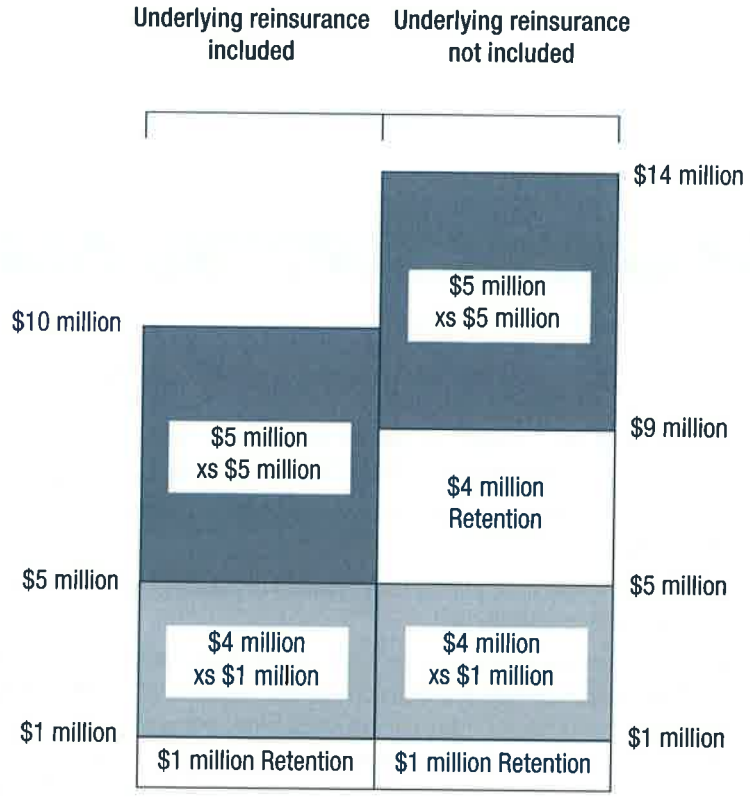
For all "Loss Occurrences," other than (ii) above, the Company may choose the date and time when any such period of consecutive hours commences provided that it is not earlier than the date and time of the occurrence of the first recorded individual loss sustained by the Company arising out of that disaster, accident or loss and provided that only one such period of 168 consecutive hours shall apply with respect to one event, except for any "Loss Occurrence" referred to in subparagraph (i) above where only one such period of 72 consecutive hours shall apply with respect to one event, regardless of the duration of the event.

As respects those "Loss Occurrences" referred to in (ii) above, if the disaster, accident or loss occasioned by the event is of greater duration than 72 consecutive hours, then the Company may divide that disaster, accident or loss into two or more "Loss Occurrences" provided no two periods overlap and no individual loss is included in more than one such period and provided that no period commences earlier than the date and time of the occurrence of the first recorded individual loss sustained by the Company arising out of that disaster, accident or loss.

No individual losses occasioned by an event that would be covered by 72 hours clauses may be included in any "Loss Occurrence" claimed under the 168 hours provision.

Source: Brokers & Reinsurance Markets Association (BRMA), www.brma.org/frommembers/contractword/Loss%20Occurrence%20BRMA%2027A-K.doc (accessed November 13, 2012). [DA05428]

Effect of Underlying Reinsurance Included



[DA05429]

Sample Other Reinsurance Clause

The Company shall maintain in force property per risk excess of loss reinsurance, recoveries under which shall inure to the benefit of this Contract.

The Company shall be permitted to carry underlying catastrophe reinsurance, recoveries under which shall inure solely to the benefit of the Company and be entirely disregarded in applying all of the provisions of this Contract.

[DA05430]

However, the reinstated reinsurance limit can be used only after the primary insurer has met its retention again. After the reinstated reinsurance limit has been exhausted, no coverage is provided under the treaty for future loss occurrences.

Typically, catastrophe treaties provide for immediate reinstatement of the limit to give the primary insurer the maximum possible limits without delay in case another loss occurrence involves the treaty. The reinstatement clause in the exhibit provides for immediate reinstatement of the limit. This clause specifies a limit per loss occurrence and an overall maximum limit. See the exhibit "Sample Reinstatement Clause."

Sample Reinstatement Clause

A. In the event all or any portion of the reinsurance hereunder is exhausted by loss, the amount so exhausted shall be reinstated immediately from the time the loss occurrence commences hereon. For each amount so reinstated, the Company agrees to pay additional premium equal to the product of the following:

   1. The percentage of the occurrence limit reinstated (based on the loss paid by the Reinsurer);
   2. The earned reinsurance premium for the term of this Contract (exclusive of reinstatement premium).

B. Whenever the Company requests payment by the Reinsurer of any loss hereunder, the Company shall submit a statement to the Reinsurer of reinstatement premium due the Reinsurer. If the earned reinsurance premium for the term of this Contract has not been finally determined as of the date of any such statement, the calculation of reinstatement premium due shall be based on the annual deposit premium and shall be readjusted when the earned reinsurance premium for the term of this Contract has been finally determined. Any reinstatement premium shown to be due the Reinsurer as reflected by any such statement (less prior payments, if any) shall be payable by the Company concurrently with payment by the Reinsurer of the requested loss. Any return reinstatement premium shown to be due the Company shall be remitted by the Reinsurer as promptly as possible after receipt and verification of the Company's statement.

C. Notwithstanding anything stated herein, the liability of the Reinsurer hereunder shall not exceed __95%__ of __$4,000,000__ as respects loss or losses arising out of any one loss occurrence, nor shall it exceed __95%__ of __$8,000,000__ in all during the term of this Contract.

[DA05431]

Typically, the reinsurer charges a pro rata amount of the original reinsurance premium as the reinstatement premium without adjusting for the length of the treaty's remaining term. The exhibit provides an example of how the reinstatement premium is often calculated for catastrophe treaties. For simplicity, the example assumes that the catastrophe treaty has neither a co-participation

provision nor inuring reinsurance. See the exhibit "Reinstatement Premium Calculation for a Catastrophe Treaty."

Reinstatement Premium Calculation for a Catastrophe Treaty

Original limit	=	100% of $4,000,000 xs $1,000,000
Gross amount of loss	=	$3,000,000
Original premium	=	$650,250

Reinstatement pro rata as to amount and 100% as to time

The reinstatement premium is calculated as follows:

Amount of loss applicable to the treaty		$3,000,000
Minus net retention		(1,000,000)
Amount recoverable		$2,000,000
Amount recoverable as a percentage of original limit*		0.50
Multiplied by the original premium	×	650,250
Reinstatement premium		$325,125

* $2,000,000 ÷ $4,000,000 = 50%

[DA05432]

The example in the "Reinstatement Premium Calculation for a Catastrophe Treaty" exhibit shows a partial reinstatement because the amount recoverable from the reinsurer ($2 million) is less than the $4 million treaty limit for each loss occurrence. A gross loss of $5 million in the example would have resulted in an amount recoverable of $4 million and payment of a reinstatement premium equal to the original premium.

Most property catastrophe occurrences are known immediately. The primary insurer and reinsurer know that some of the catastrophe treaty limit will be used, triggering a reinstatement. Although the extent of the loss is seldom known for some time, a reinstatement premium can be calculated after a reasonable estimate of the loss amount is made and then adjusted periodically until the loss is completely settled. This approach may be necessary because complicated property losses can take years to settle; some properties require difficult repairs, or the business interruption portion of a loss may involve lengthy litigation.

As a practical matter, the premium is typically due to the reinsurer concurrently with loss payments made by the reinsurer. The reinsurer usually remits to the insurer the net payment reflecting both amounts.

CATASTROPHE TREATY PRICING

Over time, a reinsurer expects to receive premiums from a primary insurer that are adequate to cover the reinsurer's share of the primary insurer's losses and loss adjustment expenses, the reinsurer's own expenses, and the reinsurer's reasonable profit.

Excess of loss treaties are frequently priced using experience rating and exposure rating techniques. However, experience rating is not generally used in pricing catastrophe treaties for these reasons:

- An insufficient number of catastrophe losses occur to accurately estimate future losses and future premiums.
- Reinsured underlying policies can change so quickly that actual losses may not be useful in accurately estimating future losses.

Regardless, a primary insurer's catastrophe loss experience data are still useful. They can be trended for any changes in the number of exposure units insured and the increased cost of construction.For example, assume that a particular region had a catastrophe loss in 20X1, when 1,000 policies were in force. However, by 20X5, the policy count for that region had changed. If the policy count had grown to 2,000 policies, the 20X1 loss may have doubled. If the policy count had dropped to 500, because the primary insurer reduced the number of underlying policies sold following the loss, the estimated loss may be one-half the 20X1 loss. The 20X1 loss could also be adjusted for increased construction costs using a construction cost index, but this type of trending is most appropriately used with exposure rating.

Catastrophe treaty pricing uses exposure rating based on trend analysis of a primary insurer's underlying policies. Catastrophe modeling is increasingly used to generate the expected loss information. Improvements in catastrophe modeling technology for measuring loss exposure have caused prices for catastrophe treaties to be based more on exposure and less on supply and demand.

Primary insurers charge insurance rates that include an amount for expected losses, including catastrophic losses. However, reinsurers charge rates for catastrophe treaties that are usually independent of, and seldom consider, the underlying insurance rates.Catastrophe treaty rates are based on other considerations, including these:

- Attachment point
- Layers and limits
- Underlying insurance analysis
- Inuring reinsurance
- Payback of prior losses
- Reinsurance limit

Attachment Point

The attachment point is the amount of ultimate net loss that the primary insurer will retain in any one loss occurrence before reinsurance coverage is triggered. Catastrophe treaties usually have very high attachment points. The cost of a catastrophe treaty generally decreases as the attachment point increases.

Layers and Limits

A primary insurer may buy several layers of catastrophe reinsurance. The treaty layers should not overlap or leave gaps in coverage. The exhibit illustrates possible layers for a medium-size primary insurer. See the exhibit "Illustration of Treaty Layer."

Illustration of Treaty Layer

Layer	Limit/Retention
1	$1.5 million xs $1 million
2	$2.5 million xs $2.5 million
3	$5 million xs $5 million
4	$5 million xs $10 million
5	$10 million xs $15 million

[DA05438]

Dividing a reinsurance program into layers allows the primary insurer to make optimal use of the reinsurance capacity available in the marketplace. Catastrophe reinsurance programs require a large amount of reinsurance capacity, more than any one reinsurer may be willing to provide. Consequently, many reinsurers may take a percentage of each reinsurance layer.

Also, reinsurers' underwriting guidelines often limit what they can provide per layer and per reinsurance program. Usually, their per-program capacity is several times their per-layer capacity.Therefore, if the primary insurer has only one layer for its total program, each reinsurer could be restricted to one participation in one layer rather than having a larger aggregate participation through several layers.

For example, assume that Descanso Re has a maximum capacity per treaty of $1 million and a reinsurance program capacity of $5 million. If a primary insurer has only one layer of $24 million xs $1 million, Descanso Re could authorize a participation of only $1 million.However, if the primary reinsurer's reinsurance program were split into five layers as shown in the "Illustration of

Treaty Layer" exhibit, Descanso Re could authorize a participation of $5 million consisting of $1 million for each layer.

The low layers of a catastrophe reinsurance program experience more loss frequency than high layers because only the largest losses affect the high layers. Typically, the limits become larger in high layers to reflect this lower loss frequency and higher loss severity.

Some reinsurers prefer low layers that have high premiums and that experience more frequent losses. Others prefer high layers with low premiums and fewer losses. Some reinsurers prefer to skip layers, also called ventilate participation. For example, a reinsurer may participate in the first, third, fifth, and seventh layers. By layering the catastrophe reinsurance program, the primary insurer provides the maximum opportunity for reinsurers to participate in the program and facilitates placement.

Underlying Insurance Analysis

Reinsurers analyze the primary insurer's underlying insurance to determine whether they want to participate in a particular catastrophe reinsurance program and to establish rates. Reinsurers consider these factors in their analyses:

- Geographic distribution of loss exposures
- Estimated subject premium for the contract year to be rated
- Subject premium and loss history
- Property residual market facility participation
- Miscellaneous information

Geographic Distribution of Loss Exposures

The geographic distribution of loss exposures by region, state, county, or zip code defines where the underlying loss exposures are physically located. The distribution can show premium, policy count, or total policy limits. Catastrophe modeling uses much of this information to perform catastrophe analysis.

The primary insurer's geographic distribution of loss exposures may change because of new marketing and underwriting strategies. Reinsurers must understand changes in the primary insurer's geographic distribution of loss exposures to accurately estimate the probable maximum loss (PML) and to develop catastrophe rates.

Estimated Subject Premium for the Contract Year to Be Rated

Reinsurers also analyze the estimated subject premium for the contract year to be rated. Catastrophe treaty pricing is often expressed as a percentage of subject premium, either written or earned, for the treaty's term. Because the actual

subject premium is not known until after the treaty's term, the primary insurer must estimate the subject premium for the reinsurer for pricing purposes.

The dollar amount negotiated for the limit of reinsurance is stated as a percentage of this estimated subject premium. If at the end of the year the actual subject premium is greater than the estimate, the premium that the primary insurer must pay to the reinsurer increases.If actual subject premium is less than the estimate, the premium that the primary insurer must pay to the reinsurer decreases, usually subject to a minimum reinsurance premium. This assumes that any differences in the estimated subject premium and actual subject premium reflect loss exposure changes.

Subject Premium and Loss History

Subject premium and loss history are additional sources of information for the reinsurers' analyses. Usually, reinsurers analyze subject premium and catastrophe loss history for at least ten prior years to establish reinsurance rates. Reinsurers often request a history of catastrophe losses, usually stated as loss occurrence above a certain dollar amount, such as 50 percent of the proposed retention, to gain insight into past loss experience. Reinsurers analyze changes made to a primary insurer's underlying insurance from the time of those catastrophe losses to determine the potential for similar losses recurring.

Reinsurers need subject premium by state for the expiring contract year and estimated subject premium by state for the coming contract year to price reinsurance coverage. States differ in their catastrophe loss exposures and their regulatory requirements for participation in involuntary catastrophe facilities. The judicial environment also differs by state.

Property Residual Market Facility Participation

Reinsurers also analyze the primary insurer's participation in property residual market facilities, which many states have formed to provide property insurance that cannot be obtained in the voluntary market. Those facilities were created to address insurance availability problems. Generally, all primary insurers that sell insurance in the state must participate in these facilities, based on their share of the voluntary property market in the state.

When a catastrophe occurs, residual market facilities can incur large losses. Typically, residual market facilities pass on any deficits to primary insurers operating in the state according to the market share of the primary insurer in the form of assessments. Because these assessments result from a specific loss occurrence, they are usually covered by catastrophe treaties by adding the assessments to a primary insurer's direct loss from the loss occurrence. Participation in property residual market facilities can be a significant component of a primary insurer's exposure to catastrophic events. To estimate potential assessments, reinsurers must know the primary insurer's participation in each such facility.

Coastal pools are examples of property residual market facilities that can cause catastrophe treaty losses. Several Gulf of Mexico and Atlantic coastal states have formed coastal pools to provide property insurance for loss exposures that are located in these coastal areas and that cannot be insured in the voluntary market.

Many states also have Fair Access to Insurance Requirements (FAIR) plans. Most state FAIR plans were established in the 1960s after urban riots occurred in Los Angeles; Detroit; and Newark, New Jersey. Initially, these facilities provided insurance in urban areas where insurance in the voluntary market was unavailable. FAIR plans subsequently evolved and now have broad definitions that allow them to offer insurance in a variety of areas. Similar to coastal pools, FAIR plans can incur a significant loss from one loss occurrence, which is then passed on through assessments to primary insurers operating in the state.

Miscellaneous Information

Finally, reinsurers should obtain this information when analyzing primary insurers' underlying policies:

- Rate change history for the subject policies
- Limits and deductibles for the subject policies, including summaries of subject policies in policy limit ranges
- Actual coverage history and proposed coverage changes

Analyzing this information enables the reinsurer to gain a better understanding of the primary insurer's underlying policies and the potential changes that may affect the current year's operating results.

Inuring Reinsurance

Inuring reinsurance reduces the amount of loss to the catastrophe treaty. Because of this, reinsurers should consider the amount of inuring reinsurance when pricing a catastrophe treaty. Also, premiums paid for pro rata inuring reinsurance reduce the amount of subject premium under the catastrophe treaty. Therefore, the reinsurance rate applies to a smaller amount of subject premium for a catastrophe treaty above pro rata inuring reinsurance than for one without pro rata inuring reinsurance.

To price a catastrophe treaty, the reinsurer needs to review the current inuring reinsurance agreements in addition to past and projected agreements and rates. If a change to the inuring reinsurance is proposed, historical subject premiums and losses should be shown as if that projected structure were in place. This adjustment ensures a consistent evaluation of losses and premiums over time.

Payback of Prior Losses

Relationships between primary insurers and reinsurers are usually long term and are represented by either continuous reinsurance treaties or multiple renewals of term treaties. The goal of a reinsurance relationship is to spread the primary insurer's unexpected losses over time. The reinsurer expects that it will be paid back for indemnification payments made to the primary insurer.

Many reinsurers use a "banking plan" in which they keep track of all the premiums they have received from a primary insurer and the losses that they have paid. Under such a plan, the primary insurer knows that a catastrophe loss payment by the reinsurer will be included in "the bank" and amortized over a specified number of years so that the reinsurer can be repaid. The number of years specified for the repayment of catastrophe losses significantly affects the reinsurance premium as the reinsurance relationship continues and catastrophe losses are incurred.

Two measures are often used in catastrophe treaty pricing to evaluate the reasonableness of the reinsurance premium relative to the number of years it would take the reinsurer to recoup catastrophe loss payments. These measures are payback period and rate on line.

The **payback period** is calculated with this equation:

$$\text{Payback period} = \text{Reinsurance limit} \div \text{Reinsurance premium paid}$$

Payback period
The number of years that a treaty would need to continue at the present reinsurance premium for the reinsurer to recoup the payment of the reinsurance limit under the treaty.

For example, if the treaty's reinsurance limit is 95% of $10 million (or $9.5 million) and the premium paid is $1 million, the payback period would be nine-and-a-half years. If a total loss to the treaty occurred, it would take nine-and-a-half years to pay back the layer with current pricing. In its evaluation, the reinsurer may be satisfied with a nine-and-a-half-year payback. However, the reinsurer may choose to increase the reinsurance premium and thereby shorten the payback period.

Rate on line (ROL) is calculated with this equation:

$$\text{Rate on line} = \text{Reinsurance premium paid} \div \text{Reinsurance limit}$$

Rate on line (ROL)
A measure of the appropriateness of the reinsurance premium relative to the reinsurance limit.

Whereas the payback period is stated in years, ROL is a percentage. For example, if the treaty's reinsurance limit is 95% of $10 million (or $9.5 million) and the premium paid is $1 million, the rate on line would be 10.5 percent. Rate on line is the mathematical inverse of the payback period calculation.

Catastrophe treaty pricing reflects the amount of loss financing the reinsurer is willing to provide the primary insurer if a catastrophe loss occurs. Payback period and, in particular, rate on line serve as a quick gauge of the treaty's pricing, although the rate on line percentage is not the reinsurance rate. Reinsurers and reinsurer intermediaries often ask prospective primary insurer clients for their rate on line to evaluate the price the primary insurer is currently paying for its catastrophe reinsurance coverage.

Reinsurer expectations for the appropriateness of the payback period and rate on line often depend on the layer of the catastrophe treaty being priced. A lower catastrophe treaty layer will often have a shorter payback period (or a higher rate on line) because lower layers are more likely to be exceeded by catastrophe losses, and the reinsurer wants to be paid back before the next catastrophe loss occurs.

Although reinsurers have an expectation of being paid back for losses covered under catastrophe treaties, those expectations are usually only met in lower layers of the treaty in which the reinsurance premium can fund the treaty over a reasonable period of time. For example, a twenty year payback may be considered an appropriate reinsurance premium for one reinsurer, while a fifty year payback may not.

The higher layers of a catastrophe treaty may be so high that no losses are expected. Consequently, the reinsurance premium charged is usually low, and the payback period, if calculated, is many more years than is practical to consider. Therefore, for high layers of catastrophe reinsurance protection, the reinsurer is trying to ensure that the reinsurance premium will fund catastrophe losses.

Reinsurance Limit

An important consideration in catastrophe treaty pricing is setting the catastrophe reinsurance limit. The primary insurer, with the assistance of the reinsurer or reinsurance intermediary, uses catastrophe models to analyze its portfolio of in-force policies and determine a range of possible outcomes from catastrophic events.

A catastrophe model can show the PML within certain time frames and can generate average annual loss figures. Using data such as these, the primary insurer can select a reinsurance limit that will protect it from the largest loss it expects to occur.

CATASTROPHE MODELING

Catastrophe models combine mathematical representations of the natural occurrence patterns and characteristics of catastrophes with exposure information, including property replacement values and construction and occupancy types, to provide information concerning the potential for large losses.

Catastrophe models can assess not only potential loss severity but also the probability that a catastrophe will occur. In the United States, the principal causes of loss modeled are hurricanes, earthquakes (ground shaking and fire following), and severe thunderstorms (inclusive of tornado, hail, and straight-line winds). Catastrophe models have also been developed for wildfire, winter storms, flood, and terrorism.

Because catastrophe modeling has become a standard industry practice, it is important to understand how catastrophe models operate, how they are used, and the various issues that can affect their reliability.

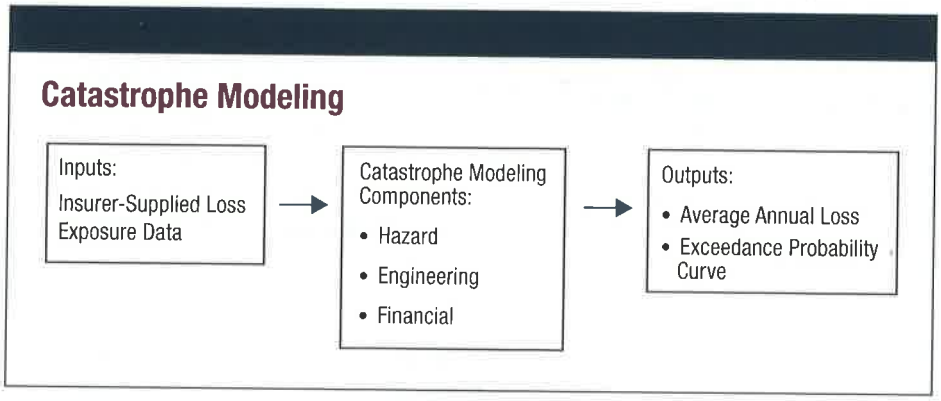
How Catastrophe Models Operate

Catastrophe models use insurer-supplied exposure data to produce a range of potential losses that may result from the catastrophes being modeled, along with their associated probability of exceedance (the probability that a loss of a specified size will be equaled or exceeded).

Catastrophe models typically include these three basic components, or modules:

- Hazard
- Engineering
- Financial

The exhibit shows the components of a catastrophe model, along with its inputs and outputs. See the exhibit "Catastrophe Modeling."



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Although the computer codes for catastrophe models are generally proprietary, modeling firms provide thousands of pages of detailed documentation in an effort to ensure that model users understand the models and the models' sensitivities, uncertainties, and implications for risk management; as well as that model users understand best practices for using model results. Because both the assumptions behind and results from different catastrophe models vary, a primary insurer often considers information derived from several catastrophe models.

Hazard Component

The first component of a catastrophe model is the hazard component. The hazard component simulates a catastrophic event to determine hazard intensity and is built by teams of scientists, including meteorologists, seismologists,

hydrologists, climate scientists, and geophysicists. The hazard component answers these questions:

- Where are future catastrophes likely to occur?
- How large or severe are they likely to be?
- How frequently are they likely to occur?

Large catalogs comprising tens of thousands of computer-simulated catastrophes are generated, representing the broad spectrum of plausible events. For each simulated event, the model calculates the intensity at each location within the affected area. For example, for earthquakes, intensity may be expressed in terms of the degree of ground shaking or the number and intensity of fires spawned by the event; for hurricanes, intensity is expressed in terms of wind speed and storm surge height.

The models incorporate large and detailed databases of geophysical information. For example, windstorm models use high-resolution digital land use and land cover data to calculate the effects of surface friction on wind speed. Earthquake models employ detailed soil data, which determine the degree of seismic wave amplification and the potential for liquefaction at specific sites affected by the event.

Catastrophe models may produce different results because they are based on different theoretical assumptions and variables. For example, over 100 years of data are available on hurricanes, but the early data are not as detailed, sophisticated, or accurate as recent data. Different modeling firms may therefore employ different datasets and consequently develop different theories about the potential frequency and severity of future hurricanes.

Engineering Component

The second component of a catastrophe model is the engineering component. The engineering component uses the intensity information from the hazard component to estimate the extent of structural damage that would occur based on information about the properties that are exposed to a simulated catastrophic event. These estimates incorporate information such as building construction, occupancy, height, age, and building code enforcement. Additional detail, such as roof shape, roof-to-wall connections, and the presence or absence of hurricane shutters can also be used, when available.

Developed by structural engineers, equations called damage functions are used to compute the level of damage that is expected to occur to buildings and their contents and to estimate the time it will take to repair or rebuild affected structures. This last type of damage function is used to produce estimates of business interruption (BI) losses or alternative living expenses (ALE) for residential policies. The catastrophe model's damage functions can incorporate published research, the results of laboratory testing, findings from on-site damage surveys, and detailed claims data provided by insurers.

Another reason that catastrophe models can produce varied results is because they use different engineering research to determine damageability. For example, research and professional opinions vary regarding the effects of hurricane winds and flying debris on different types of structures.

Financial Component

The third component of a catastrophe model is the financial component, wherein estimates of physical damage to buildings and contents are translated into estimates of monetary loss. These estimates, in turn, are translated into insured losses by applying insurance policy conditions to the total damage estimates. In essence, the financial component evaluates the effect of a simulated catastrophe on an insurer's in-force policies and operating results. Depending on the magnitude of the simulated catastrophe, the primary insurer will sustain a range of losses. The financial component usually reflects coverage characteristics of the in-force policies, such as whether they are on an actual cash value (ACV) or a replacement cost basis.

Some catastrophe models include socioeconomic factors, such as the likelihood of fraud or theft following a catastrophe. Demand surge is another factor to consider in calculating the total insured loss. Demand surge occurs when repair costs increase dramatically following a catastrophe because of supply shortages, whether of materials or labor. For example, the price of glass, roof shingles, and plywood could increase significantly in the affected area following a hurricane.

How Catastrophe Models Are Used

Primary insurers use the results of catastrophe models to understand the catastrophe loss potential given their portfolio of in-force policies. Model results are also used as input into pricing decisions, risk selection and underwriting, the design of territories, loss mitigation studies, and risk transfer strategies.

Reinsurers and reinsurance intermediaries use the results of catastrophe models to determine how an existing or proposed reinsurance program will respond under various catastrophe scenarios and to establish a rate for catastrophe reinsurance coverage. Reinsurers also use catastrophe modeling to manage catastrophe exposures assumed from their primary insurer clients and to aid in determining catastrophe retrocessional needs.

Catastrophe models provide detailed output from which various measures of loss potential and risk can be derived. Two key outputs from catastrophe modeling are the average annual loss and the exceedance probability curve.

Average Annual Loss

The average annual loss (AAL) is the long-term average loss expected in any one year for in-force polices for the cause of loss being modeled. AAL is also referred to as the catastrophe loss cost, or pure premium, and is typically expressed as the expected loss per unit of exposure.

When the analysis is performed on a zip code level, the catastrophe model produces AAL values for each zip code. Zip codes with high AAL values are particularly vulnerable to catastrophic loss. Because AAL values reflect all the components of the catastrophe model (hazard, engineering, and financial), AAL values are more effective in identifying concentrations of catastrophe-prone in-force policies than a simple review of the geographic distribution of in-force policies.

AAL analysis has several uses. Catastrophe models can generate policy-level AAL information so that reinsurance rates can be developed. AAL can be allocated between the primary insurer's net retention and the reinsurance program to determine the AAL for each layer in the reinsurance program. If the cause of loss being modeled is the only cause of loss covered by the reinsurance program, a reinsurer could develop a rate by adding its own expense and profit factors to the AAL. A risk load is also often incorporated into the rate to cover the possibility of extreme events generating losses well in excess of the AAL. Reinsurers and primary insurers can also use AAL information to compare the pricing of different reinsurance program proposals.

Exceedance Probability Curve

While AAL is a useful metric, the fundamental outputs of catastrophe models are not single numbers. One of the most commonly used outputs is the exceedance probability (EP) curve, which represents the full spectrum of potential losses and their associated probabilities of occurrence. These probabilities are called exceedance probabilities and reflect the probability that a loss of a specified size will be equaled or exceeded.

The exhibit shows an example of an EP curve. The probability that various levels of loss (in millions of U.S. dollars) will be equaled or exceeded in the coming year is shown. Also shown are return periods, in years, as the inverse of the exceedance probability. Exceedance probabilities are assigned by the catastrophe model. For example, there is a 1 percent probability that a $44 million (or higher) catastrophe loss will occur in any given year. Put another way, a loss of $44 million (or higher) is expected every 100 years, on average. Similarly, there is a 0.4 percent probability that a $75 million (or higher) loss will occur in any given year. Expressed in terms of return periods, a $75 million (or higher) loss is expected every 250 years, on average. See the exhibit "Exceedance Probability Curve."

It is prudent to focus on exceedance probabilities, rather than on return periods, to avoid thinking that "the 100-year loss won't occur in my lifetime" or that if the 100-year loss occurred this year, it won't occur again for another 100 years. In fact, there is a 1 percent probability every year that the 100-year loss will occur.

Based on an exceedance probability analysis, the primary insurer can make informed decisions regarding the size of the reinsurance limit it should purchase.

Exceedance Probability Curve

Exceedance Probability (Percent)	Return Period (Years)	Estimated Loss ($ millions)
0.01	10,000	234
0.05	2,000	146
0.10	1,000	127
0.20	500	104
0.30	333	92
0.40	250	75
0.50	200	67
1.00	100	44
2.00	50	24
3.00	33	17
4.00	25	13
5.00	20	9
10.00	10	3

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Catastrophe Modeling Issues

Although catastrophe modeling has become standard practice for primary insurer pricing, there are some issues about using catastrophe modeling in rate development. Different models from different vendors can produce different outcomes because of variation in the data and assumptions used to build each model. Further, advances in scientific and engineering research can affect model results even if the historical data have not changed.

Catastrophe models also place significant demands on primary insurers' information systems, for a primary insurer's data must be compatible with the catastrophe model's input requirements. Information that the primary insurer must capture to make the best use of catastrophe models can increase the primary insurer's costs. The reliability of model output is only as good as the quality of the exposure data used as input.

Despite these issues, catastrophe modeling is an effective, widely used method for assessing catastrophe risk. In fact, since the inception of modeling in the mid-1980s, applications of the technology have broadened to serve corporate risk managers, investors, mortgage underwriters, government officials, and any others who benefit from an enhanced understanding of their risk.

MANAGING RISK WITH CATASTROPHE MODELING

Natural catastrophes—earthquakes, hurricanes, tornadoes, and floods—and terrorism can jeopardize the financial well-being of an otherwise stable, profitable company. Catastrophe models assist companies in anticipating the likelihood and severity of potential future catastrophes before they occur so that companies can adequately prepare for the possible financial impact.

Understanding how the typical catastrophe model output is analyzed and how it can be used is an important skill, as this output is often used by many departments, such as portfolio management, claims, and underwriting. By carefully considering the case facts provided and following the necessary steps in this activity, you should better understand how a primary insurer can use the results of a catastrophe modeling analysis to develop options it can employ to manage its catastrophe exposures.

Case Facts

Andalusia Insurance Company (Andalusia) sells homeowners policies and policies for small commercial businesses; it has sold many policies in New York and New Jersey. Because the loss exposures for its existing in-force policy portfolio are located primarily in coastal areas, this insurer has a significant wind exposure.

Andalusia concluded its first catastrophe modeling analysis a year ago. That analysis yielded a 100-year (1 percent exceedance probability) loss of $20 million and a 250-year (0.4 percent exceedance probability) loss of $50 million. Andalusia has $15 million of policyholders' surplus and catastrophe reinsurance with a per occurrence limit of $25 million. Its written premiums have grown 25 percent over the last year. An updated catastrophe modeling analysis will show how that growth has affected Andalusia's loss exposure to hurricanes.

Consider these questions, which are based on the facts presented in this case:

- What input data will Andalusia need to provide for the catastrophe model?
- Will the catastrophe model analysis show more or less chance of catastrophe loss exposures than in the past?
- What options are available to Andalusia so that it can better manage its catastrophe loss exposures in the future?

When answering the questions in this case-based activity, consider only the information supported by the facts of the case and any recommended tools.

Case Analysis Tools

Andalusia will provide the necessary input data so that the catastrophe model can produce the most accurate information possible on its catastrophe exposures. After analyzing detailed output from the catastrophe model, Andalusia will determine available options to its policies and/or geographic concentration of policies sold, its reinsurance program, and its mix of business, as appropriate, so it can better manage its identified exposure to catastrophe risk.

Overview of Steps

These steps will be followed in the catastrophe modeling process:

- Andalusia will prepare and provide the necessary input data for the catastrophe model.
- The catastrophe model will provide detailed output from which various measures of loss potential and risk can be analyzed regarding Andalusia's catastrophe loss exposures.
- Andalusia will determine various options available with which to manage its catastrophe exposures.

Preparation of Input Data

Andalusia begins the catastrophe modeling process by collecting information on its in-force policies to create its loss exposure data. Andalusia's information system maintains location information for each loss exposure insured. Its reinsurance intermediary requests the information shown in the exhibit on each policy sold. See the exhibit "Information Required for Catastrophe Modeling."

For a hurricane catastrophe model, the data must indicate whether wind is an excluded cause of loss. In some coastal areas, primary insurers exclude wind, and the insured often buys wind coverage from a state-sponsored coastal pool. However, in Andalusia's case, wind is an included source of loss.

If Andalusia cannot provide certain information, it can make assumptions about that information. However, the reliability of the model's results depends on the quality of those assumptions.

The policy-level details can create a massive data file that often must be adjusted to match the catastrophe model's input criteria. For example, codes that indicate the coverage form used may need to be converted to the coverage codes used by the model. The primary insurer's information system may not capture required loss exposure data, such as the contents' replacement value for homeowners policies. Those data may need to be inserted into the data file based on Andalusia's assumptions. When the data file is ready, it is imported into the catastrophe model.

Information Required for Catastrophe Modeling

- Policy number
- Coverage form
- Type of insurance
- Location number (if multiple locations are covered under one policy)
- State code
- County code
- City
- Zip code (five-digit)
- Street number
- Street name
- Policy premium
- Policy limit
- Policy deductible
- Building limit
- Other structures limit
- Contents limit
- Loss of use limit
- Replacement values
- Coverage deductibles
- Building height in stories
- Year built
- Occupancy type
- Construction class
- Wind peril exclusions

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Catastrophe Model Analysis

Catastrophe models provide detailed output from which various measures of loss potential and risk can be derived. This output provides a basis for analyzing catastrophe risk.

Geocoding
A process of matching addresses with map positions.

Catastrophe models that perform policy-level analysis must complete geocoding. The catastrophe model tries to match policies to latitude and longitude. If the model cannot initially do this, it uses progressively less-detailed information until it can. For example, if street address-level information is provided, the model will first attempt to geocode at the street address. If the model cannot find the street address, it will attempt to match at the five-digit zip code level, then the city level, then the county level, until a latitude-longitude match is found.

The geocoded information is processed by the hazard, engineering, and financial components of the catastrophic model to produce these outputs:

- Average annual loss (AAL) analysis
- Exceedance probability (EP) curve

The AAL analysis can be compared with the geographic distribution of in-force policies. Although geographic areas with a large concentration of insured values usually also have high AAL amounts, that is not always the case. AAL is a measure of vulnerability to the cause of loss being modeled, so

a small number of strategically located policies may generate a relatively larger AAL than a greater number of policies in a lower-risk area.

Assume that Andalusia writes 25 percent of its New Jersey business in Bergen County (a northern New Jersey inland area) and 1 percent in Cape May County (a southern New Jersey coastal area). Based on geographic distribution, Andalusia may conclude that Bergen County is a serious hurricane exposure. However, a catastrophe model may show that Bergen County represents only 2 percent of the AAL and that Cape May County represents 40 percent. If the total premium collected in Cape May County were $100,000, but the AAL were $125,000, the premiums charged would be inadequate based on catastrophe modeling because the AAL from hurricanes exceeds the entire premium collected for the policies in the county. However, insurers typically aim to avoid collecting premium less than the AAL by incorporating a risk load; this enables them to arrive at a suitable rate that allows for the possibility of extreme events that generate losses greatly in excess of the AAL.

The exhibit shows Andalusia's EP curve of estimated hurricane loss amounts at various return periods. See the exhibit "Andalusia's Exceedance Probability Curve."

Andalusia's Exceedance Probability Curve

Exceedance Probability (Percent)	Return Period (years)	Estimated Loss ($)
0.10	1,000	96,798,825
0.20	500	88,630,502
0.30	333	76,741,547
0.40	250	64,455,436
0.50	200	54,325,774
1.00	100	43,719,520
2.00	50	29,466,350
3.00	33	20,644,350
4.00	25	15,796,420
5.00	20	11,460,244
10.00	10	7,434,366

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Based on last year's exposure information, Andalusia's 100-year loss was $20 million, and its 250-year loss was $50 million. Now, based on Andalusia's new portfolio, a $20 million loss is associated with a return period of just 33 years, and a $50 million loss is expected to occur about every 160 years, indicating that Andalusia's catastrophe exposure has worsened.

Determination of Options

Based on the results of the catastrophe modeling analysis, Andalusia could choose one or a combination of these options:

- Purchase additional reinsurance—Andalusia currently has catastrophe treaty limits of $25 million. It is probably not reasonable for Andalusia to purchase a catastrophe treaty for a 1,000-year event. This would require a large amount of reinsurance or significant additional capital. Similarly, Andalusia would not want to purchase reinsurance for only a 10-year event because this would leave it with a high loss exposure. Primary insurers generally attempt to address a range of losses for wind-related or earthquake events between the 100-year and 500-year return periods. Andalusia's senior management must determine its retention after considering the catastrophe model's projections. If Andalusia decides to purchase reinsurance for the 100-year event of $44 million, it should consider all events occurring above that point to ensure that none of them are a likely event. For example, it may be that every event above the 100-year mark is a Category 5 hurricane, the strongest category of hurricane on the Saffir-Simpson scale. Category 5 hurricanes are rare in the Northeast, so Andalusia may be comfortable with not reinsuring events above the 100-year event. However, if some Category 3 hurricanes are above the 100-year mark, Andalusia should consider reinsurance at that level. If Andalusia decides to manage a $44 million loss with additional catastrophe reinsurance, it will need to increase its reinsurance from $25 million to $44 million.
- Sell fewer policies in vulnerable geographic areas—Andalusia could reduce its catastrophe risk in several ways. It could develop plans to reduce the number of exposures in vulnerable geographic areas. The catastrophe model could be used to perform sensitivity testing adjusted to determine the impact on the EP curve of removing specific exposures from the portfolio. Andalusia may discover that nonrenewing selected exposures would reduce its losses to last year's level.
- Change coverages or deductibles in vulnerable geographic areas—Andalusia may also decide to limit coverages offered or increase deductibles in coastal areas. For example, it may choose to reduce the amount of additional living expense coverage offered because that coverage increases overall hurricane losses, or it may choose to increase the hurricane deductible from 3 percent to 5 percent of a property's insured value to further reduce its potential losses.

ALTERNATIVES TO TRADITIONAL CATASTROPHE REINSURANCE

Primary insurers sometimes seek alternative methods of managing their catastrophe exposures. A primary insurer may choose an alternative method to take advantage of the high credit quality of some of the capital markets or for greater capacity. Catastrophe reinsurance can be expensive after a single catastrophe or series of catastrophes reduces global reinsurance capacity. A primary insurer may seek alternative methods if it wants to replace or supplement its current catastrophe reinsurance program.

Alternative methods rely on capital markets to securitize the insurance risk. That means that instead of purchasing reinsurance to cover its potential liabilities, the primary insurer uses security instruments to finance insurance risk.

Although these products are expanding and evolving rapidly, these are among the methods used most often:

- Lines of credit
- Catastrophe bonds
- Catastrophe options
- Catastrophe risk exchanges
- Industry loss warranties
- Reinsurance sidecars

Lines of Credit

A **line of credit** is an arrangement in which a bank or another financial institution agrees to provide a loan to a primary insurer in the event that the primary insurer suffers a loss. The credit is prearranged so that the terms, such as the interest rate and principal repayment schedule, are known before a loss. In exchange for this credit commitment, the primary insurer taking out the line of credit pays a commitment fee. A line of credit does not represent any risk transfer; it simply provides access to capital.

Line of credit
An arrangement that allows borrowing up to a prescribed limit.

Catastrophe Bonds

A **catastrophe bond** is a bond issued with a condition that if the issuer suffers a catastrophe loss greater than a specified amount, the obligation to pay interest and/or repay principal is deferred or forgiven. As long as catastrophe-related losses do not exceed the specified amount, investors earn a relatively high interest rate and receive a return of their principal. If catastrophe losses exceed the specified loss amount, the interest and/or principal forgone by bondholders is used to pay losses.

Catastrophe bond
A type of insurance-linked security that is specifically designed to transfer insurable catastrophe risk to investors.

Catastrophe bonds are typically issued by the special purpose vehicles (SPVs) of insurers, large reinsurers, or large corporations for any type of catastrophic

insurable risk, such as hurricanes, earthquakes, and other adverse weather and environmental risks. The SPV is paid a fee by the insurer for arranging and administering the deal, and it pays interest and returns the principal on a specified date if the losses do not exceed the specified amount. Money paid into an SPV is typically tax-deductible as a reinsurance expense.

Catastrophe Options

Catastrophe option

An agreement that gives the purchaser the right to a cash payment if a specified index of catastrophe losses reaches a specified level.

A **catastrophe option** is another means insurers use to transfer insurance risk to financial markets. The catastrophe index, such as that provided by Insurance Services Office, Inc.'s (ISO's) Property Claims Services (PCS), keeps track of catastrophe losses by geographic region, by cause of loss, and by time of occurrence. The seller of the catastrophe option profits if the specified level on the catastrophe index—the strike price—is not reached.

Catastrophe options can be structured to imitate the operation of catastrophe reinsurance, and some insurers are using catastrophe options to replace part of their reinsurance program. However, payments from catastrophe options and from catastrophe reinsurance are not triggered by the same events.

For example, a catastrophe option would pay when hurricane-caused catastrophe losses in Florida exceed the specified amount, even though the primary insurer holding the catastrophe option has sustained only minimal losses from the hurricane that are not sufficient to trigger the reinsurance. Alternatively, the primary insurer holding a catastrophe option may sustain significant losses from a hurricane that triggered the reinsurance but where the aggregate loss for the geographic region and time period covered by the index was insufficient to trigger an option payment.

Catastrophe options are attractive to capital market investors because insurance risk does not appear to be correlated with the risk associated with other securities. Therefore, they can be used to help diversify an investment portfolio.

Catastrophe Risk Exchanges

Catastrophe risk exchange

A forum in which primary insurers can trade insurance risk with other insurers.

A **catastrophe risk exchange** provides a means through which a primary insurer can exchange a portion of its insurance risk for another insurer's. The exchange can be, for example, an Internet-based forum on which risks available for trade are advertised, negotiated, and completed. The insurance risk traded may differ by geographic area, type of property, or cause of loss insured against. A primary insurer with a geographic concentration of loss exposures can use a catastrophe risk exchange to reduce its losses from a single loss occurrence. A primary insurer can also diversify the kinds of property insured to make it less susceptible to heavy losses from a single cause of loss.

Industry Loss Warranties

An industry loss warranty (ILW) is a type of insurance-linked security that covers the primary insurer in the event that the industry-wide loss from a particular catastrophic event exceeds a predetermined threshold. Similar to catastrophe options, this instrument's coverage is triggered by industry losses as a whole, rather than the primary insurer's losses.

Many kinds of ILWs are offered, usually characterized by a specific catastrophe (such as a hurricane or an earthquake), a certain geographic area (such as a specific state, country, or continent), and the threshold amount that must be met to trigger the ILW. For example, an ILW would promise to pay if this were to happen: "An earthquake with industry-wide insured loss in North America in excess of $20 billion." A variation would be "in excess of $20 billion but less than $30 billion."

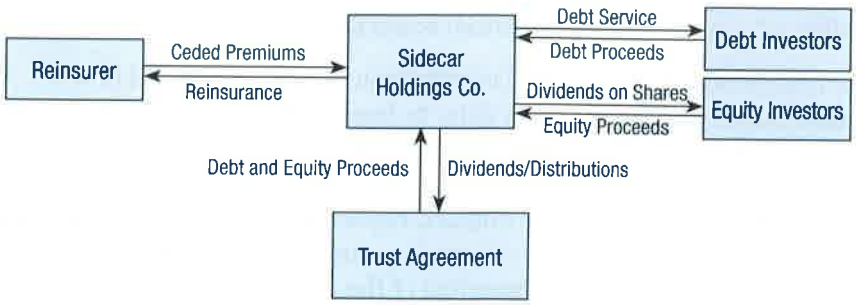
As ILWs become more widely accepted and used by primary insurers, the benefits are becoming more apparent. These products offer low transaction costs and generally provide more certainty and lower risk than other catastrophic reinsurance instruments. However, a difficulty remains in trying to determine the timing and extent of industry-wide catastrophic events.[2]

Reinsurance Sidecars

A reinsurance sidecar, referred to as "sidecar," is a limited-existence SPV, often formed as an independent company, that provides a primary insurer with additional capacity to write property catastrophe business or other short-tail lines through a quota share agreement with private investors. Investors in the SPV assume a proportion of the risk and earn a corresponding portion of the profit on the primary insurer's book of business. The primary insurer charges a ceding commission and may receive a profit commission if the book of business is profitable.[3] See the exhibit "Simplified Sidecar Structure."

Simplified Sidecar Structure

A.M. Best Company has provided the following diagram of a simplified sidecar structure.



The changing catastrophe loss landscape, including numerous costly hurricane seasons, has forced credit agencies to require greater capital levels for the insurance industry. Sidecars allow primary insurers to write more business than they would be able to by relying only on their present available capital. They can insure more properties with corresponding higher reserves, but without endangering their financial credit ratings. This additional capital, although expensive to acquire, enables primary insurers to expand in ways that would not otherwise be possible in the current constrained industry environment.[4]

SUMMARY

Catastrophe treaties operate by reimbursing a primary insurer for accumulated property losses after these losses exceed an attachment point. Their function is to help maintain financial stability and predictability for a primary insurer experiencing a low-frequency, high-severity loss event. Catastrophe treaties may be used as part of a primary insurer's entire reinsurance program, which can include forms of reinsurance that may or may not inure to the benefit of the catastrophe reinsurance treaties and often include structured layers and financial co-participation with the primary insurer.

Some of the clauses that are designed or adapted for use in catastrophe treaties include term clauses, retention and limits clauses, ultimate net loss clauses, loss occurrence clauses, other reinsurance clauses, and reinstatement clauses. Each clause is designed or adapted to provide additional details or clarification regarding the responsibilities of the primary insurer and the reinsurer.

Catastrophe treaty pricing is affected by attachment points, layers and limits, underlying insurance analysis, inuring reinsurance, payback of prior losses, and reinsurance limits.

A catastrophe model typically includes these three generic components: a hazard component, an engineering component, and a financial component. Two key outputs from catastrophe modeling are AAL and the EP curve. AAL is the loss to in-force policies that can be expected in any single year, on average over the long term, from the cause of loss being modeled. The EP curve is the full spectrum of potential losses that can occur along with their associated probabilities. Despite certain issues that exist, catastrophe models are the accepted industry standard for assessing catastrophe risk and providing valuable information on the potential financial effects of catastrophic events.

After completing this case-based activity, you should understand how a primary insurer prepares its input data, be familiar with the types of outputs produced by the catastrophe model (such as the AAL analysis and the EP curve), and consider the types of options that are available to a primary insurer based on analyses of the outputs. Beyond knowing the facts and principles of catastrophe modeling, viewing catastrophe modeling in a case-based scenario provides further understanding of the process and how a primary

insurer can use the results of a catastrophe modeling analysis to determine the best options available to manage its catastrophe loss exposures.

Primary insurers may seek methods other than purchasing reinsurance to manage their catastrophe exposures. Alternatives include lines of credit, catastrophe bonds, catastrophe options, catastrophe risk exchanges, ILWs, and reinsurance sidecars. One or several of these alternative methods can provide needed credit or additional capital to supplement or replace a primary insurer's current catastrophe reinsurance program.

ASSIGNMENT NOTES

1. Howard C. Kunreuther and Erwann O. Michel-Kerjan, "The Development of New Catastrophe Risk Markets" (Philadelphia: Center for Risk Management and Decision Processes, Wharton School of the University of Pennsylvania, 2009), p. 121, http://opim.wharton.upenn.edu/risk/library/J2009_ARRE_HK,EMK_DevelNewCatRiskMts.pdf (accessed November 12, 2012).
2. Ali Ishaq, "Reinsuring for Catastrophes Through Industry Loss Warranties—A Practical Approach," Casualty Actuarial Society Forum, Spring 2005, pp. 76, 78.
3. Information in this paragraph is adapted from the definition of "sidecar" in "Glossary of Reinsurance Terms," Reinsurance Association of America, www.reinsurance.org/SecTwoColumn.aspx?id=33 (accessed December 7, 2012).
4. Willis North America, "Perspectives—Insurance Sidecars," January 2007, pp. 1–2, www.willis.com/documents/publications/Services/Property/Perspectives-Sidecars_0107.pdf (accessed November 15, 2012).