“Guesstimating” catastrophe exposures with little historic information can lead to inappropriate risk management decisions. Modeling offers a better way to measure risk.

Application of Catastrophe Models in Risk Management

THOMAS O’BRIEN

Earthquakes. Hurricanes. Tornadoes. Hail storms. Terrorism. Evaluating property, life, and workers compensation exposure to these and other extreme events is a complex process. For workplace mishaps and other relatively frequent events, historical loss information is usually sufficient to estimate future losses through the application of actuarial techniques. But in the case of catastrophic events, which occur infrequently, the scarcity of historical loss information makes reliable estimates of future losses virtually impossible.

With little or no historical loss data, risk managers often resort to rules of thumb, “guesstimates,” or past practices when making decisions about their catastrophic risk. These blunt approaches have one of two results. Either they overestimate company exposure and companies, therefore, spend too much on unnecessary coverage, or they jeopardize the company’s financial well-being by leaving risks underinsured. Both outcomes are suboptimal at best and, in the case of the second, could result in financial ruin. Neither result, given recent advances in catastrophe modeling, is necessary.
Some risk managers rely on estimates of probable maximum loss (PML) as a benchmark for determining their coverage needs. PMLs are valuable in that they give a frame of reference for loss potential, but the frame of reference is limited because a PML is typically a single loss value. In contrast, output from a catastrophe modeling analysis is usually presented as an exceedance probability curve (see section on How to Derive Maximum Value from Catastrophe Modeling below), which enables the risk manager to see the entire loss distribution (including the PML) and the corresponding likelihood of each loss. This additional information allows for more strategic decision making and tailoring of a risk management program to correspond with an organization’s risk tolerance level.

Over the past two decades, the use of computer modeling to estimate future losses from catastrophes has become standard practice among insurers and reinsurers, yet among risk managers the use of computer modeling is still relatively rare. This is hardly surprising. Modeling is a critical component of an insurer’s operational success, and the earliest models were developed specifically to evaluate loss potential at ZIP Code and county levels. In recent years, however, models have become increasingly sophisticated and are now able to quantify loss potential at the individual address level. As a result, risk managers are slowly but surely embracing this powerful tool to quantify their exposure, reduce uncertainty, and help them make strategic risk management decisions.

Understanding the history and components of probabilistic catastrophe loss models is the first step toward applying modeled loss analyses effectively.

### The Evolution of Catastrophe Modeling Technology

In 1987, the first fully probabilistic catastrophe model for insurance applications was introduced. As is the case with new technologies, many in the insurance industry continued to rely on their existing rules-of-thumb for assessing loss potential from natural hazards. Only the most innovative insurers within the industry considered adopting the new approach. The old methods worked well enough as long as no significant catastrophes occurred.

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**Exhibit 1**

Annual Insured Losses from Catastrophes in the U.S., 1970-2002

<table>
<thead>
<tr>
<th>Year</th>
<th>Man-made</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>5</td>
<td>25</td>
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<td>72</td>
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<td>00</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>02</td>
<td>85</td>
<td>105</td>
</tr>
</tbody>
</table>

Source: Property Claim Services
In the years immediately preceding Hurricane Andrew (1992), the prevailing wisdom within the insurance industry was that the largest possible insured loss from a single hurricane might be $7 billion. After all, the largest insured hurricane loss thus far had been the $4.2 billion loss resulting from Hurricane Hugo in 1989, and that figure was several times larger than anything that had preceded it. Meanwhile, probabilistic estimates from catastrophe models clearly showed that the industry could experience $20 billion to $30 billion in hurricane losses with a reasonably significant probability. Even as Hurricane Andrew made landfall on the coast of southern Florida, catastrophe models produced “real time” loss estimates indicating that this single event could cost the insurance industry in excess of $13 billion. As the event unfolded, many dismissed those estimates as unrealistically high.

The losses from Hurricane Andrew turned out to be over $15 billion. Insurers and reinsurers were made painfully aware of the shortcomings of their traditional approaches to quantifying their exposure to catastrophe risk. Not surprisingly, catastrophe modeling developed a much larger support base within the industry in the aftermath of Andrew.

Since Andrew, economic losses from extreme events have continued to escalate, increasing the demand for effective and reliable risk assessment tools. From 1990 to 1999, total insured losses from natural disasters in the United States exceeded $87 billion, according to Property Claims Services. While losses from Hurricane Andrew and the Northridge earthquake make them the costliest natural hazard events ever to have affected the United States, total losses from the 1995 Great Hanshin (Kobe) earthquake are estimated at over $100 billion, making that the costliest natural disaster worldwide. The winter storms of 1999 that swept across Europe caused damage in excess of $17 billion. Furthermore, the tragic events of September 11, 2001, have made the risk management community acutely aware that not all catastrophe losses are of natural origin.

Exhibit 1 shows in current dollars U.S. catastrophe losses, both natural and man-made, over the past three decades. It is important to recognize that the significant increases over recent years are not due to an upward trend in the frequency or severity of natural hazard events. It is rather due to increasing concentrations of population and property values in hazard-prone areas.

As losses continue to mount, insurers and reinsurers have become acutely mindful of the need to assess their catastrophe risk accurately. A.M. Best, a rating agency for the insurance community, began to require the use of catastrophe models as a qualifying criterion for granting property insurers “Secure” (A++ to B+) ratings. As a result, catastrophe modeling technology is now used by almost all reinsurers around the world, by most primary insurers in the United States, and by an increasing number of primary insurers outside the United States.

Initially, use of models focused on aggregate analyses of insurers’ and reinsurers’ books of business. As models became more refined, they enabled loss assessment at finer resolutions. Now, underwriters use models to price risk and set premiums, while some brokers provide modeling services to their clients. Given the acceptance of and reliance on catastrophe models in the insurance industry, the question is: Why aren’t more corporate risk managers using them to optimize risk transfer and risk mitigation programs? In part, the answer has to do with unfamiliarity with how catastrophe models work and how model output should be interpreted and applied. But first, we turn to a closer examination of the perils for which the models were developed.

Sophisticated models now exist for perils affecting every major insurance market of the world.

The Perils

The first models focused on natural catastrophes specific to the United States, events that were potentially most devastating and costly to insurers. Shortly after the first hurricane model was introduced in the late 1980s, other models were developed for earthquakes. Models for severe thunderstorm, which quantify potential losses from tornado, hail, and straight-line winds, followed. Sophisticated models now exist for perils affecting every major insurance market of the world, including earthquakes in Israel, South America, and Asia Pacific, extra-tropical cyclones affecting Europe, and typhoons in Japan. Let us focus
on and review hurricanes, earthquakes, and severe thunderstorm in the United States, the largest insurance market, to add some perspective.

Hurricanes

Hurricanes in the Gulf and east coasts usually occur between June 1 and November 30, when tropical waters are warmest. Warm water (80 degrees or above) and the presence of the Coriolis force that produces the cyclonic circulation are two critical elements for the formation of hurricanes. (The Coriolus force is created by the earth’s rotation, acting upon anything moving above the earth’s surface by causing it to curve to the right [clockwise] in the Northern Hemisphere and to the left [counterclockwise] in the Southern Hemisphere.) This explains why hurricanes form only in tropical waters (warmth) but never at the equator (no Coriolis force).

Hurricanes start out as tropical depressions, i.e., low-pressure systems with thunderstorms and winds between 22 and 38 miles per hour (mph). Once winds increase to between 39 and 73 miles per hour the event is classified as a tropical storm. At 74 mph and above, the event is classified as a hurricane. Hurricanes are typically categorized using the Saffir-Simpson Intensity Scale. (See Exhibit 2.)

It is important to understand that storms in different Saffir-Simpson categories are very different in their capacity for destruction. While the actual losses incurred are largely contingent on the landfall location, duration, and path of the event, a Category 4 hurricane would, generally speaking, be expected to cause 100 times more damage than a Category 1 storm.

In developing computer simulations to quantify the potential losses from hurricanes of different intensity, it is essential that the parameters of the simulated hurricanes closely resemble those of the real events. This is especially true with regard to their frequency of occurrence, likelihood of landfall location, and the interplay of meteorological conditions. The meteorologists and engineers employed by modeling companies conduct extensive research on historical events and on the interrelationship of hurricane characteristics that determine a storm’s course.

<table>
<thead>
<tr>
<th>Exhibit 2</th>
<th>The Saffir-Simpson Intensity Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Central Pressure (millibars)</strong></td>
</tr>
<tr>
<td>1</td>
<td>≥980</td>
</tr>
<tr>
<td>2</td>
<td>965-979</td>
</tr>
<tr>
<td>3</td>
<td>945-964</td>
</tr>
<tr>
<td>4</td>
<td>920-944</td>
</tr>
<tr>
<td>5</td>
<td>&lt;920</td>
</tr>
</tbody>
</table>
and destructiveness. These researchers also rely heavily on data from various agencies and departments of the U.S. government, including the National Hurricane Center, National Weather Service, National Oceanic and Atmospheric Administration, the U.S. Army Corps of Engineers, and the U.S. Department of Commerce.

Earthquakes

Most earthquakes occur when the tectonic plates that form the earth’s surface move over, under, or past each other. One such example would be motion along the San Andreas Fault in California. Earthquakes can also occur within the interior of plates, at locations where there is a geological deformation or variations in the temperature and strength of the lithosphere — the layer of the earth’s crust that extends from the surface down to a depth of approximately 100 to 200 kilometers. The New Madrid Seismic Zone in the central United States is an example of an “intraplate” earthquake-prone area. In fact, it was here, rather than in California, that the largest historical earthquakes in the United States occurred — a series of three quakes with magnitudes ranging from 7.8 to 8.1 on the Richter Scale in the winter of 1811-1812.

It is estimated that seismic instruments record roughly 500,000 earthquakes each year worldwide, with about 10,000 of those events occurring in Southern California. Most of these, of course, do not cause damage. U.S. seismic activity is typically focused in Alaska, the Pacific Northwest, and Southern California. But even though frequent earthquake activity is associated with specific locations, it is worth noting that earthquakes can occur anywhere. Between 1975 and 1995, for example, the only states that did not experience an earthquake were Florida, Iowa, North Dakota, and Wisconsin. The New Madrid events of 1811-1812, though centered in the Mississippi River Valley, were felt as far away as Boston, Massachusetts.

Dramatic advances have been made in engineering buildings to withstand the effects of seismic events. Notably, the New Madrid Seismic Zone in the central United States is an example of an “intraplate” earthquake-prone area.

Exhibit 3

Historical Seismicity in the Continental United States (Mw ≥ 6.0)

[Map showing historical seismicity with various magnitudes indicated]
waves. Unfortunately, implementation of those design elements is generally limited to the newest buildings in the most seismically active regions of the most developed countries. Sophisticated catastrophe loss modeling differentiates between building codes in different countries and different regions within countries. Modeling takes into account the codes in force at the time of a building’s construction to more accurately assess the loss potential of a specific structure. (See the section on How to Derive Maximum Value From Catastrophe Modeling below.)

Data provided by networks of sensitive instruments capable of detecting earthquakes of low magnitude are supplemented by data from GPS stations.

Depicting the location, frequency, and magnitude of earthquakes in a model poses many of the same challenges as those in the hurricane model. There exist little reliable historical data prior to about 1900. For earthquakes that occurred before the installation of seismographs and seismic networks, which began around the turn of the century, estimates of magnitude are reconstructed from journals, personal letters, and newspaper accounts. This information is supplemented by fault trenching, which reveals offsets in soil and rock layers and ancient liquefaction sites. This so-called paleoseismic data provide information on the magnitude and recurrence rates of prehistoric earthquakes. Today, data provided by extensive networks of sensitive instruments capable of detecting earthquakes of quite low magnitude are supplemented by data from GPS stations that record the relative movement and velocity of the earth’s crust, revealing areas under stress and strain.

Nevertheless, the historical record is still relatively short. Recognizing this, models allow for earthquakes to occur not only directly on known faults, but also, with some probability, anywhere within seismic source zones. By smoothing the historical distribution of earthquake epicenters, the models allow for potential earthquakes in locations where they have not been observed in the past. A graphical depiction of this smoothing process is shown in Exhibit 4.

Severe Thunderstorms

Severe thunderstorms are atmospheric disturbances that may be accompanied by hail, tornadoes, and straight-line windstorms. Each of these can produce catastrophic consequences, including severe damage to property and large insured losses.

The U.S. National Weather Service (NWS) defines a severe thunderstorm as “a thunderstorm that
produces a tornado, winds of at least 50 knots (58 mph), and/or hail at least 0.75 inches in diameter.”

At any given moment, according to the NWS, there are approximately 2,000 thunderstorms in progress around the world. Of those that occur in the United States, only about 10 percent are classified as severe. A single thunderstorm system can spawn hundreds of individual hailstorms, straight-line windstorms, and tornadoes. The largest severe thunderstorm outbreak in the United States occurred in May 2003. During the period May 2 to May 11, the Storm Prediction Center (SPC) of the National Weather Service listed 422 tornado reports, 1,477 hailstorm reports, and 1,055 straight-line windstorm reports. The outbreak was also responsible for the largest insured loss from a severe thunderstorm system: $3.13 billion, according to PCS.

A tornado is formed by rapidly rotating wind circulating around a small area of intense low pressure. The overall diameter of a tornado typically ranges from 300 to 2,000 feet, but some are as narrow as a few yards or as wide as a mile. A tornado’s circulation on the ground is marked by a funnel-shaped cloud or a swirling cloud of dust and debris. When viewed from above, most tornadoes are observed to rotate counterclockwise. Tornado wind speeds can range from 40 mph to over 300 mph.

Measured wind speeds for a tornado are rarely available, because the lifetime of a tornado is usually brief and, due to their relatively small size, tornados are more likely than not to occur out of range of weather stations. Also, instruments in the path of the storm are often destroyed by the intensity of the winds. The Fujita Scale, or F-Scale, was developed as an indirect method for classifying tornado intensity based on observed damage. (See Exhibit 5.)

Historical data on tornadoes, hailstorms, and straight-line windstorms are available from the SPC. Modelers rely upon this database of more than 39,000 tornadoes, 108,000 hailstorms, and 145,000 straight-line windstorms to objectively estimate the distributions for the important parameters in the primary components of severe-thunderstorm models.

Despite the SPC database, there are shortcomings in the historical record of tornadoes, hailstorms, and straight-line windstorms. When they occur in sparsely populated areas, there is little or no reportable damage, and hence, no record of their occurrence. Areas that were sparsely populated 50 years ago could now be thriving commercial or residential districts. To compensate for this under-reporting, the historical data are both augmented and smoothed.

**Recent Developments: Estimating the Frequency, Severity, and Location of Terrorist Attacks**

In the wake of the tragic events of September 11, 2001, companies that previously focused their modeling efforts exclusively on natural catastrophes began developing models to help the risk management community quantify potential property and casualty losses due to terrorist attack. This posed new challenges for modelers, since historical data on terrorist attacks are extremely limited due to the fortunate rarity of such occurrences. To the extent data do exist

<table>
<thead>
<tr>
<th>F-Scale</th>
<th>Wind-Speed (mph)</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-0</td>
<td>40 – 72 mph</td>
<td>Light</td>
</tr>
<tr>
<td>F-1</td>
<td>73 – 112 mph</td>
<td>Moderate</td>
</tr>
<tr>
<td>F-2</td>
<td>113 – 157 mph</td>
<td>Considerable</td>
</tr>
<tr>
<td>F-3</td>
<td>158 – 206 mph</td>
<td>Severe</td>
</tr>
<tr>
<td>F-4</td>
<td>207 – 260 mph</td>
<td>Devastating</td>
</tr>
<tr>
<td>F-5</td>
<td>261 – 318 mph</td>
<td>Incredible</td>
</tr>
</tbody>
</table>
and are available from such sources as the FBI, the U.S. Department of State, and the Centre for Defence and International Security Studies (CDISS), among others, they may not be representative of current threats.

The uncertainty surrounding the frequency, location, and severity of future terrorist activity is much higher than for natural catastrophes.

Furthermore, while earthquakes and other natural disasters occur as the result of a physical mechanism that can be understood by the scientists who study them, terrorist attacks are a result of the malicious intentions of individuals or groups of varying size and with varying agendas. The groups themselves come and go, and their ability to attract resources in terms of both financial and human capital waxes and wanes as the larger political and economic climate changes over time. The uncertainty surrounding the frequency, location, and severity of future terrorist activity is therefore much higher than for natural catastrophes.

In the absence of historical data to which probability distributions can be fit, terrorism models are by necessity more subjective in nature. Modelers have approached the challenge of determining frequency, severity, and location of future terrorist attacks by relying on outside experts, in conjunction with quantitative techniques such as game theory, which models strategic interaction, and the Delphi Method. Developed at the start of the cold war, the Delphi Method statistically combines expert opinion to generate forecasts in many areas, including intercontinental warfare and technological change. The teams employed by the modeling companies have expertise in threat assessment, as well as counter-terrorism operational experience at the highest levels in such organizations as the FBI, CIA, Department of Defense, and Department of Energy.

Like natural catastrophe models, terrorism models were initially looked upon with skepticism. Yet now they are recognized within the industry as the best
available tool to quantify this unique risk. Terrorism models have been used to quantify loss potential as well as to evaluate the effectiveness of on-site security at specific high-profile buildings. Risk managers can use a security audit and the model analysis to demonstrate the effectiveness of their on-site security to underwriters.

How Catastrophe Models Work

The purpose of catastrophe modeling is to anticipate the likelihood and severity of potential future catastrophic events so that companies can appropriately prepare for the financial impact of such events. This is done by first creating mathematical representations of the characteristics and occurrence patterns of a given peril (such as a hurricane, earthquake, severe thunderstorm, and so forth). The mathematical “events” are then combined with information on property values, construction types, and occupancy classes. The results indicate the probable range of structural damage and monetary loss imposed by a large catalog of potential future catastrophe events; that is, models provide information concerning the potential for large losses before they occur.

In view of the limitations of historical data, as previously discussed, catastrophe modelers have developed alternative methodologies based on sophisticated stochastic simulation techniques. These mathematical techniques are designed to produce a complete range of potential annual aggregate and occurrence loss experience. The resulting models are actually computer programs that represent the physical phenomena of catastrophe events mathematically. The primary components of a catastrophe risk analysis model are illustrated in Exhibit 6.

Event Generation

This first model component addresses the hazard itself. In creating hypothetical scenarios, this component determines where events are likely to occur, how frequently they might occur, and how large or severe they are likely to be. Developing a component to create event scenarios requires both mathematical skill and a background in the science of the particular hazard. Most catastrophe modelers employ their own
scientific staff, including meteorologists, seismologists, and geophysicists, who provide knowledge of the underlying physics of natural hazards along with the ability to interpret historical data on past events.

Catastrophe models are usually capable of assessing loss potential both deterministically and probabilistically. For example, using a deterministic approach, one might ask, “What would my losses be today from a reoccurrence of the Great New England Hurricane of 1938?” (The same question can be asked about any peril, such as the Northridge earthquake, the Fort Worth tornado, etc.) Catastrophe models are well equipped to provide reliable loss estimates in response. But while it is interesting to speculate on these questions, modelers know that an exact repeat of these or other historical events has a near zero probability of occurrence.

Instead, a probabilistic approach can be used to assess events that are similar to historical events but more likely to occur, events with greater relevance to a risk manager. This is exactly what the event generation component of catastrophe models is designed to do — generate all types of event scenarios that could realistically occur.

Modelers employ a well-known statistical technique called Monte Carlo simulation to generate simulated storms. Monte Carlo simulation involves repeated random draws from probability distributions governing uncertain variables, in this case, meteorological variables. The result is a large sample of possible future outcomes. In the hurricane model, for example, the random variables being analyzed include landfall location and hurricane frequency, as well as the primary meteorological parameters of each storm, including minimum central barometric pressure, radius of maximum winds, forward speed, and so on (Exhibit 7). A range of theoretical probability distributions for the values of each variable is matched to the existing historical data using goodness-of-fit tests and relevant expertise. By repeating the simulation process, a sample of many thousands of years of event activity is generated, each event corresponding to a different set of random values assigned to event parameters.

The development of the realistic event scenarios that populate the model’s event catalog starts with an analysis of historical and geophysical data. Using this
data as a foundation, the relationship among different event characteristics can be evaluated and used to create simulated events that realistically could occur. Like real events, the simulated event characteristics are dynamic in nature, in that they interact with each other to determine the intensity, path, duration, or magnitude of the event.

Local Intensity Calculation

Depending on the event, intensity may be defined in terms of wind speed, the impact energy of hailstones, the spectral displacement of buildings when subjected to ground shaking, the number and intensity of fires spawned by earthquake, the depth of flood waters, and so on.

Once the model probabilistically generates a potential future event, it spreads the event across the affected area. For each location within the affected area, local intensity (e.g. wind speed, ground motion) is estimated. In this component as well as in the event generation component, detailed scientific and geophysical data and algorithms are employed to model the local effects of each simulated event.

Damage Estimation

For each simulated event, the generated local-intensity values are applied to a clients' database of exposed properties. The model's damage estimation component calculates the resulting damage using mathematical relationships called damage functions, which describe the relationship between the local intensity of the event and the types of building and contents exposed to that intensity. Since buildings of the same structural type will experience varying degrees of damage for a given level of intensity, damage functions are designed to capture this variability.
Catastrophe modelers employ experienced engineers who develop damage functions for different construction types. Buildings used for different purposes ("occupancies"), with different types of contents, and different potential for business interruption loss, all require their own specific damage functions. These functions are also specific to a given region, reflecting local building codes and construction practices. Damage functions provide estimates of the mean, or expected, damage ratio corresponding to each level of intensity, as well as a complete probability distribution of damage around the mean. (See Exhibit 9.)

**Insured Loss Calculation**

In this component of the catastrophe model, insured losses are calculated by applying the specific policy conditions to the total damage estimates. Policy conditions may include deductibles by coverage, site-specific or blanket deductibles, coverage limits and sublimits, coinsurance, attachment points and limits for single- or multiple-location policies, and risk- or policy-specific reinsurance terms. Since models provide explicit estimates of uncertainty in both intensity and damage calculations, it is possible to do a detailed probabilistic calculation of the effects of policy conditions.

**Model Validation**

The scientists and engineers who develop these models must validate them at every stage of development. This process involves comparing model results with actual data from historical events. Simulated event characteristics should parallel patterns observed in the historical record, and resulting loss estimates should correspond closely to actual claims data provided by clients and other insurance industry sources. In addition to detailed analysis of actual loss data, models are validated and calibrated through the use of data from extensive post-disaster field surveys. Models also undergo intensive peer review, both internal and external.

In recent years, there has been an increasing transfer of catastrophe risk to the capital markets through issuance of catastrophe ("cat") bonds. Inves-
tors have relied on the research and due diligence of securities rating agencies such as S&P, Moody’s, and Fitch to assist them in making their investment decisions. As part of the due diligence process, the models and their underlying assumptions undergo extensive scrutiny by a rating agency’s experts. Detailed sensitivity analyses of the major components of the models are performed, stress-testing each model for robustness.

How to Derive Maximum Value from Catastrophe Modeling

Simulation models provide a variety of output that can be used for many different purposes. A probability distribution of loss (the exceedance probability curve) is estimated for both annual aggregate and maximum occurrence (single event) losses for a company’s portfolio of property exposures. (See Exhibit 10.) The information may be customized to any degree of geographical resolution desired, down to individual location level. Results can also be displayed by line of business and, within line of business, by construction class, coverage, etc., for each simulated event. The results of a catastrophe risk assessment provide the necessary detail to determine which perils, regions, lines of business, or buildings drive the company’s large loss potential, including PMLs.

Insurers and reinsurers typically perform their modeling with the most basic data. But corporate risk managers can capitalize on their access to building details and use catastrophe modeling to derive more accurate assessments of loss potential. They can take full advantage of such information as building-specific structural details, occupancy, age, height, and location characteristics such as site-specific geographical and geological information.

For large property portfolios, obtaining such detailed information on each property might be a daunting task at best, or even totally impractical. But even when such detailed data on individual risks is not available, there is still significant value to be gained from catastrophe modeling. Working with the risk manager, modelers can develop assumptions that approximate the risk characteristics without diminishing the analysis results. Using such assumptions in an analysis can provide reliable results for companies without a database of details on their properties.

Uses of Model Output

The primary purpose of catastrophe modeling is to quantify property and casualty loss potential accurately for a given company. In doing so, it provides a critical tool to optimize risk management strategy. Specific applications are described below.

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### Exhibit 11

#### Probabilistic Loss Distribution

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Exceedance Probability</th>
<th>Loss ($000’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 years</td>
<td>10%</td>
<td>37,394</td>
</tr>
<tr>
<td>20 years</td>
<td>5%</td>
<td>49,470</td>
</tr>
<tr>
<td>50 years</td>
<td>2%</td>
<td>78,880</td>
</tr>
<tr>
<td>100 years</td>
<td>1%</td>
<td>121,963</td>
</tr>
<tr>
<td>250 years</td>
<td>0.4%</td>
<td>197,187</td>
</tr>
<tr>
<td>500 years</td>
<td>0.2%</td>
<td>275,551</td>
</tr>
<tr>
<td>1000 years</td>
<td>0.1%</td>
<td>346,546</td>
</tr>
<tr>
<td>Average Annual Loss</td>
<td></td>
<td>12,022</td>
</tr>
</tbody>
</table>
Primary Insurance Coverage

First and foremost, catastrophe modeling is the best way to determine the insurance coverage limits your organization needs. Simulating thousands of years of event scenarios, the models create loss distributions and depict the results in a table like the one in Exhibit 11.

The rarest and most devastating events your company may face will fall at the tail end of the probability distribution. These extremely large events are likely to occur a few times in thousands of simulated years. A company with an extremely low tolerance for risk might be comfortable buying coverage for that entire amount. Companies with a greater tolerance for risk might choose to buy coverage equal to the dollar amount of the 500-year, 250-year, or even 100-year return period loss. Therein lies one of the benefits of catastrophe modeling over providing a single PML figure: Because modeling provides a distribution of potential losses, risk managers can align their insurance buying more closely with their organization’s risk tolerance level.

Acceptance and use of catastrophe modeling among insurance and reinsurance companies is widespread.

Optimizing Deductibles

Risk managers must decide the amount of the deductible as well as the optimal way to apply it. Should it be a percentage of site replacement cost, a percentage of the aggregate loss, or a fixed sum? Should it be applied on an occurrence (single event) basis? Or should it be capped annually? Models can enable a side-by-side comparison of various scenarios, including the probable cost of each approach.

Managing Exposures

Catastrophe modeling can provide insight into more effective ways of managing exposure to catastrophe risk. That is one of the most important benefits of this approach. Model output presents a clear picture of a company’s geographical distribution of exposures and potential catastrophe losses to those exposures. The key drivers of a company’s catastrophe risk are determined, including which perils, regions, and lines of business have the greatest marginal impact on probable maximum losses. Such information can help clients fine-tune growth strategies to better manage future catastrophe loss potential. The analyses show where business can be expanded without increasing large loss potential, as well as areas in which a company is already overexposed to catastrophe losses.

Developing Mitigation Strategies

A detailed analysis of how the structural characteristics of a property affect its vulnerability to natural hazards, which will also show how modifications to those characteristics can impact potential losses, can help clients plan their overall catastrophe loss reduction program. For example, wind-specific building characteristics include roof geometry, pitch, covering and attachment systems, wall siding, percent of the exterior covered by glass, and type of window protection. Earthquake-specific characteristics include building shape, presence of a so-called “soft story,” foundation type, building-foundation connections, and presence of earthquake resistive systems.

Modifiers to the damage functions are developed through an extensive analysis of engineering principles, results of damage surveys, and expert knowledge. These modifiers take into account all possible combinations and correlations of secondary risk characteristics. “What if” analyses can be performed to measure the impact of risk mitigation efforts — such as adding storm shutters or retrofitting with cross bracing — on loss estimates. The results of these detailed sensitivity analyses can provide guidance in weighing the cost effectiveness of various mitigation measures.

Allocating Insurance Costs

Catastrophe models provide multiple metrics from which business decisions can be made. One such metric is the long-term average annual loss, which quantifies the average loss for a specific facility, business unit, geographic region, or other organizationally relevant corporate classification for reporting or accounting purposes. By quantifying the average annual loss, that reporting unit’s contribution to the overall catastrophe risk of the company can be determined, and insurance costs can be allocated accordingly.
Negotiating Insurance Coverage

It was noted earlier in this article that acceptance and use of catastrophe modeling among insurance and reinsurance companies is widespread and nearly universal for the larger organizations. Recognition of the value of modeling by risk managers thus works in the risk managers’ favor. Sharing modeling results with brokers and underwriters, particularly if analysis includes levels of detail to which the underwriter wouldn’t normally have access, can be a powerful and persuasive negotiating tool at renewal time.

Understanding the Marginal Impact of Changing or Adding Exposures

When dealing with a large portfolio of properties, it behooves the risk manager to be aware of the impact that the sale or acquisition of properties has on the organization’s risk profile. Depending upon the location, value, and construction of the properties in question, and the existing portfolio, a sale or acquisition could significantly alter exposure to loss and warrant renegotiation with an underwriter for a discount or additional coverage. A catastrophe-loss modeling analysis is the best tool to determine if a renegotiation is worthwhile and to quantify the appropriate rebate or additional coverage.

Communicating With Senior Management

As risk managers continue to become more visible within corporations, they will also be increasingly held accountable for their decisions, such as what losses to insure and which to self-insure. Justifications of decisions that have an impact on the bottom line need to be close at hand and credible when dealing with senior management. The risk manager who bases decisions on catastrophe modeling output can feel confident that the science, engineering, and statistical foundations of the models are well documented and reliable.

The Future of Catastrophe Modeling in Corporate Risk Management

Catastrophe modeling technology has evolved in terms of detail, realism, and accuracy since it was first introduced in 1987. The technology has provided reliable loss estimates for actual events in real time, as well as probabilistic loss estimates, well before the major events of the early 1990s. But extensive use of this technology has come only during the past several years. That use has been almost exclusively by reinsurers, primary insurers, and a few brokers.

Catastrophe modeling offers enormous value to risk managers — value that continues to increase as the technology evolves. Catastrophe modeling enables proactive decision-making and strategic planning. It should be an essential component in any company’s efforts to manage its risk. As modeling analyses become more accessible, whether as a service through an intermediary, directly from modelers, or accessed as needed via the Internet, risk managers need to embrace this technology and use it to their advantage.

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About AIR Worldwide Corporation

AIR Worldwide Corporation is a leading risk modeling company helping clients manage the financial impact of catastrophes and weather. Utilizing the latest science and technology, AIR models natural catastrophes in more than 40 countries and the risk from terrorism in the United States. Other areas of expertise include site-specific seismic engineering analysis, catastrophe bonds, and property replacement cost valuation. Founded in 1987, AIR offers its insurance, reinsurance, corporate and government clients a complete line of risk modeling software and consulting services that produce consistent and reliable results. Headquartered in Boston, AIR has additional offices in North America, Europe and Asia. For more information, please visit www.air-worldwide.com, or call (617) 267-6645.