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Insurance Industry
Catastrophe
Management Practices



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Insurance Industry Catastrophe Management Practices

Executive Summary

The American Academy of Actuaries' Catastrophe Management Work Group was requested by the Coordinating with Federal Regulators Subgroup on Financial Issues of the National Association of Insurance Commissioners to develop a report to discuss how property and casualty insurers manage catastrophe risks. This monograph is in response to that request and makes the following observations:

- Catastrophe exposures place special demands on insurer capitalization and require a distinct risk management approach. The risk management process for an insurer must integrate all risk management strategies of the insurer, not just a single risk, such as catastrophe risk. The interaction or covariance (versus independence) of the various risks a company faces is an important factor in determining the company's total capital requirements.
- For property and casualty insurers, catastrophes are defined as infrequent events that cause severe loss, injury, or property damage to a large population of exposures.
- Whereas most property insurance claims are fairly predictable and independent, catastrophe events are infrequent and claims for a given event are correlated. The insurance process, if left unmonitored during lengthy catastrophe-free intervals, could produce increasing concentrations of catastrophe exposure.
- Catastrophes represent significant financial hazards to an insurer, including the risk of insolvency, an immediate reduction in earnings and statutory surplus, the possibility of forced asset liquidation to meet cash needs, and the risk of a ratings downgrade.
- Insurers manage catastrophe risk through a continuous learning process that can be described in five steps. The steps are identifying catastrophe risk appetite, measuring catastrophe exposure, pricing for catastrophe exposure, controlling catastrophe exposure, and evaluating ability to pay catastrophe losses.

▲ **Identifying catastrophe risk appetite** - An evaluation of catastrophe risk appetite gives underwriters a guideline for determining whether catastrophe risk in the insured portfolio is within acceptable limits.

▲ **Measuring catastrophe exposure** - The objective of measuring catastrophe exposure is to be aware of the company's current exposure to catastrophes, both in absolute terms and relative to the company's risk management goals.

▲ **Pricing for catastrophe exposure** - In setting rates for catastrophe insurance coverage, the general trend is away from using a long historical experience period, toward the application of catastrophe models to current or anticipated exposure distributions. The shortcomings of using historical premium and loss experience are clear, and catastrophe modeling has been widely adopted in making rates for hurricane and earthquake.

▲ **Controlling catastrophe exposure** - For various reasons, insurers may decide they have a need to control or limit catastrophe risk. Usually this results in reducing exposure in segments where capacity is exceeded, and using reinsurance or capital market instruments to transfer exposure to someone else.

▲ **Evaluating ability to pay catastrophe losses** - Catastrophe claim payments are funded through normal operating cash flow, asset liquidation, debt financing, or advance funding from reinsurers.

- Actuarial standards exist for appropriate application of catastrophe models. Also, to help regulators evaluate use of the models in making rates, the Catastrophe Insurance Working Group of the NAIC published the *Catastrophe Computer Modeling Handbook* in January 2001.
- Generally, the liquidity (or illiquidity) of an insurer after a catastrophe does not cause insolvency. Rather, it is the magnitude of the event relative to company surplus. Insurers must strike a balance between the benefits of being prepared for low-probability catastrophes and the cost of pre-event preparations.
- There is no one catastrophe risk management procedural template that applies to all insurers. However, the conceptual elements are the same for any property and casualty insurer.
- Reinsurance is the traditional method used by insurers to transfer risk, but capital markets are a growing source of alternate capacity. Capital market products developed to date can be grouped into three categories: insurance-linked notes and bonds, exchange-traded products, and other structured products.
- Catastrophe risk management for reinsurers is similar to that of a primary company. For a reinsurer, the challenges are to obtain adequate catastrophe exposure information from ceding companies, to accurately measure catastrophe exposure aggregations across multiple ceding companies, and to price for the exposure.
- Insurer catastrophe risk management practices are relevant to certain questions of public policy. Examples include the amount of insurer capital, whether insurer capital needs to be segregated for catastrophe purposes, whether to encourage pre-event funding, the tradeoffs between availability and affordability, the extent of governmental involvement in the market place, and potential over-reliance on guaranty funds.
- Policy-makers considering actions designed to affect either catastrophe coverage availability or the solvency of insurers exposed to catastrophe claims can use the five step catastrophe risk management approach to anticipate market effects of the proposals they are considering. Generally, policy actions have more than one consequence, and this framework can help to anticipate secondary (and sometimes unintended) consequences.

Introduction

At the June 2000 Summer National Meeting, the National Association of Insurance Commissioners (NAIC) formed the Coordinating with Federal Regulators Subgroup on Financial Issues (Subgroup). The Subgroup was asked to:

- define the components of catastrophe, underwriting, and insurance risk
- identify relevant insurance regulatory tools that might assist the Federal Reserve Board in supervising FHCs and suggest ways federal regulators may make effective use of the tools
- determine the information needs of other functional regulators (e.g., FRS member banks, FDIC, OCC, OTS, NASD, SEC) regarding insurance companies within a FHC and develop procedures necessary to obtain such information, where appropriate
- make recommendations for information sharing and other coordination between federal functional regulators and state insurance regulators with respect to catastrophe, underwriting, and insurance risk

The Subgroup plans to meet with Federal Reserve Board staff to present their initial findings in three areas:

- how insurers manage catastrophe risk (coverage, pricing, underwriting, risk aggregation and management, and capital adequacy)
- risk transfer mechanisms for spreading catastrophe risk (reinsurance, catastrophe bonds, and other forms of securitization)
- regulation of insurance company catastrophe risk management

The Subgroup asked the American Academy of Actuaries Catastrophe Management Work Group to provide technical assistance in the form of a report to address the first and second issues: insurance company management of catastrophe risks and risk transfer mechanisms. This monograph addresses property catastrophe exposures which broadly impact the insurance industry and discusses the following issues:

- definition of catastrophes
- capital considerations
- managing catastrophe risk
- reinsurance and risk transfer
- public policy implications

Several appendices have been included that expand on topics outlined in the monograph.

I. What is a Catastrophe?

For property and casualty insurers, catastrophes are infrequent events that cause severe loss, injury or property damage to a large population of exposures.¹ While the term is most often associated with natural events (e.g., earthquakes, floods or hurricanes), it can also be used when there is concentrated or widespread damage from man-made disasters (e.g., fires, explosion, pollution or nuclear fallout).

Whether losses arising out of an event are defined as a catastrophe depends on the size of the loss to the company or to the entire industry. Property Claim Services (PCS), a unit of the Insurance Services Office, Inc., analyzes catastrophes based on their impact on the industry as a whole. PCS monitors industry loss reports and assigns a catastrophe number to an event if direct insured losses to property exceed \$25 million and it affects a significant number of insureds and insurance companies. In addition, many individual insurers establish company thresholds for defining a catastrophic loss. An insurance company may utilize internal criteria to determine whether an event is a catastrophe as it relates to its specific book of business even if the event has not been labeled as a catastrophe for the industry as a whole.

Not all catastrophes are covered by property and casualty insurers. Some may not be privately insured because of difficulties in quantifying and pricing the hazard (e.g., nuclear hazard). In addition, catastrophes that could be subject to adverse selection may be specifically excluded from coverage (e.g., flood). Frequently, if the insurance industry does not provide coverage for a catastrophic peril a governmental program or facility may be available.²

¹ The term “exposures” refers to units for measuring the size of an insurance portfolio, such as the number of policies, number of property locations, aggregated coverage amounts, or other alternative measures.

² Appendix A discusses the extent to which traditional insurance products cover catastrophe perils. Appendix B outlines various governmental programs that protect individuals against catastrophic risks.

II. Insurer Capital Considerations

A property and casualty insurer provides contractual coverages to consumers and businesses, which exposes the insurer's capital to risk. The company's owners expect financial returns commensurate with the risks.

Catastrophe exposures place special demands on insurer capitalization and require a distinct risk management approach. Catastrophe risk management is a component of a property and casualty insurers' overall risk management program, but the overall program is stronger if unique consideration is given to catastrophe risk.

The following sections further demonstrate this by contrasting noncatastrophe exposures with catastrophe exposures.

A. Noncatastrophe Exposures

Like other businesses, insurers perform most efficiently when costs are known before prices are set and sales are made. It is the nature of insurance, however, that prices must be set before coverage is sold and losses have occurred. Future insurance losses must be estimated. Thus, any arrangement that produces more accurate estimates is of great interest to insurers. In statistical terms two conditions are very desirable:³

- predictable frequency of claims over time
- each exposure experiences loss independently of other exposures

For the most part, noncatastrophe exposures are independent. By writing larger volumes of business, the occurrence of claims becomes more predictable. Under these conditions, insurers can use historical data to calculate reliable and useful statistics, such as the expected average incurred loss per future exposure. An insurer is able to compare prices it can charge in a competitive marketplace with actuarial estimates of the cost of providing coverage, and use that knowledge to develop marketing and underwriting strategies.

In theory, the goal is to insure large numbers of exposures, at prices sufficient to cover expected losses and expenses that achieve an adequate rate of return on capital commensurate with the risk inherent in the exposure portfolio.

B. Catastrophe Exposures

Catastrophe exposures differ from noncatastrophe exposures in that they do not meet the conditions identified above. By definition, catastrophes are infrequent, producing no losses in most years, and large losses in a few years, a clear violation of the first condition. The second condition for noncatastrophe exposures was independence. Catastrophes cause loss to many exposures at once. Significant or high correlation among exposures is a key feature of catastrophe risk.⁴

Assume an insurer covers a large number of policyholders who would be affected by the same catastrophes, and assume for simplicity this insurer backs up its contractual obligation to those policy-

³ The Central Limit Theorem or "Law of Large Numbers" is beyond the scope of this monograph, but it is the theoretical foundation for these two conditions.

⁴ Independence and perfect correlation are opposites. Statistically, independence is a condition in which correlation is zero. Significant correlation means "lacking independence."

holders by accumulating an extraordinary amount of capital.⁵ The insurer must either find a way to bear the cost of holding that capital, or create a catastrophe risk management plan to deal with its existing exposure. The return on capital should be commensurate with risk, given consideration to the correlation of exposures, and infrequent occurrence of events.

The insurance process, if left unmonitored during lengthy catastrophe-free intervals, could produce increasing concentrations of catastrophe exposure. Thus, insurers need a special process for catastrophe risk management.

⁵The occurrence of large natural disasters generally is not correlated with other types of insurance claims. This means that an insurer's required capital benefits from a "covariance effect." The capital an insurer requires to reach a given level of policyholder security is less than the sum of that needed to support catastrophe risks and that needed to support other types of risks

III. How Insurers Manage Catastrophe Exposures

Catastrophes present significant financial hazards to an insurer, including the risk of insolvency, an immediate reduction of earnings and statutory surplus, the possibility of forced asset liquidation to meet cash needs, and the risk of a ratings downgrade.⁶ Property and casualty insurers typically develop catastrophe risk management strategies that combine determination of risk appetite, measurement of exposures, pricing considerations, processes to limit exposure, and utilization of reinsurance or capital markets to transfer risk to third parties. This section details the five steps used by insurers to address catastrophe:

- Identifying catastrophe risk appetite
- Measuring catastrophe exposure
- Pricing for catastrophe exposure
- Controlling catastrophe exposure
- Evaluating ability to pay catastrophe losses

A. Identifying Catastrophe Risk Appetite

The starting point in managing catastrophe exposures is to understand how much loss, in a period of time, the insurer can absorb without an unacceptable adverse impact. Each insurer's risk appetite is unique and a function of:

- earnings volatility
- market pricing
- availability and cost of reinsurance
- cost of capital
- solvency regulation
- capital allocated to catastrophe exposures
- rating agency evaluations
- tax considerations
- cash flow needs
- financing requirements
- rate regulation
- other lines of business written by the insurer

A company's risk appetite is often expressed as a maximum acceptable reduction to surplus (or income) from a single event or multiple events in a year. Management may alternatively specify a maximum annual loss that can be tolerated within a certain time period, such as "\$100 million of loss likely to be exceeded only once in 100 years." Expressions like these give underwriters a maximum guideline for monitoring whether catastrophe risk in the insured portfolio is within acceptable limits.

B. Measuring Catastrophe Exposure

Once a company has established its risk appetite, it must complete an inventory of its existing exposures. In the past this may have been done by evaluating the company's loss potential arising from the aggregate policy limits written in a catastrophe-exposed area. In the past 15 years, and as a result of

⁶ Rating agencies rate insurers' financial ability to fulfill their promises and publicize the findings. Adverse ratings can be very damaging, even to the extent that investors may be unwilling to hold an insurer's debt or equity. A rating downgrade often results in an immediate loss of business and may imperil the ongoing business if agents refuse to renew or produce new business for the downgraded company.

significant losses from hurricanes and earthquakes, catastrophe modeling technology has been improved, and with improved technology has come increased rigor in measuring catastrophe risk exposure.⁷

Insurers who express risk appetite as “\$100 million of loss likely to be exceeded only once in 100 years” can refer to a model-based loss exceedence probability curve to monitor whether the 1 percent exceedence probability is associated with annual aggregate catastrophe losses at or below its \$100 million maximum.

In rigorous terms, we define the term “probable maximum loss” (PML) to be the amount of loss associated with a given exceedence probability over a specified period of time. The term PML must be put into a context of how it is being used. In the example above, \$100 million may be referred to as the company’s annual aggregate PML from the modeled peril at a 1 percent exceedence probability or a 100 year return time. The company may describe its PML as the amount of aggregate annual loss the company expects to be exceeded no more than once in a specified number of years (e.g., 100, 200 or 500).

Companies with significant earthquake or hurricane exposure commonly use catastrophe models to make a formal, rigorous statement regarding the company’s PML. Measuring catastrophe risk concentration using a model can be expensive and sophisticated. However, catastrophe exposure monitoring may be inexpensive and less formal. In a geographic area known to be disaster-prone, simple measures such as the total amount of written premium, number of insured structures, policy counts, or the sum of the limits on insured structures are easily available and can be powerful intuitive measures of risk.

Another common approach is to estimate a subjective PML arising from a described event, type of coverage, or geographic region. The term “probable maximum loss” has been widely used for many years, often without any statistical definition. In this less rigorous setting, PML may often be a subjective estimate obtained by multiplying the aggregated policy limits in the area by a selected percentage loss. Subjective PML estimates typically are used for perils where models may not be available (e.g., volcano, brush fires) to more formally estimate a company’s exposure.

Model-based PML estimates, complementing other subjective PML estimates, can be applied to manage catastrophe exposure and allocate capacity in geographic detail or by region. Whether model-based or subjective, a company should regularly update its PML estimates as part of an ongoing monitoring process. In general, the objective always is to be aware of the company’s current exposure to catastrophes, both in absolute terms and relative to the company’s risk management goals.

C. Pricing for Catastrophe Exposure

Unlike most businesses, insurance companies do not know the majority of the costs for their product at the time of sale. Most insurance costs do not arise until much later. In fact, many claims may not be reported for months or years after the policy has expired. Depending on the jurisdiction, insurance premiums may be determined by the regulatory process or by the operation of the competitive marketplace. In either case premiums provide for the following costs:

- *Expected loss and loss adjustment expense.* These represent payments that are expected to be paid directly to an insured for first party coverages or on behalf of an insured for third-party coverages plus related claim settlement expenses.

⁷ Catastrophe models provide a probability distribution of potential losses based on the company’s insured portfolio and the modeled hazards. From such a loss distribution, a number of statistical tools can be derived, including an aggregate annual exceedence probability curve. The modeling process is discussed further in Appendix C.

- *Underwriting expenses.* Expenses that are associated with obtaining new business or retaining the insurer's existing book of business including commissions, other acquisition costs, and general expenses (such as salaries, rent, and other items).
- *Premium taxes, licenses, and fees.* These represent premium taxes imposed by the individual states, as well as costs for licenses, fees, and boards and bureau assessments. In some cases provision is made for miscellaneous assessments such as guaranty fund and residual market assessments.
- *Net cost of reinsurance.* The premium required by the reinsurer to accept the catastrophe exposure, minus the expected loss transferred to the reinsurer.
- *Cost of capital.* This represents the profit provision needed to achieve the insurer's required rate of return on capital commensurate with the risk inherent in the exposure profile.

The remainder of this section addresses pricing issues associated with the expected loss and loss adjustment expense component.

It has long been recognized that it is appropriate to separate the expected loss component for property insurance coverages into two parts. One component determines the provision for noncatastrophe losses and the other component develops a provision for catastrophe losses. A company may use various approaches to estimate the catastrophe loss provision.

For most types of noncatastrophe property/casualty coverage, recent historical claim and exposure data form the basis for projections of future costs and revenue. The analysis usually includes one to five years of the most recently available data, although up to 10 years of information may be reviewed for certain types of coverage. The exact number of years of data used is based on the desire to balance responsiveness and stability in rate indications, the historical variability of the underlying frequency and severity of the claims, and the volume of data available for actuarial analysis.

Before insurers utilized models to estimate catastrophe provisions, companies traditionally utilized historic catastrophe experience for an extended period (generally 10+ years). Inherent problems arise when using historical experience to project catastrophe losses, particularly for low frequency events such as hurricanes and earthquakes. Such experience is inherently volatile and historical exposure concentrations are not representative of future policy periods. The available historical industry insurance claims record is for the time period from 1960 to the present for homeowners insurance and 1950 to the present for extended coverages. This time period is generally too short to accurately estimate expected hurricane and earthquake parameters. In addition, as measured by longer-term meteorological data, the period from 1960 to date had an unusually low frequency of intense hurricanes.

Historical insurance data may not reflect current exposures. Changes in land use, population densities, building codes, and construction practices all serve to diminish the relevance of historical data when predicting future catastrophe losses.

The traditional method is further flawed in that the occurrence or absence of individual storms can have a dramatic impact on results. The traditional method is overly sensitive to the occurrence of a single recent event.

Use of historical loss information for earthquakes and hurricanes has largely been abandoned in favor of computer modeling. Traditional rate making approaches (use of historical catastrophe experience for 10+ years) still exist where the catastrophe component is small or catastrophe events are more frequent, (e.g., private passenger automobile comprehensive insurance coverage or homeowners insurance in states where the hurricane exposure is minimal).

Insurers are increasingly using sophisticated computer models to model hurricane and earthquake losses. Models are being developed today for a broader array of perils using the technical expertise of

multidisciplinary teams made up of seismologists, meteorologists, other physical scientists, engineers, mathematicians, statisticians, actuaries, and computer technology specialists.

Although the insurance industry is increasingly comfortable with using these models for pricing, not all regulators have reached the same comfort level. Some regulators are concerned with insurers' use of catastrophe models to establish catastrophe rate provisions for several reasons. Four of the principal reasons are the technical complexities of modeling, the proprietary nature of most models, the range of estimates produced by various models, and the perception that model results may be sensitive to changes in estimated parameters.

The actuarial profession has attempted to respond to these and similar concerns about modeling. As noted in Appendix C, actuaries are guided in their use of catastrophe models by Actuarial Standard of Practice 38 *Using Models Outside the Actuary's Area of Expertise* which details the review required by actuaries before they use such tools in their work product.

One of the more extensive reviews of catastrophe model use is that of the Florida Commission on Hurricane Loss Projection Methodology. The Commission was established in 1995 by the Florida legislature to "consider any actuarial methods, principles, standards, models, or output ranges that have the potential for improving the accuracy of or reliability of the hurricane loss projections used in residential property insurance rate filings." The Commission, to date, has established 52 standards that need to be met before a catastrophe model is acceptable for ratemaking purposes in the State of Florida. The Commission's findings are not binding on the Department of Insurance; however, the findings are admissible and relevant in a rate filing or in any arbitration, administrative, or judicial proceeding.

After its creation in 1996 by the California legislature, the California Earthquake Authority began to issue earthquake policies with rates determined through the use of a catastrophe model. An extensive public hearing was held that examined both actuarial and modeling questions. After recommended changes were made to the model, the commissioner approved rates incorporating model-based estimates.

In addition, Louisiana has developed a set of computer model interrogatories that rate filers and modelers must complete and file with the state. Much of the information is similar to that required in Florida with a focus on Louisiana coastal exposure.

The Catastrophe Insurance Working Group of the NAIC published the *Catastrophe Computer Modeling Handbook* in January 2001. The handbook is a tool that regulators can use in evaluating the appropriateness of the use of catastrophe models in establishing rates. It provides a background on catastrophe models from the perspective of insurers, modelers, consumers, and regulators. The handbook includes a general overview of catastrophe models, a discussion of model input and output and a section on evaluating the models. The handbook also explores issues that have arisen or that may arise from the use of catastrophe models. It suggests areas and concepts regulators should consider and explore to become informed about catastrophe models.

In summary, the general trend is away from a traditional method using a long historical experience period, toward the application of catastrophe models to the insurer's current or anticipated exposure distribution. The shortcomings of the traditional method are clear, and catastrophe modeling has been widely adopted in making rates for hurricane and earthquake. Actuarial standards exist for appropriate application of catastrophe models, and regulators have developed guidelines to evaluate the use of the models in making rates.

D. Controlling Catastrophe Exposure

Once a company has established its risk appetite, measured its existing exposure to loss, and priced the product to the best of its ability, it may recognize a need to limit its risk. This management exercise includes:

- identifying where the company can grow its property portfolio without exceeding capacity limitations
- reducing property exposures where the company has exceeded its capacity for the region
- reducing exposure through reinsurance, capital market alternatives, deductibles, and other efforts to mitigate loss

Companies take different approaches to managing how much of a particular product or aggregate catastrophe exposure it will write in any given area.⁸ However, there are common characteristics in all good catastrophe risk management programs. For example, a company that opts to write equal amounts of product in two distinct locations covering a specific peril (e.g., earthquake) will have more capacity than a company that writes double that exposure in one location.

In addition to managing geographical distributions, companies can purchase reinsurance that transfers a portion of the risk to a reinsurer. This does not reduce the company's direct obligation to the policyholder. The company promises to pay all claims irrespective of any reimbursement from the reinsurer. Risk transfer mechanisms are discussed later in this monograph.

Expanding on the above, the company may achieve its general objectives by processes such as:

- counterbalancing existing risk accumulation with targeted growth
- limiting the accumulation using quotas or a moratorium on new business
- adopting minimum deductibles, reducing exposure and encouraging preventive mitigation
- reviewing coverage provisions to limit the potential for adverse coverage determinations after a catastrophe⁹
- excluding coverage for certain types of catastrophic perils
- limiting coverage for property that is prone to catastrophic damage

In addition, insurers may participate in programs to reduce or prevent property losses. Loss mitigation programs generally involve both public and private efforts. Building codes are examples of such programs. Recently established programs include Florida's hurricane shutter credits, mandatory Building Code Effectiveness Grading Schedules, and the minimum 5 percent dwelling retrofit credit imposed by the California Earthquake Authority.

Legal limitations on development in hurricane or earthquake-prone areas have not yet been implemented. In fact, commercial and residential development in recent decades has been especially active in locations that are exposed to hurricanes and earthquakes. The Federal Flood Insurance Program makes some attempts to control development in flood prone areas, with mixed success. In the long run, effective mitigation of property losses in catastrophe-exposed communities may be the most effective measure to prevent or reduce catastrophic exposure accumulation.

E. Evaluating Ability to Pay Catastrophe Losses

Cash demands on the insurer can vary significantly depending on the nature and intensity of the event. Catastrophes producing obvious damage (e.g., hurricanes, tornadoes) result in faster insurer payouts than those with less obvious damage (e.g., earthquakes). Further, the timing of cash needs is a function of the size of the event.

⁸ An expanded discussion of underwriting individual risks is found in Appendix D.

⁹ Coverage limits represent the maximum amount payable by an insurer on a partially or totally destroyed building. After large catastrophes the demand for materials and labor may exceed supply causing inflated prices and delays for repair and replacement. Under such conditions, coverage limits in the policy can be very important.

The period between the catastrophic event and the completion of repairs allows insurers time to fund the loss through underwriting cash flow, normal cash flow from investments, asset liquidation, debt financing, or advance funding from reinsurers. Generally, the liquidity (or illiquidity) of an insurer after a catastrophe does not cause insolvency. It is the magnitude of the event and the fact that the company does not have sufficient surplus to pay claims that is the defining factor.

Insurers with catastrophe exposures need to establish contingency plans for dealing with cash demands. Such plans generally include steps to:

- determine the potential size and timing of cash demands for catastrophe claims
- determine the dependability and flexibility of current sources of cash including daily cash flow from insurance and investment operations
- determine the willingness and ability of the company's reinsurer to advance funds
- determine whether the above cash sources might also be impacted by the catastrophic event
- determine if there is a gap between potential catastrophe cash requirements and readily available cash sources
- develop a plan that will bridge the gap when a catastrophe occurs including reductions in other spending, liquidation of assets or tapping equity or debt markets

For an insurer whose catastrophe exposures are small relative to its ongoing cash supply, the need for a plan is less pronounced. Such insurers can usually divert enough cash from insurance operations or maturing investments to pay catastrophe losses. If the plan does include liquidating investments, the insurer gives up some control over the amount and timing of investment gains including:

- liquidating assets for less than book values
- timing of catastrophe claims may complicate tax planning
- premature recognition of capital gains

In any case, asset liquidation reduces the asset base, which in turn reduces the opportunity for future investment income and capital gains. Insurers with catastrophe exposure must strike a balance between preparedness for low-probability catastrophes and the cost of pre-event preparations.

In summary, catastrophe exposures place special demands on insurer capitalization and require a distinct risk management approach. The insurer's total required capital depends on the company's overall risk profile, including any interaction or covariance, versus independence, of the various risks the insurer faces. The catastrophe risk management process for an insurer must be integrated into an overall risk management strategy.

Insurers manage catastrophe risk through a continuous learning process that may be described in five steps. The steps are identifying catastrophe risk appetite, measuring catastrophe exposure, pricing for catastrophe exposure, controlling catastrophe exposure, and evaluating ability to pay catastrophe losses. These steps form an iterative process. Insurers use what is learned in each iteration to improve future decisions.

There is no one procedural template that regulators should expect all insurers to apply to catastrophe risk management. Variations in business practices among insurers change the relative costs and benefits of different approaches to the conceptual framework outlined above. However, the conceptual elements are the same for all property and casualty insurers.

IV. Reinsurance and Risk Transfer

Insurance companies need to limit their risk exposure to an acceptable level because of concerns about solvency and the cost of capital. This section discusses various alternatives available to insurers to transfer catastrophe risk to third parties including buying reinsurance and utilizing financial instruments to transfer risk into the capital markets.

A. Reinsurance Mechanisms

Reinsurance is the traditional method insurers use to reduce or transfer risk.¹⁰ Catastrophe reinsurance provides protection when losses from a single event such as an earthquake or hurricane exceed the buyer's specified retention. Reinsurance companies spread risk differently than the insurance companies they insure and they often have different objectives in quantifying and managing their exposure to catastrophes.

The two most common types of reinsurance arrangements are treaty and facultative. Treaty reinsurance buyers agree with the seller to cede losses from all risks meeting certain criteria. The reinsurer relies on the underwriting of the ceding company. Facultative arrangements are negotiated separately by the primary company on a policy by policy basis with the reinsurer who individually prices and accepts its interest in the policy.

Generally, coverage is provided either as pro-rata or excess-of-loss. Pro-rata reinsurance cedes both premiums and losses according to the same percentage for each policy written. Excess-of-loss reinsurance is written on a per risk, per occurrence or aggregate excess basis. Catastrophe reinsurance is excess of loss reinsurance and is typically written on an occurrence basis and applies to all losses from a single event, net of other collectible reinsurance.

Because of limited reinsurance capacity and high prices for catastrophe coverage in selected areas of the country, nontraditional or finite¹¹ risk products were developed to supplement catastrophe reinsurance. These products involve the limited transfer of underwriting risk and typically are intended to provide multiyear smoothing of catastrophe losses. The finite risk products generally cover excess-of-loss or aggregate stop-loss. These excess-of-loss finite risk contracts utilize a fund that grows or is depleted based on actual experience. These contracts typically include a deficit payback or profit sharing feature. Finite risk stop-loss products provide coverage in excess of an aggregate retention amount.¹²

¹⁰ The issues that insurers consider in deciding to purchase reinsurance are outlined in Appendix E.

¹¹ Finite risk insurance and reinsurance products are customized contracts that generally include a multi-year term, larger premium-to-limit ratios, explicit recognition of investment income and profit sharing features that distribute the benefits of good experience between the parties.

¹² The use of finite risk reinsurance products has been adversely impacted by the adoption of Financial Accounting Standard No. 113 (FAS 113) and EITF 93-6 issued by the Emerging Issues Task Force. FAS 113 significantly reduced risk limiting and payback provisions. The standard also created different accounting treatment for prospective versus retroactive reinsurance that limited the accounting benefits for retroactive contracts. EITF 93-6 eliminated loss-smoothing features since accrual accounting is now required for all reinsurance contracts with deficit payback or profit sharing provisions.

B. Capital Market Mechanisms

After Hurricane Andrew and the Northridge Earthquake reduced the supply of traditional reinsurance, changes in accounting rules greatly diminished the appeal of finite risk reinsurance products. Insurers were forced to look for new sources of capacity to assume some of the catastrophe risk that could not be borne by the insurance and reinsurance industries. Capital markets are a natural place to look for such capacity, as the amount and liquidity of capital in the North American equity and debt markets alone dwarfs the combined surplus of the global insurance and reinsurance industry.

The new products developed to date can be grouped into three categories: insurance-linked notes and bonds, exchange-traded products, and other structured products.

Insurance-linked notes and bonds include “cat bonds” and contingent surplus notes. These are typically structured as a bond issued by an offshore special purpose reinsurance company, which also issues a catastrophe reinsurance contract to the insurer. In some cases, the reinsurance contract will include an index or other parametric feature that restricts recovery to events that cause an agreed level of losses for the entire industry, in order to reduce moral hazard.¹³ The premium paid for the reinsurance funds a risk premium payable to the bond investors if there are no losses under the reinsurance contract. If there are losses, the bond investors could lose some or all of the interest and, in certain cases, part of the principal.

Advantages of these products are that insurers can access new capacity for catastrophe risk, carry desirable reinsurance accounting benefits, and have a minimal level of credit risk in the event of a loss. For an investor, these products are attractive because the level of return depends solely on occurrence of a catastrophe that triggers payment under the reinsurance contract, and is relatively insensitive to the economic factors (e.g., interest rates, credit defaults) that give rise to systemic risk in other types of fixed income investments. But such transactions are expensive to structure, often require creation of offshore special purpose companies, and can carry some basis risk¹⁴ for the insurer (if the reinsurance includes an index feature). In some cases, these products may be more expensive than traditional reinsurance due to the “novelty premium” demanded by investors for assuming unfamiliar types of risk.

Exchange-traded products include catastrophe options, risk exchanges, and some weather derivatives. Catastrophe options and futures were developed by the Chicago Board of Trade in 1992 and later by the Bermuda Commodities Exchange. Trading of these products ceased in 1999 due to lower than expected demand.

Risk exchanges (e.g., Catex) allow an insurer to swap exposures with other insurers or financial intermediaries. Several markets have been established for trading weather derivatives, and various insurers, intermediaries and trading companies also provide these on an over-the-counter basis. In general, exchange-traded products have the advantages of low frictional cost, minimal information requirements, fast transaction times, low credit risk, and transparency due to observable market pricing. Common disadvantages have been standardized product offerings, lack of liquidity, lack of rein-

¹³ Moral hazard is the risk to the reinsurer that the insurer will change its behavior in a manner that will increase the reinsurer’s covered losses.

¹⁴ Basis risk is the risk that there may be a difference between the performance of the derivative or index and the losses sustained by the company. If the losses on an insurer’s book do not have enough correlation with the indices underlying the contracts, little underwriting risk is eliminated. See Harrington and Niehaus “Basis Risk with PCS Catastrophe Insurance Derivative Contracts.”

insurance accounting benefits for an insurer, creation of cash calls from exchange-mandated margin requirements, and creation of the same level of basis risk for an insurer from the use of such products.

Other structured products include over-the-counter derivatives and contingent capital products. These are typically customized products developed by a reinsurer, investment bank, or other intermediary to fit the specific goals and objectives of a customer. Because of the time and expense involved in developing a customized product, these are typically used for large and complex transactions. Contingent capital products range from relatively simple bank credit lines to contingent equity puts that give an insurer the right to sell preferred stock at pre-agreed terms after occurrence of a catastrophe event. Advantages of such products are that they are customized to meet a buyer's individual needs and can provide a large amount of contingent capital. Such transactions typically do not carry reinsurance accounting treatment, and they can be expensive to design and place.

V. Reinsurer Considerations in Managing Catastrophe Exposures

The steps used by a reinsurer in managing catastrophe exposure are similar to those described above for primary companies. The challenges faced by a reinsurer in managing its exposure are to be able to:

- obtain adequate and detailed information from ceding companies on their catastrophe exposures
- accurately measure the aggregation of potential catastrophe losses across multiple ceding companies (often using less precise data than the primary companies)
- price for the exposure

In order to overcome these challenges reinsurers require high levels of data disclosure from ceding companies, to enable them to underwrite, price products, and manage exposure accumulations. Reinsurers have also become increasingly reliant on models for pricing contracts, as traditional methods based on historical loss experience are unable to accurately price most catastrophe-exposed contracts. This change in pricing practices has created additional demand for data quality and model accuracy.

Increased awareness of catastrophe exposures has forced insurers and reinsurers to improve risk selection methodologies and carefully evaluate how individual risks fit into their overall aggregate exposure and capital allocation plan by gaining a better understanding of the correlations between different elements of the underwriting portfolio.

This analysis is particularly important for reinsurers who concentrate on excess-of-loss forms of reinsurance, as this type of risk transfer gives rise to a highly leveraged exposure to catastrophe losses. The variability in annual loss experience for this type of business is much larger than that of the primary insurance line (e.g. homeowners) underlying the catastrophe exposures.

In pricing for catastrophe exposures reinsurers must recognize that, in some cases, they cannot diversify their peak exposures. As a result, their pricing must directly reflect the cost of the additional capital that is required to support these exposures, in addition to funding for the expected loss and expense.

VI. Public Policy Implications

This monograph has discussed insurer catastrophe risk management. Many insurer managements use these approaches or others that are conceptually similar. Accordingly, policy-makers considering actions designed to affect either catastrophe coverage availability or the solvency of insurers exposed to catastrophe claims can use this framework to anticipate the market effect of the proposals they are considering. Generally, policy actions have more than one consequence, and this framework can help to anticipate these secondary (and sometimes unintended) consequences. Note that these comments concern general concepts and do not specifically address the merits of any current program or proposal. Also note that in these areas, both “too much” and “too little” may have unfortunate public policy implications.

A. How Much Capital?

Catastrophe insurance issues have steadily become more important to policy-makers. An increasing proportion of the population lives and works in areas exposed to windstorm and earthquake, so the issue of financing losses from these perils is becoming ever more significant for society. One challenge for insurer managements and insurance regulators is to provide appropriate assurance that the promises of insurers will be kept, even under catastrophic conditions.

One approach to providing such assurance is to require additional capital or reserves of writers of catastrophe coverages. However, if the safety requirements are excessive, too much capital may be required to support the writing of catastrophe-exposed coverage. In turn, the required return on the additional required capital raises the cost of the catastrophe coverage. Paying for more security than is needed becomes a deadweight burden on economic progress. Of course, inadequate attention to insurer solvency and inadequate capital requirements could cause the insurance product to lose value when it is most needed.

B. “Ring Fenced” Capital

Some policy proposals “ring fence” (i.e., capital for one purpose) capital required to bear catastrophe risk. These proposals grow more expensive as larger and less frequent catastrophes are required to be funded. Dedicated capital for a “1 in 100 year event” must be fully paid for every year by the policyholders for whose benefit it is held. On the other hand, “multi-use” capital is not segregated and can be called on for other purposes, such as to finance claims resulting from other risks the insurer takes on for its clients. Accordingly, part of the cost of the “multi-use” capital is borne by entities other than those exposed to potential catastrophe.

C. Pre-event Catastrophe Reserves

Proposals have been made to allow the tax deductibility of pre-event catastrophe reserves. These pre-event catastrophe reserves are designed to accumulate, over time, a portion of the capital an insurer may require to pay catastrophe claims. This capital is “ring fenced” so that normally it can only be used to fund catastrophe claims. The advantage to the insurer is that this capital is put aside on a pre-tax basis and held in a liability account known as a catastrophe reserve. In noncatastrophe years, the catastrophe reserve reduces federal income tax on the apparent “annual profit” arising from catastrophe-related premium when there are no offsetting catastrophe claims to pay. That federal tax reduction is reversed in catastrophe years when the catastrophe reserve is reduced to pay catastrophe claims.

One issue for policy-makers is what constraint to put on insurers who are establishing a catastrophe reserve. An inflexible formula approach can either trap unneeded capital in the catastrophe

reserve or not allow an insurer to accumulate capital commensurate with its exposure. Too flexible an approach could allow an insurer to vary its reserve increments in accord with its desire to manage its earnings.

Another issue for policy-makers is what constraint to put on the types of catastrophes the reserve fund can be used for. Policy-makers must balance the desire to provide funding for large, infrequent catastrophes with the cost associated with “ring fencing” capital that cannot be used for other purposes. This analysis resembles that for a self-insurance versus risk transfer decision. Large and infrequent risks are good candidates for risk transfer approaches.

Finally, tax policy-makers must consider the catastrophe reserve tax deduction in the context of overall tax policy. A catastrophe reserve tax deduction can help to finance the nation's catastrophe exposure, but a deduction that is “paid for” with a tax increase on other types of insurance coverages will not make the average insurance consumer better off.

D. Availability/Affordability of Programs

Recent increases in our knowledge of the risk of catastrophic claims events have caused changes in both the perceived need for and the perceived cost of providing insurance coverage for catastrophes. Accordingly, there are programs and proposals at various levels of the state and federal governments that attempt to improve the availability and affordability of such coverages.

In evaluating the impact of these programs on the insurance market, it is important to remember that management decides where to write policies based on anticipated profitability. Anticipated profitability on catastrophe-exposed coverages can be reduced if significant price controls are imposed on these coverages, or if the insurer faces underpriced competition from state-mandated programs providing similar coverages.

E. Exit Restrictions

Insurance consumers generally prefer, and benefit from, a stable marketplace. This stability is imperiled when insurers are allowed to exit a market in reaction to an actual catastrophic event, or a newly perceived catastrophic problem. A natural regulatory reaction is to restrict such exits, either in total or to a limited amount per year. However, restrictions can lead to trapped capital, which discourages both existing insurers and potential new insurers from investing in that marketplace. As a result, restrictions on market exits (i.e., mandatory renewals of existing customers) need to be balanced with the desire for a robust market.

F. Insurance Guaranty Funds

As a last resort, policyholders of impaired or insolvent insurers that lack sufficient resources to pay claims resulting from a catastrophe may receive some reimbursement of their insured losses from the state guaranty fund. Over-reliance on guaranty funds may cause some regulators to allow some insurers to charge inadequate premiums. As noted above, inadequately priced insurance can drive responsible insurers out of the marketplace, leaving insurers whom may not have adequate resources to respond when a large natural disaster occurs.

G. Use of Catastrophe Simulation Models

Prohibitions or restrictions on the use of catastrophe simulation models to determine price may cause insurers to limit their exposures in areas where they perceive prices are not adequate. This will make it difficult for consumers to find coverage.

Regulators may find applications of catastrophe simulations models useful in conducting company examinations. Problems identified will give companies who are otherwise unaware of problems a chance to solve them prior to the occurrence of a catastrophe event. This will lessen the likelihood of catastrophes placing unnecessary demands on guaranty funds and other public support mechanisms.

Rating agencies are likely to find increasing value in using models to evaluate company performance and value.

VII. Conclusion

People and businesses want to transfer their risk to an insurer or other entity, if it can be done at a reasonable cost. Insurers and other risk transfer entities can assume such risk most efficiently if claims occur predictably over time, and the people or businesses in the risk pool are independently exposed to loss. Catastrophe events violate the conditions of predictability and independence. As a result, catastrophes present a major risk of insolvency for insurers and other entities that aggregate catastrophe exposure in the normal course of writing property insurance.

There are few regions within the United States that are free of catastrophes and practically every insurance operation writing property exposures accumulates at least some catastrophe exposures. Selling “catastrophe-free” insurance products is generally not an option. Growing a book of property business requires a company to manage its catastrophe exposures.

Managing an insurer’s exposure to catastrophic claims can be analyzed as a multistep process:

- identifying catastrophe risk appetite
- measuring catastrophe exposure
- pricing for catastrophe exposure
- controlling catastrophe exposure
- evaluating ability to pay catastrophe losses

These steps are an iterative process. The insurer will use what it learns in going through these steps to improve its decisions in the next round of the same process.

There is no one procedural template that regulators should expect all insurers to apply to catastrophe risk management. Variations in the business practices of each insurer change the relative costs and benefits of different approaches to the conceptual framework outlined above.

Measurement of catastrophe exposure has improved significantly in recent years. Key developments include the refinement of sophisticated windstorm and earthquake simulation models along with better collection of exposure information by insurers.

The increase in catastrophe losses over the past decade has resulted in significant industry efforts by the industry to better manage its catastrophe exposures. This is evidenced by the continuing improvement of sophisticated tools used to measure and monitor catastrophe exposures, increased interest and monitoring by regulators and rating organizations, and proactive exposure management by companies.

Reinsurance is the traditional method used by insurers to transfer risk, but capital markets are a large potential source of new capacity.

Catastrophe risk management for reinsurers is similar to the five step process for a primary company. For a reinsurer, the challenges are to obtain adequate detailed information on catastrophe exposures from ceding companies, to accurately measure catastrophe exposure aggregations across multiple ceding companies, and to price for a highly leveraged exposure to catastrophes.

Insurer catastrophe risk management practices are relevant to certain questions of public policy. Examples include the amount of insurer capital, whether insurer capital needs to be segregated for catastrophe risk, whether to encourage pre-event catastrophe reserves, the tradeoffs between availability and affordability, the extent of governmental involvement in the market place, and potential overreliance on guaranty funds.

Policy-makers considering actions designed to affect either catastrophe coverage availability or the solvency of insurers exposed to catastrophe claims can use this framework to anticipate the market effect of proposals they are considering. Policy actions often have more than one consequence.

Appendix A

Insurance Industry Products

The insurance industry provides catastrophe coverage through a variety of products. With a few exceptions, insurers do not sell stand-alone catastrophe related products. Catastrophe coverage is provided as part of the standard peril (e.g., fire or wind damage), is granted through an optional endorsement (e.g., earthquake coverage on buildings), or is available from a government program rather than from the private insurance industry (flood coverage on buildings).

Coverage for catastrophe losses does not exist under all insurance contracts. You need to refer to the provisions of each insurance contract that may apply to property under specified catastrophic event scenarios and consider the financial effects on each party involved.

Homeowners and Dwelling Policies¹

Homeowners insurance contracts generally provide broad coverage for an owner-occupied single family dwelling, other structures associated with it, and the owner's personal property. While the home is under repairs for covered damage, loss of use is covered. Coverage may also be provided for debris removal, and for measures taken to prevent further damage.

Dwelling policies generally cover homes that are ineligible for homeowners coverage, most commonly because the dwelling is not owner-occupied. Homeowners and dwelling policies provide similar coverage for losses due to catastrophes.

Typically, the dwelling coverage in homeowners and dwelling policies is defined by a broad grant of coverage, modified by a list of exclusions. The intention behind some exclusions is to avoid granting coverage for certain catastrophe exposures because 1) insurers would not be able to withstand worst-case potential losses if covered on all policies, and 2) the coverage, if properly priced, would cost more than many people are willing to pay. There are historical reasons why certain catastrophic events are covered while others are not, but that is beyond the scope of this paper.

Homeowners policies generally exclude most or all damage to the property from flood (including hurricane storm surge), earth movement (due to settling, shrinking, expansion, earthquake, volcano, and landslide), pollution, war, and nuclear accidents. The intent of homeowners policies is to grant coverage for the dwelling if there's no applicable exclusion, so there would be coverage for non-excluded damage from hurricanes, tornadoes, or hailstorms.

Coverage is granted for catastrophe-induced fires, such as fire-following earthquake, wilderness fires, and fires spreading from building to building. Explosion, falling objects, and aircraft are covered, including coverage for some low-probability catastrophes. Riot, labor unrest, and civil commotion are covered; these at times have resulted in catastrophic property loss. Significant coverage is often provided for damage from winter storms (water, freezing, snow, or ice damage). A close reading will also reveal exceptions to certain exclusions, such as coverage for breakage of building glass due to an earthquake.

Commercial Property

The property coverage section of a package or business owners policy provides catastrophe coverage

¹ We will focus on forms that include property coverage for a building structure. Renters multi-peril insurance covers personal property but not the structure. Homeowners forms are available for condominium owners and cooperative apartment owners, with coverage for building components that are part of the owner's unit. Dwelling policies are more flexible than homeowners policies regarding the property and perils covered, but the most typical situation described here for homeowners and dwelling policies is a dwelling structure covered for "special perils."

for commercial property. Catastrophe coverage may take the form of coverage through one of the named perils (fire, wind, etc.) or may be specifically excluded from the basic coverage form and made available as an optional endorsement.

Financial effects of a catastrophe on the owners or business occupants of a commercial facility depend on such variables as location, construction, equipment, inventory, and the ability to use alternative facilities during recovery. Aside from direct damage, loss of use of a special facility may cost the owner or occupying business even more than the structure's replacement cost. Larger, more specialized facilities are thus more likely to be engineered, with one objective being to minimize or avoid business interruption due to potential catastrophes. Large, specialized facilities are also more likely to be insured under a "difference in conditions" policy, which extends coverage to an all risk basis, negotiated to meet the limited financial needs of a sophisticated and well-financed commercial insured.

Most small to medium sized structures with no difficult-to-replace equipment, such as stores, offices, or apartment buildings, can be covered by a building and personal property coverage form or similar property coverage included in a business owners package policy. These policies can be modified by endorsement to add or extend coverage for property and causes of loss not included in the basic form, making general statements about coverage for catastrophes difficult or impossible to make.

Automobile Insurance Policies

Coverage for catastrophes is provided through the comprehensive coverage portion on personal automobile policies. Comprehensive coverage applies to any kind of damage to the vehicle, except for collision and certain listed exclusions. Comprehensive coverage is purchased on approximately three-fourths of insured personal autos.

Commercial automobiles and mobile equipment are highly diverse, and vary greatly in their vulnerability to catastrophes. Small commercial entities often buy insurance coverage for damage to their vehicles and equipment, but large commercial entities are much more willing to retain the exposure.

When purchased under a comprehensive business auto form, coverage for damage to commercial autos is materially the same as the comprehensive coverage for personal autos. Coverage may alternatively be on a more restricted "specified causes" basis, but in both forms there would be coverage for fire, explosion, windstorm, hail, earthquake or flood. Mobile equipment would be covered under an inland marine policy. Distinguishing between commercial autos and mobile equipment is an intricate exercise, and since inland marine catastrophe coverage is similar in breadth to auto comprehensive we need not outline the distinction here.

Catastrophes contribute measurably to the cost of auto comprehensive insurance, but are far outweighed in auto insurance by injuries and vehicle damage from crashes. The exposure to personal autos from natural disasters is not of a magnitude that could jeopardize most insurers' viability.

Earthquake Policies

Prior to about 1985, earthquake coverage on residential property was not widely purchased, but when it was, the general practice was to attach the coverage by endorsement to a homeowners or dwelling policy. After several earthquakes in California, demand for the coverage increased, and in 1985 it became mandatory in California for an insurer to periodically offer earthquake coverage to holders of such policies.

By the end of 1993, about 30 percent of California homeowners policies included earthquake coverage. The Northridge earthquake in January 1994 raised serious questions about whether insurers

could pay earthquake claims from any major earthquake. The mandatory requirement to offer earthquake coverage indirectly caused unavailability of homeowners coverage in California. Several major reforms were necessary to revive the homeowners market, including legislation enabling companies to write separate earthquake policies with lower coverage limits and higher deductibles than the associated homeowners policy. Also, the voluntary state-run California Earthquake Authority (CEA) was created to gradually lift financial responsibility for earthquake coverage on California residential property from homeowners insurers. The CEA is discussed in greater detail in Appendix B.

Several companies have entered the California earthquake insurance market selling earthquake insurance without requiring an associated homeowners or dwelling policy on the same property. Thus options have evolved in California to place earthquake insurance with a different carrier than the homeowners or dwelling insurer. Further examples will be given in Appendix B, but briefly, when an insurer excludes specific catastrophic losses from coverage, another source may offer separate catastrophe-only coverage.

Inland Marine

The concept of “all risks” coverage originated with marine insurance, which was historically subdivided for legal purposes into “ocean marine” versus “inland marine.” Inland marine insurance covered property that was involved in communication or transportation. Examples of commercial inland marine exposures at fixed locations include bridges, tunnels, high-tension wires, and radio towers.

Coverage in most cases is tailored to fit the particular exposure, but we might infer that the coverage is broad enough to include a long list of catastrophic perils, but with the likely exclusion of war risks and nuclear hazards. Inland marine insurance may also cover goods in transit, or scheduled items of personal property. Again, the coverage is broader than would be typically available if the property were associated with a fixed location. In particular, there would be inland marine coverage for items lost or damaged by earthquake or flood.

Other Property Insurance

The following coverages are briefly discussed because they potentially present catastrophic exposures to individual companies often arising from an individual risk. They do not represent catastrophe exposures on an industry scale.

Boiler and machinery insurance protects against catastrophic failure of industrial equipment. For example, a steam boiler that bursts may, like an explosion, destroy the entire facility housing it and perhaps nearby exposed facilities as well. The basic goal of boiler and machinery coverage is to virtually eliminate catastrophic damage to property. This is accomplished by a rigorously enforced safety regimen. A boiler and machinery insurer may at times incur a very large loss under a single policy.

Ocean marine insurance covers maritime activity, which can range from pleasure yachts up to oil tankers and offshore drilling operations. U.S. insurers do not typically insure a great amount of this business, but will at times bear some share of financial burden in a maritime catastrophe. It is worth noting that a storm making landfall may cause ocean marine losses at sea or in port, compounding insured loss from the storm under homeowners and commercial property policies.

Aircraft insurance, from the standpoint of catastrophes, is much like ocean marine insurance.

Workers’ Compensation

Workers’ compensation insurance responds with a schedule of benefits fixed by law, to injuries and

some diseases arising out of work activities. Rather infrequently, work activity results in injury or disease for multiple employees, but when that happens there is no policy limit on the insurer's obligation.

When multiple employees are injured while at work, property damage may only be incidental, but the event may be a catastrophe from the viewpoint of the employer, the community and the workers' compensation insurer. For example, an earthquake during working hours could cause numerous injuries that are covered by workers compensation insurance, and could accumulate to substantial losses.

Architect's or Engineer's Errors and Omissions Insurance

When a building collapses during an earthquake, or for some other reason, one possibility is that the architect or engineer failed to perform the work as agreed, or performed the work without appropriate recognition of the risks. The financial consequences could encompass loss of the building and contents, as well as bodily injury to the occupants. If policy limits are sufficient, the insurer could view its exposure to a single E&O claim as a potential catastrophe. However, if this claim were to coincide in time with other catastrophe claims, for example if the building were lost during an earthquake or a hurricane, the E&O claim would exacerbate the catastrophe for this particular insurer.

General Liability Insurance

These contracts usually include promises to defend the insured and pay any covered legal damages. As with the architect's or engineer's errors and omissions insurance, natural or man-made disasters may prompt persons who are injured or whose property is damaged to seek recovery from any party perceived to have negligently contributed to the loss. Indeed, after making loss payments to their policyholders for damaged property or medical costs, insurers themselves will often seek recovery from a negligent party. If that party is insured, their insurer is called upon to defend and/or pay.

In addition to events doing great harm at a particular place and time, general liability insurers experience a subtler sort of catastrophe. For example, industrial practices may be discovered to have very harmful effects after years of product distribution and/or waste disposal. Insurance coverage may be found through legal testing of the facts and the policy language, interpreting insurers' intentions, and expectations years or decades earlier. These mass tort exposures can be viewed as analogous to a catastrophe in some respects. In this paper, we acknowledge the existence of such catastrophes, but the focus is restricted to events that damage property at a particular time and place.

Appendix B

State and Federal Programs

Not every catastrophic exposure can be transferred to an insurance carrier through the purchase of an insurance contract. In many cases the state and federal governments have stepped in to provide alternative solutions. This appendix deals with a brief description of various state and federal solutions available in catastrophe prone areas.

State Programs

Arkansas Earthquake Authority

The purpose of the Arkansas Earthquake Authority (Authority), created in 1999, is to operate a Market Assistance Program (MAP) to assist applicants in obtaining residential earthquake coverage and to provide a mechanism to issue policies if a market for earthquake insurance does not exist. The Authority would not begin issuing policies without a legislative vote and as long as at least one carrier is willing to write monoline residential coverage.

If triggered, the Authority can issue residential earthquake insurance up to \$100,000, and an insurer would not be able to transfer a substantial number of policies to the Authority without a hearing in which the Commissioner agrees.

Initial operating capital to set up the Authority (if triggered) would require contributions from all authorized insurers of \$500 or \$1,000 plus 2.5 percent of their net direct written premium. Post event assessments would be capped at 5 percent of the insurer's net direct property premiums (excluding commercial and crop hail) which could be recouped as surcharges, exempt from premium taxes. Post event assessment totals would not exceed \$250 million.

The Authority is run by an appointed board of directors which has the authority to hire an administrator, enter into contracts, issue bonds, and purchase reinsurance. Rates must be set in an actuarially sound manner, take into account geographical variation, retrofitting, and other mitigation efforts. Authority rates cannot be competitive with the voluntary market.

California Earthquake Authority

To ensure the availability of residential earthquake insurance, the California legislature established the California Earthquake Authority (CEA) as a privately financed, publicly managed entity in 1996. Today the CEA is the world's largest residential earthquake insurer, issuing over 914,000 policies in 2000 and representing over 70 percent of the California residential earthquake market.

By law, insurers writing homeowners policies in California must either offer earthquake coverage or participate financially in this program. When the CEA first began, over \$0.7 billion in capital was raised through the contributions of insurers who wished to participate in the program. Today, the CEA has approximately \$0.8 billion in cash and invested assets available for paying claims and additional claims paying capacity up to \$6.9 billion. This additional capacity is provided through a combination of member company assessments, reinsurance, and the ability to issue debt.

By statute, member companies may not be assessed more than their market share of \$5.0 billion during the lifetime of the CEA. Since the current market share of the CEA is about 70 percent, the amount currently available through assessments is \$3.5 billion. Similarly, the maximum debt that may be issued at any given time is the CEA's current market share multiplied by \$1.0 billion or \$0.7 billion. The capacity provided by reinsurance is not dictated by statute and is currently almost \$2.7 billion.

The CEA offers earthquake policies to homeowners, mobile home owners, condominium owners, and renters. The basic homeowners policy provides dwelling coverage at its stated value, as well as \$5,000 for contents and \$1,500 for loss of use. A base deductible of 15 percent is applied to dwelling losses and no claims for contents are paid until that dwelling deductible has been pierced. The deductible does not apply to loss of use. Supplemental coverage may also be purchased to provide higher contents and loss of use limits, or to obtain a lower deductible (10 percent). To encourage retrofitting, a 5 percent premium discount is also offered for qualifying properties.

The Florida Windstorm Underwriting Association

In 1970, the Florida Legislature created the Florida Windstorm Underwriting Association (FWUA) as a residual market to cover wind risk in the Florida Keys. The FWUA has since expanded to provide windstorm-only coverage in selected eligible geographic areas (now including 29 of 35 coastal counties in Florida) for risks unable to obtain windstorm coverage in the voluntary market. Among the criteria for eligibility is the area's adoption of the Standard Building Code published by the Southern Building Code Congress International (SBCCI). The FWUA now provides premium discounts of up to 50 percent to customers who make and verify certain disaster-prevention improvements to their homes to meet specific FWUA guidelines.

Following Hurricane Andrew until the end of 1998, the number of FWUA policies in force grew significantly. Beginning in 1999, the number of policies decreased. As of April, 2001, the FWUA had 426,813 policies, representing \$93.4 billion in exposure. That compares to 465,008 policies with \$90.3 billion in exposure on December 31, 1999, and is about 12 times the estimated \$7.5 billion in loss exposure before Andrew. In April 2001, about 65 percent of FWUA policies and dollars of exposure were concentrated in Dade, Broward, Monroe, and Palm Beach counties.

The FWUA's funds come from premiums from policyholders, regular assessments of insurers, and emergency assessments on policyholders collected by insurers. The FWUA has about \$5 billion in claims-paying capacity. In the event of a catastrophe, the FWUA has issued \$1.75 billion in pre-event notes, has made arrangements to access the Florida Hurricane Catastrophe Fund (FHCF), and has a \$1.0 billion line of credit. If premiums and reinsurance recoveries (including the FHCF) are insufficient to pay claims, the FWUA can assess private property insurers up to 10 percent of the statewide property premium volume or 10 percent of the deficit, whichever is greater, based upon their respective Florida market shares adjusted for voluntary writings. Insurers may recoup these assessments through policyholder surcharges. Deficits in excess of the caps are funded through bonds whose debt service is supported by direct surcharges on all policyholders in the state collected by insurers.

The Florida Hurricane Catastrophe Fund

Following Hurricane Andrew in 1992, some insurers went insolvent, some became financially impaired, and others reduced their exposure to hurricane losses as catastrophe reinsurance capacity contracted. In order to ensure a viable private sector market for property insurance, the Florida Legislature passed a bill in November 1993 that provided for a state trust fund, the Florida Hurricane Catastrophe Fund (FHCF), under the control of the State Board of Administration. After passage of the enabling legislation, Florida succeeded in obtaining a federal tax exemption status. This exemption enables the FHCF to retain millions of dollars that insurers would otherwise pay in federal income taxes.

Florida's law requires each property insurer doing business in the state to pay premiums to the FHCF based on the insurer's hurricane exposures and the coverage level it selects (45 percent, 75 percent, or 90 percent). In return, the FHCF will pay each insurer for 45 percent, 75 percent, or 90 per-

cent of its losses from each covered event in excess of the insurer's retention. As the coverage level decreases, the retention level remains constant.

In 2000, the FHCF had 276 participating insurers, down from its peak of 378 in 1994. (The law was changed in 1995 to eliminate commercial nonresidential insurer participation.) The FHCF had a projected \$3.7 billion cash balance for year-end 2000 with borrowing capacity for another \$7.3 billion in the form of revenue bonds. This gives the FHCF a total estimated capacity of \$11 billion to pay hurricane claims which exceed a company's loss retentions on a per storm basis. The revenue bonds are financed by levying an emergency assessment of no more than 4 percent of all Florida property and casualty premiums, except workers compensation. Insurers can recoup the assessments through special rate filing procedures.

To stabilize the state's reinsurance capacity, Florida lawmakers passed a bill in 1999 which limited the capacity of the FHCF to \$11 billion for an initial season until there is enough bonding capacity and cash balance to fully recharge the FHCF for the next hurricane season. The \$11 billion limitation was specifically designed to prevent the removal of larger amounts of private reinsurance from the property market which would have resulted in the FHCF continued to grow in capacity year after year. As an additional measure to stabilize the state's reinsurance capacity, the bill provided for an additional 2 percent emergency assessment which could be used to finance bonds or other debt, thus adding back capacity in the event that the previous season FHCF reimbursements have reduced the FHCF capacity below \$11 billion for the current contract year. This is commonly referred to as "subsequent season" coverage with the FHCF having an estimated "subsequent season" reimbursement capacity of \$5.5 billion in 2000. The assessment base would be the prior-year direct written premiums for all property and casualty business in Florida, except for workers' compensation.

Florida law authorizes the FHCF to appropriate at least \$10 million each fiscal year to improve hurricane preparedness, reduce potential hurricane losses, provide for mitigation research, assist the public in financing appropriate mitigation upgrades, or protect local infrastructure from potential hurricane damage. On June 9, 1999, Governor Bush signed into law provisions creating the Hurricane Loss Mitigation Clearing Trust Fund. The law authorizes the legislature to transfer at least \$10 million annually from the FHCF to this loss mitigation trust fund.

Florida Residential Property & Casualty Joint Underwriting Assoc.

After Hurricane Andrew, the Florida Legislature created the Florida Residential Property & Casualty Joint Underwriting Association (FRPCJUA or the JUA) as an insurer of last resort. Statewide, the JUA writes homeowners insurance, as well as fire and extended coverage insurance on both personal and commercial structures serving as residences. Coverage excludes windstorm and hail in areas where property owners can get coverage through the FWUA.

In each county, the JUA sets its average rates for personal lines policies no lower than the average rates charged by the insurer among Florida's 20 largest insurers (by market share for that line) that had the highest average rates in that county for the preceding year. For mobile home coverage, the JUA sets its average rates in each county no lower than the average rates charged by the insurer among Florida's five largest insurers of mobile homes that had the highest average rate in that county in the preceding year.

At its peak, the JUA became the state's second largest homeowners insurer. The JUA peaked at 936,837 policies in September 1996 and \$98.2 billion of coverage A and C exposure in October 1996. Since then, the JUA's board of directors, the insurance commissioner, and key state legislators have sought to transfer JUA policies back to the voluntary market. The JUA implemented incentives for private insurers to assume or "take out" JUA business and receive certain exemptions from JUA assess-

ments. As of April 2001, the JUA's personal lines policy count had dropped to 70,606 statewide and its coverage A and C exposure had fallen to about \$11.2 billion.

The JUA's funds come from premiums from policyholders, regular assessments of insurers, and emergency assessments on policyholders collected by insurers. The JUA has approximately \$1.88 billion in claims-paying capacity, including a \$570 million line of credit and an anticipated \$270 million reinsurance recovery from the FHCF. Like the FWUA, the FRPCJUA can assess private property insurers up to 10 percent of the statewide property premium volume or 10 percent of a deficit, whichever is greater, based upon their respective Florida market shares adjusted for voluntary writings. Insurers may recoup these assessments through policyholder surcharges. Deficits in excess of the caps are funded through bonds whose debt service is supported by direct surcharges on all policyholders in the state collected by insurers.

The Hawaii Hurricane Relief Fund

This Hawaii Hurricane Relief Fund (HHRF) was created in 1993 after most insurers excluded losses from hurricanes following Hurricane Iniki. The HHRF was intended to be a stopgap measure. Subsequently, many insurers have reentered the market and the HHRF stopped writing new policies as of December 1, 2000. At the time there were about 80,000 policies written by the fund.

Other State Market Assistance Programs (MAP)

In Texas, the insurance department has set up a MAP for 427 zip codes where insurance may not be readily available, including hail-prone regions. Insurers may offer higher deductibles for claims associated with wind, hurricane, and wind-driven rain up to 5 percent of a home's insured value with premium discounts of up to 16 percent. Data for 1996 show that Texas had the highest average homeowners premium (\$855) in the nation.

The insurance department of New York State has set up a Coastal Market Assistance Plan (C-MAP) for coastal homeowners having trouble finding insurance. This MAP is a clearinghouse and referral mechanism that helps insurance agents to match up homeowners with companies willing to issue policies for coverage that might be difficult to obtain.

FAIR Plans, Beach Plans, and Windstorm Pools

Serious riots and civil disorders in many states from 1965 to 1968 led to diminished insurance availability in some urban areas. Many states addressed availability problems in urban areas by creating FAIR (Fair Access to Insurance Requirements) plans.¹

Each state with a FAIR plan has formed a pool or syndicate to make property insurance available to property owners who cannot obtain coverage in the regular market. FAIR plan insurance is not intended to replace coverage normally available, but is intended to provide fair access to insurance based on the physical characteristics of properties. FAIR plan insurance seeks to overcome rejection of coverage based solely on a property's location. To guarantee that insurance is available to those who qualify, 28 states, Puerto Rico, and the District of Columbia have established such plans. Twelve hurricane-prone jurisdictions have FAIR plans. They are: Delaware, the District of Columbia, Georgia,

¹ In general, FAIR plans can deny or cancel coverage only if one or more of the following conditions apply: one or more private insurers have not already denied coverage to the insured; the property is in poor physical condition, including unrepaired fire damage; the insured practices poor housekeeping, including overcrowding and the storage of rubbish or flammable material; the property is in violation of law or public policy; the property does not conform to appropriate building or safety codes; or the insured has failed to pay premiums.

Hawaii, Louisiana, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, and Virginia.

Similarly, some states have addressed the insurance availability problems in coastal areas by creating beach plans or windstorm pools.² Alabama and Louisiana have beach plans that provide fire and extended coverage insurance. Louisiana's plan also provides homeowners multiple peril insurance and windstorm and hail only policies for monoline dwelling or commercial properties. Mississippi, North Carolina, South Carolina, and Texas have plans providing only wind and hail coverage. Insurance from FAIR plans, beach plans, and windstorm pools is often more costly and less comprehensive than the coverage that private insurers offer.

Federal Programs

For a number of catastrophe exposures state solutions cannot adequately address the broad exposure across geographic boundaries or where the potential magnitude of losses would exhaust state program resources. In several cases, the federal government provides mechanisms to address the exposure or has proposed legislative solutions to support industry.

Crop Insurance

The agricultural industry and individual farmers have a unique and substantial exposure to the weather. Insurance protection for droughts, for example, is critical for many individual farmers to protect their incomes and property. Due to the potential widespread and severe nature of weather related events, insurance coverage through the private insurance industry for weather related damage to crops is limited. While there is a private insurance market available, the coverage provided through the federal program offers broader coverage.

In order to make crop insurance widely available, the federal government provides Multi-Peril Crop Insurance (MPCI). MPCI is a voluntary program that provides protection to the agricultural industry for either or both the percentage of normal crop yield and the market price. MPCI works in conjunction with private insurers and agents, who sell and service crop coverages and frequently enhance the basic MPIC coverages on a private basis. The federal government reinsures the basic MPIC coverages, thereby providing virtually unlimited capacity and financial security in the event of a widespread weather-related catastrophic event. This approach also provides the federal government with flexibility in balancing any subsidies for the premiums for the voluntary basic coverage with the potential need for other governmental financial assistance in the event of a weather-related catastrophic event.

Federal Flood Insurance Program

The National Flood Insurance Program (NFIP) was created by Congress in 1968 to respond to the rising cost of damages caused by floods and to assist with relief for flood victims. The program is managed by the Federal Emergency Management Agency (FEMA). The federal agency has identified flood prone areas and produced flood hazard boundary maps, flood insurance rate maps and flood boundary, and floodway maps.

The NFIP works with participating property and casualty insurers to write coverage in certain areas that may be prone to floods. The program also helps state and local governments develop floodplain management standards and building codes for structures.

² These are: the Alabama Insurance Underwriting Association, the Louisiana Insurance Underwriting Plan, the Mississippi Windstorm Underwriting Association, the North Carolina Windstorm Underwriting Association, the South Carolina Wind and Hail Underwriting Association, and the Texas Windstorm Insurance Association.

Nuclear Facilities

The commercial nuclear power industry in the United States has the unique potential of a nuclear incident creating catastrophic loss. The industry also has a long-term investment in power generating infrastructure, which by its nature cannot be wound down quickly. The nuclear industry therefore has a critical need for adequate, dependable, third-party liability insurance.

Virtually all property insurance policies, whether provided to individuals or businesses, include policy language to exclude coverage for loss by nuclear reaction, radiation, or radioactive contamination, regardless of the cause. Hence, to ensure protection for these individuals and businesses, the federal government also has an incentive to ensure the availability of adequate and dependable third-party liability coverage for the nuclear power industry.

This awareness led to the Price-Anderson Act, which requires commercial nuclear power plant operators to provide financial protection to the public in an amount equal to the maximum liability insurance capacity available from private sources. Currently this limit is \$200 million.

To meet the Price-Anderson requirement and ensure that insurance capacity would remain available to operators of nuclear power reactors, a joint underwriting association, American Nuclear Insurers (ANI) was formed. It is an unincorporated association of approximately 60 member insurance companies that pool their financial assets to provide property and liability coverage to the nuclear industry, both in the United States and worldwide. Other countries with significant commercial nuclear power generation have similar organizations, or pools, and frequently these organizations provide reinsurance to each other to increase capacity. Specialized loss prevention engineering services are also an important function of the ANI.

The approach taken by the federal government has the advantage of minimizing any federal subsidies and ensures that the costs of providing protection to the public are borne by the commercial nuclear power industry.

Appendix C

Catastrophe Modeling

Catastrophe simulation models employ sophisticated stochastic simulation procedures and powerful computer models of how natural catastrophes behave and act upon insured exposures. They can overcome the issues of having to adjust historic losses by creating tens of thousands of potential combinations of variables that describe catastrophe events and estimate the impact of these simulated events on insured exposures.

Figure 1.1 below illustrates the component parts of catastrophe models.

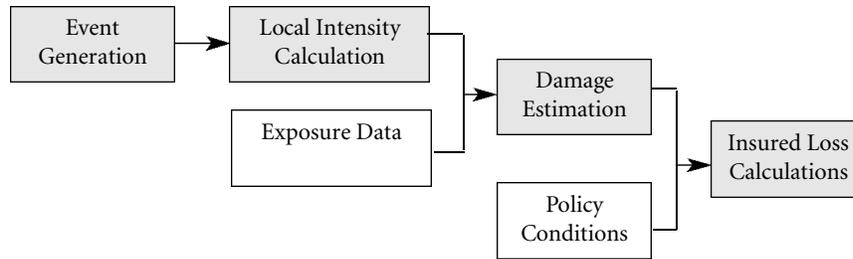


Figure 1.1: Catastrophe Model Components (in gray)

Event Generation Module

The event generation module answers the questions of where, how big, and how often catastrophe events occur. Catastrophe events are extremely complex and their characterization requires the use of large numbers of variables. The event generation module determines the frequency, magnitude, and other characteristics of potential catastrophe events by geographic location. This requires, among other things, a thorough analysis of the characteristics of historical events. The available scientific data pertaining to these variables come from many different sources.

After rigorous data analysis, researchers develop probability distributions for each of the variables, testing them for goodness-of-fit and robustness. The selection and subsequent refinement of these distributions are based not only on the expert application of statistical techniques, but also on well-established scientific principles and an understanding of how catastrophic events behave.

The probability distributions are used to produce a large catalog of simulated events. By sampling from these distributions, the model generates simulated "years" of event activity. Note that a simulated year represents a hypothetical year of catastrophe experience that could happen in the current year. The models allow for the possibility of multiple events occurring within a single year. That is, each simulated year may have no, one, or multiple events, just as might be observed in an actual year. Tens of thousands of these scenario years can be generated to produce the complete and stable range of potential annual experience of catastrophe event activity, and to ensure full coverage of extreme events, as well as full spatial coverage.

Local Intensity Module

Once the model probabilistically generates the characteristics of a simulated event, it propagates the event across the affected area. For each location within the affected area, local intensity is estimated. This requires, among other things, a thorough knowledge of the geological and/or topographical features of a region and an understanding of how these features are likely to influence the behavior of a catastrophe event. The intensity experienced at each site is a function of the magnitude of the event, distance from the source of the event, and a variety of local conditions. Researchers base their calcu-

lations of local intensity on empirical observation as well as on theoretical relationships between the variables.

Damage Module

Scientists and engineers have developed mathematical functions called damageability relationships, which describe the interaction between buildings, both their structural and nonstructural components as well as their contents, and the local intensity to which they are exposed. Damageability functions have also been developed for estimating time element losses. These functions relate the mean damage level as well as the variability of damage to the measure of intensity at each location. Because different structural types will experience different degrees of damage, the damageability relationships vary according to construction materials and occupancy. Total damage is calculated by applying the appropriate damage function to the replacement value of the insured property.

Insured Loss Module

In this last component of the catastrophe model, insured losses are calculated by applying the policy conditions to the total damage estimates. Policy conditions may include deductibles by coverage, site-specific or blanket deductibles, coverage limits and sublimits, loss triggers, coinsurance, attachment points and limits for single or multiple location policies, and risk specific reinsurance terms.

Model Output

After all of the insured loss estimations have been completed, they can be analyzed in ways of interest to risk management professionals. For example, the model produces complete probability distributions of losses, also known as exceedance probability curves (see Figure 1.2). Output includes probability distributions of overall loss and gross insured and net insured (net of reinsurance recoveries) losses for both annual aggregate and annual occurrence losses. The probabilities can also be expressed as return periods as shown in the upper right corner of Figure 1.2. For example, the loss associated with a return period of 10 years is likely to be exceeded only 10 percent of the time or, on average, in one year out of 10.

Output may be customized to any desired degree of geographical resolution down to location level, as well as by line of business, and within line of business, by construction class, coverage, etc. The model may also provide summary reports of exposures, comparisons of exposures and losses by geographical area, and detailed information on potential large losses caused by extreme events.

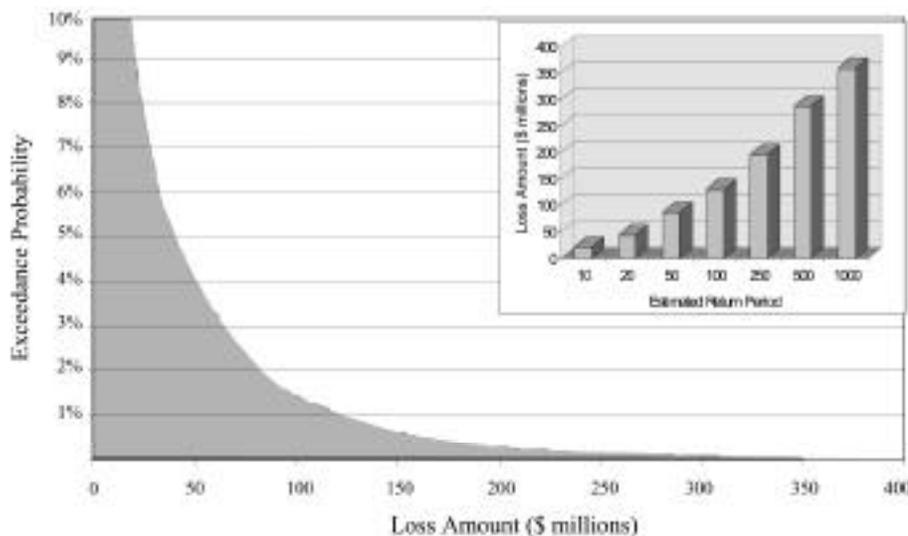


Figure 1.2: Exceedance Probability Curve (Occurrence)

Validation of Catastrophe Models

Scientists and engineers validate the models at every stage of development by comparing model results with actual data from historical events. The simulated event characteristics parallel patterns observed in the historical record and resulting loss estimates correspond closely to actual claims data provided by insurers.

The construction of these models relies on the expertise of many scientific disciplines such as seismology, meteorology, civil engineering, statistics and actuarial analysis. Thus the expertise required to construct these models is broader than the traditional actuarial domain. Actuaries are guided in their use of catastrophe models by Actuarial Standard Of Practice 38 - Using Models Outside the Actuary's Area of Expertise which details the review required by actuaries before using such models in their work product.

Currently, U.S. catastrophe models are only commercially available for hurricane, earthquake, and certain kinds of windstorm.

Appendix D

Underwriting Individual Risks

When an insurer decides whether to issue a property insurance policy, catastrophe exposure is rarely the primary focus. Rather, underwriters review the property exposure and the coverage desired, applying underwriting procedures and practices that have evolved largely in the context of noncatastrophe loss experience.

In some ways, solid individual policy underwriting helps to underwrite for catastrophic losses as well. For example, insurers like to cover well-maintained property for a number of reasons. Well-maintained property tends to perform better than most under extreme weather or seismic disturbance. In some other ways, catastrophe exposure requires a special approach. An example of this could be masonry construction, which is generally good in a fire, windstorm and hail, but performs poorly in an earthquake.

Thus, underwriters need to consider any catastrophe hazards where insured property is located. The insurer may have decided whether to restrict attention to catastrophe hazards within the scope of intended coverage, or to consider potential insurance implications of excluded hazards. In either case, the underwriter will apply underwriting practices to the individual contract, based on policies and procedures of the insurer. If the property is vulnerable and can't (or won't) be protected, such hazards deserve increased emphasis. For example, the location of real property is information required by the underwriter.

Underwriters can infer catastrophe exposure based on location and other information collected by the insurer. Inferring damageability, however, depends on detailed knowledge of the property's construction and occupancy. Underwriters would like assurance that design and construction are appropriate considering local conditions, but obtaining ideal information has high costs. For example, think of a business interruption policy that will pay if a key manufacturing component fails. The insurer may ask many questions about the equipment and the financial consequences of its failure, but may not ask about the construction of the facility housing it. In a hurricane or earthquake, building failure may cause a covered equipment failure, but the underwriter has no hard information about the building's vulnerability. The underwriter will still underwrite, but the point is that a balance must be achieved between cost and detail.

For large or unique properties, structural engineering analysis may be cost-justified, and may be best done prior to construction. Engineered facilities are built to withstand quantified levels of stress. The plans may identify the components most likely to fail, and the financial effects of facility failures may be simulated under any foreseen catastrophic scenarios. In any case, very detailed plans make it possible to organize a thorough but efficient engineering review. An engineered retrofit may even be cost-justified.

For more standard, perhaps medium-sized commercial properties, it may still be cost-beneficial to inspect the property, suggesting or requiring specific loss control measures. For homes, it may be cost-justified to inspect no more than the exterior, and loss control efforts may be limited to a customer newsletter or perhaps premium credits for common protective features.

In principle, the underwriter wants to insure individual exposures that are not overly exposed or vulnerable within their pricing groups. To the extent that the market subdivides pricing groups and prices them accurately, underwriting selection practices would optimally respond by making coverage available to all. In any case, an underwriter who manages to select individual risks in ways that promote profitable growth is valued. In the long run, the incentive exists to make price or selection adjustments to compensate for elevated exposure to all kinds of loss. Insurers rely on actual experience to monitor how well they are doing. In the short or medium term, including actual catastrophe insurance experience in the analysis can be misleading.

The following illustrates the process a company must go through to establish guidelines and underwrite individual risks.

- 1) Establish company's "appetite" for the largest loss at one location
- 2) Establish a definition of "location"
- 3) Identify and set limits on risks more likely to have a loss
 - a) For these "higher loss potential" risks, consider
 - i) limiting the "value-at-one-location"
 - ii) authority of underwriters
 - iii) establishing higher minimum deductibles
 - iv) price the risk consistent with the higher exposure
 - v) require controls on the exposures and hazards inherent in these risks
- 4) Underwrite the individual location to establish a likelihood of loss, and the maximum loss likely at the location, for each covered cause of loss
 - a) Determine how the risk fits into the exposure limits that have been set for the corporation. The following information should all be considered in the risk acceptance and pricing decision:
 - i) Consider geographic location and meteorological conditions, proximity to fault lines, subduction zones, tectonic plate weak zones, and other geographic features such as slope, soil type and consistency, distance from water, elevation from water, adequacy of drainage (natural and man-made)
 - ii) Determine the values requested to be insured and make a judgment as to whether those values are realistic
 - iii) Determine the COPE of the risk
 - (1) Construction: How well does it burn? How "brittle" is it? How well is it connected together and to the ground? How old is it and how well maintained? Is there any deterioration?
 - (2) Occupancy: How combustible are the contents of the building? How susceptible are they to loss by fire? Smoke? Water? Breakage? How well are the common and special hazards controlled? What is the economic activity at the location? How is it conducted? Hours of occupancy? How does the activity depend on the various components of that activity (are there bottlenecks)? How does the activity depend on other locations?
 - (3) Protection: Are there sprinklers, other automatic fire suppression systems? Fire extinguishers? Do employees know how to use fire suppression equipment? Is it maintained? Adequate? What is the location's proximity to a fire hydrant? What is the quality of the flow and supply of water? What is the location's proximity to a fire department, and how well does the fire department respond to fires? How is the fire department notified of a need for their presence?
 - (4) Exposure: Does the economic activity and the methods for conducting that activity create a higher chance that there will be a loss? Do the surroundings create higher chances for a loss at the insured location? Do ecological, geographic, or meteorological conditions around the location create higher chances for loss?

- b) Catastrophe characteristics of the risk will differ by type of catastrophe exposure
- c) Adequacy of price level
 - i) Adequacy of overall rate structure and by geographical location
 - ii) Adequacy of catastrophe load
 - iii) Market conditions
 - iv) Individual risk premium modification plans
 - (1) Commercial policies only
 - (2) Credits for favorable hazard characteristics
 - (3) Debits for unfavorable hazard characteristics
 - v) Multiple location premium and dispersion credit plans
 - (1) Commercial policies only
- d) Usage of deductibles/limits
- e) Physical inspection of risk
 - i) Meet underwriting guidelines
- 5) Consideration of reinsurance on the individual risk

Appendix E

Why Insurers Purchase Reinsurance

Each insurance company utilizes a unique set of criteria in designing and implementing its reinsurance program. Such a program will be created to meet the individual goals and objectives of the company, and will be adjusted as these goals and objectives change over time. In addition to catastrophe protection, motivations for buying reinsurance include risk sharing, reciprocity, obtaining capacity to write large risks, stabilizing experience, financing growth, accessing underwriting expertise and removing blocks of unwanted business. This appendix will provide further discussion of some common considerations including stability, capital strength, cost of capital, balance sheet protection, liquidity, perceived exposure, regulatory and rating agency considerations.

Stability

Stable earnings and the ability to write business are essential ingredients in all insurance company business plans. Reinsurance is used to enhance earnings stability by balancing the benefits of recoveries when losses occur against the cost of reinsurance during periods when there is little in the way of recoverable losses. Reinsurance is used to give insurers the capacity to grow, to write large property risks, to provide high liability limits, and write property business in catastrophe-prone areas. All forms of reinsurance provide some elements of stability and capacity to the reinsurance buyer.

Tracking, reporting, explaining, and accepting results all are easier if the income statement behaves in a predictable manner. Companies are inclined to reduce income statement uncertainties by transferring risk, if the cost is reasonable. However, there are problems with predictable losses that take years to settle, or losses that may be predictable in the long run, but are unpredictable on a year-to-year basis. An estimation error in either situation can result in volatile earnings patterns.

Company Capital Strength

Capital allows an organization to absorb risk. Large companies generally have greater capacity to absorb risk than small companies. However, this is an oversimplification because it is possible for a company that is very large in terms of assets or premium to have a relatively small or dwindling capital base.

Large companies with geographically dispersed and homogeneous books of business have the capacity to take on risk by writing more business without transferring part of it to another organization. Small companies need to pass on part of the risk associated with growth or forego that growth. Thinly capitalized companies with substantial premiums in force and/or loss reserves may need to transfer risk in order to sustain their current scale of operations or to continue growing.

Cost of Capital

Motivations driven by the cost of capital are more complex. If capital is becoming cheaper and more plentiful, organizations generally will have more capacity to absorb risk and there will be less need to transfer risk from one organization to another. In such a market, organizations that are experiencing capital constraints will find it very attractive to transfer risk to organizations that are hungry to take it on. Conversely, a market with higher costs of increasingly scarce capital will find many organizations looking to shed risks they no longer can handle. Organizations with strong capital bases coming into such a market will be able to charge a premium for taking on unwanted risk. In addition, insurers often use reinsurance to supplement their capital base.

When reinsurance is perceived as being inexpensive, insurance companies will expand their reinsurance programs accordingly by increasing limits, reducing retentions, and otherwise acquiring more liberal coverage terms and conditions. In addition, insurance companies will be inclined to issue policies covering more risky exposures because they can pass them on to reinsurers.

Expensive reinsurance, by contrast, results in the opposite effect, with risk bearing generally being pushed back from the reinsurer to the insurer to the insured or uninsured as the case may be.

Balance Sheet Protection

Catastrophes, which may be predictable only over periods of time measured in hundreds of years, present significant challenges. One possible way for an organization to self-fund for such losses is to pre-fund incrementally over an extended period of time. In practice, many primary insurers and reinsurers have done this by accumulating retained earnings. This strategy has not been effective for many reasons, including the fact that catastrophes tend to occur before an insurer has surplus large enough to be fully pre-funded. Stock insurers may pursue pre-funding through the equity markets. A third, and more common possibility, is to buy reinsurance, in effect relying on the reinsurance market to solve the problem. In any case, insurers want to defend their balance sheets against substantial cash demands that must be met in a short period of time after catastrophes occur.

Liquidity/Asset Management

The risk of a sudden large cash demand causing forced sale of assets is real. Undesirable affects can include unplanned taxes on realized investment gains, realized investment losses on untimely sales, and deviation from the asset management plan. Every insurance company has a strong incentive to eliminate these possibilities. The current tax system offers a partial cushion against this risk. The tax benefit of an underwriting loss may be partly balanced by the tax on investment gains. In the case of realized losses on untimely asset sales, tax benefits soften the damage from dual investment and underwriting losses. One can see that asset management, investment decisions and tax planning are complex and are directly affected by changes to accounting rules or tax law. Purchasing reinsurance simplifies these issues and helps an insurer avoid or control asset management and tax problems.

Perceived Exposure

Actual exposure to loss and insurance companies' understanding thereof do not evolve in perfect harmony. This was made painfully obvious by hurricane Andrew and the Northridge Earthquake. The sudden awareness of a gross underestimation of risk leads to shedding of risk, to the extent and at a rate allowed by regulation, and an explosion in demand to fund or transfer the risk that remained.

Insurance rates increased and property owners scrambled to find coverage giving rise to overpopulation of involuntary market plans and creation of the Florida Hurricane Cat Fund and the California Earthquake Authority.

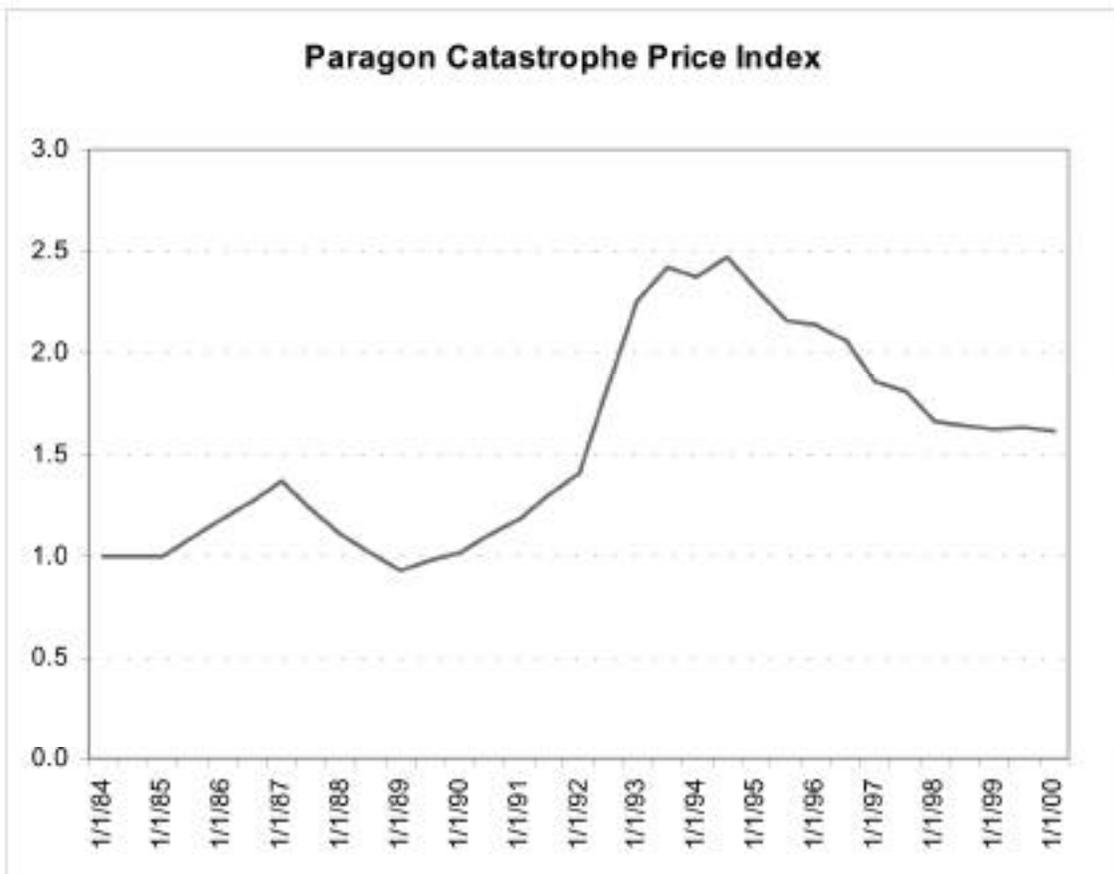
Misconceptions about exposure are possible for any type of catastrophe, but location and concentration of exposures are key variables. The state of science and engineering are also key variables. Weather is better understood than seismicity. Also, there are more frequent opportunities for engineers to survey weather-related damage than damage to insured property from earthquake. Events that reveal significant misconceptions of risk result in abrupt changes in the motivations to bear and transfer it.

The influence of Hurricane Andrew (1992) and the Northridge Earthquake (1994) on catastrophe risk perceptions is apparent in the increased ratio of ceded premium to direct and assumed premium for property lines immediately following these events.

| Reinsurance Ceded Rate | | | | | | | | | |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| 17.3% | 17.2% | 17.6% | 18.6% | 20.7% | 21.5% | 19.9% | 19.1% | 18.0% | 19.6% |

Source: Industry Schedule P for Property Lines of Business

The market impact of Hurricane Andrew is much more dramatically illustrated by the Paragon Catastrophe Price index.¹ As a result of Andrew, the price of catastrophe reinsurance nearly doubled, driving the index from 1.4 to 2.4.



¹ The Paragon Catastrophe Price Index is a relative measure of composite domestic U.S. property catastrophe prices. It compares the average market price at each renewal date with the average market price of one year prior. A standardized industry distribution reflecting variation in region, company size, limits, and retentions is used to compare the price of reinsurance over time. The index reflects overall market prices separate from shifts in actual reinsurance purchased. Weights used to compute the index are adjusted periodically and will reflect changes in the distribution of market purchases over an extended period of time. Paragon Reinsurance Risk Management Services, Inc. is a wholly owned subsidiary of E.W. Blanch Holdings, Inc.

Regulatory Considerations

Regulators have a responsibility for solvency oversight and may encourage companies to buy reinsurance in the interest of policyholder protection. Regulators may consider an insurer's catastrophe exposure during their financial solvency examination process.

Rating Agency Considerations

The rating of an insurance company is vital to its growth as it directly influences the creditworthiness that stockholders and policyholders place on the company. Therefore, most insurers take all necessary actions to retain and upgrade their ratings. The increasing level of concern about catastrophe exposures has also led rating agencies to pay greater attention to how insurers manage their catastrophe risk. Rating agencies use their own analytical models to assess an insurer's ability to manage its catastrophe exposure. Property insurers who are not taking appropriate steps to manage their catastrophe exposures, including appropriate use of reinsurance, may be subject to rating downgrades.

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