CHAPTER 10
SPECIAL ISSUES

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With increasing frequency, casualty actuaries are using their skills to perform analyses that extend beyond the traditional actuarial functions associated with ratemaking and loss reserving. An actuary's quantitative expertise, combined with an understanding—obtained through the examination process or experience or both—of an insurance company's operational and financial processes, means that the actuary is often called upon to study and opine on important nontraditional questions and issues. These opportunities for expanded responsibility require familiarity with topics and techniques beyond those previously covered in this book.

This chapter discusses a number of "special issues," that include several recent developments in actuarial science and insurance. Only a brief outline of each topic can be provided in this chapter; it is hoped that these descriptions will encourage the interested reader to pursue the articles referenced in this chapter, along with other relevant material associated with these topics. The first section of this chapter covers the valuation of insurance companies, including accounting principles and the measurement of surplus or net worth, approaches to allocating surplus, and valuation issues involving environmental and catastrophic exposures. The second section considers issues relating to operating an insurance company, including planning and forecasting, dynamic financial analysis, and insurance securitization. The third section discusses the regulation of insurance companies, including solvency issues and risk-based capital. The final section describes data sources that might be useful in support of actuarial analyses.

VALUING AN INSURANCE COMPANY

This section introduces several issues involved in the valuation of an insurance company. A number of different definitions of "value" are described, and the differences between these various value measures are examined. Issues surrounding the allocation of surplus to different operating entities or lines of business or both are also discussed, and accounting and ratemaking considerations related to surplus allocation are examined. Finally, two exposures that can significantly impact insurance company valuation are discussed: environmental liabilities and catastrophic risks.

Measuring Surplus or Net Worth

The determination of an accurate value for the net worth of an insurer is important for operational and regulatory purposes. In addition, the insurance industry—in fact, the entire financial services sector—has periodically been characterized by significant merger, acquisition, and consolidation activity. Such activity entails evaluations of insurers' net worths. Thus, it is critical that actuaries understand how company "value" is determined from many different perspectives. This section defines these perspectives, describes the specific orientations and users of each measure of value, and discusses their attributes and differences.

Statutory Value

Statutory valuation and accounting conventions are peculiar to the insurance industry. The measures and methods used to determine statutory values are promulgated by the regulatory authorities that oversee the insurance industry, and may—and very often do—differ from other valuation conventions (discussed later). Despite the existence of "distortions" in statutory accounting, statutory values are relied upon heavily by regulators.

It is useful to characterize different accounting and valuation conventions according to their overall perspective. Statutory values can be characterized as having the following orientations:

- *Solvency:* The historical development and primary purpose of statutory accounting revolved around helping regulators to evaluate the solvency of insurance companies better.
- *Conservatism:* Statutory valuation is typically oriented toward providing a conservative estimate of a company's value and solvency potential. To that end, assets are sometimes valued below their "fair market" values and liabilities above their economic values. Some of the specific statutory valuation rules are discussed below.
- *Balance sheet:* Consistent with its solvency orientation, statutory accounting often focuses on the balance sheet of the insurance company, in an effort to determine a (conservative) estimate of the value of the company.
- *Liquidation value:* Statutory accounting can be viewed as ultimately providing a value of the company as if it had to be liquidated as of the date of the balance sheet. Such a perspective provides regulators with an indication as to whether or not the various claimholders of a company—especially policyholders—would be satisfied financially in the event of the company's insolvency.

Some of the specific statutory conventions include the following rules. Several of these rules are instrumental in establishing the "conservative" nature of statutory valuation.

- Bonds (those in good standing) are generally valued at "book" value, i.e., amortized value. (Note that this rule may or may not be "conservative," depending upon the relationship between the book and market values of a bond on the valuation date, which in turn depends upon the path that interest rates have taken between the purchase date of the bond and the valuation date.)
- Common stock values are based on market value.

- Certain assets are "nonadmitted"—that is, considered to have no value—such as agents' balances over 90 days past due, reinsurance recoverables over 90 days past due, and furniture and equipment.
- Expenses are recognized on a cash basis.
- Loss reserves are generally not discounted to reflect the time value of money.

An insurer's statutory surplus is equal to its statutory assets minus its statutory liabilities. Thus, the statutory surplus is, in a sense, the regulator's conservative estimate of the net worth of the company, i.e., the value of the owners' interest in the company. For a stock company, the statutory surplus represents the stockholders' value or interest in the insurer; for a mutual company or a reciprocal, it reflects the policyholders' interest.

GAAP Value

"GAAP" accounting stems from Generally Accepted Accounting Principles. GAAP principles are largely based upon rules promulgated by the Financial Accounting Standards Board. One of the primary functions of GAAP accounting is to provide information to the investment community about the performance of companies. Since earnings information is critically important to investors, GAAP tends to have an income statement orientation. Also consistent with this investment perspective, GAAP views the company as a going concern.

GAAP principles tend to be less conservative, and more "realistic," than statutory accounting rules. Some of the GAAP principles include the following.

- Bonds are booked at amortized value only if they are categorized as being "held to maturity." "Trading" and "available for sale" bonds are booked at market value.
- Common stock is booked at market value.

- There are no "nonadmitted assets" under GAAP—all receivable assets are accounted for to the extent that they are reasonably expected to be collectible.
- Expenses associated with the writing of policies are matched against the revenues associated with those policies.

Thus, there are several important differences between GAAP and statutory accounting in terms of asset valuation, nonadmitted assets, and the treatment and timing of policy acquisition expenses. While statutory accounting tends to be the more conservative of the two, this sometimes depends upon specific company or financial conditions.

"Economic" Value

The term "economic value" has been used in a variety of ways. Here, it is intended to reflect the value of an asset, liability, or company by beginning with statutory or GAAP accounting conventions, and then incorporating more "realistic" economic adjustments than allowed for under either statutory or GAAP rules. For example, the economic value of the equity of a property-liability insurer might be considered as an adjustment to statutory surplus:

Economic value of equity = Statutory surplus

+ Equity in the unearned premium reserve

+ Excess of statutory over statement reserves

+ Nonadmitted assets

+ Difference between nominal and time-discounted loss reserves

+ Difference between market value and book value of bonds

– Tax liability on equity in unrealized capital gains

Market Value

If a financial entity or instrument is actively traded, a possible basis for valuation is the price at which it is bought and sold. The market value of a publicly traded insurer is calculated by multiplying the number of outstanding shares of stock of the company by its current stock price. This represents the company value as interpreted by the capital markets. For nonpublicly traded companies, or for insurers that are owned by large publicly traded companies, this process cannot be done directly. It is possible that an indirect method could be used, for example by applying a market value to book value ratio from a "comparable" stock insurer. Since the stock price represents the capital market's assessment of the firm as a whole, using the stock price can, in theory, provide an indication of the *franchise* value of the firm. The franchise value includes certain aspects of an insurer that are difficult to quantify, such as reputation, goodwill, and the value of the existing book of business. Goodwill, for example, can be a significant asset, which is generally not included in either statutory or GAAP valuations (although it might be recognized as an asset when a company is acquired).

In some instances, two or more of the valuation frameworks described above—statutory, GAAP, economic, and/or market values—might result in similar or identical indications of a company's surplus or equity. However, they can often produce significantly different surplus values. The relationships between the values depend upon a company's specific asset distribution, the type of insurance the company is engaged in, general financial and economic conditions, and a variety of other factors.

Allocation of Surplus

It is important that actuaries be comfortable with the underpinnings of each valuation technique described above. While the terms "equity" and "surplus" are frequently used interchangeably and as general labels, there are many instances in which one or another measure of equity described above is required for a specific application—for example, in the allocation of surplus for ratemaking purposes. Depending upon the type of ratemaking formula used, different specifications of "equity" may be necessary. Certain ratemaking formulas require that the amount of capital allocated to the insurance business being priced represents the amount of capital on which a competitive rate of return should be achieved. This "capital attraction" standard recognizes that assets can be redeployed to alternative investments if a competitive rate of return cannot be earned on the insurance business. Other formulas simply require a capital allocation in order to determine a level of investment income, and, in turn, to determine the amount of tax liability incurred on that investment income.

There is no generally accepted approach to allocating surplus. Some of the possibilities include:

- *Premium-to-surplus ratio*. This essentially assumes that surplus is no longer needed to support business after the premium has been written. However, to the extent that surplus exists to provide a safety margin, surplus should be allocated to business as long as there is any potential for future activity and uncertainty relating to that business, for example, until all possible losses have been paid.
- *Loss reserve-to-surplus ratio*.
- *Proportion of total marginal profit*. This approach has its underpinnings in microeconomic theory.
- *Relative "riskiness."* Under this approach, surplus is allocated in such a way that the expected return on equity is the same across all types of business.

Financial Analysis

Regardless of the valuation framework used, the purpose of accounting and accounting rules is to summarize the financial activity of a company. Financial statements that provide these summaries can be utilized by at least four different sets of interested parties: internal decision makers, external investors, regulators, and taxing authorities. Because each of these parties has specific interests and concerns, different sets of accounting rules have been developed for each purpose: management, financial, statutory, and tax accounting, respectively, corresponding to each of the four sets of interested parties.

Financial statements represent sources of financial information, which can be important to evaluating the status of a company for a number of purposes. Some of the more important statements include:

- *Balance sheet:* provides a snapshot of the company's financial position as of a specified date.
- *Income statement:* summarizes the operations of a company over a period of time.
- *Statement of cash flows:* summarizes the sources of cash receipts and payments from the various company activities over a period of time.
- *Letter to shareholders in the annual report:* often provides significant qualitative information about the company's activities, results, and performance, as well as goals for the future.

Whether investigating the financial condition of an insurer or a noninsurance corporation, there are certain quantitative tests that are commonly performed. These tests typically take the form of ratios, with their component elements derived from the financial statements of the company, and they help to identify the company's operating condition. Some examples of important ratios and their purposes include:

- Ratios that measure ***liquidity***
  — *Current ratio* = current assets divided by current liabilities ("current" assets and liabilities are those that are expected to mature or be paid in the "short-term," say within one year)
  — *Cash ratio* = cash plus marketable securities, divided by current liabilities

- Ratios that measure ***financial leverage*** or ***capital structure***
  - *Leverage ratio* = debt divided by equity
- Ratios that measure ***profitability***
  - *Return on equity* (ROE) = net income divided by equity
  - *Asset turnover* = annual sales divided by assets
- Ratios that reflect ***market value***
  - *Market-book ratio* = stock price divided by book value per share
  - *Earnings yield* = earnings per share divided by stock price
  - *Tobin's Q* = market value of the firm divided by its replacement value

These and other ratios can be used to indicate the relative operating position of the company, either with respect to other companies and industry standards, or in relation to the company's own historical performance. In the "Regulating an Insurance Company" section later in this chapter, insurance-specific versions of some of these tests—the Insurance Regulatory Information System (IRIS) tests—are discussed.

Issues in Valuing an Insurance Company: Environmental Liabilities

For many companies, the liabilities arising from asbestos, pollution, and other mass torts (referred to here as "environmental" liabilities) comprise a significant portion of the losses from casualty policies written prior to 1990. This section describes the history and evaluation of these liabilities.

Until recently, environmental liabilities were not believed to be "reasonably estimable" as required by Financial Accounting Statement 5: Accounting for Contingencies. The Securities and Exchange Commission required companies to provide more detail on environmental liabilities in their financial reports starting in June 1993. This was followed by the Financial Accounting Standards Board Issue 93-5 release requiring disclosure of these liabilities. Later, the National Association of Insurance Commissioners required the reporting of five calendar years of incurred loss and reserve history for asbestos and pollution as a note in the Annual Statement. These disclosures helped focus attention on the problem of quantifying environmental losses.

According to A. M. Best (1998), ultimate environmental losses due to asbestos are estimated to be $40 billion, and losses due to pollution are estimated to be $56 billion (both estimates are based upon evaluations made as of December 1997). Net incurred environmental losses caused the industry's combined ratio to increase by 4.1 percentage points in 1995, 2.1 points in 1996, and 0.7 points in 1997.

Companies faced with heavy environmental losses have handled the problem in various ways. Some have formed run-off entities, while others have formed specialized claim units within the company. The 17 (as of this writing) run-off entities are structured so that the environmental losses are not intermingled with their current business. The separation can be total (the losses are transferred to the new entity with supporting surplus and an aggregate reinsurance arrangement), or the separation can be partial (when the insurance group guarantees the solvency of the run-off entity using the group's surplus). Both types heavily depend upon reinsurance recoveries and commutations as important aspects of their solvency considerations.

Asbestos—History

Asbestos is a group of naturally occurring silicates that have been found to be incombustible, flexible, durable, strong, and resistant to heat, corrosion, and wear. Asbestos fibers were used in thousands of products, such as building materials, brake and boiler linings, insulation, and fire-retardant and electrical products. Unfortunately, the characteristics that make the fibers so useful in products make them dangerous to human health. Asbestos becomes dangerous when it becomes airborne and is inhaled into the lungs. Four main diseases either caused or aggravated by asbestos include mesothelioma (a cancer of the lung lining), lung cancer, asbestosis (severe scarring of the lung lining), and other benign pleural plaques. Severity of the resulting illness is directly correlated with the exposure concentration and length of exposure. If smoking is a factor, the chance of serious illness is magnified.

The Environmental Protection Agency (EPA) virtually banned asbestos mining and manufacture in the U.S. in 1989, but not before more than 30 million workers were exposed to asbestos. Since 1950, workers compensation has covered those workers with occupational diseases caused by asbestos. In 1973, the first significant lawsuit, *Borel vs. Fibreboard*, held manufacturers of asbestos responsible for the harm resulting from exposure to their products.

Asbestos—Issues for Insurers

A number of issues related to asbestos exist for insurers. They include:

- Which policies are triggered in the event of an asbestos-related loss?
- How should the litigation burden be handled?
- What is an occurrence?
- What coverage is available?

The most commonly applied trigger of coverage is the continuous trigger. All policies in effect during the time of exposure, through the latency period and including the manifestation of the disease, are deemed to be exposed to loss. Two other less frequently used triggers are the exposure trigger and the manifestation trigger. Under the exposure trigger, only policies in effect during the period of time the individual was exposed to asbestos will respond to the claim. Under the manifestation trigger, response to the claim is determined by the single policy year during which the medical diagnosis was made. Under any trigger, the most vulnerable policies are those with no clear asbestos exclusion.

The number of suits is staggering. There were close to 200,000 suits pending in state courts by 1992. In order to manage and settle so many claims in so many jurisdictions, negotiations between policyholders and insurers establish the applicable trigger, claim handling procedures, expense cost-sharing agreements, and the allocation of loss payments to insurer and year of coverage, to establish a "coverage block." The claims are allocated, as agreed, across the years of the coverage block until the policy's aggregate limit is exhausted. If no aggregate limit exists, the insurer's liability is unlimited.

The majority of asbestos losses have been claimed as product liability losses. There have been a small number of premises/operations claims filed as a result of installation activities of contractors. The coverage issues are enormous, including the lack of an aggregate limit. A major mitigating factor is that liability is not strict and, therefore, negligence must be proven by the claimant.

For ease of evaluation, the defendants of asbestos losses have been classified into tiers. The first and second tiers consist of major and minor manufacturers of asbestos products. Many of these are now bankrupt from the financial burden of asbestos claims. The third tier, also called the second wave, consists of distributors of asbestos products. The next tier, or the third wave, refers to the premises/operations claims.

Asbestos—Risk Factors

The following factors (modified from Cross and Doucette (1997)) may indicate a greater likelihood that the insurer may experience significant liabilities due to asbestos. This list is not intended to be comprehensive.

- Policy years 1975 through 1988
- General liability market share greater than 1.5%
- Incomplete or inconsistent application of the asbestos exclusion
- Insureds that are Fortune 1000 companies
- Insureds in manufacturing/construction industries
- Coverage layers up to $5 million are high risk
- Inconsistent use of aggregate limits
- Policies that cover expenses in addition to limits

Pollution—History

"Pollution" refers to a subset of claims that arise because of pollution activity. For purposes of this discussion, pollution refers to gradual releases of pollution being claimed against general liability policies issued prior to 1987. Pollution sites include waste dumps, landfills, and other places containing hazardous substances.

The EPA was formed in 1960 in response to growing concerns about the level of pollution in U.S. cities and the water supply. The Love Canal disaster in the 1970s led to the passage of the Comprehensive Environment Restoration, Compensation, and Liability Act (CERCLA), commonly known as Superfund. The primary purpose of the Superfund law is to clean up the nation's most hazardous abandoned waste sites. Superfund applies joint and several, strict and retroactive liability to anyone who has contributed to a site, including generators, past or present owners, lenders, and transporters. The worst sites are placed on the National Priority List (NPL). The potentially responsible parties (PRPs) are identified by the EPA and ordered to clean up the site or reimburse the EPA for doing so.

Of the over 40,000 identified sites, 1,211 were listed on the NPL as of July 1999. Only 185 sites have been removed from the NPL, while 63 are currently (as of this writing) being considered for addition to the NPL. As many as 30,000 sites may not require any remediation, and others are being cleaned up by state or local environmental agencies. The estimation of ultimate pollution costs for the non-NPL sites is hampered by a lack of information regarding site characteristics and costs. It is believed that the average clean-up cost is lower for non-NPL sites due to their less hazardous nature and the less stringent clean-up rules.

Pollution—Issues for Insurers

Insurer concerns can be grouped into four major categories:

- Judicial interpretations of coverage issues
- Determination of estimated clean-up costs
- Cost allocation over policy years
- High costs of litigation

In 1966, the Insurance Services Office (ISO) converted the standard general liability policy form from an "accident" basis to an "occurrence" basis, clarifying that the covered event must be "neither expected nor intended from the standpoint of the insured." In 1973, the coverage was further clarified as applying to "sudden and accidental" pollution events, not to gradual releases. Court interpretations about the meaning of "sudden" varied, prompting ISO to clarify the language in 1985, adopting the so-called "absolute" pollution exclusion. Nevertheless, the courts in many states have ordered insurers to cover the pollution losses of their insureds, in spite of the language. Many states have yet to rule on important pollution coverage issues, causing more uncertainty as to the ultimate costs.

Clean-up costs are difficult to estimate due to the evolving nature of clean-up standards. Over the years, the standards have been relaxed—in particular, the future use of the site can be considered in estimating the costs of cleanup.

Like asbestos, the trigger and allocation scheme is negotiated between the PRPs and their insurers. The results of these discussions may not reflect the PRPs' true proportional shares of the damage. Insurers and PRPs have strong incentives to litigate over responsibility, shares, allocations, and other coverage issues or to find other PRPs for a given site. This causes ALAE costs to be high compared to the loss payments made and the number of sites remediated.

Pollution—Risk Factors

The following factors (see Bouska and McIntyre (1994)) indicate an increased likelihood that the insurer may experience significant liabilities due to pollution. This list is not intended to be comprehensive.

- Policy years 1970 through 1985
- Incomplete or inconsistent application of the absolute pollution exclusion
- Insureds that are Fortune 1000 companies
- Primary insurers with limits less than $5 million
- Policies that cover expenses in addition to limits

Mass Torts

Mass tort claims are characterized by the large number of people affected and the latent and/or sustained nature of their injuries. The list of torts considered "mass torts" varies from company to company, but can include blood products, breast implants, chemical exposure, hearing loss, lead paint, and repetitive stress syndrome. There are many unresolved coverage and causation issues causing ALAE cost to be high in relationship to the losses paid.

Methods for Estimating Environmental Losses

There are two primary classes of methodologies for estimating an entity's environmental liabilities: *benchmark* and *ground-up*.

Benchmark methods include the market share method, the aggregate loss development method, and the survival ratio method. Ground-up methods include policy exposure models and the claim department method. This section briefly discusses these techniques. (In the subsequent discussion, the phrase "type of loss" refers to either asbestos or pollution.)

Standard actuarial methods do not work with environmental losses for several reasons. First, judicial and legislative decisions impact all accident years at once, forcing a strong calendar year influence on the loss development triangle. In addition, multiple policies over several layers and policy years are often triggered, blurring the accident-year distinction. Loss dollars are not all equal: for example, some reflect settlements, while others reflect court orders.

Benchmark Methods

Market Share Method: This method is intuitive. Beginning with a range of estimated ultimate industry losses, these losses are allocated to year. Then an insurer's share of the industry losses by year is determined from its share of the GL market premium for the same period. Alternatively, an average market share for the period in question can be used rather than allocating the industry ultimate by year.

Usually several adjustments are made to the market share estimates. Notably, premium on policies without significant exposures, such as medical malpractice, should be removed. The market share estimates can be adjusted for other qualitative factors such as limits written or mix of business. It is common to omit CMP premium, as CMP has not produced significant environmental losses due the smaller insureds written.

Aggregate Loss Development Method: This nontraditional development approach ignores accident-year detail in favor of aggregate cumulative paid losses and case reserves evaluated at a series of successive year-ends. In its simplest form, an incurred-to-ultimate or paid-to-ultimate factor is then applied to the appropriate cumulative value to produce the ultimate losses.

Determining the appropriate factor is complicated and subjective. One way is to project a calendar year payment pattern based on the number and amount of new claims and expected developments on existing claims. Alternatively, a statistical curve, such as the S-curve formula, could be used (see Ollodart, 1997).

Survival Ratio Method: The survival ratio is the carried reserves divided by calendar year payments, thereby measuring the time in years until the reserves are exhausted, providing a rough benchmark statistic. It assumes that future year payments are equal to current calendar year payments.

The survival ratio method works in reverse. Required reserves are estimated using a projected annual payment multiplied by a selected survival ratio. The survival ratio selected is based on the distribution of attachment points, the layers of coverage, and the applicable policy years. It may be higher for excess and umbrella coverage, due to both the relatively low amounts of payments to date and a significant reporting lag.

Ground-Up Methods

While the benchmark methods give basic indications of an insurer's ultimate liabilities, they frequently provide widely divergent results. There may be a need for greater understanding of the types of policies and losses that are contributing to the company's overall position. Methods are needed that allow for the individual characteristics and expert knowledge of the company and provide documentation of the assumptions used in the scenario.

There are two basic types of ground-up methods in use for environmental liabilities. It is important to note that each of these calculates the liabilities on *known* accounts—a provision for *unknown* cases (pure IBNR) will be needed. IBNR is commonly added by estimating the number and cost of new cases or by estimating an IBNR factor.

Policy Exposure Model: Policy exposure models use databases of policy information and loss information to simulate insured losses and apply the policy/reinsurance terms. The process differs for asbestos and pollution, so each is described briefly below.

- *Asbestos:* Insureds are categorized based on a tier structure, as described earlier, to form relatively homogeneous insureds for analysis. The analysis is done on a gross of reinsurance basis, and a range of ceded factors is used to estimate ceded amounts. For the highest tier groups, the insured's policy terms are examined individually, while for the lower tier groups, a small sample group of insureds is used. The policy exposure model projects ground-up loss and ALAE for each insured in the sample and allocates, using the policy terms, the loss and ALAE to policy year in that insured's coverage block. The losses are projected using information about the insured's losses and the actual insured losses. The lower tiers are examined by "burn factors," which represent the percentage of a coverage layer expected to be eroded by asbestos losses.
- *Pollution:* The pollution policy exposure model works similarly. For reported pollution liabilities, the insureds are matched to PRPs on NPL lists or to other known polluters. For PRPs on NPL sites, the site costs are extracted from the NPL site cost database and combined with the PRP's share, policy terms, limits, and other coverage factors. For non-NPL sites, the number and cost of sites are simulated for each insured. Then the insured's policy terms, limits, and other factors are combined to calculate the insured's cost.

Claim Department Method: The claim department method uses the company's environmental claim unit analysts to provide ultimate settlement costs by policy and site for all known exposures. In this way, the analyst can implicitly take into account the coverage issues, the success of litigation relating to the case, the progress of settlement talks with the insured, and the impairment of the limit by nonenvironmental losses. To calculate the net amount, the losses by policy are laid out and the reinsurance terms and limits applied to estimate the ceded.

Issues in Valuing an Insurance Company: Catastrophe Exposures and Modeling

Catastrophe exposures have a huge impact on insurer performance, and thus have generated tremendous attention in the property/casualty insurance industry. The unprecedented economic losses stemming from Hurricane Andrew in 1992 and the Northridge earthquake in 1994 forced the industry to re-examine how to evaluate the impact of natural disasters. The coincidence of these major natural catastrophes with the exponential growth in computing capability has created a niche for catastrophe modelers.

This section discusses recent technology associated with the simulation of natural peril catastrophic risk and the impact that this technology has had on the insurance industry. Specific topics include the evaluation of catastrophic risk, how advanced models are built, what exposure information is required, and how the models are validated. In addition, this section describes the utilization of model results for ratemaking, portfolio management, reinsurance strategies, and marketing purposes, and discusses the impact of catastrophe models on third parties, such as regulators and rating agencies.

The Evolution of Catastrophe Modeling

It is difficult to pinpoint when insurance carriers began to evaluate their losses from natural disasters. Some of the earliest tools were paper maps manufactured by Sanborn Maps Corp., which were used to monitor the density of insured properties in key cities. The intent was to avoid underwriting risks in proximity to existing insureds. The 1960s and 1970s brought about the beginnings of computer-assisted modeling, which motivated insurers to aggregate exposure information. This early methodology applied an approximate damage percentage to the exposures, producing a deterministic loss estimate. This evolution continued with research pioneered by Dr. Don Friedman at the Travelers Insurance Company through their Natural Hazard Research Service (NHRS). Dr. Friedman was the first to compile loss information from hurricanes, and his work continues to be used by modelers.

The deterministic approach was later enhanced by increasing the number of simulated events, and by assigning a probability of occurrence for each event. The first service provider of this technology was Applied Insurance Research (AIR), which provided the results for several thousand events, greatly improving the resolution of analysis. Risk Management Solutions (RMS) followed with a PC-based product for primary insureds. More recent providers, such as EQECAT, have introduced models that simulate many hundreds of thousands of events. These full probabilistic models now allow companies to analyze the impact of changing insurance policy terms and conditions, as well as allow catastrophe claims response teams to handle clients' needs effectively.

Natural Hazards—Modeled and Not Modeled

It is very difficult for models to analyze the full impact of a natural peril. For example, an earthquake model may not include the impact of fire following the quake, or the losses associated with a subsequent tsunami or landslide. While these ancillary perils typically do not generate a major portion of a loss, they need to be considered when estimating a peril's loss potential.

In addition to loss causes that may not be modeled, not all lines of business are handled at this time. For example, losses to mobile assets, such as automobiles, goods in transit, and watercraft, are very difficult to estimate since it is impossible to determine where the assets are located at the time of the event. Workers compensation is another line of business that has not received much attention by the catastrophe modeling industry—and yet, the potential injuries and loss of life from a major earthquake striking a manufacturing facility could be significant.

Exposure Data Requirements

The type of exposure data required by catastrophe models varies. Some require no more than the name of the insurance company, while others can handle over 90 fields of data. Those that simply need the company name rely on A. M. Best premium information to estimate a market share loss. Slightly more sophisticated models rely on insured values by county by line of business. The newest models handle exact street address locations and construction type details. While the examples of data requirements given above seem basic, they do reflect the evolutionary aspect of catastrophe models. Basic data elements are:

- *Geographic location of assets at risk:* address information
- *Structural information of risks:* class of business, type of construction, age of building
- *Values at risk:* total insured value for each coverage type for each location
- *Insurance structure:* deductible and limit information

While the computing technology permits more parameters to be analyzed, the user needs to have confidence that the modeler has the appropriate skill to handle this additional information. The user should also investigate what minimal level of data is appropriate for the company being modeled. A user might find it valuable to experiment with a model by feeding it fictitious data to see whether the model results are intuitive.

Model Analysis

A catastrophe model has three major components:

- *Hazard calculation:* an estimate of the hazard intensity

- *Damage calculation:* an estimate of the ground-up damage, given the hazard
- *Loss calculation:* the loss to the insurer or reinsurer, given the damage estimate

Hazard Module

The hurricane peril will be used as an example, since it receives significant news coverage when an event is forming, and since most individuals can visualize the components of a hurricane. Analogies to other perils will be given as appropriate.

Hurricane models are primarily based on historical records of landfall location and intensity. The historical record used spans roughly one hundred years. While this might appear to be an impressive sample to draw from, the quality of the data is very suspect prior to the 1940s—good information did not become available until the 1960s. Meteorologists developing these models have diligently reviewed the historical data and tried to adjust for any inconsistencies. New information is becoming available from core samples of lake beds, satellites, oceanic recording devices, and aircraft reconnaissance.

The process typically begins by segmenting the coastline of the U.S. into uniformly spaced sections, say 100 miles. These sections are referred to as bins; the size of the bins can vary by modeler. Each historical event is placed into the bin that corresponds to the landfall location. Too small a bin can generate spiking of results as one moves from one bin to a neighboring bin; too large a bin may not reflect the topographical and climatic patterns that influence an area. The meteorological information for each bin is then analyzed to evaluate the range of potential outcomes for that region.

Modelers create a distribution of all the parameters associated with hurricanes in each bin. Distributions for parameters such as forward speed of the hurricane, the radius to maximum winds, and the profile of hurricanes in that area are derived. A stochastic set of hurricanes is then sampled from these distributions. The size of the stochastic set can vary significantly: some modelers use a few thousand events, while others use several hundred thousand.

Hurricane models use these parameters in their meteorological formulas to define the windspeed that exposes a risk. Other factors such as terrain features are modeled to reduce or increase the wind speed. All hurricane models generate a smooth wind field representation of the hurricane. In reality, the chaotic nature of hurricanes generates small tornadoes, which no modeler can currently simulate.

Damage Calculation

Generally speaking, the damage calculation module of a catastrophe model needs two pieces of information: the location of the risk, and the type of structure. The location of the risk is typically referred to as geocoding; the structure description is usually characterized by a vulnerability function. Geocoding will be discussed first, followed by vulnerability.

The location of a risk can be presented in several different ways, such as CRESTA (Catastrophe Risk Evaluating and Standardizing Target Accumulations) zones, counties, zip codes, or street addresses. Geocoding assigns an exact latitude and longitude for the location of the risk. Geocoding is used to determine where the risk is relative to a coastline or earthquake fault, whether it is eligible for a windpool, or to identify what type of soil is beneath the risk.

The damage module also requires information regarding the type of construction for each risk. These construction classes define the vulnerability curves used to estimate the amount of damage at each level of hazard intensity. Vulnerability functions can be derived from three primary sources: empirical claim information, engineering consensus, and engineered simulation.

For some recent catastrophic events, such as the Northridge earthquake or Hurricane Andrew, there is considerable claim data available to modelers. Modelers take the claim information at a given location and overlay the corresponding exposure information in force at the time of the event. It is important that the modeler use all exposure information, and not just the exposure information for those risks that sustained losses. This is necessary in order to capture the portion of risks that might not sustain a loss. The modeler determines what the actual intensity was at the claim location for that event. Estimating the intensity at the location of the claim is very difficult, as there are a limited number of instruments that measure the hazard intensity. Ultimately, the modeler develops a relationship of damage to intensity.

Another approach to developing vulnerability curves is by engineering opinion. For many years, the vulnerability curves used for earthquake were based on Applied Technology Council Report 13 (ATC-13). These vulnerability curves were essentially based on a Delphi method of consensus opinion on the damage likely to be inflicted on a given structure, given the intensity level. This method can be acceptable when there is no actual claim experience. Another approach to developing vulnerability curves, especially for complex commercial structures, is to create computer-aided design (CAD) simulations that analyze the failure mode of a structure given different loads.

Loss Calculation

The final module involves estimating the loss associated with the given level of damage. The commercially available models differ significantly in the variety of insurance and reinsurance structures allowed. Some are very basic and might be too limiting for insurers who underwrite complex commercial risks. The same applies for reinsurance programs: some models do not address reinsurance at all, while others can handle very complex facultative or treaty reinsurance.

Industry-altering events like Northridge and Andrew have spurred the introduction of insurance policies with very high deductibles. For example, the California Earthquake Authority and many other insurers in California now write a policy that requires a 15% deductible. In many hurricane-prone states there now are parametric triggered deductibles that apply once a hurricane reaches a certain windspeed or SSI. These newer policy structures are forcing catastrophe modelers to modify their software to address this evolution.

Model Validation

Due to the rare nature of perils being analyzed, it is virtually impossible to validate a model. A model *can* be reviewed from a scientific perspective to determine whether it has the appropriate components. This is a lengthy and costly exercise with minimal interest to users, since they are not typically interested in whether the model has the latest soil database or the most accurate terrain component, but rather whether the loss estimates are accurate. Models can generate two different types of loss estimates: deterministic and probabilistic. A deterministic analysis involves fixing all the necessary parameters associated with an event and calculating the loss. In this type of analysis, there is no consideration given to the likelihood of the event occurring. A deterministic analysis of an event can be validated—for example, a user can input the exposure that was at risk at the time of Hurricane Andrew, and allow the model to then simulate Hurricane Andrew on that risk portfolio. The typical model output is an expected loss for that event. Models can also provide some confidence bounds around these estimates. A form of validation would then be to compare the actual loss with the modeled loss.

Probabilistic analyses consider many individual events, with each event assigned a likelihood of occurrence. Exceedance probability (EP) curves are derived by aggregating the loss estimates resulting from each event and the likelihood of occurrence. EP curves represent the likelihood that the portfolio will sustain a loss over a certain loss level. For example, if the 1%

exceedance probability for a portfolio is $125 million, this indicates that within the next year, there is only a 1% chance that an event will generate a loss greater then $125 million. It is difficult to validate an EP curve, but it is possible to take actual event losses and compare them with points on the EP curve. If a relatively low severity event generates a loss in excess of high probabilities, then the EP may be understated.

The Florida Commission on Hurricane Loss Projection Methodology (FCHLPM) is the only agency that has undertaken a review of catastrophe models, but it was limited to residential ratemaking for Florida hurricane exposures. The FCHLPM requires that any modeler desiring to have a model considered for ratemaking purposes must provide a comparison of results with respect to the expected annual state-wide loss generated from running all of the historical events that have impacted Florida in the past century. The process begins by inputting a portfolio that represents risks throughout the state. The modelers then run the 57 historical events that have affected Florida in the past 100 years. The average of the expected loss for each event is then compared to the expected loss generated from the probabilistic event set. While this is a fruitful exercise for validating the mean loss, it does not allow for an accurate comparison of the EP curve.

Utilization of Catastrophe Models

Catastrophe models have grown in popularity over the years. Reinsurers and regulators have put pressure on primary insurers to manage and price their risks better. The use of models has evolved from simply being used by corporate risk management departments to becoming a key component in the underwriting process. This evolution includes the expansion of the traditional portfolio management roles to the allocation of capital, reinsurance structuring, claims handling, marketing, dynamic financial analysis, rating agencies, and securitization.

Property lines of business can be greatly enhanced by the use of catastrophe models. If a carrier feels it is necessary to cull risks from a portfolio, models can be used to supplement this decision making process by selecting those risks that generate the highest loss relative to the premium received. In today's merger environment, catastrophe models are incorporated into the decision-making process by determining whether a portfolio under consideration correlates with an existing portfolio.

OPERATING AN INSURANCE COMPANY

Actuaries have had, over time, increasing involvement in various aspects of insurance company operations. Historically, the traditional underwriting function of insurers provided the primary focus of actuarial efforts. Recently, the importance of investment income and asset portfolio management to insurer results has led to actuarial involvement in these areas. Even more recently, other operational developments in the insurance industry have provided opportunities for actuarial input—in some cases, these developments have been spearheaded by actuaries. This section will introduce the reader to several of the issues and recent developments involving the operations of an insurance company. First, some of the types of insurer planning and forecasting processes that casualty actuaries often find useful are described. Next, the process of dynamic financial analysis will be examined. Finally, the evolution and early development of insurance securitization will be discussed.

Planning and Forecasting

This section describes the business planning process, some of the specific forecasting techniques available, and how those techniques might be utilized in the planning effort. Most attention is given to describing several important statistical forecasting techniques—in particular, various types of regression and time series analyses. In addition, scenario analysis and stochastic simulation are described, and their differences discussed.

Planning

"Planning" is the process by which management makes operational and financial decisions that affect the company's future. Ideally, a plan will be responsive to changes in the company's operating environment. Specifically, planning involves the following steps.

- *Determine the corporation's objectives.* A company's short-term and long-term objectives are a function of the firm's particular situation, including its management, products, and operating environment. Objectives may relate to the company's solvency, revenues, profitability, or other measures of performance.
- *Identify possible alternative plans and actions.* A company may entertain a variety of possible plans that are anticipated to satisfy, probably to varying degrees, the objectives of the organization. The strategic impact of each plan is considered and evaluated.
- *Evaluate alternatives and select a plan.* The company's management achieves a consensus regarding which plan is optimal. This step relies on the forecasting process (discussed below) to identify the potential financial consequences of the various courses of action. A variety of metrics that measure the anticipated performance of each alternative plan may be considered. Possible plan outcomes may also be measured against the projected consequences of maintaining the status quo.
- *Implement the plan.* For a plan to be successful, it must be coordinated and carried out at all appropriate levels of the organization.
- *Monitor the effectiveness of the plan.* Appropriate databases and information systems must exist in order for the plan to be adequately monitored and evaluated. Adjustments may be made to the plan as necessary.

Like any other type of business, insurers can improve their decision-making through appropriate planning and forecasting. Because of the need to project the future financial consequences of different action plans, the input of actuaries is important. In some insurance companies, actuaries have significant responsibility for long-range forecasting, and thus they can have a large impact on the planning process. At a minimum, the actuary would provide information about such critical items as loss reserves and rate adequacy.

Lowe (1985) mentions two categories of property/casualty insurance company planning activities: financial planning (typically resulting in a forecast of financial results over a 1- to 5-year time horizon), and operation planning. According to Lowe, the primary goal of insurance company planning is to determine estimates of the insurance cash flows. This requires consideration of, and appropriate data regarding, the insurance, investment, and financial/accounting processes. Analysis involving the interaction of these areas is a cornerstone of, for example, dynamic financial analysis.

One of the corollary benefits of a thorough planning process is the opportunity it presents for the various functional areas and departments within an insurance company to communicate with each other. The development of goals, consideration of alternative courses of action, and implementation of a final plan all potentially involve interaction between several departments and divisions: actuarial, underwriting, marketing, financial, accounting, claims, and information systems.

Forecasting

In order to create and evaluate plans, companies must be able to forecast the potential future consequences of current actions. The development of future financial scenarios and the valuation of contingencies are inherently quantitative processes, and thus might logically be considered to be, at least in part, actuarial functions. There are a variety of mathematical forecasting techniques available to the actuary. One way to categorize these techniques is as either regression or time series approaches. Regression techniques involve the relationships between different variables, and include simple regression and multiple regression. Time series techniques involve characterizing the movement of a variable or variables through time.

Simple Regression

In simple linear regression, two variables have the following functional relationship:

$$y_t = b_0 + b_1 x_1$$

where

y_t = the observation of the "dependent" variable at time t,

x_t = the observation of the "independent" variable at time t,

b_0 = the intercept of the relationship between variables x and y, and

b_1 = the slope of the relationship between variables x and y.

Historical data are used to parameterize the model. Typically, the estimates of the b coefficients are chosen to minimize the sum of the squared differences between the actual and the fitted dependent variable data. This is referred to as a least squares estimate. The formulas for the b coefficients in a simple regression framework, when determined according to least squares, have straightforward forms:

$$b_1 = \frac{\sum (y_i - \bar{y})(x_i - \bar{x})}{\sum (x_i - \bar{x})^2} \qquad \text{and} \qquad b_0 = \bar{y} - b_1 \bar{x}$$

Determining the "quality" of a regression, i.e., it's "appropriateness," can involve several more or less sophisticated techniques. Two basic and common statistical measures of a regression's appropriateness are the following:

- The coefficient of determination (R^2) indicates the proportion of the overall variability in the dependent variable y, which is explained by the regression relationship. R^2 values range from zero to one. All else equal, an R^2 value closer to 1.0 indicates a better explanatory relationship. R^2 can be calculated according to the following formula:

$$R^2 = \frac{\sum (\hat{y}_i - \bar{y})^2}{\sum (y_i - \bar{y})^2}$$

- The t-statistic of each coefficient in the regression equation indicates the statistical significance of the constant or the independent variable x in explaining the values of the dependent variable. The t-statistic, calculated as the value of the estimated regression coefficient divided by its standard error, identifies the number of standard errors the coefficient value is removed from zero. Relatively high absolute values of the t-statistic suggest greater significance, with the specific "threshold" depending upon the degree of statistical confidence desired.

Multiple Regression

When there are multiple independent or explanatory variables, a linear relationship with the dependent variable might be specified as follows:

$$y_t = b_0 + b_1 x_{1,t} + b_2 x_{2,t} + \cdots + b_n x_{n,t}$$

where

y_t = the observation of the "dependent" variable at time t,

$x_{j,t}$ = the observation of the j^{th} "independent" variable at time t,

b_0 = the intercept of the relationship between the x_j variables and y, and

b_j = the coefficient specifying the relationship between the x_j variable and y.

This framework is referred to as multiple linear regression. Again, the estimates of the *b* coefficients are based on historical data, and are typically chosen to minimize the sum of the squared differences between the actual and the fitted dependent variable data. Approaches similar to those mentioned for simple regression above can also be used to evaluate the appropriateness of any given hypothesized multiple linear regression relationship. However, the analysis is more complex. For example, "multicollinearity," which involves two or more of the independent variables being correlated, can cause difficulties in performing and interpreting a multiple regression analysis. Such problems, once identified, can often be dealt with through more sophisticated statistical techniques or adjustments.

For both simple and multiple regression, transforming the variables prior to implementing the model might provide a better fit. For example, natural logs of variables are sometimes taken prior to fitting a regression. Another adjustment might involve using differences between successive values of variables, instead of the variable values themselves. From this perspective, regression analysis is often art as well as science.

Time Series Methods

Time series techniques are based on the underlying assumption that patterns exist in the historical data of a variable, and those patterns can be analyzed to determine the manner in which they will recur over time. Common versions of such patterns can be categorized (e.g., Wheelwright and Makridakis, 1985) as trend (general increases or decreases over time), horizontal (involving no trend), cyclical, or seasonal patterns. Where there are multiple patterns in a single time series, a variety of decomposition techniques can be employed to help identify the separate components.

Time series techniques vary significantly according to their level of sophistication. For example, a basic business forecasting technique is the *simple moving average*, in which the average of

n past values of a variable is used as the forecast of the next value. As actual new data emerges, the average is recalculated to incorporate the new information (the number of past values, n, is judgmental and kept constant). Essentially, each new forecast represents an adjustment of the prior forecast in light of the new data that has emerged; the larger the value of n, the smaller the periodic adjustments, resulting in greater "smoothness." Another basic time series technique is *exponential smoothing*, which—in contrast to the simple moving average, which produces a forecast by weighting the n past values equally—applies greater weight to the more recent data, and less weight to the older information. In practice, this takes the form

$$\hat{y}_{t+1} = \alpha y_t + (1 - \alpha)\hat{y}_t$$

where each forecast is considered a weighted average of the most recent data and the previous forecast (which in turn is a function of the prior data).

More generally, time series models can be categorized according to whether the current value of the time series variable is specified as a function of the prior values of the variable, of the prior residuals, or a combination of these two. An *autoregressive* (AR) model of degree n is characterized by the following equation:

$$y_t = b_1 y_{t-1} + b_2 y_{t-2} + \cdots + b_n y_{t-n} + e_t$$

where e_t is an error term. This is a regression equation, but the independent variables are previous values of the dependent variable. A *moving average* (MA) model has the following form:

$$y_t = e_t + c_1 e_{t-1} + c_2 e_{t-2} + \cdots + c_n e_{t-n}$$

where the e_{t-j} terms represent the prior residuals. This model assumes that values of the dependent variable are a function of the time series of error terms. An *autoregressive moving average*

(ARMA) model combines these two time series models:

$$y_t = b_1 y_{t-1} + b_2 y_{t-2} + \cdots + b_n y_{t-n} + e_t + c_1 e_{t-1} + c_2 e_{t-2} + \cdots + c_n e_{t-n}$$

An advanced time series framework that has become very popular is known as the Box–Jenkins approach. While there has been a great deal of development and sophistication in this area, essentially the Box–Jenkins approach involves a multistep process. First, an appropriate model (which could be AR, ARMA, etc.) is tentatively identified. Next, the model is fit to historical data in order to evaluate its adequacy (the model is discarded if found to be inappropriate, and another form is hypothesized). Finally, once an appropriate model has been determined, a forecast is developed.

Econometric Models

Regression and time series forecasting models can be employed at a variety of levels. When a system of multiple equations, involving several interconnected variables, is needed in order to quantify an economic or financial system, the framework may be termed an *econometric model*. In the type of pure multiple regression framework discussed above, each of the independent variables is assumed to be exogenous (originating externally). In an econometric model, economic reality can be served by allowing for the possibility that one or more of the independent variables, in one or more of the multiple equations that comprise the system, is itself endogenous or dependent. As mentioned in Wheelwright and Makridakis (1985), "The basic premise of econometric modeling is that everything in the real world depends upon everything else."

Much of the development of an econometric model is similar to the work performed in a regression analysis. However, the process can be significantly complicated by the fact that the system involves interactions between many variables. For example, the variable interrelationships must be accounted for when specifying the functional forms of the equations, and the parameters of each equation must now be estimated simultaneously. The potential size and complexity—both economic and statistical—of these models has led to the creation of several specialized firms that provide forecasting services for a fee. Several such firms are mentioned in the *Data Sources* section later in this chapter.

Dynamic Financial Analysis

Dynamic financial analysis (DFA) is a recent and important extension of planning and forecasting in the insurance industry. In this section, the DFA process is defined and described, and the various risk factors underlying an insurance company's operations—both underwriting and investment—are summarized. The end uses of DFA models are also discussed.

Definition and Perspective

DFA can mean very different things to different people. Some might use the DFA label only when, for example, a simulation program uses sophisticated interest rate, asset, and liability models, and produces pro forma financial statements; others characterize DFA much more broadly, almost to the point where any consideration of financial or economic issues in an insurance context is DFA. Despite these different characterizations, DFA is actually a process that can be fairly accurately described by its name. By examining each of the three words "dynamic financial analysis," we can get a good idea of the essence of DFA.

DFA is "dynamic" in the sense that it recognizes that the various factors to which the insurance process is subject are variable and stochastic, as opposed to fixed and deterministic. It is important that actuaries go beyond the analysis of "static" processes, and recognize the stochastic nature of many of the insurer's underlying asset and liability processes. In this way, the uncertainty inherent in these processes can be recognized.

The word "financial" indicates an important recent development in property/casualty actuarial work: the recognition that *both* the financial and the underwriting operations of an insurer need to be considered. Historically, property/casualty actuaries have placed far greater emphasis on the liability side of the balance sheet and the traditional insurance operations of the insurer. However, an actuary's skills can also be effectively applied to the asset and financial areas, and, in fact, a thorough financial analysis of an insurer must recognize the *interaction* between assets and liabilities. This interaction is, to some degree, a product of underlying economic and financial processes common to both assets and liabilities.

The final word in "DFA," "analysis," indicates that the DFA process involves an examination of the various economic, financial, and insurance relationships, and suggests the development and use of a "model" to perform this examination. A quote from a monograph by William S. Jewell (1983) nicely describes the notion of a model:

> "A model is a set of verifiable mathematical relationships or logical procedures which is used to represent observed, real-world phenomena, to communicate alternative hypotheses about the causes of the phenomena, and to predict future behavior of the phenomena for purposes of decision-making."

This sentence identifies the essence of what actuaries have been attempting in their recent development of DFA models.

A nice summary of DFA is provided in the Casualty Actuarial Society's *Dynamic Financial Analysis Handbook* (Valuation and Financial Analysis Committee, 1996):

> "Dynamic Financial Analysis is the process by which an actuary analyzes the financial condition of an insurance enterprise. Financial condition refers to the ability of the company's capital and surplus to adequately

> support the company's future operations through an unknown future environment.... The process of DFA involves testing a number of adverse and favorable scenarios regarding an insurance company's operations. DFA assesses the reaction of the company's surplus to the various selected scenarios."

Note that, given the reference in this quote to "the company's future operations," DFA recognizes the "going concern" nature of an insurer.

DFA, then, involves evaluating distributions of outcomes resulting from a variety of scenarios. Those outcomes that are classified as "unacceptable"—e.g., the company becomes insolvent, the business is not sufficiently profitable—can then be reviewed to determine the causes of, or primary factors relating to, that particular outcome. If necessary, a change in the operations of the company can be implemented in the model; the analysis can then be performed again, and the impact evaluated.

Placed in a broader perspective, and consistent with the description of the general planning process discussed in a preceding section of this chapter, DFA is a critical component of the overall financial risk management process, the steps of which include the following.

- *Determine the corporation's objectives*—e.g., profitability, solvency
- *Identify the risk exposure*—e.g., interest rate risk, catastrophe potential
- *Quantify the exposure*—e.g., measure volatility
- *Assess the impact of the exposure on the company*—this is the primary role undertaken by DFA
- *Examine alternative financial risk management tools*—e.g., reinsurance, financial and insurance derivatives

- *Select the appropriate tools and approach*
- *Implement and monitor the financial risk management program*

Viewed from this broad perspective, dynamic financial analysis is analogous to similar efforts in other disciplines and industries. Recent articles in the popular press have introduced the public to this emerging brand of quantitative analysis. For example (Valdmanis, 1999):

> "…real option valuation, or ROV, could quickly become the new standard for valuing risky ventures that exist not just in M&A activity, but also in making billion-dollar bets from setting up oil fields in Azerbaijan to developing cancer cures… (ROV is) a 'dynamic road map,' outlining the future risks of big projects and strategic investments and how management might adjust to them."

This description of "real option valuation" sounds analogous to the dynamic financial analysis process that has recently emerged in the property/casualty insurance industry. Actually, DFA does not merely have close relatives in other industries—its predecessors came from another financial service industry. Banks began to develop DFA-type models in response to the U.S. savings and loan crisis, which largely resulted from increases in interest rates during the late 1970s and early 1980s. The objectives of the banking models were to quantify risk and evaluate the impact on S&Ls of various economic events. Later, the essence of this analytical framework spread to other financial services, including insurance.

DFA Modeling

Although its essential goals are straightforward, the implementation of the DFA process can take a variety of forms. Broadly speaking, there are two approaches to DFA from a modeling perspective: scenario testing or stochastic simulation. Scenario testing involves the projection of financial and operating results under certain specified conditions. For example, the impact on the company of a catastrophic loss or a significant movement in interest rate levels can be evaluated, either in isolation or in combinations of events. Such analyses are often used for cash flow or stress testing, and may be required in certain regulatory environments (e.g., New York life insurance regulations). The disadvantages of scenario testing involve the potential incompleteness of the specified scenarios, and the lack of probabilities associated with the scenarios.

These problems can be addressed by incorporating stochastic simulation into the DFA model. In this framework, entire probability distributions are specified, to the extent possible, for each of the stochastic variables underlying an insurance company's results. A large number of outcomes are generated by randomly selecting values from each of these probability distributions, and allowing the model to determine the interactions of the variables. The collection of simulated outcomes is then analyzed to assess the proportion of "acceptable" versus "unacceptable" outcomes. In a good stochastic simulation dynamic financial analysis model, the unacceptable outcomes can then be analyzed to determine the primary cause(s) of those outcomes. Such an analysis might suggest operational changes that the company can consider to alleviate the unacceptable results.

Ultimately, regardless of the specific form, a DFA model must consider and evaluate the types of risks, both underwriting and economic/financial, that can impact the results of an insurance company. There are a variety of ways to classify these risks. For example, risks can be classified on a balance sheet basis, according to whether each risk is associated with assets or with liabilities. On the other hand, risks can be categorized on an operating basis, as relating either to the underwriting operations or to the investment operations of an insurer. Regardless of the classification scheme, there are a number of variables that can impact an insurer's operating situation. Specifically, some of the important variables in a dynamic financial analysis model might include the following.

1. **Financial variables**

   a. ***Interest rates:*** Interest rates are one of the fundamental variables in the economy. The simulation of future interest rates is critical for a DFA model because of their potential impact on, and correlation with, other financial and underwriting variables. For example, there is a clear and well-established empirical relationship between interest rates and inflation. In addition, interest rate movements can affect stock market performance and other financial variables. But interest rates might also have an impact on some insurance-specific processes, for example the underwriting cycle. Some of the specific interest rate characteristics that a DFA model should consider include:

      i. *Short-term/"risk-free" rate:* The interest rate model employed must consider issues such as possible reversion to a mean level over time (and what that long-run mean level is), as well as the nature of the volatility of the rate.

      ii. *Term structure:* Since insurers invest in bonds of different maturity lengths, it is important to analyze the impact of simulated movements in the yield curve.

      iii. *Default premium:* Different yields apply to financial instruments with different default characteristics. For example, corporate bonds typically offer higher yields than government bonds of the same maturity, because of the additional risk of default. The difference between the yields or interest rates applicable to these two instruments can be termed the "default premium."

b. ***Inflation:*** General inflation is correlated with interest rates. In turn, claim inflation by line of business is to some degree related to overall inflation, although each line of business has its indigenous characteristics. This variable is important, because it impacts the ultimate costs of future claim payouts.

c. ***Equity market performance:*** Although most property/casualty insurer assets are invested in bonds, insurers also invest significant monies in the equity markets. Simulations of overall investment performance should thus include an equity market component (which, again, is likely to be related to interest rate movements).

d. ***Mortgage prepayment patterns:*** The incidence of mortgage prepayments depends largely on the path that interest rates take over time. This variable is important since it affects the values of mortgage-backed securities.

2. **Underwriting variables**

a. ***Non-catastrophe losses:*** An insurer's future losses and loss adjustment expenses must be simulated, either on an aggregate basis, or as a compound frequency-severity process.

b. ***Catastrophe losses:*** One of the most significant insurance-specific risk factors in determining insurer results is the incidence of natural catastrophes. Because of their significance, and the fact that such large losses are often treated separately for reinsurance purposes, a DFA model might simulate catastrophes separately from non-catastrophe losses.

c. ***Exposures:*** The number of exposure units to be insured by the company must be projected. This is an important component of the loss simulations, and will be related to, among other things, the company's growth targets and to overall insurance market conditions.

d. ***Expenses:*** In addition to losses, the writing of insurance business involves incurring expenses, which may be stochastic to a certain degree.

e. ***Underwriting cycle:*** The profitability of an insurer depends, in part, on the general economic and industry conditions within which the company does business. The rate level at which the company can write business is a function of the position of the industry along the underwriting cycle. A DFA model could include a variable that simulates the possible future implications of the industry's movement from one point on the underwriting cycle to another.

f. ***Loss reserve development:*** One of the inputs to a DFA model would be the loss and loss adjustment expense reserves held by the company at the beginning of the time period being simulated. Reserve redundancies or deficiencies in that initial reserve can be simulated according to the run-off of those liabilities.

g. ***Jurisdictional risk:*** Insurers writing in different jurisdictions are exposed to different judicial and regulatory environments. Jurisdictional risk reflects, for example, the delays in implementing rate increases or decreases, any limitations imposed by the jurisdiction on such rate changes, and possible mandated premium rebates.

h. ***Payment patterns:*** There is risk associated with the speed with which losses are paid. Payments must be simulated in order to properly project the future cash flows of the insurer.

In addition to these stochastic variables, the following elements of an insurer's operations should be considered by a DFA model.

1. ***Rates:*** As alluded to above, future rates charged by the insurer will be a function of a number of factors, e.g., historical and emerging loss experience, the position in the underwriting cycle, competitive forces, and the specific jurisdictional and regulatory forces involved.
2. ***Ceded reinsurance:*** A DFA model should be capable of accommodating common types of reinsurance—proportional, working excess, catastrophe, and aggregate/stop-loss. The specific approach to programming reinsurance recoveries depends upon the manner in which direct losses are simulated, i.e., whether losses are simulated on an individual basis, an aggregate basis, or some combination. In addition, a DFA model should be capable of simulating the degree to which the insurer's ceded reinsurance is unrecoverable, a variable that might be a function of general economic conditions such as the underwriting cycle and interest rates.
3. ***Taxes:*** In addition to projecting statutory and market values, financial statements consistent with the prevailing tax code also need to be projected by a DFA model, in order to simulate future cash flows associated with taxes properly.

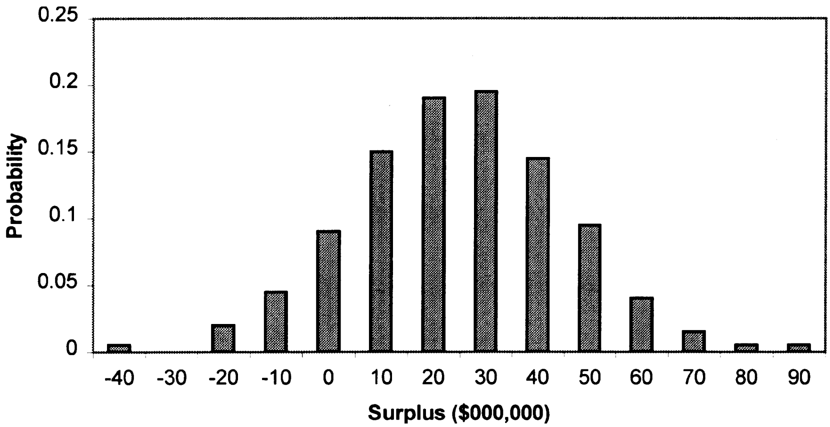
Outputs and Uses of DFA Models

Depending upon the size and sophistication of the model, a variety of useful outputs can be generated by the DFA process. Possible outputs, reflecting simulated results over a multiyear projection period, and for a given operating scenario, include:

- Pro forma balance sheets and income statements (statutory or market value)

FIGURE 10.1

DISTRIBUTION OF 5-YEAR PROJECTED SURPLUS



- Loss ratio reports
  - Aggregate versus line of business
  - Direct versus net of reinsurance
- Results of IRIS or other regulatory tests
- Probabilities of ruin at various critical likelihood levels
- Histograms of future surplus (statutory or market value) that display the distribution of the simulated trials

The last type of output is a useful management tool, as it shows graphically the likelihood of unacceptable results. A hypothetical example of such a chart, showing the relative probabilities of various levels of simulated company surplus five years into the future, is shown in Figure 10.1. Comparison of histograms representing simulations under different operating assumptions—e.g., different ceded reinsurance programs—can demonstrate the impact of different management decisions.

The uses of a DFA model and its output include those that can aid internal decision-making, and those that involve parties external to the insurer. Internal uses include general strategic planning, analyzing valuation and merger and acquisition activity, asset-liability management, reinsurance planning, and analyzing competitors' situations. External uses include projecting company ratings, supporting discussions with regulators (e.g., regarding solvency or risk-based capital considerations), and communicating with financial markets.

Insurance Securitization

An understanding of how insurers manage their financial and underwriting risks is becoming critical for actuaries. The potential use of a recent development—securitized insurance products and techniques—should be a consideration with regard to any insurer's operations. In this section, the insurance securitization process is defined, and related to its noninsurance forebears. The evolution of insurance securitization is then presented through a description of the various instruments that have been developed. Examples of the more important types of securitized products are provided, with emphasis on their general structure and format.

Definition of Insurance Securitization

"Insurance securitization" can be considered to involve two elements: the *transformation* of underwriting cash flows into tradable financial securities, and the *transfer* of underwriting risks to the capital markets through the trading of those securities. *Transformation* essentially corresponds to "financial engineering," which basically involves the bundling and/or unbundling of cash flows into new and different financial securities. This has become a common practice in the financial markets—examples include Treasury strips or "zero-coupon bonds" (that essentially involve separating the principal and coupon payments in a Treasury bond, which are then sold as single-cash-flow securities), and collateralized mortgage obligations (involving the unbundling and rebundling of cash flows on mortgages). The second element of insurance securitization, *transfer*, involves the ultimate recipient of the traded risks. Instead of an insurance company transferring its underwriting risk to a reinsurer within the insurance industry, securitized insurance risk is transferred to the broader capital markets (which might well include other insurers and reinsurers, as well as banks, pension funds, and mutual funds, among others). This is typically accomplished by the buying and selling of financial instruments whose cash flows (payoffs) are contingent upon underwriting experience.

Securitization in Historical Perspective

It is instructive to consider "insurance securitization" not in isolation, but rather within the broad context of "financial risk management" (FRM). By understanding the history of securitization in general, and by becoming familiar with FRM concepts and terminology, including the types of derivative securities that have been imported into the insurance industry, actuaries will be better prepared to implement and deal with securitized insurance products in a broad financial and corporate context.

Although securitization first came to the significant attention of the insurance industry in the 1990s, the process has existed in the general financial markets since the late 1970s. The original securitization efforts grew out of a response by the financial markets to a funding shortfall in the home mortgage market. In particular, excess demand for mortgages led the financial markets to explore alternatives for more efficiently moving funds from the suppliers in the capital markets to the mortgage demanders. These efforts resulted in the development of the mortgage securitization industry, in which the interest and principal payments on groups of individual mortgages formed the backing for the cash flows of newly created, tradable, and more liquid securities. The development of these securities and this market facilitated the transferring of funds from investors to borrowers. The first mortgage securitization product was issued in 1977, by the Bank of America. Since that time, the securitization market has grown significantly—with some help from changes in the tax code and improvements in investment technology. Some of the benefits of the securitization process include enhanced *liquidity*, more readily determinable *market values*, and more efficient and *lower cost* ways of moving funds from the capital markets to those entities needing the funds.

The Evolution of Insurance Securitization

Insurance derivatives—specifically, reinsurance futures—were first speculated upon even before the word "securitization" was initially used by the financial markets (Goshay and Sandor (1973)). The later emergence of actual securitized insurance products represented an evolutionary step in the general securitization process. It is interesting, however, to note some of the differences between early insurance securitization efforts and the other prior securitized products. For example, the existence of a "funding shortfall" in the mortgage financing market was the primary motivation for the initial development of securitization. Conversely, insurance securitization initially evolved during a period of time generally characterized by a soft insurance market, in which many kinds of insurance were available and even relatively inexpensive. Another interesting issue involves the types of things that have been securitized. Historically, the assets that have been most successfully securitized have been those involving significant volume and that are in some sense relatively "stable"—e.g., mortgage loans, auto loans, and credit card receivables. Conversely again, the property/casualty insurance industry initially concentrated its securitization efforts primarily upon an extremely volatile and unpredictable process: natural catastrophes.

Although it had been more than two decades since insurance derivatives were first suggested, only in the mid-1990s did a market begin to develop for such products. There appear to have been three primary factors affecting the timing of the insurance securitization industry's emergence:

- The significant *catastrophe losses* in the first half of the 1990s, particularly Hurricane Andrew in 1992 and the Northridge earthquake in 1994, which caused the insurance industry to reassess its exposure to catastrophe risk.
- The *maturation of the capital markets* and the continued development of new financial instruments aimed at achieving high yields and/or additional diversification.
- The changing *structure of the insurance industry* in the 1990s, which involved a number of mergers, acquisitions, and consolidations. This increased the impact of Wall Street and financial considerations on the insurance industry.

These trends led to two commonly accepted reasons for the development of securitized insurance products: (1) *capacity* considerations, which focus on the ability of the capital markets, due to their enormous size, to handle potentially large catastrophic events that might otherwise impair the insurance industry; and (2) *investment* considerations, which suggest that investing in instruments with cash flows related to catastrophe exposures would have diversification benefits, since they are uncorrelated with movements in other capital market instruments. While both of these reasons are arguable, they are commonly given as reasons for the development of the insurance securitization industry.

Types of Securitized Insurance Products

There are several ways to categorize the many types of insurance-related instruments that exist or have been proposed. One approach is as follows:

- Those that *transfer risk*. These techniques include *reinsurance, swaps, catastrophe bonds*, and *exchange-trade derivatives*, and may involve the transfer of risk to either another insurer/reinsurer or to the capital markets.

- Those that provide *contingent funding*. Such techniques include a *line of credit* (which involves the right to borrow), *contingent surplus notes* (which represent an option to borrow contingent upon the occurrence of an event), and *catastrophe equity puts*. Several of these categories of instruments are described in more detail below.

Exchange-Traded Derivatives

During the 1990s, two exchanges attempted to develop and trade insurance derivatives: the Chicago Board of Trade (CBOT) and the Bermuda Commodities Exchange (BCOE). The CBOT derivatives underwent a significant evolutionary process over a period of years [see, for example, D'Arcy, Gorvett, and France (1999)], culminating on September 29, 1995, when catastrophe option spreads were introduced [see Chicago Board of Trade (1995) for extensive and detailed descriptions.] These instruments were European cash options (settled in cash at the expiration of the contract), with either quarterly or annual calendar loss periods, with values based upon estimates of aggregate industry catastrophic losses made daily by *Property Claim Services* (PCS). These estimates were expressed in the form of an index, with each index point being equivalent to $100 million of aggregate industry catastrophe losses and having a cash value (in terms of the settlement value of the option) of $200 per index point. An option had value when the aggregate industry catastrophe losses exceeded the option's "strike value." Nine different geographical instruments were available, allowing a purchaser either to speculate upon or hedge exposures with respect to different geographic catastrophe exposures. Essentially, the CBOT option spreads worked much like excess reinsurance, where the retention and reinsurance limit were expressed in index points and, hence, in terms of aggregate industry catastrophe losses.

An example demonstrates the analogy with excess reinsurance. Suppose a December 30/50 Texas call option spread has been purchased by an insurer that has property exposure in that state. The insurer's purpose might be to hedge the catastrophe risk associated with that property exposure. Essentially, this option spread is analogous to a \$2 billion in excess of \$3 billion layer on fourth-quarter aggregate industry catastrophe losses in Texas, since

$$[50 - 30] \times \$100 \text{ million} = \$2 \text{ billion}, \qquad \text{and}$$

$$30 \times \$100 \text{ million} = \$3 \text{ billion}.$$

(Financially, the excess nature of the spread is accomplished by buying a call option with an exercise price of 30, and selling an option with an exercise price of 50. This buy-sell combination is built into the spread.) If, for example, fourth-quarter Texas catastrophe losses to the industry amount to \$4.5 billion, the company that purchased this option spread would receive \$3,000:

$$[(\$4.5 \text{ billion}/\$100 \text{ million}) - 30] \times \$200 = \$3{,}000.$$

The Bermuda Commodities Exchange also traded insurance derivatives. Although the basic concept underlying these options was the same as that of the CBOT PCS options, there were some important differences. The BCOE option index values were based on a Guy Carpenter Catastrophe Index [see, for example, Major (1997)], which was in the form of a loss-to-value (or damage) ratio (paid homeowners losses divided by housing values). Values for the index were available as finely as by zip code, and updated quarterly. Three different types of catastrophe options were available: single loss (largest catastrophic event during a period), secondary loss (the second largest event), and aggregate cat. The risk periods underlying the options were semi-annual: either the first-half or the second-half of the calendar year. The BCOE options were "binary options," i.e., the options paid off either \$0 or \$5,000 at expiration; there was no intermediate value possible (as there was with CBOT option spreads).

Risk Exchanges

While there are many forms that a financial "swap" can take, one example of the swap concept in the insurance industry is the risk exchange. Catastrophe Risk Exchange (CATEX) New York is a computer-based exchange that was designed to allow subscribers to swap their catastrophe exposures. Thus, subscribers can adjust their risk distribution profiles—by geographic location and/or by property type—by trading written exposures. Risks available for trade can be "advertised" on the electronic system, where trades can be negotiated and completed. Since its inception, CATEX has expanded into a facilitator for commercial insurance and reinsurance. Another risk exchange is CATEX Bermuda, which is a joint venture between CATEX and the Bermuda Stock Exchange.

Catastrophe Equity Puts

Catastrophe equity puts are a form of contingent financing. A financial put is the right (but not the obligation) to sell an asset at a pre-specified price (the "exercise" price), on a certain date or dates, or during a certain period of time. Catastrophe equity puts are agreements whereby an insurer, in the event of a catastrophe, has the right to sell equity (usually preferred stock) to investors at a pre-specified price. This right to sell equity is triggered by a specified catastrophic event, for example when catastrophe losses exceed a certain threshold (e.g., when the insurer's catastrophe reinsurance protection has been exhausted). This contingent infusion of equity allows the insurer to shore up its balance sheet by replacing equity immediately after a catastrophe.

Catastrophe Bonds

Of the various forms of insurance securitization introduced in the 1990s, perhaps the greatest amount of activity and publicity involved catastrophe bonds. In general, a catastrophe bond is a debt issue by an insurance company. The debt is similar to a traditional corporate bond, except that, in certain circumstances, the insurer is relieved (fully or partially) from the obligation of making interest and/or principal payments to the bondholders. Circumstances providing such relief involve the occurrence of a catastrophic event. Thus, the essential concept is that, in the event of a catastrophe, one type of debt—payments of catastrophic losses to policyholders—is at least partially offset by the diminishment of payment obligations by the insurer under the bond issue.

To a large extent, a securitized product's ability to hedge catastrophe risk depends on the type of "trigger" used. Here, "trigger" refers to the "event" that causes an adjustment to the payoff of the instrument. With a *direct trigger* the contingency upon which the payoff of the instrument depends is based on the company's losses. Under an *industry trigger* the payoffs depend upon overall industry loss experience, as reflected by an index. Under an *event trigger* the payoffs depend upon the occurrence of a defined event, such as an earthquake that exceeds a certain measure on an intensity scale.

A common practice in capital markets is to subdivide a series of cash flows into different segments, called "tranches." These tranches differ based upon maturity, riskiness, or other characteristics. A catastrophe bond may have several tranches. From the standpoint of an investor in such bonds, depending upon the tranche invested in, there is the risk of losing some or all of the principal invested, and/or the risk of diminished or lost interest payments. Very often, there is a tranche in which both principal and interest is at risk (and the coupon rate on that tranche reflects this large amount of risk and is, appropriately, relatively high). In addition, there is often a tranche in which at least part of the principal is "protected" or "defeased." This means that, when the bonds are issued, some of the proceeds are placed in a protected account that funds the repayment of the principal. Often, there is a provision whereby, in the event of a catastrophe, the protected principal is repaid over an extended period of time.

The issuance structure underlying the initial catastrophe bonds has typically involved the insurer setting up a Special Purpose Vehicle (SPV) to act as an "intermediary" between the company and the capital markets. Generally, the SPV has been an offshore reinsurer (this structure is used to maintain favorable tax and accounting treatments). The SPV issues a reinsurance contract to the company; in turn, the company issues bonds to the capital markets through the SPV. The SPV pays the cash flows on the bonds (and funds the reinsurance protection) from the reinsurance premiums paid by the company, and from the invested bond proceeds.

The June 1997 USAA catastrophe bond, one of the earlier of such bonds issued, can be used as an example. This bond was originally intended to be a $150 million offering, but was significantly over-subscribed, and USAA ended up issuing, through a Cayman Islands SPV called Residential Re, $477 million of catastrophe bonds. These one-year bonds were sold to 62 investors; several investment banks were involved in the advising and issuing process. Of the $477 million in proceeds, $400 million represented a reinsurance cover provided by Residential Re; the other $77 million was placed in a defeasance account to fund the principal repayment on tranche A-1 (see below). The reinsurance, in effect, represented a layer equal to 80% of $500 million in excess of $1 billion on USAA's hurricane losses. Thus, the bond involved a "direct" trigger: principal and/or interest payments would be affected in the event of a hurricane loss to the company in excess of $1 billion.

The USAA bond issue involved two tranches: tranche A-1, in which only interest (but not principal) was at risk from the standpoint of the investor; and tranche A-2, in which both principal and interest were at risk. Tranche A-1, which received an investment rating of AAA (the highest available), had its principal protected via a defeasement account. In the event of a catastrophic loss, principal repayment was guaranteed for tranche A-1 investors, but an extension of as much as ten years to repay the principal would be permitted. Tranche A-2, which was rated BB (below investment grade), was exposed to the risk of both lost interest and lost principal, and thus was riskier than tranche A-1. This relative riskiness between the two tranches was reflected in their respective coupon rates. The USAA bonds were floating-rate bonds that paid a specified risk premium in excess of the London Interbank Offer Rate (LIBOR). The risk premium for tranche A-2 was more than twice that for tranche A-1.

Other significant early insurance securitization successes included a Swiss Re (1997) bond involving an industry trigger on a California earthquake, and a Tokio Marine & Fire (1997) bond involving an "event" trigger (based on the Japanese Meteorological Association scale) on a Tokyo earthquake. A review of these and other successful bond offerings reveals certain traits common to many or most of them: they typically involved highly volatile catastrophic risk, relatively high levels of protection, relatively short maturities (except, for example, the Japanese issues), some protection of principal, and high coupon rates. However, with respect to the last trait, subsequent bond issues (e.g., the USAA bond issues in 1998 through 2000) suggested that coupon rates were diminishing, perhaps reflecting growing comfort with the mechanism and a lower "newness premium."

The Outlook for Insurance Securitization

The insurance securitization industry developed quickly during the late 1990s. As the industry and techniques evolve and mature, the future success and development of insurance securitization is a function of a number of issues and questions:

- The *relative costs* of traditional insurance and reinsurance products on the one hand, and of securitized instruments on the other. The former involves the state of the market at any given time, as well as supply-demand pressures stemming from competitive and alternative products. The latter includes, for example, with respect to catastrophe bonds, the costs of setting up a special purpose vehicle, the level of coupon rates, and the like.

- Advances in *technology*, and the acceptance of that technology by both insurers and the capital markets for quantifying risks.
- Potential *efficiencies* in the insurance intermediation process that might be introduced through cooperation with the capital markets.
- The *types of risks* securitized—e.g., catastrophe risks versus more traditional insurance lines.
- The *legal status* of securitized insurance instruments. Each jurisdiction will need to come to terms with the question of whether investors in insurance securitization products are engaging in the business of insurance.
- The *tax and accounting implications* of the various instruments.

What forms will insurer financial risk management take in the future? There is a wide range of techniques available to insurers—e.g., asset hedges, liability hedges, asset-liability management, contingent financing, and post-loss financing and recapitalization. "Insurance securitization" encompasses one group of techniques in a broad rainbow of financial risk management tools available for the insurer's consideration.

REGULATING AN INSURANCE COMPANY

The regulatory environment in which insurance companies operate is rather unique. In the United States, property/casualty insurers are primarily regulated by the individual states (which interact, to a degree, via the National Association of Insurance Commissioners). There are specific reporting requirements, accounting standards, and various rate filing regulations. This section introduces several issues involved in regulating insurance companies and the insurance industry. The property/casualty insurance regulatory process will be described, including an overview of guaranty funds, and the risk-based capital process and calculations will be discussed.

Regulation and Solvency Issues

This section describes the regulatory environment of the property/casualty insurance industry. Several of the important historical court cases and pieces of legislation are summarized, the state-versus-federal issue is discussed, and the NAIC framework is described. Also described are the guaranty fund system and the NAIC early warning (IRIS) tests.

The Property/Casualty Regulatory Environment

Regulation of insurance is a well-established aspect of the industry. Nevertheless, the question can be asked: why should insurance be regulated? Some of the possible reasons that have been offered for the existence of regulation include the following:

- *Solvency/solidity:* Since policyholders have purchased a promise from insurers to provide indemnification in the event of a loss, those policyholders must be protected from possible insurer insolvency. This is done by monitoring the financial conditions of insurers.
- *Asymmetric information:* Consumers have inadequate knowledge of the insurance process, and must be protected.
- *Reasonable rates:* Since the purchase of insurance can be a legal or practical necessity, and because the individual consumer typically has little "power" in the transaction relative to insurance companies, consumers must be protected from unfair pricing practices.
- *Availability:* The insurance market must be kept healthy and competitive, in order to ensure the existence and availability of insurance coverages.

These and other regulatory considerations have been evaluated and discussed over a long period of time—perhaps as far back as the beginnings of insurance regulation itself. In the U.S., states took increasingly active roles in overseeing the insurance industry throughout the 1800s. The responsibilities of chartering, licensing, and taxing insurance companies led to the creation in the various states of departments devoted to regulating the insurance industry. The first state to create a commission specifically devoted to the insurance industry was New Hampshire in 1851.

The first watershed judicial event in the history of U.S. insurance regulation is normally considered to be the *Paul vs. Virginia* case of 1869. This case, which was ultimately decided by the U.S. Supreme Court, involved a New York fire insurance agent named Samuel Paul, who was sued for selling insurance in Virginia without a Virginia license. Paul, claiming he was involved in interstate commerce, contended that Virginia's licensing requirements were unconstitutional. The Court, finding against Paul, held that insurance is *not* commerce, and thus not subject to the commerce clause of the U.S. Constitution. As a result, this case espoused the rights of states, as opposed to the federal government, to regulate insurance. Two years later, this state regulatory framework led to the organization of the National Convention of Insurance Commissioners (later the National Association of Insurance Commissioners, or NAIC), with the goals of enhancing regulatory consistency across states and sharing important information.

The legal position that insurance was not interstate commerce was maintained until 1944, when the U.S. Supreme Court made a contrary ruling in the *United States vs. Southeast Underwriters Association (SEUA)* case. The SEUA was a rating bureau that, the U.S. federal government claimed, violated antitrust laws (in particular, the Sherman Act). Agreeing with the U.S., the Court found the SEUA guilty of price fixing, on the basis that insurance *is* interstate commerce, and thus subject to federal regulation.

The insurance industry and the states responded to the SEUA decision quickly by putting pressure on Congress to address this issue. The very next year, in 1945, Congress passed Public Law 15, better known as the McCarran-Ferguson Act. This law puts the primary responsibility for insurance regulation back into the hands of the states. In particular, except for cases of boycott, intimidation, or coercion, federal antitrust laws do not apply to the insurance industry. However, federal regulation *is* considered appropriate and authorized in the event that state regulation is found to be inadequate.

This regulatory framework has existed into the 21st century. The primary efforts involving regulation of the insurance industry have come from the states, to some degree coordinated by the NAIC. Typical areas of state regulation include licensing, approval or disapproval of rates and policy forms, solvency and market conduct monitoring, and the rehabilitation and liquidation of insurers.

Insurer Insolvencies

During the 1970s and 1980s, insolvencies in the property/casualty insurance industry increased rather alarmingly. A. M. Best (1991) examined 372 U.S. property/casualty insurer insolvencies that occurred between 1969 and 1990; of those, Best's was able to determine primary causes behind 302 of the insolvencies, distributed as follows:

Primary Cause of Insolvency	Percentage of 302 Cases
Deficient loss reserves (inadequate pricing)	28%
Rapid growth	21
Alleged fraud	10
Overstated assets	10
Significant change in business	9
Reinsurance failure	7
Catastrophe losses	6
Miscellaneous	9

Initial indications of potential insurer difficulty can come from a number of sources. Regulatory examinations often provide a warning regarding existing or future problems. Similarly, audit reports, actuarial loss reserve opinions, or consumer complaints can bring coming difficulties to the attention of regulators.

A state insurance department, when it suspects an insurer of being in financial trouble, has a number of options and responsibilities. A typical regulatory process involving an insurer in potential difficulty would begin with an examination of the company to identify and quantify the problem. Financial statements and accounting records are analyzed, and on-site investigations of the company and its operations are made. Following this analysis, the regulator might decide to place the company under *supervision*. This is an administrative action by the regulator, and may or may not involve restrictions on the company's operations. In any case, closer scrutiny is paid by the regulator to the insurer.

If warranted, the regulator might then obtain a court order for *conservation* or *seizure* of the company. Essentially, this places the company under the control of the regulator. Finally, a decision may be made to either *rehabilitate* or *liquidate* the company. Rehabilitation typically involves an inflow of cash, often from a party interested in taking an ownership interest in the insurer. Liquidation occurs when it is decided that rehabilitation is not a viable option; bankruptcy law and guaranty fund regulations then take control of the situation.

Guaranty Funds

When a property/casualty insurer does become insolvent, a mechanism known as a "guaranty fund" responds. Guaranty funds, which exist in each state, essentially guarantee (with certain limitations) the promises made by an insurer to its policyholders. Although the specific parameters of each fund can vary by state, some of the general characteristics of a property/casualty insurance guaranty fund include the following (see Duncan (1984) and Lee, Mayers, and Smith (1997) for details; both articles describe the NAIC model which was adopted in 1969).

- Guaranty funds are involuntary, not-for-profit associations. Each state's fund is comprised of all insurers licensed in the state that write covered lines of insurance.

- Guaranty funds pay policyholders' loss claims that go unfulfilled by insurers due to insolvency. They also provide for refunds of unearned premiums in the event of insurer insolvency. These payments do not necessarily make the policyholder whole: the insured's policy coverage limits apply, there is a cap on claims paid by the guaranty fund (although the cap does not apply to workers compensation loss claims), and a deductible applies to unearned premium claims.

- Policyholder claims are funded by assessments on the member insurers of the association. The assessment made on each insurer is proportional to the relative amount of business the insurer writes in the state. Typically, the maximum assessment on an insurer in a given year is 2% of the company's net direct written premium in that state (based on the preceding year's writings). All states assess their companies on a post-insolvency basis, except for New York, which operates as a pre-assessment fund. There is a provision for a company to pass along at least some of those assessments in the form of future rates.

Over the years, net guaranty fund assessments for the property-liability insurance industry have totaled billions of dollars. Assessments increased dramatically in the mid-1980s, in line with the increase in the incidence of insolvencies. Through 1992, annual assessments have been as high as nearly 0.5% of industry premiums. [See Klein (1995) for these and other figures.]

Insurance Regulatory Information System

Regulators have developed processes—both quantitative and qualitative—to monitor the performance and financial health of insurers. In a prior section of this chapter, a number of financial ratios were described that can assist analysts in quantifying the financial performance and solidity of companies. Such ratios are based upon information found in a company's financial reports, e.g., balance sheets and income statements. Similar quantitative measures are utilized by insurance regulators, largely based upon information provided in the Annual Statement (discussed further in the "Data Sources" section of the chapter). Such quantitative measures are an important component of the Insurance Regulatory Information System (IRIS), which has been used by the National Association of Insurance Commissioners since 1973.

IRIS is a system that provides a framework for monitoring insurance companies, and for identifying those companies in need of additional attention. The 11 statistical measures that comprise the *IRIS ratios* (at one time, referred to as "Early Warning Tests") represent the first quantitative step in the process of evaluating insurer solvency. The tests are summarized briefly below.

Leverage Tests:	1. Ratio of premium to surplus
	2. Change in premium writings
	3. Ratio of surplus aid to surplus
Profitability Tests:	4. Two-year operating ratio
	5. Investment yield
	6. Change in policyholders' surplus
Liquidity Tests:	7. Ratio of liabilities to liquid assets
	8. Ratio of agents' balances to surplus
Loss Reserving Tests:	9. One-year reserve development to surplus
	10. Two-year reserve development to surplus
	11. Estimated current reserve deficiency to surplus

These tests provide regulators with an initial screen, helping to identify insurers with potential solvency problems. Associated with each ratio is a "normal" industry range, which may be revised periodically to reflect changes in the general economic or industry environment. Consideration is given to the number of "unusual" ratio results a company has—along with a variety of other criteria—when determining what level of priority to assign a company with respect to the need for additional regulatory investigation.

The importance of monitoring insurer solvency has been manifested by the recent development of additional tests and measures. For example, the Financial Analysis and Surveillance Tracking (FAST) system includes 20 financial ratios (some of which are also IRIS ratios). Whereas the result of applying an IRIS ratio is binary (the ratio is either in or out of the normal range), the FAST system assigns point values for different ratio ranges. Another, very significant, development in the regulatory analysis of solvency is risk-based capital.

Risk-Based Capital

Risk-based capital (RBC) is more than a recently implemented regulatory mechanism—it is also a new and important framework for considering, examining, and measuring insurance company value. In this section, the RBC system is discussed, and the relevant formulas are described in general terms.

Traditionally, an insurer's required capital and surplus levels have been determined simplistically, without appropriate consideration given to the riskiness of the company's operations. After the significant number of insolvencies experienced by the industry in the 1980s, regulators began to recognize that traditional measures of required capital were becoming quickly outdated in an increasingly volatile industry and financial environment. Regulators felt that a new approach to quantifying insurer risk was necessary. In the 1990s, this led to the development of the risk-based capital approach.

The NAIC adopted risk-based capital standards for the property-liability insurance industry beginning with the 1994 annual statement. (Life insurance RBC standards had been adopted one year earlier.) The objectives of these requirements are to:

- Promote the financial stability of property/casualty insurance companies,
- Encourage timely corrective regulatory action in the event a company experiences financial difficulties (in some cases

within the RBC framework, corrective action by the regulator is mandatory (see below), which potentially removes some of the discretionary and political aspects of the regulator's job in such situations), and

- Minimize the costs of insurer insolvencies through early identification and treatment of potential financial distress.

These objectives are addressed by a regulatory structure that attempts formally to relate a company's surplus requirements to the nature and riskiness of its operations. These risk-based surplus standards are meant to replace prior flat dollar minimum requirements.

The essence of the RBC formula involves the identification of the nature and degree of risk-taking by the insurer [see, for example, Cummins, Harrington, and Niehaus (1995), Cummins, Harrington, and Klein (1995), Feldblum (1996), and Laurenzano (1995) for more details]. In general, risks are categorized according to type, and a "charge" for each element of risk is applied, with the various charges ultimately totaling an amount that is related to the required amount of surplus. The two broad risk categories are:

- *Asset risks*. The charge associated with each risky asset reflects the relative riskiness of the asset. For example, for unaffiliated bonds held in the insurer's asset portfolio, the charge ranges from 0 to 30 percent, depending upon the default risk of the bond. (All RBC charges referenced here are as of this writing; future charges may differ.) Bonds with greater risk receive higher charges, and the NAIC assigns each bond to one of six classes, from Class 1 (bonds of highest quality) to Class 6 (bonds in or near default). Preferred stock is treated similarly to bonds, with slightly different charges. Unaffiliated common stock holdings receive a charge of up to 15 percent. Finally, the charges are adjusted to reflect the degree of asset concentration. In effect, this adjustment provides an incentive for a company to diversify its investment portfolio. Specific asset classifications include subsidiary insurers (R0), fixed income (R1), equity (R2), and credit (R3). The "credit" classification refers to the possibility of unrecoverable reinsurance, and involves a charge to reinsurance recoverables.

- *Underwriting risks.* The focus of this category is the charge for the riskiness of loss and loss adjustment expense reserves. Specific risk classifications include reserves (R4) and net written premium (R5).

After all the risk charges have been applied, a formula provides the "Authorized Control Level" (ACL) risk-based capital. This amount can then be compared with the company's actual capital, and the relationship between the two values determines the result of the RBC process. According to the NAIC Risk-Based Capital Model Law, there are four levels of regulatory activity resulting from the process:

- *Company Action Level:* If an insurer's capital is less than 200% of the ACL, the insurer must submit a plan to the regulator. In this plan, the insurer explains the company's financial situation, and proposes corrective action.

- *Regulatory Action Level:* If an insurer's capital is less than 150% of the ACL, the regulator must examine the company and specify corrective action.

- *Authorized Control Level:* If an insurer's capital is less than 100% of the ACL, the regulator is authorized to rehabilitate, liquidate, or otherwise take control of the company.

- *Mandatory Control Level:* If an insurer's capital is less than 70% of the ACL, the regulator is required to take control of the company.

As insurance enters the 21st century, many regulatory issues are still being debated. The respective positions of state and federal regulation, the place and role of regulation as financial markets converge, and appropriate methods for ensuring continued solvency are among the contested topics. Insurance continues to be one of the most heavily regulated industries in the United States, and an understanding of the regulatory framework in which insurers operate is critical for actuaries.

DATA SOURCES

The insurance industry is a significant producer and user of information, both quantitative and qualitative. Much of the information that insurers generate is a product of regulatory requirements, e.g., financial statements, information in support of rate filings. Actuaries are prime users of such information, whether their specific roles involve regulatory oversight or corporate or consulting actuarial activities. This section describes for the reader several of the many data sources, both internal and external to the insurance industry, that are available to aid the actuary in performing analyses.

Insurance Industry Data

NAIC Annual Statement

The National Association of Insurance Commissioners (NAIC) requires that each insurance company file an Annual Statement with the insurance department of each state within which the company is licensed to do business; the due date for filing is March 1 of the year following the operating year summarized by the company's statement. The Annual Statement is the industry's primary source of regulatory information, and is prepared under statutory accounting rules and procedures. Each year, the NAIC considers, and sometimes approves, changes to the Annual Statement blank. However, the general format of many of the pages, exhibits, and schedules in the document have been essentially the same for many years. The following list summarizes several of the important components of the Annual Statement.

- *Title page (page 1).* Identifies the company, address, state of domicile, officers, directors, and other administrative information.

- *Balance sheet (pages 2 and 3).* Lists the assets (page 2) and the liabilities and surplus accounts (page 3) of the insurer, as of the end of the operating (generally calendar) year. Classifications of assets and liabilities at this point are fairly broad; later pages and schedules provide much greater detail regarding year-end accounts.

- *Income statement (page 4).* Shows the statutory income earned during the year. Premiums, losses, and investment income are identified in broad, general categories.

- *Statement of cash flows (page 5).* Shows the movements of cash during the year. Cash flows resulting from premiums collected, losses paid, expenses paid, and investment operations are identified.

- *Underwriting and Investment Exhibit.* This multi-part exhibit provides information at greater levels of detail than the preceding pages. Specifically, various parts of the exhibit show detail regarding:

  — Interest, dividends, and real estate income

  — Capital gains

  — Premiums written and earned, by line of business

  — Losses paid and incurred, by line of business

  — Expenses

- *Analysis and Reconciliation of Assets.* Shows the changes in asset categories during the year.

- *Five-Year Historical Data.* Provides historical data for each of the following:

— Gross and net written premiums, by line of business categories

— Underwriting and investment income, policyholder dividends, and taxes

— Various balance sheet items (e.g., admitted assets, losses, unearned premium reserves)

— Asset allocations by investment category

— Capital and surplus accounts

— Gross and net losses paid

— Various operating ratios

— One- and two-year loss development

- *Schedule A*. Shows real estate acquired and sold during the year, as well as real estate owned at the end of the year.
- *Schedule D*. Shows activities in bonds and common stocks during the year, and the holdings in each at the end of the year. Given that nearly two-thirds of the property/casualty insurance industry's assets are typically in bonds, this is an extremely important exhibit, especially for asset-liability management and dynamic financial analysis purposes. Bonds are listed separately, and summarized by type (e.g., governments, political subdivisions, etc.), by quality (classes 1 through 6), and by maturity distribution (five categories: maturing within one year, over one but within five years, over five but within ten years, over ten but within twenty years, and over twenty years).
- *Schedule F*. Shows the amount of ceded reinsurance, by assuming reinsurer. In addition, it documents the sources and amounts of assumed reinsurance, and shows the funds held on account of reinsurance in unauthorized companies.
- *Schedule P*. This is, for actuaries, potentially one of the most useful sections of the Annual Statement. This is the only data

in the Statement that is configured on an "accident year" basis. Ten years of information are included for each major line of business category; specific information includes:

- — Direct and assumed, ceded, and net earned premiums
- — Direct/assumed and ceded loss payments
- — Direct/assumed and ceded allocated loss adjustment expense payments
- — Salvage and subrogation received
- — Unallocated loss adjustment expense payments
- — Losses and allocated loss adjustment expenses unpaid
    - On a case basis (direct/assumed and ceded)
    - Bulk and IBNR (direct/assumed and ceded)
- — Unallocated loss adjustment expenses unpaid

In addition, various loss development triangles are provided for the major line of business categories. Ten-year triangles (on a net basis) are provided for total incurred losses and allocated loss adjustment expenses, cumulative paid loss and ALAE, and bulk and IBNR reserves. These exhibits can be used to analyze loss development and historical reserve accuracy.

- *Schedule T.* Shows direct premiums and losses by state.
- *Insurance Expense Exhibit.* Shows premiums, losses, and expenses allocated to the statutory lines of business.

One other item associated with the Annual Statement is the "Statement of Actuarial Opinion," which is to be included with the Annual Statement. This is a document in which a qualified actuary, generally appointed by a company's board of directors, opines on the company's loss and loss adjustment expense reserves. A "qualified actuary" is typically considered to be a member in good standing of the Casualty Actuarial Society, although other persons can also qualify if they meet certain conditions.

The opinion statement includes a *scope* paragraph that identifies the subjects being opined upon, an *opinion* paragraph in which the actuary expresses an opinion on those subjects, and possibly one or more *relevant comments* paragraphs that permit the actuary, if necessary, to qualify or explain the opinion. The opinion statement typically includes comments regarding the impact on loss and loss adjustment expense reserves of relevant material issues, e.g., collectibility of reinsurance, discounting. Since loss and loss adjustment expense reserves generally represent the largest liability on a property/casualty insurer's balance sheet, the Statement of Actuarial Opinion is an important piece of information for regulators.

A. M. Best

A. M. Best is a firm that collects, compiles, and publishes significant information with regard to both the property-liability and life insurance industries. Much of this information has its source in the Annual Statements filed by insurers. Based on this information, and both quantitative and qualitative analyses of insurers and the insurance industry, Best also promulgates ratings that reflect its estimate of an insurer's ability to meet its future obligations to its policyholders. (Although this description will focus on A. M. Best, other organizations also analyze and evaluate the solvency of property/casualty insurance companies; such organizations include Weiss, Standard & Poor's, Duff & Phelps, and Moody's.)

A. M. Best produces a number of different statistical compilations and other publications, including:

- *Aggregates and Averages.* This annual publication provides aggregate industry financial values, both current and historical. The information is compiled from Best's database, permits evaluations of historical industry performance, and provides industry aggregate measures against which to compare an individual insurer's financial and operating results. Specific sections of the publication include consolidated industry information, historical time series of important financial and operating results, performance measures by line of business, and summaries of results for the "leading" property/casualty companies.

- *Insurance Reports*. Another annual publication, this volume provides summary reports on property/casualty insurers, with current and some historical financial and operating information on both an individual company and a group basis. This publication also includes a description of Best's insurer rating system, a list of companies by location (city and state), and a list of companies that either changed names or retired (voluntarily or involuntarily) recently. The summary report on each company includes the rationale for the current Best's rating and a five-year history of ratings and key financial indicators, a review and description of the company's business and operations, and a summary of recent financial performance.

Best's ratings process results in two distinct ratings: a "Best's Rating," which reflects Best's opinion—based on both quantitative and qualitative evaluations—of a company's financial strength, operating performance, and market profile; and a "Financial Performance Rating," which is a financial and operating evaluation based primarily on a quantitative analysis. Specifically, Best's Rating categories include "secure" ratings (A++ through B+), and "vulnerable" ratings (B and below); specific Financial Performance Ratings range from FPR 9 (very strong) to FPR 5 (good) in the "secure" category, and FPR 4 (fair) to FPR 1 (poor) in the "vulnerable" category.

For both Best's and FPR ratings, the evaluation is with respect to a company's ability to meet its policyholder obligations, and to its vulnerability to potentially adverse economic and underwriting conditions. According to A. M. Best, "The objective of Best's rating system is to evaluate the factors affecting the overall performance of an insurance company in order to provide our opinion of the company's financial strength and ability to meet its contractual obligations" [A. M. Best (1991), page

63]. Best uses quantitative and qualitative analysis in evaluating the financial and operating condition of a P-L insurance company. The quantitative tests can be categorized into three groups: profitability tests (e.g., combined ratio, operating ratio, change in surplus), leverage tests (e.g., premium-to-surplus ratio, liabilities-to-surplus ratio), and liquidity tests (e.g., net cash flow, agents' balances to surplus). The qualitative evaluation includes the following five areas: spread of risk, adequacy and soundness of reinsurance, quality and estimated market value of assets, adequacy of loss reserves, and management.

Standard & Poor's

Standard & Poor's (S&P), as well as other financial rating organizations, provides evaluations and ratings on the claims-paying ability of property/casualty insurance companies. For each company rated, on a scale of AAA to CCC, S&P provides a corporate summary, including a rationale for the rating, a review of the company's business, a summary of management and corporate strategy, a summary of historical operating performance, and descriptions of the company's underwriting, investments, capital, liquidity, and reinsurance.

Insurance Services Office and the National Council on Compensation Insurance

Insurance Services Office, Inc. (ISO) provides actuarial and statistical services and information to the property/casualty industry. Member companies can subscribe to these services, which might provide, for example, ratemaking information (such as loss costs) for a particular line and in a particular state. In addition, they periodically produce a number of research reports which compile and analyze information with regard to important topics. The subject matter of some of the recent reports produced by ISO includes:

- Risk/return and profitability of the industry
- Projecting and financing catastrophic risks

- Personal auto insurance profitability and costs
- Legal defense costs
- Health care costs

Subscriptions are available to ISO's "ISOnet" Web Site, which provides on-line access to ISO circulars, downloadable spreadsheets and exhibits, policy forms, surveys, and a variety of other services. Loss and premium experience on CD-ROM is also available for certain lines of business.

The National Council on Compensation Insurance (NCCI) is, like the ISO, an insurance advisory organization. Both organizations employ a number of actuaries, and provide information useful for ratemaking and other actuarial processes to their member companies. The NCCI focuses its efforts and services on workers compensation (the primary line of business not addressed by ISO). The NCCI also publishes articles and perspectives on the workers compensation industry and environment.

Reinsurance Association of America

The Reinsurance Association of America (RAA) is a property/casualty reinsurance trade association. In addition to its work with state and federal authorities, the RAA also produces periodic reports regarding reinsurance data. These reports include a historical reinsurance loss development study, and an annual reinsurance underwriting review.

GAAP Financial Statements

Many of the data sources described above are based upon financial information provided by insurers within a statutory accounting framework. In order to record and summarize financial activity for shareholders and other external claimholders, publicly traded insurers are required to file a variety of reports with the Securities and Exchange Commission (SEC). These include an annual report to shareholders, and a yearly Form 10-K. These reports are prepared on a GAAP basis, making them an interesting complement to statutory filings such as the NAIC Annual Statement.

Other Sources of Information

Insurance-specific information has historically provided the foundation for actuarial analyses. However, the property-liability insurance industry evolved significantly during the late 20th century. The operating environment is now multinational, insurer performance is linked to economic and financial conditions, and ratemaking is taking on a total rate of return perspective. Under these circumstances, and consistent with the broad planning perspective provided by dynamic financial analysis, sources of general business and economic information are becoming critical for actuaries. Some such sources include the following.

- *Wall Street Journal*. This newspaper is a source for daily information regarding interest rates, foreign exchange rates, commodity prices, and stock prices (individual and indices). These items can be found in Section C of the paper.
- *Ibbotson Associates*. This is a commercial organization that sells several products, including the *Stocks, Bonds, Bills and Inflation Yearbook*. This book is an annual publication that provides long-run historical information on interest rates, inflation, and equity market performance. These data can be useful for analyzing long-term financial trends and the correlations between financial variables.
- *Commercial forecasting services*. These firms, which provide economic forecasts using econometric and mathematical models, include Chase Econometrics, Data Resources, Inc., and Wharton Econometrics, among others.
- *Academic publications:* Some of the journals that publish research relevant to actuaries include the *Proceedings of the Casualty Actuarial Society*, the *North American Actuarial Journal*, the *Journal of Actuarial Practice*, the *Geneva Papers*, the *Scandinavian Actuarial Journal*, *Insurance: Mathematics and*

Economics, and the *Journal of Risk and Insurance*. The *Journal of Economic Literature* can also be useful in scanning for relevant articles, as it categorizes and lists recent papers published in a number journals, on a variety of economic and financial subjects.

- *Internet-based sources:* Web-based sources of information are becoming numerous and popular. Some of the sites that actuaries might find useful include the following.
  - — The *Casualty Actuarial Society* maintains a Web Site (www.casact.org) with a number of useful pages and links, including an on-line catalog with a large collection of recent and past CAS articles and abstracts.
  - — The *Federal Reserve Bank of St. Louis* maintains its "*FRED*" (Federal Reserve Economic Data) database (www.stls.frb.org/fred/), which includes a number of economic and financial time series of value to actuaries, including employment and population data, interest rates, consumer price indices, and monetary information.
  - — The *U.S. Census Bureau* (www.census.gov) provides demographic information of importance for personal lines ratemaking and strategic planning.
  - — *State insurance department* Web Sites, in addition to consumer information, may have data on consumer complaints, rate comparisons, industry experience, and legislative updates.

* * * * *

Prior chapters of this book have provided readers with an understanding of the key concepts and techniques traditionally used by property/casualty actuaries. In this chapter, several special and emerging areas have been presented. Actuaries need to not only master the traditional areas of expertise, but also be able to apply those techniques in nontraditional and emerging settings.

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