INSURANCE

The notion of an insurance contract traces its earliest historical roots to the use of bottomry contracts in Babylonian society of the third millennium BC. Under this type of arrangement, a land or marine trader would take out a loan of merchandise or money from a merchant, agreeing to a high rate of interest (usually, at least 100 percent). If all went well, then the principal and interest would be paid at the end of the trading expedition; however, if the merchandise were lost or stolen, then the principal and interest would be forgiven. The merchant was compensated for assuming the risk of the trading venture through the large interest payment. The bottomry contract illustrates the concept of risk transfer, in which one party cedes responsibility for an uncertain outcome to another party, who assumes the risk in return for some financial compensation.

A somewhat different practice developed among Chinese marine traders around 3000 BC. Rather than simply transferring all risk from one party to another, groups of traders established reciprocal arrangements in which each trader's store of merchandise was subdivided into small equal shares, each of which was carried on a different ship. In this way, no trader would be completely devastated by the sinking of one ship. This type of arrangement illustrates the concept of risk pooling, in which each member of a group cedes responsibility for small shares of its own uncertain outcome to the other members of the group, and assumes similar shares of risk from the other members in return.

There were approximately 2,700 property-liability insurance companies licensed to conduct business in the United States in 2004, compared with approximately 2,750 companies in 2003 [see (1)]. In recent years, the number of active companies has declined because of corporate mergers and acquisitions designed to reduce operating costs and general overhead, and many companies are members of international insurance groups. United States property-liability insurance premiums totaled $421 billion in 2005 [see (2)]. Overall, the United States property-liability insurance market is by far the largest nonlife market in the world, with over six times the premium volume of its nearest rival, Germany.

On the life insurance side, there were approximately 1,180 licensed United States companies in 2004, compared with approximately 1,230 companies in 2003 [see (3), p. 2]. Again, the decreasing number of active companies is the result of corporate consolidation, and many companies are members of global groups. Although the United States life insurance market is the world leader, with annual premiums of about $539 billion [see (2)], its premium volume is only a little more than 1.3 times that of second-place Japan.

During the first decade of the 21st century, the international insurance industry has continued to evolve in several directions. Since the 1960s, the alternative property-liability market, composed of captive insurance subsidiaries, risk retention groups, and self-insurers has grown and matured and may now account for as much as one-third of total commercial property-liability premiums (although the actual proportion is difficult to pin down). The decades of the 1980s and 1990s witnessed major changes in the nature of health insurance in the United States, with an increasing emphasis on managed care delivery systems such as HMOs and PPOs. Current worldwide trends include the integration of traditional insurance with other financial service products and the globalization of insurance markets as various nations embark on the deregulation of their financial sectors.

Today's insurance products, like their ancient progenitors, are characterized by the presence of risk transfer and risk pooling. However, in the modern insurance world, competition from alternative markets and other financial service industries has continued to emphasize the importance of market forces in defining the nature of the insurance contract.

TYPES OF INSURANCE

In the United States and most other industrialized nations, insurance companies are generally licensed to sell either (1) property-liability insurance, or (2) life and health insurance. Although regulatory requirements may prevent one company from being licensed in both categories, corporate insurance groups frequently include members from both sectors. While the lines of business written by property-liability and life and health insurers are substantially different, one area of overlap is in the writing of accident and health insurance. Accident and health insurance may also be provided by various nonprofit health insurers, HMOs, PPOs, and similar healthcare delivery systems, as well as by self-insured employers.

Property-Liability Insurance

Property-liability insurance encompasses all lines of business associated with damage to property (including theft and loss) and injury to individuals (including disease). Claim payments can be made on either a first-party basis to an affected insured, or on a third-party basis to compensate victims of an insured in tort cases. Although first-party benefits for loss of life are generally within the domain of life insurance, such death benefits may be offered by property-liability insurers in a special context, such as for automobile accident deaths covered by an automobile insurance policy.

Standard Property-Liability Lines. The principal standard lines of property-liability insurance include private passenger and commercial automobile; workers' compensation; medical malpractice, general, professional, and product liability; homeowners, commercial, and farmowners multiple peril; fire and allied lines; inland and ocean marine; and surety and fidelity. In addition, property-liability insurers write a substantial amount of accident and health coverage.

Individual lines of property-liability insurance are often classified as either personal lines, for which the insureds are individuals, or commercial lines, for which the insureds are businesses. Personal lines include private passenger automobile, homeowners multiple peril, as well as personal fire, inland marine, and accident and health

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insurance. Commercial lines include most other property-liability products.

Policy Coverages. For a given line of business, a property-liability policy is often subdivided into one or more coverages—that is, separate components of the policy providing financial protection against different types of risks. For example, an automobile insurance policy usually includes some combination of first-party personal injury coverage (often called personal injury protection, medical, or wage-loss), first-party property damage coverage (often called collision and comprehensive), and third-party bodily injury and property damage coverage. Similarly, a homeowners or commercial multiple peril policy includes both first-party property and third-party liability coverages.

Individual coverages often include restrictions limiting the amount of loss that the insurer will pay to compensate the insured. These restrictions are of three general types: (1) deductibles, which require the insured to pay loss amounts up to a certain level, after which the insurer takes over, (2) limits, which place a cap on the total amount that the insurer will pay, and (3) co-payments, which require the insured to pay a certain percentage of each loss amount, with the balance paid by the insurer. The purpose of deductibles and co-payments is generally to reduce problems of moral hazard (that is, situations in which the presence of insurance provides a financial incentive for the insured to increase risk), whereas the purpose of limits is to protect the insurer from unlimited, and therefore less predictable, losses. However, deductibles are also commonly used to eliminate smaller claims for which the administrative expense of processing the claim comprises a significant portion of the total claim amount.

Coverages Relevant to Electrical and Electronics Firms. Commercial enterprises involved in the development, manufacturing, distribution, or extensive use of computers and other electronic components are exposed to a variety of risks that are different from those of other businesses. Specifically, electronic components may be targets for theft, including employee-related theft, because of their relatively small size and relatively high resale value. Also, electronic components are subject to various hazards associated with their intrinsic nature—that is, heat and atmospheric disturbances, electrical surges, mechanical failure, computer fraud, computer viruses, etc.

In addition to property risks, developers and manufacturers of electronic components face potential liabilities arising from the failure of their products to perform in an expected manner. This type of risk is especially great for firms that produce devices that could have an impact on human mortality or morbidity, such as systems used in surgery and other medical procedures, or by law enforcement and other public safety agencies.

Information technology and the internet are of increasing importance to commercial enterprises, especially data-processing firms. Greater dependence on information technology, however, carries with it increased risks of security breaches, information theft, denial-of-service attacks, and faulty software products.

Many companies still do not have sufficient identity- and information-theft control provisions in their user-authentication and access systems. Wireless networks present especially difficult challenges to businesses, because many are not completely encrypted or otherwise secured. Companies that permit employees to connect to their systems remotely without encryption, as well as those with insecure transactional websites, are particularly vulnerable.

Denial-of-service attacks involve the unauthorized consumption of computational resources (such as bandwidth, disk space, or CPU time), or the disruption of one or more of the following: configuration/routing information, network devices (e.g., websites), electronic mail, and system servers. By sending more requests to a server than it can handle, these attacks can interfere with normal network traffic and legitimate access, sometimes forcing the victim system to discontinue its intended service, at least temporarily. Any business with a significant internet presence is susceptible to such attacks; however, high-profile enterprises are the most likely targets.

Although software-development companies historically have been fairly successful at avoiding substantial product-liability claims, their good fortune eventually may run out. Time-to-market pressures continue to force software developers to lower testing standards, making software failures as common as ever. Given the increasing complexity and pervasiveness of software in all facets of society, the threat of expensive liability actions is very real.

Electrical, electronics, and data-processing firms can avoid or minimize many hazards with appropriate investments in security products and personnel; however, certain risks—especially those involving potential legal liability—are not so easily managed. To finance these risks, companies may choose either traditional insurance or the alternative market. Those electing the former approach often purchase a standard commercial multiple peril policy, which is then endorsed to recognize hazards of particular concern. Relevant hazards include: network and/or website business interruption; identity theft; computer fraud; electronic vandalism/injury to information assets; crisis communication management; cyber/internet media liability; network security and/or privacy liability; and failsafe technology liability.

United States Market. Table 1 presents a breakdown of the property-liability market in the United States among the various standard lines (as of 2005). As is apparent from this table, private passenger and commercial automobile together account for about 44% of the total property-liability market. One reason for the large premium volume of the automobile insurance line is that most states require all motorists to demonstrate financial responsibility through either traditional insurance or self-insurance reserves. Workers' compensation, which accounts for an additional 9–10% of the market, is required of employers in almost all states through traditional insurance, self-insurance, or government funds.

Table 1. The United States Property-Liability Market: Net Written Premiums by Line of Business, 2005

Line of Business	2005 Premiums (in $ 000s)	Percentage of Total Market
Auto liability, private passenger	94,645,760	22.49
Auto physical damage, private passenger	64,922,222	15.43
Auto liability, commercial	19,832,301	4.71
Auto physical damage, commercial	6,946,014	1.65
Workers' compensation	39,734,079	9.44
Medical malpractice	9,734,417	2.31
Other liability	42,664,245	10.14
Homeowners multiple peril	53,013,230	12.60
Commercial multiple peril	29,668,133	7.05
Farmowners multiple peril	2,266,571	0.54
Fire and allied lines	16,125,475	3.83
Inland marine	8,246,499	1.96
Ocean marine	2,946,374	0.70
Surety and fidelity	5,036,344	1.20
Accident and health	9,577,392	2.28
Other lines	15,432,301	3.67
Total	420,791,357	100.0

Source: Authors' calculations based upon National Association of Insurance Commissioners Annual Statement Database, 2005.

Life and Health Insurance

The life and health insurance sector includes lines of business associated with payments for loss of life, injury, and disease on a first-party basis, and frequently encompasses annuity savings plans as well. The pure life insurance market is commonly broken down into three types of products: individual, group, and credit.

Types of Life Insurance Products. Individual life insurance includes traditional whole life, term life, and endowment and retirement income policies, as well as interest-sensitive universal and variable life plans. Although usually purchased by individuals, these products also may be purchased by businesses that depend on the financial earnings of certain key employees. Life insurance offered by fraternal benefit societies is also counted in this category.

Group life insurance is purchased by individuals at a group rate made available through their employer, professional association, labor union, etc. Premiums for the group policy take into account the risk characteristics and operational expenses associated with the group as a whole, and premium payments for individual members (certificateholders) are usually lower than premiums for comparable individual life insurance policies. In employer-based groups, premiums may be paid, at least in part, by the individual's employer. Employees often can retain their life insurance coverage after retirement by paying premiums directly to the life insurance company.

Credit life insurance is purchased by individuals who have incurred debt to finance a major purchase such as a house or an automobile. The credit policy protects both the insured's beneficiaries and the lender by paying off the debt in the event that the borrower dies before the loan is discharged. This type of life insurance can be bought on either an individual or a group basis.

United States Market. Table 2 presents a breakdown of the life insurance market in the United States by amounts of coverage and numbers of policies in force as of 2004.

Table 2. The United States Life Market: Coverage in Force by Type of Product, 2004

Life Insurance in Force	2004	Percentage of Total Market
Face amount ($ millions)		
Individual	9,717,377	55.50
Group	7,630,503	43.58
Credit	160,371	0.92
Total	17,508,252	100.00
Number of policies (000s)		
Individual	167,741	45.01
Group	165,476	44.40
Credit	39,483	10.59
Total	372,700	100.00

Source: American Council of Life Insurance, *2005 Life Insurance Fact Book*, p. 82.

Clearly, individual and group life products together constitute the vast majority of all life insurance.

Other Accident and Health Insurance

As noted earlier, accident and health insurance is written by a variety of insurers other than property-liability and life and health insurance companies. These entities include non-profit health insurers, HMOs, PPOs, and similar healthcare delivery systems. Like life insurance, accident and health coverage may be provided on either an individual or group basis.

INDUSTRY PRACTICES

Company Ownership

An insurance company may have one of a variety of ownership structures: stock, mutual, reciprocal exchange, syndicate, or nonprofit. Stock insurers, like other stock corporations, are owned by shareholders who have purchased common stock and have the right to vote for members of

the board of directors. Mutuals or reciprocal exchanges are owned by their policyholders who elect the directors. (A mutual exists as a formal incorporated entity, whereas a reciprocal exchange is technically just an agreement among its member policyholders.) Syndicates, like those of Lloyd's of London, are owned by groups of investors whose underwriters bid for insurance contracts against other syndicates. Nonprofit insurers operate much as other nonprofit organizations but may be formed in accordance with laws and regulations designed specifically for nonprofit insurance entities.

Company Operations

With regard to business operations, there may also be substantial diversity among insurers within a given market. However, general patterns of institutional practice reveal that all traditional insurers engage in certain operations that are intrinsic to the insurance business. These operations include

1. Writing contracts of insurance, through which the responsibility for financial loss from a random hazard is transferred to the insurer in return for a premium payment made by the insured
2. Complying with insurance regulation, by securing company and agent licenses necessary to sell insurance, by satisfying required solvency standards, and by receiving the approval of policy forms and rates subject to regulatory authority
3. Bearing risk, by taking ultimate responsibility for the payment of random loss amounts that may be substantially greater than premiums collected
4. Underwriting, by selecting a portfolio of insureds with various risk characteristics, where the losses generated by the selected insureds are expected to allow a certain profit given current premium levels
5. Pricing, by selecting premium levels to achieve a certain expected profit given an anticipated portfolio of insureds
6. Claim management, through which reported claims are evaluated to identify appropriate payments and loss reserves; unreported claims are estimated to establish additional loss reserves; paid losses may be offset by salvage and subrogation efforts; and potential fraud is investigated and challenged
7. Financial management, through which the insurer's invested assets are managed to achieve the desired balance between risk and return, subject to regulatory constraints on the types of investments permitted, as well as the need to match investment returns with future loss payments
8. Loss control, by designing products and setting prices to reduce moral hazard and adverse selection, and by working with insureds to prevent and control the variability of losses
9. Administration, through which the various operations of the company are coordinated, and accounting, auditing, and legal functions are carried out
10. Marketing, through which new primary and reinsurance business is generated, and old business is retained, in concert with the marketing efforts of any brokers and independent agents involved in the production of business.

In general, the first six of these operations individually, and all ten operations collectively, characterize a company engaged in the business of insurance. However, some companies, especially those in the alternative market, may contract one or more of the above operations to third-party entities. [See (4).]

Distribution Systems

There are four principal types of distribution systems through which insurance companies sell their products:

1. Insurance brokers, who may arrange insurance transactions between insureds and any insurer in the market
2. Independent agents, who may arrange insurance transactions between insureds and any insurer with whom they have a contractual relationship
3. Captive agents, who carry out the same basic functions as independent agents but have a contractual relationship with only one insurer
4. Direct marketers, who are employees of an insurer and contact insureds directly by telephone, conventional mailings, or the internet.

Uses of Technology

Like other businesses today, insurance companies are rapidly incorporating and expanding the use of computers in their various operations. Especially important in the operations of underwriting and claim settlement departments, computers enable insurers both to tailor their services to the needs of an increasingly complex market and to track and prosecute fraudulent claim activity more effectively than in the past. In addition, computers are critical for the actuarial functions of pricing and reserving, including the implementation of more sophisticated solvency monitoring efforts.

In recent years, the increased use of the internet has enhanced the dissemination of information in the insurance market. Insurers now regularly post summaries of policy options on the world wide web, and some regulators provide pricing and policy availability information for interested consumers.

Beyond the impact of computers, modern electronic technology has also assisted insurers in their loss control efforts, especially with regard to theft. Obvious examples include surveillance systems, which are now more commonly used to prevent crime and apprehend lawbreakers, and satellite tracking systems, which aid in the recovery of stolen automobiles.

ROLE OF GOVERNMENT

The role of government in insurance markets differs greatly from nation to nation and often differs from one line of business to another within a given nation. At one extreme, government may take a *laissez-faire* approach, relying on market forces to set prices and thin the herd of weak insurers. At the other extreme is the establishment of a government monopoly as the sole provider of insurance. In between, there are several dimensions along which government can be more or less active in an insurance market: (1) solvency regulation, (2) rate regulation, (3) market conduct regulation, and (4) government insurance programs.

Government activity may originate at either the national or subnational (i.e., state or provincial) level. In some cases, both national and subnational governments may be involved with regulating, or providing insurance in, a particular line of business. In the United States, most regulation of insurance is carried out by state governments. However, there are also important government insurance programs provided at the federal level.

Solvency Regulation

The goal of solvency regulation is to protect the financial interests of insurance consumers by enhancing the ability of insurers to make good on their obligations to pay claims. This type of regulation is a fundamental activity of insurance regulators throughout the world, and is seen as the principal area for government involvement by several nations of Europe and states within the United States.

Governments have a number of tools at their disposal for regulating the solvency of insurers:

1. Restrictions on licensing, which can be used to require that insurers maintain a certain substantial capitalization level before writing business in a given market, and which can also be used (or abused) to protect currently licensed companies from competition by limiting the number of insurers active in a market
2. Solvency monitoring, which involves the close review of annual financial statements, financial ratios, and recently developed risk-based capital methods (discussed further under Actuarial Issues, below), so that financially weak companies are directed to take prompt action to correct their problems
3. Company rehabilitation, in which regulators take control of the day-to-day operations of an insurer in order to save it as a viable corporate entity
4. Company liquidation, in which regulators take control of the assets and liabilities of an unsalvageable insurer and manage all payments to creditors to make sure that policyholders are treated fairly
5. Guaranty funds, which use assessments of financially healthy insurers to pay the insurance claims of policyholders whose insurers have gone into liquidation (subject to certain prespecified deductibles and limits)

In the United States, the ultimate measure of an insurer's solvency is its surplus (i.e., net worth, or assets less liabilities), as calculated according to the insurance accounting system known as Statutory Accounting Principles (*SAP*). All insurers are required to file annual financial statements with regulators in their state of domicile, prepared on a SAP basis, while stock insurers must also file annual financial (10K) statements with the Securities and Exchange Commission (an agency of the federal government) on a Generally Accepted Accounting Principles (*GAAP*) basis.

Generally speaking, SAP results in a more conservative (lower) calculation of net worth than does GAAP, because SAP (1) requires certain expenses to be debited earlier, and certain recoveries and tax assets to be credited later, (2) imposes restrictions on the discounting of loss reserves as well as on credits for unauthorized reinsurance, and (3) excludes certain nonliquid assets, such as furniture and fixtures. These differences arise from the fact that SAP seeks to measure the liquidation value of an insurer, whereas GAAP measures the value of the insurer under a going-concern model.

Rate Regulation

Although not as universal as solvency regulation, rate (or price) regulation is used extensively by most nations of the world and often relied upon for market stability by developing countries. In the United States, the purpose of rate regulation is two-fold: (1) to protect insurance consumers from excessive or unfairly discriminatory premiums (i.e., discriminatory premiums that cannot be justified by differences in risk characteristics among insureds), and (2) to protect insurers from inadequate premiums that may threaten company solvency.

Most state governments regulate at least some insurance premiums, although the level of regulatory activity generally varies greatly from line to line. Five categories are often used to describe the various levels of rate regulation:

1. Fix and establish, under which the regulator sets insurance premium levels, with input from insurers and other interested parties
2. Prior approval, under which insurers must secure regulatory approval before making any adjustments in premiums
3. File-and-use, under which insurers must notify regulators of premium adjustments by a specified period of time before implementing them in the market
4. Use-and-file, under which insurers must notify regulators of premium adjustments by a specified period of time after they have been implemented
5. Open competition, under which insurers can make premium adjustments without seeking authorization from or providing notification to regulators

Under all of the above systems, regulators generally have the right to challenge—through an administrative or court hearing—premiums that are in violation of applicable rate

regulatory or consumer protection statutes.

In many property-liability insurance markets around the world, rates are established through a bureau or tariff rating system, under which an industry or quasi-governmental agency collects statistical data from many or all insurers and computes manual rates that are then approved by the insurance regulator. Under a system of bureau rating, an individual insurer is often permitted to deviate by a constant percentage from the manual rates based upon the insurer's historical losses and/or expenses. Price competition may also take place through policyholder dividends awarded by insurers to individual insureds. In recent years, state regulators in the United States have sought to reduce the anticompetitive appearance of bureau rating by requiring that, for certain lines of business, expense and profit components be excluded from the calculation of manual rates and filed separately by the individual insurers.

Another governmental tool for addressing issues of insurance pricing, as well as insurance availability, is the establishment of residual markets. These *insurers of last resort* are generally industry-operated entities, commonly taking either of two basic forms: (1) an assigned risk plan, through which hard-to-place insureds are allocated randomly among the insurers writing in a given market, or (2) a joint underwriting association or insurance facility, through which hard-to-place insureds are provided insurance by a pooling mechanism in which all insurers in the market share the risk of these insureds. In some cases, residual markets may be handled through government insurance programs.

Market Conduct Regulation

General oversight of the business relationship between insurers and insureds is the purpose of market conduct regulation. Two areas in which consumers commonly bring complaints to the attention of regulators are (1) the underwriting practices of insurers (e.g., unfair refusals-to-write, refusals-to-renew, or policy cancellations), and (2) the claim settlement practices of insurers (e.g., bad-faith practices).

Under applicable insurance or consumer protection laws, individual consumers may take legal action against an insurer through either an administrative or court hearing. Also, the regulator may bring action against a company based upon either information provided by consumers or the regulator's own examination of the company's business practices.

Government Insurance Programs

In most industrialized nations, governments tend to enter the insurance market reluctantly and usually only when they are convinced that private insurance markets are not capable of providing a line of insurance in a manner that achieves all desired social objectives. Government insurance programs fall into two general categories: (1) residual market programs, and (2) social insurance programs.

Residual Market Programs. In addressing the need for a residual market, the first course of action is usually to create an industry-operated mechanism. However, if this is not feasible or is believed to create economic incentives for inefficiency, then a government may form its own insurance program. In the United States, government insurance programs exist in some states to fill residual market needs for lines such as workers' compensation, medical malpractice, hurricane, and earthquake insurance. At the federal level, a residual market government insurance program exists for flood insurance.

Social Insurance Programs. In developing a strategy for addressing the universal need for healthcare, disability insurance, and retirement pensions, governments often create social insurance programs to which large segments of society must belong. Most industrialized nations of the world (with the United States as a major exception) require their populations to take part in a national health insurance program, supported by premium payments and/or tax revenues. The major social insurance programs in the United States are (1) the Social Security/Medicare program, operated by the federal government, which requires individual workers and their employers to contribute to a central fund that provides pension and medical benefits for disabled workers, retirees, and their dependents, and (2) the Medicaid program, administered by state governments and funded by both the federal and state treasuries, which provides medical benefits to the poorest families and individuals.

ACTUARIAL ISSUES

Actuarial science is the study of the statistical and financial principles underlying the business of insurance. The two principal concerns of professional actuaries are (1) the setting of adequate reserves to maintain an insurer's solvency, and (2) the setting of rates that are competitive, yet adequate to protect solvency. In both of these areas, the work of actuaries is subject to the scrutiny of insurance regulators.

Solvency Issues

Financial Ratios and Risk-Based Capital. The analysis of various financial ratios—for example, the ratio of written premiums (net of reinsurance) to surplus—has been a major component of solvency monitoring by regulators in many nations for many decades. In the United States, the review of financial ratios was formalized by the National Association of Insurance Commissioners (*NAIC*) in its Early Warning System, created in the early 1970s. In the 1980s, this system evolved into the NAIC's Insurance Regulatory Information System (*IRIS*), based upon the calculation of 11 financial ratios for property-liability insurers and 12 financial ratios for life and health insurers [see (5) and (6), respectively].

With a spate of major insurer insolvencies in the late 1980s, the IRIS ratios, as well as the entire system of solvency regulation at the state level, came under sharp criticism. The main statistical criticisms of the IRIS ratios were (1) that the particular ratios used had been chosen subjectively, as opposed to being identified through a formal discriminant analysis of solvent and insolvent insurers, and

(2) that the normal ranges for the individual ratios were also chosen subjectively rather than through a formal statistical procedure.

In the early 1990s, in response to criticisms of IRIS, the NAIC implemented the more sophisticated Risk-Based Capital (*RBC*) system as its primary statistical tool for solvency monitoring [see (7)]. The RBC analysis (modeled after a similar approach applied by the SEC to commercial banks) identifies various categories of risk for insurers and then computes a minimum surplus requirement associated with each category as the product of a specified annual statement item and a subjective factor. The insurer's overall minimum surplus, called the authorized control level RBC, is then calculated as the sum of the individual surplus requirements for the various risk categories, adjusted for correlations among the different risks.

For property-liability insurers, there are four major risk categories:

1. Asset risk—the potential decline in market value of assets
2. Credit risk—the possibility that premiums and reinsurance credits may not be recoverable
3. Underwriting risk—the potential inadequacy of premiums and/or loss reserves
4. Off-balance sheet risk—the potential for adverse outcomes from excessive premium growth and from liabilities not reported in the annual financial statement.

Each of these major categories is further subdivided into smaller categories (e.g., asset risk is partitioned into risk from stocks and bonds, respectively). For life and health insurers, there are also four major risk categories:

1. Asset risk (the same as for property-liability insurers)
2. Insurance risk (comparable to underwriting risk for property-liability insurers)
3. Interest risk—potential losses due to changes in interest rate levels
4. Business risk—the possibility of adverse fortunes generally, and guaranty fund assessments specifically.

As for property-liability insurers, these risk categories are further subdivided.

Under the RBC approach, regulators are authorized to take action (e.g., company rehabilitation) if an insurer's surplus falls below its authorized control level RBC. Moreover, regulators are required to take action if an insurer's surplus falls below 70 percent of this minimum RBC. Outside the regulatory arena, the RBC analysis may be used by insurers, insurance rating agencies, and insureds, as part of a comprehensive evaluation of company solvency.

By clearly identifying and attempting to quantify the various sources of risk confronting an insurance company, the RBC approach provides a clear improvement over the more primitive IRIS. However, as with IRIS, there are subjective elements—that is, the factors associated with the various risk categories—that call into question the statistical accuracy of RBC methods for predicting insurer insolvencies.

Theory of Risk. The mathematical theory of risk addresses the solvency of an insurance entity more abstractly than does the empirical study of financial ratios or RBC. This approach benefits from mathematical rigor, but usually at the expense of ignoring all categories of risk other than those associated with insurance premiums, losses, and financial returns.

The focus of risk theory is the statistical behavior of an insurer's surplus over some period of time. Risk-theoretic analyses may generally be divided into two basic types: (1) finite horizon models, and (2) infinite horizon models. [See, for example, (8), pp. 27–49, 367–434.]

Finite Horizon Models. In the finite horizon approach, one considers the statistical behavior of an insurer's surplus at the end of a fixed, short interval of time $[0, t]$ (e.g., one year). Ignoring the impact of insurer expenses and investment income, this final surplus may be written as

$$S(t) = S(0) + P(t) - L(t) \tag{1}$$

where

$S(0)$ denotes the initial surplus at time 0
$P(t)$ denotes the total premiums collected in $[0, t]$ and
$L(t)$ denotes the total losses incurred in $[0, t]$

In the simplest case, one would consider an insurer that provides insurance to n homogeneous insureds, $i = 1, 2, \ldots, n$, and one would assume that both $S(0)$ and $P(t)$ are nonstochastic.

Given these assumptions, the stochastic behavior of the final surplus, $S(t)$, depends entirely on the total losses, $L(t)$. These total losses can be modeled using either of two approaches: (1) the individual risk model, or (2) the collective risk model. Under the individual risk model,

$$L(t) = \sum_{i=1}^{n} X_i \tag{2}$$

where the X_i are independent and identically distributed *(i.i.d.)* random variables denoting the losses of the individual insureds i during $[0, t]$, and X_i is equal to 0 if insured i does not generate a loss. Under the collective risk model,

$$L(t) = \sum_{j=1}^{N} X_j \tag{3}$$

where N is a random variable denoting the total number of losses incurred during $[0, t]$ (without regard to which insureds generated the losses), and the X_j are i. i. d. random variables denoting these individual losses.

Using either an individual or collective risk model, one can study the probability distribution of $S(t)$, with particular attention to the finite horizon probability of ruin (or insolvency),

$$\begin{aligned} \psi_t(s) &= Pr\{S(t) \le 0 | S(0) = s\} \\ &= Pr\{S(0) + P(t) - L(t) \le 0 | S(0) = s\} \end{aligned} \tag{4}$$

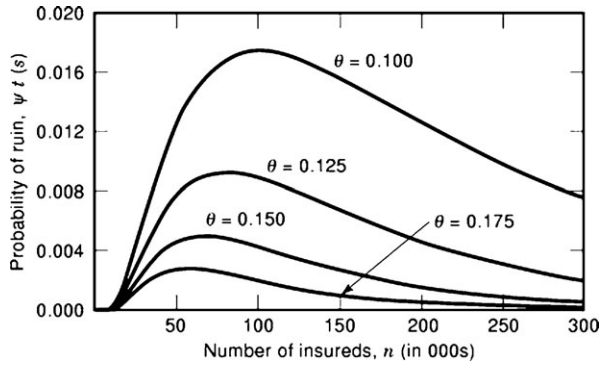

Figure 1. Finite horizon ruin probability versus number of insureds.

In general, the availability of analytical forms for this probability will depend largely on assumptions regarding the distribution of the individual losses (X_i or X_j), the mutual independence of these losses, and the distribution of N (under the collective risk model).

Without making distributional assumptions about the X_i, one can use the individual risk model (with i. i. d. losses) to rewrite the ruin probability as

$$\begin{aligned}\psi_t(s) &= Pr\left\{s + n(1+\theta)\mu - \sum_{i=1}^{n} X_i \le 0\right\} \\ &= Pr\left\{\overline{X} - \mu \ge \frac{s}{n} + \theta\mu\right\}\end{aligned} \tag{5}$$

where

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

$$\mu = E[X_i]$$

and $\theta > 0$ denotes the insurer's profit loading expressed as a proportion of expected losses.

It then follows from the right-hand side of Eq. (5) that, for any fixed value of n, the ruin probability is monotonically decreasing over both s and θ, and that $\psi_t(s) \to 0$ as either $s \to \infty$ or $\theta \to \infty$. Moreover, from the weak law of large numbers, it can be seen that, for fixed values of s and θ, $\psi_t(s) \to 0$ as $n \to \infty$.

This last result—that the probability of ruin approaches zero as the number of insureds goes to infinity—is often used to argue that writing more policies increases stability, and is therefore always beneficial to the insurer. However, this conclusion is not always correct. For example, if one assumes that $X_i \sim N(\mu, \sigma^2)$, so that

$$\begin{aligned}\psi_t(s) &= Pr\left\{s + n(1+\theta)\mu - \sum_{i=1}^{n} X_i \le 0\right\} \\ &= \Phi\left(-\frac{\theta\mu}{\sigma/\sqrt{n}} - \frac{s/n}{\sigma/\sqrt{n}}\right)\end{aligned} \tag{6}$$

it can then be shown that $[\partial\psi_t(s)]/\partial n > 0$ for $n < s/\theta\mu$. See Fig. 1 for plots of $\psi_t(s)$ against n for several values of θ, given the hypothetical parameter values s = 10,000,000, μ = 1,000, and σ = 30,000.

Infinite Horizon Models. In the infinite horizon case, one treats the insurer's surplus as a stochastic process over an unbounded interval of time. Again, ignoring the impact of insurer expenses and investment income, the surplus may be written exactly as in Eq. (1), except that t becomes arbitrary. Because of the infinite horizon, one must now consider the probability distribution of the time until ruin,

$$T = \inf[t : S(t) \le 0\} \in (0, \infty] \tag{7}$$

In much of the risk-theoretic literature, special attention is paid to the infinite horizon probability of ruin,

$$\psi(s) = Pr\{T < \infty\} \tag{8}$$

In the last century, H. Cramér and F. Lundberg employed a collective risk model for total losses, assuming that

$$L(t) = \sum_{j=1}^{N(t)} X_j \tag{9}$$

where $N(t)$ is a homogeneous Poisson process with parameter λt. With respect to total premiums, they assumed further that

$$P(t) = (1+\theta)\nu\lambda t \tag{10}$$

where $\nu = E[X_j]$. Given these assumptions, the following basic result was obtained:

$$\psi(s) = \frac{e^{-Rs}}{E[e^{-RS(T)} | T < \infty]} \tag{11}$$

where R is the *adjustment coefficient,* that is, the unique positive solution of the equation

$$1 + (1+\theta)\nu R = E[e^{RX_j}] \tag{12}$$

Several additional well-known results related to Eq. (12) include

1. $$\lim_{s\to\infty} e^{Rs}\psi(s) = \text{constant} \tag{13}$$

2. $$\psi(s) = \frac{1}{1+\theta}\exp\left[-\frac{\theta s}{(1+\theta)\nu}\right], \text{ when } X_j \sim \text{Exponential}(1/\nu) \tag{14}$$

3. $$\psi(0) = \frac{1}{1+\theta} \tag{15}$$

[See, for example, (8), pp. 399–434 and (9), pp. 1–8.]

The risk-theoretic literature provides generalizations and extensions of the basic infinite horizon model discussed above, with particular focus on the joint distribution of the X_j and $N(t)$. In recent decades, substantial effort has been made to incorporate the stochastic effects of premiums and investment income into the infinite horizon model, often through the use of diffusion processes [see (9) and (10)].

Pricing Issues

For a given line of business with n (not necessarily homogeneous) insureds, the average insurance premium for a

specified policy period is given by the following equation:

$$P = \frac{1}{n} E\left[\sum_{i=1}^{n} X_i + C\right] \tag{16}$$

where

P denotes the average premium over the n insureds
X_i denotes the loss associated with insured i, for $i = 1, 2, \ldots, n$ and
C denotes total profit and expenses

Apart from corporate income taxes, insurance company expenses may be broken down into three major categories: (1) those that are proportional to premiums, including agent/broker commissions and state premium taxes, (2) those that are proportional to losses, including some claim settlement expenses, and (3) those that are fixed, including general operating expenses, as well as some marketing and claim settlement expenses. Therefore, the total profit and expense component, C, may be expressed as

$$C = \epsilon_P nP + \epsilon_L \sum_{i=1}^{n} X_i + F + \pi nP \tag{17}$$

where

ε_P denotes the loading for expenses proportional to premiums
ε_L denotes the loading for expenses proportional to losses
F denotes total fixed expenses and
π denotes the pretax underwriting profit loading

Substituting Eq. (18) into Eq. (17) then yields

$$P = \frac{E\left[\overline{X}\right](1 + \epsilon_L) + \frac{F}{n}}{1 - \epsilon_P - \pi} \tag{18}$$

where

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

Generally speaking, the estimation of the expense parameters—ε_P, ε_L, and F—is fairly straightforward using historical accounting data. However, the estimation of the expected average loss, $E[\bar{X}]$, and the determination of an appropriate underwriting profit loading, π, require more sophisticated statistical and financial methods, respectively.

Expected Average Loss. The expected average loss amount, often called the pure premium in property-liability insurance and the net premium in life insurance, can be expressed as the product of two factors: (1) a frequency rate, reflecting the expected rate of loss occurrences per unit of risk, and (2) a severity amount, reflecting the expected loss amount per loss occurrence.

Exposure Unit. In life and health insurance, the basic unit of risk, or exposure unit, is essentially one human life. However, exposure units vary widely across property-liability lines, from individual vehicles in automobile insurance, to an employer's payroll in workers' compensation insurance, to square-footage, gross receipts, and various other measures in general liability insurance.

The choice of a particular exposure unit for a given line of business is based upon several considerations:

1. A strong relationship between the exposure unit and loss potential (i.e., the more exposure units, the greater the expected total loss)
2. Ease of identifying and verifying the number of exposure units for a given insured
3. Sensitivity of the exposure unit to changes in the expected total loss over time (often meaning sensitivity to inflation)
4. Consistency with historical practice, so that collected data retain their utility over time

Estimation and Credibility. Frequency rates and severity amounts are estimated by a variety of statistical methods. In life insurance, the frequency rate is usually a probability of death, given by the human mortality curve, and the severity amount is often a fixed benefit level, or a benefit level that earns interest over time. In property-liability insurance, however, frequencies and severities must be estimated based upon historical data from a limited (and often small) number of exposure units.

Once estimated, the frequencies and severities may have to be combined with estimates from other data sources. This is especially true in commercial property-liability insurance and group life and health insurance, where the premiums for large insureds are often calculated using both the individual account's experience and the insurer's entire portfolio. In such cases, actuaries use credibility methods to take weighted averages of the alternative estimates.

Traditionally, actuaries have often used the *ad hoc* limited fluctuation credibility technique in which a minimum portfolio size was established based upon a requirement that the actual value of the frequency (or pure premium) be within a certain percentage of its expected value with a specified confidence level. If the minimum portfolio size were met by the data underlying an estimate, then the estimate would be said to have full credibility, and all other estimates would be ignored; if this criterion were not met, then the estimate would be combined with another estimate using a weighting scheme based solely upon the original portfolio size, with no regard for the relative accuracy of the alternative estimate. In recent years, however, more rigorous minimum mean squared-error techniques, often in a Bayesian or empirical Bayes framework, have become more popular [see, for example, (11), pp. 59–114].

Underwriting Profit Loading. Historically, property-liability insurance companies and their regulators have determined insurer profitability through the use of informal underwriting profit loadings, without explicit recognition of investment income and corporate income taxes. In the United States, profit loadings of 5%, 6%, and 2.5% of premiums have commonly been used in automobile, homeowners, and workers' compensation insurance, respectively. Although these types of *ad hoc* profit loadings

are still used as guidelines in many jurisdictions, it is generally recognized that they are without analytical support.

Over the past thirty-five years, primarily as a result of rate litigation between insurers and regulators in the United States, a number of more rigorous financial methods for establishing the underwriting profit loading have been proposed.

Return on Underwriting. In the 1970s, regulators in Massachusetts adapted the Capital Asset Pricing Model (*CAPM*) of financial theory to the analysis of automobile and workers' compensation insurance. Specifically, the CAPM was used to estimate the expected return associated with the systematic risk of the underwriting results from these two lines [i.e., the results from just the insurance part of the business, without regard for investment returns; see (12)].

Taking this approach, one is able to solve for the underwriting profit loading as follows:

$$\pi = -k(1-x)\left(\frac{1-t_I}{1-t_U}\right) r_f + \beta_U \{E[r_m] - r_f\} + \left[\frac{t_I}{(1-t_U)(P/S)}\right] r_f \qquad (19)$$

where

k denotes the average time lag from receipt of premium to payment of claim, for the given line of insurance

x denotes the ratio of total expenses to premiums

t_I denotes the effective corporate income tax rate on investment income

t_U denotes the effective corporate income tax rate on underwriting profit

β_U denotes the sensitivity of the insurer's underwriting results to stock market returns

r_m denotes the return of the stock market for the future period

r_f denotes the "risk-free yield" and

P/S denotes the ratio of the insurer's net written premiums to surplus

To implement the expression in Eq. (21), it is necessary to estimate a variety of model parameters from historical financial data. The most difficult parameter to estimate is β_U, whose computation involves certain theoretical and practical difficulties [see, for example, (13), pp. 43–44]. Nevertheless, this approach has been used in rate regulation in Massachusetts and other jurisdictions and has received generally favorable support from insurance scholars.

Total Return. The CAPM may also be used to estimate the expected return associated with the systematic risk of the total results from a given line of business (i.e., the underwriting results plus investment results). Using this approach, one obtains a different expression for the underwriting profit loading:

$$\pi = \frac{r_f + \beta_S\{E[r_m] - r_f\} - (1-t_I)E[r_A](A/S)}{(1-t_U)(P/S)} \qquad (20)$$

where

β_S denotes the sensitivity of the insurer's total results to stock market returns

r_A denotes the return on the insurer's invested assets for the future period and

A/S denotes the ratio of the insurer's invested assets to surplus

As in Eq. (21), several parameters must be estimated from historical data, the most difficult of which are the beta parameter, β_S, and the expected yield on invested assets, $E[r_A]$ [see, for example, (14), p. 529].

The total return analysis has been applied in a number of jurisdictions and is very similar to the type of analysis used in public utility rate regulation. It should also be noted that the total return approach may be carried out using a discounted cash-flow model in which the relationship between stock prices and shareholder dividends is used to estimate the expected total return for a given line of business.

Other Financial Models. Two other financial models that have been proposed for insurance pricing are the Arbitrage Pricing Model (*APM*) and the Option Pricing Model (*OPM*). However, both of these approaches suffer from serious drawbacks that make them currently unsuitable for most rate regulatory forums. Specifically,

- The APM, which is a generalization of the CAPM, presents substantially more parameter estimation problems than does the CAPM
- The OPM, although theoretically elegant, suffers from generally unrealistic distributional assumptions regarding the underlying portfolio of insurance losses

[See, for example, (13), pp. 89–91.]

Rating Factors. Once the average premium is calculated for a given line of business, it is often necessary to compute appropriate individual premiums for insureds with different risk characteristics. These premiums are calculated using a system of rating factors, or relativities, that reflect, either multiplicatively or additively, the risk differentials associated with various characteristics.

Rating factors in life and health insurance include such characteristics as age, gender, and previous medical history. Like exposure bases, they vary considerably from one line of property-liability insurance to another. For example, rating factors include age, gender, geographical territory, and driving history in automobile insurance, and various employment codes in workers' compensation insurance.

The selection of rating factors must take into account the following considerations:

1. Statistical issues, including the predictive accuracy of the factors, the homogeneity of insureds possessing a given factor, the availability of data for individual

factors, and the stability of the factors over time
2. Operational issues, including the ease of identifying and verifying the factors associated with an insured
3. Social and fairness issues, including the maintenance of privacy despite the disclosure of factors, the assurance of a causal relationship between the factors and risk, and the ability of responsible insureds to control and modify their factors
4. Legal issues, including whether or not a factor discriminates among individuals or businesses in a manner that is prohibited by constitution, statute, or regulation

Market Equilibrium. The most serious shortcoming of the insurance pricing literature is its failure to consider fully the impact of the market demand curve. It is important to note that all of the actuarial and financial methods mentioned above—as well as all variations of those methods in common use—simply compute equilibrium under an assumption of inelastic demand. Thus, from the perspective of insurers and regulators involved with issues of insurance pricing, competitive equilibrium remains largely a theoretical construct.

The lack of attention to market demand results partly from the fact that the two lines of insurance that have generated the most controversy with regard to insurance pricing—automobile and workers' compensation—are mandatory coverages in many jurisdictions. Thus, at least for these two lines, an assumption of inelastic demand may not be that unreasonable.

REINSURANCE MARKETS

Like their insureds, insurance companies often desire to cede responsibility for their financial losses to another party; this type of risk transfer is known as reinsurance. The four principal motivations for an insurer to seek reinsurance are

1. To limit the insurer's exposure to catastrophic losses
2. To smooth underwriting and operational results over time
3. To enable the insurer to write new or additional business for which it does not currently have sufficient capacity (i.e., surplus)
4. To enable the insurer to profit from fronting arrangements with reinsurers, in which the primary insurer provides the written policy, but the reinsurer assumes all or most of the risk

To satisfy these objectives, reinsurance markets operate throughout the world, offering a variety of risk transfer arrangements to primary insurers.

Reinsurance arrangements may be divided into either of two types: (1) facultative agreements, in which the primary insurer cedes losses from only one insured to the reinsurer, subject to certain restrictions, and (2) treaty agreements, in which the primary insurer cedes losses from broad portfolios of insureds to the reinsurer, subject to certain restrictions.

The restrictions on losses ceded, under both facultative and treaty programs, fall into three further categories: (1) quota-share or proportional coverages, in which the primary insurer retains responsibility for a fixed percentage of all primary losses, and the reinsurer covers the balance, (2) excess-of-loss coverages, in which the primary insurer retains responsibility for loss amounts up to a specified level for each loss occurrence, after which the reinsurer takes over, and (3) stop-loss coverages, in which the primary insurer retains responsibility for loss amounts up to a specified level on an aggregate loss basis, after which the reinsurer takes over.

ALTERNATIVE RISK-FINANCING

Over the past four decades, various methods of alternative risk-financing have flourished throughout the world. By some accounts, the alternative property-liability market now captures as much as one-third of total commercial property-liability premiums. More recently, a new type of risk-financing mechanism has emerged: insurance-based securities.

Alternative Market

The alternative property-liability market includes three principal types of risk-financing entities: (1) captive insurers, which are formal insurance subsidiaries formed primarily to finance the risks of their owners, (2) risk retention groups, which are groups of insureds with similar risk exposures who join together to form an insurance or risk-pooling arrangement, and (3) self-insurers, who establish formal internal mechanisms to reserve for future losses.

Alternative market entities have offered several important advantages to insureds, most of which derive from the ability of these mechanisms to focus on a limited number of risk types:

1. Reduced underwriting expenses
2. More accurate (and presumably more favorable) expected loss estimates
3. Enhanced loss prevention and reduced potential for adverse selection and moral hazard
4. Direct control of investing unearned premium and loss reserves
5. More efficient claim settlement

Insurance-Based Securities

As a result of major insurance losses from Hurricanes *Hugo* (1989) and *Andrew* (1992), the decade of the 1990s witnessed the emergence of a new alternative to traditional insurance and reinsurance products: insurance-based securities. These financial instruments appeared in two forms: property catastrophe derivatives (financial options and futures based upon insurance industry losses), and catastrophe bonds (corporate bonds in which the principal and/or interest payments are restructured in the event of a catastrophe). The primary motivation for the development of these securities was the belief that the demand for greater

capacity in some lines of business (e.g., property catastrophe insurance and crop insurance) could attract the capital of investors wishing to specialize in risk bearing without taking on any of the other operational risks of the insurance enterprise.

Although highly touted as an inexpensive alternative to reinsurance, catastrophe derivatives were traded only briefly by the Chicago Board of Trade and the Bermuda Commodities Exchange before dying out completely. Even the subsequent multi-billion-dollar insured losses from the attacks of September 11, 2001 and Hurricane *Katrina* (2005) have failed to rekindle interest in this area. The catastrophe-bond market has met with substantially more success, but still remains rather limited in scope, and has not significantly altered the overall landscape of the insurance/reinsurance business.

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MICHAEL R. POWERS
PIYAWADEE KHOVIDHUNKIT
The Fox School of Business and Management, Temple University, Philadelphia, PA
School of Applied Statistics, National Institute of Development Administration (NIDA), Bangkok, Thailand