European Approaches to Insurance Solvency

Biography

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Abstract

A "balance sheet" approach is used by American regulator to evaluate the financial strength of Property/Casualty insurance companies. Leverage ratios, adverse development, and income statement results are drawn from Annual Statements to examine solvency. This approach relies on ad hoc rules of thumb, makes little distinction between insurers or lines of business, and provides no quantitative connection between the ratios and the chance of insolvency.

The British and Finnish Solvency Working Parties use an "emerging costs" approach to insurance solvency. All elements that affect an insurer's financial strength, such as asset values, underwriting income, investment income, loss reserve estimates, and reinsurance recoverables, are incorporated in a cash flow simulation model to project the likelihood that the insurer will not be able to meet its payment obligations. The emerging costs approach quantifies the probability of insolvency and allows the actuary to examine alternative scenarios, such as the effects on insolvency of different investment strategies.

The balance sheet approach is simple: each insurer receives an IRIS scorecard, not the results of actuarial assumptions and a simulation model. The British and Finnish Solvency Working Parties recommend that an actuarial report be provided with the simulation results, to explain the model in lay terms. The challenge for American actuaries is to synthesize the theoretical accuracy of the European approach with the clarity needed for state regulation.

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Section I: Introduction

Financial solvency is of paramount concern to the insurance industry. Insolvencies of non-insurance firms affect primarily investors, but insolvencies of insurance firms affect consumers as well. Sophisticated investors are rewarded through higher expected returns for the risks of uncertain investments. The unwary public harmed by insurance failures, such as policyholders and claimants, must rely on government financial examinations for protection.[1]

It is difficult to evaluate insurance solvency. Loss reserve adequacy, reinsurance collectibility, and reserve "equities" are not apparent from published financial statements. They are estimated by company actuaries and rating agency analysts; consumers and regulators have few objective means to verify these estimates.

Government regulators examine the financial soundness of insurance companies, both in the U.S. and abroad. American regulators use a balance sheet approach, examining items like premium to surplus ratios, reserves to surplus ratios, adverse loss development, surplus relief reinsurance, and overdue and unauthorized reinsurance. These measures may be supplemented by earnings statement items, such as combined ratios, operating ratios, and investment yields.

The European actuaries associated with the British Solvency Working Party and the Finnish Solvency Working Party recommend an alternative approach to solvency valuation. Solvency

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[1] Compare Daykin, et al. [1987], page 237: "The insurance policyholder purchases a product that involves a promise which is to be met in the future in monetary terms. Buyers of other goods and services, outside the financial field, do not generally suffer major financial loss from the insolvency of a company, which in such cases primarily affects shareholders, creditors, management and employees. It is the nature of the promise built into the insurance product, and its impact on unconnected third party claimants, that ensures that there will be public interest in the financial soundness of insurance companies and that governments will feel the need to regulate the industry." American regulators similarly emphasize solvency concerns. See Brock [1990], page 288: ". . . *solvency regulation . . . is the preeminent regulatory* function"; Mayerson [1965], page 51: ". . . solvency is the main aim of insurance supervision"; and Pomeroy [1990], page 23: "What are the state regulators' duties? Regulating solvency is their essential function."

implies that existing cash, together with future cash inflows, will cover future cash outflows. Since both inflows and outflows are uncertain, a solvency examination must estimate the likelihood that the inflows will suffice for the outflows. The British and Finnish Working Parties use cash flow simulation to model this "emerging costs" view of solvency.

The emerging costs view of solvency, with its emphasis on simulation, cash flows, economic scenarios, and consideration of both assets and liabilities, is similar to the SOA valuation actuary concept, though it has had little influence yet on American Property/Casualty work. This paper introduces the British and Finnish perspective to the CAS literature, so that casualty actuaries can apply this approach to American problems.

Section II: The Measurement of Solvency

Financial Institutions versus Other Firms

A firm is considered insolvent when it can not meet its obligations. Its creditors may force the firm to meet its payments, reorganize, or be liquidated.

Lenders and suppliers are sophisticated investors. If lenders believe the firm may encounter financial difficulties, they will charge high interest rates, if they lend at all, and suppliers will demand quick payment terms. The risk premium in the interest rate compensates for the losses of default, and the quick payment terms mitigate the losses to suppliers. The government has no need to further regulate the transactions.

Financial institutions are different. The insolvency risk is faced by consumers – depositors at banks and policyholders at insurers. Consumers receive no "default risk premium" to compensate for the risk of insolvency. Moreover, payment lags are so long for life insurers and Commercial Lines Property/Casualty insurers that the insurer may have a negative net worth years before it defaults on its obligations.

The Balance Sheet Approach

So governments regulate insurance company solvency. American regulators use a "balance sheet" approach: an insurer is insolvent when its statutory surplus dips below its minimum required capital. If statutory surplus were no less than economic net worth, the usefulness of this measure would depend on the size of the required capital and the fluctuations in surplus. Since minimum required capital levels are low (see Danzon [1983] and Klein [1986], page 86), and fluctuations in both asset and liability levels are high, an insurer with economic net worth just exceeding required capital faces a high probability of being unable to meet future payments.

Conservative statutory accounting principles circumvent this problem. Statutory surplus is lower than economic net worth, since reserves are held at undiscounted values, there is no recognition of deferred acquisition costs, and many assets are not admitted on the statutory balance sheet. The additional margin between surplus and net worth provides a solvency cushion.

Three problems limit the usefulness of this measure.

1. Statutory accounting is not always conservative. For instance, unrealized capital gains are not offset by deferred federal income taxes on statutory statements, and bonds in good standing are held at amortized value even when their market value falls.

2. This measure does not differentiate among firms or lines of business. Some insurers have conservative loss reserves; some have inadequate reserves. Long tailed lines have a large unrecognized interest discount in the loss reserves; short tailed lines have a smaller implicit discount.

3. This measure has no explicit relationship to solvency. If statutory surplus is $10 million greater than economic net worth for a certain insurer, does this suffice for solvency?

The Emerging Costs Approach

The "emerging costs" approach to solvency, as proposed by the British and Finnish Working

Parties, says: "An insurer is solvent if the probability that it can not meet its payments for its current business is below a certain level." This definition depends on three elements: the probability level, the current business, and the method of quantification.

1. *Probability Level:* Since insolvencies harm consumers, the probability level should be low. If it is too low, however, the additional capital required by insurers would raise premium levels or curtail insurance availability, which also harm consumers (Hartman et al. [1992]) and would provide insufficient returns to investors (Cody [1988]). The optimal probability level must be judgmentally selected.

2. *Current Business:* If the solvency examination were done daily, and the results were reported immediately to regulators, it would be sufficient to examine just the existing liabilities. In practice, a solvency examination would be done annually. Examination lags, reporting delays, and the time needed for remedial action mean that results will be acted upon months later. Thus, the "current business" comprises both in force business and insureds written during the next year or two.

3. *Method of Quantification:* A closed form mathematical solution is not feasible for an emerging costs projection of insurance solvency. Instead, the British and Finnish Working Parties use cash flow simulation models, along with actuarial assumptions and statistical distributions for each variable in the model.

Scorecards and Reports

The simplicity of the American balance sheet approach appeals to non-technical analysts. Failing and passing grades may be assigned to each financial test. For instance, an insurer fails the first NAIC Insurance Regulatory Information System (IRIS) test if the ratio of written premium to policyholders' surplus exceeds 300%. The number of IRIS tests failed becomes a scorecard for the insurer (see NAIC [1989]).

The emerging costs approach demands a sophisticated understanding of the risks of insurance operations, as well as familiarity with economic scenarios and simulation models. The regulator must check that the actuarial assumptions are reasonable and that the statistical work is accurate. An actuarial report must accompany the model to explain the assumptions and

results in non-technical terms.

There is no inherent flaw in simplicity. But if the simple scorecard does not reflect an insurer's true financial strength, it serves little purpose. The emerging costs approach provides a sophisticated but complex measure of an insurer's condition. The challenge for American actuaries is to mold this approach into a clear, non-technical report that may be used for solvency examinations.

Section III: The Balance Sheet Approach

The "balance sheet" approach to Property/Casualty insurance solvency uses statutory accounting principles to conservatively measure an insurer's financial condition. It then tests that condition by examining balance sheet and earnings statement ratios. This section briefly describes the balance sheet approach and its problems for regulating solvency. The subsequent sections discuss the emerging costs approach.

Statutory and GAAP Accounting

Statutory accounting principles (SAP) for insurance enterprises differ from generally accepted accounting principles (GAAP) in two ways. First, SAP emphasizes company solvency and balance sheet strength, whereas GAAP emphasis the accuracy of the earnings statement and the matching of revenues and expenses (Berthoud [1988]). For instance, office furniture is a non-admitted asset under SAP, since its liquidation value is small. GAAP values office furniture at original cost less depreciation, to estimate its "value in use."

Second, some SAP principles serve the particular needs of the insurance industry. Only by happenstance are they more or less "conservative" than GAAP. For instance, bonds in good standing are valued at amortized cost, instead of being marked to market. This practice began in the 1930's to smooth earnings statement fluctuations that would result from "temporary" changes in interest rates. GAAP amortizes fixed income securities only if the decline in value is truly temporary (AICPA [1990], chapter 8).

Conservatism in Statutory Accounting and Regulations

There are several principle areas of conservative statutory accounting practices. These seek to ensure a company's solidity while accurately portraying its financial performance.

1. *Loss Reserve Discounting:* Loss and loss expense reserves are generally shown at undiscounted values in financial statements. [Two exceptions are the tabular discount allowed on Workers' Compensation lifetime pension cases and the discounting permitted for certain single-state Medical Malpractice carriers.[2]] The excess of full value reserves over discounted reserves is an implicit safety margin.[3]

2. *Deferred Acquisition Costs:* In statutory accounting for Property/Casualty insurance, underwriting and acquisition expenses are written off when they are incurred, and 100% of the unearned portion of the premium is shown as a liability.[4]

3. *Invested Assets:* State statutes restrict the types and amounts of insurance company investments (Kimball and Denenberg [1968]). Property/Casualty financial portfolios consist predominately of investment grade government and corporate bonds.

   One statutory approach for conservative asset valuation is to require a Mandatory Securities Valuation Reserve (MSVR, or Asset Valuation Reserve, AVR). Life insurers, for instance, have significant amounts of high yield bonds, mortgages, private placements, and real estate.

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[2] Yow, et al. [1990]. Some jurisdictions allow greater discounting; see, for instance, the Massachusetts Insurance Code, §12, "Computation of Reserves of Liability Companies," paragraph 2: "For all compensation claims under policies written more than three years prior to [the Statement] date, the present values at four per cent interest of the determined and the estimated future payment."

[3] Lowe and Philbrick [1986] estimate the implicit margin at 15% of reserves. GAAP also uses undiscounted values for loss reserves, though recent AICPA statements suggest a movement toward discounted values (AICPA [1983]; FASB [1990]). The 1986 Tax Reform Amendments require discounted loss reserve estimates (Almagro and Ghezzi [1988]; Gleeson and Lenrow [1987]). The NAIC Risk Based Capital Working Group is considering the use of discounted loss reserves to measure capital requirements (Laurenzano [1991A]; Goodfriend, Turberg, and Kavanaugh [1991]; Kaufman and Liebers [1992]).

[4] See Morgan [1988]. GAAP capitalizes and amortizes insurance expenses that are "primarily related to the acquisition of new and renewal policies" (FASB [1982]).

They carry an MSVR as a balance sheet liability, which requires annual additions that vary by type of security. American Property/Casualty insurers require no MSVR.[5]

4. *Other Assets:* Many non-liquid and uncertain assets are not admitted in statutory balance sheets. Examples of non-liquid assets are office furniture and equipment. Examples of uncertain assets are agents' balances over 90 days due, recoverables from unauthorized reinsurers, and 10% of accrued but not collateralized retrospective premium (McKinnon [1988], pages 52-53; NAIC [1990A], page 9-1).

5. *Policyholders' Surplus:* The first NAIC IRIS test examines the relationship of net written premium to policyholders' surplus; a ratio above 300% causes a failure of the test (NAIC [1989]). The A. M. Best Corporation and many state insurance departments examine various "reserves to surplus" leverage ratios as well (Best's [1991C], pages xiii-xiv).

The current NAIC IRIS tests illustrate a balance sheet approach to insurance solvency with implicit margins. The implicit margins are the differences between the statutory valuation of an asset or liability and its economic worth. For instance, the difference between the statutory "full value" loss reserve and the discounted loss reserve is the implicit margin. The NAIC Risk Based Capital Task Force will replace some of the implicit margins with explicit margins, but it retains the balance sheet approach to insurance solvency. For instance, the solvency examiner may begin with discounted (or partially discounted) loss reserves, but incorporate an explicit margin for reserving risk.

Criticisms of Statutory Accounting

The weaknesses of the balance sheet approach to insurance solvency are of two types. First, the conservatism in statutory accounting is a poor protector of solvency. This conservatism is sometimes too restrictive and sometimes too liberal; it is inexact and ad hoc; and it is often

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[5] The NAIC Risk Based Capital Working Groups are leaning towards an MSVR type capital requirement that would be the same for life and Property/Casualty insurers. See Steinig [1991], Part II, Section 1, page 2: "The intention of the subcommittee is that C-1 formula factors are consistent with those for the annual statement Asset Valuation Reserve (AVR or, formerly, MSVR)." Some life actuaries are now proposing more sophisticated asset margins (Sega [1986]; Vanderhoof, Albert, Tenenbein, and Verni [1988]; Auger, Cabanilla, Reiskytl, and Roth [1991]). Canada requires an MSVR for Property/Casualty insurers (Clark and Oakden [1988], pages 346-347).

counter to economic forces. Second, the balance sheet approach does not measure the actual chance of insolvency. There is no explicit, quantitative link between conservative accounting and solvency measurement.

The first set of criticisms of SAP conservatism may be grouped into three categories.

1. *Excessive and Restrictive versus Insufficient:* State regulations and accounting practices may be too restrictive for some insurers and too liberal for others. For short-tailed lines of business in a low interest rate environment, the unrecognized interest discount in full value reserves is small. Holding undiscounted reserves may be viewed as a "provision for adverse deviations in loss reserve adequacy." For long-tailed lines of business, however, full value reserves greatly exceed discounted reserves, particularly when interest rates are high. Not recognizing the interest discount may lead to overcapitalization and impede the performance of the insurance enterprise.

   Investment portfolio composition illustrates the restrictiveness of some state statutes. Investment grade fixed income securities are held at amortized values, thereby masking any fluctuations in market values. Fluctuations in the value of equities, such as common stocks and real estate, are not protected by statutory accounting. State statutes prohibit certain real estate investments, and insurers concerned about smooth annual earnings avoid some stock investments. These restrictions discourage otherwise economically sound investment strategies.

2. *Ad Hoc and Inexact:* The 3 to 1 premium to surplus ratio used in the NAIC IRIS tests derives from the "Kenney rule," which originally recommended a 2 to 1 ratio for fire insurance (Kenney [1967]). The simplicity of this test has contributed to its longevity, particulary in contrast to the complexity of some "probability of ruin" analyses (see, for instance, Beard, Pentikäinen, and Pesonen [1977]). Best's used a ratio of 2.8 in 1990 and 2.0 in 1991 (Best's [1990; 1991C]). No explicit justification for these ratios has been offered.

   The "revenue offset" provision of the 1986 Federal Tax Amendments provides another illustration of simplicity overriding accuracy. The Internal Revenue Code mandates that 20% of the unearned premium reserve not be a deduction to taxable income, since it represents the "deferred acquisition cost" equity. The industry average ratio of acquisition

expenses to written premium varies by line of business, ranging from 13% in Workers' Compensation to 37% in Fire Insurance (Best's [1991A]; Feldblum [1992B]). The discrepancy between the true acquisition cost in Workers' Compensation and that implied by the Internal Revenue Code has encouraged some insurers to collect and book premiums on a monthly basis (NAIC [1990B]). Had statutory accounting avoided the conservative valuation of unearned premium reserves, the deferred acquisition cost would not appear as a liability. The IRS would have continued to base taxable premium revenue on statutory accounting, it would not have imposed a uniform "revenue offset" provision for all lines, and carriers would not modify premium payment and booking schedules for accounting and tax reasons.

3. *Economics and Regulation:* Economic forces are not easily suppressed. Legislative mandates that run counter to economic incentives may cause firms to circumvent the most onerous regulations. For instance, holding loss reserves at undiscounted values reduces policyholder surplus, raises "premium to surplus" and "reserves to surplus" leverage ratios, and reduces reported earnings. To avoid these effects, insurers may enter into financial reinsurance transactions, hold statutorily inadequate (but economically sufficient) reserves, or convert claims payments into structured settlements.[6] Statutory accounting should help regulators discern solvency problems; it should not lead to inefficient insurance operations.

Accounting Systems and Solvency

Changes in statutory accounting principles may make financial statements more useful, but they would not make the balance sheet approach an accurate measure of insurance solvency. Accounting conservatism provides an implicit margin, with unquantified implications for financial solidity. But the solvency examiner wants explicit measures, not vague assurances

[6] See Lowe and Philbrick [1986], Hutter [1991], and Laurenzano [1991B]. The financial reinsurance transactions and structured settlements may be economically inefficient, since third parties, such as reinsurers, life insurance companies, and attorneys, require a profit. Statutorily inadequate but economically sufficient reserves may lead to regulatory intervention to correct a problem that is an accounting illusion.

that the company is healthy.[7]

The balance sheet approach does not fully consider company programs which change the likelihood of insolvency. For instance, excess of loss reinsurance protection on General Liability exposures has multiple effects. A well conceived program lowers the chance of insolvency for a small cost; a poorly conceived program may result in high cost and uncollectible reinsurance recoveries. Similarly, the mix of exposures in the line of business, such as premises/operations coverage for retail stores versus products liability coverage for pharmaceutical corporations, affects the likelihood of insolvency.

Expanding the balance sheet approach to separately consider each set of exposures, reinsurance programs, geographical hazards, and so forth would make the solvency examination exceedingly complex. The needed margins for each risk, and the interrelationships of the risks with each other, are difficult to ascertain. The "emerging costs" approach uses a simpler procedure, as described next: it posits assumptions about each hazard, and simulates the future course of the company.

Section IV: The Emerging Costs Approach

Solvency examinations consider the likelihood that the insurer will be unable to meet its payment obligations. The emerging costs approach quantifies this likelihood directly, without detours through the balance sheet.[8]

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[7] Compare Daykin, et al. [1987], page 307: "A proper appreciation of financial soundness cannot be made if there are implicit but unquantifiable margins taken in the valuation of assets or liabilities. In general, reliance on unquantifiable implicit margins should be avoided by the actuary." Bailey [1969], page 1, in discussing investment regulation of insurers, says: "The present methods are a study in indirection. None of them attack the problem of insolvency directly."

[8] Daykin, et al. [1987], pages 238-239, compare balance sheet values with emerging costs regulation: "The assets will not in practice have to be realized on a particular date and, in any case, by the time the accounts or returns have been prepared, the market value at the date to which those accounts relate is a matter of no more than historical interest. What is important is whether the proceeds of the assets, both capital and income, will prove sufficient

Early Approaches - The Probability of Ruin

Early attempts to determine the likelihood of insolvency used a risk theoretic "probability of ruin" analysis. The actuary postulated distributions for claims frequency and claim severity, such as Poisson or negative binomial for the former and lognormal or Pareto for the latter. The individual distributions would be combined, by means of convolutions or other statistical techniques, to form aggregate distributions. The probability of ruin was the probability that total incurred losses exceeded assets.[9]

This approach has three drawbacks:

1. *Complexity:* Probability distributions for claim frequency and severity, though appealing to the pure actuary, are incomprehensible to most laymen. Moreover, it is difficult to judge the reasonableness of abstract probability distributions.

2. *Closed Form Solutions:* Except in limited instances, closed form solutions for the probability of ruin can not be derived. Combining claims from different lines of business with different frequency and severity distributions, which is essential for the financial examination of

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to meet the liabilities as they emerge. This is what solvency is really about." See also Daykin, et al. [1989], page 92.

This view of solvency is emerging among academicians and life actuaries as well. Bar-Niv and Smith [1987], page 413, write: "An insurer is insolvent if the value of its assets as they mature is insufficient to satisfy maturing insurance claims." Cummins and Derrig [1989], pages xvii-xviii, say that "the traditional accounting approach to solvency measurement . . . is outmoded. This approach is essentially static, relying on accounting ratios and reflecting a liquidation rather than a going-concern view of the insurance firm." Cody [1988], page 154, contrasts the traditional and new perspectives on insolvency: "Ultimate ruin has been defined as the failure of assets to exceed reserves at some future duration. . . . the redefinition would be that ultimate ruin exists if the present value of future net cash flows is negative."

[9] On probability of ruin analyses, see Seal [1969], Gerber [1979], and Bowers, et al. [1986]. To simplify the models, many actuaries have turned from individual risk theory to aggregate approaches. For instance, the British Solvency Working Party moved from lognormal distribution for individual claim severities to a normal distribution for aggregate losses (Daykin, et al. [1987], page 241; Coutts and Devitt [1989]). Monte Carlo simulations then eliminated the need for the complex formulas that bedeviled non-technical readers of actuarial solvency studies. For the movement of the Finnish Solvency Working Party from individual risk theoretic approaches to simulation models, compare Pentikäinen and Rantala [1982] with Pentikäinen, et al. [1989].

multiple-line companies, makes the procedure intractable.

3. *Other Risks:* This method quantifies the process risk from random claim occurrences. It does not deal with parameter risk for losses or any other risks that affect solvency, such as asset risk, interest rate risk, reserving risk, credit risk, and reinsurance risk (compare Mayerson [1969], page 148).

Assumptions, Simulation, and Risks

The emerging costs approach resolves each of these drawbacks:

1. *Assumptions:* Instead of probability distributions drawn from individual risk theory, aggregate assumptions can be used for each stochastic variable. Instead of saying, "claim frequency is Poisson with a mean of 100," one might say, "There is a 60% chance that there will be 100 claims, a 20% chance there will be 80 claims, and a 20% chance there will be 120 claims." The aggregate distribution is clearer to laymen. If it reasonably reflects the true distribution, it provides a similar probability of ruin and can be modeled by Monte Carlo simulation.

   Such aggregate assumptions may be formulated for each line or block of business. The assumptions may be checked for reasonableness by non-technical insurance underwriters and claims officers, as well as by government examiners.

2. *Simulation:* Instead of seeking closed form solutions, the actuary runs the assumptions through a Monte Carlo simulation. The selected probability of ruin determines the number of simulation runs required. For instance, if one uses a 1% probability of ruin, 500 to 1,000 simulation runs may be needed for credible results. If one uses a 0.1% probability of ruin, about 5,000 to 10,000 runs are needed for a similar level of credibility.

   The number of stochastic variables influences the complexity of each run. If separate variables are used by line of business, asset class, and type of risk, then each run will be elaborate. Twenty years ago, in an era of desk calculators, complex simulation models were not feasible. The advances in computer power have now made simulation models an ideal tool for the valuation actuary.

3. *Risks:* The solvency examination considers all risks of the insurance enterprise: pricing risk, reserving risk, catastrophe risk, asset risk, interest rate risk, reinsurance risk, credit risk, and various miscellaneous risks. A major task for the actuary is to model the correlations among these risks. For instance, an earthquake not only raises the insurer's direct losses but also increases the risk that reinsurance collectibles will not be recovered, since the reinsurer may suddenly face claims from numerous primary companies.[10] Similarly, a rise in inflation and interest rates may simultaneously lower the market value of long-term bonds and raise the undiscounted value of long-term inflation sensitive insurance liabilities.

   Separate consideration of interrelated risks is insufficient. The SOA valuation actuary concept emphasizes economic scenarios, with their implications for interest rate paths: a change in interest rates affects the earned rate on assets, the credited rate on interest sensitive policies, and policyholder persistency (SOA [1987]; Alpert [1989]). The task for the Property/Casualty actuary is equally complex. A recession may cause equity values to fall, fixed income securities to default, auto liability claim frequencies to decline, Workers' Compensation claim severities to rise, and the credit risk for premiums receivable to increase. This interdependence of risks, which can be modeled by Monte Carlo simulation, carries the most danger for insurance solvency.[11]

Cash Flows and Accounting Conventions

Statutory and GAAP accounting conventions pertain to balance sheet values and income statement entries. They relate to accrual values, admissibility of assets, and valuation of liabilities. They have no effect on cash flows.

For example, accounting conventions affect the valuation of assets, such as amortized versus market value of bonds, and of liabilities, such as ultimate value versus discounted value of loss

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[10] Pentikäinen [1988], page 16, refers to this as the "channel problem."

[11] Compare Pentikäinen [1988], page 32: "Some background factors . . . simultaneously affect several segments of the model. Therefore, the variables should not be assumed to be mutually independent. Such an assumption would lead to an underestimation of the risks."

reserves. Balance sheet values and income statement entries depend on the accounting conventions. The expected cash flows, however, depend on the actuarial assumptions, not on the accounting conventions. The expected cash flows do not differ between amortized and market value of bonds or between ultimate value and discounted value of loss reserves.

When future cash flows depend on the insurer's financial condition, both actuarial assumptions and accounting conventions depend upon the scenario. For instance, future cash flows from agents' balances depend on agents' perceptions of the insurer's solidity. If the company is financially strong, agents will remit most balances; this is the GAAP treatment. If the company seems troubled, agents may fail to remit overdue balances; this is the statutory treatment.

The emerging costs approach handles this problem by differentiating among three situations: "winding up," "run off," and "going concern." The "winding up" basis is the forced liquidation of the company. Assets are marked to realizable value, so office furniture, overdue agents' balances, and similar non-admitted assets have little worth. [This is similar to statutory accounting for certain non-admitted assets, though not for bond valuation.] The "going concern" basis is similar to GAAP accounting. The value of overdue agents' balances, for instance, may be estimated from expected collections and write-offs. The "run off" basis presumes that the insurer ceases to write new business, but it pays its liabilities normally.[12]

Section V: The Risks of Insurance Enterprises

An emerging costs simulation model can incorporate any risk for which actuarial assumptions can be formulated. This section discusses the types of risk which affect insurance solvency.

Different actuaries emphasize different risks. For instance, the Finnish Working Party analyzes the effects of underwriting cycles, or market prices, on expected profitability

12 The British Solvency Working Party uses these scenarios primarily to estimate overhead expenses and asset values. On a going concern basis overhead expenses are covered by the loading in the gross premiums; on a winding up basis, the expenses of liquidation must be covered by existing assets. Of more importance for insurance solvency is the credit risk for Commercial Lines premiums receivable. Workers' Compensation carriers often write retrospective rating plans with cash flow premium payment plans. The amounts shown on lines 9.1, 9.2, and 9.3 of the Annual Statement [agents' balances and accrued retrospective premiums] exceed 50% of policyholders' surplus for many carriers (Best's [1991A]).

(Pentikäinen and Rantala [1982]; Pentikäinen [1988]; Pentikäinen, et al. [1989]). The British Solvency Working Party acknowledges the relevance of underwriting cycles, but does not incorporate them into its simulation model (see Pentikäinen's comments to Daykin, et al. [1987]). American analysts place great importance on both underwriting cycles and "insurance crises" (see, for instance, Cummins, Harrington, and Klein [1991]; Consumer's Reports [1986]; Manders [1990]). Any risk that affects solvency and can be reasonably modeled should be included in the emerging costs simulation.

Types of Risk

The following list summarizes the types of risk relevant for insurance enterprises, the subdivisions of each type, and examples of each subdivision.[13] The subsequent discussion notes how they may be incorporated into simulation models.

1. Underwriting Risk [also termed: Pricing Risk, Profitability Risk, SOA C-2 Risk][14]
   a. Catastrophes (e.g., windstorms, earthquakes)
   b. Underwriting cycles (e.g., General Liability cycle in the early 1980's)
   c. Regulatory action (e.g., California's Proposition 103, New Jersey JUA activities)
   d. Parameter risk (e.g., changes in inflation)
   e. Process risk (e.g., traditional "probability of ruin" analyses)

2. Reserving Risk
   a. Unforseen liabilities (e.g., toxic torts, Environmental Impairment)
   b. External changes (e.g., economic adversity lengthening durations of disability in WC)
   c. Internal changes (e.g., shift to higher deductibles raising loss development in GL)
   d. Inappropriate methods (e.g., failure to adjust for changing case reserve adequacy)

3. Asset Risk [SOA C-1 Risk for "a" and "b"; C-3 Risk for "c"]
   a. Default risk (e.g., high yield bonds)
   b. Loss of principal (e.g., speculative real estate)
   c. Asset/liability matching (e.g., long term bonds supporting short term liabilities)

4. Other Risks [SOA C-4 Risk]
   a. Reinsurance risk (e.g., unregulated and undercapitalized reinsurers)
   b. Credit Risk (e.g., agents' balances, accrued retrospective premiums)
   c. Management Risk (e.g., malfeasance)

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[13] See Daykin, et al. [1989], pages 233-234; Pentikäinen, et al. [1989], section 3. For the relative importance of each risk, see Best's [1991B], pages 45-46.

[14] For the Society of Actuaries terms, see Hickman, Cody, Maynard, Trowbridge, and Turner [1979] or CAS [1991].

Underwriting Risk

Underwriting risk is the risk of unexpected losses, regulatory actions, or competition that adversely affect the firm's profitability. On a "winding up" or "run off" basis, underwriting risk relates to business in force on unexpired policies and expected renewals on noncancellable policies. Business in force may be measured by the unearned premium reserve minus the "equity" in the reserve (i.e., the unamortized acquisition and underwriting costs). The reserve should be "annualized" for Commercial Lines policies, such as Workers' Compensation, where monthly premiums are booked as billed or at audit dates, rather than annual premium being booked at policy inception (NAIC [1990B]). Similarly, the reserve must be increased for Personal Automobile policies where state statutes contain non-renewal constraints.

On a "going concern" basis, the analyst must consider underwriting risk on new business as well. If solvency examinations are performed annually, and there is a lag of six months to a year before results are acted upon, the analyst should assume two years of new business. (See Daykin, et al. [1987; 1989]; Pentikäinen [1988], page 4, recommends one year of new business, with more frequent examinations for troubled companies.).

The magnitude of expected operating ratios and the variability of historical operating ratios affect the size of the underwriting risk margin needed. The risk margin covers potential premium deficiencies on policies in force. If the expected operating ratio is low enough (say, 85%), then even a large historical variability (say, ±15%) leaves a low probability of inadequate premiums. If the historical variability is low enough (say, ±5%), then even a high expected operating ratio (say, 95%) leaves a low probability of inadequate premiums. But a high expected loss ratio combined with wide historical variability calls for a large underwriting risk margin.

The British Solvency Working Party begins with a 100% operating ratio, or expected losses equal to the pure premium, on each of two blocks of business: long-tailed and short-tailed.[15]

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15 The Working Party separates loss cost inflation from expected losses, so that they can be modeled independently. Thus, the "100% operating ratio" is actually a 100% ratio of losses to net premium [that is, premium net of commissions and initial expenses], before losses are increased for inflation.

For the simulation model, expected losses are raised or lowered by 20%. The effect on the probability of ruin is great: using "base case assumptions" for the other stochastic variables, the probability of ruin is 6.7 times greater with the high operating ratio than with the low operating ratio.[16]

The variability in the loss ratio has a much smaller effect in the British Solvency Working Party model. When the standard deviation of the short term business loss ratio is raised from 5% of the pure premium to 15% of the pure premium, the probability of insolvency increases by less than 20%. Moreover, claim variability is reduced by diversification along lines of business. The implication is that process variance has little effect on the solvency of a large multiple-line insurer.[17]

Underwriting Risk Dimensions

Underwriting risk is caused by various factors, which have different effects by line of business and which must be modeled separately.[18]

1. *Catastrophes:* Natural disasters affect primarily first party coverages: windstorms for Homeowners' insurance, fires for large Commercial Property risks, and epidemics (such as AIDS) for health insurance. The implications for solvency depend on the quality of the reinsurance program and the stability of the reinsurers. An earthquake in an urban center may adversely affect the profitability of direct business as well as the collectibility of reinsurance recoveries.

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16 In his discussion of the 1987 British Solvency Working Party paper, J. Plymen comments: ". . . the profitability of the company . . . is more important than anything else. If a company has a reasonable record of performance and is normally fairly profitable, but is hit hard by some underwriting or investment disaster or by a reinsurance failure, then it will not go into liquidation and policyholders will not lose money. New parties will come in and put up money to reorganize the business to get is going again . . ." (Daykin, et al., [1987], page 316).

17 Daykin, et al. [1987], page 250: "The results do not change significantly for different levels of variability in the claim ratio." See also Woll [1982], who notes that process variance has almost no effect on the loss ratios of a large Personal Lines carrier.

18 On underwriting risk by line of business, see Hammond and Schilling [1978] and Feldblum [1990].

2. *Underwriting Cycles:* Insurance company profitability follows a cyclical pattern, particularly in third party lines of business, such as General Liability, Workers' Compensation, and Automobile Liability. Periods of low operating returns, when market prices are below actuarial rate indications, alternate with periods of high returns.

   The importance of underwriting risk depends on premium rate adequacy. The Finnish Solvency Working Party suggests that underwriting risk varies *inversely* with the underwriting cycle. At the peak of the cycle, when insurers are profitable, expected future premium rates decline, so a larger solvency margin is needed to avoid ruin. At the nadir of the cycle, when insurers are unprofitable, expected future premium rates rise, so a smaller solvency margin is needed.[19]

3. *Regulatory Action:* Underwriting risk in the Personal Lines frequently stems from regulatory or statutory actions that modify rates, compensation systems, non-renewal and cancellation rights, classification systems, or terms of coverage. For example, California's Proposition 103 (November 1988) forced rate rollbacks, limited non-renewal rights, and prohibited certain classification variables. The Massachusetts Tort Reform Changes (January 1989) raised the no-fault tort threshold and expanded the PIP coverage limits, but simultaneously mandated a large and actuarially insupportable reduction in premium rates. Since Massachusetts and California have "take all comers" Personal Automobile insurance environments, this underwriting risk affects future renewals in addition to the current book of business.

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[19] See Pentikäinen [1988]; Pentikäinen, et al. [1989]. Pentikäinen commented on the 1987 British Solvency Working Party paper: ". . . some classes of insurance . . . are subject to substantial cyclical movements . . . During the high phase of the cycle a fairly high solvency margin is necessary to meet a low phase which is likely to follow. On the other hand during a deep trough of the cycle lower margins can be accepted as being satisfactory, because an upward phase can be expected in a situation where all, or at least very many, insurers have arrived at a strongly reduced level of margins" (Daykin, et al., [1987], page 318). Daykin, et al. [1987], page 243, contend that "the added complexity [of incorporating underwriting cycles] can be justified only if the parameters of the model can be satisfactorily determined. . . . Although the adequacy of premium rates does exhibit the characteristics of a business cycle, experience seems to show that the variation does not have a regular periodicity or a constant amplitude. A considerable degree of judgement is needed to decide where in the 'cycle' the industry finds itself at any particular moment." American insurance stocks show a pattern consistent with recurring cycles: they rise at the nadir of the cycle and drop once investment analysts believe the peak has been reached. See also Feldblum [1992A] for an examination of underwriting cycles and their relationship to insurance solvency.

4. *Parameter Risk:* In high frequency, low severity lines of business, insurance profitability is affected more by inaccurate estimation of the expected loss ratio than by random occurrences of individual losses. The divergence between actual and expected loss ratios may result from unexpected inflation, changes in speed limits or gasoline prices in Automobile insurance, or changes in unemployment rates that affect claim frequency and durations of disability in Workers' Compensation.

5. *Process Risk:* In high severity, low frequency lines of business, such as excess of loss reinsurance treaties, Medical Malpractice, and large property risks, much underwriting risk depends on the occurrence of individual losses.

Quantification

An emerging costs simulation model quantifies the probability of insolvency. It says: "Given the assets and liabilities of the company, the current book of business, and the expected writings over the next two years, what is the probability that the insurer will not be able to meet its payments?" One seeks probabilities, not leverage ratios or operating returns.

The government regulator would rephrase the question. To certify that the company's assets are sufficient, the regulator might ask: "Given the assets and liabilities of the company, the current book of business, and the expected writings over the next two years, if we wish a 99% chance that the insurer will meet its payments, how much additional capital is needed?"

Each insurer is different. A leverage ratio appropriate for one company may be excessive or insufficient for another. The solvency requirement is a capital amount, not a leverage ratio.

For "what if" questions, however, leverage ratios are useful. The actuary may ask: "If we grow more rapidly, if loss fluctuations are greater, or if expected profitability is lower, how much more capital do we need?" Relationships – or leverage ratios – are most suitable, not dollar amounts.

The British Solvency Working Party uses two types of relationships. The required capital for existing business is related to technical provisions (reserves). The required capital for new

business is related to net written premium in the most recent year. [The Working Party term "net written premium" is the gross premium minus the expense loading, or the "pure premium" in American actuarial parlance.]

Using "base case assumptions," or "standard parameters," the British Working Party estimate required capital for two years of new business as 35 to 40% of annual written premium and required capital for existing business as 10% of technical provisions. (The latter ratio depends on the reserve assumptions and implicit margins. The British Working Party base case assumptions are 5% per annum loss cost inflation and no reserve discounting; see Daykin, et al. [1987].) The Finnish Solvency Working Party estimates similar ratios: 40% to 60% of premium (Pentikäinen and Rantala [1982]). These capital requirements are high for European insurers, but they are below industry average for American Property/Casualty insurers.[20]

Reserving Risk

The uncertainty in loss reserve estimates is a significant accounting risk for insurance enterprises. The year to year changes in loss reserve estimates, particularly in General Liability and Workers' Compensation, underscore the uncertainty in these liabilities. Some fluctuation in reserve estimates may be attempts to smooth company earnings over the course of the underwriting cycle. In addition, some adverse loss reserve development may result from "implicit discounting" by carriers averse to holding full value reserves. Much fluctuation in loss reserves, however, reflects true uncertainty of the estimates.[21]

The insolvency risk is strongly affected by loss reserve adequacy, irrespective of loss reserve

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[20] In an emerging costs model, the "equities" in the unearned premium and loss reserves increase "balance sheet" capital. Current industry premium to surplus leverage ratio, when surplus is increased by the reserve "equities," is about 1.5 to 1. This is lower than the leverage ratio implied by the British or Finnish Working Party base case assumptions. Capital *requirements* should be substantially lower than *target* capital, though the relationship between the two is unclear; see Hartman, et al. [1992] and Steinig, et al. [1991].

[21] Best's [1991B], page 45, notes: "The most frequent cause of insolvency, accounting for 28% of the 302 insolvencies, was deficient loss reserves, which is intrinsically linked to inadequate pricing." Cholnoky and Cohen [1989], examining adverse loss development from Schedule P, emphasize the reserve uncertainty in General Liability. Butsic [1989], Ryan and Fein [1988], and Conning & Co. [1987] discuss the use of loss reserve strengthening and weakening to smooth calendar year results.

uncertainty. As Daykin, et al. [1987] note:

> The adequacy of the technical provisions is of particular importance, since they determine what assets are apparently available as a margin. There is, therefore, a need either for consistent standards to be applied in setting technical provisions or for a clear statement of the basis on which they have been obtained, suggesting that there would be considerable advantages in requiring the provisions to be established on the basis of advice from an actuary or other claims reserving expert, acting within the framework of an appropriate professional standard. However, it has to be acknowledged that there is always likely to be some uncertainty about the strength of technical provisions.[22]

The British and Finnish models assume that the reserves are adequate – or at least that whatever margin of adequacy or deficiency exists in the reserves is explicitly accounted for in the emerging costs approach. The emphasis, therefore, is on reserve uncertainty.

Reserving Risk Categories

The causes of loss reserve uncertainty can be grouped into several categories, ranging from those least foreseeable by the actuary to those which a loss reserve specialist might anticipate.

1. *Unforseen Liabilities:* Certain exposures, which insurers thought were excluded from their insurance contracts, have been judged by the courts or by Congress to be covered by the policies. For example, "Exclusion F" of the pre-1986 Comprehensive General Liability policy excludes all pollution except that which is "sudden and accidental." In the mid-1980's, some jurisdictions considered the exclusion ambiguous. In accordance with the

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[22] By "the basis on which they have been obtained," the British Solvency Working Party refers to the assumed inflation rate for loss costs and the assumed discount rate in setting the reserves. The actuarial opinion required for Property/Casualty loss reserves in statutory statements fulfills the requirement that "the provisions . . . be established on the basis of advice from an actuary or other claims reserving expert, acting within the framework of an appropriate professional standard" (see NAIC [1991]). It is unclear what effect actuarial opinions will have on loss reserve adequacy; see AAA [1991] and Bethel [1991].

The emerging costs approach proposed by the British and Finnish Working Parties requires an independent regulatory evaluation of loss reserve adequacy. However, the same is true for the American balance sheet approach and for the NAIC Risk Based Capital approach. See Feldblum [1991A] for a review of regulatory means of assessing loss reserve adequacy.

"contract of adhesion" rule, they interpreted the exclusion in favor of policyholders.[23]

2. *External Changes:* Changes in the economic, statutory/regulatory, or social environments can affect loss reserve liabilities. For example, lack of employment opportunities during a recession or an increase in statutory benefit levels may tempt injured workers to remain disabled and receive Workers' Compensation benefits, thereby increasing the required loss reserve (Borba [1989]; Gardner [1989]; Butler and Worrall [1985]). A change in the Personal Automobile compensation system (e.g., between tort and no-fault) will change claim emergence and settlement patterns, increasing the uncertainty in the reserve estimates (Marter and Weisberg [1991]).

3. *Internal Changes:* Changes in the company's underwriting procedures may affect the reserve indications. For instance, a shift to higher deductible General Liability policies will cause a drop in claim counts and lower payments at early valuations in a net loss reserve analysis. The reserving actuary may reduce the estimates too much, not allowing for the greater loss development in higher layers of insurance (Pinto and Gogol [1987]).

4. *Inappropriate Methods:* Different loss reserve methods may provide different estimates. For instance, an incurred loss development may be misleading when the average case reserve adequacy is changing, and a paid loss development may be misleading when claim settlement practices change (Berquist and Sherman [1977]).

Variations by Line and Insurer

In practice, the actuary may not know the cause of loss reserve fluctuations from quarter to quarter or between one method and another. The fluctuations may be ascribed to "randomness" or to the "inherent uncertainty in loss reserve estimates." But the categories listed above are important for solvency examinations.

The fourth category, "inappropriate methods," applies to all situations. The third category,

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[23] The Jackson Township case in New Jersey is a prominent example of this (Hamilton and Routman [1988]; Wright [1991]). By 1991, most jurisdictions ruled that the CGL exclusion F does indeed negate exposure for gradual pollution. See Manta and Welge [1990] for a good survey of current legal opinion on Environmental Impairment Liabilities.

"internal changes," varies by company. Small, rapidly growing insurers are more prone to under-reserving than large, stable companies are.[24] The second category, "external changes," varies by state, when statutory changes increase reserve uncertainty (e.g., the 1991 Workers' Compensation reform in Texas or the 1989 Personal Auto changes in Massachusetts). The first category, "unforseen liabilities," varies by line of business.

The British Solvency Working Party models the total amount of claims paid during a given calendar period by a normal distribution with mean X and standard deviation $aX + b\sqrt{X}$.[25] "The extent of the assumed variability can be adjusted by varying the constants *a* and *b*" (Daykin, et al., [1987], page 242; Daykin, et al. [1989], page 95). Since reserving risk is greatest when comparable historical experience is not available, the values of these constants would often be based on actuarial judgment.

Asset Risk

Asset risks are becoming increasingly important to Property/Casualty insurers. Asset risk comprises bond and mortgage defaults, destruction of principal in equity investments (common stocks and real estate), and income losses resulting from changes in interest rates (asset-liability mismatch). The increasing importance of asset risks stems from several factors. First, the ratio of assets to surplus is growing, as insurers write at higher premium to surplus ratios, business shifts to longer tailed lines, and claims payment patterns lengthen. Second, the rising interest rates in the 1970's and early 1980's highlighted the importance of investment returns. Third, increasing competition in the insurance industry has led some insurers to more speculative investments.

Present statutory valuation of financial assets is doubly unusual: not only is there no risk margin, whether implicit or explicit, but the valuation is not even conservative. Bonds in good standing are reported at amortized values; they are not marked to market. If interest rates

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[24] I am indebted to Stephen Lowe and Allan Kaufman for this observation. As Allan has remarked, a new insurer lacks historical experience and is apt to mis-estimate future development on old claims. See Anderson and Formisano [1988] for the relationship between rapid growth and potential insolvency.

[25] Pentikäinen, et al. [1989], page 181, uses a compound mixed Poisson distribution for claim frequency and a "free choice of claim size distributions."

rise, and the market value of bonds declines below the purchase value, the statutory value of the bonds remains unchanged. Equities are held at market values, but unrealized gains or losses are direct charges or credits to surplus, with no offsetting entry for deferred federal income taxes.[26]

Asset risk varies by type of security and with general economic conditions. Default risk, for instance, is greater for private mortgages than for Treasury notes. Moreover, the default risk for private mortgages depends on economic conditions, spendable income, and unemployment rates.

Asset Risk Categories

Asset risks may be grouped into the following categories:

1. *Default Risk:* Long term bonds are the largest asset on most insurers' balance sheets. Default risk is the risk that the bond issuer will cease to make coupon payments. If the issuer's net worth is insufficient to redeem the bond, bondholders suffer a permanent loss. Even if the issuer's net worth exceeds the bond's par value, liquidation delays and court costs impair the bond's value.

   Default risks vary by the financial strength of the issuer. At the issue date, the expected default risk may be measured by the risk premium incorporated in the yield. Treasury securities, which have almost no risk of default, have the lowest risk premium and the lowest coupon yields. Conversely, bonds issued by new or small firms have high risk premiums and high yields.

   Default risk changes over time. If a once solid company becomes unprofitable and in danger of insolvency, the default risk on its outstanding bonds increases (see Altman [1989], Vanderhoof, Albert, Tenenbein, and Verni [1989], and the references cited therein). For balance sheet accounting, if the reduction in the bond rating causes an unrealized capital loss, the risk margin may be reduced; if there is no change in the accounting value, the risk margin should be increased. For an emerging costs approach, the reduction in the bond

[26] GAAP corrects for this; see Berthoud [1988] and AICPA [1990].

rating lowers the expected income from the bond and increases the fluctuation in income, both of which indicate higher capital requirements.

2. *Destruction or Diminution of Principle:* Capital losses on equity investments may result from destruction or diminution in value of the principle or from general changes in investors' expectations. The British and Finnish Solvency Working Parties rely on Wilkie's work on equity values and economic inflation. Wilkie [1986] uses an autoregressive model for share prices: an above average increase in price in one period is correlated with a below average increase in price in the subsequent period. Most American financial analysts use a "random walk" model: there is no correlation among relative price movements in adjoining periods.[27] Using the Capital Asset Pricing Model, for instance, stock fluctuations would be based on average market fluctuations and the undiversifiable risk of the portfolio, not on the past performance of the particular securities.[28]

   Several recent U.S. Property/Casualty failures suggest that excessive investments in affiliates may be an indicator of management fraud and potential insolvencies.[29] Indicators of fraud are difficult to model. Nevertheless, differentiation of the asset risk for investments in affiliates versus non-affiliates seems necessary for solvency examinations.

3. *Asset-Liability Mismatch:* Changes in interest rates affect the market values of both assets and liabilities. A rise in interest rates causes a decline in the value of fixed income assets, such as bonds, and of fixed liabilities, such as life insurance benefits. The effects of interest

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[27] Compare Cohen, Zinberg, and Zeikel [1982], page 17: "The random-walk believer holds it is impossible to predict the prices of a security or of the market from past performance," or Malkiel [1973], page 121: "The history of stock price movements contains no useful information that will enable an investor consistently to outperform a buy-and-hold strategy in managing a portfolio."

[28] For average market fluctuations, see Ibbotson and Sinquefield [1982]. For the CAPM, see Sharpe [1964], Lintner [1965], Weston and Copeland [1986], chapters 16 and 17, or Cohen, Zinberg, and Zeikel [1982], pages 143-241.

[29] See Petrelli [1991]. Bailey [1969], page 9, recommends that "all investments in affiliates, whether parents, subsidiaries, or cousins, [be excluded] from the minimum amounts of assets required to support the insurer's liabilities," and he adds that "investments in affiliates are often not as liquid as other investments and their value is difficult to establish" (page 10). Similarly, the NAIC Risk Based Capital standards have higher requirements for investments in affiliates (Laurenzano [1991A]; Kaufman and Liebers [1992]).

rate changes on interest sensitive assets, such as common stock, and interest sensitive liabilities, such as tort liability judgments, is less clear (Feldstein [1980]; Lintner [1975], Fama and Schwert [1977]; Schwert [1981]; Feldblum [1989]).

Assets and liabilities are said to be "matched" if a change in interest rates affects them equally. Most Property/Casualty insurers, with investments in long-term corporate and government bonds but short-term, inflation sensitive liabilities, have mismatched portfolios. A rise in inflation and interest rates will lower the asset values more than the liability values. An emerging costs approach to measuring solvency would select scenarios of interest and inflation rates, and model the cash flows of assets and liabilities.[30]

Modeling Asset Risks

The composition of the financial portfolio at the examination date is available from company records. The expected distributions of default rates for bonds, price movements for equities, and interest rate changes must be posited by the actuary.

Many insurers hold bonds until maturity and do not actively trade stocks. Solvency testing, however, asks whether assets will suffice to pay the liabilities of the current book of business. As the reserves run off, assets must be sold. [Even a "going-concern" basis of the British Solvency Working Party assumes only two more years of new business, and a subsequent run off of liabilities.] Thus, an emerging costs simulation model requires assumptions for disinvestment (as well as a short period of reinvestment if the "going concern" basis is used).

The British Solvency Working Party divides assets into three categories: cash, shares, and irredeemable government consols (gilts). They use Wilkie's model for fluctuations in share

[30] On asset-liability management for life insurance companies, see Redington [1952], Tilley [1980], Wise [1984A; 1984B], and Geyer [1989]; for Property/Casualty companies, see Feldblum [1989]. For the effects of interest rate changes on stock values, and the implications for "equity durations," see Leibowitz, Sorensen, Arnott, and Hanson [n.d.]. Jetton and his discussants [1988] and Carr and French [1989] present methods for selecting interest rate path scenarios. Mereu [1989], pages 149-151, uses a random walk model to generate inflation rates with maximum and minimum bounds. Interest rates are derived in two components: a deterministic component determined from the change in inflation and a stochastic component reflecting variability. Mereu aptly compares the interest rate to "a drunk chasing a moving inflation rate." The British Solvency Working Party uses a stochasic model for inflation; see Daykin, et al. [1987], Appendix 2, pages 275-277.

prices and interest rates, and examine several disinvestment strategies, such as sell proportionate amounts of each security class, sell the best performers first, or sell the security classes sequentially (such as consols first and equities last).[31] [32]

Other Risks

Insurance enterprises are subject to numerous other risks, the most important of which are reinsurance risk and credit risk. Both reinsurance recoveries and uncollected premiums are subject to statutory accounting penalties. Since the penalties are based on balance sheet values, they are not necessarily related to the actual risks.

1. *Reinsurance Risk:* Recoverables from unauthorized reinsurers, overdue recoverables from authorized reinsurers, and recoverables from late-paying authorized reinsurers are not admitted in statutory financial statements, unless the recoverables are secured by letters of credit or funds withheld. This penalty seems excessive for solid but unauthorized reinsurers, and possibly insufficient for major catastrophe risks. For solvency examinations, reinsurance risk should be differentiated among recoveries from affiliates, involuntary pools, solid reinsurers (whether American or alien), and small off-shore

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[31] The "sell the best performer first" strategy reflects the negative autocorrelation of the Wilkie model: good performers in one period should have poor performance in the subsequent period. The British Solvency Working Party found the lowest probabilities of insolvency with the "sell equities last" strategy. Equities have the greatest variability in value but also the highest expected return. As with loss ratios, expected values appear more important than random fluctuations. See, however, the discussion by J. P. Ryan, who questions the reasonableness of this result (Daykin, et al. [1987], page 312).

[32] Federal income taxes are a complicating factor, particularly for investment income. In theory, earnings should be reduced for taxes, but "it seems likely that with a company that is in any danger of becoming insolvent there will be past losses carried forward, as well as future claims outgo, that will probably absorb most, if not all, of the income. This will mean that the effective rate of tax on interest will be very low" (Daykin, et al. [1989], page 127). Conversely, losses should be reduced for tax credits, but "the use of tax credits assumes that other assets or product lines are generating gains that at least offset the losses of the modeled risk. . . . For the bond modeling we assumed that 50% of the possible tax credit would be taken as an offset to the default loss" (Steinig, et al. [1991], Part II, Section 1, page 5). The appropriate treatment of Federal income taxes when modeling insurance solvency is unclear.

reinsurers (on evaluating the solidity of reinsurers, see Ludwig and McAuley [1988]).[33]

2. *Credit Risk:* Credit risk refers to uncollected premiums: agents' balances, accrued retrospective premiums, and bills receivable taken for premium. Agents' balances over 90 days due and 10% of accrued retrospective premiums are not admitted on statutory financial statements (McKinnon [1988]; NAIC *Proceedings* [1991], Vol. 1A, page 373). GAAP financial statements do not use these penalties. An emerging costs simulation must commence with actuarial assumptions about these future cash flows.

3. *Malfeasance and Fraud:* Management malfeasance, incompetence, and fraud contribute to insurance failures (Hank [1989]). These risks can not easily be quantified, since they are not exogenous variables. They may be excluded from the simulation model, but incorporated as separate solvency margins.[34]

Section VI: Simulation

The emerging costs approach uses Monte Carlo simulation to test insurance company solvency. Most influences on solvency are modeled as stochastic variables. Various methods are possible, such as discrete distribution functions with only 3 or 4 elements, continuous distribution functions, or Markov models with transition probabilities. The method chosen depends on ease

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[33] Daykin, et al. [1989], pages 112-113 (or [1987], page 262), note: "A detailed examination of the reinsurance programme can hardly be practicable for the supervisory authorities. . . ." As a "rough and ready solution," they note the EEC supervisory practice of "reducing the solvency margin requirement calculated on the basis of gross written premiums to allow for reinsurance based on actual recoveries in the past three years, but with a maximum reduction of 50%."

[34] The British Solvency Working Party has suggested an additional solvency margin of 50% of management expenses to cover miscellaneous risks; this is also the approach of a preliminary New York life insurance Risk Based Capital formula. Steinig, et al. [1991], Part II, section 4, page 1, argue that "an arbitrarily assigned risk charge [for miscellaneous risks] is indefensible. . ." See also Pentikäinen, et al. [1989], pages 136-142.

of interpretation and accuracy of representation.[35]

The scope of the simulation depends on computer capacity. The British Solvency Working Party chose to vary only two stochastic variables at a time, since varying all the variables simultaneously made the simulation runs too time-consuming. For the same reason, the Working Party used simple asset portfolios and only two lines of business. An actual examination, of course, must use realistic financial and insurance portfolios.

Simulation models have several advantages (Pentikäinen [1988], pages 169-170):

- They show confidence areas, and thereby the uncertainty in the projections.
- They allow explicit statement of the assumptions, as well as flexibility in the assumptions.
- They provide easily grasped graphical presentations.

The output of the simulation model can graph various variables against time, such as total assets, net worth, or solvency margin. The graph below shows time along the horizontal axis and economic net worth along the vertical axis. Economic net worth is the difference between assets and liabilities, when both are estimated at realistic (market) values. If all variables were deterministic, the net worth would change with economic inflation only. Since most variables are stochastic, net worth will change with fluctuations in their values. The solvency test asks: "In how many simulation runs does the net worth become negative?"[36]

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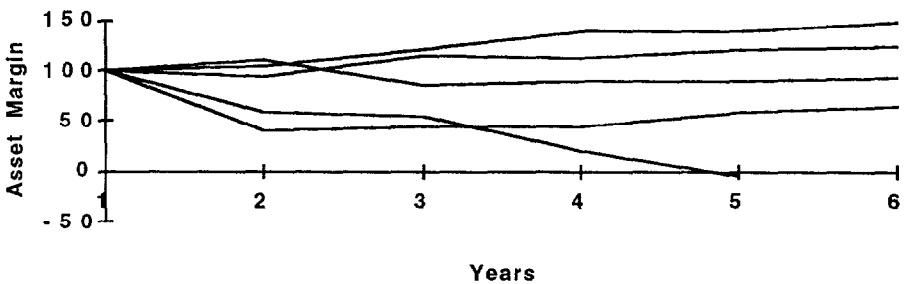
35 Discrete distribution functions are the most comprehensible to non-technical insurance examiners. Continuous distribution functions are often more accurate representations of reality (Beard, Pentikäinen, and Pesonen [1977]). Venezian [1981] uses Markov transition rules to model auto accident frequencies.

36 Daykin, et al. [1987], page 246 (or [1989], pages 99-101) graph total assets against years, so the lines slope downward. Pentikäinen, et al. [1989] graph the solvency ratio against years. The solvency ratio, u(t), is defined as

$$u(t) = r_m(t)^{-1}u(t-1) + b(t) + i(t) - x(t) - e(t) - d(t) + u_{new}(t),$$

where $r_m(t) = M(t)/M(t-1)$, M(t) is a volume measure, such as premium or assets, and b(t), i(t), x(t), e(t), d(t), and $u_{new}(t)$ are the premium ratio, investment income ratio, loss ratio, expense ratio, dividend ratio, and new capital ratio, where the ratios are to M(t), the volume

The chart below shows a simplified set of five simulation runs. The economic net worth, or the asset margin, begins at $100. Simulation is continued for six years, by which time all liabilities are settled. In four of the five runs, the asset margin remains positive; in one run, the asset margin becomes negative by the fifth year. In other words, this simulation shows a 20% chance that the insurer will not meet its payments before all liabilities are settled.



In practice, the allowed probability of insolvency would be set at 1% or less. For credible results, the number of simulation runs must be several times the inverse of the probability of insolvency.[37]

The British Solvency Working Party models the probability of actual ruin: that is, the probability that assets will be depleted before all liabilities are paid. The Finnish Working

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measure (pages 8-15). Graphing the solvency ratio is meaningful only for a long duration going concern simulation (thirty years, in the Finnish example). In a run-off, premium income ceases and assets decrease rapidly, so the solvency ratio increases or becomes infinite.

37 For instance, for a probability of insolvency of 0.5%, and a multiplier of 10, one needs 2,000 simulation runs. The true credibility level, or confidence interval, depends on the shape of the probability distribution functions. With different distribution functions for each stochastic variable, determining the credibility level accurately is an intractable mathematical problem. It is also not essential. Enough simulations must be run that the result can be reproduced by another analyst, not that the first analyst can accurately determine the confidence of his result. The two objectives are interrelated: if the result can almost always be replicated, then the credibility is high. But if the results can generally be replicated, there is no need to quantify the confidence interval.

Party uses a "ruin barrier" (U_{req}) as a determinant of authority to write new business:

> "The required solvency ratio, which triggers the discontinuation of the simulated course of business, should be placed so high that the probability of a negative end value of the solvency margin would be very small" (Pentikäinen, et al. [1989], page 186).

Simulation can also be used to answer "What if" questions. The analyst may say: "If the loss ratio on new business is 20% more than expected, how much greater is the probability of insolvency? If interest rates rise by 5 points and then remain steady, what is the effect on the probability of insolvency?" The British Solvency Working Party has run numerous such "what if" situations, to determine the effects of each stochastic variable on the risk of insolvency.[38] Moreover, several components of the simulation analysis are endogenous decision variables, such as the investment strategy and reinsurance retentions. The potential effects of modifying these variables can be clearly seen in an emerging costs approach.

Section VII: The Actuarial Report

The emerging costs approach to insurance solvency is complex. The results depend on the assumptions chosen by the valuation actuary, such as the expected values and distribution functions of each stochastic variable, and the interrelationships among the risks. To evaluate an emerging costs projection, the regulator must understand the workings of the simulation model. The valuation actuary may be comfortable with the assumptions and the modeling, but the government examiner may feel lost. This is true particularly in the United States, since many state insurance departments do not have casualty actuaries.

Reviewing an emerging costs solvency projection is time-consuming. Most European countries have a small number of Property/Casualty insurance companies and one centralized government

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[38] The Finnish Solvency Working Party varies such parameters as the insurer's size, the net retention, the time span of the simulation, the structure variation, the inflation rate, the time lag between claim and premium inflation, the amplitude and length of the underwriting cycle, the safety loading, and the real growth rate (Pentikäinen, et al. [1989], page 174). The British Solvency Working Party varies the size of the insurer, the proportion of long-tailed business, the initial asset distribution, the asset selling rules, the real growth rate, the mean claim ratio, and the variability of the claim ratio (Daykin, et al. [1987], tables 3, 4, 5, 6).

office. A review of each insurer's financial strength is feasible.

In the United States, there are several thousand Property/Casualty insurance companies and 50 insurance departments. Few departments have the resources to review emerging costs solvency projections. Simplifying the review process, which may take two forms, is essential.

First, "base case assumptions" or "standard parameters" may be used for many variables. For instance, expected stock price fluctuations and bond default rates would not vary among insurers with similar financial portfolios. Industry wide assumptions may be used, which vary by security class, not by insurer. Other variables, such as collectability of reinsurance recoverables and premium receivable, depend on the insurer's reinsurance program, distribution system, and premium payment plans, so industry wide assumptions are not appropriate.

Second, all mathematical assumptions must be expressed in clear terms in an actuarial report (see Coutts and Devitt [1989] for a sample report, and Daykin, et al. [1987], pages 307-310, "Draft Notes on Recommended Practice"). Using industry wide assumptions as benchmarks may simplify the report. For instance, the actuary could presume a 70% loss ratio for new Personal Automobile business and justify this figure with company experience. Alternatively, he could begin with the industry wide expected loss ratio (say, 75%) and justify a five point differential for his company (e.g., past experience has been 5 points better, the company writes lower risk insureds, or revised company underwriting programs should improve the loss ratio).

This is the challenge for American actuaries. The theoretical foundations for the emerging costs approach to insurance solvency have been firmly laid by the British and Finnish Solvency Working Parties. American solvency regulation for Property/Casualty companies continues with a balance sheet approach: a simpler but less justified method. The CAS must help American regulators achieve solvency examinations no less accurate than those in other countries.

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