# Forecasting the Future: Stochastic Simulation and Scenario Testing

*by Sholom Feldblum*

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### Biography

Sholom Feldblum is an Assistant Vice President and Associate Actuary with the Liberty Mutual Insurance Company in Boston, Massachusetts. He was graduated from Harvard University in 1978 and spent the next two years as a visiting fellow at the Hebrew University in Jerusalem. He became a Fellow of the CAS in 1987, a CPCU in 1986, an Associate of the SOA in 1986, and a member of the American Academy of Actuaries in 1989.

In 1988-89, while working at the Allstate Research and Planning Center in California, Mr. Feldblum served as President of the Casualty Actuaries of the Bay Area, as Vice President of Research of the Northern California Chapter of the Society of CPCU, and as editor of the CABA newsletter. In 1989, he served on the CAS Education and Testing Methods Task Force, and in 1990-92, he served on the industry advisory committee to the NAIC Casualty Actuarial (Technical) Task Force.

Mr. Feldblum is presently a member of the CAS Syllabus Committee, the CAS Committee on Review of Papers, and the American Academy of Actuaries task force on risk based capital, and he is the associate editor of the *Actuarial Review*. He is the author of numerous papers on ratemaking, loss reserving, statutory accounting, insurance economics, competitive strategy, solvency monitoring, and finance. He was the recipient of the CAS Michelbacher Prize in 1993 for his paper on "Professional Ethics and the Actuary."

### Abstract

The envisioned role of the Appointed Actuary encompasses the evaluation of the insurance company's financial condition under a range of likely future conditions. Two types of valuation methods are being developed for this task: stochastic simulation and scenario testing.

Stochastic simulation is presently the more heralded method, due to the seminal work of British and Finnish actuaries. This paper, in contrast, presents a full description of scenario testing. It contrasts the underlying assumptions of scenario testing with those of stochastic simulation, and it compares the usefulness of the two evaluation procedures for strategic planning.

The paper proceeds to the building of scenarios for both adverse economic conditions, such as a recession, and adverse insurance conditions, such as a severe underwriting cycle downturn. Various illustrative insurers are presented, such as a personal automobile insurance writer and a workers' compensation carrier, with different investment portfolios and underwriting characteristics, to show the interrelationships of external (economic and financial) conditions and internal (company) attributes. The paper demonstrates how scenario testing can help transform the valuation actuary from a backroom model-builder into a central member of the company's management team.

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## Forecasting the Future: Stochastic Simulation and Scenario Testing

*Insurance company management should be required to obtain each year a written report on surplus adequacy by an appropriately qualified actuary. That report should evaluate the company's financial status, both currently and under a range of likely future financial conditions. The long-term nature of insurance risks and the increasing volatility of the U.S. economy dictate that the report be as much as possible a long-range view of a company's financial health, instead of just a year-end report.*

### Introduction

The quotation above portrays the role envisioned for the appointed actuary of the future by the American Academy of Actuaries' September 1992 "Position Statement on Insurer Solvency." The actuary's task has been expanded, from deterministic point-estimates of indicated reserves to a future financial status that is wrapped in uncertainty. But how might the actuary determine the needed valuations?

There are two methods currently in vogue for forecasting the future financial status of an insurance enterprise: stochastic simulation and scenario testing. Each method has advantages and drawbacks, and each is more appropriate in certain situations.

Stochastic simulation has the longer and more dignified actuarial history, being grounded in the risk theoretic and cash flow modeling studies of European actuaries. It provides solid and mathematically precise results, which are as fluid as the uncertain assumptions upon which they are based.

Scenario testing has its genesis in the "interest rate paths" used in life insurance asset-liability management studies. This method does not strive for statistical precision, such as a "probability of ruin." However, it is more understandable to government regulators and non-technical company persons.

Scenario testing is easier to implement for permanent life and annuity products, where the cash flows depend primarily on market interest rates and their relationship with credited interest

rates. The method is more difficult to apply to casualty insurance products, where loss costs depend on a host of factors besides interest rates.

## Stochastic Simulation

Suppose one is asked: "How much capital is needed such that there is a 99% probability that assets will exceed liabilities in five years' time?" Early property-casualty risk theory considered only the liabilities of the insurance enterprise. It used probability distributions of claim frequency and severity, along with assumed risk premiums in the rates, and performed the necessary convolutions to reach a solution.

With a single line of business, and stochasticity only in claim frequency and severity, this method is reasonable. If the model is made realistic, with uncertain investment yields and stock market movements, multiple lines of business, and pervasive underwriting cycles, the mathematics becomes intractable.

Stochastic simulation, or "Monte Carlo" methods, resolves this intractability. Instead of an analytic solution, one selects values for each factor based on a probability distribution and a random number generator. This approach has been championed by the British Solvency Working Party and by the Finnish Working Party.[1]

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[1] The British Solvency Working Party research is summarized in C. D. Daykin, G. D. Bernstein, S. M. Coutts, E. R. F. Devitt, G. B. Hey, D. I. W. Reynolds, and P. D. Smith, "Assessing the Solvency and Financial Strength of a General Insurance Company," *Journal of the Institute of Actuaries*, Volume 114, Part 2 (1987), pages 227-325; C. D. Daykin, G. D. Bernstein, S. M. Coutts, E. R. F. Devitt, G. B. Hey, D. I. W. Reynolds, and P. D. Smith, "The Solvency of a General Insurance Company in Terms of Emerging Costs," in J. David Cummins and Richard Derrig, *Financial Models of Insurance Solvency* (Boston: Kluwer Academic Publishers, 1989), pages 87-149, or in *ASTIN Bulletin*, Volume 117, No. 1 (1987), pages 85-132; and C. D. Daykin and G. B. Hey, "Managing Uncertainty in a General Insurance Company," *Journal of the Institute of Actuaries*, Volume 117, Part 2, No. 467 (September 1990), pages 173-277. The Finnish Working Party methods are summarized in Teivo Pentikäinen and Jukka Rantala, *Solvency of Insurers*, Two Volumes (Helsinki: Insurance Publishing Co., 1982); Teivo Pentikäinen, Heikki Bonsdorff, Martti Pesonen, Jukka Rantala, and Matti Ruohonen, *Insurance Solvency and Financial Strength* (Helsinki, Finland: Finnish Insurance Training and Publishing Co., 1989); and Teivo Pentikäinen, "On the Solvency of Insurers," in J. David Cummins and Richard Derrig (eds.), *Classical Insurance Solvency Theory* (Boston: Kluwer Academic Publishers, 1988), pages 1-48.

The techniques used by these two parties have been lucidly and systematically laid out in a new

## Presentation

There are several drawbacks to the simulation approach, both in the presentation of results and in the underlying theory. Whether the results are presented graphically or tabularly, they generally show insolvency ratios, or probabilities of ruin: that is, the percent of realizations in which the enterprise's net worth (or policyholders' surplus, for statutory accounting analyses) drops below a "ruin barrier."

This probability of ruin figure might have meaning for the technical actuary, at least if the probability distributions upon which it is based were firm. But the assumed probability distributions are guesses, particularly for long-term macroeconomic forces such as business cycles or investment yields.

Even if the technician is satisfied, the lay reader of the actuary's report may find it of little use. First, the analysis gives only a probability of ruin; it does not say *why* the company failed in a particular realization. Second, the reader may not accept the actuary's assumed probability distributions for each factor. For instance, the actuary may have assumed that investment yields during the coming five years will average 8% per annum, with a standard deviation of 3%. The reader may say, "if you assume an average of 9% per annum, with a standard deviation of 2.5%, how does this change the results?"

Well, the actuary must rerun the simulation model, and the resulting probability of ruin will indeed change. But one does not know how much of the change stems from the revised assumption, and how much of the change stems from randomness – from the particular realizations produced by the random number generator in each run.

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textbook by Chris D. Daykin, Teivo Pentikäinen, and M. Pesonen, *Practical Risk Theory for Actuaries*, First Edition (Chapman and Hall, 1994). Much of this textbook is now on the casualty actuarial examination syllabus, so new actuaries are being tutored in stochastic simulation. This education is good, but it is incomplete.

## Underlying Theory

Many simulation models presume independence of most factors entering the model. For instance, claim frequency is assumed to be independent of claim severity which is independent of common stock values.

In truth, these factors are interrelated, though the strength of the correlation is often difficult to ascertain.[2] Accelerating inflation, if driven by a prosperous economy, may be associated with the following items:

- higher personal automobile claim frequency as insureds drive more frequently,
- lower workers' compensation claim severity, in real dollar terms, as employees with minor injuries return to the work-force,
- decreases in the market value of fixed income investments, as interest rates follow inflation upward, and
- changes in equity values that depend on the monetary and fiscal policies accompanying the resurgent economy.

These interrelationships are difficult to incorporate in the simulation model.

## Scenario Testing

Yet these interrelationships are the crux of the actuary's task. A well managed insurance enterprise does not fail because claim frequency shows a random upward spike one year, or because the common stock portfolio suddenly declines in value. On the contrary: well-run insurance companies do consider these potential occurrences – at least in isolation. But they may still fail because they do not properly anticipate the overall consequences of realistic but adverse future conditions. Their managements do not ask: "If the economy enters a severe recession, what are the probable effects on our insurance and financial portfolios?" or "If the market softens and our peer companies cut rates, what is the probable effect on our financial condition?"

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2 See Robert P. Butsic, "Report on Covariance Method for Property-Casualty Risk-Based Capital," (*Casualty Actuarial Society Forum*, Summer 1993 Edition, pages 173-202).

Let us qualify this. The management officers of well run companies indeed desire to ask these questions. But the questions are stymied by the lack of answers. Each individual question can be answered: one can always forecast the effect of a rise in interest rates on the market values of bonds. But the global questions elicit no answers because insurance professionals – including actuaries – lack the expertise and the tools to provide them.

Scenario testing links the effects of assumed future conditions on the various components of the company. One first constructs a scenario: that is, a complete set of interlinked attributes. One determines the set of attributes not by a random number generator that produces a chance confluence of elements. Rather, one selects the scenario because it realistically represents a potential future condition.

### Bottom-Up and Top-Down

The comments above might be rephrased as follows: Simulation proceeds "bottom-up"; scenario testing proceeds "top-down." Simulation takes a random draw from the probability distributions of each component factor and combines them into a realization. Whether the resulting scenario is realistic is not the concern of the actuary. On the contrary: the assumed independence of most input factors implies that all resulting scenarios are realistic. Stochastic simulation places importance on having a wide range of resulting scenarios unaffected by preconceived notions of the actuary or of the company's management.

Scenario testing has the opposite perspective. Scenario testing implies that because the individual factors are strongly correlated one with another, only a relatively small group of the possible "simulated" outcomes are realistic.

For instance, a soft insurance market has many components. Each soft market may be somewhat different from the preceding one, but the general pattern is the same. By testing a set of paradigmatic scenarios - with, say, scenarios for soft insurance markets, economic recessions, natural catastrophes, and the like – one has tested most of the realistic future conditions that might adversely affect an insurance enterprise.

### Meaningfulness and Modifiability

In addition, using scenarios has two other advantages:

- The results are meaningful to the company's management. If one is told that the company fails four realization out of a thousand stochastic simulations, one can not do much with this information. But if one is told that the company can not withstand a severe recession with certain characteristics, the company's management may decide to restructure its operations to prepare for the adverse contingency.

- The users of the actuary's analysis can modify the scenarios and ask for a revised report. For instance, for a "soft market" scenario, the actuary may assume that premium rates will decline by 10%. The company's director of underwriting may believe that rates will be cut by as much as 25% in the next underwriting cycle downturn, and that they will stay at the low levels much longer than the actuary assumed. The company's management might request analyses of both scenarios, thereby seeing the resilience of the company to the severity of future underwriting cycles.

If the model is a "black box," with probability distributions and simulation processes that are opaque to the user, the results will have little influence. But if the model allows the user to help compose the scenario to be tested, then the results directly address the user's concerns. By combining the expertise of the actuary in model building and the strengths of other company officers in specifying scenarios, the results achieve additional authority.

### Accounting Conventions and Cash Flow Approaches

Both scenarios testing and stochastic simulation require the analyst to combine the results of different parts of the company, such as combining investment results with underwriting results. There are two methods for making such linkages.

- An accounting perspective specifies the entries on the company's books resulting from each component of the enterprise. For instance, an increase in inflation, accompanied by a similar increase in interest rates, would lower the market value of fixed income securities and increase the nominal (undiscounted) value of inflation-sensitive reserves.

Accounting conventions, however, hinder the usefulness of this method. For instance, whether the change in the market value of the fixed income securities is reflected on the company's books depends on whether GAAP or statutory accounting is used. Moreover, whether the change in market value of the securities is reflected in GAAP statements depends on the classification of the fixed income securities: whether "held to maturity," "for trading purposes," or "available for sale."

Moreover, traditional accounting perspectives rarely provide the information needed either by the company's management or by insurance regulators. Suppose the actuary's report says that the increase in the inflation rate will increase nominal General Liability reserves by 15%, and that this (combined with other results) may create financial difficulties. The company's management might respond: "Is the actuary saying that ten years from now our assets may be insufficient to cover our liabilities, and twenty years from now we may unable to meet our claim payment obligations? Or is the actuary saying that we may be facing a liquidity crunch next year, and we should take immediate steps to shorten the duration of our investment portfolio?"

- To avoid these distorting effects of accounting conventions, and to enable users to respond to the actuary's results, a scenario testing model can use a cash flow approach: "How will a particular scenario affect the premiums collected, the losses paid, and the investment income received?"

For instance, a liquidity crunch results from an excess of cash outflows from insurance obligations over cash inflows from premiums and investment yields. To prospectively meet this potential problem, the company may rebalance its financial portfolio, combining evenly spaced maturity dates for its long term bonds with greater emphasis on Treasury bills, corporate paper, and other short-term investments.

If the potential future problems relate to having insufficient assets to pay claims twenty years hence, the opposite investment response may be called for: heavier investment in equities, such as common stock and real estate, that offer higher expected returns and are more likely to retain their values in an inflationary environment.

Stochastic simulation is the progeny of risk theory, nurtured at the actuary's hearth. When analytic solutions became too complex, simulations replaced them. Theoretical actuaries hope that as they refine their methods, these models will one day answer the questions that their managements pose. And if the models don't – well, just change the questions.

Scenario testing stems from the questions asked by regulators and company officers. The questions and the format of the desired responses are known. For instance, to a question like: "How will the company fare under the following conditions?" an appropriate response would be a report showing the expected year-by-year cash flows, along with pro forma financial statements at the end of the future period.[3] All the actuary needs is the requisite techniques for performing the analysis.

Fortunately, the techniques needed are the very ones that have been developed by the stochastically simulating actuaries. Simulation models have two components:

❶ Developing probability distributions for each factor and using a random number generator to select a set of inputs.

❷ Running the inputs through a cash flow model to generate a multi-year realization.

The scenario testing approach replaces the first component with scenario building: the construction of realistic scenarios by the actuary and by other company officers. The cash flow models used for stochastic simulation are equally applicable for testing scenarios.

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[3] For a "run-off" analysis, where no new business is assumed to be written, the cash flow analysis suffices, as long as the future period is long enough. For a "going-concern" analysis, where the company continues its insurance operations, pro-forma accounting statements for the end of the future period are necessary. The latter is the type of analysis for which scenario testing is most commonly used.

## Scenario Building

This paper concentrates on the first phase: scenario building. This phase is difficult for many actuaries because it can not be reduced to mechanical, "cookbook" techniques. It requires a keen understanding of the overall economy and of the insurance industry, along with a grasp of the interlocking effects of the manifold components of each.

Scenario construction may be subdivided into three phases:[4]

❶ *Scenario Selection:* The actuary selects potential future scenarios that are internally consistent. For many applications, such as solvency monitoring by regulators or the envisioned future task of the Appointed Actuary, the focus should be on adverse future scenarios. As examples, this paper presents an adverse economic scenario and an adverse insurance scenario.

- The adverse *economic* scenario assumes a moderately severe recession. The associated economic conditions that may affect an insurance company's financial status include higher unemployment, lower GNP growth, stock market declines, increased bond default rates, and several possible interest rate and inflation rate effects (depending on government monetary policy, among other items).

- The adverse insurance scenario assumes a prolonged unprofitable ("soft") phase to the underwriting cycle, similar to the General Liability conditions during the first half the of the 1980's, or the workers' compensation conditions during the latter half of the 1980's. The associated insurance conditions include intense competition for high-quality risks, increases in the involuntary markets, and potential regulatory and legislative efforts to mitigate insurance "availability" problems as the cycle begins to turn.

❷ *Effects:* The actuary projects how the elements of each scenario might affect the insurance enterprise. For instance,

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[4] These "phases" serve as a useful heuristic device, but there is no implication that they must be done sequentially. On the contrary: the valuation actuary may first examine all three phases for one component of the scenario before moving on to a second component.

- Higher unemployment may suppress workers' compensation claim frequency but cause an offsetting lengthening of durations of disability. Layoffs and plant closings, however, may increase both claim frequency and claim severity.[5]

  The projected effects of macro-economic changes vary by line of business. The relationships noted above between (a) macroeconomic conditions and (b) claim frequency and severity pertain to workers' compensation insurance. Different relationships are valid for personal automobile insurance.

- The effects on the insurer's investment portfolio depend on the types of securities that it owns. For instance, a recession associated with reduced interest and inflation rates may lead to a decrease in the value of equities and high-yield bonds, but to an increase in the market value of non-callable, investment grade, corporate or government bonds.[6]

The effects of insurance adversity – that is, of underwriting cycles – depend on the market structure in each line of business. The effects are most adverse in the potentially overcapitalized lines of business, such as workers' compensation. In these lines of business,

- the cost efficiencies of alternative risk management plans (such as self-insurance, or "administrative services only" plans),
- the continuing burden of involuntary market assessments and premium taxes on traditional commercial products, and
- the exodus of many multi-line carriers from the Personal Lines market to an intensified concentration on Commercial Lines

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5 See the discussion later in this paper for a more complete explanation of these relationships, which are based on studies by the Workers' Compensation Research Institute in Cambridge, Massachusetts.

6 The high-yield bond portfolio often loses value during recessions because of sharp increases in default rates. The high-grade corporate bond portfolio often gains value during recessions because of decreases in market interest rates.

suggest that little long-term relief should be expected from the soft markets.[7]

❸ *Calibration:* The actuary must determine how "adverse" each scenario should be. Perhaps the most persuasive way to calibrate the adversity of the scenario is to use actual past experience. For instance, the adverse economic scenario might assume an increase in unemployment no less strong than that which prevailed in the early 1990's. Alternatively, the calibration may be based on management's expectations for the coming years. For instance, the company may fear a soft workers' compensation market no less unprofitable than the soft General Liability market of the early 1980's.[8]

## Recessions

Any well-managed firm will prepare for future uncertainties by analyzing the effects of an economic recession on the company's fortunes. The usual analysis is of the following form: "If the economy turns down and demand for our product falls, how will we react? Are we locked into long-term production commitments, such as union contracts or supplier agreements? Is our operating ratio so high that it is too costly to move to a lower production level?"

In past years, insurance companies have been less likely to engage in this type of analysis, for several reasons.

❶ The traditional analysis focuses on changes in consumer demand caused by economic conditions. But property-casualty insurance is viewed as an inelastic product. Employers

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[7] The implication is that the profitable 1994 industry-wide workers' compensation results stem from unexpected vigor of state reform legislation and from macroeconomic conditions that have not been reflected in policy pricing. The persistency of these profits over the long-run is uncertain.

Lines of business with atomistic market structures should also be contrasted with lines of business having market leaders. The personal lines are of the latter type, with State Farm serving as the market leader. The commercial lines are of the former type, though the rating bureaus (ISO and NCCI) serve as partial substitutes for the market leaders.

[8] Although a replication of past adverse conditions may be most persuasive to internal company management, state regulatory authorities may wish to examine the company's ability to withstand an even more adverse "worst case" scenario. See the discussion below in the text of "Calibration" for a more complete traatment of this.

must purchase workers' compensation insurance in good times and in bad times. Drivers must purchase automobile liability insurance as long as they continue to drive.[9]

Similarly, life insurance products are long-term contracts. Policyholders may pay fifty years of annual premiums on whole life policies, with no difference between prosperous years and recessionary periods.[10]

❷ The property-casualty insurance industry has its own profit cycles, or underwriting cycles, which are distinct from industrial business cycles. The effects of macroeconomic changes on the insurance industry are less well understood than their effects on other industries.

❸ Life insurance shows neither underwriting cycles nor standard business cycles. Life insurance financial modeling, which is the prototype for property-casualty modeling, has focused on interest rate paths. Interest rate changes, however, have far less effect on property-casualty insurance company profitability than on life insurance company profitability.

**Scenario Building**

But macroeconomic conditions do affect property-casualty insurance companies. The effect on consumer demand for insurance may be less than the corresponding effects in manufacturing

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9 One may wonder: durable goods, such as automobiles, are extremely price elastic. So why should automobile insurance be inelastic? After all, if one does not buy the automobile, one need not buy auto insurance.

The explanation is that the demand elasticity for durable goods refers to new purchases, not to the use of the good. In prosperous years, sales of new automobiles increase sharply, as consumers replace their old vehicles with new ones. The total number of autos on the road, which determines the demand for automobile liability insurance, does not increase as rapidly. Thus, the demand for auto liability insurance is far less elastic than the demand for automobiles themselves.

10 Certain macroeconomic conditions do affect policyholder lapse rates. For instance, lapse rates on interest sensitive policies increase as the spread between investment rate and the credited rate increases. However, the effects of this spread on policyholder lapse rates and the insurer's profitability is far different from the consumer demand effects studied by industrial economists.

industries, but the effects on (i) the costs of the product, (ii) the financial assets of the company, and (iii) the collectibility of certain revenues are great. The scenario building task is more complex for insurers than for other firms – which makes it all the more important for evaluating financial strength.

### Economic Characteristics

So let us begin the scenario building task for an economic recession. First, the actuary constructs a generic scenario, selecting attributes that are consistent and realistic. The lines of business written by the insurer affect the economic attributes that should receive the most attention.

A recession may be characterized by a drop in real per-capita gross national product (GNP). A review of past recessions may suggest an average duration of 11 months, ranging from half a year to about a year and a half, with "depressions" extending for longer periods. The severity of recessions is more variable, ranging from almost nil (e.g., minor downturns in GNP for two successive quarters) to the harsh conditions of the 1929 Depression.[11]

The attributes of a recession depend partly on government policy. To combat a recession, a monetarist policy may call for decreases in the federal reserve rate, thereby lowering market interest rates and stimulating investment. A fiscal policy may call for either increased government spending or lower federal income taxes, both of which would expand aggregate demand. The choice between these options may depend more on Republican versus Democratic control of the levers of government than on economic views regarding the proper course of action. In other words, scenario building relies less on actuarial models and mathematical

[11] Econometricians have produced a wealth of data on the historical characteristics of U.S. recessions, such as the 11 month average mentioned in the text. This paper, however, seeks to steer clear of excessive quantification, for two reasons. First, a plethora of figures would serve only to obscure the qualitative themes of the paper. Second, statistical studies are but the secondary half of scenario building. More important are such qualitative items as political actions (legislative enactments and regulatory decisions), business strategy (premium rate changes and new product lines), and consumer responses (elasticity of demand and choice of risk management method).

profundity than on an awareness of political constraints on economic activity.[12]

### Financial Characteristics

Suppose that two valuation actuaries are analyzing the effects of a recession on two insurance companies. Insurer A writes Private Passenger Automobile liability coverage, and it invests all its assets in common stocks.[13] Insurer B writes retrospectively rated workers' compensation policies, and it invest all its assets in long term corporate bonds.

The two insurers are concerned with different attributes of the recession. The stock market is a leading indicator of economic conditions. In other words, a drop in stock values will generally precede an economic recession. In this phase of the scenario building process, the focus is on the timing and relative magnitude of the stock market reaction to GNP changes. For instance, a survey of past recessions might indicate that movements in the Dow Jones common stock index precede those of the GNP by about two quarters, and that each 1% change in real GNP translates into about a 3% change in real market values. The valuation actuary for Insurer A, when examining asset values, is concerned with the interrelationship between GNP and stock market indices.[14]

The valuation actuary for Insurer B has different concerns. Recessions are generally characterized by falling inflation rates. Lower inflation rates, in turn, are associated with lower nominal interest rates. Lower interest rates lead to increases in the market values of long duration investment grade bonds.

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12 The latter is forbidding terrain for some actuaries, which partially accounts for their leaning towards stochastic simulation techniques.

13 Yes, many states expressly forbid such investment strategies. But this example is for heuristic purposes only. In practice, the valuation actuary simply begins with the actual investment portfolio of the company.

14 If the insurer holds a particularly aggressive or defensive stock portfolio, the valuation actuary may also consider the market (CAPM) *beta* of the financial portfolio and its relevance for the forecast stock values.

Note the differing concerns of the two valuation actuaries – in the characteristics of recessions that each is concerned with, in the effects on the insurance companies, and in macroeconomic and political causes that must be considered. Not only would different attributes of recessions be emphasized in their reports, but the likely effects on the insurance companies are the opposite, and different influences should be analyzed.

❶ Insurer A is concerned with the relationship of common stock indices with changes in GNP. Insurer B is concerned with the effects of GNP movements on nominal interest rates.

❷ Since Insurer A invests entirely in common stocks, it is hurt if the market declines during recessions. Since Insurer B invests entirely in high grade bonds, it is helped if nominal interest rates decline during recessions.[15]

❸ The relationships between market indices and macroeconomic conditions are not easily influenced by political initiatives. Monetary policy, however, may have an immediate effect on market interest rates. The valuation actuary for Insurer B may wish to consider the economic philosophy of the current Federal Reserve Board when forecasting the likely movements of market interest rates during a recession.

**Effects on Claim Costs**

Differences also surface in the effects of a recession on the insurer's liabilities. Insurer A, the personal automobile writer, is concerned with the effects of recessions on income levels, traffic density, and vacation travel. Insurer B, the workers' compensation carrier, is concerned with the effects of recessions on employment, job opportunities, and durations of disability.

Recessions are characterized by fewer new cars, less travel to and from work, fewer automobiles on the roads, and less vacation travel. All of these lead to lower claim frequencies for personal automobile liability insurance. Claim severities should remain constant (in real

15 Offsetting this is the "market value" increase in certain fixed payment liabilities, such as workers' compensation disability payments. Thus, the net effect on insurer B's economic net worth is not as positive as the effect on its investment portfolio.

dollar terms), so overall loss costs should decline.[16]

Claim frequency shows an equally marked decline in workers' compensation. Younger, less experienced workers have higher claim frequency rates than do older, more experienced workers. During recessions, the younger, more recently hired workers are laid off first, leaving a more experienced work force. Moreover, workers with minor injuries are reluctant to press claims, lest they find themselves out of a job once they have recuperated.

The decline in claim frequency is offset, however, by a rise in claim severity. Durations of disability lengthen during recessions, (i) as recovering workers find that they have no jobs to return to, and (ii) as employers are without the means to provide alternative work for partially disabled workers.[17]

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16 To be accurate: claim severities by type of accident should remain stable. For instance, the average claim severity for highway crashes should not differ between recessions and more prosperous times. But since the mix of claims by type of accident may change between recessions and more prosperous years, the overall claim severity may change as well.

17 Some readers may ask: How does one quantify these effects? In practice, any figures used in these analyses will be "soft." For instance, one research institute estimated that a recession causes a 4% decline in claim frequency offset by a 3% increase in claim severity, for a net decrease in claim costs of 1%. But these numbers are uncertain, since so many factors affect claim frequency and severity. Each recession is different, and precise quantification eludes us.

The value of scenario testing is not dependent on the accuracy of these "soft" figures. The task of the actuary is to identify the potential relationship and to incorporate them into the valuation model. The magnitudes of the effects can best be chosen by the company officers most directly involved.

For instance, the effects of a recession on workers' compensation claim frequency and durations of disability may be selected by the manager of claims operations. The effects of a recession on equity values and on interest rates can best be selected by the company's investment officer.

The valuation actuary's task is to identify the potential relationships, elicit the needed information from other company officers, and use this information in the valuation model. Indeed, by allowing other company officers – whether in operating divisions or in management ranks – to choose the values for these relationships, the actuary increase the probable acceptance of the valuation results.

### Premium Collection

The workers' compensation carrier in this example writes retrospectively rated policies. If the insured employer goes bankrupt during the recession, there will probably be a surge in claims, for two reasons:

1. First, Injuries and ailments that were not reported previously because the employees feared that they might lose their jobs will now be pressed as workers' compensation claims.

2. Second, workers' compensation often provides larger and longer lasting benefits than does unemployment insurance. Laid-off employees have an incentive to press workers' compensation claims even for non-work related accidents and ailments.

When these claims are reported, the insurer is obligated to pay them (unless it can justifiably deny them). Bankrupt insureds, however, rarely pay accrued retrospective premiums. The insurer may discover large losses on policies that were originally thought to be relatively riskless cash transactions.

As before, the valuation actuary builds the scenario differently for the two insurance companies. For the personal automobile insurer, the valuation actuary asks how recessions affect the number of cars on the roads and the type and amounts of driving done by the insureds.[18] For the workers' compensation carrier, the valuation actuary asks how recessions affect unemployment levels and bankruptcy rates.[19]

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18 Whence might one obtain the data for scenario building? Historical statistics are available from many state transportation departments or departments of motor vehicles; California, for instance, has produced many such studies. In addition, the large Personal Lines direct writers collect extensive statistics on automobile use by region and by quarter.

There is no lack of data for the resourceful actuary. However, the data are rarely in the desired form. The available reports do not say: "If GNP declines by 1%, then miles driven in the U.S. decline by 2%." Rather, the actuary must extract the needed information from the available data.

19 Again, there are abundant data available for analysis, though they are rarely in final "actuarial" form. Various departments of the U.S. government publish unemployment statistics and workplace injury statistics; OSHA, in particular, compiles extensive reports. The Workers' Compensation Research Institute in Cambridge, Massachusetts, and the Economic

## Calibration

To calibrate the model is to choose the magnitude of the scenario's parameters. For instance, should the recession scenario be a 1% drop in real GNP for 9 months, or a 6% drop in real GNP for two and a half years?

There are two purposes of scenario testing, and there are two methods of calibration, giving four options in a two-by-two matrix. The purposes are management planning versus solvency monitoring. The methods are statistical distributions versus extrapolation from experience.

### Purposes

- *Management Planning*: The primary *internal* use of scenario testing is for management planning. Suppose the company anticipates that the economy will enter a recession in the coming year or two. It desires to know the probable effects on the company's operations and financial condition. The scenario should be calibrated in accordance with the expected severity of the coming economic conditions. For testing the sensitivity of the company's financial strength to the characteristics of the economy, the actuary may construct "adjacent" scenarios: one with a more severe recession and one with a less severe recession.

- *Solvency Monitoring*: State regulators are concerned with ensuring insurer solvency, not with optimizing insurer strategy. The regulator will choose a recession scenario sufficiently adverse that if the company can withstand these economic conditions then it can presumably withstand most future economic conditions.

### Methods

- *Statistical Distributions*: Probability distributions are available for the durations and severities of recessions. To calibrate the scenarios, one might use (i) average severity, (ii) average severity plus one standard deviation, and (iii) average severity plus two

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Research Division of the National Council on Compensation Insurance in Boca Raton, Florida, have examined such issues as the relationships between economic conditions and workers' compensation claim filing.

standard deviations. These calibrations have corresponding intuitive explanations. The "average severity plus two standard deviations" calibration, for instance, may be explained as "this recession is at least as severe as 95% of potential future recessions."

- *Extrapolations from Experience*: Standard deviations may be meaningful to the statistician, but they are often opaque to the lay person. Business planners do not think of economic conditions in terms of probability distributions. Rather, they say: "If we have another recession similar to that of the early 1980's, how will the company fare?" *The most influential model is one which shows the likely future effects of a recurrence of a past condition that is still fresh in management's mind.* If the actuary says: "Given another recession like the one in the early 1980's, the following are the likely effects on the company's operations and financial condition," management will pay close heed.

In practice, the "management planning" purpose is generally calibrated with the "extrapolations from experience" method, and the "solvency monitoring" purpose is calibrated with the "statistical distributions" method. When composing the actuary's report, the appointed actuary might say: "The company has the financial resources to withstand 95% of potential future recessions, with a surplus margin of $500 million." When speaking to the company's management, the valuation actuary might say: "Given a recession like the one in the early 1980's, the company's expected cash flows and statutory surplus each year will be as follows . . ."

## Insurance Markets

Periodic profit fluctuations, or underwriting cycles, transverse the property-casualty insurance industry. Though the causes of the cycles are only imperfectly understood, several characteristics of underwriting cycles are clear.

- Underwriting cycles are not simply reflections of business cycles. An often mentioned distinction between the two is that business cycles are "demand driven" whereas underwriting cycles are "supply driven."[20] In other words, underwriting cycles can not be

20 See, for instance, Barbara D. Stewart, "Profit Cycles in Property-Liability Insurance," in John D. Long and Everett D. Randall (eds.), *Issues in Insurance*, Volume 1, Third Edition (Malvern, PA: The American Institute for Property and Liability Underwriters, 1984), pp.

modeled simply as by-products of changing macroeconomic conditions.

❷ Underwriting cycles can be severe – more severe than standard business cycles. As the cycles moves from peak to trough, premiums may be cut in half. As a result, policy year profits may shrink from a large gain to a large loss – particularly after adjustment for calendar year "smoothing" caused by loss reserve strengthening and weakening.

❸ Although many insurers believe that they can anticipate the future movements of the cycles, they feel helpless to modify them. The insurer might say: "General Liability rates are heading downwards, and the industry will lose money during the coming year in this line of business." But all the insurer can do is to plan its operating strategy in accordance with the expected unfolding of the underwriting cycle. It is unable to mitigate the severity of the cycle itself.

❶ Underwriting cycles contain a variety of interlocking elements, all of which must be considered in evaluating the effects of the cycle on the insurer's operations and financial strength. For instance, a hardening of the insurance market may be associated with increases in the size (and costs) of involuntary markets and with the exodus of insureds to alternative risk management schemes. It is the interplay of these elements that is crucial for the valuation actuary's work.

**Cycles, Simulation, and Scenarios**

Stochastic simulation is not well suited for modeling underwriting cycles because the factors causing cycles are not random. Insurance profit cycles do not result from random large losses. Rather, they reflect industry-wide rate reductions and increases, coupled with associated underwriting and residual market changes.

There are no "probability distributions" for industry-wide rate level changes. And even if such a distribution could be constructed, a simulation model would not be appropriate. The insurer's management does not ask, "What is the probability of rates being cut next year?"

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Rather, the insurer's management asks: "If we go through another underwriting cycle in General Liability, what will be the effects on our financial condition?"

When modeling recessions, with their likely effects on equity values, bond values, claim frequency, and claim severity, many insurance executives are willing to leave the assumptions to economists, investment analysts, and actuaries. But when modeling underwriting cycles, with their likely effects on internal rate levels, peer company actions, consumer demand, and regulatory responses, few insurance executives are content with black box Monte Carlo models.

The company needs the valuation actuary for two functions: (i) to map out the components of the cycle and (ii) to show the combined effects of the various elements. For instance, the effects of underwriting cycles on premium rate levels are easy to model. But the effects on the relative populations in the voluntary market, the involuntary market, and the self-insured market are less clear. The valuation actuary must identify these relationships and provide starting parameter values in the scenario building phase. Once the scenario is completed, the valuation actuary must run it through a cash flow (or similar) model to determine the combined effects on the company's financial strength.

### Workers' Compensation

Workers' compensation cycles serve as an excellent illustration because their components, although strong, are unlike the "traditional" elements that actuaries are accustomed to dealing with. The valuation actuary is concerned not with claim frequencies and claim severities, but with such items as state legislation and consumer demand.

The basic scenario for an underwriting cycle may be constructed as a six year stretch: three years of premium rates dropping to X% below adequate levels, and then three years of premium rates rising to Y% above adequate levels.[21]

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[21] Six years is the average duration of property-casualty underwriting cycles in the U.S. The pattern of premium rate changes may be modeled in various ways. Some pure actuaries like sine curves, more for their mathematical elegance than for their adherence to reality. Actuarial underwriting cycles show quicker declines and increases in premium levels, along with flatter plateaus and valleys, than sine curves have.

When modeling macroeconomic conditions, most insurance executive will be content with replicating historical conditions. But the course of the underwriting cycle depends on the structure of the insurance industry in a given line of business. In general, lines of business with an excess of suppliers and a dearth of dominant companies, and which have the opportunity for competitive pricing, are susceptible to more severe cycles.

The continuing exodus of large, independent agency companies from the personal lines, and their intensified focus on the commercial lines, along with the departure of large insureds from the traditional insurance markets to self-insurance and excess covers, is increasing the insurance supply in the workers' compensation market. Until this line is purged of its excess capacity, one might expect increasingly severe profit fluctuations. The valuation actuary uses these relationships to select appropriate "X" and "Y" initial parameters for the cycle's severity.

Ultimately, however, these parameters are based not on historical experience, but on management expectations. In fact, workers' compensation cycles have historically been modest until the 1980's, when the cycle turned severe. Presumably, this reflects the change from administered pricing to open competition in certain jurisdictions, in addition to the over-capitalization effects discussed above. The continuing latitude in pricing along with the increasing excess of supply over demand should lead to even more severe cycles in coming years.

The actuary's initial choice of parameters is based on an analysis of the underlying characteristics of the workers' compensation market. But the true worth of scenario testing is its ability to adjust the scenario in accordance with the desires of the audience.

**Consumer Demand and State Legislation**

Suppose the values of the "X" and "Y" parameters have been chosen as –20% and +20%: that is, premium rates will decline 20% below their adequate level during the soft market phase and then increase to 20% above their adequate level during the hard market phase. These values should reflect management's prognosis for the coming years – or perhaps their concerns after a survey of the market.

The valuation actuary now turns to consumer demand, or market populations. Over the past two decades, the traditional workers' compensation market has been shrinking. Large insureds are

turning to alternative risk management techniques, such as large dollar deductible policies, excess covers, administrative services only plans, captives, and pure self-insurance. Small insureds are being relegated to the involuntary markets, particularly since the movement from a manufacturing economy to a service economy reduces the expected workplace injury costs and raises the relative importance of fixed underwriting expenses.

For the relationship between the traditional insurance market and the self-insured market, the valuation actuary may assume that demand will stay level during the soft phase of the cycle, and that it will decline by 5% during the hard phase. Involuntary market population levels are subject to additional influences, such as policy characteristics in the residual pools (e.g., up-front premium payment versus installment plans) and relative rate levels in the voluntary versus involuntary markets.[22]

Legislative and regulatory actions have greater influence on workers' compensation than on other lines of business. The workers' compensation underwriting cycle of the mid- to late-1980's precipitated reform legislation in many jurisdictions, which in turn raised workers' compensation profitability in the early 1990's. The valuation actuary may begin constructing the underwriting cycle scenario with assumptions like the following: When insurer profitability is high at the peak of the cycle, state legislatures are tempted to increase worker benefits. When insurer profitability is low and underwriting standards begin to tighten at the upturn of the cycle, state legislatures are exhorted to pass reform legislation to preserve the compensation system.[23]

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22 Logically, one can expect involuntary markets to grow during the hard phase of the cycle and to depopulate during the soft phase. During the soft phase, insurers loosen underwriting standards and seek out even risky business. During the hard phase, insurers tighten underwriting standards and cast off unprofitable risks.

Yet this generalization is subject to so many exceptions that its validity may be questioned. It is appropriate for setting initial parameters for the underwriting cycle scenario. The final scenario, however, should reflect management's expectations, not solely those of the valuation actuary.

23 Intuitively, this relationship seems simple; in practice, it is complicated by legislative time lags. The phases of a typical cycle last two or three years at most. The time span between first conception and final implementation of state legislation is generally longer. Once again, the simple generalization in the text is useful only as a starting point. The final scenario should reflect management's expectations for the coming years, based less on actuarial considerations than on pending or proposed legislation.

The task of the valuation actuary is not to predict the course of the future. Rather, the actuary develops a scenario that can incorporate changes in all areas that significantly affect the company, such as residual market populations and the effects of state reform legislation. The audience of the actuary's report may select the particular parameters, such as the expected growth or decline in the residual market population that would accompany each stage of the underwriting cycle. The actuary then uses these assumptions to determine the combined cash flows from each of the insurer's operations and their effects on the insurer's financial strength.

## Conclusion

The actuarial profession is seeking new responsibilities: opining on both assets and liabilities, on surplus adequacy, and on long-term financial strength. The techniques being developed are of many types, of which stochastic simulation and scenario testing are two of the most promising.

Stochastic simulation resides squarely in the actuary's domain. It has had a long actuarial adolescence in Europe, and it is now embodied in the casualty actuarial educational syllabus in the United States.

Actuaries must indeed know the fundamentals of simulation models. But of the two options, stochastic simulation and scenario testing, the latter is the more practical choice. Scenario testing involves the users of the valuation model in the portrayal of the future. It hears their questions, and it directly addresses their concerns. It converts the envisioned appointed actuary from the keeper of a black box to the guardian of an unfolding future. This is the role we desire for members of our profession.