Dynamic Financial Models of Property/Casualty Insurers by the Subcommittee on Dynamic Financial Models of the CAS Committee on Valuation and Financial Analysis

DYNAMIC FINANCIAL MODELS OF
PROPERTY-CASUALTY INSURERS

Prepared by
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CHAPTER 1

PURPOSE

The purpose of this report is to discuss and provide guidance on the important issues and considerations that confront actuaries when designing, building or selecting dynamic financial models of property-casualty risks. It has been prepared by the Subcommittee on Dynamic Financial Models of the Casualty Actuarial Society's Valuation and Financial Analysis Committee. It constitutes part of the Society's ongoing educational efforts on issues affecting actuaries responsible for the strategic and dynamic financial analysis of insurers.[1]

In writing this report, the Subcommittee has intentionally avoided placing requirements on actuaries or the models used by actuaries. These requirements have been and will continue to be addressed by the Actuarial Standards Board.

[1] Other sources of information regarding dynamic financial models is included in Appendix A.

CHAPTER 2
INTRODUCTION AND BACKGROUND

What is Dynamic Financial Analysis?

One of the early references to dynamic financial analysis comes from Jay W. Forrester in Industrial Dynamics. He defines it as ". . a way of studying the behavior of industrial systems to show how policies, decisions, structure, and delays are interrelated to influence growth and stability. It integrates the separate functional areas of management -- marketing, investment, research, personnel, production and accounting. Each of these functions is reduced to a common basis by recognizing that any economic or corporate activity consists of flows of money, orders, materials, personnel, and capital equipment. These five flows are integrated by an information network."[2]

Models are the key tools in dynamic financial analysis. Such models are ". . , a systematic way to express our wealth of descriptive knowledge about industrial activity. The model tells us how the behavior of the system results from the interactions of its component parts."[3]

The Actuary's Need for Dynamic Financial Models

Historically, casualty actuaries have focussed primarily on rates and loss and loss adjustment expense reserves. As the portion of insurers' liabilities arising from casualty insurance has increased, their use of reinsurance has decreased and actuarial valuations of liabilities have become increasingly important. Property-casualty actuaries, and in particular members of the Casualty Actuarial Society, have had increasing responsibility to provide opinions on the loss and

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[2] MIT Press, 1961, p. vii.

[3] Ibid.

loss adjustment expense reserves of property-casualty insurance companies in the U.S. since 1980, when the first state introduced such requirements.

In more recent years, regulatory and competitive pressures, as well as the desire for a more holistic understanding of the insurance process, have led and continue to lead to expansions of the casualty actuary's role. It is anticipated that, with the emergence of the Appointed Actuary concept for property-casualty insurers in the United States, actuaries will be responsible for understanding insurance company assets, cash flows and investment risks as well as liabilities. Property-casualty actuaries are expected to place increased reliance on dynamic financial models similar to the mandated use of dynamic financial models in emerging standards for life insurers. As such, it is becoming increasingly important that casualty actuaries become familiar with dynamic financial models.

Concurrent with the changing role of the property-casualty actuary have been changes in computer power and software ease that have made the use of dynamic financial models more practical. Specifically, models that would have taken days to code a decade ago can now be implemented in minutes and results can now be. expressed graphically using standard software, easing interpretation.

Why Use Dynamic Financial Models?

Dynamic financial models generally reflect the interplay between assets and liabilities and the resultant effects on income and cash flows. This explicit recognition of all of the insurer's' operations gives dynamic financial models the power to illustrate the links between strategies and results. Therefore these models make a unique contribution to the actuary's set of tools for financial analysis.

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[4] Throughout this report, the application of dynamic financial models to insurers is discussed. These models are equally useful for captives, risk retention groups, self-insurance pools and large self-insureds.

Dynamic financial models are characterized by the projection of both income and cash flows over a period of time. The time delays between occurence of claims and their payment in the property-casualty insurance business make it difficult or impossible to evaluate strategies and decisions without explicit consideration of their effects on flows of funds. Indeed, the results of management decisions or the effects of outside forces may often be counter-intuitive unless a dynamic financial model has clarified the situation.

A scenario is a set of assumptions about the environment in which the insurer's operations will take place. Scenarios are used to illustrate the implications of strategies and decisions in the context of information about the risks that confront the insurer. The explicit consideration of scenarios gives a dynamic financial model a unique role in helping management in identifying profit opportunities and encouraging investment in the company. Such explicit consideration also assists regulators in understanding problems before they grow to crisis size. Management can often identify potential problems earlier, and regulators can distinguish short-term problems that do not warrant intervention from long-term problems that require action.

CHAPTER 3

USES, USERS AND RESOURCES

The design and/or selection of a dynamic financial model will depend heavily upon the purpose of the engagement (use of the model), the users of the model and its results, and the available resources.[5]

Uses

Dynamic financial models have many uses, including:

- Determining the value of an insurance company or block of policies to a potential buyer or seller.
- Assessing how an insurer might fare in a range of future economic environments.
- Strategic planning, including asset-liability management, tax planning, reinsurance planning and costing, and market strategy.
- Feasibility studies.
- Tactical decision-making, including product pricing. (Although dynamic financial models are not yet widely used to price property-casualty insurance products today, they are already widely used to price life insurance products.)

[5] These considerations, along with the others identified in this report, are summarized in Appendix B.

- Identifying the kinds of risks that most threaten the solvency of the insurer.

The use of the model will be a key determinant of many of its requirements. Examples include:

(1) Model input and output depend on the use. For example, if modelling a worst-case scenario for solvency testing, a complex tax module is not important because the insurer is unlikely to pay substantial income taxes, at least under current federal income tax laws,

(2) The use of the model helps determine the time frame and accounting basis. For example, if regulators ask the actuary to model solvency over a two-year time horizon and ensure that risk-based capital requirements are met, then a minimum of two years of future statutory accounting statements is required.

(3) The use of the model may determine whether a deterministic or stochastic model is more appropriate. This decision in turn will greatly affect the resources and data needed. the model structure and the form that output will take. As an example, if the goal is to develop probability distributions of results, then an actuary will be more likely to use a stochastic model.

Users

Future Appointed Actuaries and insurers that wish to anticipate the results of the Appointed Actuary's work are the users who are driving the CAS's educational efforts on dynamic financial analysis. Other users of dynamic financial models include consulting firms and insurers that employ such models as tools for tactical and strategic decision-making, including pricing decisions. Third-party users of the results of dynamic financial models can include regulators, reinsurers, investment bankers, financial intermediaries, institutional investors, securities rating organizations, and financial analysts.

The intended users' needs are a consideration in designing and selecting the model. The type of model used and its structure depend on customers (users) and their needs. As an example, regulators may focus mainly on the insurer in total. Company management may focus on the total corporation or on each individual product.

Resources

The choice of dynamic financial model will depend on the available resources, whether these resources are people available for system design and programming, data from which to derive assumptions and with which to initialize the model, money available to purchase an existing software package, or computer architecture.

Detailed dynamic financial models require a significant investment of time for research to determine assumptions, as well as for maintenance to keep the model's logic current and to revise assumptions in light of new data. Such models also require a significant expenditure of time in interpreting the results.

The choice of computer architecture is often determined by the purpose of the analysis and the level of detail of the projections. A simple spreadsheet might be appropriate if the purpose of the study is to highlight the effects on financial results of one particular risk, such as adverse development of loss reserves. At the other extreme, complex, report-generating software with a user-friendly front-end and efficient coding of the detailed calculations might be appropriate if the model is intended to cope with a wide range of different problems and be used by a wide range of users.

CHAPTER 4

RISKS OF THE PROPERTY-CASUALTY INSURANCE BUSINESS

The evaluation of risk is the focus of dynamic financial models. The relative importance of each type of risk will determine the detail of assumptions and analyses built into any model. In this chapter, the risks of the propertycasualty industry are described and the related modelling considerations addressed.

Property-casualty insurance risks can be divided into many categories. In this paper, we will follow the definitions originated by the Committee on Valuation and Related Matters of the Society of Actuaries and will discuss these risks in the following four categories:

- C-l risk - Uncertainty surrounding cash flows from invested assets other than from uncertainty regarding interest rate risk.

- C-2 risk - Uncertainty surrounding cash flows from the obligation or underwriting aspects of an insurance company.

- C-3 risk - Uncertainty surrounding cash flows from interest rate fluctuations in the presence of a mismatch of assets and liabilities and the risk of disintermediation caused by embedded options that are sensitive to changes in interest rate.

- C-4 risk - Uncertainty emanating from mismanagement, i.e., making incorrect or fraudulent actions in light of the available information.

As do many discussions of insurance risks, this paper will focus on the first three of these risks. At present, measuring the risk of mismanagement is beyond the scope of most actuarial engagements.

Asset Risk

Asset risk, also known as C-l risk, is the risk that the amount or timing of items of cash flow connected with assets will differ from expectations or assumptions as of the valuation date for reasons other than a change in interest rates. It encompasses uncertainty regarding:

- Default rates.
- Future'market value of equity assets.
- Liquidity of assets.

In addition to these inherent asset risks, there is also the risk that the character of the assets will not be evident from their general descriptions. This problem is increasing as capital markets develop a greater range of non-equity investments that have many of the risk characteristics of equity investments.

Appropriate data and methods are critical to the development of ranges of assumptions to reflect asset risk in the projected performance of the insurer. Historical data developed for investment managers is readily available, including time series of default rates of various classes of assets as a function of age.

Dynamic financial models can be used to estimate the effects of these risks alone on the projected performance of the insurer and can also be used to estimate the interrelationships between these risks and other risks. In modelling, asset risks may be assumed to correlate with inflation or some other variable or to be autoregressive.

Obligation Risk

Obligation risk, also known as C-2 risk, is the risk that the amount or timing of items of cash flow connected with the obligations considered will differ from expectations or assumptions. For property casualty companies, obligation risk encompasses:

- Reserve risk - the risk that the actual cost of losses for obligations incurred before the valuation date will differ from expectations or assumptions.

- Premium risk - the risk that premium for future obligations will differ from expectations or assumptions.

- Loss projection risk - the uncertainty regarding assumptions about future loss costs.

- Catastrophe risk - the uncertainty regarding the costs of natural disasters and other catastrophes.

- Reinsurance risk - the uncertainty regarding the cost, value, availability and collectibility of reinsurance.

- Expense risk - the risk that expenses and taxes will differ from those projected.

Dynamic financial models can be used to estimate the effects of these risks individually on the projected performance of the insurer and to evaluate the interrelationships between these risks and other risks.

Reserve risk may be a function of:

- Inflation in medical costs and other determinants of claims costs.
- The legal environment in which claims will be resolved, including the environment in which claims are pursued by policyholders or third parties.
- The possibility of a breakdown in some basic premise underlying the reserves for a particular coverage (such as has occurred with environmental impairment liability).
- Past patterns of pricing adequacy which affect case reserves or financial reserves.
- Corporate culture, training, and incentives that affect the payment of claims or the adequacy of case reserves.
- Currency fluctuations which affect the costs of losses when expressed in local currency.
- The randomness of the claims process itself.[6]
- Incompleteness of data bases.

[6] The randomness of the claims process itself can be studied by modelling the patterns of loss development or by more detailed analysis of the claims process. Inevitably, however, data for such models always include the effects of other factors affecting the claims process.

Premium risk may be a function of:

- Competitive pressures that do not allow the insurer to achieve assumed levels of exposure and/or rate adequacy.

- Regulatory intervention that restrains premium increases or decreases or that requires business to be underwritten that would not be underwritten in the absence of such intervention.

- Premiums for involuntary business underwritten at premium rates and in volumes that differ from assumptions.

- Retrospective premiums or dividends that differ from assumptions.

- Amounts collectible from agents that differ from assumptions.

If premium risk is expected to arise from a cyclical pattern of premium adequacy in the competitive market, a cyclical component could be incorporated into the model or into the premium adequacy assumptions.

Loss projection risk is a function of the factors that affect reserve risk and also of the uncertainty regarding:

- Changes in loss costs and exposures from the historical experience period.

- Loss costs for the mix of new policies being underwritten, including the effect of adverse selection.

- Loss adjustment practices in the future that may differ from those in the past.

Catastrophe **risk** can **be** considered a component of loss projection risk. It is a function of:

- The coverage being written.

- The concentration of insured values in specific geographic areas or legal jurisdictions.

- Uncertainty regarding the frequency, seventy and nature of catastrophic events.

Computerized models of the damage arising out of certain types of catastrophes are available which may be of value in determining assumptions about the probabilities and sizes of catastrophic losses. Output from these catastrophe models may be used as input to a dynamic financial model or a link between the models may be established so as to include the impact of catastrophe risk in dynamic financial models.

Reinsurance risk is a function of changes in the price and availability of desired reinsurance, and of uncertainty regarding the collectibility of reinsurance recoverables arising from the financial condition of the reinsurer or ambiguity about the coverage provided. Reinsurance risk exists in each of the four obligation risks identified thus far. In many models, projections are made on a net of reinsurance basis. Such projections incorporate implicit assumptions regarding reinsurance risks, whereas projections made on a gross of reinsurance basis require explicit instructions regarding the reinsurance mechanism. Reinsurance risk recognizes how reinsurance responds under stress, such as a large catastrophe or other strain on collectibility, aggregates, reinstatements and other reinsurance parameters.

Expense risks, those associated with expenses (other than loss adjustment expenses) and taxes, include uncertainty regarding:

- Contingent commissions to agents.
- Marginal expenses of adding new business.
- Overhead costs, including the risk that overhead costs will be changed by regulatory intervention and the risk that there may be periods of changing premium during which overhead costs will not change in proportion to premium.
- Assigned risk overburdens, second injury funds and other assessments.
- Federal and local income taxes, both in interpreting the current Internal Revenue Code and in anticipating changes in the code.

These lists of uncertainties regarding the major components of obligation risk are illustrative. Other factors may affect obligation risk.

Interest Rate Risk

Interest rate risk, also known as C-3 risk, is the risk that net cash flows will depart from expectations or assumptions as the result of interest rate fluctuations. Interest rate risk encompasses uncertainty regarding cash flows from assets, including bond yields, mortgage interest rates, real estate income, and dividends on equity investments. It also encompasses uncertainty regarding cash flows related to borrowing, such as the interest rate on any loans taken out by the company or cost of capital.

Reinvestment risk is uncertainty regarding yields that will be. available on reinvestment of proceeds from investments that are currently held. In many dynamic financial models, a set of assumptions must be made about the yields that will be earned on future investments. Often in practice the apparent solvency or insolvency of the enterprise will be sensitive to the choice of interest rate ("reinvestment rate").

Another component of C-3 risk is the uncertainty regarding the market value of any fixed-income assets that must be sold prior to maturity to meet cash flow needs. C-3 risk includes market value uncertainty related only to changes in interest rates; market value uncertainty related to changes in perceived credit or default risk is a component of C-l risk. The reinvestment rates, discussed above as being determinants of reinvestment risk, also determine market value risk for fixed-income assets. Thus, the reinvestment rate can have a significant impact on the results of the model, resulting in an under- or over-statement of risks because of an inexact choice of reinvestment rate.

CHAPTER 5

RISKS INHERENT IN THE MODELLING PROCESS

Once the risks to be incorporated in the model have been identified and the model built, there are a number of risks inherent in the modelling process to consider, including:

- The range of scenarios may not reflect the user's intent.
- The model may be incorrectly or incompletely specified for the intended purpose.
- The model's results may be inappropriately interpreted.

Importance of Scenario Testing and Selection of Assumptions

Proper use of a model depends on the selection of appropriate scenarios to evaluate and the development of consistent assumptions within each scenario. The purpose of the model will influence the data and methods used to provide assumptions for understanding the projected performance of the insurer. Scenarios permit links between assumptions for various parts of the model. For example, a high interest rate scenario might include assumptions of high bond yields, low common stock values with high dividends, high inflation in medical costs, and a low level of unemployment.

Scenarios provide an especially relevant tool for determining the implications of risks on the projected performance of an insurer. Observing the results for a variety of scenarios yields information about the company's response to risk. Careful selection of scenarios is essential.

One of the reasons for using dynamic financial models is that they can provide information about the interactions among risks. Dynamic financial models can indicate the extent to which components of the company interact with one another. Depending on the purpose of the model, the actuary may have a responsibility to describe the ways in which several components appear to be interacting, particularly if they alter the risk that arises from uncertainty about the assumptions or logic for a single component.

In many situations, the actuary will be constrained with respect to the choice of scenarios. At this time, life insurance regulatory authorities specify certain scenarios to be modeled by the actuary, at a minimum. Similarly, Canadian regulations provide general guidance regarding the choice of scenarios. This kind of regulatory requirement may expand to U. S. property-casualty actuarial work in the future. Sometimes the scenarios to be studied will be specified by company management rather than by the actuary. However the range of scenarios is selected, its choice will impact the results that the model produces. It may be appropriate to observe the model under scenarios other than those specified by regulators or management to adequately understand the implications of the scenarios that were specified.

When the range of scenarios has been selected using only retrospective tests as a guide, the model may be prone to be over-determined. For example, the risk that the probability distributions in a stochastic model are incorrectly specified can be minimized by choosing probability distributions that have greater uncertainty (central tendency, dispersion, and skewness) than historical data.

Model Specification

The risk that a model is incorrectly or insufficiently specified can be minimized by validation, i.e., matching the model to the insurer's own history over some period of time. A well-specified model will reasonably reproduce past actual results. Actual results varying from projections may not be an indication of a poor model. Rather, it is generally appropriate to investigate such differences and reconcile the model's results with the actual results. This process of reconciliation may identify weaknesses in the model, or it may clarify ways in which the enterprise's activities departed from what would have been reasonably expected (e.g., writing more, rather than less, unprofitable business to cover up poor experience).

Interpreting the Results for a Range of Scenarios

Summarizing a range of outcomes includes development of measures of the performance of the insurer, as well as description and explanation of anomalous results. Measures of performance include:

- Risk-adjusted present value of future cash flows.
- Management-defined objectives.
- Probability or cost of "ruin."
- Option-adjusted pricing.

Other measures may also be appropriate. The method of summarizing results will depend on the purpose of the model.

Under the first approach, value is calculated as the risk-adjusted present value of the future cash flows. Calculations of risk-adjusted present value may include separate risk adjustments for stochastic or process risk (random variation) and scenario or parameter risk (variation among scenarios). This approach allows for specific consideration of the cost of risk, Similar results may be obtained by observing the model's results under a set of assumptions that are conservative in light of the uncertainties indicated by the model and computing the present value of the resulting flows of funds at a risk-free rate.

An insurer's modeled performance may also be measured in terms of objectives defined by company management. For example, management may set objectives such as maintaining acceptable risk-based capital results, failing no more than two IRIS tests or maintaining a combined ratio less than 100%. The insurer's performance relative to these benchmarks can be measured by using a model that calculates these statistics.

In the third of these measures, the probability and expected value of each outcome is estimated. The actuary may decide on a threshold characterized as "ruin," and use a stochastic model to estimate the probability of ruin for a given set of assumptions. Alternatively, the actuary may establish a cost of ruin (and perhaps establish nominal values for certain other types of outcomes as well), and compute an average of the adjusted financial outcomes over a range of assumptions. The actuary may also select a threshold much closer to the current financial condition, such as a decline in financial rating by one level, and estimate the probability of such an outcome.

Under the fourth measure, the total value of the insurer is summarized as the current market price of a set of investments available in the capital markets which has the same risk characteristics as the model indicates for the insurer. Such a set of investments almost always includes a large proportion of options because the insurer's cash flows are typically inflows first and outflows second, so the resulting value is called the option-adjusted price of the insurer's assets and liabilities. This value reflects the insurer's strategies for investment and for handling unexpected shortages of cash, at least as far as those strategies are reflected in the model.

There is an ongoing dialogue among actuaries about the appropriate basis for summarizing the results of a model. The Combination of Risks Task Force of the Society of Actuaries' Committee on Valuation and Related Problems concluded that the appropriate basis for summarizing the results of a dynamic financial model is the cash basis.[7] According to this school of thought, the other accounting bases (statutory, GAAP, and tax) are important only insofar as they serve to identify constraints on the enterprise's operations (e.g., tax payments).

On the other hand, the Actuarial Standard of Practice for Appraisals, promulgated by the Actuarial Standards Board, suggests that statutory accounting is the appropriate basis for measuring financial results. In this school of thought, the statutory and tax accounting rules place real constraints on the cash flows that can be realized by the investor.

[7] Transactions of the Society of Actuaries, 1991-92 Reports, p. 451.

Depending on the purpose of the model, the actuary may need to describe anomalous results indicated by the model. The results of the model may suggest that-either some assumptions are incorrect (in which case the assumptions will likely be revised before results are presented) or that the insurer's strategies could be improved. As an example of the latter, the results of the model may suggest that the insurer is particularly at risk due to one or more sources of risk.

The risk of inappropriate interpretation can be minimized by communicating the limited extent of variation among scenarios compared to the potential range of variation in the results of the insurer's operations.

CHAPTER 6
OTHER MODEL CHARACTERISTICS

However simple or sophisticated, a model is no more than a metaphor for the insurer. Dynamic financial models differ in the types of risks they are effective at measuring. A key consideration in the selection of a dynamic financial model is its ability to evaluate material sources of solvency risk for the case at hand.

Generalized vs. Tailor-Made

Generalized models, such as those developed by several consulting firms and software vendors, usually permit the user to specify several different types of insurance products, or lines of business, and a range of different investments. Other models are often tailor-made, such as one that addresses the unique characteristics of a company or because a simple model is sufficient. If a generalized model is used, it is important to consider whether results may be distorted by features inapplicable to a particular application or because a characteristic of the particular company is not addressed. For example, if a general purpose model is used for an insurer that plans to invest only in bonds and cash equivalents. the model does nor need to include a strategy that involves investment in other assets. If it does, the ramifications of that logic should not distort the projections.

Logic vs. Input

Whatever computer hardware and software may be used to implement the model, there are always tradeoffs between the coding of logic versus the selection of parameters. Dynamic financial models differ in the choices the developers make about which assumptions will be represented by variables and which will be fixed by the software or hardware. Also, the user will be able to determine the values of certain variables used by the model, whereas others will have been pre-set by the developer. The mix between input and logic will be determined in part by the users of the model (both the operator and the decision-maker), as models with extremely large numbers of variables can be daunting to use and difficult to interpret.

In selecting or building a dynamic financial model, decisions must also be made about the level of detail to be captured about the insurance coverage (by broad product group, statutory line of business, individual form, etc.), the factual context (including the level of detail about accounting and tax rules), and the precision with which strategies will be defined.

Strategies are inevitably a part of the logic of a model. The strategies incorporated in the model should be reasonably consistent with its purpose. Some software allows the user to build in explicit recognition of management strategies. Other software assumes certain strategies, even to the extent of letting presumptions about strategies affect the architecture or modular design of the model.

Time Frame

The time frame for the analysis is an important consideration in the choice and design of dynamic financial models. For example, it may be appropriate to use a time frame of 24 months to evaluate strategies for a property insurer (although a longer time frame may be needed to address recovery from a large catastrophe), whereas a time frame of 24 years may be more appropriate to evaluate the solvency of an underwriter of products' liability. The choice of time frame will also be a reflection of whether the model includes only the run-off of current business, a going concern for some stated period, or a going concern in a long-range projection valuation.

In addition to the time horizon of the model, the model also reflects a choice about the length of time intervals under study. While annual time intervals may be appropriate for some purposes, quarterly or even monthly time intervals might be appropriate for other purposes.

Basis of Accounting

Comprehensive dynamic financial models of the corporate insurance enterprise usually include accounts on at least four bases simultaneously: cash, statutory, GAAP, and tax[8]. Doing so is the only way to reflect the details of the interrelationships among constraints imposed by investment opportunities, underwriting commitments, laws and regulations, generally accepted accounting principles, and income tax laws. Less comprehensive models may be appropriate, however, for some purposes.

Relationship between Parent and Subsidiaries

Parents and subsidiaries have a number of different effects on an enterprise. A consolidated model of the entire organization can be developed, or the existence of the parent and subsidiaries might simply show up as assumptions about flows of funds, tax calculations, and income. A model may explicitly reflect a range of scenarios regarding the availability of or drain on surplus due to external influences. Alternatively, each entity may be modeled separately, with output from one model serving as input for other models.

Feedback Loops

Dynamic financial models may employ feedback loops (automatic conditional decisions) which are algorithms that make calculations for each modeled time period dependent on values calculated for earlier periods. Feedback loops provide for reactions to specific conditions. Models without feedback loops may be underdetermined, showing excessive income under favorable scenarios and excessive loss under unfavorable scenarios. Models with feedback loops, however, may be overdetermined, showing little risk regardless of the scenario because the model builder often assumes that management will respond quickly to increased risk with appropriate strategic or operational responses.

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[8] Financial reporting, and therefore modelling, may be more complex for international users.

stochastic Risk

Purely random fluctuations in the modelled variables may be important for a particular application. Stochastic features surrounding input assumptions can be added to a model. Random fluctuations around projected losses, for example, may be incorporated into a model by introducing probability distributions about loss costs or loss ratios, by modelling the collective risk process, or by modelling the underlying claim settlement process.

A simple model of the collective risk process may assume, only a probability distribution for the frequency of losses as a function of some assumptions and a probability distribution of the sizes of losses as a function of other assumptions. A more complicated model of the collective risk process may include estimates of the uncertainty of the parameters of frequency and size-of-loss, and may include a number of different kinds of losses, each with its own frequency and size-of-loss assumptions. A model of the underlying claim settlement process may be a multi-state Markov chain model or some other appropriate model.

The importance of identifying and modelling the interactions among risks increases when stochastic models are used. When assumptions are stochastically generated, a model that does not reflect these interactions may produce meaningless results in certain scenarios. At best, the results of such models would be difficult to interpret.

CHAPTER 7
FORCES FOR CHANGE

Thus far, this report has focused on the state of art and practice at this time. There are sweeping changes underway that may affect modelling in the future.

Proliferation of Insurance Products

Although regulation and custom tend to slow the creation of insurance products by entrepreneurs, changes in the markets served by insurance enterprises constantly press for new products and services. Dynamic financial models may need to be refined to adapt to these changes.

Competitive Pressures

In the past, pressures were perceived to arise from competition at the point of sale of the insurance product. From at least as long ago as 1970, competitive pressure has increasingly come to mean competition at the point that capital is being raised. Dynamic financial models are playing an increasingly visible role in corporate decisions regarding purchases and sales of business units, means to tap capital markets, and trade-offs between capital and reinsurance. This trend might reasonably be expected to continue.

Innovation in Assets

Recent innovations in asset design make it difficult to understand the riskiness of many investments by looking at their designations for accounting purposes. For example, some bonds have the risks of stock investments or mortgages and mortgages are backed **by** a wide range of security. Existing accounting classifications may be misleading to tabulate information about assets for input into dynamic financial models.

New types of asset classes are emerging, some with purposes other than purely generation of investment returns. For example, some assets, such as catastrophe futures, can hedge risks undertaken by the insurer's underwriting activities. More innovation can be expected, along with the need to model these kinds of investments.

Regulatory, Accounting, and Tax Requirements

Dynamic financial models may need to be revised from time to time to reflect the latest developments in regulation. Such changes may be as simple as adding a set of calculations, or they may require modelling of the corporate response to the impact of the regulations (e.g., a shift in marketing or investment strategy to accommodate surplus constraints of risk-based capital). Projections of cash flow may react to changes in these constraints differently from projections of statutory results, and dynamic financial models with feedback loops may react differently from static models.

Hardware

Although changes in computer hardware over the past twenty years have in some ways increased the speed with which tasks get done, they have had a fundamental and irreversible effect on the kinds of problems that people address. For example, before data processing was available that could prepare an extensive Schedule D (details of assets of insurers), regulators simply prohibited and restricted investments outside a few narrow categories; today, they attempt to monitor insurers' investments. Models of corporate financial results were not considered to be important tools for actuaries until computer hardware existed on which such models could be run, The actuary can expect that the changes in hardware will transform both the problems the actuary will be expected to address and the nature of actuarial work.

One major change on the horizon is distributed processing. In the future, the actuarial tool kit may consist of essentially instant communication with a large number of models of a given insurance enterprise, each being updated with new information essentially in real time. Between that future and to&y lies a time of rapid change in the power and distributions of hardware, software, and data.

Life Insurance Models

Dynamic financial models of a high degree of sophistication now exist for life insurance enterprises. These models are being used for product pricing and corporate valuation as well as for strategic and tactical (e.g. tax) planning. These models, and the experiences of their users, may have an important effect on the direction of development of models of property-casualty insurance companies. Life insurance models affect the perceptions and expectations of regulators, many of whom have responsibility for both life insurance regulation and property-casualty insurance regulation.

Other Countries

The increasing degree of globalization of the national economies, and the long-standing trend to lower economic borders between countries, suggest that actuarial work in the United States will be affected by innovations developed outside the United States and vice versa.

For example, Canada recently introduced solvency regulation for property-casualty insurance companies. All companies are required to designate an appointed actuary who is a Fellow of the Canadian Institute of Actuaries (CIA). In addition to performing the valuation of loss reserves, unearned premium reserves and deferred acquisition expenses for a company, the appointed actuary is required to report to the Board of Directors at least once a year on the current and expected future solvency of the company. To make this report, the appointed actuary is expected to perform dynamic solvency testing in conformance with the standards of practice set by the CIA. In cases in which a company is thought to be in difficulty, federal regulators can require that the appointed actuary submit a report on the results of a dynamic solvency test of the company's business plan over a planning horizon of one year.

APPENDIX A

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APPENDIX B
CHECKLIST OF CONSIDERATIONS

1. Is the model appropriate for the intended use?

2. Are the model and related communications appropriate for the expected users of its results?

3. Can the model be developed, purchased, maintained and/or used within the personnel, time, hardware, software and budget resources available?

4. Does the model contain input, output and processing regarding each of the risks to be evaluated in appropriate detail? Are the available historical data regarding these risks sufficient to use to derive the assumptions needed by the model? These risks include:

    - Asset risk
    - Obligation risk
        - Reserve risk
        - Pricing risk
        - Loss projection risk
        - Catastrophe risk
        - Reinsurance risk
        - Expense risk
    - Interest rate risk

5. Is the range of scenarios broad enough to reasonably address the questions at hand?

6. Is the model specification accurate and appropriately complete?

7. Are the measures used to summarize and interpret the range of results reasonable for the application?

8. Have the limitations of the model and range of scenarios been communicated clearly to reduce the risk of misinterpretation?

9. Is a generalized model reasonable for the application or would a tailor-made model better address specific issues?

10. Does the model have a reasonable balance between input assumptions and hard-coded logic?

11. Is the model's time horizon appropriate to the application?

12. Are the accounting bases upon which the model makes forecasts of appropriate breadth to the application?

13. Does the model provide sufficient detail (input and output) with respect to interactions with parents, subsidiaries and affiliates?

14. Will the value of the model results be enhanced enough by the presence of feedback loops (automatic conditional decisions) to warrant a model with such features?

15. Is a deterministic or stochastic model better suited for the application?