

Wharton

Financial
Institutions
Center

*Risk Management by Insurers:
An Analysis of the Process*

by
David F. Babbel
Anthony M. Santomero

96-16

THE WHARTON FINANCIAL INSTITUTIONS CENTER

The Wharton Financial Institutions Center provides a multi-disciplinary research approach to the problems and opportunities facing the financial services industry in its search for competitive excellence. The Center's research focuses on the issues related to managing risk at the firm level as well as ways to improve productivity and performance.

The Center fosters the development of a community of faculty, visiting scholars and Ph.D. candidates whose research interests complement and support the mission of the Center. The Center works closely with industry executives and practitioners to ensure that its research is informed by the operating realities and competitive demands facing industry participants as they pursue competitive excellence.

Copies of the working papers summarized here are available from the Center. If you would like to learn more about the Center or become a member of our research community, please let us know of your interest.

Anthony M. Santomero
Director

*The Working Paper Series is made possible by a generous
grant from the Alfred P. Sloan Foundation*

Risk Management by Insurers:
An Analysis of the Process ¹

May 1996

Abstract : Through the past year, on-site visits to financial service firms were conducted by a team of researchers from the Wharton Financial Institutions Center to review and evaluate their risk management systems. In the insurance sector, this evaluation covered a number of prominent life/health and property/casualty insurers, both in the U.S. and abroad. The information obtained on the philosophy and practice of financial risk management comes primarily through intensive interviews and analysis of the reports and procedures that are in place at these insurance firms. The purpose of this paper is to outline the results of this investigation. It reports the state of risk management techniques in the industry, questions asked, questions answered and questions left unaddressed by respondents. It reports the standard of practice and evaluates how and why it is conducted in the particular way chosen.

But, even the best practice employed within the industry is not good enough in some areas. Accordingly, critiques are offered where appropriate. The paper concludes with a list of questions that are currently unanswered, or answered rather unsatisfactorily in the current practice employed by this group of relatively sophisticated insurers.

Here, we discuss the problems which the industry finds most difficult to address, shortcomings of the current methodology used to analyze risk, and the elements that are missing in the current procedures of risk management.

David F. Babbel is Associate Professor of Insurance and Finance at the Wharton School of the University of Pennsylvania. Anthony M. Santomero is the Richard K. Mellon Professor of Finance at the Wharton School of the University of Pennsylvania.

I. Introduction

The past decade has seen a dramatic rise in the number of insolvent insurers. The ostensible causes of these insolvencies were myriad. Some of the insolvencies were precipitated by rapidly rising or declining interest rates. Others resulted from losses on assets such as junk bonds, commercial mortgages, CMOs, real estate and derivatives. Mispricing of insurance policies, natural catastrophes, and changes in legal interpretations of liability and the limits of coverage hurt still others. The “churning” of policies by unscrupulous sales agents, insolvencies among the reinsurers backing the policies issued, noncompliance with insurance regulation, and malfeasance on the part of officers and directors of the insurance companies affected some as well. But despite the numerous and disparate apparent causes of these insolvencies, the underlying factor in all of them was the same: inadequate risk management practices. In response to this, insurers almost universally have embarked upon an upgrading of their financial risk management and control systems to reduce their exposure to risk and better manage the amount they accept. In short, the industry has turned to financial risk management techniques as a way to improve performance.

Coincidental to this activity, and, in part, because of our recognition of the industry’s vulnerability to financial risk, the Wharton Financial Institutions Center, with the support of the Sloan Foundation, has been involved in an analysis of financial risk management processes in the financial sector. Through the past academic year, on-site visits were conducted to review and evaluate the risk management systems and the process of risk evaluation that is in place.

In the insurance sector, system evaluation was conducted covering a number of prominent life/health and property/casualty insurers, both in the U.S. and abroad. The information obtained on the philosophy and practice of financial risk management comes primarily through intensive interviews of these insurance firms, conducted by a team of researchers from the Wharton Financial Institutions Center.¹ Measured in terms of admitted assets, these firms range in size from \$7 billion to well over \$100 billion. They are organized as stock, reciprocal, or mutual insurers. Some firms restrict their activities to life insurance and pensions; the others are multi-line insurers, selling the full range of property/casualty and life/health products. These visits were augmented by interviews conducted with additional large insurance firms domiciled in Japan and Europe as well as North America. As was the case above, these firms include life companies, property/casualty companies, and a multi-line company.

Our information was then supplemented by five recently published surveys. Three of these were the 1994, 1995, and 1996 “Insurer CIO Surveys,” conducted by Goldman, Sachs & Co.² These surveys were based on responses from 58-79 companies, depending on the survey, with approximately two-thirds from the life lines and one-third from the property/casualty lines. The response rate in these surveys was roughly 40%. Over 90% of the responding companies had assets in excess of \$1 billion. Another pair of surveys was conducted by Joan Lamm-Tennant.³ Her surveys were of a much more extensive set of insurers, ranging in assets from \$75 million to over \$100 billion. There were 119 and 144 respondents to her 1995 and 1996 surveys, respectively, representing a response rate between 11 and 20% of the firms surveyed. The business mix of these firms was split about equally between life/health and property/casualty insurance.

The purpose of this paper is to outline the results of this investigation. It reports the state of risk management techniques in the industry — questions asked, questions answered and questions left unaddressed by respondents. This report cannot recite a litany of the approaches used within the industry, nor can it offer an evaluation of each and every approach. Rather, it reports the standard of practice and evaluates how and why it is conducted in the particular way chosen. But even the best practice employed within the industry is not good enough in some areas. Accordingly, critiques will also be offered where appropriate. The paper concludes with a list of questions that are currently unanswered, or answered rather unsatisfactorily in the current practice employed by this group of relatively sophisticated insurers. Here, we discuss the problems which the industry finds most difficult to address, shortcomings of the current methodology used to analyze risk, and the elements that are missing in the current procedures of risk management.

II. Why Manage Risk — Some Generic Answers

It seems appropriate to begin our analysis of risk management techniques with a review of the reasons given for firm level concern over the volatility of financial performance. The finance literature on why firms manage risk at all is usually traced back to 1984. In that year Stulz [1984] first suggested a viable reason for objective function concavity, and his contribution is widely cited as the starting point of this burgeoning literature. Doherty [1985] provides the first comprehensive treatment of this topic in a finance framework. Since that time a number of alternative theories and explanations have been offered. Recently, Santamero [1995A] presented a useful review of these explanations upon which we shall draw here.

The goal, as noted above, is to offer viable economic reasons for firm managers, who are presumed to be working on behalf of firm owners, to concern themselves with both expected profit and the distribution of firm returns around their expected value. The rationales for risk aversion can usefully be segmented into four categories:

- a) Managerial Self Interest
- b) The Non-Linearity of Taxes
- c) The Cost of Financial Distress
- d) The Existence of Capital Market Imperfections

In each case, the economic decision maker is shown to face a non-linear optimization because of the reason offered, and this leads the decision maker to be concerned with the variability of returns. In the first case the objective function itself is concave, while in the others the effect of some feature of the economic environment is to lead firm managers to behave in a risk averse manner. We begin with an explanation of each theory.

A. Managerial Self Interest

As mentioned above, this rationale is generally attributed to the work of Stulz [1984]. There, it was argued that firm managers have limited ability to diversify their own personal wealth position, associated with stock holdings and the capitalization of their career earnings associated with their own employment position. Therefore, they prefer stability to volatility

because, other things equal, such stability improves their own utility, at little or no expense to other stakeholders. In truth, this argument can be traced back to the literature on the theory of agency. In this area, the relationship between firm performance and managerial remuneration is clearly developed in such works as Ross [1973] and Ross [1977].

Objections have been offered, however, to this line of reasoning. Some find the theory unconvincing, because it offers no reason for the manager to hedge his/her risk within the firm, rather than directly in the market. According to this view, managers with highly non-linear employment contracts could enter the financial market to offset the effect of such agency agreements on their own wealth position. By taking a short position in the firm's stock, the stocks of competitors, or the market, managers could obtain any level of concentration in firm-specific profitability.

However, this argument misses at least three important features of the employment relationship. First, it is illegal for senior management to take a short position in the firm's stock and problematic for them to be seen divesting themselves or systematically diversifying the investments that are correlated with firm performance. Yet, such a public divestiture would be required to properly hedge management's personal investment profile. Moreover, in the case of mutual insurers, it is even more difficult to offset a long position in firm-specific performance risk. Second, to the extent that some outcomes, defined as financial distress, lead to termination of the contract, it may be in the best interest of managers to constrain firm-level outcome, if only not to lose the future value of the employment earnings. More will be said about this under Section C below. Third, arguments in favor of expected value managerial decisions neglect the fact that managerial ability itself is not directly observable. Therefore, as Breeden and Viswanathan [1990] and DeMarzo and Duffie [1992] argue, observed outcomes may influence owner perception of managerial talent. This would, in turn, favor reduced volatility, or at least the protection of firm specific market value from large negative outcomes that may be found within the distribution of possible returns. For all, or any one of these reasons, therefore, there appears to be ample justification for the assumption that managers will behave in a manner consistent with a concave objective function.

B. The Non-Linearity of Taxes

Beyond managerial motives, firm level performance and market value may be directly associated with volatility for a number of other reasons. The first is the nature of the tax code, which both historically and internationally is highly non-linear. This point was brought to our attention by Smith and Stulz [1985] and Gennotte and Pyle [1991]. It has recently been emphasized in Smith and Smithson [1990] and Fite and Pfleiderer [1995] as a key rationale of risk reduction. In each case, the authors indicate that, with a non-proportional tax structure, income smoothing reduces the effective tax rate and, therefore, the tax burden shouldered by the firm. By reducing the effective long term average tax rate, activities which reduce the volatility in reported earnings will enhance shareholder value.

However, two points are worth mentioning in this context. First, with the advent of more proportional tax schedules, particularly in the U.S., the arguments here are somewhat mitigated. In fact, one should observe, *ceteris paribus*, a decline in the interest in risk management by American firms over the last decade because of the reduced progressivity of U.S. tax schedules.

No one, however, has suggested that such is the case. Second, the tax argument rests on reported income, not true economic profit. To the extent that accounting principles permit tax planning, this argument may favor tax motivated reporting, and more careful management of the difference between book and market value of profits. For example, in the financial sector there is a long literature on tax planning that speaks to this distinction between reported and operating profit. Greenawalt and Sinkey [1988] document the existence of substantial income smoothing through the use of the loan loss provision expense item, while Scholes, Wilson and Wolfson [1990] present evidence of portfolio selection which accomplishes the same end. However, the argument here is that real economic decisions are affected by the tax code, not just their reporting. To the extent that significant discretion exists in tax reporting, tax consideration may not motivate actual decision making nearly as much as this theory suggests. Evidence on these points for the insurance industry is provided by Cummins and Grace [1994] and Lamm-Tennant and Rollins [1994].

C. The Cost of Financial Distress

Firms may also be concerned about volatility of earnings because of the consequences of severely negative deviations from expected value and their implications for corporate viability. It is known that corporate debt creates a fixed cost that can be used as a competitive weapon in gaming models. (See Brander and Lewis [1986] and Maksimovic [1988], for example.) In such models, severely negative outcomes cause disruption and bankruptcy. To the extent that the bankruptcy state — or any set of specific states — is associated with a discrete increase in costs, the firm will be forced to recognize this fact in its choice calculus. In such cases, the firm behaves as if it had a concave objective function, because its payoff structure is non-linear across states.

The literature is filled with such stories. The classic paper by Warner [1977] was the first to present empirical evidence of this cost, but more recent studies, such as Weiss [1990] continue to reinforce its importance. As a result, standard corporate finance textbooks make clear reference to the cost of bankruptcy in their analysis of the investment decision. Smith and Stulz [1985] use this same argument to justify a desire for reduced volatility.

The cost is, perhaps, more important in regulated industries, however. In these cases, large losses may be associated with license or charter withdrawal and the loss of a monopoly position. For example, in the banking literature, Marcus [1984] makes this same argument for financial firms subject to charter review by regulatory agencies, and Santomero [1989B] and Herring and Santomero [1990] used this story to justify corporate separation for financial services firms. Staking and Babbel [1995] provide empirical support for its application to the insurance industry. In all cases, however, the cost of financial distress must be non-linear, as linear cost functions do not lead to the required behavior.

Yet, the authors are on firm ground here, as there is ample evidence that financial distress leads to substantially increased costs associated with bankruptcy proceedings, legal costs, and perhaps most importantly the diversion of management attention from creating real economic value. Interested readers are referred to Smith, Smithson and Wilford [1990] for an extended discussion of these costs.

D. Capital Market Imperfections

Recently the above argument has been extended in the work of Froot, Scharfstein and Stein [1993, 1994]. The theoretical core of their contribution is in the 1993 paper. Here, they accept the basic paradigm of the financial distress model above, but rationalize the cost of bad outcomes by reference to Myers' [1977] debt overhang argument. In their model, external financing is more costly than internally generated funds due to any number of capital market imperfections. These may include discrete transaction costs to obtain external financing, imperfect information as to the riskiness of the investment opportunities present in the firm, or the high cost of the potential future bankruptcy state. In the case of mutual insurers, who have little access to the capital market, this line of argument is particularly compelling.

At the same time, the firm has an investment opportunity set which can be ordered in terms of net present value. The existence of the cost imperfections results in underinvestment in some states, where internally generated funds fall short of the amount of new investment that would be profitable in the absence of these capital market imperfections. Stated another way, the volatility of profitability causes the firm to seek external finance to exploit investment opportunities when profits are low. The cost of such external finance is higher than the internal funds due to the market's higher cost structure associated with the factors enumerated above. This, in turn, reduces optimal investment in low profit states.

The cost of volatility in such a model is the forgone investment in each period that the firm is forced to seek external funds. Recognizing this outcome, the firm embarks upon volatility reducing strategies, which have the effect of reducing the variability of earnings. Hence, risk management is optimal in that it allows the firm to obtain the highest expected shareholder value.

The authors can support their theory with reference to evidence offered by Fazzari, Hubbard and Peterson [1988] and Hoshi, Kashyap and Scharfstein [1991], who present evidence that internal cash flow is, in fact, correlated to corporate investment. In addition, Smith, Smithson and Wilford [1990] regale us with anecdotes that further support this contention.

E. Summary of Rationales

Together, the stories work fairly well. Firm managers are interested both in expected profitability and the risk, or variability, or reported earnings or market value. The latter can be rationalized by the existence of non-linear costs across the range of profit states associated with any given expected value. The non-linearity is associated with managerial incentive effects, the tax structure, the costs of crisis, and/or forgone investment opportunities. In any or all of these cases, the firm is led to treat the variability of earnings as a choice variable that it selects, subject to the usual constraints of optimization. How it proceeds to manage the risk position of its activity is the area to which we now turn.

III. Risk as a Central Ingredient in the Industry's Franchise

A. The Role of Insurers in the Financial Sector

Insurers are in the risk business. In the process of providing insurance and other financial services, they assume various kinds of actuarial and financial risks. Over the last decade much has been written of the role of insurers within the financial sector.⁴ This literature will not be reviewed in detail here. Suffice it to say that market participants seek the services of insurers because of their ability to provide actuarial risk pooling through their major product lines of life, property/casualty and health insurance, pension products, annuities, and other financial instruments. At the same time, they are major providers of funds to the capital market — particularly to the fixed income sectors. In performing these roles they generally act as a principal in the transaction. As such, they use their own balance sheet to facilitate the transactions and to absorb the risks associated with them. Therefore, it is here that the discussion of risk management and the necessary procedures for risk control has centered. Accordingly, it is in this area that our review of risk management procedures will concentrate.

B. What Risks Are Being Managed?

The risks contained in the insurer's product sales, i.e., those embedded in the products offered to customers to protect against actuarial risk, are not all borne directly by the insurer itself. In many instances the institution will eliminate or mitigate the actuarial and financial risk associated with a transaction by proper business practices; in others it will shift the risk to other parties through a combination of reinsurance, pricing and product design. Only those risks that are not eliminated or transferred to others are left to be managed by the firm for its own account. This is the case because the insurance industry recognizes that it should not engage in business in a manner that unnecessarily imposes risk upon it, nor should it absorb risks that can be efficiently transferred to other participants. Rather, it should only manage risks at the firm level that are more efficiently managed there than by the market itself or their owners in their own portfolios. In short, it should accept only those risks that are uniquely a part of the insurer's array of services.

Elsewhere it has been argued that risks facing all financial institutions can be segmented into three separable types from a management perspective.⁵ These are:

- a) risks that can be eliminated or avoided by standard business practices;
- b) risks that can be transferred to other participants, and
- c) risks that must be actively managed at the firm level.

In the first of these cases, the practice of risk avoidance involves actions to reduce the chances of idiosyncratic losses from standard insurance activity by eliminating risks that are superfluous to the institution's business purpose. Common risk avoidance practices include at least three types of actions. The standardization of process, insurance policies, contracts and procedures to prevent inefficient or incorrect financial decisions is the first of these. Another is the construction of portfolios on both sides of the balance sheet that benefit from diversification and the application of the Law of Large Numbers and Central Limit Theorem, which reduce the effects of any one loss experience. Finally, the implementation of incentive compatible contracts with the institution's management to require that employees be held accountable is the third. In each case, the goal is to rid the firm of risks that are not essential to the financial service provided, or to absorb only an optimal quantity of a particular kind of risk.

There are also some risks that can be eliminated, or at least substantially reduced through the technique of risk transfer. Markets exist for many of the risks borne by the insurance firm. Actuarial risk can be transferred to reinsurers. Catastrophe risk can be offset somewhat by undertaking a position in catastrophe futures and perhaps even in catastrophe bonds. Interest rate risk can be hedged or transferred through interest rate products such as swaps, caps, floors, futures, or other derivative products. Insurance policies and lending documents can be altered to effect a change in their duration and convexity. Equity market risk can be reduced with an appropriate futures position in equities. In addition, they can offer products which absorb some financial risks, while transferring some of these risks to the purchaser. Defined contribution pension plans and variable universal life policies are clear examples of this approach. Finally, the insurer can buy or sell financial claims and reinsurance to diversify or concentrate the risk that results from servicing its client base. To the extent that the actuarial and financial risks of the insurance policies underwritten by the firm are understood by the market, they can be sold in part or in whole at their fair value. Unless the institution has a comparative advantage in managing the attendant risk and/or a desire for the embedded risk they contain, there is no reason for the insurer to absorb such risks, rather than transfer them.

However, there are two classes of activities where the risk inherent in the activity must and should be absorbed at the insurance firm level. In these cases, risk management must be aggressive and good reasons exist for using firm resources to manage insurance-level risk. The first of these includes actuarial exposures where the nature of the embedded risk may be complex and difficult to communicate and transfer to third parties. For example, Progressive Insurance Co. has a definite niche in the high risk auto insurance business owing to its concentration of underwriting activities, and Lutheran Brotherhood has a natural advantage for writing life insurance to its clientele. A similar situation may arise on the asset side of the business where the insurer holds private placements and other complex, proprietary assets that have thin, or even non-existent, secondary markets. Communication in such cases may be more difficult or expensive than hedging the underlying risk. Moreover, revealing information about the customer may give competitors an undue advantage. The second case includes risk positions that are central to the insurer's business purpose and are absorbed because they are the *raison d'être* of the firm. Actuarial risk inherent in the key insurance lines where the insurer may enjoy a competitive advantage or a market niche is a clear case in point. In all such circumstances, risk is absorbed and needs to be monitored and managed efficiently by the institution. Only then will the firm systematically achieve its financial performance goal.

C. How Are These Risks Managed?

In light of the above, what are the necessary procedures that must be in place to carry out adequate risk management for those risks that are essential ingredients to the insurer's franchise? What techniques are employed to both limit and manage the different types of risk, and how are they implemented in each area of risk management? It is to these questions that we now turn.

In general, the management of an insurance firm relies on a variety of techniques in their risk management systems. However, it appears that common practice has evolved such that four elements have become key steps to implementing a broad based risk management system. These include:

- a) standards and reports
- b) underwriting authority and limits
- c) investment guidelines or strategies, and
- d) incentive contracts and compensation

These tools are established to measure risk exposure, define procedures to manage these exposures, limit exposures to acceptable levels, and encourage decision makers to manage risk in a manner that is consistent with the firm's goals and objectives. To see these four parts of basic risk management achieve these ends, we elaborate on each part of the process below. Section V illustrates how these techniques are applied to control each of the specific risks facing the insurance community.

Standards and Reports

The first of these control techniques involves two different conceptual activities, i.e., standard setting and financial reporting. They are listed together because they are the *sine qua non* of any risk management system. Underwriting standards, risk classification, and standards of review are all traditional tools of risk control. Consistent evaluation and rating of exposures of various types are essential for management to understand the risks on both sides of the balance sheet, and the extent to which these risks must be mitigated or absorbed.

The standardization of financial reporting is the next ingredient. Obviously, outside audits, regulatory reports, and ratings agency evaluations are essential for investors to gauge asset quality and firm level risk. But the types of information collected and the manner in which it is assembled and presented in statutory accounting reports are inadequate for the purposes of managing an insurance company. For instance, it is difficult to discern the magnitude and import of options insurers have effectively written on both sides of the balance sheet, e.g., call and prepayment options and loan commitments on the asset side, lapse, loan and surrender options on the liability side, by relying merely on statutory accounting reports. It is also difficult to estimate interest rate risk and default risk from the information provided there.

The statutory accounting reports have long been standardized, for better or worse. However, the need here goes beyond public reports and audited statements to the need for management information on actuarial risk, asset quality and overall risk posture. Such internal reports need similar standardization but much more frequent reporting intervals, with daily, weekly and monthly reports substituting for the quarterly statutory accounting periodicity. Thus, the collection and presentation of sufficient data to adequately manage the risk exposure of a company is a starting point.

Underwriting Authority and Limits

A second technique for internal control of active management is the use of position limits, and/or minimum standards for participation. In terms of the latter, the domain of risk taking is restricted to only those customers or assets that pass some prespecified quality standard. Then, even for those that are eligible, limits are imposed to cover exposures to counterparties, credits, and overall position concentrations relative to various types of risks. In general, each person who can commit capital, whether on the asset or liability side of the ledger, will have a

well-defined limit. This applies to underwriters, portfolio managers, lenders, and traders. Summary reports show limits, as well as current exposure by business unit on a periodic basis. In large organizations, with thousands of positions maintained, accurate and timely reporting is difficult, but even more essential.

Investment Guidelines or Strategies

Investment guidelines and recommended positions for the immediate future are the third technique that is commonly in use. Here, strategies are outlined in terms of concentration and commitments to particular areas of the market, the extent of desired asset/liability mismatching or exposure to interest rate risk, and the need to hedge against systematic risks of a particular type. These limits lead to passive risk avoidance and/or diversification, because managers generally operate within position limits and prescribed rules. Beyond this, guidelines offer firm level advice as to the appropriate level of active management, given the state of the market and the willingness of senior management to absorb the risks implied by the aggregate portfolio. Such guidelines extend to firm level hedging and asset/liability matching. In addition, securitization and even derivative activity are rapidly growing techniques of position management open to participants looking to reduce their exposure to be in line with management's guidelines.

Similar guidelines are required on the liability side of the balance sheet. Underwriting standards and strategies are needed to ensure that the risks accepted conform to the parameters that the insurer is capable and willing to accept. They also foster better pricing of products, and prevent any one underwriter from compromising the future solvency of the firm.

Incentive Schemes

To the extent that the firm can enter incentive compatible contracts with senior management, line managers, and sales agents and make compensation related to the risks borne by these individuals, then the need for elaborate and costly controls is lessened. However, such incentive contracts must be consistent with the insurers' financial goals and require proper internal control systems. Such tools, which include underwriting risk and loss analysis, investment risk analysis, the allocation of costs, and the setting of required returns to various parts of the organization is not trivial. Notwithstanding the difficulty, well designed systems align the goals of managers with other stakeholders in a most desirable way. In fact, most financial debacles can be traced to the absence of incentive compatibility. For instance, the linkage of compensation to sales can lead to reckless and dangerous growth and poor underwriting or mispricing of risks. The linkage of managerial compensation to book earnings can lead to the acquisition of investments with negative convexity, duration mismatch risk, liquidity risk and credit risk, whose book yields are higher than their expected returns.

IV. Risks in Providing Insurance Services

How are these techniques of risk management employed by the insurance sector? To explain this, we must begin by enumerating the risks which the insurance industry has chosen to manage, and illustrate how the four step procedures outlined are applied to risk control in each area.

A. The Actuarial View of Risks

As a starting point, most of the insurers interviewed classified their risks by adapting a framework which was proposed years ago by the Society of Actuaries' Committee on Valuation and Related Problems. Even though the Society of Actuaries is focused on life insurance and pensions, the property/casualty insurers interviewed also had adapted the same risk classification paradigm. The various categories of risks are dubbed C-1, C-2, C-3, and C-4, deriving these names from the Committee assigned to make recommendations on these issues.⁶ We begin our review of the perceived risks with an explanation of the industry's own definitions.

C-1 risks are **asset risks**, which arise from the possibility that borrowers of insurer funds may default on their obligations to the company, or that the market value of an insurer's investment assets may decline. They include interest rate risk, credit risk, market risk, and currency risk.

C-2 risk is **pricing risk**, which stems from uncertainty about future operating results relating to items such as investment income, mortality and morbidity, frequency and severity of claims and losses, administrative expenses, sales and lapses. If an insurer's pricing is based on assumptions that prove inadequate, it may not be able to meet its obligations to policy owners.

C-3 risk is **asset/liability matching risk**, which springs from the impact of fluctuating interest and inflation rates on the values of assets and liabilities. If the impact of fluctuating rates is different on assets than on liabilities, the values of assets and liabilities will change by different amounts, and could expose the insurer to insolvency.

C-4 risks are **miscellaneous risks**, generally thought to be beyond the ability of insurers to predict and manage, but they nevertheless represent real risk to the company. These risks include tax and regulatory changes, product obsolescence, poor training of employees and sales agents, and malfeasance, malversation, or misconduct of managers or other employees. Also included is the risk that laws or legal interpretations will change in a way that will alter the firm's obligations *ex post*. Another manifestation of C-4 risk is that there will be an unforeseen downgrade of acquisitions that could lead to a "run" on the assets of the insurance company. One firm referred to C-4 risk as "stupidity risk" — failure to employ and retain good people.

Two firms wryly referred to a new category of risk, dubbed **C-5** risk, which is the havoc that arises when a person who has strong political ambitions or is running for higher political office is appointed to be state insurance commissioner.

The use of the Society of Actuaries' risk classification taxonomy was viewed merely a useful point of departure by some of the insurance firms we interviewed, while others viewed it as satisfactory for their purposes. In our view, none of the risk classification schemas we saw was completely satisfactory. However, most of the conceivable risks that would impact insurers were included somewhere on the lists that we saw. In most cases, however, the industry was straining to define the inherent financial risks as part of the C1 through C4 paradigm that had been developed years ago. In addition, it appeared that most schemas had undue focus on risks in isolation, rather than on their contribution to overall firm risk.

B. The Financial View of Risks

As an alternative to the actuarial decomposition of risk which is unique to the insurance industry, standard financial risk definitions are increasingly being proposed in the industry. For the sector as a whole, these risks can be broken into six generic types: actuarial, systematic, credit, liquidity, operational and legal risks. Briefly, we will discuss each of these risks facing the insurance institution; in Section V we indicate how they are managed. Our focus will be on the financial risks, which include the first four of the risks listed below. Of course the risks associated with the provision of insurance services differ by the type of service rendered.

Actuarial risk is the risk that arises from raising funds via the issuance of insurance policies and other liabilities. It is the risk that the firm is paying too much for the funds it receives, or alternatively, the risk that the firm has received too little for the risks it has agreed to absorb. If an insurer invests its funds in efficiently traded securities, it should expect to have, on average, a zero net economic profit. If the insurer pays too much for these funds it cannot expect to earn a satisfactory profit in the long run. Another aspect of actuarial risk is that during any given time period, the underwriting losses will be in excess of those projected. This could happen for two reasons. First, the expectations themselves may be based on an inadequate knowledge of the loss distribution. Second, the losses may exceed their expectations in the normal course of business simply because losses fluctuate around their mean. The degree to which they deviate from the mean will depend, of course, on the characteristics of the loss distribution, which depend on the nature of the risks insured.

Systematic risk is the risk of asset and liability value changes associated with systematic factors. It is sometimes referred to as market risk. As such, it can be hedged but cannot be diversified completely away. In fact, systematic risk can be thought of as undiversifiable risk. All investors assume this type of risk whenever assets owned or claims issued can change in value as a result of broad economic factors. Systematic risk comes in many different forms. For the insurance sector, however, three are of greatest concern, viz., variations in the general level of interest rates, basis risk, and (especially for property/casualty insurers) inflation.

Because of the insurers' dependence on these systematic factors, most try to estimate the impact of these particular systematic risks on performance, attempt to hedge against them, and thus limit the sensitivity of their financial performance to variation in these undiversifiable factors. To do so, most will both track and manage each of the major systematic risks individually. The first of these is undoubtedly *interest rate risk*. Here, they measure and manage the firm's vulnerability to interest rate variation, even though they cannot do so perfectly. At the same time, insurers with large corporate bond, mortgage and common stock holdings closely monitor their *basis risk*. Here the concern is that yields on instruments of varying credit quality, liquidity, and maturity do not move together, exposing the insurer to market value variation that is independent of liability values. In this case too, they try to manage, as well as limit, their exposure to it. Finally, to the extent that the frequency and severity of claims are influenced by *inflation risk*, expected losses will also be affected. This is particularly the case where insurance policies are written on a replacement cost basis. The inflation of concern can be general inflation, affecting repair costs, medical costs, and the like, or specific and localized inflation, like the quadrupling of certain building materials costs in

southern Florida shortly after hurricane Andrew. All three of these systematic risks will be recognized as sources of performance variation.

Credit risk is the risk that a borrower will not perform in accordance with its obligations. Credit risk may arise from either an inability or an unwillingness on the part of the borrower to perform in the pre-committed contracted manner. This can affect the investor holding the bond or lender of a loan contract, as well as other investors and lenders to the creditor. Therefore, the financial condition of the borrower, as well as the current value of any underlying collateral is of considerable interest to an insurer who has invested in the bonds or participated in a direct loan.

The real risk from credit is the deviation of portfolio performance from its expected value. Accordingly, credit risk is diversifiable but difficult to eliminate completely, as general default rates themselves exhibit much fluctuation. This is because a portion of the default risk may, in fact, result from the systematic risk outlined above. In addition, the idiosyncratic nature of some portion of these losses remains a problem for creditors in spite of the beneficial effect of diversification on total uncertainty. This is particularly true for insurers that take on highly illiquid assets. In such cases, the credit risk is not easily transferred, and accurate estimates of loss are difficult to estimate.

Liquidity risk can best be described as the risk of a funding crisis. While some would include the need to plan for growth, the risk here is more correctly seen as the potential for a funding crisis. Such a situation would inevitably be associated with an unexpected event, such as a large claim or a write down of assets, a loss of confidence or a legal crisis. Because insurers operate in markets where they may receive clustered claims due to natural catastrophes, or massive requests for policy withdrawals and surrenders due to changing interest rates, their liabilities can be said to be somewhat liquid. Their assets, however, are sometimes less liquid, particularly where they invest in private placements and real estate. Given this situation, it is important for an insurer to maintain sufficient liquidity to easily handle any demands for cash. Otherwise, an insurer that would be solvent without a sudden demand for cash may have to sell off illiquid assets at concessionary prices, leading to large losses, further demands for cash, and potential insolvency.

Operational risk is associated with the problems of accurately processing claims, and accurately processing, settling, and taking or making delivery on trades in exchange for cash. It also arises in record keeping, processing system failures and compliance with various regulations. As such, individual operating problems are small probability events for well-run organizations but they expose a firm to outcomes that may be quite costly.

Legal risks are endemic in financial contracting and are separate from the legal ramifications of credit and operational risks. New statutes, court opinions and regulations can put formerly well established transactions into contention even when all parties have previously performed adequately and are fully able to perform in the future. For example, changes in the application of statutes of limitations for filing suits have affected the losses arising from property/liability policies. Similarly, the change to joint and several liability rules has also altered the distribution of risks that may be covered by insurance policies.⁷

Another type of legal risk arises from the activities of an institution's management, employees and agents. Fraud, violations of regulations or laws, and other actions can lead to catastrophic loss. Even a situation where the insurer legally fulfills all of its contract obligations can result in massive litigation if some policy owners had different expectations or understandings about the performance of their policies than what was specified in the contracts.

Every insurer faces a different exposure to each of these risks, depending on its business mix. In all its activities, an insurer must decide how much business to originate, how much to finance, how much to reinsure, and how much to contract to agents. In so doing, it must weigh both the return and the risk embedded in the asset and liability portfolios. Management must measure the expected profit and evaluate the prudence of the various risks enumerated above to be sure that the result achieves the stated goal of maximizing shareholder value, in the case of a stock insurer, or maximizing ownership interests, in the case of a mutual or reciprocal insurer. If the product's expected profit warrants the risk, then the activity is added to the insurer's balance sheet, and the risk must be managed. This risk management is achieved through the four step process outlined above. How this is implemented for each of the key financial risks enumerated above is the focus of our next section.

V. Insurance Risk Management Systems

A. Actuarial Risk

The risk of paying too high a price to raise funds is an important risk, particularly in light of the fact that insurers raise few funds in the competitive capital market. Most of their debt is raised in the form of issuing insurance policies. Policies are written today in exchange for lump sum or periodic premiums, but the amounts and timing of the repayment of these funds are often unknown and may occur within a month or more than 80 years later. Because the pricing of the policies reflects not only expected losses but also the yields an insurer can earn on the funds between the inception of a policy and its termination or the payment of benefits, the interest assumption used in developing insurance prices is of critical importance. Two things complicate this process. Forward interest rates cannot be synthesized to lock in a spread, for the insurer has no way of knowing if future periodic premium payments will be forthcoming. Also, the loss distributions can undergo substantial evolution over time, as more information is revealed and as the economic environment changes.

Insurers are typically quite skilled in managing actuarial risk. The manner in which this is done is described in insurance and actuarial textbooks.⁸ Therefore, here we will focus on what developments have occurred during the past decade that improve an insurer's ability to price and manage this risk.

Until recently, life insurance prices were developed using conservative static assumptions regarding loss distributions and interest rates. While this approach was satisfactory for much of the past century, it was ill-equipped to accommodate the interest rate volatility that began during the late 1970s. Life insurance policies are replete with options — settlement options, policy loan options, over-depositing privileges, and surrender or renewal privileges, on the part of the insured, and discretionary dividend and crediting rate options on the part of the insurer. Indeed, some have even viewed a life insurance policy as little more than a package of options.⁹ In

stable interest rate environments, policy owner utilization of these options is often predicated on individual or family circumstances. Hence, in the aggregate, utilization rates are fairly steady and amenable to forecasting.

However, when interest rates are volatile, the options gain in value and their utilization rates can fluctuate wildly. Traditional actuarial methods, which depended upon stability, were incapable of correctly valuing these options; hence, many policies were woefully underpriced.¹⁰ Today the standard valuation methods that have been adopted by most of the sophisticated life insurers explicitly value these embedded options. Thus, insurers now can estimate the cost of the various option-like provisions of all kinds of life insurance policies. Most life insurers we interviewed were using the PTS software of Chalke, Inc. (now SS&C, Inc.). This software, and competing software offered by Tillinghast and others, use modern stochastic valuation techniques, familiar in the pricing of fixed income and mortgage-backed securities, to estimate the values of insurance policies in a manner consistent with that used to value the assets. Needless to say, this represents a big advance in the tools with which insurers can practice risk management.

Lest our enthusiasm for this advance be misconstrued as euphoria, we hasten to add that all is not well here. First, the stochastic valuation methodology most commonly used relies on a single stochastic factor. Most fixed income and mortgage-backed security valuation models are based on at least two stochastic factors. Without two factors, one tends to produce model values that are too highly correlated, and whose movements in value are perfectly correlated. Also, the speed of the software is sufficiently slow that it is difficult to implement more than a handful of path simulations in arriving at “option-adjusted” values. Moreover, it is unrealistic to attempt to model a prepayment feature or a call feature, which may be triggered by changes in long-term yields, while using the short-term rate paths to value the instrument. The second drawback is perhaps even more serious. Most insurers have inadequate data collected and assembled with which to reliably model the interest sensitivity of policy option utilization. Accordingly, the valuation models really allow an insurer only to better quantify the impact of its guesses about what those utilization functions might look like. We encountered much frustration among insurers that even though the valuation software had taken a long time to develop, the data requirements of the valuation software have still not been met.

Nonetheless, the availability of valuation software that is consistent with modern valuation principles is an important step forward, and software that is currently under development will remedy the shortcomings of being based on a single stochastic factor and producing value estimates, dare we say, at a relaxed pace. With this software, actuaries produce pricing estimates based on a dozen or so scenarios. However, they typically also test their prices using hundreds and thousands of additional scenarios, albeit not in an option-adjusted framework.

In the property/casualty sector, there is no counterpart to the modern valuation software for pricing liabilities. However, option-adjusted arbitrage-free valuation tools may be overly powerful given the imprecision associated with many of the risks that are insured. There are few options that compare with those available in life policies, and nominal values are often not guaranteed; guarantees are sometimes in terms of covering repair costs, replacement costs,

medical costs, and so forth. Even when there are nominal maximum amounts of coverage, the losses below the maximum are subject to additional uncertainty because of inflation.

The use of reports and standards for underwriting life/health and property/casualty risks is routine. It is common to have dozens, and sometimes over a hundred “cells” in which to classify the risks. Base rates can be related to a number of factors, such as age, gender, occupation, schooling, health status and history, property characteristics, nature of business, and so forth. These base rates are then adjusted to reflect experience factors (e.g., past claims, driving behavior). While the fair premiums will be a function of interest rates, in practice the premiums charged will not adjust to reflect current interest rates very often. This is probably because it is administratively cumbersome to alter insurance premium schedules every time the interest rates change.

Underwriting limits are commonly established. Authority is limited to a certain amount. While insurance agents may have temporary binding authority, it is a common practice to have a party who is not involved in the policy sale to review the underwriting and make a determination whether the risk will ultimately be accepted and insured. Insurers are typically better at keeping track of sales commissions than in tracking losses to a particular sales agent or underwriter. However, many of the leading life/health and property/casualty insurers are carefully tracking the experience of their sales and underwriting personnel. If the experience falls outside the norm, it is common to place restrictions on further sales or more severe limitations on underwriting; alternatively, the activities of these sales agents and underwriters could be subject to greater oversight.

Perhaps the area of greatest concern in the area of actuarial risk is the misalignment of incentives between owners of the insurance firm and its sales and marketing staff. Much can be done to improve it. The typical arrangement is to pay commissions for sales of new policies, with the commissions on a multiperiod contract heavily front-loaded, particularly for life/health products. This creates a tremendous incentive for agents to sell as much business as possible, whether it is profitable for the company or not. It also creates strong incentives to replace existing policies, whose commission rates have dwindled to the low single digit percentage range, with new policies that pay commissions ranging from 20 to 100% of first year premiums. Sales managers and marketing personnel are also often rewarded based on volume of sales. Even senior management may sometimes have their compensation tied to sales growth.

Experience has shown that rapid growth is one of the factors most commonly associated with insolvency. It is useful to remember here that what is growing most rapidly is the accumulation of liabilities, not assets. One way to foster rapid growth is to underprice liabilities. Employees and agents whose compensation is tied to sales growth are therefore strong proponents of more “competitively-priced” insurance policies. Senior management often comes from a sales background, and is sympathetic with the notion that what is good for the insurance agents is good for the company. Pricing actuaries, who are supposed to be the watchmen and gate keepers in this area, are often placed under tremendous pressure to alter their assumptions so that the company’s products can be priced more competitively. Of course, over time it will become apparent if the insurance policies are mispriced, but that is weighed against the immediate benefits of higher commission earnings and growth.

The sales side has one powerful club in this battle for determining policy prices. Sales agents often work for a number of insurers and can shift new business toward them. Worse, they can take existing business away from the firm, before it breaks even from heavy initial policy costs, and direct it elsewhere if they can demonstrate satisfactorily that policy illustrations or prices appear to be more favorable elsewhere. Many firms in the insurance industry are well aware of this misalignment of interests, yet feel thwarted by regulations about commission schedules.

In the long run, of course, insurers offering non-economic policies will go bankrupt. But the long run can take a long time to arrive; hence, the insurer who is trying to rationally price its policies faces a quandary. Does it succumb to the uneconomic pricing temporarily and hope to survive beyond the irrational players, and then restore sensible pricing, or does it choose to write very little current business and lose its distribution force? Neither choice is an attractive alternative.

B. Systematic Risk

Systematic Risk of Liabilities

No area in financial risk management of insurance has evolved as much as the analysis of systematic risk of liabilities during the past decade. This is, in large measure, due to the fact that insurers feel an increased sense of urgency in applying the tools of asset/liability management to measure and manage interest rate risk. We note that the two most recent Goldman Sachs surveys of life insurance Chief Investment Officers ranked asset/liability management (ALM) at the top of the list of their concerns, whereas the topic did not surface in the top four rankings in their earlier surveys. Property/liability companies are also giving greater attention to the area.

The increased importance given to ALM was echoed in the 1995 and 1996 surveys of Lamm-Tennant, who found it near the top of the factors that influence investment policy. Her findings are notable because they combine the results of both life/health and property/casualty insurers, and cover companies that are much smaller than those in the Goldman Sachs surveys. When contrasted with the earlier surveys of Babbel and Lamm-Tennant [1987], Babbel and Klock [1988], Lamm-Tennant [1989], and Bouyoucos and Siegel [1992], the increased importance of interest rate risk and ALM during the past few years is remarkable. All of the life/health and property/liability insurers we interviewed perceived this source of risk to be crucial to understand, measure and manage. However, the insurers we interviewed ran the gamut from naive to very sophisticated when it came to measuring interest rate risk.

On the liability side of the balance sheet, most of the life insurers were using PTS software developed by Chalke, Inc. to measure the effective duration and convexity of their liabilities.¹¹ The others were using TAS from Tillinghast, or some internally developed software. Most of the life insurers who were using the commercially available software packages had implemented some of their own customized enhancements to meet better their needs, capabilities, focus and concerns.

The use of effective duration and convexity measures represents a quantum leap from what the practice was only a few years earlier. Prior to 1992, virtually none of the insurers had

access to a commercially available software package that could compute measures of effective duration and convexity for their liabilities. Even the PTS, TAS (formerly CALMS) and Milliman and Robertson software packages available at that time would not produce measures of effective duration and convexity. Rather, the duration numbers, in those cases where they were produced, were simple modified or Macaulay measures, which assume that all cash flows are fixed. Yet, liabilities are virtually all interest sensitive to some degree. They produce errors so large as to lead to reckless investment decisions, while imbuing such decisions with a veneer of analytical and quantitative credibility.¹² Back then, insurers who were concerned about interest rate risk relied heavily upon simulations. Indeed, duration estimations were considered so primitive that they were generally eschewed in favor of simulations, and rightfully so in our opinion. This is because many of the duration estimates that we saw then did not fully incorporate the interest rate sensitivity of cash flows for either assets or liabilities.

Today, convexity measures are also produced by the PTS software that is most commonly used. We found that insurers placed less confidence in the convexity numbers produced than in the duration numbers. This is because convexity numbers are much more sensitive to lapse assumptions than are duration numbers; while a misspecification of the interest rate sensitivity of lapses and other options can cause a large error in effective duration estimates, it will cause an even greater error in the estimates of convexity. Most insurers feel that they do not have enough reliable data on which to specify the relation of lapses and policy surrenders to interest rate movements. The lack of confidence they have in this crucial input to convexity estimates translates into a lack of confidence in the convexity estimates themselves. However, most companies did pay some attention to convexity estimates, but placed wide ranges around those estimates. The most common way to grasp the impact of convexity was in toggling the lapse/surrender sensitivity parameters in numerous simulations. The standard among the companies we interviewed was to perform simulations of between 500 and 10,000 paths to capture the impact of changing interest rate levels on policy lapses/surrenders.

While life insurers have more interest than confidence in the convexity estimates, they have progressed a long way over the past few years. Prior to 1992, the commercially available software did not even produce convexity estimates for life insurance liabilities. Instead, firms relied almost entirely on simulations. Many firms used only the seven highly artificial scenarios required of New York's Regulation 126. Prior to its passage, some insurers did not use the simulation method at all. Rather, they relied simply on their "best point estimates" and static lapse assumptions. Even today, there are insurers who use nothing more than the seven scenarios required under Regulation 126 to assess their exposure to interest rate risk.

The property/casualty insurers with whom we spoke had less concern about interest rate risk than their life/health counterparts. Nonetheless, they manifested greater understanding of the problem than a few years earlier. All of them were well aware of the importance of measuring duration of assets, producing in-house estimates of duration, or acquiring them from outside vendors, for most of their fixed income assets. More problematic was the estimation of duration for their real estate and equity portfolios. However, an analysis of the duration of their liabilities was generally missing. They had a notion that the duration was relatively short — perhaps a couple of years or so — but no more specific information.¹³ Convexity was even less of a concern for these property/casualty insurers. Nonetheless, there appears to be at least some

interest rate sensitivity in the payments made to satisfy property/casualty claims. For example, it is well known that workers' compensation claims tend to increase during periods of unemployment, as fraudulent claims seem to be filed with greater frequency. Similarly, fires and arson tend to occur with greater frequency when insured values exceed market values. To the extent that these and other situations are linked to interest rate levels, it can be supposed that some property/ casualty liabilities are interest sensitive. Available evidence on this front is scant, however.¹⁴ Where the sensitivity is measurable, it tends to be more closely linked to inflation than to nominal interest rates. Therefore, the influence of inflation on their liabilities was deemed more important.

It would be fair to say that most property/casualty insurers paid little attention to the duration of their liabilities. It is generally thought that interest rate risk accounts for only a small portion of the change in the value of liabilities over time, and that other risks, such as actuarial risk, price regulation, legal risk, underwriting risk, inflation risk, and event or catastrophe risk swamp the influence of interest rate movements on the pricing and valuation of property and casualty insurance liabilities.

Systematic Risk of Assets

Insurers are concerned with interest rate risk more than other systematic risk factors, and rightly so. Over the past two decades, it has been the source of much of the fluctuation in the value of fixed income assets, which constitute the majority of their assets. However, while it is the crucial systematic risk on the life insurance liability side,¹⁵ and of some importance for property/casualty liabilities as well, it is prominent but less dominating on the asset side of the balance sheet. This is because asset values are perceived to be affected not only by general interest rate levels, but also by basis risk, default risk, liquidity risk, call risk, prepayment risk, extension risk, sinking fund options, convertibility, real estate and equity risk. Yet, several of these risks are simply different manifestations of interest rate risk, making accurate measurement of paramount importance.

The measurement of interest rate risk on the asset side of the balance sheet is generally well done, although some insurers have a long way to go. Many insurers use the actuarial software mentioned earlier to estimate the durations and convexities of their investments. Some use software and pricing services like GAT and Bloomberg that are oriented strictly toward the asset side of the balance sheet. Several have developed their own, more sophisticated in-house programs for estimating values of both sides of the balance sheet. We noted that it was common to use more than a single source to assess the duration and convexity of assets. One stated reason for this was the divergence of opinion between the various programs and pricing services.

We did not encounter any property/casualty insurers who carefully measured the interest rate risk of both sides of their balance sheet. What was more common was for the focus to be on the interest rate risk of only the assets. Here the tools of duration and convexity measurement were applied, and insurers took steps to manage the overall exposure of their assets to interest rate risk and keep it within some targeted range. It was common for property/casualty insurers to use interest rate futures, swaps, and options to moderate this risk to acceptable levels. Options and futures were also used to hedge equity market risks, where the insurer maintained a large

position in common stocks. The hedges were put in place, and then removed, as market conditions changed and the insurers' appetites for equity risk waxed and waned.

Asset/Liability Management

Asset/liability management typically did not go far beyond an assessment of the impact of interest rate movements on the value of the firm. Other systematic risks were usually dealt with in a more piecemeal fashion. The standard practice is to produce estimates of liability durations and convexities for each line of business, as well as for each asset class. These estimates are then weighted by the fair value of liabilities, or market value of assets, to arrive at overall asset and liability duration and convexity estimates. After factoring in leverage, the insurers are able to obtain measures of surplus duration and convexity. Examples of product level and firm level analyses are given in Exhibits 1 and 2.

The frequency for providing analysis of interest rate risk varies widely. Some firms provided weekly summaries of their asset durations and convexities, and monthly or quarterly summaries of their liabilities. In the case of interest rate futures and options, reports were more frequent, owing to their tremendous impact on overall interest rate risk. Some firms assessed their liability interest rate risks only on an annual basis, and among the property/casualty companies, liability durations were often not measured at all, nor was the interest rate sensitivity taken into account in liability simulations.

Many companies coupled this kind of analysis with one that shows the distribution of the future market value, or more typically, book value of surplus, based on hundreds of scenarios. An example is provided in Exhibit 3. This approach is conceptually fine, although we caution that when looking at distant future values of surplus, the values produced are extremely sensitive to slight variations in assumed yield spreads, which can get compounded for 30 years, and often are overly optimistic. Rarely are these approaches implemented with sufficient skill to account for the various correlations and patterns that can be observed in practice.

Although many firms use the same general frameworks for analysis, when it comes to implementation we begin to see divergence in the quality of inputs and practice. By relying on a number of outside sources to provide the estimates of interest rate sensitivity for assets and liabilities, a number of insurers have injected another risk into the mix: divergent technologies and assumptions. We believe that for the purposes of asset/liability management, it is a misdirected effort to obtain the most credible measures of interest sensitivity of certain assets or liabilities. It is far more important to get measures of interest rate sensitivity that are calibrated similarly. After all, the absolute values are of less importance here than their relative values and the implication these have for the volatility of equity.

We saw a number of practices that invite problems. One prominent insurer used effective duration and convexity estimates for the liability side of the balance sheet, and Modified Macaulay duration measures for the asset side. Another insurer did exactly the opposite. Some insurers base their aggregate duration and convexity numbers on book value weights, rather than market value weights. More than one insurer was frustrated that their actuarial departments relied entirely on simulations and provided no duration or convexity measures whatsoever. The actuarial scenarios run were based on completely random interest rate paths, inconsistent with

EXHIBIT 1**OPTION ADJUSTED DURATION / CONVEXITY****Life Product XX**

Int. Rate Shift (b.p.)	ASSETS			LIABILITIES			SURPLUS		
	Option- Adjusted Value	Effective Duration	Convexity	Option- Adjusted Value	Effective Duration	Convexity	Option- Adjusted Value	Effective Duration	Convexity
-200	1,600	2.9	N/A	1,545	4.1	N/A	55	-30.8	N/A
-150	1,500	3.0	-66	1,405	2.9	60	95	4.5	-3,000
-100	1,400	3.1	-85	1,330	2.1	450	70	22.1	-25
-50	1,300	3.3	-176	1,243	1.8	700	57	36.0	-125
0	1,200	3.5	-190	1,151	1.5	680	49	50.5	-10,000
50	1,100	3.8	-121	1,061	1.4	390	39	69.1	-8,555
100	1,000	4.2	-50	975	1.2	85	25	121.2	-6,000
150	900	5.0	0	901	1.1	20	-1	-3,508.9	100
200	800	5.9	N/A	845	1.0	N/A	-45	-86.1	N/A

EXHIBIT 2

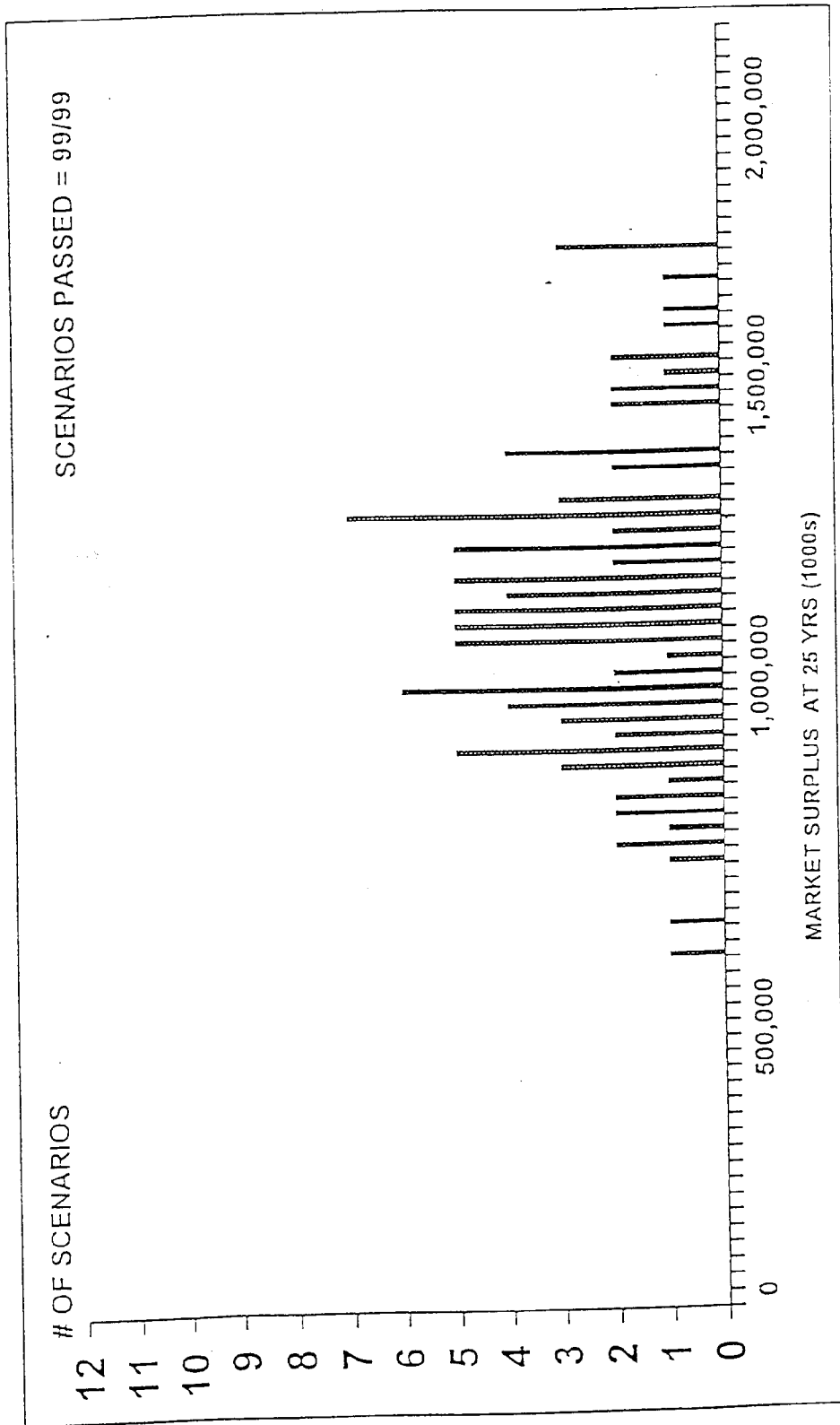
**XYZ Insurance Company
Surplus Duration Analysis**

Asset Class	Market Value	Effective Duration	Liabilities	Fair Value	Effective Duration	Economic Surplus	Effective Duration
Bonds	10,000,000	6.5	SPDA 1	8,500,000	3.2		
Mortgage-Backed Se	5,000,000	4.2	SPDA 2	4,000,000	2.0		
Preferred Stock	200,000	8.1	Universal Life	400,000	7.9		
Common Stock	3,000,000	2.1	Term Life	300,000	1.3		
Mortgage Loans	6,000,000	5.7	Whole Life	12,000,000	6.8		
Equity Real Estate	2,000,000	1.0	Endowment	500,000	8.5		
Short-Term & Cash	1,500,000	0.8					
TOTALS	27,700,000	4.74		25,700,000	4.85	2,000,000	3.36

EXHIBIT 3

Distribution of Surplus Accumulation

Results of 99 Random Scenarios



any financial theory or history of interest rates. Several insurers relied on liability duration estimates based on only one interest rate factor, but on asset duration estimates based on two factors. Some insurers used duration measures for corporate bonds and mortgage-backed securities supplied by Wall Street that were based on different volatility parameters and processes than those used for other asset and liability categories. Some estimates were based on lattice models, while others were based on simulation models, or simulating through lattices. Only one insurer we know of is attempting to correct the duration measures on corporate bonds for the basis risk between corporate and government bonds.¹⁶ Some insurers took the basis risk between movements in long-term vs. short-term interest rates into account, but many did not. Some took into account all kinds of potential twists in the yield curve, while others allowed only for parallel shifts.

In setting limits on the amount of systematic risk the company desires to retain, a common approach is the one used by a leading multi-line insurer. The company places limits on its desired portfolio structure to reflect the variety of risks to which it is exposed. Limits are set on individual asset holdings, on industry concentration, and on asset type including mortgage-backed securities and collateralized mortgage obligations, all in a risk-based capital context. However, nowhere did we observe a methodology to derive such limits, or even a standardized approach across business lines.

For the balance sheet as a whole, limits are employed in two different ways. One approach is to impose a limit on the amount of duration mismatch allowed, either for particular product lines or for aggregating across all assets and liabilities. For instance, one company applies these restrictions on a product segmentation basis, allowing up to a year duration mismatch on participating whole life products, but only 1/10 of a year on GICs. Another company does not place restrictions on duration mismatches on a product by product basis, but on an aggregate portfolio basis. In our view, although most companies we interviewed used some sort of product segmentation approach, it is not necessary to do so. The advantage of a segmentation approach is the discipline it imposes on the pricing process, so that long term yields do not get used for pricing short term liabilities, and so forth. However, if this same discipline can be achieved in the pricing of insurance policies without a segmentation of assets into various product groupings, it seems that advantage would disappear. On the other hand, valuable resources would not be consumed in notionally dividing up the general account into the various segments, and it could be managed on an aggregate basis. This would avoid the costly duplication of efforts, where one product manager is selling an asset and another is buying the same or a similar asset, incurring transaction costs. Some firms simply transfer the assets between portfolio segments and use some sort of internal transfer pricing mechanism. Assets are acquired by the firm and then allocated to each product group according to perceived needs. This is done to foster a better sense of accountability and used in performance evaluation. But to reward a product group for producing net profits between liability costs and rates of return on assets which they had no responsibility in acquiring or divesting seems to be rewarding them for risks over which they had no control. While we appreciate the need for pricing discipline and control, we feel this could be achieved more simply and that the asset portfolios can be managed better on an aggregate basis.

The other limit is a restriction on the amount of scenarios that are allowed to reveal losses due to asset/liability mismatches. These limits are typically placed not only on the distribution of final simulated results, but also on the evolution of solvency over time associated with the simulations. One firm has almost no tolerance for scenarios showing negative profitability due to interest rate risk exposure. Because it is persuaded that interest rates are virtually impossible to forecast, and over which it has no control, it has decided to avoid interest rate risk of any kind, to the extent possible.

At the firm that decided to avoid as completely as possible interest rate risk, portfolio managers are not rewarded in any way for taking interest rate risk and trying to “time” the market. Indeed, their job could be lost if they stray outside narrow boundaries. Some firms purport to eschew interest rate risk, yet reward their investment department personnel if they achieve investment income or total rates of return above some benchmark level. By measuring only periodically the interest rate risk of assets, this invites the portfolio managers to “game” the system and attempt to improve their returns by incurring interest rate risk for brief periods of time. Some firms have duration targets but ignore convexity, leading portfolio managers to try barbell, ladder, or bullet maturity approaches to achieve higher investment income, depending on the shape of the term structure.

But by in large, the major difference between investment practices that we saw during this study, compared to what was occurring less than a decade ago, was that there was far less emphasis on yield and more on total rate of return. As recently as five years ago a survey of the American Council of Life Insurance revealed that two-thirds of chief investment officers did not even consider total rate of return as an investment objective. Yield was the primary focus. This was an impediment to effective asset/liability management but is beginning to dwindle. Nonetheless, we observed more concern with book yield than we feel is appropriate, given its lack of importance to the true economic performance of the firm.

C. Credit Risk

In addition to the credit risk that reveals itself as basis risk in the systematic risk factors listed above, there is also the risk of default on significant firm investments. While it may be idiosyncratic risk to the market as a whole, it is not idiosyncratic risk to the insurer maintaining a significant position in an asset that goes into default.

Insurance firms are generally very focused on credit risk, as are rating agencies and regulatory authorities. They produce weekly and monthly reports that monitor the credit risk of their assets. They rely on outside rating agencies, such as Moody’s, Standard and Poor’s, Duff and Phelps, and Dunn and Bradstreet. In addition, virtually all of their investments are assigned credit ratings by the Securities Valuation Office of the National Association of Insurance Commissioners, which are used for statutory reporting purposes. These ratings are not always viewed as sufficient measures of credit risk for those insurers who feel that absorbing credit risk is an important part of their franchise. Many insurers have their own due diligence requirements to meet before they will take on an investment that has credit risk. They undertake internal credit risk ratings, in some ways quite similar to those of Moody’s or Standard and Poor’s, although with different weightings on the risk factors. Moreover, they are prone to update their

internal credit risk ratings promptly as important information bearing on the creditworthiness of a major investment position is revealed.

Insurers produce “Watch Lists” of firms they feel are in financial jeopardy, likely to be downgraded or become insolvent. They often have a dual track credit risk assessment, one for the asset itself, and another for the underlying collateral. They place limits on the portfolio exposure by industry, by geographic region, by business (e.g., real estate prohibited), and by company. They also have lists of approved counterparties for brokerage, settlement and swaps.

In Exhibits 4 and 5 we provide an example of one set of investment guidelines, with general and specific authorizations and limits that we feel are representative of the industry. However, there is substantial variation in the practices that we have seen. Perhaps the poorest approach we saw was a firm that used Moody’s ratings, and assigned numerical values to each rating class. For instance, 1.0 was assigned to a rating of Aaa, 2.0 was assigned to Aa, 3.0 to A, 4.0 to Baa, 5.0 to Ba, 6.0 to B, 7.0 to Caa, 8.0 to Ca, 9.0 to C, and 10 to D. Adjustments are made to accommodate the modifiers of 1, 2, and 3 that Moody’s often uses to designate relative quality within a ranking class. The company then has a target number of 3.0 to achieve in its overall credit risk plan. One problem with this approach, which they recognize, is that default rates and volatility of default rates do not grow linearly as rating is decreased step by step. Coupled with an incentive structure that rewards portfolio managers for the investment yields they book, this system leads to a credit barbell approach, as shown in Exhibit 6, because the portfolio manager can achieve superior yields by doing so.

The best approach we saw included a more refined ranking of credit risk, not by letter but by default probability coupled with standard deviation of defaults for each ranking. Covariance of asset returns was also taken into account, and the entire credit risk problem was cast in a surplus oriented mean-variance model. Diversification guidelines were incorporated through constraints on the optimization. Liquidity risk was reflected by reducing the expected returns by a number of basis points that was deemed appropriate from historical experience.

D. Liquidity Risk

Although insurance companies are faced with liquidity risk, most of the insurers we interviewed had little concern for it. Only one was concerned about having too little liquidity, and one was concerned about having too much liquidity. The others did not seem to be concerned, believing their situation to be well managed.

Liquidity is not as big a concern with many insurance firms as it is in other financial institutions for one good reason: most of their policies are less liquid than their assets. Life insurance companies issue policies that commonly feature high surrender charges. These charges are either explicitly stated, or implicit in the schedule of cash build-up. For example, a single premium deferred annuity, with annual crediting rate reset and a seven year maturity, may feature surrender charges beginning at 7-10% during the first year, and declining in steps toward zero at maturity. Similarly, universal life and whole life products often have very low surrender values during the first year or two of a policy, and begin building up rapidly after that point. Other policies, such as variable universal life, have surrender provisions that act much like a mutual fund, where the amount received depends on the value of the underlying fund.

EXHIBIT 4
Investment Guidelines
General Authorizations

These general authorizations are to remain in effect until January 1997 unless modified or canceled.

The total investment in any one credit (total of bonds, preferred stock, convertible securities and common stock) is limited to 1% of net admitted assets, with the exception of direct U.S. Treasury and full faith and credit obligations and U.S. government-sponsored enterprise obligations, as further specified below.

The following authorizations specify which transactions the Investment Officers of the Company are authorized to conduct that their discretion.

Fixed Income Securities - Non Convertible¹

- A. Purchase U.S. Treasury and full faith and credit obligations in unlimited amounts.
- B. Purchase U.S. Government sponsored enterprise obligations. Such purchases to be limited to 3% of net admitted assets per enterprise, and an aggregate limitation of 10% .
- C. Purchase corporate , municipal , or foreign bonds denominated in U.S. dollars which are rated in the Baa category or better; purchase private placement issues rated in the Baa category or better, or its equivalent.
- D. Purchase mortgage-backed securities and collateralized mortgage obligations consistent with Investment Committee limitations and the Specific Authorizations.
- E. Purchase asset-backed securities consistent with Investment Committee limitations and Specific Authorizations.
- F. Purchase preferred stocks of companies whose bonds or preferred stocks are rated in the Baa category or better, or its equivalent.

Short Term Fixed Income

- H. Purchase commercial paper (with maturities not exceeding 270 days), certificates of deposit or bankers acceptances which are rated wither A-1 or better by Standard & Poor's or P-1 by Moody's.

Such purchases to be limited to 1% of net admitted assets per credit.

Repurchase Agreements

- I. Repurchase agreements may be purchased with banks or security dealers as designated in the Specific Authorizations with the following characteristics: at least 102% collateralized by U.S. Treasury or Agency obligations; for periods not exceeding 60 days.

Total amount outstanding limited overall to 5% of net admitted assets and with any one counter party to 2%.

Reverse Repurchase Agreements

- J. Reverse repurchase agreements may be transacted with banks or security dealers by Specific Authorization.

Total amount outstanding to be limited to 5% of net admitted assets and per counter party to 2%.

¹"Baa category" should be interpreted to mean having a rating no lower than either Baa3 (by Moody's) or BBB- (by Standard & Poor's).

Dollar Rolls

- K. Enter into dollar roll transactions with banks or security dealers designated in the Specific Authorizations. Total amount outstanding to be limited to 5% of net admitted assets and per counter party to 2%.

Other

- L. Enter into CMO residual commitments as specified in the Specific Authorizations.
- M. Use financial futures contracts and interest rate options (exchange traded and over-the-counter) to reduce interest rate risk exposure.
- N. Sell securities held in the portfolio. Any purchaser or transfer agent of such a security need not inquire into the authority for such sale upon the Secretary's certification that it is made under this subdivision "N".

Convertible Securities²

- O. Under the limits specified for non convertible bonds, purchase convertible bonds of companies with issues rated in the Baa category or better, or of companies with lower or non rated issues according to the following schedule:

Moody's (or S&P) Rating	Authorized Limit per Issuer as Percentage of the Convertible Portfolio
Ba1 (BB+) to Ba3 (BB-)	2.0%
B1 (B+) to B3 (B-)	1.0%
No Rating	1.0%
Caa (CCC+) to C (D)	0.5%

Purchases must not cause the aggregate statement value of convertible debt rated less than 2 by the NAIC to exceed the following percentages of the convertible debt portfolio:

NAIC Rating	Restrictions
3 3Z 6 6Z	60.0%
4 4Z 6 6Z	40.0%
5 5Z 6 6Z	7.5%
6 6Z	2.5%

- P. Purchase of medium or lower grade bonds must not cause the aggregate statement value of bonds, including convertible debt, rated less than 2 by the NAIC to exceed the following percentages of net admitted assets:

NAIC Rating	Restrictions
3 3Z 6 6Z	10.0%
4 4Z 6 6Z	5.0%
5 5Z 6 6Z	3.0%
6 6Z	1.0%

- Q. No more than 25% of the portfolio's bonds rated less than 2 by the NAIC can be companies within a single industry nor should these issues in aggregate conduct business within one narrow geographic region. The duration of these issues as a group should be viewed in the context of the total bond portfolio.
- R. Purchase convertible preferred stocks under the limits specified for non convertible with issues rated Baa or better, or of companies with lower or non rated issues according to the following schedule:

²At market value: includes debentures and preferreds.

Moody's (or S&P) Rating	Authorized Limit per Issuer as Percentage of the Convertible Portfolio
Ba1 (BB+) to Ba3 (BB-)	2.0%
B1 (B+) to B3 (B-)	1.0%
No Rating	1.0%
Caa (CCC+) to C (D)	0.5%

Common Stock

- S. The Investment Officers are authorized to purchase common stocks of any United States or Canadian corporation or any foreign corporation whose shares are included in the S&P Common Stock Index in amounts consistent with the Investment Policy Statements as approved by the Committee subject to these additional restrictions. Specifically, the Investment Officers may not:
1. Invest in the equity securities of closed end funds, investment companies, limited partnerships or real estate investment trusts without specific authorizations
 2. Make any purchase of common stock which would result in more than 5% of the value of the common stock portfolio being invested in the securities of one issuer
 3. Purchase a common stock if as a result thereof more than 25% of the assets of the common stock portfolio will be invested in a particular industry
 4. Purchase a common stock if as a result more than the authorized limit of the assets of the common stock portfolio will be invested in common stock of that particular issuer. The authorized limit per issuer will be a function of the issuer's common stock market capitalization in accordance with the following schedule:

Market Capitalization of Issuer of Common Stock	Authorized Limit per Issuer as % of the overall Common Stock Portfolio
\$0 - \$25 million	0%
\$26 - \$50 million	0.25%
\$51 - \$100 million	0.50%
\$101 - \$200 million	1.00%
\$201 - \$500 million	2.00%
\$501 - \$1,000 million	3.00%
\$1,001 - \$2,000 million	4.00%
more than \$2,000 million	5.00%

Furthermore, the Investment Officers will make a quarterly presentation to the Investment Committee on the performance of the common stock portfolio and its risk characteristics in relation to appropriate benchmarks.

- T. The Investment Officers are authorized to use stock index futures and options contracts (exchange traded and over-the-counter) to reduce stock market risk exposure.

Real Estate / Commercial Mortgages

- U. The Investment Officers are authorized to:

1. Commercial Mortgages and Real Estate Equity

Consummate transactions for the purchase, sale, exchange and disposition of real estate loans or equities, up to \$2.5 million with the approval of any three of the following officers of the Company:

Chairman of the Board, President, Chief Investment Officer and Senior Real Estate Investment Officer.

All transactions completed under this authority will be reported to the Real Estate Subcommittee of the Investment Committee of the Board of Directors

EXHIBIT 5
Investment Guidelines
Specific Authorizations

The following specific authorizations for the purchase of securities to be executed at the discretion of the Officers of the Company were renewed by the Committee:

1. Bonds, Short-Term Investments, Convertibles Subordinated Debentures
None

2. Common Stocks

a. Domestic
None

	Authorization
<u>Foreign Companies</u>	<u>Percent</u>
DeBeers Consolidated Mines (ADR)	1.0%
Sea Containers Ltd.	1.0%

3. Convertible Preferred Stock
Sea Containers Ltd. 1.0%

4. Repurchase Agreements, Reverse Repurchase Agreements and Dollar Roll Transactions

There is a list of banks and security dealers authorized for repurchase agreements and reverse repurchase agreements and dollar roll transactions.

5. Hedging Transactions

A. The following officers of the Investment Department are hereby authorized to execute hedging transactions in accordance with the guidelines:

- Executive Vice President & Chief Investment Officer
- Senior Vice President, Vice President, and Second Vice President, Equity Securities
- Senior Vice President, Vice President, and Second Vice President, Fixed Income
- Assistant Vice President, Equity Trader

B. There is a list of banks and brokerage firms approved for the establishment of futures trading accounts.

C. Maximum amount which may be hedged is 5% of admitted assets.

6. Residual Commitments

The maximum amount of CMO Residual commitments is limited to \$100 million.

7. Mortgage-Backed Securities Commitments

In the aggregate, the maximum amount of FHLMC, FNMA, and whole loan commitments is limited to \$750 million at book value.

8. Asset-Backed Securities

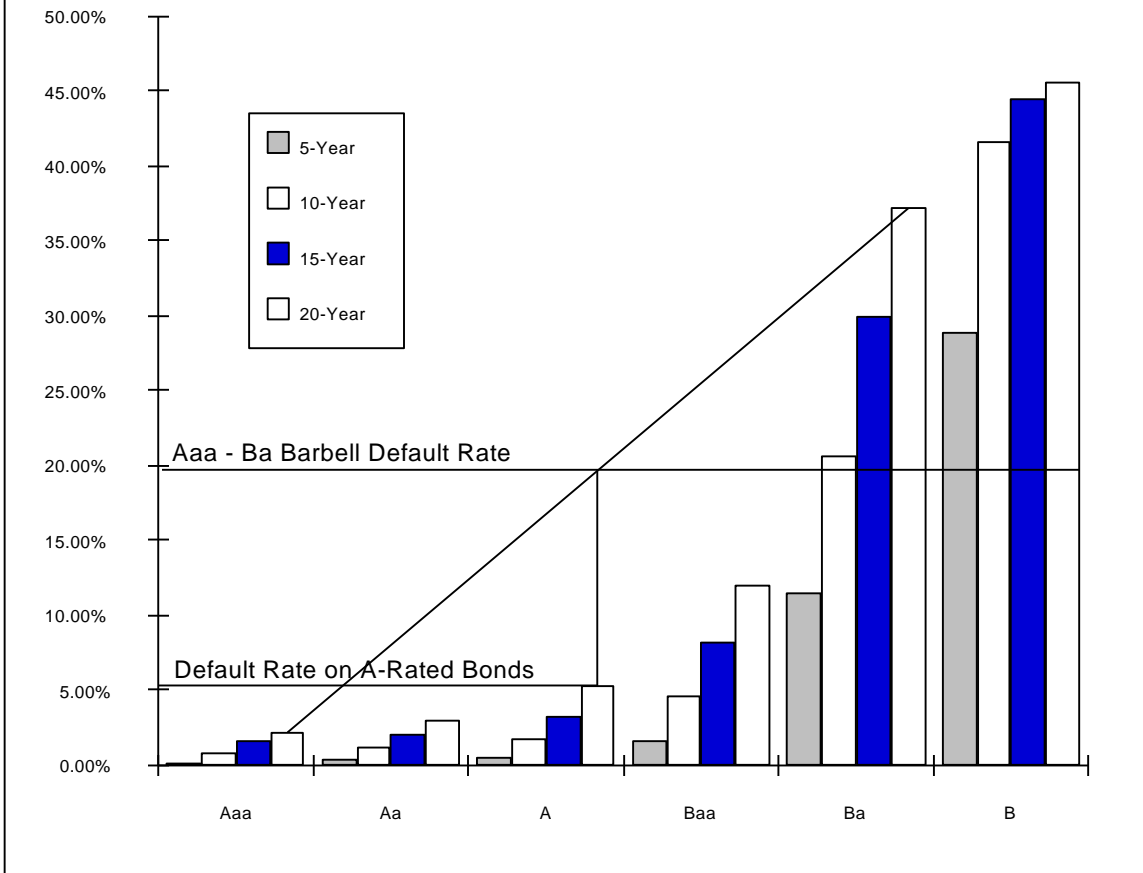
In the aggregate, the maximum amount of ABS is limited to \$250 million at book value.

9. Short Term Borrowing

Up to a maximum amount of \$100 million, such maximum amount not to exceed \$50 million with any one bank or financial institution

EXHIBIT 6

5, 10, 15, and 20-Year Cumulative Default Rates: 1970-1995



A decade or so ago, the problem of illiquidity was more pronounced. Policy surrenders for some companies approached a 60% rate, and massive amounts of policy loans were withdrawn. The industry has managed this problem in two ways. First, much of the new business written is sensitive to market rates of interest, so that there is not as wide a divergence between crediting rates on life policies and annuities vs. market rates of interest. Thus, the incentive to surrender a policy is lessened. Second, policy loans are now mostly offered at variable rates that track market rates of interest, rather than the fixed policy loan rates of yore. An alternative to the variable rates charged on loans is a process known as “direct recognition,” whereby the schedule of cash value build-up is altered if policy loans are incurred. The tax environment has also changed, and interest paid on policy loans is now no longer a deductible expense for tax purposes. Thus, the interest rate arbitrage incentive has virtually disappeared.

Not long ago, however, several well known life insurance companies, such as First Capital Life, Fidelity Bankers Life, Executive Life of California, Executive Life of New York, and Mutual Benefit experienced severe liquidity problems. But in each of these cases, there were other factors that precipitated a “run on the bank” phenomenon. The run in each case was caused, in part, by well publicized investment performance problems. In the case of the first four of the above mentioned companies, there were vast sums of policies in force with minimal, and even zero surrender charges. Some of the policies had been marketed through Wall Street brokerages, and were therefore of the “hot money” variety. Although the first four of these companies had large amounts of liquid assets, the withdrawal rates were so high that even these liquid resources were strained. Generally, however, life insurers are managed in such a way as to avoid these runs on the bank, either through policy design, sales channel, investment policy, or level of surplus.

Another problem that was more prevalent a decade ago was that all bonds were essentially reported at amortized book values. If a bond was sold prior to maturity, any capital gain or loss would need to be recognized. Many insurers, particularly during the early 1980s, could not afford to have the large capital losses appear on their books and impact their surplus. Today, however, a large portion of fixed income holdings are placed in accounts available for sale or trading, and are therefore already marked to market. Therefore, whether they are sold or not does not impact the reported values or the surplus as much.

On the property/casualty side of the business, the liquidity risk comes mostly from event risk or catastrophe risk. Most policies do not feature cash values that are easily accessible through surrender, although some policies will allow insureds to cancel prior to maturity and receive a portion of their premium. Moreover, the policies are typically very short term, renewable annually. With the relatively large surplus positions of most property/casualty insurers, most policyholders are willing to ride out a storm, knowing that renewal time will approach in just a few months.

In terms of the accounting policies of property/casualty companies, they tend to mark-to-market a larger portion of their fixed income securities than life companies, and also tend to hold more liquid, shorter term securities on average. Thus, their liquidity concerns almost always stem from event risk or catastrophe risk. They can avoid some of these risks by reinsuring portions of their books of business, and by broadly diversifying their risk portfolios geographically, by industry, and by type of risk. Alternatively, they can hold large amounts of

liquid surplus assets. One leading property/casualty company attempts to keep enough surplus on hand to accommodate a “once in 500 years” event.

We provide some tables that are representative of the practice of liquidity risk measurement and management. The company defines liquidity risk as the risk of having inadequate net cash flows to meet expenses, benefits, withdrawals, and loan payments. It views product liquidity risk as the fluctuations in cash flows outside of the ranges that are expected. It first ranks assets by relative liquidity. It then projects its cash flows over a multiple year horizon on both sides of the balance sheet using a form like Exhibit 7. For those firms that maintain segmented accounts by product line, these liquidity reports are generated by product, as in the case of Exhibit 8.

A company’s asset/liability committee is typically responsible for measuring and managing liquidity risk. Despite the lack of concern regarding this risk, there is still a large amount of analysis that is done to guard against illiquidity. In this regard, liquidity risk decisions are part of the analytics and scenario testing used by the company. In its investment plan, management of liquidity risk is two-fold. First, the company uses corporate and Regulation 126 modeling to measure net cash flow under various interest rate scenarios. Second, control is achieved by imposing constraints on investment. One such constraint includes ensuring that over 50% of the assets are held in “marketable securities.”

Many companies use PTS for most of their analysis and stress testing. The scenario testing includes about 50-100 scenarios which shift the yield curve, both parallel and slope changes. For each path created by the scenario, net cash flows must be positive. Solvency of the company is also determined along each path. Reports are used for each product, and cash flows are projected out for about 30 years under each of the scenarios. By aggregating across products for each scenario, the company has an idea of the distribution of liquidity at the firm level.

After all the scenario tests, the results have little impact on immediate decisions. For instance, if net cash flows were negative for a large portion of the stress tests, this would not imply that asset composition would change immediately. Suggestions would of course be made, but there is no guarantee that the portfolio would change immediately. Similarly, concentrations are not altered unless there are modifications to limits which would only occur quarterly or annually.

In addition to running these scenario tests, there is also a “worst case scenario.” This includes cash outflows of over 300% over a 2-3 year period and a lapse rate of 45%. For comparison, the highest lapse rate the company has ever experienced is 18% when it decided to decrease significantly dividends after a long history of either increasing or maintaining dividend payments.

There are no managers at the companies studied whose performance is based on the management of liquidity risk. Although it would be difficult to base everyday compensation on unlikely events, the company may benefit in the future from having a clearer line of responsibility with regard to liquidity management. The general procedure is that any ongoing problems with liquidity would be brought to the attention of the Chief Financial Officer. Any

EXHIBIT 7

Liquidity Report

Life Product XXX Projected Cash Flows

PERIOD	ASSET CASH FLOW	LIABILITY CASH FLOW	NETCASH FLOW
1996			
1997			
1998			
1999			
2000			
2001			
2002			
2003			
2004			
2005			
2006			
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			

EXHIBIT 8

Relative Liquidity of Assets and Liabilities

Life Product XXX

LIABILITIES*				
	Current Quarter	Prior Quarter -1	Prior Quarter -2	Prior Quarter -3
Level 1 Liquidity				
Level 2 Liquidity				
Level 3 Liquidity				
Level 4 Liquidity				
(Levels 1+2)÷Total				

*Liabilities are net of Policy Loans

ASSETS				
	Current Quarter	Prior Quarter -1	Prior Quarter -2	Prior Quarter -3
Level 1 Liquidity				
Level 2 Liquidity				
Level 3 Liquidity				
Level 4 Liquidity				
(Levels 1+2)÷Total				

SUMMARY				
	Current Quarter	Prior Quarter -1	Prior Quarter -2	Prior Quarter -3
Level 1 (Assets) ÷ Level 1 (Liabilities)				
Level 1 -2 (Assets) ÷ Level 1-2 (Liabilities)				
Guideline				
Level 1 -3 (Assets) ÷ Level 1-3 (Liabilities)				

NOTE:	<u>Level 1</u>	<u>Level 2</u>	<u>Level 3</u>	<u>Level 4</u>
Liabilities	Book	Int Grnty Expires	Market;	Now Allowed
Surrender is at:	SChg<2%	+ Scheduled	Market & SChg;	
		Ann Paymts,	Book,	
		Next 12 months	SChg>2%	
Assets	Cash, STI	Mtg amort	Inv Grade Bonds	Mtg.; Below
	Inv Grade Bonds	Nll over	with aggregate	Inv Grade
	with aggregate	Next 12 months	market loss in	Bonds;
	market loss < IMR;		excess of IMR	Affil; VC:
	Other			Other

changes to the company's credit ratings which could potentially affect liquidity demands are very much a concern of the auditing group.

E. Other Risks Considered But Not Modeled

Beyond the basic four financial risks, viz., actuarial, systematic, credit and liquidity, insurers have a host of other concerns, as was indicated above. Some of these, like operating risk, are a natural outgrowth of their business and insurers employ standard risk avoidance techniques to mitigate them. Standard business judgment is used in this area to measure the costs and benefits of both risk reduction expenditures and system designs, as well as operational redundancy. While generally referred to as risk management, this activity is substantially different than the management of financial risk addressed here.

Yet there are still other risks, somewhat more amorphous, but no less important. In this latter category are legal, regulatory, reputational and environmental risk. In each of these risk areas substantial time and resources are devoted to protecting the firm's franchise value from erosion. As these risks are less amenable to *a priori* financial measurement, they are generally not addressed in any formal, structured way. However, they are not ignored at the senior management level of the insurance firm.

In passing from this topic it is worthwhile and timely to pause to consider one of the legal risks now encroaching upon the life industry. During the course of our interviews, a number of firms had been sued in the area of misrepresentation of insurance products by insurance agents. At the time of this writing, 44 class action lawsuits had been filed against firms for their so-called "vanishing premium" policies whose premiums did not vanish, as illustrated, owing to a prolonged decline in market interest rate levels. New class action lawsuits were being filed at the rate of one every three days. The damages claimed are staggering for some of the companies.

The manner in which insurers are responding to these lawsuits ranges from attempts to gain a quick and comprehensive settlement to attempts to have the arguments heard in court. Some insurers are merely biding their time to see how other firms fare in the struggle. But more interesting is how insurers are acting to avoid future problems stemming from alleged agent misrepresentation. One of the larger firms has established a department of compliance to train and monitor the behavior of its sales agents. All of its sales and promotional literature is undergoing careful scrutiny by the legal department.

Another firm has created an auditing division to oversee compliance from a central location, computerizing each transaction. Management is concerned with five components of compliance: customer satisfaction, new products, stable earnings, expansion capabilities, and corporate miscellaneous. They are building controls into the centralized computer system. Should an agent exceed the allotted number of address changes, disbursements, lapses, or sales, the computer will not process the policy until the auditing department has had a chance to investigate further. These stop measures are not announced to either the customer or the sales agent. The director of auditing indicated that the system is intended to prevent problems rather than react to them.

A compliance division has been introduced to complement the role of the internal audit group. This division is responsible for insuring the field force and also providing training to sales agents so they will better be able to represent the company's products. This division is currently sending out surveys to its customers to find out if they really understand the products they now hold. It is hoped that these measures will mitigate any class action suits in the future.

VI. Risk Aggregation and Knowledge of Total Exposure

Thus far, the techniques used to measure, report, limit, and manage individual risks have been presented. In each of these cases, a process has been developed, or at least has evolved, to measure the risk considered, and techniques have been deployed to control each of them.

The extent of the differences, across risks of different types, is quite striking. Actuarial risk is carefully modeled, but reported at infrequent intervals. There is often a lack of follow-up to see whether, based on the insurer's experience, the actuarial assumptions have been appropriate. Systematic risk, particularly interest rate risk, is typically measured by life insurers on both sides of the balance sheet, and by property/casualty insurers at least on the asset side. Interest rate risk exposure is discerned using measures of effective duration and convexity, scenario simulations, or a combination of the two. For assets it may be reported as often as weekly or monthly, but for liabilities it is generally reported only quarterly or annually. The credit risk process is a qualitative review of the performance potential of different bonds and borrowers. It results in a rating, periodic re-evaluation at reasonable intervals through time, and on-going monitoring of various types or measures of exposure. Liquidity risk, on the other hand, more often than not, is dealt with as a planning exercise, although some reasonable work is done to analyze the effect of adverse events that affect the firm.

The analytical approaches that are subsumed in each of these analyses are complex, difficult and not easily communicated to non-specialists in the risk considered. The insurer, however, must select appropriate levels for each risk and select, or at least articulate, an appropriate level of risk for the organization as a whole. How can and is this achieved?

The simple answer is "not very well." Senior management often is presented with a myriad of reports on individual exposures, such as specific credits, and complex summaries of the individual risks, outlined above. The risks are not dimensioned in similar ways, and management's technical expertise to appreciate the true nature of both the risks themselves and the analyses conducted to illustrate the insurer's exposure to them is limited. Accordingly, over time, the managers of specific risks have gained increased authority and autonomy. In light of recent losses, however, things are beginning to change.

At the organizational level, overall risk management is being centralized into a Risk Management Committee, headed by someone designated as the Senior Risk Manager. The purpose of this institutional response is to empower one individual, or group, with the responsibility to evaluate overall firm-level risk, and determine the best interest of the company as a whole. At the same time, this group is holding line officers more accountable for the risks under their control, and the performance of the institution in that risk area. Activity and sales incentives are being replaced by performance compensation which is based, not on business volume, but on overall profitability.

At the analytical level, aggregate risk exposure is receiving increased scrutiny. To do so, however, requires the summation of the different types of risks outlined above. This is accomplished in two distinct, but related ways. In the first approach, risk is measured in terms of variability of outcome. Where possible, a frequency distribution of net returns is estimated, from historical data, and the standard deviation of this distribution is estimated. Capital is allocated to activities as a function of this risk or volatility measure. Then, the risky position is required to carry an expected rate of return on allocated capital, which compensates the firm for the associated incremental risk. By dimensioning all risk in terms of loss distributions, and allocating capital by the volatility of the proposed activity, risk is aggregated and priced in one and the same exercise.

The second approach is similar to the first, but depends less on a capital allocation scheme and more on cash flow or earnings effects of the implied risky position. This approach can be used to analyze total firm level risk in a similar manner to the first approach. Again, a frequency distribution of net returns from any one type of risk can be estimated from historical data. Extreme outcomes can then be estimated from the tail of the distribution. Either a worst case historical example is used for this purpose, or a three or four standard deviation outcome is considered. Given the downside outcome associated with any risk position, the firm restricts its exposure so that, in the worst case scenario, the insurer does not lose more than a certain percentage of its surplus or current income. Therefore, rather than moving from volatility of equity value through capital, this approach goes directly to the current earnings implications from a risky position. The approach, however, has two very obvious shortcomings. It is cash flow based, rather than market value driven; and it does not necessarily directly measure the total variability of potential outcomes through *a priori* distribution specification. Rather, it depends upon a subjectively pre-specified range of the risky environments to drive the worst-case scenario.

Both measures attempt to treat the issue of trade-offs among risks using a common methodology to transform the specific risks to firm-level exposure. In addition, both can examine the correlation of different risks and the extent to which they can, or should be viewed as offsetting. As a practical matter, however, only two of the insurers interviewed that were using these approaches viewed the array of risks as a standard portfolio problem. Rather, they separately evaluate each risk and aggregate total exposure by simple addition. As a result, much is lost in the aggregation. Perhaps over time this crucial issue will be addressed more widely.

VII. Areas Where Further Work Will Improve Methodology

The insurance industry is clearly evolving to a higher level of risk management techniques and approaches than had been in place in the past. Yet, as this review indicates, there is significant room for improvement. Before the areas of potential value added are reviewed, however, it is worthwhile to reiterate an earlier point. The risk management techniques reviewed here are not the average, but the techniques used by firms at the higher end of the market. The risk management approaches at smaller institutions, as well as larger but relatively less sophisticated ones, are less precise and significantly less analytical. In some cases they

would need substantial upgrading to reach the level reported here. Accordingly, our review should be viewed as a glimpse at best practice, not average practices.

Nonetheless, the techniques employed by those that define the industry standard could use some improvement. By category, recommended areas where additional analytic work would be desirable are listed below.

A. Actuarial Risk

There remains too much disagreement in the most fundamental area of actuarial science — namely, what discount rate or rates does one use to value insurance liabilities.¹⁷ With such broad disagreement about what insurance is worth, or what it will cost the insurer, it is little wonder that we encounter difficulties when it comes to managing risk. On the bright side, it must be acknowledged that there is a flurry of activity taking place directed toward solving this conundrum. In our opinion, as the scope of what exactly is being valued is more carefully defined, there is a convergence in the estimates produced by the alternative valuation methods.¹⁸

During the past decade the tools have been developed that can take into account the interest rate sensitivity of policy cash flows. However, many insurers have not employed these tools. Among those who have, there is a severe problem with the data inputs that are necessary to produce useful output. Insurers have not tracked or organized their lapse, surrender and claims data in a manner that allows them to accurately model their interest rate sensitivity. While the models are capable of accommodating virtually any functional form of this behavior, including the effects of policy seasoning, channel of distribution, and so forth, little data exist to estimate the functional form. Of course, this was also the case with regard to the modeling of mortgage-backed securities prepayment a decade ago, but since that time data were collected and analyzed, allowing for the enlightened application of the valuation tools that we see today in that sector. We expect that the same will be true for insurers in a few more years.

Another area where we expect to see rapid improvement is in the versatility of the actuarial software and its speed. Currently, only single-factor stochastic models are being widely used. This results in output that is inconsistent with the other side of the balance sheet, where two or more factors are typically used. Moreover, the speed of processing is so slow that insurers make undesirable compromises when it comes to fully modeling their products. Emerging computer technology undoubtedly will remove this impediment to better policy pricing and risk analysis.

B. Systematic Risk

Tremendous progress has already been made over the past five years in this arena. Most of it has been directed toward interest rate risk management, which is appropriate given its importance to insurers. An important area for further development is the incorporation of basis risk and equity risk. Another important advance will be a consistent valuation methodology for both sides of the balance sheet.

While simulation studies have substantially improved over the past few years, the use of book value accounting measures and cash flow losses continues to be problematic. Movements

to improve this methodology will require increased emphasis on market-based accounting. Such a reporting mechanism must be employed on both sides of the balance sheet, however, not just the asset portfolio.

The simulations also need to incorporate the advances in dynamic hedging that are used in complex fixed income pricing models. As it stands, these simulations tend to be rather simplistic, and scenario testing is rather limited.

C. Credit Risk

The evaluation of credit rating continues to be an imprecise process. We note divergence's between the NAIC ratings assigned to particular public and private placements vs. the ratings assigned by the Wall Street ratings agencies. We should never expect to see a complete convergence here, as there is no single set of weights to apply to the risk factors across all industries and firms. However, we do expect to see less divergence over time, as more becomes known about the factors that lead to default.

We also expect to see more enlightened practices when it comes to aggregating credit risks. A sensible aggregation scheme would take into account default rates, default losses, and the shape of the distribution of losses across all ratings categories. In time we may even see a move toward market-based default measures, at least on publicly traded debt instruments. We anticipate that credit risks will soon be evaluated in a framework consistent with other financial risks. Some insurers are already moving in this direction.

D. Liquidity Risk

For the life companies, this seems to be the least of their major financial risks. Most companies are doing a satisfactory job of managing this risk. With the advent of mark-to-market accounting, the problems for liquidity caused by the fiction of book accounting will gradually subside. Most life insurers model this risk well. In the property/casualty sector, it remains a large risk. Crisis models need to be better linked to operational details. In addition, the usefulness of such exercises is limited by the realism of the environment considered.

If liquidity is to be managed, the price of illiquidity must be defined and build into illiquid positions. While this logic has been adopted by some institutions, this pricing of liquidity is not commonplace.

E. Firm Level Risk

The ability of insurance companies to estimate and manage firm level risk is a long way off. To reach this goal requires much more precision in the estimation and management of the individual risks within the firm. Aggregation only has meaning to the extent that the individual elements can be aggregated. This presumes that they are measured correctly, dimensioned in a similar manner, and incorporated in a unified framework of risk. When this is accomplished, risks of different types will be contrasted and compared, and trade offs will become possible. However, to achieve this requires a significant amount of work on the individual risks within the industry before any reasonable aggregation can transpire.

References

- Altman, E. I. and I. T. Vanderhoof, editors, *Fair Value of Insurance Liabilities*, Irwin Press, forthcoming 1996.
- Alexander, J. N., P. J. Bouyoucos, M. H. Siegel, and A. Gola, "The Goldman Sachs Insurer CIO Survey," *Industry Resource Group*, May 1994.
- Babbel, D. F., "A Perspective on Model Investment Laws for Insurers" *C.L.U. Journal*, September 1994.
- Babbel, D. F., "Financial Valuation of Insurance Liabilities," *Fair Value of Insurance Liabilities*, E. Altman and I. T. Vanderhoof, editors, Irwin Press, forthcoming 1996.
- Babbel, D. F., "Asset-Liability Matching in the Life Insurance Industry" *The Financial Dynamics of the Insurance Industry*, E. Altman and I. T. Vanderhoof, editors, Irwin Press, 1994.
- Babbel, D. F. and D. R. Klock, "Insurance Pedagogy: Executive Opinions and Priorities" *Journal of Risk and Insurance*, December 1988.
- Babbel, D. F. and D. R. Klock, "Measuring the Interest Rate Sensitivity of Property/ Casualty Insurer Liabilities" *Insurance, Risk Management, and Public Policy*, S. G. Gustavson and S. E. Harrington, editors, Kluwer Press, 1993.
- Babbel, D. F. and J. Lamm-Tennant, "Trends in Asset/Liability Management for Life Insurers" *Insurance Perspectives*, Goldman Sachs, November 1987.
- Babbel, D. F., C. B. Merrill, and W. Panning, "Default Risk and the Effective Duration of Bonds" *Financial Analysts Journal*, forthcoming 1996.
- Babbel, D. F., R. Stricker, and I. T. Vanderhoof, "A Modern Approach to Performance Measurement for Insurers" *Operations Research Models in Quantitative Finance*, R. L. D'Ecclesia and S. A. Zenios, editors, Physica-Verlag, 1994.
- Barton, E., G. Bodnar, and A. Kaul, "Exchange Rate Variability and the Riskiness of U.S. Multinational Firms: Evidence from the Breakdown of the Bretton Woods System," Working Paper 94-6, Wharton Weiss Center, 1994.
- Beard, R. E., T. Pentikäinen, and E. Pesonen, *Risk Theory*, 3rd ed., Chapman and Hall, New York, 1984.
- Beaver, W. H. and G. Parker, *Risk Management, Problems and Solutions*, McGraw Hill, New York, 1995.
- Black, K. Jr. and H. D. Skipper, Jr., *Life Insurance*, 12th ed., Prentice Hall, Englewood Cliffs, N.J., 1994.

- Bouyoucos, P. J. and M. H. Siegel, "The Goldman Sachs Insurer CIO Survey," *Industry Resource Group*, October 1992.
- Brander, J., and T. Lewis, "Oligopoly and Financial Structure: The Limited Liability Effect," *American Economic Review*, December 1986.
- Breeden, D., and S. Viswanathan, "Why Do Firms Hedge? An Asymmetric Information Model," Working Paper, Duke University, 1990.
- Campbell, T., and W. Kracaw, *Financial Risk Management: Fixed Income and Foreign Exchange*, Harper Collins, New York, 1993.
- Campbell, T., and W. Kracaw, "Information Production, Market Signaling and the Theory of Financial Intermediation," *Journal of Finance*, 1980.
- Choi, J. H., "Estimating Market Value of Loss Payments of Property/Liability Insurance Companies Using Modern Valuation Technology," Working Paper, Wharton School, 1992.
- Cummins, J. D. and R. A. Derrig, *Financial Models of Insurance Solvency*, Kluwer Academic Publishers, Boston, 1989.
- Cummins, J. D. and G. Grace, "Tax Management and Investment Strategies of Property-Liability Insurers," *Journal of Banking and Finance*, 1994.
- DeMarzo, P., and D. Duffie, "Corporate Incentives for Hedging and Hedge Accounting," Working Paper, Northwestern University, 1992.
- Doherty, N. A., *Corporate Risk Management: A Financial Exposition*, McGraw Hill, 1985.
- Fazzari, S. M., R. G. Hubbard, and B. C. Petersen, "Financial Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1988.
- Fite, D., and P. Pfleiderer, "Should Firms Use Derivatives to Manage Risk?" in *Risk Management Problems and Solutions*, (Beaver and Parker, eds.) McGraw Hill, New York, 1995.
- Froot, K., D. Scharfstein, and J. Stein, "A Framework for Risk Management," *Harvard Business Review*, November 1994.
- Froot, K., D. Scharfstein, and J. Stein, "Risk Management: Coordinating Investment and Financing Policies," *Journal of Finance*, December 1993.
- Geezy, D., B. Minton, and C. Schrand, "Why Firms Hedge: Distinguishing Among Existing Theories," Working Paper, 1995.
- Gennotte, G. and D. Pyle, "Capital Controls and Bank Risk," *Journal of Banking and Finance*, September 1991.

- Gerber, H. U., *An Introduction to Mathematical Risk Theory*, Richard D. Irwin, Inc., Homewood, Illinois, 1979.
- Greenawalt, M. and J. Sinkey, "Bank Loan Loss Provisions and the Income Smoothing Hypothesis: An Empirical Analysis," *Journal of Financial Services Research*, December 1988.
- Helfat, C. and D. Teece, "Vertical Integration and Risk Reduction," *Journal of Law, Economics and Organization*, Spring 1987.
- Hoshi, T., A. Kashyap, and D. Scharfstein, "Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups," *Quarterly Journal of Economics*, 1991.
- Huber, P. W., *Liability: The Legal Revolution and Its Consequences*, Basic Books, 1988.
- Jorion, P., "The Pricing of Exchange Rate Risk in the U.S. Equity Markets," *Journal of Financial and Quantitative Analysis*, July 1991.
- Lamm-Tennant, J., "Asset/Liability Management for the Life Insurer: Situation Analysis and Strategy Formulation," *Journal of Risk and Insurance*, September 1989.
- Lamm-Tennant, J., "Survey and Commentary on Investment Policies and Practices of the U.S. Insurance Industry," Chalke Incorporated, Chantilly, Virginia, 1994.
- Lamm-Tennant, J. and D. Gattis, "Survey and Commentary on Investment Policies and Practices of the U.S. Insurance Industry," SS&C, Bloomfield, Connecticut, 1996.
- Lamm-Tennant, J. and T. Rollins, "Incentives for Discretionary Accounting Practices: Ownership Structure, Earnings and Taxation," *Journal of Risk and Insurance*, September 1994.
- Litterman, R. and K. Winkelmann, "Managing Market Exposure," *Risk Management Series*, Goldman, Sachs & Co., New York, January 1996.
- Marcus, A., "Deregulation and Bank Financial Policy," *Journal of Banking and Finance*, December 1984.
- Maksimovic, V., "Capital Structure in Reported Oligopolies," *Rand Journal of Economics*, August 1988.
- Merton, R. C., "Financial Innovation and the Management and Regulation of Financial Institutions," *Journal of Banking and Finance*, June 1995.
- Merton, R. C., "On the Application of the Continuous-Time Theory of Finance to Financial Intermediation and Insurance," *Geneva Papers on Risk and Insurance*, July 1989.
- Millette, M. J., A. J. Levinson and J. A. Oleinick, "The Goldman Sachs Insurer CIO Survey," Industry Resource Group, June 1996.

- Moody's Investor Services, *Moody's Credit Ratings and Research*, Moody's 1995.
- Myers, S. C., "Determinants of Corporate Borrowing," *Journal of Financial Economics*, 1990.
- Nance, D. R., C. W. Smith, and C. W. Smithson, "On the Determinants of Corporate Hedging," *Journal of Finance*, 1993.
- Oldfield, G. and A. Santomero, "The Place of Risk Management in Financial Institutions," Working Paper, Wharton Financial Institutions Center, 1995.
- Ross, S., "The Determination of Financial Structure: The Incentive Signaling Approach," *Bell Journal of Economics*, Spring 1977.
- Ross, S., "The Economic Theory of Agency: The Principal's Problem," *American Economic Review*, May 1973.
- Santomero, A., "Financial Risk Management: The Whys and Hows," *Financial Markets, Institutions, and Investments*, December 1995.
- Santomero, A., "Commercial Bank Risk Management: An Analysis of the Process," Working Paper, Wharton Financial Institutions Center, 1995.
- Santomero, A., "The Changing Structure of Financial Institutions: A Review Essay," *Journal of Monetary Economics*, 1989A.
- Scholes, M., G. P. Wilson and M. Wolfson, "Tax Planning, Regulatory Capital Planning and Financial Reporting Strategy for Commercial Banks," *Review of Financial Studies*, 1990.
- Siegel, M. H., M. J. Millette and D. Pouraghabagher, "The Goldman Sachs Insurer CIO Survey," *Industry Resource Group*, April 1995.
- Smith, C. W. and R. Stulz, "The Determinants of Firm's Hedging Policies," *Journal of Financial and Quantitative Analysis*, 1985.
- Smith, C. W., C. Smithson, and D. Wilford, *Strategic Risk Management*, Harper and Row, New York, 1990.
- Smith, M. L., "The Life Insurance Policy as an Options Package," *Journal of Risk and Insurance*, September 1982.
- Staking, K. B. and D. F. Babbel, "The Relation between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry," *Journal of Risk and Insurance*, December 1995.
- Stulz, R., "Optimal Hedging Policies," *Journal of Financial and Quantitative Analysis*, 1984.
- Warner, J., "Bankruptcy Costs: Some Evidence," *Journal of Finance*, May 1977.

Weiss, L., "Bankruptcy Resolution: Direct Costs and Violation of Priority Claims," *Journal of Finance and Economics*, 1990.

Footnotes

¹Members of the team included Anthony Santomero (leader), David Babbel, Yuval Bar-Or, Richard Herring, Paul Hoffman, Susan Kerr, Spencer Martin, Steve Pilloff, Jeffrey Trester, and Sri Zaheer.

²See Alexander et al [1994], and Siegel, Millette and Pouraghabagher [1995].

³See Lamm-Tennant [1995] and Lamm-Tennant and Gattis [1996].

⁴See, for example, Merton [1989, especially pp. 242-258].

⁵See Oldfield and Santomero [1995].

⁶Our discussion of these risks follows that of Black and Skipper [1994].

⁷See Huber [1988].

⁸See Black and Skipper [1994] and Beard, Pentikäinen, and Pesonen [1984], Gerber [1979], and Cummins and Derrig [1989].

⁹See M. Smith [1982].

¹⁰The value of the policy loan option by itself could account for 20-45% of the present value of all future insurance premiums, if the option were used optimally. When factoring in the suboptimal utilization of this option, he estimated that the cost to an insurer of providing this option was in the 8-12% range. Yet insurers had historically charged *nothing* for this option. Indeed, it was simply mandated that insurers begin to offer this option.

¹¹Measures of interest rate sensitivity which take into account the interest-sensitive cash flows of an asset or liability stream are referred to as “effective duration and convexity,” or alternatively, “option-adjusted duration and convexity.” Measures of interest rate sensitivity which assume all cash flows are fixed, or at least insensitive to movements in interest rates, include “modified duration and convexity” and “Macaulay duration.”

¹²For example, we estimated the duration on a block of participating whole life policies for one mutual company. Its Macaulay duration was around 22 years, while its effective duration was approximately 5.6. See Lamm-Tennant [1989] for a revealing survey of the level of sophistication in understanding and applying duration and Babbel [1994] for a discussion of the pitfalls in using the older duration measures.

¹³See Babbel and Klock [1993].

¹⁴See Choi [1992].

¹⁵See Babbel [1996] for an explanation.

¹⁶See Babbel, Merrill and Panning [1996] for an explanation of the correction procedure.

¹⁷See Altman and Vanderhoof [1996].

¹⁸See Babbel [1996].