SOCIETY OF ACTUARIES

ASSET-LIABILITY MANAGEMENT

Overview

This Specialty Guide is a background reading reference for the practice of asset-liability management (ALM). It is being published to offer guidance not only to actuaries seeking to gain knowledge on ALM as it relates primarily to life and health insurance, but also to practitioners in the property and casualty insurance and pensions fields. Indeed, some of the sections have property/casualty-specific and pension-specific references shown separately, and special sections at the end are devoted to property/casualty-specific references and to pension-specific references. The guide also contains a section on "Bank ALM and Value at Risk." We also hope that this guide will be useful to an audience beyond the actuarial profession seeking to understand a difficult but increasingly important subject.

The guide should be viewed as a preliminary road map for any practitioner seeking direction to enhance his or her knowledge of ALM. No particular level of expertise is assumed, although some basic understanding of the investments available to a financial institution is assumed. To make the guide as widely useful as possible, we have attempted to indicate the level of difficulty of each reference.

What Is ALM?

ALM is the practice of managing a business so that decisions on assets and liabilities are coordinated; it can be defined as the ongoing process of formulating, implementing, monitoring, and revising strategies related to assets and liabilities in an attempt to achieve financial objectives for a given set of risk tolerances and constraints.

Financial objectives and acceptable risk levels are defined by the organization. ALM is relevant to, and critical for, the sound management of the finances of any institution that invests to meet liabilities.

The Role of the Actuary

Actuaries measure, model, and manage risk. Risk associated with the ALM process is one of the most important risks faced by many insurance companies. Actuaries involved with insurance companies should be familiar with assets and liabilities and how they are interrelated. They should understand the operation of financial markets, the instruments available (particularly those involving fixed income) and the options embedded in such instruments, and the synthetic instruments available to insurance companies. In addition, financial reporting and product development actuaries need to understand the relationship of the company's assets to its liabilities so as to reflect the risks inherent in the insurer's business and thereby enhance its profitability or possibly even its solvency. Investment products are continually being redesigned, updated, expanded, and replaced. The practicing actuary must be aware of these changes and of how they affect the company and must be able to communicate regarding such changes with the company's portfolio managers (or be part of such portfolio management). The coordination of product development, investment operations, and financial reporting is essential for a successful insurance company; actuaries are well qualified to perform this coordination.

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How to Use this Guide

The references cited in this guide have been categorized as follows:

1. Introduction to ALM
2. Basics in Financial Economics Relevant to ALM
3. Immunization
4. Arbitrage-Free Interest Rate Models
5. The Efficient Frontier and Asset Allocation
6. Derivatives
7. Bank ALM and Value-at-Risk (VAR)
8. Corporate ALM
9. Performance Measurement and Benchmarking
10. ALM in Product Development
11. Market Value of Insurance Liabilities
12. Property and Casualty Insurance
13. Pension Plan ALM

For most references, we label each for its level of difficulty and include a brief commentary introducing the contents. If the reference forms part of any reading for the examinations of the Society of Actuaries, we indicate the course.

1. Introduction to ALM

ALM means different things to different people. It can mean duration and convexity matching, immunization, optimization, stochastic modeling, performance management and measurement, risk management, and so on. These different notions of ALM occur in part due to differences by practice area (for example, pension fund management versus life insurance product development) and in part due to differences in training, such as Casualty Actuarial Society (CAS) versus Chartered Financial Analyst (CFA). The readings listed in this introductory section are intended to provide a basic overview on most topics and concepts in ALM. Some of the materials go well beyond a basic level, but can be used to explore topics of special interest.

In general, to provide professional ALM services, actuaries need to be reasonably well versed in assets and the functioning of financial markets, in addition to having an in-depth knowledge of specific liability behavior. We also need to explore and learn the tools, techniques, and mathematical models, whether developed within our profession or by other financial professionals, that may be useful in solving the broad range of financial problems faced by our clients now and in the future. The readings here and in the subsequent sections can help you keep your ALM practice up-to-date.

Babbel, David F., and Merrill, Craig B. "Spot Interest Rates, Forward Interest Rates, Short Rates, and Yield-to-Maturity," and "An Introduction to Valuation of Fixed and Interest-Sensitive Cash Flows," Chapters 1 and 2 in "Valuation of Interest-Sensitive Financial Instruments," *SOA Monograph M-F196-1.* New Hope, PA: Frank J. Fabozzi Associates, 1996. Basic

Bodie, Zvi, Kane, Alex, and Marcus, Alan J. *Investments.* 3rd ed. Chicago: Richard D. Irwin, Inc., 1996. Basic

The SOA uses this reference for Course 220 in its examinations.

Forbes, Stephen W., Hays, Michael D., Reddy, Steven D., and Stewart, Kenneth D. *Asset-Liability Management in the Life Insurance Industry.* Atlanta, GA: Life Office Management Association, 1995.

Ingram, David N., and Zacheis, Laird D. "Asset/Liability Matching," Chapter 22 in *Life Insurance Accounting,* edited by Brenner. 3rd ed. Durham, NC: Insurance Accounting & Systems Association, Inc., 1994. Basic

The SOA uses this reference for Course F-385 and F-580 in its examinations.

Jacob, David P., Lord, Graham, and Tilley, James A. "A Generalized Framework for Pricing Contingent Cash Flows," *Society of Actuaries Study Note 480-27-92,* 1992. Intermediate

The SOA uses this reference for Course V-480 in its examinations.

Smink, Meije. "A Numerical Examination of Asset-Liability Management Strategies," *Society of Actuaries Study Note 595-22-95,* 1995.

The SOA uses this reference for Course F-595 in its examinations.

Smink, Meije, and van der Meer, Robert. "Strategies and Techniques for Asset-Liability Management: An Overview," *Society of Actuaries Study Note 595-21-95,* 1995.

The SOA uses this reference for Course F-595 in its examinations.

Williams, Eliot P., ed. *Managing Asset/Liability Portfolios.* Charlottesville, VA: ICFA Continuing Education, 1991.

2. Basics in Financial Economics Relevant to ALM

Financial economics is a very broad topic. Readings in this section are intended to cover those major concepts from modern financial economics that are directly relevant to ALM. These readings provide the framework for the following sections, and the level of difficulty for all is either "basic" or "intermediate."

Four topics are covered by the suggested readings. The first is the Markowitz portfolio selection model. Under the Markowitz model, given a risk-less lending and borrowing rate and a common set of inputs, all investors will prefer a single portfolio of risky assets, the optimal portfolio. Markowitz (1952, 1959) and Tobin (1958) developed a model of investor behavior in a mean-variance framework. In this model, investment portfolios are evaluated in terms of their mean returns and the total variance of their returns. The model can be justified by assuming either that investors have quadratic utility functions or that asset returns are normally distributed. In such a model, investors would choose mean-variance efficient portfolios, that is, portfolios with the highest mean return for a given level of variance of returns. For his contributions to portfolio selection theory of investments, James Tobin was awarded the 1981 Nobel Prize in economics. Harry Markowitz was a co-winner of the 1990 Nobel Prize in economics for his work on portfolio theory.

The capital-asset-pricing model (CAPM) and other related models for evaluating a security's risk and return form the second topic. The CAPM gives a precise prediction of the relationship between the risk of an asset and its expected return. While this model does not fully withstand empirical tests, it is widely used because it has sufficient accuracy for many applications. The CAPM was developed by Sharpe (1964), Lintner (1965), and Mossin (1996); William Sharpe was a co-winner of the 1990 Nobel Prize in economics. Index models, a second class of models, assume that systemic or market risk can be represented by a broad index of stock returns, thereby reducing the input needed to perform a Markowitz portfolio selection procedure.

Single-index models assume that stock prices move together only because of common movements within the market; multi-index models incorporate additional influences such as industry-specific factors. The arbitrage pricing theory (APT) is the last of the models discussed in the readings. Like the CAPM, the APT defines a relationship between expected return and risk. APT models yield an expected return-beta relationship by using a well-diversified portfolio that can in practice be constructed from a large number of securities. Unlike the CAPM and index models, APT models do not assume that the same expected-return-risk relationships hold for all assets. Single- and multi-factor APT models are discussed in the readings.

The third set of readings covers derivatives. Derivatives are a powerful tool for hedging portfolio risks. Basic types of derivatives are described, and option valuation techniques are presented. Modern option-pricing theory was developed by Black and Scholes (1973) and Merton (1973). Myron Scholes and Robert Merton shared the 1997 Nobel Prize in economics; Fischer Black died in 1995.

The final topic is behavioral finance. Theories of modern finance assume that all investors make rational choices based upon rational expectations; behavioral finance studies cases for which individual behavior does not conform to these expectations. By highlighting incidences in which investor and policyholder behavior diverge from rational behavior, this area has important implications for modeling asset and liability cash flows.

The suggested readings for this section are, in general, taken from standard textbooks used for basic education by the Society of Actuaries. The primary reference for all the topics is *Investments* by Bodie, Kane, and Marcus, which is also used by the Association for Investment Management and Research. *The Handbook of Fixed Income Securities* by Fabozzi is another excellent reference and guidebook for practitioners. *Modern Portfolio Theory* by Elton and Gruber gives a more advanced and more technical presentation than the Bodie, Kane, and Marcus text. In contrast to the Fabozzi text, Elton and Gruber focus on the management of equity portfolios. *Corporate Finance* by Brealey and Myers presents the concepts of financial economics in the context of corporate management rather than that of portfolio management; *Behavioral Finance* by Thaler is a collection of key articles on this topic.

Markowitz Portfolio Selection Model

Bodie, Zvi, Kane, Alex, and Marcus, Alan J. Chapters 6 and 7 in *Investments.* 3rd ed. Chicago: Richard D. Irwin, Inc., 1996. Basic

This text is used by AIMR for the CFA exams and by the SOA for Courses 220 and 230. It provides a basic introduction to the topic.

Brealey, Richard A., and Myers, Stuart C. Chapter 8 in *Principles of Corporate Finance.* 4th ed. New York: McGraw-Hill, Inc., 1991. Basic

This text is the industry standard for corporate finance and is typically used for first-year MBA students. It presents the issues in the context of corporate management rather than investment management. The SOA uses this text for Course F-580.

Elton, Edwin J., and Gruber, Martin J. Chapters 1–4 in *Modern Portfolio Theory and Investment Analysis.* 5th ed. New York: Wiley, 1995. Intermediate

This text is used by the SOA for Course V-485. It focuses on management of equity portfolios and gives a more advanced and technical presentation than the other references.

Capital-Asset-Pricing and Other Related Pricing Models

Bodie, Zvi, Kane, Alex, and Marcus, Alan J. Chapters 8-10 in *Investments.* 3rd ed. Chicago: Richard D. Irwin, Inc., 1996. Basic

See comments in previous section.

Brealey, Richard A., and Myers, Stuart C. Chapter 8 in *Principles of Corporate Finance.* 4th ed. New York: McGraw-Hill, Inc., 1991. Basic

See comments in previous section.

Elton, Edwin J., and Gruber, Martin J. Chapters 13–16 in *Modern Portfolio Theory and Investment Analysis.* 5th ed. New York: Wiley, 1995. Intermediate

See comments in previous section.

Derivatives

Bodie, Zvi, Kane, Alex, and Marcus, Alan J. Chapters 19–24 in *Investments.* 3rd ed. Chicago: Richard D. Irwin, Inc., 1996. Basic.

See comments in previous section.

Brealey, Richard A., and Myers, Stuart C. Chapters 20–22 in *Principles of Corporate Finance.* 4th ed. New York: McGraw-Hill, Inc., 1991. Basic

See comments in previous section.

Elton, Edwin J., and Gruber, Martin J. Chapters 22–23 in *Modern Portfolio Theory and Investment Analysis.* 5th ed. New York: Wiley, 1995. Intermediate

See comments in previous section.

Fabozzi, Frank J., ed. Chapters 56–62 in *The Handbook of Fixed Income Securities.* 5th ed. Chicago: Richard D. Irwin, 1997. Basic

See comments in previous section.

Behavioral Finance

DeBondt, Werner F. M., and Thaler, Richard H. "Financial Decision-Making in Markets and Firms: A Behavioral Perspective," *Society of Actuaries Study Note 580-35-96,* 1996. Basic

This article provides a brief review of recent work in the area of behavioral finance. It is used by the SOA as reading for Course F-580.

Dreman, David N. "Exploiting Behavioral Finance: Portfolio Strategy and Construction," *Society of Actuaries Study Note 485-34-96,* 1996. Basic

This article discusses the implications of overconfidence and overreaction for security analysts' and corporate management's estimates of future earnings. It is used by the SOA as reading for Course V-485.

Thaler, Richard H., ed. *Advances in Behavioral Finance.* New York: Russell Sage Foundation, 1993. Intermediate

This text is a collection of key articles discussing major behavioral concepts useful to finance, including overconfidence, overreaction, loss aversion, and fads and fashions.

3. Immunization

Immunization is the act of establishing a position such that the value of the position is insensitive to changes in some specified parameter. The term is most commonly used to describe a liability and a supporting portfolio such that the net (surplus) market value of the position is insensitive (immune) to changes in interest rates, although the term could readily be applied to any business whose profits or values have been protected from changes in the price of an input or output. *Duration* measures the sensitivity of the value of an asset to changes in interest rates, while *convexity* measures the sensitivity of the duration of the instrument to changes in interest rates (otherwise known as the first and second derivatives of a price with respect to interest rates).

Duration and convexity can be measured on either absolute or relative bases. Absolute duration and convexity (the derivatives of total market value) are referred to as *dollar duration* and *dollar convexity.* Relative measures (derivatives of the price "per unit") are what is normally intended by the terms *duration* and *convexity* when encountered alone. Duration can also be viewed as the elasticity of price with respect to interest rates.

Macaulay duration is (minus one times) the percentage change in price divided by the percentage change in the interest rate factor (l + *i*). *Modified duration* is (minus one times) the percentage change in price divided by the absolute change in the interest rate. Defined in this manner, both Macaulay and modified durations are positive for securities with fixed and certain cash flows.

Macaulay and modified durations are sometimes interpreted as applying only to fixed and certain cash flows, although the concepts are useful whenever the price function is differentiable. Some people use the terms *option-adjusted duration* or *effective duration* to clarify that they are explicitly considering that the cash flows generated by a position may in fact depend on interest rates (see, for example, Fabozzi and Fabozzi). This is typically true of callable bonds, options, floating rate notes, and residential mortgages with prepayment provisions. When making this distinction, Macaulay and modified durations can be understood to be partial derivatives. More generally, though, the sensitivity of price to interest rates is an appropriate measure for any security; thus, the reference list includes articles on determining duration for equities.

Duration and convexity concepts become more complicated when certain simplifying assumptions are relaxed. For example, most duration and convexity values are calculated assuming that the yield curve is flat and that all yields move in parallel. An alternative assumption, that different points on the yield curve can change independently, requires a vector or matrix approach to calculation (see, for example, the Reitano papers). If interest rates are assumed to follow a stochastic and arbitrage-free model, then neither of these assumptions is appropriate and more complex approaches are necessary. The optimal approach under these assumptions is an area of current research (see, for example, the papers by Ho and Albrecht).

Once the values of duration and convexity for a given position are determined, immunization can be accomplished more easily by using securities that have large (positive or negative) relative duration and convexity characteristics in relation to their market values. Such securities include futures, forwards, swaps, caps, floors, warrants, and options.

Fixed and Certain Cash Flows

Bierwag, G.O., Kaufman, George G., and Latta, Cynthia M. "Bond Portfolio Immunization: Tests of Maturity, One and Two-Factor Duration Matching Strategies," *The Financial Review* 22, no. 2 (May): 203–219, 1987. Intermediate

Fabozzi, F. J., ed. "Valuation of Risky Securities" and "Bond Immunization: An Asset/Liability Optimization Strategy," Chapters 5 and 48 in *The Handbook of Fixed Income Securities,* 5th ed. Chicago: Irwin, 1997. Basic

The SOA uses this text for Courses 220 and 230 in its examinations.

Ho, Thomas S.Y. "Duration" and "Convexity," Chapters 6 and 7 in *Strategic Fixed Income Investment.* Homewood, IL: Dow Jones-Irwin, 1990. Basic

Platt, R. B., ed. "Use of Duration Analysis for the Control of Interest Rate Risk" (by A. L. Toevs), Chapter 3 in *Controlling Interest Rate Risk: New Techniques and Applications for Money Management.* New York: Wiley, 1986. Intermediate

Sharpe, W. F., and Alexander, G. J. "Bond Portfolio Management," Chapter 14 in *Investments.* 4th ed. Englewood Cliffs, NJ: Prentice-Hall, 1990. Basic

Shiu, Elias S. W. "On Redington's Theory of Immunization," *Insurance: Mathematics and Economics* 9, no. 2/3 (September):171–75, 1990. Intermediate

Interest-Sensitive Cash Flows

Committee on Investment Practice, "Measurement of Exposure to Interest Rate Risk." *Canadian Institute of Actuaries Guidance Notes.* Ottawa, ON: March 1994. Basic

The SOA uses this text for Course F-595 in its examinations.

Fabozzi, F. J., ed. "Valuation of Bonds with Embedded Options," "A Comparison of Methods for Analyzing Mortgage-Backed Securities," and "OAS and Effective Duration," Chapters 36, 37, and 40 in *The Handbook of Fixed Income Securities,* 5th ed. Chicago: Irwin, 1997. Basic

The SOA uses this text for Courses 220 and 230 in its examinations.

Finnerty, John D. "Measuring the Duration of a Floating Rate Bond," *The Journal of Portfolio Management* Summer:67–72, 1989. Intermediate

Fisher, Lawrence, and Weil, Roman L. "Coping with the Risk of Interest Rate Fluctuations: Returns to Bondholders from Naive and Optimal Strategies," *The Journal of Business* 44:408–31. 1971. Intermediate

Fong, H. Gifford, and Vasicek, Oldrich A. "A Risk Minimizing Strategy for Portfolio Immunization," *Journal of Finance* XXXIX, no. 5 (December):1541–46, 1984. Advanced

Griffin, M. W. "A Guide to Buying Convexity," *Society of Actuaries Study Note 595-24-95,* 1995. Intermediate

The SOA uses this reference for Course V-595 in its examinations.

Hiller, R.S., and Schaak, C. "A Classification of Structured Bond Portfolio Modeling Techniques," *Journal of Portfolio Management* (Fall):37–48, 1990. Advanced

The title of this paper is misleading; it is really about immunization and cash-flow matching (deterministic and stochastic). If the reader wants to read only one paper about these two ALM techniques, this is the one.

Jacob, David P., Lord, Graham, and Tilley, James A. "A Generalized Framework for Pricing Contingent Cash Flows," *Society of Actuaries Study Note 480-27-92,* 1992. Intermediate

The SOA uses this reference for Course V-480 in its examinations.

Jacob, David P., Lord, Graham, and Tilley, James A. "Price Duration and Convexity of a Stream of Interest-Sensitive Cash Flows," *Morgan Stanley Fixed Income Analytical Research* (April) 1986. Intermediate

Johnson, Lewis D. "Equity Duration: Another Look," *Financial Analysts Journal* (March-April):73–75, 1989. Advanced

Labuszewski, John W. "Examining Duration, Hedge Ratio, and Basis Risk to Hedge Securities," *Futures* (May):50–61, 1989. Advanced

Leibowitz, Martin L., and Kogelman, Stanley. "Resolving the Equity Paradox," *Society of Actuaries Study Note 485-33-94,* 1994. Advanced

The SOA uses this reference for Course V-485 in its examinations.

Leibowitz, M. L., Sorenson, E. H., Arnott, R. D., and Hanson, N. H. "A Total Differential Approach to Equity Duration," *Financial Analysts Journal* (September-October):30–7, 1989. Advanced

Milgrom, Paul R. "Measuring the Insurance Rate Risk," *Transactions of the Society of Actuaries* XXXVII: 241–302, 1985. Intermediate

Noris, P. D., and Epstein, Sheldon. "Finding the Immunizing Investment for Insurance Liabilities: The Case of the SPDA," *Society of Actuaries Study Note 230-22-91,* 1991. Intermediate

The SOA uses this reference for Course 230 in its examinations.

Platt, R.B., ed. "Hedging Interest Rate Risk of Fixed-Income Securities with Uncertain Lives" (by A. L. Toevs) and "Risk Control Techniques for Life Insurance Companies" (by J. A. Tilley), Chapters 7 and 9 in *Controlling Interest Rate Risk: New Techniques and Applications for Money Management.* New York: Wiley, 1986. Intermediate

Tilley, James A. "The Application of Modern Techniques to the Investment of Insurance and Pension Funds," *Transactions of the 23rd International Congress of Actuaries, Helsinki,* R:301–326, 1988. Intermediate

Hedging with Swaps, Futures and Options

Chew, D. H. "The Arithmetic of Financial Engineering," "The Evolving Market for Swaps," and "Forward Swaps, Swap Options, and the Management of Callable Debt," Chapters V.6, V.9, and V.10 in *The New Corporate Finance: Where Theory Meets Practice.* New York: McGraw-Hill, 1993. Basic, Basic, Advanced

The SOA uses this text for Courses V-480, F-580, F-585, and V-595 in its examinations.

Fabozzi, F. J., ed. "Hedging with Futures and Options," Chapter 60 in *The Handbook of Fixed Income Securities,* 5th ed. Chicago: Irwin, 1997. Intermediate

Fen, A.M. "Interest Rate Futures: An Alternative to Traditional Immunization in the Financial Management of Guaranteed Investment Contracts," *Transactions of the Society of Actuaries* XXXVII: 153–186, 1985. Intermediate

Hull, J. C. "Futures Markets and the Use of Futures for Hedging" and "Forward and Future Prices," Chapters 2 and 3 in *Options, Futures and Other Derivatives.* 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1997. Intermediate

The SOA uses this text for Course V-480 in its examinations.

Platt, R.B., ed. "Hedging with Financial Futures" (by A. L. Toevs and D. P. Jacob), Chapter 4 in *Controlling Interest Rate Risk: New Techniques and Applications for Money Management.* New York: Wiley, 1986. Intermediate

Sharkey, R. J. "Strategies and Tools for Managing Interest Rate Risk," *Society of Actuaries Study Note 595-25-95,* 1995. Intermediate

The SOA uses this reference for Course V-595 in its examinations.

Multivariate Models

Albrecht, P. "A Note on Immunization under a General Stochastic Equilibrium Model of the Term Structure," *Insurance: Mathematics and Economics* 4 (October): 239–44, 1985. Advanced

Ho, Thomas S. Y. "Key Rate Durations: Measures of Interest Rate Risk," *Society of Actuaries Study Note 595-29-95,* 1995. Advanced

The SOA uses this reference for Course V-595 in its examinations.

Ho, Thomas S. Y. "Factorization and Its Application in the Fixed-Income Market," Chapter 15 in *Strategic Fixed-Income Investment.* Homewood, IL: Dow Jones-Irwin, 1990. Advanced

Hull, J. C. "General Approach to Pricing Derivatives," Chapter 13 in *Options, Futures and Other Derivatives.* 3rd ed. Upper Saddle River, NJ: Prentice-Hall, 1993. Intermediate

The SOA uses this text for Course V-480 in its examinations.

Reitano, R. R. "Non-Parallel Yield Curve Shifts and Duration Leverage," *Society of Actuaries Study Note 595-26-95,* 1995. Advanced

The SOA uses this reference for Course V-595 in its examinations.

Reitano, R. R. "Non-Parallel Yield Curve Shifts and Immunization," *Society of Actuaries Study Note 595-27-95,* 1995. Advanced

The SOA uses this reference for Course V-595 in its examinations.

Reitano, R. R. "Non-Parallel Yield Curve Shifts and Spread Leverage," *Society of Actuaries Study Note 480-22-92,* 1992. Advanced

4. Arbitrage-Free Interest Rate Models

The valuation of interest-sensitive assets and liabilities requires an arbitrage-free interest rate model. So far there exists no completely satisfactory arbitrage-free model for the evolution of future interest rates. The most sophisticated is probably the continuous-time model proposed by Heath, Jarrow, and Morton; however, it is highly mathematical and very difficult to implement in practice. The Black-Derman-Toy model, which is a discrete-time binomial model, is a favorite among many practitioners; but while it is easy to program on a computer, it generates unrealistically high interest rates. The method of forward induction provides an efficient way to implement the Black-Derman-Toy model; see Sherris (1994).

Ang, A., and Sherris, M. "Interest Rate Risk Management: Developments in Interest Rate Term Structure Modeling for Risk Management and Valuation of Interest Rate Dependent Cash Flows," *North American Actuarial Journal* 1(2):1–26, 1997.

Discrete-Time Term-Structure Models

Black, F., E. Derman, and W. Toy. "A One-Factor Model of Interest Rates and Its Applications to Treasury Bond Options," *Financial Analysts Journal* (January-February):33–9, 1990. Intermediate

This paper presents the most popular binomial lattice model in use today.

Ho, T. S. Y., and Lee, S. B. "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance* XLI, no. 5 (December): 1011–29, 1986. Intermediate

This is perhaps the most famous paper on binomial lattice term-structure models.

Jamshidian, F. "Forward Induction and Construction of Yield Curve Diffusion Models," *Journal of Fixed Income* 1, no. 1:62–74, 1991. Advanced

Nearly everything that one needs to know about binomial lattice models of interest rates is here; however, it is not easy to read.

Sherris, Michael. "A One-Factor Interest Rate Model and the Valuation of Loans with Prepayment Provisions," *Transactions of the Society of Actuaries* XLVI:251-320, 1994. Intermediate

This paper illustrates Jamshidian's method of forward induction.

Tian, Yisong. "A Reexamination of Lattice Procedures for Interest Rate-Contingent Claims," *Advances in Futures and Options Research* 7:87–111, 1994. Advanced

This paper develops a general framework for the construction of path-independent multinomial lattice approximations to single-state variable diffusion processes.

Survey of Continuous-Time Term-Structure Models

Continuous-time models are much more difficult mathematically; all involve advanced mathematical tools such as stochastic calculus. Below are two elegant surveys.

Back, K. "Yield Curve Models: A Mathematical Review," in *Option Embedded Bonds,* edited by Lederman, J., Klein, R., and Nelkin, I. Chicago: Irwin, 1996. Advanced

Vetzal, Kenneth. "A Survey of Stochastic Continuous Time Models of the Term Structure of Interest Rates," *Insurance: Mathematics and Economics* 14:139–161, 1994. Advanced

Books

Babbel, David F. and Merrill, Craig B. "Valuation of Interest-Sensitive Financial Instruments," *SOA Monograph M-F196-1.* New Hope, PA: Frank J. Fabozzi Associates, 1996. Advanced

The first part is particularly well-written.

Baxter, Martin, and Rennie, Andrew. *Financial Calculus: An Introduction to Derivative Pricing.* New York: Cambridge University Press, 1996. Advanced

The authors try hard to be user-friendly and are willing to give up mathematical rigor; recommended if the reader wants to use only one book.

Campbell, John Y., Lo, Andrew W., and MacKinley, A. Craig. *The Econometrics of Financial Markets.* Princeton, NJ: Princeton University Press, 1997. Advanced

Interest rate models are treated in Chapters 10 and 11. This book has extensive discussions on empirical evidence and statistical techniques.

Duffie, Darrell. *Dynamic Asset Pricing Theory,* 2nd ed. Princeton, NJ: Princeton University Press, 1996. Advanced

Chapter 7 is on term structure models.

Jarrow, R.A. *Modeling Fixed Income Securities and Interest Rate Options.* New York: McGraw Hill, 1996. Advanced

The Heath-Jarrow-Morton model is the most comprehensive interest rate model ever developed. This book is about applying this model to price and hedge fixed-income securities and interest rate options. The author claims that the book is designed so that the material is accessible to MBAs and advanced undergraduates.

Rebonato, Riccardo. *Interest-Rate Option Models: Understanding, Analysing and Using Models for Exotic Interest-Rate Options.* New York: Wiley, 1996. Advanced

5. The Efficient Frontier and Asset Allocation

In 1952 Harry Markowitz published a revolutionary article called "Portfolio Selection" in the *Journal of Finance.* This paper proposed that the investor should take into account the impact of a risky security on not only a portfolio's expected return but also its variability of return. He suggested that a primary function of portfolio management is to identify an asset allocation strategy that provides the highest expected (mean) return for a given level of risk that is acceptable to the investor or, alternatively, that provides the lowest level of risk (variance) for a specified level of expected return. Markowitz's paper introduced the concept of the "efficient frontier," which represents the entire set of optimal mixes of risky assets for each level of risk. All rational, risk-averse investors will want to select a strategy that is on the efficient frontier. The actual strategy selected will reflect the investor's risk tolerance.

This approach allows the portfolio manager to evaluate risk-versus-reward tradeoffs of alternative asset allocations. It can also be used to assemble portfolios of asset classes or individual securities that take advantage of the benefits of diversification when asset class returns do not exhibit perfect correlation. The efficient frontier approach can be used in an asset-liability framework if the risk and return measures are changed to reflect the joint effect of assets and liabilities on financial results. For example, an insurance company may want to select an asset allocation strategy that maximizes the expected ending surplus for a given level of risk or that minimizes the probability of not meeting its profit objectives.

The efficient frontier approach is not limited in its usefulness to asset allocation applications. Indeed, it can be used to evaluate risk-versus-reward tradeoffs for any asset-liability management decision, such as testing alternative crediting strategies or product designs.

General

Bodie, Zvi, Kane, Alex, and Marcus, Alan J. "Risk and Risk Aversion," "Capital Allocation between the Risky Asset and the Risk-Free Asset," and "Optimal Risky Portfolios," Chapters 5, 6, and 7 in *Investments.* 3rd ed. Chicago: Richard D. Irwin, Inc., 1996. Basic

The SOA uses this text for Course 220. Also covered in section on "Basics in Financial Economics." The authors cover the key concepts underlying portfolio theory, including risk aversion, risk-free versus risky assets, risk-return trade-offs, diversification, and the efficient frontier.

Elton, Edwin J., and Gruber, Martin J. "Delineating Efficient Portfolios," "Techniques for Calculating the Efficient Frontier," and "Simple Techniques for Determining the Efficient Frontier," Chapters 5, 6, and 9 in *Modern Portfolio Theory and Investment Analysis.* 5th ed. New York: Wiley, 1995. Intermediate

Also covered in section on "Basics in Financial Economics" (except Chapter 7).

Arnott, Robert D., and Fabozzi, Frank J., ed. "Asset Allocation Optimization Models," in *Asset Allocation: A Handbook of Portfolio Policies, Strategies and Tactics.* Chicago: Probus Publishing Co., 1988.

Fong, H. Gifford. "Utilizing Concepts of Modern Portfolio Management in an Asset/Liability Management Context," Speech at ICFA *Managing Asset/Liability Portfolios* Continuing Education seminar. Taken from paper, "Fixed-Income Volatility Management," by Fong, H. G., and Vasicek, O. A., *Journal of Portfolio Management* (Spring) 1991. Advanced

This somewhat technical article covers the extension of efficient frontier concepts to an asset-liability framework. The proposed approach starts by characterizing both assets and liabilities in terms of cash flows and risk factors and then using the relationships between the risk factors to create a mean-variance-covariance matrix for returns on assets and liabilities. Finally, these inputs are used to determine optimal asset-liability strategies.

Kritzman, Mark. "Strategic Asset Allocation," "Strategic Asset Allocation with Liabilities," and "Estimation Issues in Asset Allocation," Chapters 1, 5, and 8 in *Asset Allocation for Institutional Portfolios.* Homewood, IL: Business One Irwin, 1990. Basic

This text provides a very readable introduction to the subject of the efficient frontier asset allocation technique.

Lummer, Scott L., Riepe, Mark, and Siegel, Laurence B. "Taming Your Optimizer: A Guide Through the Pitfalls of Mean-Variance Optimization," in *Global Asset Allocation: Techniques for Optimizing Portfolio Management.* Lederman, Jess, and Klein, Robert, ed. New York: Wiley, 1994. Basic

Available on the Internet at Ibbotson Associates Worldwide Web site: http://www.ibbotson.com/Research/asset.htm. This article gives a good overview of the process of mean-variance optimization in an asset-only framework. It points out the limitations of the process and describes an approach to developing the required inputs.

Property/Casualty

Almagro, Manuel, and Sonlin, Stephen. "An Approach to Evaluating Asset Allocation Strategies for Property/Casualty Insurance Companies," in *Incorporating Risk Factors in Dynamic Financial Analysis.* Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press, 1995. Basic

> This paper presents a basic introduction to the asset-liability efficient frontier approach for determining optimal investment strategies from the perspective of a property/casualty company. The method considers the interaction of the underwriting and investment operations and their joint impact on financial risk. This same technique can be used to evaluate other business strategies, such as business mix and reinsurance decisions, in a consistent framework.

Weinberger, Alfred. "Allocation Techniques for an Asset/Liability Portfolio" in *Managing Asset/Liability Portfolios.* Speech at ICFA Continuing Education seminar. Taken from paper, "Asset Allocation for Property/Casualty Companies: A Going-Concern Approach" by Alfred Weinberger and Vincent Kaminski. New York: Salomon Brothers, July 1991. Intermediate

> The author demonstrates the application of efficient frontier analysis to a property-casualty company. The model described in the paper seeks to optimize the return on economic surplus while taking into account both asset and liability uncertainty, accounting and regulatory constraints, and taxes. A case study is presented.

Pensions

Burk, James E. "Determining the Portfolio Mix," Chapter 11 in *Pension Plan Management Manual: Administration and Investment.* Boston: Warren, Gorham & Lamont, 1987. Basic

> Exam P-363 study note. This nontechnical article provides a good overview of the key concepts of asset allocation and diversification.

Liebowitz, Martin L., Bader, Lawrence N., and Kogelman, Stanley. *Return Targets and Shortfall Risk: Studies in Strategic Asset Allocation.* Chicago: Irwin, 1996. Intermediate

> This book provides a comprehensive discussion of the process of asset-liability management and performance measurement for pension plans under the efficient frontier framework, incorporating various research pieces previously published by Salomon Brothers. Note: Several chapters are or have been study notes on P-363 and F-595.

6. Derivatives

ALM is a decision-making process, and the use of derivatives is an integral part of this process. To understand the general functionality of derivatives and how they can be used in ALM is very important. As a basic requirement, the ALM personnel should at minimum be equipped with fundamental knowledge of the functionality of derivatives, the principles of derivatives pricing, and the application of derivatives in ALM.

General Functionality

Derivatives are a very powerful tool in ALM. They can be used to hedge asymmetric risks using options, such as calls and puts on underlying instruments, and interest rate contracts such as caps and floors. The power of applying options and interest rate contracts comes from their asymmetric payout pattern. For example, a call option gives the buyer the right, but not the obligation, to purchase the underlying cash instrument at a fixed price at a predetermined future time. If the price of the underlying instrument goes up, the call option holder can buy the instrument at a cheaper level and, therefore, realize gains on the instrument. If the market sells off, the holder will let the option expire worthless. The same principle applies to interest rate floor contracts: when interest rates drop below the reference rate, the contract holder will receive cash from the seller; when interest rates go up, the contract holder has no obligation to pay the seller. The asymmetric payout pattern is therefore very desirable and can hedge risks embedded in the liabilities, such as the minimum guarantee on a fixed annuity.

Another application of derivatives is to adjust or hedge market exposure using bond futures, which allow the user to participate in market movement without committing large amounts of asset. This property makes bond futures very useful in hedging the timing of cash flows.

For example, suppose that an insurance company is selling interest-rate-sensitive products. A client has committed *x* millions of dollars to this product, say SPDA. The product is priced based on today's market interest rate, but the money will come in sometime in the next two months. If the insurance company does not invest the money today, it will be subject to the risk of market movement. If the insurance company buys cash instruments (bonds), it will need cash by the time the bonds are delivered, while the timing of the cash inflow from the policyholder is uncertain. Using futures contracts will solve the timing problem because of the following properties of a futures contract:

1. The futures contract allows the investor to participate in the market movement (long position in the market) without committing a lot of cash up-front. Only a margin account, which is a small percentage of the notional amount of the contract, is required.
2. The futures market is standard and liquid. The investor can tailor his futures portfolio to match his duration target with minimum transaction cost.
3. There is no timing constraint. The investor can buy, sell, and roll the futures contracts at any time. When cash comes from the liability side, the investor can liquidate an equivalent amount of futures contracts and invest in cash instruments.

Interest rate swaps represent another means of managing a portfolio using derivatives. They can be used for asset-liability duration management or cash-flow matching. By overlaying a swap, a portfolio manager can purchase attractive assets regardless of duration and can achieve his/her goal in portfolio management without incurring unnecessary transaction costs. For example, if the asset portfolio supporting a certain liability portfolio has a longer duration than that of the liability, the portfolio manager can sell longer-duration instruments and buy shorter-duration instruments. However, this will result in high transaction costs and may also incur capital gains, which could be taxable. The transaction cost can be avoided by entering into a swap to pay fixed-rate interest and receive floating-rate interest. This will shorten the duration of the asset portfolio. Swaps can also be used for cash-flow matching when a fixed-rate asset portfolio is used to support floating-rate liabilities, or when a floating-rate asset portfolio is used to support fixed-rate liabilities.

Derivatives Pricing

We intend this section not only to help the actuary understand the pricing models and algorithms themselves, although that is very important, but also to apply the same logic to product design, which may be the most crucial point of ALM. To remain competitive in the marketplace, almost all insurance companies offer embedded options in their products. Employing well-thought-out and reasonably priced embedded options will reduce the majority of unhedgible risk in the future. Readings for this section include some easy but fundamental articles, which are meant to introduce the basic logic of derivatives pricing. Some advanced pricing models are also included for pricing actuaries and others inter-ested in this topic. Note that many references overlap between this section and the stochastic modeling section. Even though the references here all address derivatives pricing, their logic and methodologies can be used to price the embedded options in liabilities to a certain accuracy based on reasonable assumptions.

Derivatives Application in ALM

This is the core of this section and has the fewest references. Because of the complexity of liability products, there is no standard way of hedging risks in the ALM process. Given the flexibility of derivatives, there are many ways to hedge the same risk, such as call options on bonds, swaps, swaptions (an option to enter a swap with a given counterpart), interest rate floor contracts to hedge the minimum guarantees of an SPDA, or put options or interest rate caps to hedge the surrender risk of SPDAs. It is the responsibility of people who understand both the embedded options in the products and the use of derivatives to decide how derivatives should be used in the ALM process. We have tried to list as many references as possible for this section; some may overlap with the immunization and stochastic modeling sections.

General Functionality

Cox, John C., and Rubinstein, Mark. *Options Markets.* Englewood Cliffs, NJ: Prentice-Hall, 1985. Advanced

The major graduate school textbook on options pricing in the latter half of the 1980s.

Dattatreya, Ravi E., Venkatesh, Raj E.S., and Venkatesh, Vijaya E. *Interest Rate and Currency Swaps: The Markets, Products and Applications.* Chicago: Probus, 1994. Basic

This text gives a broad overview of the swap market. It is very easy to read and suitable for beginners.

Derivatives Week, "Learning Curve." Intermediate

This section, called "Learning Curve," introduces one derivatives structure each week. *Derivatives Week* has also published a book collecting all "Learning Curves'" published to date.

Derman, Emanuel, and Kani, Iraj. "The Ins and Outs of Barrier Options," *Quantitative Strategies Research Notes.* New York: Goldman Sachs, June 1993. Advanced

This research publication summarizes almost all barrier options to date. It uses graphical illustration to help demonstrate the value change and payoff pattern.

Fabozzi, Frank J., ed. Part 7 in *The Handbook of Fixed Income Securities.* 5th ed. Chicago: Irwin, 1997. Basic

Part 7, which gives an overview of all derivatives, overlaps significantly with John Hull's *Options, Futures and Other Derivative Securities* but has a very different approach in style. This book uses only broadly descriptive definitions and examples. It suits those who only want to have a general knowledge about derivatives, while John Hull's book allows readers to dig deeper into the logic and algorithms.

Global Derivatives Study Group. *Derivatives: Practice and Principles.* Washington, DC: The Group of Thirty, July 1993 *(Society of Actuaries Study Note 480-31-94).* Basic

Very good introductory material: simple, general, easy to read, and accompanied with real examples. The first part of the publication is also very useful for legal and accounting purposes. The second half (from page 26) gives clear, descriptive definitions of various derivatives contracts and their functionality. It is suitable for all readers. The SOA uses this reference for Course V-480 in its examinations.

Derivatives Pricing

Amin, Kaushik. "Jump Diffusion Option Valuation in Discrete Time," *The Journal of Finance* XLVIII, no. 5 (December):1833–63, 1993. Advanced

This paper provides an alternative method of option pricing by incorporating jumps in option valuation. The markets do occasionally crash, but those who are worried can have the peace of mind that someone is addressing the issue.

Black, Fischer, Derman, Emanuel, and Toy, William. "A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options," *Financial Analysts Journal* (January-February):33–9, 1990. Intermediate

The BDT model introduced in this paper is widely used in the financial industry. It uses the yields on zero-coupon Treasury bonds' yields (yield curve) and yield volatilities (volatility curve) as inputs to generate a binomial interest rate term structure. It is one of the best models for its accuracy and easy to use.

Black, Fischer, and Scholes, Myron. "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* (May-June):637-54, 1973. Advanced

This is the most important and fundamental paper on options pricing. Criticism of its assumptions should not make this paper less meaningful.

Gerber, Hans U., and Shiu, Elias S. W. "Option Pricing by Esscher Transforms," *Transactions of the Society of Actuaries* XLVI:99–140, 1994. Advanced

The paper shows that a classical actuarial technique, the Esscher transform, is an effective tool for pricing options and other derivative securities.

Gerber, Hans U., and Shiu, Elias S.W. "Actuarial Bridges to Dynamic Hedging and Option Pricing," *Insurance: Mathematics and Economics* 18:183–218, 1996. Advanced

This paper presents modern option-pricing theory in the framework of actuarial risk theory.

Heath, David, Jarrow, Robert, and Morton, Andrew. "Bond Pricing and the Term Structure of Interest Rates: A Discrete Time Approach," *Journal of Financial and Quantitative Analysis* 25, no. 4 (December): 419–500, 1990. Advanced

> This paper presents the well-known HJM model, which is theoretically complete but hard to implement. This article takes time for complete reading and is recommended only for those who are very strong in mathematics and statistics and are very interested in interest rate term structure and derivative pricing.

Ho, Thomas S.Y., and Lee, Sang-Bin. "Term Structure Movements and Pricing Interest Rate Contingent Claims," *The Journal of Finance* XLI, no. 5 (December): 1011–29, 1986. Intermediate

> This paper, which developed the framework for pricing contingent claims, introduces a methodology for constructing subsequent term structures from a given term structure. This is the basic framework used by GAT's original software (with improvement) and the linear path space (LPS).

Hull, John. *Options, Futures and Other Derivative Securities.* 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1993. Basic/Intermediate

> This book offers a complete package of derivatives from descriptive definitions and payoff patterns to pricing algorithms. This includes exotic options and more up-to-date pricing models. The first few sections of each chapter give a very good introduction of the functionality and payoff pattern for beginners, and the rest suit those who want to learn more and maybe do some hands-on programming.

Hull, John, and White, Alan. "The Pricing of Options on Interest Rate Caps and Floors Using Hull-White Model," in *Advanced Strategies in Risk Management,* Schwartz, Robert J., and Smith, Clifford W., ed. Englewood Cliffs, NJ: New York Institute of Finance, 1993. Intermediate

> This article gives formulas to price simple interest rate derivatives.

Hull, John, and White, Alan. "One-Factor Interest Models and the Valuation of Interest-Rate Derivative Securities," *Journal of Financial and Quantitative Analysis* 28, no. 2 (June):235–54, 1993. Intermediate

> This informative and insightful paper compares different approaches to developing arbitrage-free models of the term structure. It leads the reader through the model-fitting process and is a very good paper for those who want to learn more on hands-on derivatives pricing.

Application

Global Derivatives Study Group. *Derivatives: Practice and Principles.* Washington, DC: The Group of Thirty, July 1993 *(Society of Actuaries Study Note 480-31-94).* Basic

> Very good introductory material: simple, general, easy to read, and accompanied with real examples. The first part of the publication is also very useful for legal and accounting purposes. The second half (from page 26) gives clear, descriptive definitions of various derivatives contracts and their functionality. It is suitable for all readers. The SOA uses this reference for Course V-480 in its examinations.

"Derivative Strategies for Managing Portfolio Risk," Continuing Education Publication. Charlottesville, VA: Association for Investment Management and Research, ICFA, 1993. Basic

Recommended Journals

ASTIN Bulletin
Finance and Stochastics
Insurance: Mathematics and Economics
Journal of Financial Economics
Journal of Finance and Quantitative Analysis
Mathematical Finance
North American Actuarial Journal
The Journal of Fixed Income
The Review of Financial Studies
The Journal of Finance
The Journal of Portfolio Management
The Journal of Derivatives

7. Bank ALM and Value at Risk (VAR)

What Is VAR?

VAR measures in dollars the risk of a portfolio. In order to attach a quantifiable number to VAR, a more precise definition of risk is needed. Some examples follow:

1. In the next week (time t), with 95% confidence (x% of confidence, or significant level of α), what is the maximum amount of money by which the value of the portfolio (VAR) may decline (5-day VAR with 95% confidence, or 5% VAR)?
2. In a period of 10 days, portfolio value may not decline by $X (VAR) or more for more than 1 out of 100 times (X is the 10-day VAR with 99% confidence, or 1% VAR).
3. The Lehman ABC benchmark is used to measure performance. If performance is reviewed quarterly (today is the first day of the quarter, say) with 99.5% (x%) confidence, what will be my worst performance in dollars relative to the benchmark (3-month 99.5% VAR relative to the ABC benchmark)?
4. VAR = min (x, P((loss >= x)<α)), where α is the significant level, or 100* (1 - α) is the degree of confidence, and loss can be either absolute or benchmark relative.

Factors Affecting the Calculation of VAR

The value of VAR depends on the average return of the portfolio, the return volatilities of the securities, the correlation of the returns of assets in the portfolio, the time horizon, the assumption of the underlying (joint) distribution of the returns, and the confidence level. If VAR is benchmark-relative, then the VAR can be calculated as portfolio net of the benchmark. In that case, the choice of the benchmark also affects VAR.

Who Uses VAR and How To Use It

VAR measures and controls risk and is primarily used by the big security firms and investment banks that hold significant positions, especially derivatives. For a portfolio of bullet bonds, VAR can to some degree be replaced by dollar duration. However, for a derivatives portfolio with complex structures and offsetting positions, understanding risk becomes very challenging. In this case, VAR becomes very handy as a risk measure: a trader can be instructed to "limit portfolio exposure to a VAR of $X with confidence level of yy%." SEC released a new Market Risk Disclosure Rule to include a disclosure of 5% VAR (VAR with 95% confidence) for the reporting period.

Money managers, especially fixed-income money managers, will find it more meaningful to use a VAR relative to a benchmark. The methodology used to compute VAR should also be disclosed.

How Much Information Does VAR Contain?

VAR tells us only that a portfolio manager or a firm may lose no more than a certain amount with a certain confidence level; it does not give us the whole picture of loss distribution, nor does it tell us the potential return that should be expected by a portfolio manager or firm. Two portfolios can have the same VAR but very different return profiles. Therefore, for risk-reward analysis, VAR is not sufficient.

Time Horizon

The time horizon is a very important factor in calculating VAR and determining its validity. For security firms and banks, due to the liquidity concern and daily mark-to-market, a daily VAR is a valid measure of risk with a given confidence level. For firms with less interest-rate-sensitive liability or with nonfinancial investment cash flow, a time horizon matching their accounting period (monthly/quarterly) would be adequate.

Return Distribution

Return distribution is the most often-addressed problem. Normal distribution is most commonly used because of its simplicity but can only roughly describe the return pattern of most securities. For portfolios with embedded or stand-alone options, a normal distribution will fail to capture the asymmetric return behavior. In this case, nonparametric methods can be used for VAR calculation. The nonparametric method uses historic return patterns (of histograms) of given time intervals (for example, daily, monthly, and so on) as the distribution of the underlying security and calculates the x-percentile as the x% VAR for the given observation interval. Various time intervals can be used for different VAR time horizons. How long a history needs to be used for VAR purposes is user-dependent and has always been a point of discussion.

VAR Calculation

There are many ways of calculating VAR, but all can be classified into two categories: parametric and nonparametric. In the parametric category, the commonly used methods are closed-form formulas for simple situations, mostly univariate return distribution, and simulation using the parametric distribution, mostly for either complex securities or for multivariate return distributions (for example, for an international fixed-income portfolio with given covariance matrix and underlying distribution).

In the nonparametric category, the most commonly used methods are ranking in order the historical returns and historical simulation (by resampling). A new approach in the nonparametric area is to fit the histogram of return locally, then smooth the resulting distribution curve. For SEC and other regulatory agencies and for rating agencies, all methods with sufficient disclosure about methodology and assumptions are currently acceptable.

Volatility and Correlation Estimation

The parametric method raises two issues regarding estimation of the volatility and correlation matrix, or variance-covariance matrix. One issue is how long a time series of return history to use: too short a time series will result in a trend-dependent result, while too long a series may fail to capture the "change of regime," including market conditions and policy changes. The second issue is whether to weight the observations equally or with time decay. JP Morgan uses an exponential-decay-weighted average of 100 days as the estimate of daily volatility, and a similar figure for correlation. Trying to estimate a longer-horizon volatility, say, monthly return volatility, becomes problematic. One hundred monthly return volatilities of nonoverlapping monthly intervals will require 8.3 years of data. Regime change, lack of data (in the case of emerging markets), global consolidation (in the case of global investment), consumer sophistication, and market structure (MBS prepayment and CMO production) are examples of markets where both volatility and correlation may change over time. The investment bankers and security firms are content to use 100 observations of daily return volatility and correlation with time decay to estimate daily volatility. There is very little if any published research on volatility estimation for returns of longer observation-time intervals.

Conclusion

VAR is becoming a very important concept and risk measurement tool for investors and corporations. Corporate risk management departments, investors, and regulators have gradually recognized its importance and require more and more timely information on VAR. SOA members should at least be aware of the issues related to VAR and may contribute some research on this front.

Value at Risk

Jorion, Philippe. *Value at Risk: The New Benchmark for Controlling Market Risk.* New York: McGraw-Hill, 1997.

JP Morgan Internet Home Page on RiskMetrics and VAR, http://www.JPMorgan.com.

Conference transcript of "Practical Implementation of Value-at-Risk to Quantify Risk," sponsored by the Institute for International Research, January 28, 1997.

ALM Banking

Comptrollers Handbook. *Interest Rate Risk: Liquidity and Funds Management.* Washington, DC: Comptroller of the Currency/Administrator of National Banks, June 1997.

8. Corporate ALM

How does a financial institution set up ALM capability, and what ground rules need to be established for existing ALM programs? This section focuses on these aspects of "corporate ALM."

The establishment of ALM capability involves many important decisions that need to be made at an early stage and that will have a long-lasting impact on the institution's financial management. It is becoming increasingly common for not just pension funds but also insurance companies to create special ALM committees or working parties to regularly make important ALM decisions. Decisions that need to be made on establishing such a committee include:

- How to set up the committee
- Who should be on the committee
- The responsibilities of the committee
- What structure needs to be in place to implement the committee's decisions.

A recent Society of Actuaries survey (see *Risks and Rewards,* July 1996) found that, although 23% of respondents indicated that a single individual was responsible for ALM at their institution, 37% indicated that their institutions already had an ALM committee that made ALM decisions. The survey also indicated that the actuarial and investment teams met regularly to discuss ALM issues. Clearly, the concept of an ALM committee or working party is gaining momentum.

Once a committee is in place, what should its ground rules be? The considerations that need to be addressed when looking at ALM on a corporation-wide level include:

- Corporate governance
- Trading rules (for example, no more than 5% of funds to be held in international investments)
- Rules for derivatives trading and bookkeeping
- Procedures for the reporting of ALM decisions and results across the corporation.

The literature on corporate ALM is in a developmental stage, so at this point we are publishing a very limited list of references. However, we expect to see the literature on this increasingly important subject expand in years to come, and we anticipate developing a broader list of references for future versions of this guide.

"An Overview of an Investment Policy Statement in an Asset/Liability Management Context," *Society of Actuaries Study Note 230-30-97,* 1997. Basic

The SOA uses this reference for Course 230 in its examinations.

"Finance Aspects of Corporate Governance," *Society of Actuaries Study Note 585-22-94,* 1994. Basic

Global Derivatives Study Group, *Derivatives: Practice and Principles.* Washington, DC: The Group of Thirty, July 1993 *(Society of Actuaries Study Note 480-31-94).* Basic

Very good introductory material: simple, general, easy to read, and accompanied with real examples. The first part of the publication is also very useful for legal and accounting purposes. The second half (from page 26) gives clear, descriptive definitions of various derivatives contracts and their functionality. It is suitable for all readers. The SOA uses this reference for Course V-480 in its examinations.

9. Performance Measurement and Benchmarking

Investment performance measurement has always been a critical element of pension fund financial management. Now, however, it is becoming increasingly important, as senior management personnel of insurance companies recognize that assessing their fund managers simply on the basis of money- or time-weighted returns on assets wholly compared to the return on a market index and regardless of underlying liabilities does not provide a fair assessment and is probably not the best foundation for deciding how best to manage the insurance company's assets.

Investment performance can be measured in three ways:

- Performance relative to the market in general
- Performance relative to other fund managers regardless of the funds for which they are responsible
- Performance relative to other institutions with similar liability profiles.

Measuring performance relative to the market in general or against competitor fund managers is the traditional analysis, in which the money- or time-weighted return on an institution's portfolio is compared with the corresponding return on a popular market index such as the S&P 500 Industrials. AIMR's *Performance Presentation Standards,* which is required reading for the CFA examinations, offers a good description of how to perform such calculations.

Analyzing performance relative to other institutions with the same liability profile involves measuring performance using asset-liability benchmark analysis. The objective is to compare returns on the actual asset portfolio against a notional portfolio that has generally the same expected cash-flow characteristics as the underlying liabilities. If the notional portfolio is chosen so that it best immunizes the liabilities, then it represents the assets that might be held by competitive insurance companies offering the same type of product or by pension funds with a similar liability profile (if they are taking little or no risk in their investment strategy).

The published work on performance measurement using asset-liability benchmark analysis is only just beginning to emerge, and the ideas are still in their primitive stages. Therefore, the references given below should be regarded only as an introduction to what is in practice becoming an increasingly complex area.

Dietz, Peter O., and Kirschman, Jeannette R. "Evaluating Portfolio Performance," Chapter 14 in *Managing Investment Portfolios,* Maginn, John L. and Tuttle, Donald L., ed. 2nd ed. Boston: Warren, Gorham and Lamont, 1991. Intermediate

The SOA uses this text for Course V-485 in its examinations.

Performance Presentation Standards. Charlottesville, VA: AIMR, 1993. Basic

Required reading for the CFA examinations.

Reilly, Frank K., and Leahigh, David J., ed. "Evaluation of Portfolio Performance," Chapter 26 in *Investment Analysis and Portfolio Management.* 4th ed. Orlando, FL: Dryden Press, 1993. Intermediate

This provides a good introduction to some important concepts, including the notion of risk-adjusted performance and customized benchmarks.

10. ALM in Product Development

Actuarial Standard of Practice (ASOP) No.14, "When To Do Cash Flow Testing for Life and Health Insurance Companies," mentions "product design and pricing studies" and "testing of policyholder dividend scales and future nonguaranteed elements" as areas for which cash-flow testing should be considered. This standard was issued in 1990, by which time many companies had recognized the importance of using ALM techniques in the ongoing monitoring of product portfolios and in product pricing.

Although ALM techniques have been used in product pricing for several years, there is not a great deal of literature available. The list below attempts to provide a reference guide to pricing using ALM techniques.

The rapidly increasing sales of variable products with guaranteed minimum death benefits and, more recently, guaranteed minimum income benefits, has heightened the need for ALM in pricing. The application of ALM is also an integral part of pricing equity-indexed products, the latest innovation of the life insurance industry. Undoubtedly, there will be more published references on the application of ALM in product pricing in the future, and the following list will need to be expanded.

Griffin, Mark. "The Excess Spread Approach to Pricing and Valuing SPDA," *Transactions of the Society of Actuaries* XLII:231, 1990.

Griffin, Mark. "Determining Interest Crediting Strategy Using the Excess Spread Approach," *Product Development News* (December):12–15, 1990.

Griffin, Mark. "A Market-Value Accounting Framework for Insurance Companies," *The Financial Reporter* no. 15 (March):1–2, 1992.

Hughes, Michael, Nelson, Robert A., Gathje, Steven M., and Davis, Mark A. "Asset Liability Techniques for Product Design and Management," SOA Product Development Seminar, Reno, Nevada, September 4, 1996.

"Equity Indexed Annuities—New Territory on the Efficient Frontier," *Society of Actuaries Study Note 441-99-96,* 1996.

The SOA uses this reference for Course I-441U in its examinations.

11. Market Value of Insurance Liabilities

The actuarial and accounting professions have debated the relative merits of various methods for estimating the market value of insurance liabilities. This discussion has been driven by a desire to move toward market-value accounting or to provide additional financial disclosures to the insurance company's constituents on the interest-rate sensitivity of the shareholders equity. To date, no single method has emerged as a preferred approach. The following papers discuss some of the proposed methodologies and describe key issues to be considered.

Asay, Michael R., Bouyoucos, Peter J., and Marciano, Anthony M. "An Economic Approach to Valuation of Single Premium Deferred Annuities," *Financial Institutions Research.* New York: Goldman Sachs, April 1989. Intermediate

This paper provides a case study that describes the option-pricing approach to estimating the market value, option-adjusted duration, and convexity of an SPDA liability that exhibits various embedded options.

Becker, David N., "The Objective (Function) of Asset/Liability Management," *Risks and Rewards,* January 1998.

Vanderhoof, Irwin T., and Altman, Edward I. *The Fair Value of Insurance Liabilities.* Boston: Kluwer Academic Publishers, 1998.

This two-volume package contains several papers that were presented on Dec. 7–8, 1995 at a conference held at the New York University Stern School of Business, including:

1. "A Market Value Accounting Framework for Insurance Companies" by Mark Griffin.
2. "The Value of the Firm: The Option Adjusted Value of Distributable Earnings" by David N. Becker.
3. "The Derivation and Application of Accounting Standards to the Market Value of Liabilities" by Christopher D. O'Brien.
4. "Indexed Discount Rate Method" by S. Michael McLaughlin.
5. "Is Paul vs. Virginia Dead?" by Krzysztof M. Ostaszewski.
6. "Fair Valuation of Life Insurance Company Liabilities" by members of the American Academy of Actuaries Fair Valuation of Liabilities Task Force.
7. "Allowing for Asset, Liability and Business Risk in the Valuation of a Life Company" by Shyam Mehta.

Reitano, Robert R. "Two Paradigms for the Market Value of Liabilities," *North American Actuarial Journal* 1, no. 4 (October):104–134, 1997. Intermediate

Dr. Reitano describes and compares two alternative frameworks for estimating the market value of insurance liabilities: the "direct" approach, which discounts liability cash flows, and the "indirect" approach, which computes this value by subtracting the market value of distributable earnings from the market value of assets.

"Finding the Immunizing Investment for Insurance Liabilities: The Case of the SPDA," *Society of Actuaries Study Note 220-22-91,* 1991. Intermediate

The SOA uses this reference for Course 220 in its examinations. This study note describes some key principles related to estimating the market value and duration of an interest-sensitive SPDA liability. A good case study is presented where the approach is used to develop an investment strategy that immunizes the profitability of the SPDA.

Zenios, Stavros A., ed. Part II.5 in *Financial Optimization.* New York: Cambridge University Press, 1993.

12. Property and Casualty Insurance

Background

The investments and finance background that actuaries need for ALM analyses is largely the same for property-casualty insurance as for life insurance, with two exceptions: stock durations and options pricing.

Stock Durations

Property-casualty (P/C) companies have more common stocks in their investment portfolios (on average) than life companies. Duration measures for common stocks, and the relationships of stock values to changes in interest and inflation rates, are more important for P/C companies than for life companies.

In the early 1980s, many analysts assumed that common stocks had a long duration. Estimates of 20 to 25 years were often used, with dividends being treated as interest payments on a perpetual bond (that is, the Macaulay duration was estimated at $1/d$, where d equals the common stock dividend rate). These estimates erred in that they treated common stocks as fixed-income perpetuities, ignoring the effects of inflation and interest rate changes on the expected dividend yields.

Leibowitz et al. (n.d.) discuss the measurement of duration for common stocks and arrive at a significantly lower figure.

The inverse correlation of the market values of fixed-income securities with interest rate changes underlies duration and immunization analyses. For common stocks, there is no obvious relationship between market values and interest rate changes or inflation changes. In theory, there should be a zero correlation between market value changes and interest rate changes, or a positive correlation between nominal value changes and interest rate changes. This is the meaning of the assertion that "stocks are a hedge against inflation."

Fama and Schwert (1977) examine the empirical relationships between various asset returns and both expected and unexpected inflation, and find that stock returns have a negative correlation with inflationary changes. Subsequent studies repeated their findings for other periods and other countries, though with differences in the magnitude of the correlation, and with different explanations for the empirical findings.

Actuaries doing ALM analyses for P/C companies must take into account the effects of inflation and interest rate changes on the values on common stocks as well as their effects on the market values of bonds and other fixed income securities. The papers by Leibowitz et al. and by Fama and Schwert are essential components of such analyses.

Options Pricing

The fundamentals of corporate finance, such as the CAPM and APT, are used equally by life and casualty actuaries for ALM analyses. In addition, options-pricing methods are being increasingly used by casualty actuaries for the quantification of risk. Since ALM analyses deal with a trade-off of risk and return, particularly for P/C companies, the yardstick for measuring risk is an essential component of such analyses. Options pricing probably has more applications in life insurance contract pricing than in P/C insurance contract pricing, because policyholder options are prevalent in the life industry but not in the P/C industry; however, expected policyholder deficit (EPD) analyses are rarely used by life actuaries.

European actuaries generally use a probability of ruin analysis for quantifying risk; see, for instance, the Daykin, Pentikainen, and Pesonen textbook discussed below. U.S. casualty actuaries are now turning to EPD analyses, following Butsic (1995). The EPD analysis calculates the expected loss to policyholders/claimants per anticipated dollar of benefit payment.

Butsic demonstrates the equivalence of the EPD to the cost of a simulated option purchased by the insurer's stockholders, following a similar analysis by Cummins for determining the fair risk-based guarantee fund premium (the Cummins paper is not directly applicable to ALM). The paper by Butsic is abstract; a full illustration of insurance company financial simulation using an EPD solvency yardstick may be found in Hodes, Feldblum and Blumsohn (1996).

The coverage of options pricing in the Brealey and Myers textbook is difficult for most readers (see references for "Basics in Financial Economics Relevant to ALM"). The treatments in Black and Scholes (1973) and in Cox and Rubenstein (1985) are considerably more difficult. One of the clearest texts on options pricing is Hull (1995). (Note: Hull is the textbook of choice for options pricing, both for life and P/C actuaries.)

D'Arcy and Doherty (1988) presents the major topics in modern portfolio theory, such as CAPM, APT, and options pricing theory, as they apply to the pricing of property-liability insurance contracts.

Duration, Immunization, and P/C Reserves

For fixed-income assets and fixed-liability payments, immunization analyses and investment strategy for P/C companies parallel those for life insurance companies; see Ferguson (1983) and Noris (1985) for introductory treatments. However, P/C loss reserves present three types of complications not found in traditional life insurance reserves:

- P/C reserves are inflation-sensitive. The ultimate benefit payment varies with inflation between the date of accident and the date of loss settlement, thereby reducing the effective duration of these liabilities. See Butsic (1981) on inflation sensitivity of reserves; see D'Arcy (1984) on the implications for duration measurement.
- P/C reserves generally have short durations, particularly if the inflation sensitivity of these liabilities is taken into account. Holding a "duration-matched" investment portfolio necessitates a reduction in investment yield; see Feldblum (1989).
- The P/C industry has short-duration contracts but high (de facto) renewal ratios. The premium on renewal contracts is partially sensitive to current interest rates. Duration calculations for property-liability insurance portfolios are complex. The common simplification of assuming that all policies are one-year term policies may yield inaccurate results; see Panning (1995).

Modeling

Financial modeling of P/C insurance enterprises has been done in two fashions: stochastic simulation and scenario testing [see Feldblum (1995) for an overview of this subject]. Both methods can be used in ALM for P/C companies.

Stochastic simulation developed from extending classical risk theory analyses of P/C liabilities to the asset side of the balance sheet. Daykin, Pentikainen, and Pesonen (1994) is the most comprehensive textbook on this subject, combining the accounting approach of the Finnish Working Party with the cash flow approach favored by the British Solvency Working Party [see Pentikainen and Rantala (1982) and Pentikainen et al. (1989) for the Finnish Working Party; see Daykin et al. (1987) and Daykin and Hey (1990) for the British Solvency Working Party].

The Daykin, Pentikainen, and Pesonen textbook and the earlier papers by the Finnish and British Working Parties are abstract. Practical illustrations of stochastic analyses of insurance company financial performance can be found in Kreps and Steel (1996) and in Hodes, Feldblum, and Blumsohn (1996).

Scenario testing is the more common approach for P/C companies because of the multitude of interrelated variables that influence such a company's financial performance. Scenarios may vary with financial variables, such as interest rates, economic variables, such as unemployment, and insurance variables, such as underwriting cycle movements.

Hodes, Neghaiwi, Cummins, Phillips, and Feldblum (1996) is the most comprehensive scenario testing paper dealing with ALM. It runs a 200-basis-point interest rate jump through a complete financial model, dealing with bonds, common stocks, and mortgage-backed securities on the asset side and with various lines of business loss reserves on the liability side.

Interest Rate Risk

ALM relates primarily to market valuations; capital requirements for interest rate risk are the statutory equivalent. Hodes and Feldblum (1996) explain the means of including interest rate risk concerns within a risk-based capital solvency measurement system.

With regard to life insurance, the statutory correspondence to ALM analysis is cash-flow testing, as first put forth in New York's Regulation 126. For property-casualty, the statutory correspondence is the capital required to guard against interest rate risk.

Almagro, Manuel, and Sonlin, Stephen M. "An Approach to Evaluating Asset Allocation Strategies for Property/Casualty Insurance Companies," pp. 55–80 in *Incorporating Risk Factors in Dynamic Financial Analysis.* Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press, 1995. Basic

> This paper presents a basic introduction to the asset-liability efficient frontier approach for determining optimal investment strategies from the perspective of a P/C company. The method considers the interaction of the underwriting and investment operations and their joint impact on financial risk. This same technique can be used to evaluate other business strategies, such as business mix and reinsurance decisions, in a consistent framework.

Black, Fischer, and Scholes, Myron. "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 81, no. 3 (May/June):637–54, 1973. Advanced

> Very difficult. This seminal paper on options pricing is recommended only for the financial professional.

Butsic, Robert P. "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," in *Inflation Implications for Property-Casualty Insurance.* Casualty Actuarial Society Discussion Paper Program:51–102, discussion by Rafal J. Balcarek, pp. 103–109. Arlington, VA: CAS, 1981. Intermediate

> Influential paper on effects of inflation on P/C loss reserves. The CAS uses this on the Part 10A examination syllabus.

Butsic, Robert P. "Solvency Measurement for Property-Liability Risk-Based Capital Applications," *Journal of Risk and Insurance* 61, no. 4 (December):656–90, 1994. Advanced

> Major influence on casualty actuarial thought; explains and justifies the use of the expected policyholder deficit ratio for solvency monitoring of insurance companies. The CAS uses this on the Part 10C examination syllabus.

Cox, John C. And Mark Rubinstein. *Options Markets.* Englewood Cliffs, NJ: Prentice-Hall, 1985. Advanced

> The major graduate school textbook on options pricing in the latter half of the 1980s.

D'Arcy, Stephen. Discussion of "Duration" by Ron Ferguson, *Proceedings of the Casualty Actuarial Society* 75, no. 135:8–25. Arlington, VA: CAS, 1984. Basic

Extension of life-insurance techniques to P/C insurance. D'Arcy's discussion covers the inflation-sensitive attributes of P/C loss reserves. The CAS uses this reference on the Part 10 syllabus.

D'Arcy, Stephen P., and Doherty, Neil. *The Financial Theory of Pricing Property-Liability Insurance Contracts.* Homewood, IL: Richard D. Irwin, Inc., 1988. Basic

Good introductory textbook for finance and investment principles applicable to P/C insurance contract pricing. The CAS uses this text on the Part 10C syllabus.

Daykin, C.D., Bernstein, G.D., Coutts, S.M., Devitt, E.R.F., Hey, G.B., Reynolds, D.I.W., and Smith, P.D. "Assessing the Solvency and Financial Strength of a General Insurance Company," *Journal of the Institute of Actuaries* 114, Part 2:227–310, 1987. Intermediate

This paper presents the British Solvency Working Party cash flow approach.

Daykin, C.D. and Hey, G.B. "Managing Uncertainty in a General Insurance Company," *Journal of the Institute of Actuaries* 117, Part 2, no. 467 (September):173–259, 1990. Intermediate

This paper applies the British Solvency Working Party cash flow approach to internal company management.

Daykin, C.D., Pentikaien, T., and Pesonen, M. *Practical Risk Theory for Actuaries.* 1st ed. New York: Chapman and Hall, 1994. Advanced

A basic text on stochastic simulation approaches to financial modeling. The CAS uses this text on the Part 10C syllabus.

Fama, Eugene F., and Schwert, William G. "Asset Returns and Inflation," *Journal of Financial Economics* 5:115–146, 1977. Intermediate

Seminal paper, which was followed by scores of subsequent reanalyses of the issues; examines correlations of common stock returns with both expected and unexpected inflation. Jargon-ridden writing style makes for difficult reading. The CAS uses this text on the Part 10C syllabus.

Feldblum, Sholom. "Forecasting the Future: Stochastic Simulation and Scenario Testing," pp. 151–177 in *Incorporating Risk Factors in Dynamic Financial Analysis.* Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press, 1995. Basic

A comparison of stochastic simulation and scenario testing for the lay actuary.

Feldblum, Sholom. "Asset-Liability Matching for Property/Casualty Insurers," pp. 117–154 in *Valuation Issues.* Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press, 1989. Basic

Explains implications of inflation sensitivity of P/C loss reserves for ALM. The CAS uses this text on the Part 10C syllabus.

Hodes, Douglas M., and Feldblum, Sholom. "Interest Rate Risk and Capital Requirements for Property/Casualty Insurance Companies," *Proceedings of the Casualty Actuarial Society* 83:490-562. Arlington, VA: CAS, 1996. Intermediate

Shows how interest rate risk should be measured in a risk-based capital framework. The CAS uses this reference on the Part 10 syllabus.

Hodes, Douglas M., Neghaiwi, Tony, Cummins, J. David, Phillips, Richard, and Feldblum, Sholom. "The Financial Modeling of Property/Casualty Insurance Companies," *Casualty Actuarial Society Forum* (Spring): 3–88. Arlington, VA: CAS, 1996. Intermediate

Co-winner of $10,000 prize paper competition at the July 1996 CAS DFA seminar. A scenario testing approach to insurance company financial performance, this is practically the only paper showing an actual ALM analysis for a P/C company.

Hodes, Douglas M., Feldblum, Sholom, and Blumsohn, Gary. "Workers Compensation Reserve Uncertainty," Casualty Loss Reserve Seminar Discussion Paper Program, *Casualty Actuarial Society Forum* (Summer): 61–149. Arlington, VA: CAS, 1996. Basic

Practically the only paper showing the use of stochastic simulation and expected policyholder deficit analysis in a P/C company.

Hull, John C. *Introduction to Futures and Options Markets.* 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1995. Intermediate

Excellent; recommended for self-study of options pricing techniques.

Kreps, Rodney E., and Steel, Michael M. "A Stochastic Planning Model for the Insurance Corporation of British Columbia," *Casualty Actuarial Society Forum* (Spring):153–173. Arlington, VA: CAS, 1996. Intermediate

Illustration of stochastic modeling for an automobile insurance enterprise.

Leibowitz, Martin L., Sorensen, Eric H., Arnott, Robert D., and Hanson, H. Nicholas. *A Total Differential Approach to Equity Duration.* New York: Salomon Brothers, Inc., 1985. Intermediate

This seminal paper discusses the effective duration of common stocks. It overthrew the conventional wisdom by well-reasoned analysis.

Noris, Peter D. *Asset/Liability Management Strategies for Property and Casualty Companies.* New York: Morgan Stanley, May 1985. Basic

Application of life insurance ALM techniques to P/C insurance. The CAS uses this text on the Part 10C syllabus.

Panning, William H. "Asset-Liability Management for a Going Concern," Chapter 12 in *The Financial Dynamics of the Insurance Industry,* ed. by Altman, Edward I., and Vanderhoof, Irwin T. New York: Irwin Professional Publishing, 1995. Advanced

This paper shows the effects of premium determination procedures on P/C ALM; difficult in its second half. The CAS uses this text on the Part 10C syllabus.

Pentikainen, Teivo, and Rantala, Jukka. *Solvency of Insurers and Equalization Reserves.* Helsinki: Insurance Publishing Company, 1982. Intermediate

Illustrates the Finnish Working Party approach, with a stochastic use of accounting figures.

Pentikainen, Teivo, Bonsdorff, Heikki, Pesonen, Martti, Rantala, Jukka, and Ruohonen, Matti. *Insurance Solvency and Financial Strength.* Helsinki: Finnish Insurance Training and Publishing Company, 1989. Intermediate

Illustrates the Finnish Working Party approach, with a stochastic use of accounting figures.

Weinberger, Alfred. "Allocation Techniques for an Asset/Liability Portfolio" in *Managing Asset/Liability Portfolios.* Speech at ICFA Continuing Education seminar. Taken from paper, "Asset Allocation for Property/Casualty Companies: A Going-Concern Approach" by Alfred Weinberger and Vincent Kaminski. New York: Salomon Brothers, July 1991. Intermediate

The author demonstrates the application of efficient frontier analysis to a property-casualty company. The model described in the paper seeks to optimize the return on economic surplus while taking into account both asset and liability uncertainty, accounting and regulatory constraints, and taxes. A case study is presented.

13. Pension Plan ALM

ALM operates in a distinctly different framework for pension plans than it does for life insurance companies, due to one very important difference in financial risk exposure: sudden, adverse capital market results that have the potential to push a life insurance company into a "terminal condition"—bankruptcy or failure. Pension plans, on the other hand, do not go bankrupt. Adverse capital market results can certainly cause a painful increase in ongoing pension cost to the sponsoring organization, but as long as the sponsor remains viable as an ongoing entity, the pension plan can continue. In effect, the ongoing pension plan has a very important asset that automatically adjusts to keep the total assets balanced with total plan liabilities, namely, the current value of all future contributions from the sponsor to the plan.

The consequences of this difference are very significant. Life insurance ALM is often focused on matching assets and liabilities in such a way that short-term mismatches are very tightly controlled. Pension plan ALM is more focused on quantifying the various financial implications of having a greater or lesser portion of the fund in equity-type investments (that is, assets that do not match the short-term interest sensitivity of the liabilities). This analysis helps the sponsor establish an asset-allocation policy mix that comfortably balances the competing goals of reducing long-term cost (through higher equity returns) and controlling upside cost risk in both the short term and the long term. In addition to this asset-allocation policy decision, sponsors also have some discretion on whether to fund liabilities more or less rapidly, within limits established by law. Pension plan ALM can also be useful in analyzing this strategic policy choice.

Pension plan ALM is carried out through Monte Carlo-type simulations of plan assets, liabilities and costs over a relatively long time horizon, typically from 10 to 20 years. The key economic and capital market variables that need to be simulated are inflation (both price and wage), interest rates (with a strong emphasis on long-term bond yields) and investment returns for all asset classes being modeled. Almost all models in use are proprietary with either an actuarial consulting organization or with selected investment consultants. Critical model features will be those that deal with the longer-term dynamics (changes that occur over periods of one full year and over multiple-year periods) of the economic and capital market variables: correlations between variables, mean reversion, serial correlation, and volatility patterns. To be really useful, a model should also go beyond merely simulating plan liabilities on some type of a market value measurement basis, and should capture the real-world methods and processes followed by the pension actuary in her annual valuations to determine plan cost for the sponsor.

Probably because of the proprietary nature of the models and consulting practices followed in this area, there is very little technical guidance available in published form. Most of the references shown here are fairly general descriptions of the overall process, rather than specific descriptions of models or modeling techniques.

Davis, Rowland M., and Sloan, Matthew T. "Pension Plans: A Risk Management Perspective," *The Journal of Investing* (Summer):58–61, 1993. Basic

Jaeger, Stefan, and Zimmermann, Heinz. "On Surplus Shortfall Constraints," *The Journal of Investing* (Winter):64–74, 1996. Advanced

Extension of the Leibowitz/Bader/Kogelman ideas.

Kritzman, Mark P. "Strategic Asset Allocation With Liabilities" and "Dynamic Hedging Strategies With Liabilities," Chapters 5 and 6 in *Asset Allocation for Institutional Portfolios.* Homewood, IL: Business One Irwin, 1990. Intermediate

Good introduction to the efficient frontier based on surplus optimization and to portfolio insurance techniques.

Leibowitz, Martin L., Bader, Lawrence N., and Kogelman, Stanley. *Return Targets and Shortfall Risks: Studies in Strategic Asset Allocation.* Chicago: Irwin Professional Publishing, 1996. Intermediate

Collection of Salomon Brothers research pieces on asset allocation, using a static, interest-sensitive concept of liabilities.

Peskin, Michael W. "Asset Allocation and Funding Policy for Corporate-Sponsored Defined-Benefit Pension Plans," *Journal of Portfolio Management* (Winter):66–73, 1997. Basic

Good overview of the ALM process.

Wendt, Richard Q. "Strategic Asset Allocation: Asset/Liability Forecasting, from A to Z," Chapter 10 in *Global Asset Allocation, Techniques for Optimizing Portfolio Management,* edited by Lederman, Jess, and Klein, Robert A. New York: John Wiley and Sons, Inc., 1994. Basic

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