Society of Actuaries
Professional Actuarial Specialty Guide
Asset-Liability Management

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SOCIETY OF ACTUARIES

Asset Liability Management (web page)

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Asset-Liability Management

Introduction

This specialty guide is a background reading list reference for the practice of asset-liability management (ALM). It is intended to provide guidance to anyone seeking to gain knowledge regarding ALM, especially with respect to its application to financial security systems such as life or health insurance, property and casualty insurance and pensions. Some sections have property/casualty-specific and pension-specific references shown separately, and special sections are devoted to property/casualty-specific references and to pension-specific references. We hope that this guide also will be useful to an audience beyond the actuarial profession seeking to understand a challenging 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 a basic understanding of the investments available to a financial institution is helpful. To make the guide as widely useful as possible, we have attempted to indicate the level of difficulty of each reference (basic, intermediate, advanced).

Recently, there has been much discussion regarding the concept of enterprise risk management (ERM). ERM is a broader concept than ALM. ERM can be viewed as a comprehensive and integrated process of identifying, assessing, monitoring and managing the risk exposure of an organization, ideally through a formal organizational structure and a quantitative approach. The goal of ERM is to minimize the effects of risk on an organization's capital and earnings, and to better allocate its risk capital. Thus, ERM considers the broad range of risks associated with operating a business, including financial, strategic, operational and hazard risks. Because financial institutions thrive on the business of risk, they are good examples of companies that can benefit from effective ERM. ALM is a significant component of ERM because it is an important process in addressing financial risk. This guide is primarily concerned with ALM, but includes a short section on ERM.

For additional information regarding ERM, see the Society of Actuaries (SOA) Risk Management Task Force Web site. (rmtf.soa.org) The work of the task force also involves a review of other risk management issues including economic capital calculation and allocation, equity modeling, extreme value models, health risk management, policyholder behavior in the tail, pricing for risk, risk-based capital covariance, risk management future and strategy, and risk management metrics.

What Is ALM?

ALM is the practice of managing a business so that decisions and actions taken with respect to assets and liabilities are coordinated. ALM can be defined as the ongoing process of formulating, implementing, monitoring and revising strategies related to assets and liabilities to achieve an organization's financial objectives, given the organization's risk tolerances and other constraints. ALM is relevant to, and critical for, the sound management of the finances of any organization that invests to meet its future cash flow needs and capital requirements.

Traditionally, ALM has focused primarily on the risks associated with changes in interest rates. Currently, ALM considers a much broader range of risks including equity risk, liquidity risk, legal risk, currency risk and sovereign or country risk.

ALM is practiced in diverse settings:

- Derivative dealers manage their long and short positions.
- Bankers coordinate the repricing horizons of their assets and liabilities.
- Pension plans adjust their investments to mirror the characteristics of their liabilities with respect to interest rates, equity returns and expected changes in wages.
- Insurers select investment strategies to ensure they can support competitive pricing and interest crediting strategies.

While each of these involves the application of ALM techniques to a particular financial problem, the implementations in these situations may bear little resemblance to each other. The derivative dealer must make many decisions during the course of a trading day, and is therefore likely to use a technique such as Value at Risk (VAR) based on intra-day market price volatility that can be used quickly and easily. Simulation modeling of those risks is a luxury not available due to time constraints. On the other hand, insurers typically manage ALM risks using simulation models that may take weeks or months to operate and validate. Daily application of risk limits is neither feasible nor necessary. Similarly, bankers' ALM risks are primarily those that will show up in profits in the near- to medium-term future, so their approach to ALM may emphasize short-term income and expenses, while a pension plan, taking a longer view, may focus on the present value of required contributions.

These are all valid applications for ALM, but the appropriate tools and measurements for each situation can differ significantly. The choice of appropriate tools and measurements depends in turn on identifying the primary risk of concern. For example, in a pension fund, risks include levels of contributions, expenses, or net income, and balance sheet items. Minimizing risk in any of these areas may increase risk to others. Senior management of a financial organization often needs help in focusing on the primary risk.

The readings listed in this introductory section are intended to provide a basic overview of most topics and concepts in ALM. The sections that follow survey the broad range of ALM tools and applications that exist today. The approach to ALM in a particular situation must be chosen with regard to available time, human resources, capital, information and management philosophy.

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 financial security systems. The current professional actuarial education and qualification process provides actuaries knowledge and understanding of assets and liabilities and how they are interrelated. This knowledge includes an understanding of the operation of financial markets, the instruments available and the use of synthetic instruments. Financial reporting and product development actuaries are expected to understand the relationship of the company's assets to its liabilities so as to reflect the risks inherent in the business and thereby enhance its profitability and solvency. Insurance and investment products are continually being redesigned, updated, expanded and replaced. The practicing actuary considers these changes and how they affect the company. The actuary must be able to communicate such changes to 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 financial security system. Actuaries are well prepared through education and experience to perform this role.

The Role of Scientific Principles and Actuarial Standards of Practice

Actuarial standards of practice provide guidance to actuaries as they fulfill their various responsibilities in order to ensure that their employers, clients and the public interest are well served. As described by the Actuarial Standards Board (ASB) in the United States: "Standards of practice serve to assure the public that actuaries are professionally accountable. At the same time, standards provide practicing actuaries with a basis for assuring that their work will conform to generally accepted

principles and practices." Thus, actuarial standards of practice are an important reference for ALM work, as well as any other actuarial task.

Actuarial standards of practice are established by the ASB in the United States and by the Canadian Institute of Actuaries (CIA) in Canada. The standards that have been established, or are in the process of being established (exposure drafts or discussion drafts), by the ASB can be viewed by accessing the ASB Web site at www.actuarialstandardsboard.org. The standards established, or in the process of being established, by the CIA can be viewed by accessing the CIA Web site at www.actuaries.ca and clicking on "Publications" and then selecting "Blue Book (Standards)."

To assist the ASB and the CIA in developing standards of practice, the SOA has formed a number of committees and task forces to articulate an intellectual and scientific basis for such standards. The SOA Task Force on Asset/Liability Management Principles is in the process of articulating that basis for ALM. The goal is to have a final draft of a principles document completed during 2003. The first publication of the document may be an exposure draft.

Relevant Professional Organizations

There are a number of organizations that provide information that might be of value to those interested in learning about ALM. For your information and convenience the following table lists a few of the key organizations and their Web addresses.

Organization	**Web Address**
American Academy of Actuaries (AAA)	www.actuary.org
Canadian Institute of Actuaries (CIA)	www.actuaries.ca
Casualty Actuarial Society (CAS)	www.casact.org
Society of Actuaries (SOA)	www.soa.org
Association for Investment Management and Research (AIMR)	www.aimr.org
Global Association of Risk Professionals (GARP)	www.garp.com
Professional Risk Managers' International Association (PRMIA)	www.prmia.org

Format of the Guide's Content

Each section of the guide includes commentary introducing the topic of the section and related issues. For most references, the guide identifies the reference's level of difficulty. The guide also identifies references that have been part of the syllabus for SOA or CFA examinations.

The appendix lists alphabetically, by author (or source if, for example, the reference is a compilation of papers presented at a conference or seminar), all the references included in the guide, and the section(s) in which they are referenced. The appendix is intended to provide users of the guide an opportunity to navigate through the guide based on reference(s) of interest, to identify all the sections in which a particular reference appears or to determine the scope of the references.

We welcome your suggestions for changes or additional references. Please direct your comments to Julie Young at the SOA office (jyoung@soa.org).

References

Reference	*Level of Difficulty*	*Comments*
Bodie, Z., A. Kane, and A. Marcus. 2002. *Investments.* 5th ed. New York: Irwin McGraw Hill.	Basic	Has been part of the SOA exam syllabus.
Canadian Institute of Actuaries ALM Practitioners Association.		Focus is life insurance. The group discusses practice-related and emerging issues as part of an ongoing process to exchange knowledge and develop ALM best practices.
Canadian Institute of Actuaries Working Group on ALM.		Formed to further education and research in ALM and to promote best practices. The focus of the group is life insurance.
Forbes, S., M. Hays, S. Reddy, and K. Stewart. 1993. *Asset-Liability Management in the Life Insurance Industry*. Atlanta, GA: Life Office Management Association, Inc.	Basic	
Ingram, D., and L. Zacheis. 1994. "Asset-Liability Matching," Chapter 22 in *Life Insurance Accounting.* 3rd ed. IASA.	Basic	Has been part of the SOA exam syllabus.

Reference	*Level of Difficulty*	*Comments*
Laster, D., and E. Thorlacius. 2000. "Asset-Liability Management for Insurers," Swiss Re *Sigma* (June): 7-11.	Basic	Has been part of the SOA exam syllabus. It can be downloaded from the Swiss Re Web site, www.swissre.com. (Click on "Research and Publications," "sigma insurance research," "sigma archive," and scroll down to "No. 6, 2000.")
Ostaszewski, K. 2002. *Asset-Liability Integration.* M-FI02-1. Schaumburg, IL: Society of Actuaries.	Basic to Intermediate	Analyzes the ALM process in the financial intermediation industry, especially among insurers, from the perspective of what is known about capital markets and practiced in financial engineering. The monograph strives to define a mission for the modern insurance industry, its place in the financial intermediation network, and the role of ALM in that mission. It reflects a positive bias toward philosophy, but also reflects the belief that philosophical questions addressed will eventually prove themselves to be worthy of practical consideration. (SOA monographs can be downloaded for free from: www.soa.org/bookstore/mono.html.)
Redington, F. 1952. "Review of the Principles of Life-Office Valuations," *Journal of the Institute of Actuaries* 78, Part III: 286-340.	Intermediate	Available in the Investment Section Monograph (SOA Monograph M-AS99-2), which was published in honor of the Society of Actuaries 50th anniversary, and includes important investment literature. (SOA monographs can be downloaded for free from: www.soa.org/bookstore/mono.html).

Reference	*Level of Difficulty*	*Comments*
Shiu, E. 2004. "Matching," in *Encyclopedia of Actuarial Science*. John Wiley & Sons.	Basic	A brief survey of various methods for matching assets and liabilities, with a comprehensive list of references. The *Encyclopedia of Actuarial Science* is expected to be published in 2004.
Society of Actuaries Risk Management Task Force. :		The task force has identified four major activities: 1. Promotion of actuarial expertise in areas of risk management. 2. Promotion of opportunities for actuaries in the arena of risk management. 3. Sponsorship of seminars on risk management. 4. Development of new risk management educational materials. Additional information about the work of the task force and its subgroups is available at http://rmtf.soa.org

Reference	*Level of Difficulty*	*Comments*
Society of Actuaries Task Force on Asset/Liability Management Principles. "Asset Liability Management Principles." (Not yet available.) Society of Actuaries.	Basic	The statement of principles is not yet final. The task force was formed to articulate an intellectual and scientific basis for the development of a set of standards of practice for ALM that will apply to all practice areas. The goal is to have a final draft of the principles document completed during 2003. The first publication of the document may be an exposure draft.
Williams, E., ed. 1992. *Managing Asset/Liability Portfolios*. Charlottesville, VA: ICFA Continuing Education.	Basic	Available from AIMR. Ordering information available at www.aimr.com/publications/catalog/portfolio.html

Basics in Financial Economics Relevant to ALM

Introduction

Financial economics is a very broad topic. Readings in this section are intended to cover the 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 the readings is either "Basic" or "Intermediate." Basic investment knowledge, such as knowledge of the dividend discount model and common asset types, is assumed as background for these readings. The suggested readings for this section are, in general, taken from standard textbooks used for basic education by the Society of Actuaries. Many colleges and universities also provide course descriptions and reading lists on their Web sites.

References—Introduction

Reference	*Level of Difficulty*	*Comments*
Bodie, Z., A. Kane, and A. Marcus. 2002. *Investments.* 5th ed. New York: Irwin McGraw Hill.	Basic	The primary reference for all general topics. Has been part of the SOA and AIMR exam syllabus.
Brealey, R., and S. Myers. 2003. *Principles of Corporate Finance.* 7th ed. McGraw Hill.	Basic/Intermediate	Has been part of the SOA exam syllabus.
Fabozzi, F. (ed.) 2000. *Handbook of Fixed Income Securities.* 6th ed. McGraw Hill Trade.	Basic/Intermediate	Has been part of the SOA exam syllabus. Good reference and guidebook for practitioners.
Maginn, J., and D. Tuttle. 1990. *Managing Investment Portfolios: A Dynamic Process.* 2nd ed. Warren, Gorham & Lamont.	Basic/Intermediate	Has been part of the SOA and AIMR exam syllabus.
Panjer, H., ed. 1998. *Financial Economics: With Applications to Investments, Insurance and Pensions.* Schaumburg, IL: Actuarial Foundation.	Basic/Intermediate	Has been part of the SOA exam syllabus.

Overview of Financial Markets

The books listed in the introduction of this section do a very good job of introducing the reader to various markets and instruments. The term structure of interest rates, dissecting the yield curve using bootstrapping techniques into forward and spot curves is essential to understanding ALM. These texts make it clear that the landscape is ever changing, with new classes of assets being created as quickly as the quants can think them up. It is important for ALM practitioners to understand the cash flow optionality purchased or sold. Unintended consequences can leave the practitioner in worse shape than before a supposed hedge was purchased. Counterparty risk must also be considered.

Reference—Overview of Financial Markets

Reference	*Level of Difficulty*	*Comments*
Fabozzi, F. 1999. *Bond Markets, Analysis and Strategies*. 4th ed. Prentice Hall.	Basic/Intermediate	This reference has been part of the AIMR exam syllabus

Risk/Return Tradeoff Models

Many models have been developed to evaluate a security's risk and return. The capital asset pricing model (CAPM) predicts the relationship between the risk of an asset and its expected return. While this model assumes efficient markets and does not fully withstand empirical tests, it is widely used because it has sufficient accuracy for many applications. Another limitation of all these models is that they are one-period models, not multi-period, as needed by insurers. Index models form a second class. These models assume that systemic or market risk can be represented by a broad index of stock returns. This assumption reduces the input needed to perform a Markowitz portfolio selection procedure. Single-index models assume that stock prices move together only because of common movements with 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 CAPM, arbitrage pricing theory defines a relationship between expected return and risk. The 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, this model does not assume that the same expected return to risk relationship holds for all assets. Single and multifactor APT models are discussed in the readings. The CAPM was developed by Sharpe (1964), Lintner (1965) and Mossin (1966). William Sharpe was co-winner of the 1990 Nobel Prize in economics.

References—Risk/Return Tradeoff Models

Reference	*Level of Difficulty*	*Comments*
Bodie, Z., A. Kane, A. Marcus, and L. Pojman. 2004. *Essentials of Investments.* 5th ed. Chapters 9-11. McGraw Hill.	Basic	Has been part of the SOA and AIMR exam syllabus. It provides a basic introduction to the topic.
Brealey, R., and S. Myers. 2003. *Principles of Corporate Finance.* 7th ed. Chapter 8. McGraw Hill.	Basic	This text is the industry standard for corporate finance. Typically used for first-year MBA students, it presents the issues in the context of corporate management rather than investment management. Has been part of the SOA exam syllabus.
Elton, E., M. Gruber, S. Brown, and W. Goetzmann. 2002. *Modern Portfolio Theory and Investment Analysis.* 6th ed. Chapters 13-16. John Wiley & Sons.	Intermediate	Has been part of the SOA and AIMR exam syllabus. Focuses on management of equity.
Panjer, H., ed. 1998. *Financial Economics: With Applications to Investments, Insurance and Pensions.* Schaumburg, IL: Actuarial Foundation.	Intermediate	Has been part of the SOA and AIMR exam syllabus.

Beginning Derivatives

Derivatives can be a powerful tool for hedging portfolio risks. Basic derivatives are described, and option valuation techniques are presented here. Advanced treatment of derivatives is covered later in the guide.

For insurance companies and pension plans, derivatives are usually entered into as hedges against interest-rate and equity-exposure risks. Multinationals often hedge their currency exposure as well. It should be noted that an insurer should research the current accounting treatment of hedges. Formal accounting bodies may not approve the portfolio cash–flow-based approach. Derivatives utilized to hedge interest rate risk include caps and floors, swaps, puts and calls, along with more exotic combinations of these basic instruments. For equities, insurers are often concerned with drops in market value when they have guaranteed a fixed, or ratcheted, return. They may utilize various derivatives that pay off when stock returns are poor.

Fisher Black and Myron Scholes (1973) and Robert Merton (1973) developed option-pricing theory. Scholes and Merton shared the 1997 Nobel Prize in economics (Black died in 1995).

References—Beginning Derivatives

Reference	*Level of Difficulty*	*Comments*
Berkshire Hathaway. 2002. "Berkshire Hathaway Annual Report." Omaha: Berkshire Hathaway Inc. 13-15.	Basic	Currently available online at: www.berkshirehathaway.com/2002ar/2002ar.pdf
Bodie, Z., A. Kane, A. Marcus, and L. Pojman. 2004. *Essentials of Investments.* 5th ed. Chapters 20-23. McGraw Hill.	Basic	Has been part of the SOA and AIMR exam syllabus.
Brealey, R., and S. Myers. 2003. *Principles of Corporate Finance.* 7th ed. Chapters 20-22. McGraw Hill.	Basic	Has been part of the SOA exam syllabus.
Elton, E., M. Gruber, S. Brown, and W. Goetzmann. 2002. *Modern Portfolio Theory and Investment Analysis.* 6th ed. Chapters 22-23. John Wiley & Sons.	Intermediate	Has been part of the SOA and AIMR exam syllabus.
Fabozzi, F. (ed.) 2000. *Handbook of Fixed Income Securities.* 6th ed. Chapters 55-58. McGraw Hill.	Basic	Has been part of the SOA exam syllabus. It provides a basic understanding of a variety of derivatives topics.
Global Derivatives Study Group (The Group of Thirty). 1993. "Derivatives: Practice and Principles." Washington, D.C: The Group of Thirty.	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. Has been part of the SOA exam syllabus.
Partnoy, F. 2003. *Infectious Greed: How Deceit and Risk Corrupted the Financial Markets*. Times Books.	Intermediate	Partnoy follows up FIASCO: The inside story of a Wall Street trader by recounting recent derivatives blow-ups and provides suggestions to limit future problems.

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. Alternatively, the strategy 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 set of optimal combinations of risky assets for each level of risk. In the absence of borrowing, 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.

Under the Markowitz model, given riskless lending and borrowing rates and all investors working with the same set of inputs, all investors will prefer a single portfolio of risky assets. This is 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. The 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.

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 its not meeting profit objectives.

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.

References—General

Reference	*Level of Difficulty*	*Comments*
Bodie, Z., A. Kane, A. Marcus, and L. Pojman. 2004. *Essentials of Investments.* 5th ed. Chapters 6-8. McGraw Hill.	Basic	Has been part of the SOA and AIMR exam syllabi. 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.
Chow, G. 1995. "Portfolio Selection Based on Return, Risk and Relative Performance," *Financial Analysts Journal*. March-April.	Intermediate	Author defines reward and risk in terms of investment returns relative to a benchmark, then uses these definitions to create an efficient frontier. Has been part of the SOA exam syllabus.
Harlow, W. 1991. "Asset Allocation in a Downside Risk Framework," *Financial Analysts Journal.* Sept.-Oct.: 28-40.	Intermediate	Author defines several classes of downside risk measures and develops an efficient frontier using these downside risk measures. Has been part of the SOA exam syllabus.
Michaud, R. 1998. *Efficient Asset Management.* Oxford University Press.	Intermediate	Author provides practical methods for investment optimization.
Panjer, H. ed. 1998. *Financial Economics: With Applications to Investments, Insurance and Pensions.* Schaumburg, IL: Actuarial Foundation.	Advanced	Covers the Markowitz model, its properties and an extension of the model to an asset-liability problem. Single- and multi-period applications are covered. Has been part of the SOA exam syllabus.
Reilly, F., and K. Brown. 1999. *Investment Analysis and Portfolio Management.* 6th ed. Chapters 8-10. South-Western College Publishing.	Intermediate	Covers risk aversion, alternate measures of risk, the efficient frontier and investor utility. Has been part of the AIMR exam syllabus.

References—Property/Casualty

Reference	*Level of Difficulty*	*Comments*
Babbel, D., and F. Fabozzi, eds. 1999. "Asset Allocation for Property and Casualty Insurers," *Investment Management for Insurers.* John Wiley & Sons.	Basic	The authors illustrate the use of efficient frontier analysis in a P&C application. Has been part of the SOA exam syllabus.
Burkett J., T. McIntyre., and W. Sonlin. 2001. "DFA Insurance Company Case Study, Part I: Reinsurance and Asset Allocation." Casualty Actuarial Society.	Advanced	Presents a case study using an asset-liability efficient frontier 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. Can be found on the CAS Web site at www.casact.org/pubs/forum/01spforum/01spf059.pdf.

References—Pensions

Reference	*Level of Difficulty*	*Comments*
Fabozzi, F. (ed.) 2000. *Handbook of Fixed Income Securities.* 6th ed. Chapter 46. McGraw Hill.	Intermediate	Has been part of the SOA exam syllabus.
Leibowitz M., S. Kogelman, and L. Bader. 1992. "Asset Performance and Surplus Control: a Dual-Shortfall Approach," *Journal of Portfolio Management*. Winter.	Intermediate	Covers the use of efficient frontier in a pension fund application. Has been part of the SOA exam syllabus. Study Note 8V-307-00, on the SOA Course 8 Investments Syllabus.

Behavioral Finance

Theories of modern finance assume that all investors make rational choices based upon rational expectations. Behavioral finance is a study of cases where individual behavior does not conform to these expectations. Whether it is prepayment speed on residential mortgages or surrender activity on deferred annuities, results vary based on the interaction of current and past economic environments with market psychology. By highlighting incidences where investor and policyholder behavior diverges from rational behavior, behavioral finance has important implications for modeling asset and liability cash flows.

Behavioral Finance by Richard Thaler is a collection of key articles on this topic. There are many sources available that apply the teachings of Benjamin Graham and Warren Buffett. With a focus on margin of safety, qualitative research is valued over excessive quantitative research. This provides a common-sense approach to finance. The Berkshire Hathaway annual reports, written by Buffett and, in particular, the management discussion found in the company's 10-Q filings are readable references.

References—Behavioral Finance

Reference	*Level of Difficulty*	*Comments*
DeBondt, W., and R. Thaler. 1994. "Financial Decision-Making in Markets and Firms: A Behavioral Perspective." Working Paper, National Bureau of Economic Research, Cambridge, MA.	Basic	Provides a brief review of recent work in the area of behavioral finance. Has been part of the SOA exam syllabus.
Drennan, D. 1995. "Exploiting Behavioral Finance: Portfolio Strategy and Construction," in *Behavioral Finance and Decision Theory in Investment Management*, edited by A.S. Wood. Charlottesville, VA: Association for Investment Management and Research.	Basic	Discusses the implications of overconfidence and overreaction on security analysts' and corporate management's estimates of future earnings. Has been part of the SOA exam syllabus.
1999. *Financial Analysts Journal*, 55(6).	Intermediate	Focuses on behavioral finance and includes articles by Richard Thaler, Meir Statman and Terrance Odean.

Reference	*Level of Difficulty*	*Comments*
Hagstrom, R. 2000. *Latticework: The New Investing*. Texere. (Also titled *Investing: The Last Liberal Art)*	Intermediate	Discusses how a latticework of mental models can provide a basis for investing The Santa Fe Institute is highlighted in chapters covering physics, biology, social sciences, psychology, philosophy, literature and decision-making.
Hagstrom, R. 2000. *The Warren Buffett Portfolio*. John Wiley & Sons.	Intermediate	Discusses alternative investment strategies (focus investing) to those developed by academia in the latter 20th century.
Shiller, R., and R. Thaler. Behavioral Finance Conferences: http://cowles.econ.yale.edu/behfin/	Basic/Intermediate/ Advanced	These seminars have been held since 1991 under the auspices of the National Bureau of Economic Research.
Shiller, R. 1992. *Market Volatility*. MIT Press.	Intermediate	Provides a mathematical and behavioral analysis of price fluctuations in speculative markets.
Shiller, R. 1999. "Behavior and the Efficiency of the Financial System," in *Handbook of Macroeconomics Volume 1C,* edited by J. Taylor and M. Woodford. North-Holland.	Intermediate	
Shiller, R. 2001. *Irrational Exuberance.* Broadway Books.	Intermediate	Provides an analysis and explanation of the stock market boom since 1982.
Shleifer, A. 2000. *Inefficient Markets: An Introduction to Behavioral Finance.* Oxford University Press.	Basic	
Thaler, R. ed. 1993. *Advances in Behaviora Finance.* Russell Sage Foundation.	Intermediate	A collection of key articles discussing major behavioral concepts useful to finance. These concepts include overconfidence, overreaction, loss aversion, and fads and fashions.

Tools and Techniques

Basic Risk Management Metrics

Risk can be defined as a measure of volatility of value, either absolute or relative to a benchmark. Measures of risk can be based on backward-looking empirical realized estimates, forward-looking estimates implied by the market, or both. This section will introduce some of the basic risk measurement methodologies and metrics.

General Introduction of Duration and Convexity

Duration and convexity are the two most important measures of interest rate risk for fixed-income securities and interest-bearing liabilities. Duration measures the sensitivity of the value of an asset to changes in interest rates, (i.e., duration is the negative of the slope of the price function centered at the current price and divided by the price). Convexity measures the curvature of the price profile of the instrument to changes in interest rates. (Convexity is the second derivative of a price with respect to interest rates and is divided by the price). Positive convexity opens upward, like a smile. Negative convexity opens downward, like a frown. Note: Both of these measure sensitivity to small parallel rate changes in the yield curve, not bends or twists in rates.

General Definition

Duration: For any security, portfolio or liability S with current value P, the **duration $D_{S,r}$ of S with respect to the interest rate r** is

$$D_{S,r} = (-1/P)\,(\partial P/\partial r) \text{ or } (-1)(\partial P/\partial r)/P,$$

where $\partial P/\partial r$ denotes the partial derivative of P with respect to r. In descriptive terms, duration is the (negative of) the percentage change in price P per unit change in interest rate. The negative sign in front of the equation is to signify the fact that price and yield move in opposite directions.

A positive duration means that when interest rates go up, the price (or the market value) of the instrument goes down, which is the case for most fixed-coupon, fixed-income instruments and for liabilities with reasonably well-defined cash flows. (For example, a bond priced at 100 and with duration of 5 would be worth approximately 105 if rates fell by 1 percent.) Negative duration means that the price (or market value) of the instrument will go up when the interest rate goes up. (If some instrument existed that was priced at 100 and had a duration of –5, it would be worth approximately 105 if rates rose by 1 percent.) Examples of instruments with negative durations are interest rate caps, long positions of put options on fixed-coupon bonds, and some exotic CMOs whose cashflows may increase faster than the increase in discount rates. Floating rate instruments have very short duration.

For both historical and practical reasons, there are variations on the general definition of duration. The most frequently referenced duration definitions are Macaulay duration, modified duration (the fixed cash flow variation of the general duration equation shown above), effective duration, and most recently, key-rate duration or partial duration. To capture other risk exposures, financial investment practitioners created new risk sensitivity measures and terminologies such as spread duration, prepayment duration and volatility duration. Of these new measures, spread duration is the one most commonly used to capture the price or market value sensitivity to spread change in the corporate bond area.

Convexity is a second-order term that measures the change in price from the duration estimate for a small change in rates. For a positive duration instrument with no embedded options, positive convexity means that the duration extends (get longer) when interest rates fall (which is good), and the duration shortens when interest rates rise (also good.) All fixed cash-flow bonds have positive duration and positive convexity. Securities with embedded options may have regions with negative or reduced positive convexity. For example, home mortgages can have negative convexity as rates lower and increase the likelihood of prepayments, resulting in lower duration as rates fall, and convexity may turn positive from lower likelihood of prepayment or extension resulting in greater duration as rates rise. Some structured products can have very nonlinear price profiles that transition from positive to negative duration and convexity as rates change.

Variations of the General Definition of Duration

Effective duration will be formally defined later and is an appropriate measure across a portfolio of debt or liabilities with fixed cash flows or embedded options in one currency only. A problem with any duration measure is that it cannot be aggregated across multiple currencies as it only measures interest rate risk within

each currency. The classical duration measures, Macaulay duration and Modified duration, are discussed below for historical purposes only; please note that these are *not* applicable to any asset or liability with embedded options. Also note that Macaulay duration is not an analytic used by many investment practitioners, as it does not adequately capture changes in price sensitivity at different rate levels. In the special case of a noncallable, default-free, zero-coupon bond, Macaulay duration is always equal to the time to maturity.

Macaulay Duration

For any bond with scheduled cash flow payments $P_1, \ldots, P_n$ at times $t_1, \ldots, t_n$ and interest rate r, the Macaulay duration is defined as:

$$D^{Mac} = \frac{\sum_{i=1}^{n} P_i(1+r)^{t_i} t_i}{\sum_{i=1}^{n} P_i(1+r)^{t_i}}$$

According to Frank Fabozzi, in *Fixed Income Mathematics*, (pages 157-158), Macaulay duration measures the "weighted average time-to-maturity of the bond's cash flows." The weightings are the present values of each cash flow. These "time-weighted, discounted cash flows" tell you, on average, how long it takes to get your money back.

Modified Duration

Modified duration is a special form of the general definition. For bonds with fixed cash flows, the duration defined by the general definition and the Macaulay duration have a special relationship, $D(general) = D^{Mac} / (1+r)$. In this case, the duration defined by the general definition is called modified duration, or

$$D^{mod} = D^{Mac} / (1+r).$$

For a bond with k interest payments per year and interest rate r compounded k times per annum, the modified duration is

$$D^{mod,\,k} = D^{Mac}/(1+r/k).$$

The modified duration of a 10-year, noncallable, zero-coupon bond will be slightly less than 10 and depends on the level of rates. If the current level of rates is 3 percent, then the modified duration would be 9.7 (which is the Macaulay duration divided by 1+.03); if interest rates go up by 1 percent, then the price will drop by approximately 9.7 percent. If rates are at 6 percent the modified duration would be 9.4, and for a 1 percent rise in rates the price will drop by approximately 9.4 percent. As rates approach 0 percent, modified duration approaches Macaulay duration; if the current rate level is .05 percent, the modified duration would be 9.95. Also, Macaulay and modified duration are equal for continuous compounding.

Macaulay and modified duration should only be applied to fixed and certain cash flows (without embedded options), although the concepts are useful whenever the price function is differentiable.

Investment professionals use the term *option-adjusted duration* or *effective duration* (see definition below) 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, *Handbook of Fixed Income Securities*). This interest rate dependency is typically true of any security with an embedded option, such as callable bonds, options, floating rate notes and residential mortgages with prepayment provisions. If future cash flows differ when rates rise and then fall from when rates fall and then rise, then the security is termed *path dependent*.

Models are required that use either a lattice of rates (path independent) or a set of interest rate scenarios (path dependent) for valuation and are calibrated to the term structure of rates and term structure of volatility to observed prices. This term structure is shocked and lattice or scenarios are produced to calculate sensitivity (see Financial Market Modeling section).

Effective Duration

Effective duration D is defined as the approximation:

$$D \approx (-1/P)\left((P^{+} - P^{-})/(r^{+} - r^{-}) \right) \text{ or } (-1)(\Delta P/\Delta r)/P,$$

where P is the price of the instrument before any parametric shift (for interest rates this represents the base case unshifted yield curve), P^{+} is the value for the positive shifted scenario r^{+} (parallel up shift) and P^{-} is the value for the negative shift r^{-} (parallel down shift). Note the denominator is two times the change in rates $(r^{+} - r^{-}) = 2*r^{+} = 2*\Delta r$. Note: This measure can be very sensitive to the size of the rate shift,

especially if the price function is nonlinear and asymmetric. As such, it is an approximation for the slope of the price as a function of rates divided by the price.

Note that when cash flows are fixed (not interest rate dependent) and when the size of the shift used in the effective duration calculation is sufficiently small, the effective duration definition is equivalent to that of the modified duration or the general definition of duration. In addition, because the effective duration is calculated using discrete calculation, it is also applicable to instruments where either the derivative of a price with respect to interest rate is too complex to calculate, or the price function is not readily differentiable. In this regard, effective duration should be thought of as an extension of modified duration.

Other Related Concepts

Key rate duration, or partial duration, is a slightly more advanced concept that measures the local sensitivity to a shift in just a portion of the yield curve (see Ho and also Reitano). This measures the sensitivity to the changes in yield curve shape. Key rate shifts are constructed so that their sum equals a parallel shift and thus the sum of key rate durations is equal to effective duration for fixed cash flow instruments and is usually very close for most others. However, key rate durations can be computationally intensive for complex path-dependent securities such as structured products. Applications such as key rate immunization or yield curve immunization will be addressed later in the section on immunization.

Definition of Key Rate Duration or Partial Duration

Consider a security S with current value P and cash flows at times $t_1, \ldots, t_n$. Let $r_1, \ldots, r_n$ be the interest rates on the yield curve for this security with terms to maturity $t_1, \ldots, t_n$. The key rate duration or partial duration D_{S, r_i, t_i} of S with respect to interest rate r_i and term to maturity t_i is

$$D_{S, r_i, t_i} = (-1/P)(\partial P/\partial r_i),$$

where the partial derivative is calculated under the assumption that $r_1, \ldots, r_n$ are independent, i.e., $\partial r_j/\partial r_i = 0$ for $j \neq i$.

Key rate duration or partial duration is a useful metric when one wishes to measure a portfolio's sensitivity portfolio to movement in various parts of the yield curve. By matching partial durations of asset and liability portfolios it is possible to obtain a degree of protection against nonparallel shifts in the yield curve (see the Applications section at the end of this note). However, one should keep in mind that

the rates corresponding to various terms to maturity are not independent, so additional tools are required to fully quantify the sensitivity of a portfolio to nonparallel shifts.

Dollar duration is equivalent to the absolute sensitivity of a position in dollars, instead of percentage change in price, to a 1 percent change in rates. This is equivalent to the duration times the market value of the position.

DV01, or "dollar value of one basis point," is the market value sensitivity to a 1 basis-point change in rates. For fixed-income securities, DV01 equals (duration*0.01%*MV). DV01 is typically used for instruments for which the concept of duration is not an appropriate risk measurement. Such instruments include futures, options, caps, floors, etc.

Spread duration or *option-adjusted spread (OAS) duration* measures a bond or liability product's sensitivity to changes in implicit credit worthiness as measured by the OAS; similarly, the impact on value due to the change in the spread can also be associated with changes in the probability of default or changes in the financial strength denoted by a rating.

Swap spread duration measures a bond's sensitivity to changes in the spread of the swap curve to the Treasury curve (see Golub and Tilman).

Empirical duration is a measure that was in vogue for mortgage-backed securities in the mid-90s and tried to quantify the curve shifts that were not exactly parallel. It can be thought to blend yield curve twist, effective duration and implied volatility to measure a combination of parallel sensitivity amplified by the volatility (i.e., the short end is more sensitive, and in an effective duration calculation the short end is shifted more than the long end. By including volatility, this can be considered a precursor to value-at-risk (VAR), which will be described later in the Advanced Risk Measures section.)

There is a set of option price sensitivity measures referred to as "the Greeks" that reflect other sensitivities. Risk measures *delta, gamma, vega*, *theta*, *rho* and other basic risk metrics will be discussed below.

Delta, like duration, measures the price sensitivity of a derivative financial instrument to changes in the underlying value.

Gamma, like convexity, measures the price sensitivity to changes in delta resulting from changes in the underlying instrument's price. Said another way, gamma measures the delta's sensitivity to changes in the price of the underlying asset. For a bond option, a positive gamma indicates a position with positive convexity.

Vega measures price sensitivity to changes in the volatility of the underlying asset.

Theta measures sensitivity to time decay.

Rho measures sensitivity to changes in the risk-free interest rate.

Equity duration was debated in 1989 when Leibowitz, Sorensen, Arnott and Hanson produced a seminal paper that discussed the *effective duration of common stocks.* It overthrew the conventional wisdom of the day by well-reasoned analysis.

Key rate duration, spread duration, swap spread duration, volatility duration, prepayment duration, lapse duration, "the Greeks" and other risk sensitivity measures are becoming more useful in both risk management and ALM.

Applications of Duration

Duration is used in hedging since it measures price sensitivity. The next section will discuss the applications in immunization.

Weaknesses of Duration as a Risk Measure

Duration measures local sensitivity and cannot be extrapolated for large factor changes.

Besides the citations below, an evolving resource for risk management metrics is the SOA's Risk Management Task Force and their Web page, www.soa.org/sections/rmtf/rmtf.html.

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Chambers, D., and S. Nawalkha, eds. 1999. "Interest Rate Risk Measurement and Management," *Institutional Investor.* May.	All levels	A collection of seminal articles in interest rate risk management.
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References—Multivariate Models

Reference	*Level of Difficulty*	*Comments*
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Immunization and Dedication

Immunization is the act of establishing a position such that the value of the position is insensitive to *small* 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 *small* changes in interest rates, although the term could readily be applied to any business where its profits or values have been protected from changes in the price of an input or output.

Immunization is an often-misinterpreted concept. Some use this term to mean duration matched and others use it to mean cash-flow matched. The latter is called portfolio dedication.

A classic form of portfolio immunization is maximizing portfolio yield while subject to present value and dollar duration constraints. Note that for immunization, the larger the change in rates, the larger the drift of duration and hence the larger risk.

A more constrained portfolio concept is *dedication,* where cash flows are matched explicitly for a portfolio to the liability. Because the dedicated portfolio relative to the liability is so well matched, and not just to local sensitivities, it has the same duration and has less ALM risk than an immunized portfolio.

Note that the liability cash flow may not be very predictable with a high degree of certainty. Therefore, we recommend that the concept "dedication" or "cash-flow match" not be taken too literally. The level of precision in cash flow match is dictated by the cash flow certainty of the liability and the organization's total return objective and risk tolerance level.

A half-way approach between immunization (or duration match) and dedication (or cash flow match), is to match the duration and convexity of the asset and liability. Additional improvement can be made by partial or key-rate duration match.

For extremely long-tail liabilities, one could take a mix-and-match approach, also called *horizon immunization*, to cash flow match the near term liability cash flows and total return management for the long-term liability cash flows.

Finally, for historical purposes, one should thank Frank M. Redington, the late British actuary who introduced the concept of asset-liability immunization in a 1952 paper, "Review of the Principles of Life-Office Valuations," published in the *Journal of the Institute of Actuaries*.

References—Fixed and Certain Cash Flows

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Advanced Risk Management Metrics

Advanced Risk Management Metrics are sophisticated tools that can help measure both absolute and relative exposures and their combined effect on instruments, portfolios, and the complex relationships that different interactions of factors and the changes in those interactions produce. An increasing number of books have covered both basic and advanced risk management theory and applications. Understanding model assumptions and calibration is important in order to provide the best explanatory power. Sometimes there is insufficient historical data, if any, and mapping to proxies may be the only option. When data becomes available, adaptive processes can be developed to incorporate the new information.

The most conservative aggregation of risk is a summation of risks, adding the independent totals of risk from the various risk factors, which may overstate the total risk during normal market conditions.

Diversification benefit is the reduction in risk from low or negative correlation between each risk factor. Modern portfolio theory (MPT) is based on the premise that an investor is better off in a risk vs. reward sense by mixing an investment to include other low or negatively correlated assets. From Harry Markowitz's work on the efficient frontier, the expected risk is lower for a portfolio than the average, unless the assets are perfectly correlated. The risk vs. return scatter plot of every combination of two low correlation assets will lie on a curve to the left and above the line connecting the risk vs. return points of each asset. The lower the correlation, the greater the diversification benefit. However, during times of extreme market crisis, this diversification benefit may vanish as correlations tend to 1.

Value-at-Risk (VAR) measures the magnitude of expected loss (total risk) over a given time frame based on the probability distribution and a specified confidence level, and is usually *not* the maximum possible loss. For example, for a 95 percent confidence interval, if VAR is $20 million, then the maximum loss out of 20 trials is expected to be $20 million or greater. VAR can measure the **absolute** risk of a portfolio of assets and/or liabilities or the **active** risk of the difference between a portfolio and its benchmark. VAR can aggregate across multiple risk factors like currency, interest rate risk and equity. VAR can also be forward looking (ex ante) or backward looking (ex post) as it can be based on market and/or historical data (i.e. VAR can be parametric or historical).

The time period for estimation will vary according to the application. For trading desks, the time period may be one day, while for insurers the time period may be a calendar year or calendar quarter. Banks, money managers and P&C insurers will generally use time intervals between these extremes.

There are several empirical methods by which risk is measured:

1. Ex ante standard deviation for absolute risk and tracking error for active total risk of portfolios relative to benchmarks (Barra, BlackRock, Lehman, Northfield, Risk Metrics and Wilshire)
2. Ex post is measured by evaluating actual history (Barra, MorganRisk)
3. Historical simulation (dbRiskOffice, MorganRisk),
4. Multiple-scenario simulation (Algorithmics, Measurisk, MorganRisk), or
5. Pure statistical factor models (APT).

Historical data is used to estimate a variance/covariance matrix over some period that can be used to estimate the reduction in risk from diversification; sometimes this is weighted to put more emphasis on recent events. VAR utilizes a variance covariance approach that extends the methodology described by empirical duration across many more parametric or historical estimates of risk; there is no other meaningful parametric methodology of aggregating interest rate risk across multiple currencies.

Marginal contribution of risk—once you account for the diversification benefit, the net risk is the result of the full sensitivity minus the contribution to the diversification related to the factor.

Tracking error can be an ex-ante estimate or ex-post-realized measure of the standard deviation of active outperformance/underperformance of a portfolio relative to the benchmark; it is used as a comparative measure of asset managers' active return volatility and is closely related to VAR (equals tracking error times a coefficient for the level of confidence when an assumption of a normal distribution is appropriate).

Other advanced concepts not addressed here are economic capital, downside risk, linear vs. nonlinear estimation and supplementing measures like VAR with stress tests.

References—Advanced Risk Management Metrics

Reference	*Level of Difficulty*	*Comments*
Golub, B., and L. Tilman. 2000. *Risk Management: Approaches for Fixed Income Markets*. John Wiley & Sons.	Advanced	An excellent fixed-income risk management reference that conveys more intuition and practical innovation than most other books.
Hardy, M. 2003. *Investment Guarantees: Modeling and Risk Management for Equity-Linked Life Insurance*, 1st ed. John Wiley & Sons.	Advanced	
Ho, T., M. Abbott, and A. Abrahamson. 1999. "Value at Risk of a Bank's Balance Sheet," *International Journal of Theoretical and Applied Finance* 2(1): 43-58.	Advanced	
Ho, T., M. Chen, and F. Eng. 1999. "VAR Analytics: Portfolio Structure, Key Rate Convexities, and VAR Betas in Interest Rate Risk Measurement and Management," *Institutional Investor* May.	Advanced	
Jorion, P. 1998. *Value at Risk: The New Benchmark for Managing Financial Risk.* John Wiley & Sons.	Basic	An excellent primer for VAR
Jorion, P. 2000. *Financial Risk Manager Handbook.* John Wiley & Sons.	Advanced	Intended to be a review. Touches on many aspects of risk management. Originally commissioned by GARP as a study guide for their FRM exam. See suggested reading materials for the FRM exam.
Kahn, R., and R. Grinold. 1995. *Active Portfolio Management: A Quantitative Approach for Producing Superior Returns and Controlling Risk.* Probus.	Advanced	An excellent book on risk measures as applied to investment management, covering tracking error and other advanced topics.

Reference	*Level of Difficulty*	*Comments*
Kahn, R. 1997. "Fixed Income Risk," in *Managing Fixed Income Portfolios*, edited by F. Fabozzi. McGraw Hill.	Basic	Describes basic risk measures and introduces absolute, relative and marginal contribution to risk.
Markowitz, H. 1959. "Portfolio Selection: Efficient Diversification of Investment" in *Cowles Foundation Monograph 16*. New Haven CT: Yale University Press.	Advanced	Seminal article on mean variance and the efficient frontier.
PRM_Self_Study_Guide.doc PRMIA's Professional Risk Manager Certification program at www.PRMIA.org.	Basic	Good overview of important core and advanced risk management sources.
www.gloriamundi.org.		Extensive compilation of VAR research

Financial Market Modeling

The choice of financial market model depends on how the model is to be applied, the data available for estimation and the computing power available. The most important factor is the model's application. If the application is pricing securities that are traded in an efficient market (or pricing insurance policies as if they were traded), then the market model should be free of arbitrage, which is called an arbitrage-free model. The Black-Scholes (1973) equity market model and the Vasicek (1977) bond market model are two of the earliest arbitrage-free models, and they are still important. Both models are single-factor models, which are complex enough to reflect important market characteristics, but simple enough to provide formulas for options on the underlying equity or bond. They are important because theory and practice focus primarily on arbitrage-free models.

In the context of theoretical financial economics, the concept of an arbitrage-free model involves some technical constructs. However, in nontechnical terms it means that a model is arbitrage-free when one cannot construct portfolios within the model that cost nothing initially, have no additional costs in the future and pay positive benefits with positive probability in the future. Two examples:

1. If a security in an arbitrage-free model pays one with probability one in the future, it must have a positive price.

2. There can be no free lottery tickets in an arbitrage-free model.

As desirable as the arbitrage-free property may seem, the requirements to eliminate arbitrage can make a model so complex that compromises are necessary in order to use it in practice. Some applications are therefore better modeled using a model that is not necessarily arbitrage-free. This approach requires that the model have a reasonable mathematical structure, allowing for estimation of parameters and goodness of fit tests. For example, a parametric model based on judgment and experience may fit a large volume of sample data empirically. There is no guarantee that the model is arbitrage-free, even if the sample data is drawn from an arbitrage-free market. However, the model can be estimated, tested and explained more easily than a model based strictly on the arbitrage-free approach.

Whenever market values of assets are important, in ALM or other applications, arbitrage-free models are appealing. There are two reasons for this. First, despite market anomalies, many practitioners believe that public markets for traded bonds, equities, currencies and their derivatives are essentially free of arbitrage. Thus, the arbitrage-free assumption can be viewed as a reflection of an actual market characteristic. Second, the arbitrage-free assumption, when cast in mathematical terms, is very powerful. It is the basis for valuation formulas such as the Black-Scholes and the Vasicek models mentioned earlier. Mathematical financial modeling theory often relies on the assumption that the market is arbitrage-free.

However, there are practical problems with arbitrage-free models. First, as the number of factors in the model increases, neat closed-form solutions (like the Black-Scholes formula) are no longer available. The equations implied by the arbitrage-free assumption are still there, but closed-form solutions are not. Moreover, numerical solutions of the equations can be sufficiently hard to obtain as to be impractical.

There is another problem, even for models with a small number of factors—the arbitrage-free approach may yield a model that has unrealistic characteristics. In other words, from a practical point of view, the arbitrage-free assumption is not enough to guarantee that the model is realistic. Of course, the requirement that a model be arbitrage-free is normally interpreted to be a necessary condition for a model to be reasonable, and nothing about sufficiency is implied. For example, the Black-Scholes model requires equity rates of return to be normally distributed, while studies of equity returns indicate that the distribution of equity returns has heavier tails than the normal distribution. Analogous comments apply to interest rate models such as the Vasicek model and the popular Cox-Ingersoll-Ross model. The

problems with arbitrage-free models may be avoided with another approach. Make a reasonable, simple model, complex enough to reflect market characteristics that you are concerned about and fit it to actual market data. The goal is less stringent than the arbitrage-free approach. The following models use this approach:

- The Wilkie model (Wilkie, D. 1986. "A Stochastic Investment Model for Actuarial Use," *Transactions of the Faculty of Actuaries* 39: 341-403.);
- Publicly available dynamic financial analysis (DFA) models such as Dynamo (described on the CAS Web site); and
- Models developed by some actuarial consulting firms.

Related discussion of this issue may be found in Panjer (1998). It is common for such economic models to be based on a core of arbitrage-free components that are merged with not necessarily arbitrage-free model components. The recent book by Alexander (2001) provides a wide range of modeling tools designed to fit real data, and these tools may or may not fit into the arbitrage-free framework.

The amount of literature available on financial market models is enormous. We are listing a few of the most important books and articles on the subject. Most papers treat arbitrage-free models. The list is subdivided into models of markets for Treasury bonds, equities, currencies, corporate bonds and markets for two or more of these. Data is important for either approach (strict arbitrage or the alternative), so we also list references for financial market data.

Arbitrage-Free Interest Rate Models

There are many ways to go about building models for interest rates. Naturally, the method that one uses will depend on the application of the model, available data, ability to estimate the model and the importance of capturing precise econometric features of the data. Other related considerations include computational tractability, ease of simulation and numerical evaluation. As the art of interest rate modeling has developed, the relative strengths and weaknesses of various model types have become much better understood. However, the intricacies of these issues are sufficiently involved that we cannot provide much detail here. The reader should be aware that these issues pervade any attempt to apply interest rate models of all classes. In this section we are referring to arbitrage-free models of the default-free term structure. In nontechnical language, these are models for U.S. Treasury securities in which there is considered to be no material risk of default. Models incorporating the risk of default (credit risk) can be constructed using many of the same tools and will be commented on in other parts of this document.

The original classes of arbitrage-free interest rate models consisted of what are now called factor models. These include Vasicek and Cox-Ingersoll-Ross models, which are now considered classical approaches to continuous-time models. Other early models were developed in discrete-time, including the Black-Karasinski (Black, F., and P. Karasinski. 1991. "Bond and Option Pricing When Short Rates are Lognormal," *Financial Analysts Journal* July: 52-59) model and the Black-Derman-Toy model (Black, F., E. Derman, and W. Toy. 1990. "A One-Factor Model of Interest Rates and Its Applications to Treasury Bond Options," *Financial Analysts Journal* (January-February): 33-39). Discussions of these discrete time models and related tools may be found in Tuckman (2002) and Panjer (1998). Sherris (1994) illustrates an efficient way to implement the Black-Derman-Toy model, the method of forward induction. Among the practical inconveniences of these pioneering models was the fact that they did not immediately allow one to produce a given yield curve. This issue can be addressed in a number of ways including:

1. An adjustment method based on tinkering with the short-rate process as in Dybvig, P. "Bond and Bond Option Pricing Based on the Current Term Structure," in *Mathematics of Derivative Securities*, edited by M. Dempster and S. Pliska, Cambridge University Press, and

2. A numerical computation of parameter values involving integral equations as in Hull and White 1990: "Pricing Interest Rate Derivative Securities," *Review of Financial Studies*, 3: 573-592. Another approach to interest rate modeling with the concept that the initial yield curve is automatically produced was developed in the seminal paper by Heath, Jarrow and Morton 1992: "Bond Pricing and the Term Structure of Interest Rates: A New Methodology for Contingent Claims Valuation," *Econometrica*, 60: 77-105.

As is always the case in modeling, what one gains in one area is often paid for by increased delicacy in some other area. Among the issues that emerge with the Heath-Jarrow-Morton (HJM) approach is that certain technical conditions must be placed on interest rate volatility in order for Monte Carlo simulation to be tractable.

Neither of the following conditions necessarily violates the most basic accepted definition of an arbitrage-free interest rate model.

- The model admits negative nominal interest rates (as can happen in the class of models with lognormal interest rates).
- The yield curve produced by the model does not agree with the yield curve observed in today's market.

If one is using forward rate (HJM) models then the issue of replicating the current yield curve does not arise but other issues arise instead.

Many of the important issues for factor and HJM models can be found in books by James and Weber (2000), Avellaneda and Laurence (1998) and Kwok (1998). A discussion of the use of principal components analysis in calibrating HJM models, which is referred to as factor analysis, may be found in Avellaneda and Laurence (1998). The general idea is to reduce the number of factors in the system and then impose "no-arbitrage" restrictions in combination with tractable and realistic volatility structures.

Another generation of models then emerged based on the ideas of Kennedy, Brace-Gatarek-Musiela, Goldstein, Björk and others. This class of models is variously referred to as random field models, LIBOR market models or string models among other names. A recent book focusing on these models is Rebonato (2003). Other types of models include:

- Positive interest rate models
- Gauge models
- Quadratic interest-rate models
- Nonlinear models
- Nonparametric models.

References for many of these models may be found in Duffie (2001).

The following two papers use regime switching to model interest rates:

- Gray, S. 1996. "Modeling the Conditional Distribution of Interest Rates as a Regime-Switching Process," *Journal of Financial Economics* 42: 27-62.
- Lee, M., and V. Naik. 1993. "The Yield Curve and Bond Option Prices with Discrete Shifts in Economic Regimes." Working Paper: University of British Columbia.

Other recent books on interest-rate modeling include Brigo and Mercurio (2001) and Hunt and Kennedy (2000).

Interest Rate Modeling with Default Risk

Government bonds are in many ways the simplest fixed-income instruments. Bonds issued by the United States government are generally considered to bear negligible default risk, as are bonds issued by many other sovereign nations. The bonds of two different governments may have different credit ratings. However, if both ratings are strong we generally model these countries in the same fashion, ignoring default risk. For example, United States government bonds and Canadian government bonds are rated AAA and may be considered to have no default risk. At any rate, such a convention is not a merely a matter of convenience; there is no default data for United States government bonds or Canadian government bonds, and thus we could not really build such a model.

More importantly, bonds issued by private enterprises generally require that default be modeled because they are secured only by that corporation's creditworthiness. These are generically referred to as corporate bonds. Some such bonds are traded, but many are not, or are traded so infrequently as to be illiquid. Liquidity risk is another consideration that is distinct from credit risk. The Society of Actuaries has sponsored research on the default experience of bonds that are privately placed and generally not traded and this is periodically published as studies on private placements. Default data and data on changes of rating class are available commercially in varying degrees of detail.

Books on credit risk modeling include Duffie and Singleton (2003); Ong (1999); Bluhm, Overbeck and Wagner (2002); and Schönbucher (2003).

Equity Models

The first equity model was the Black-Scholes model; it has normal returns with constant volatility. However, it is well documented that equity markets tend to exhibit clustering in volatility. In other words, periods of low volatility tend to be followed by periods of low volatility, while periods of high volatility tend to be followed by periods of high volatility. Several approaches have been developed to allow financial econometricians to allow accurate modeling of these effects. Some such models include:

- GARCH models
- Stochastic volatility models
- Regime-switching models

As is the case in actuarial modeling, different models share some characteristics and ideas, and the same can be said for these models. However, the philosophical and practical motivations for each of these models differ.

Regime-switching models are able to capture empirical features of equity returns such as fat tails and stochastic persistent volatility. General background reading on regime-switching models in discrete time may be found in the following references to Hamilton (1994), Tsay (2001), Kim and Nelson (1999) and Mills (1999).

One recent reference on the application of regime-switching models to equity markets is Hardy, M. 2000. "A Regime-Switching Model of Long-Term Stock Returns," *North American Actuarial Journal* 5(2): 41-53. This is the basis for a worksheet on the Society web site. A recent brief illustration of the application of this model to GMDB modeling may be found in: Stone, R. 2002. "Comparing a Lognormal Model to a Regime-Switching Lognormal Model," *Risks and Rewards* (October): 22-23.

Asset allocation in a global economy with regime switching is studied in: Ang and Bekaert. 2002. "International Asset Allocation with Regime Shifts," *Review of Financial Studies*, 15(4): 1137 – 1187.

A chapter on heavy tails in asset returns is available in: Thomas, M., and R. Reiss. 2001. *Statistical Analysis of Extreme Values: With Applications to Insurance, Finance, Hydrology and Other Fields*. 2nd ed. Birkhäuser.

Data Issues

An issue that is remarkably thorny in the implementation of all types of financial market models is data. Let us consider what one faces when implementing a basic model for Treasury bonds. Theoretical models are normally developed using zero-coupon bonds. Thus, one immediately needs zero-coupon bond data to estimate the model. In the United States, the modeler has at least two choices. One option is to use the freely available H15 data set published by the Federal Reserve. A second option is to collect data on Treasury STRIPS (real traded zero-coupon bonds).

Information on stripping algorithms, tax effects and other practical issues in yield curve modeling may be found in Anderson, Breedon, Deacon, Derry, and Murphy (1996) and Olivier de La Grandville (2001).

A host of related problems arises when one attempts to calibrate interest-rate models using forward rates. Evidently, as a practical matter, the type of model one constructs will be constrained if not dictated by the type and quality of available data. A few representative data vendors include the following:

- Bloomberg (Bloomberg Data License)
- Global Financial Data
- Ryan Labs
- Ibbotson Associates
- Datastream

For an overview of global interest rates, inflation, and market returns, see Dimson, Marsh and Stauntan (2002). A general overview of the U.S. economy may be found in Ibbotson Associates (2001).

Role of Inflation

Inflation can be an important component of ALM modeling. Inflation directly affects both sides of an insurer's balance sheet. While asset models are typically calibrated in nominal terms, this does not mean that the effects of inflation have been properly accounted for.

If a financial market model must include macroeconomic variables, one must relate all relevant variables in ways that make economic sense while still allowing for a range of reasonable outcomes that have not been seen in data. However, most practitioners would agree those improbable model features such as environments with high inflation and low interest rates should not be possible.

An interesting recent note on real versus nominal dividend yields may be found in: Wendt, R. 2002. *Risks and Rewards* (October): 4.

Practical Problems

As a practical matter, the tractable models available in the literature are of a stationary nature. By stationary we mean that the models are designed to capture aspects of the historical data such as average volatility and average interest-rate levels. While one can calibrate such models over different windows of time, the stochastic simulations one obtains from such models will not significantly deviate from the historical behavior used to calibrate the model. For the most part, this is as it should be. However, there are periods of history when there appears to be a "regime change." For example, one might argue that a change of regime occurred in

the Japanese economy in the 1990s. Among the results of this change was a decade of remarkably low nominal interest rates—negative in a few cases.

Another practical problem that can confound interest-rate models is, for want of a better term, outliers in the data. Recent interest-rate data in the United States provides an excellent example.

Discrete-Time vs. Continuous-Time Models

It is a frustrating fact in both theory and practice that more is not known about the limiting behavior of discrete-time models. For example, in some cases one is able to obtain a very satisfactory GARCH fit to an economic time series, but one is not able to formulate this model as a continuous-time stochastic differential model.

If one is going to construct discrete-time models, the issue of what time interval the model is to be used at immediately emerges (of course, this should also have been thought through even when building a continuous-time model). For example, suppose one wants to use a model for quarterly dynamic financial analysis (DFA) simulation. When a discrete-time model is estimated over quarterly data, it is usually difficult to adjust the model parameters for use in a monthly or a semi-annual simulation. If the model was formulated in continuous-time, then one is able to alter the simulation procedure to correctly generate observations at the appropriate frequency. In either case, some adjustment needs to be made.

Interpretation of Financial Market Models

An important part of being able to effectively apply financial market models is interpreting what the model has to say. When one simulates the 10-year Treasury rate, the interpretation of these results seems relatively straightforward. For example, one might say that over N paths each of 30 years in length, the rate reached a low of 2 percent, a high of 12 percent and averaged 5.6 percent. Now suppose that one is instead interested in pricing the guaranteed minimum death benefit (GMDB) for a variable annuity. Certainly one might say that over N paths each of 30 years in length the present value of the GMDB benefit reached a low of 0 percent of the benefit premium, a high of 5000 percent of the benefit premium and averaged 90 percent of the benefit premium.

One might further sum up by saying that the average present value of the GMDB benefit is its price if the simulations were done under the so-called equivalent martingale measure. (The equivalent martingale measure refers to the probability distribution for which prices are discounted expected values.) However,

when computing prices the story does not end there. One must at least be aware that the basis for this price is what it would cost to form an investment portfolio that, when properly adjusted, will be sufficient to cover all liabilities due under the GMDB benefit. In short, price is intricately linked to the hedging strategy that one must use to "lay off" the risk. Unfortunately, hedging or risk mitigation strategies work imperfectly in practice. Certainly it is well known that short selling is impossible in a disorderly market and naïve delta hedging strategies require the most activity when the underlying is the most active. While it's an advanced issue, overlooking of pricing and risk mitigation issues have been at the heart of the recent reversals in the fortunes of some insurers involved in the variable annuity business.

Reference—Interpretation of Financial Market Models

Reference	*Level of Difficulty*	*Comments*
Ang, A., and M. Sherris. 1997. "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.	Intermediate	A survey paper written for an actuarial audience on arbitrage-free term structure models and interest rate risk management.

References—Discrete-Time Term-Structure Models

Reference	*Level of Difficulty*	*Comments*
Black, F., E. Derman, and W. Toy. 1990. "A One-Factor Model of Interest Rates and Its Applications to Treasury Bond Options," *Financial Analysts Journal* (January-February): 33-39.	Basic	Presents the most popular binomial lattice model in use today.
Ho, T., and S. Lee. 1986. "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance* 41: 1011-1029.	Intermediate	Perhaps the most famous paper on binomial lattice term-structure models.
Jamshidian, F. 1991. "Forward Induction and Construction of Yield Curve Diffusion Models," *Journal of Fixed Income* 1(1): 62-74.	Advanced	Provides thorough coverage of binomial lattice models of interest.
Sherris, M. 1994. "A One-Factor Interest Rate Model and the Valuation of Loans with Prepayment Provisions," *Transactions of the Society of Actuaries* 46: 251-301, Discussion 303-320.	Intermediate	Illustrates Jamshidian's method of forward induction.

Reference	*Level of Difficulty*	*Comments*
Tian, Y. 1994. "A Reexamination of Lattice Procedures for Interest Rate-Contingent Claims," *Advances in Futures and Options Research* 7: 87-111.	Advanced	Develops a general framework for the construction of path-independent multinomial lattice approximations to single-state variable diffusion processes.

References—Survey of Continuous-Time Term-Structure Models

Continuous-time models are more sophisticated mathematically. All involve advanced mathematical tools such as stochastic calculus. Below are two elegant surveys.

Reference	*Level of Difficulty*	*Comments*
Back, K. 1996. "Yield Curve Models: A Mathematical Review," in *Option Embedded Bonds*, edited by J. Lederman, R. Klein, and I. Nelkin. Irwin.	Advanced	
Vetzal, K. 1994. "A Survey of Stochastic Continuous Time Models of the Term Structure of Interest Rates," *Insurance: Mathematics and Economics* 14: 139-161.	Advanced	

References—Books

Reference	*Level of Difficulty*	*Comments*
Alexander, C. 2001. *Market Models: A Guide to Financial Data Analysis.* John Wiley & Sons.	Intermediate	Provides a range of econometric and statistical modeling tools that can be used to capture many of the important aspects of real financial data.
Anderson, N., F. Breedon, M. Deacon, A. Derry, and G. Murphy. 1996. *Estimating and Interpreting the Yield Curve*. John Wiley & Sons.	Advanced	Provides information on stripping algorithms, tax effects, and other practical issues in yield curve modeling.
Avellaneda, M., and P. Laurence. 1998. *Quantitative Modeling of Derivative Securities: From Theory to Practice.* Chapman & Hall/CRC.	Advanced	Covers important issues for factor models and HJM models.
Babbel, D., and C. Merrill. 2000. *Valuation of Interest-Sensitive Instruments*. M-FI96-2. Schaumburg, IL: Society of Actuaries.	Advanced	Intended to be an introduction to the topic.
Baxter, M., and A. Rennie. 1997. *Financial Calculus: An Introduction to Derivative Pricing*. Cambridge University Press.	Advanced	Authors try hard to be user-friendly and are willing to give up mathematical rigor. Recommended if the reader wants to read only one book.

Reference	*Level of Difficulty*	*Comments*
Bluhm, C., L. Overbeck, and C. Wagner. 2002. *An Introduction to Credit Risk Modeling*. CRC Press.	Advanced	
Brigo, D., and F. Mercurio. 2001. *Interest Rate Models*: *Theory and Practice*. Springer-Verlag.	Advanced	Detailed coverage of one-factor (discrete and continuous), two-factor models and the HJM model. It has a particular emphasis on LIBOR market models and the calibration of market models. The final three chapters of the book deal with the application of the models to the pricing of derivatives.
Campbell, J., A. Lo, and A. MacKinley. 1997. *The Econometrics of Financial Markets*. Princeton University Press.	Advanced	Interest rate models are treated in Chapters 10 and 11. Has extensive discussion on empirical evidence and statistical techniques.
de La Grandville, O. 2001. .*Bond Pricing and Portfolio Analysis*. MIT Press.	Advanced	Provides information on stripping algorithms, tax effects and other practical issues in yield curve modeling.
Dimson, E., P. Marsh, and M. Staunton. 2002. *Triumph of the Optimists: 101 Years of Global Investment Returns*. Princeton University Press.	Intermediate	Provides an overview of global interest rates, inflation and market returns.
Duffie, D. 2001. *Dynamic Asset Pricing Theory*. Princeton University Press.	Advanced	Widely used in finance doctoral programs and covers all topics mentioned in this section.
Duffie, D., and K. Singleton. 2003. *Credit Risk*. Princeton University Press.	Advanced	Provides an in-depth treatment of pricing and managing credit risk.
Financial Analysts Journal.	Intermediate	
Hamilton, J. 1994. *Times Series Analysis*. Princeton University Press.	Advanced	Provides general background reading on regime-switching models in discrete time.
Hunt, J., and J. Kennedy. 2000. *Financial Derivatives in Theory and Practice*. John Wiley & Sons.	Advanced	An excellent book of a more technical nature, containing some insightful comments such as those in section 8.3 (page 187) on modeling the term structure. It also includes a good discussion of the historical importance and development of market models on page 316.

Reference	*Level of Difficulty*	*Comments*
Ibbotson Associates. 2001. *Stocks, Bonds, Bills and Inflation 2002 Yearbook Market Results for 1926 – 2001*. Ibbotson Associates.	Intermediate	Provides a general overview of the U.S. economy.
James, J., and N. Weber. 2000. *Interest Rate Modeling*. John Wiley & Sons.	Advanced	An encyclopedic treatment of interest rates and interest rate derivatives.
Jarrow, R. 2002. *Modeling Fixed Income Securities and Interest Rate Options.* Stanford University Press.	Advanced	Applies the HJM model to price and hedge fixed-income securities and interest rate options. The author claims that the book is accessible to MBAs and advanced undergraduates.
Kim, C., and C. Nelson. 1999. *State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications*. MIT Press.	Advanced	Provides general background reading on regime-switching models in discrete time.
Kwok, Y. 1998. *Mathematical models of Financial Derivatives.* Springer-Verlag.	Advanced	Covers important issues for factor models and HJM models.
Mills, T. 1999. *The Econometric Modelling of Financial Time Series.* Cambridge University Press.	Advanced	Provides general background reading on regime-switching models in discrete time.
Ong, M. 1999. *Internal Credit Risk Models: Capital Allocation and Performance Measurement.* Risk Books.	Advanced	
Panjer, H., ed. 1998. *Financial Economics: With Applications to Investments, Insurance and Pensions.* Schaumburg, IL: Actuarial Foundation.	Intermediate	Attempts to capture some of the key elements of financial economics with a strong emphasis on applications in investments, insurance and pensions.
Rebonato, R. 1996. *Interest-Rate Option Models: Understanding, Analyzing and Using Models for Exotic Interest-Rate Options*. John Wiley & Sons.	Advanced	
Rebonato, R. 2003. *Modern Pricing of Interest-Rate Derivatives*. Princeton University Press.	Advanced	
Schönbucher, P. 2003. *Credit Derivatives Pricing Models: Models, Pricing, and Implementation*. John Wiley & Sons.	Advanced	An in-depth discussion of state-of-the-art credit risk tools together with discussion of estimation and implementation issues.

Reference	*Level of Difficulty*	*Comments*
Thomas, M., and R. Reiss. 2001. *Statistical Analysis of Extreme Values With Applications to Insurance, Finance, Hydrology, and Other Fields*. Birkhäuser.	Advanced	
Tsay, R. 2001. *Analysis of Financial Time Series*. John Wiley & Sons.	Advanced	Presents the basic concepts of hedging and pricing in fixed-income markets in an intuitive way with a minimum of mathematical rigor.
Tuckman, B. 2002. *Fixed Income Securities: Tools for Today's Markets*. John Wiley & Sons.	Intermediate	Provides general background reading on regime-switching models in discrete time.

Derivatives

Asset-liability management is a decision-making process. The use of derivatives is an integral part of the process. Understanding the general functionality and use of derivatives in the ALM process is very important. As a basic requirement, the ALM personnel should, at minimum, be equipped with the fundamental knowledge of the general 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. One example is 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, of purchasing 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 option holder will let the option expire worthless. Similarly, for 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 very desirable to hedge risks embedded in the liabilities, such as the minimum guarantee on a fixed annuity.

Another example is to adjust or hedge market exposure using bond futures contracts. A futures contract is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain price. Futures allow the user to participate in market movement without committing large amounts of assets. This property makes it very desirable to hedge the timing of cash flows. For example, suppose that an insurance company is selling interest-rate-sensitive products. A client committed $X million in this product, which 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 the futures contract:

1. The futures contract allows the investor to participate in the market movement (long position in the market) while not 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 uses standardized contracts and many of the contracts are liquid.

3. One can tailor a futures portfolio to match a duration target with a minimal transaction cost.

4. 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.

One can achieve similar goal using forward contracts. Similar to the futures contract, a forward contract is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain price. The main differences are that:

- Futures contracts are traded on the exchange market with the standard contract size and delivery date, while forward contracts are traded in the over-the-counter market.
- The size and the delivery date of a forward contract can be customized to meet particular needs of the parties.
- Futures contracts require deposit of a variation margin to limit credit risk.

An interest rate swap is another example of managing the portfolio using derivatives. It can be used for the purpose of asset-liability duration management or cash-flow matching. By overlaying a swap, a portfolio manger can purchase attractive assets regardless of the swap's duration. By employing swaps, a portfolio manager can achieve his or 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 a lot of transaction costs and may also increase current taxes. The transaction costs 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 a floating-rate asset portfolio is used to support fixed-rate liabilities.

Derivatives Pricing

The intention of this section is not only to understand the pricing models and algorithms themselves, although that is a very important part of it, but also to introduce the same logic of thinking in product design, which may be the most crucial point of ALM. In order to keep the competitiveness in the marketplace, almost all insurance companies offer embedded options in their products. Employing well-thought and reasonably priced embedded options will reduce the majority of unhedgable 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 the pricing actuaries and those who are interested in this topic. Even though the references here are all on derivatives pricing, the 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 with the fewest references. Due to the complexity of liability products, there is no standard way of hedging risks in the ALM process. Thanks to 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 counterparty), interest rate floors contracts to hedge the minimum guarantees of an SPDA, or put options or interest rate caps to hedge the

surrender risk of SPDAs. We have tried to list as many references as possible for this section. 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.

References—General Functionality

Reference	*Level of Difficulty*	*Comments*
Cox, J., J. Ingersoll, Jr., and S. Ross. 1985. "A Theory of the Term Structure of Interest Rates," *Econometrica* 53: 363-384.		
Cox, J., and M. Rubinstein. 1985. *Options Markets*. Englewood Cliffs, NJ: Prentice-Hall.	Advanced	The major graduate school textbook on options pricing in the latter half of the 1980s.
Derivatives Week, www.derivativesweek.com. "Learning Curve."	Intermediate	Section called "Learning Curve" which introduces one derivatives structure each week. There is also a book by Derivatives Week, which is a collection of all "Learning Curves" published to date.
Derman, E., and I. Kani. 1993. "The Ins and Outs of Barrier Options," *Quantitative Strategies Research Notes*. June. Goldman Sachs.	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, F. (ed.) 1997. *Handbook of Fixed Income Securities.* 5th ed. Part 7, 1139-1287. McGraw Hill.	Basic	Part 7 gives an overview of all derivatives. There is a significant overlap with John Hull's *Options, Futures and Other Derivative Securities,* but with a very different approach in style. This book only uses very descriptive definitions and examples. It suits those who only want to have a general knowledge about derivatives while John Hull's book allows the readers to dig deeper into the logic and algorithms.

References—Derivatives Pricing

Reference	*Level of Difficulty*	*Comments*
Black, F., E. Derman, and W. Toy. 1990. "A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options," *Financial Analysts Journal*. January-February: 33-39.	Advanced	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 ease of use.
Black, F., and M. Scholes. 1973. "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*. May-June: 637-654.	Intermediate	The most important and fundamental paper on options pricing. Criticism of its assumptions should not make this paper less meaningful.
Gerber, H., and E. Shiu. 1994. "Option Pricing by Esscher Transforms," *Transactions of the Society of Actuaries* XLVI: 51-92.	Advanced	Shows that a classical actuarial technique, the Esscher transform, is an effective tool for pricing options and other derivative securities.
Gerber, H., and E. Shiu. 1996. "Actuarial Bridges to Dynamic Hedging and Option Pricing," *Insurance: Mathematics and Economics*. 18: 183-218.	Advanced	Presents modern option-pricing theory in the framework of actuarial risk theory.
Heath, D., R. Jarrow, and A. Morton. 1990. "Bond Pricing and the Term Structure of Interest Rates: A Discrete Time Approach," *Journal of Financial and Quantitative Analysis*. 25(4): 419-500.	Advanced	This is the well-known HJM model. It is theoretically complete, but hard to implement. It takes time for complete reading. This article is only recommended to those who are very strong in mathematics and statistics, and are very interested in interest rate term structure and derivative pricing.
Ho, T., and S. Lee. 1986. "Term Structure Movements and Pricing Interest Rate Contingent Claims," *The Journal of Finance*. 41 December: 1011-1029.	Intermediate	Introduces a methodology to construct subsequent term structures from a given term structure. It developed the framework for pricing contingent claims.

Reference	*Level of Difficulty*	*Comments*
Hull, J. 2003. *Options, Futures and Other Derivative Securities.* 5th ed. Prentice Hall.	Basic/Intermediate	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 the beginners, and the rest suits those who want to learn more and perhaps do some hands-on programming. The difficulty level is low to medium.

Recommended Journals

ASTIN Bulletin	http://www.casact.org/library/astin/
Finance and Stochastics	http://link.springer.de/link/service/journals/00780/index.htm
Insurance: Mathematics and Economics	http://www.elsevier.com/homepage/sae/econworld/econbase/insuma/frame.htm
Journal of Financial Economics	http://jfe.rochester.edu/
Journal of Finance and Quantitative Analysis	http://www.jfqa.org/
Mathematical Finance	http://www.blackwell-synergy.com/servlet/useragent?func=showIssues&code=mafi
	http://www.soa.org/bookstore/naaj.html
North American Actuarial Journal	http://www.iijfi.com/
The Journal of Fixed Incomes	http://rfs.oupjournals.org/
The Review of Financial Studies	http://www.afajof.org/jofihome.shtml
The Journal of Finance	http://www.iijpm.com/
The Journal of Portfolio Management	http://www.iijod.com/
Journal of Derivatives	

Credit Derivatives—Credit Default Swap

A credit default swap is a contract between the credit protection buyer (to mitigate the credit risk) and the credit protection seller (to achieve the credit risk exposure) on a given credit name or a "reference entity." The protection buyer pays the protection seller a periodic (or up-front) premium. (The periodic premium is equivalent to the corporate bond spread over LIBOR.) In case of default (or credit event defined in the contract,) the protection seller would pay the protection buyer the loss associated with the credit event either in the form of a cash settlement or actual security delivery. In the former, the protection seller pays the difference between par and the reference security's "market price." In the latter, the protection buyer delivers the reference security to the protection seller and receives par. Both the reference entity and the reference securities are predefined in the credit swap contract. There are also credit derivatives contracts on a basket of corporate bond names instead of with just one reference entity.

Credit default swaps are a credit risk transfer tool. Via credit default swap contracts, the credit default risk is transferred from the protection buyer to the protection seller. From a credit risk exposure point of view, selling credit default protection is similar to purchasing corporate bonds outright.

The credit default swap, however, gives the investors more flexibility to customize the term of the risk exposure. For example, one can achieve a five-year credit risk exposure on a certain entity by selling a five-year default protection when that entity has no five-year corporate bond issues outstanding in the cash market. One can also hold a 30-year corporate bond and buy a two-year credit default protection to capture the long-term upside of the bond while protecting the short-term credit risk. Credit default swaps are also a way to get into markets when outright cash instruments are not readily available. Credit default swap contracts can be on a single entity or on a portfolio of entities.

There are many participants in the credit default swap market. The buyers include banks, brokerage firms, corporations and fund managers who want to hedge their credit risk exposure from the operating side of the business or from their credit market exposure. Insurance and reinsurance companies tend to be sellers of credit default swaps for different reasons. Reinsurers use credit default swaps as a means to get into "credit risk reinsurance" to diversify their reinsurance business. Insurance companies tend to use credit derivatives as a yield enhancement tool for their investment portfolio.

For the most part, the credit default swap is as liquid (or illiquid) as cash instruments are. The default swap spreads are, in general, very comparable to the spread over LIBOR of the reference securities. Short-term spread disparity does happen from time to time due to market technical reasons.

For strategic ALM purposes, cash instruments should be considered first. Credit derivatives can be used for short-term corporate bond default risk hedging purposes or other tactical reasons. There are special features of credit derivatives that the users should be aware of. One of these features is the treatment of debt restructuring.

Other New Corporate Bond Products

There are other corporate bond "closed-end fund" types of products in the marketplace. The purpose of such products is to give investors quick access to the corporate bond market with reasonably diversified exposure. These products typically consist of large liquid corporate issues with similar maturity within a given quality range and are diversified across broad industrial sectors. Once chosen, the individual bonds in a product are fixed subject only to pre-defined rules.

Morgan Stanley introduced its first such product, a 10-year TRACERS Series 2002-1, in October 2001. It consists 35 corporate bonds with the maturity range from 2009 to 2011. (Please refer to Bloomberg with cusip ID 61744AAD2 for more detail.) They subsequently issued five-year TRACERS and 30-year TRACERS.

Other brokerage firms also started developing such products. Lehman Brothers created its version of such a product, called TRAINS. Some other firms are also contemplating such products. There are also exchange-traded corporate bond funds available. These corporate bond exchange-traded funds (ETFs) are also convenient ways to achieve quick corporate bond exposure for ALM purposes. Please refer to the Chicago Mercantile Exchange and the Chicago Board Options Exchange Web sites for detailed available ETFs.

In the long-term ALM process, insurance companies should still invest in multi-sector, well diversified, actively managed portfolios. However, these types of diversified corporate bond products allow investors to get quick market exposure and reduce market-timing risk at the portfolio ramp-up stage. They are not a long-term substitution for corporate bond portfolio management.

References

Reference	*Level of Difficulty*	*Comments*
Caouette, J., E. Altman, and P. Narayanan. 1998. *Managing Credit Risk: The Next Great Financial Challenge*. John Wiley & Sons.		Has a very comprehensive explanation of credit-risk-related topics (Chapters 9, 15, 16, 17, 18). Chapter 20 focuses on credit derivatives, but it is always beneficial to understand the credit risk, credit risk pricing (spread) and the implications to the corporate bond (including bank loans and private placements) investment process before applying the derivatives form of such risks for either hedging purposes or for initiating risk exposure.
Chicago Board Options Exchange (CBOE) Web site: www.cboe.com.		
Chicago Mercantile Exchange (CME) Web site: www.cme.com.		
Crouhy, M., R. Mark, and D. Galai. 2001. *Risk Management*. 1st ed. McGraw Hill.		Chapter 11 covers various industry-sponsored credit risk models and is a good overview of the credit risk management systems marketplace. Note: some changes in the credit risk systems market may not be reflected here.
Das, S., et al. 2000. *Credit Derivatives and Credit Linked Notes.* 2nd ed., John Wiley & Sons.		This might be the most comprehensive book about credit derivatives. It consists of a collection of chapters contributed by influential academia and practitioners in the credit risk analysis and credit derivatives area. Chapter 1 goes into detail about the structure of credit derivatives transactions. There are many chapters focusing on the application, analytics, pricing and legal issues of credit derivatives. The contents range from basic to advanced.

Reference	*Level of Difficulty*	*Comments*
Francis, J., J. Forst, and J. Whittaker. 1999. *The Handbook of Credit Derivatives*. McGraw Hill.		
Hull, J., and A. White. 2000. "Valuing Credit Default Swaps I," *Journal of Derivatives* 8(1). Hull, J., and A. White. 2001. "Valuing Credit Default Swaps II," *Journal of Derivatives* 8(3).		
Nelken, I. 1999. *Implementing Credit Derivatives*. McGraw Hill.		
Schwartz, R., and C. Smith Jr. 1997. *Derivatives Handbook: Risk Management and Control*. 1st ed. John Wiley & Sons.	Intermediate	Chapter 2 of this handbook is about credit derivatives.

Selected Web Sites Regarding Research on Credit Risk Analysis

- Credit Metrics Technical Document: www.riskmetrics.com
- Moody's KMV model: www.creditedge.com
- UBS Warburg: www.creditdelta.com
- Algorithmics: www.algorithmics.com
- Most brokerage firm Web sites

Fair Value of Liabilities

Background

Classical economic theory attempts to explain the interactions of buyers and sellers of goods, including capital and labor. These interactions, taken together, are said to form a "market." The transactions occurring in a market permit observations of the amounts of one good that is needed, at a particular instant, to complete an exchange for a given amount of another good. In this way, the market provides an objective valuation of one good in terms of another.

However, if market trades for a good are infrequent, or if the market for such a good is known to be inefficient or incomplete, it may be difficult to obtain a market value. In such cases, it may nevertheless be possible to assign a value using information known about the market values of other goods with similar characteristics. Such a value is called a fair value. More precisely, a fair value is an

estimate of the price of a good provided by a market value model for another good with similar characteristics if the model is potentially valid with respect to observations of prices and other market behavior of the first good. Liabilities often require use of the concept of "fair value" because they often do not have a market value.

The reference "Principles Underlying Actuarial Science," exposure draft, October 15, 1999" provides additional development and discussion of the concept of fair value.

References—Fair Value of Liabilities, Background

Reference	*Level of Difficulty*	*Comments*
Casualty Actuarial Society Committee on Principles, and Society of Actuaries Committee on Actuarial Principles. 1999. "Principles Underlying Actuarial Science," Exposure draft. October 15, 1999.	Basic	The objective of this exposure draft is to articulate the current understanding of the significant principles that form the scientific framework underlying all areas of actuarial practice. The exposure draft includes the following sections: Statistical Framework, Economic and Behavioral Framework, Principles Underlying Actuarial Modeling and Risk Management, and Principles Underlying Financial Security Systems. The exposure draft can be viewed at: http://www.soa.org/ccm/content/research-publications/research-projects/exposure-draft-principles-underlying-actuarial-science/

stock markets within the European Union (EU) must report using IASB standards. However, the IASB issued a Draft Statement of Principles – Insurance Contracts, scheduled for completion in 2003, but it is not expected to be fully implemented by the 2005 timeframe.

Given the unfolding standards, please refer to the accounting websites and the various actuarial societies (www.actuary.org, www.actuaries.org, www.actuaries.org.uk, www.casact.org) for current developments and comments. In particular, the American Academy of Actuaries published a public policy monograph entitled, *Fair Value Principles and Methods* in September 2002 (www.actuary.org/pdf/finreport/fairval_sept02.pdf) and the International Actuarial Association has a comprehensive index of topics on standards issues www.actuaries.org/public/en/committees/insstddocuments.cfm). Finally, this topic is covered at many national actuarial meetings along with special conferences or major actuarial consulting or accounting Web sites. Obviously, the actuarial profession should have considerable input into these accounting developments.

At a high level, the IASB is moving toward a 'balance sheet' (or prospective) approach rather than an 'income statement' (or deferral and matching) focus that has been the cornerstone of FASB. Two alternatives, known as the "entity-specific value" and "fair value," are being considered to introduce this new approach. Both methods focus on determining the present value of cash flows that the enterprise will incur in settling its obligations to its policyholders over the life of its liabilities. The principal difference between the two methods is whether the company may reflect factors and assumptions based on its own experience (i.e., entity specific) or must always use those consistent with an arm's length transaction between knowledgeable, willing parties (i.e., fair value).

To begin to understand fair value, it is suggested that one review, "The Coming Revolution in Insurance Accounting" by Gutterman, which provides an overview of the impetus, approaches, assumptions and techniques. Then read the Reitano paper that outlines the two actuarial approaches:

1. The direct (or option-pricing) method which discounts liability cash flows, and
2. The indirect (or actuarial appraisal) method, which computes this value by subtracting the market value of distributable earnings from the market value of assets.

Girard shows these methods produce the same results using consistent assumptions. Babbel, Merrill and Gold provide three methods to determine the fair value of liabilities via the direct approach. With the above as background, the reader should

be able to identify the debatable topics and issues of the underlying assumptions such as market value of margins (MVM), discounting methods (including credit spreads) and measurement / reporting. Further information on these topics can be obtained from articles in the *North American Actuarial Journal* or newsletters from the various SOA sections (*Risks and Rewards, The Financial Reporter*). Additional readings are provided as examples or case studies.

References—Draft Accounting Standards

Reference	*Level of Difficulty*	*Comments*
International Accounting Standards Committee (IASC). 1999. "Insurance Issues paper." London: IASC.		www.iasc.org.uk/cmt/0001.asp?s=1655339&sc={33f552b2-ffa2-4278-a9b1-e3127736ddb2}&n=3225. This issues paper generated 138 responses from various actuaries, companies and associations. They are available at http://www.iasc.org.uk.
International Accounting Standards Board (IASB). 2001. "Draft Standards of Principles: Insurance Contracts." London: IASB.		www.iasc.org.uk/cmt/0001.asp?s=1655339&sc={33F552B2-FFA2-4278-A9B1-E3127736DDB2}&n=4124.

References—Actuarial Task Force Reports

Reference	*Level of Difficulty*	*Comments*
American Academy of Actuaries. 2002. "Fair Valuation of Insurance Liabilities: Principles and Methods." Washington, DC: AAA.		www.actuary.org/pdf/finreport/fairval_sept02.pdf.
Casualty Actuarial Society Task Force on Fair Value Liabilities. 2000. "White Paper on Fair Valuing Property/Casualty Insurance Liabilities." Arlington, VA: CAS.		http://casact.org/research/tffvl/whitepaperfinal.PDF.
International Actuarial Association (IAA) Comments to the IASC Insurance Issues Paper. 2000. "General Overview of a Possible Approach to Insurance Liabilities: Valuation and Capital Requirements." "Valuation of Risk-Adjusted Cash Flows and the Setting of Discount Rates—Theory and Practice."		In the 'Members' section of www.actuaries.org.

References—Theoretical Readings and Examples

Reference	*Level of Difficulty*	*Comments*
Abbink, M., and M. Saker. 2002. *Getting to Grips with Fair Value*. London: Staple Inn Actuarial Society.		www.sias.org.uk/papers/fairvalue.pdf.
Babbel, D., and C. Merrill. 1998. "Economic Valuation Models for Insurers," *North American Actuarial Journal* 2(3).		www.soa.org/bookstore/naaj.html.
Girard, L. 2000. "Market Value of Insurance Liabilities: Reconciling the Actuarial Appraisal and Option Pricing Methods," *North American Actuarial Journal* 4(1).		www.soa.org/bookstore/naaj.html.
Babbel, D., J. Gold, and C. Merrill. 2002. "Fair Value of Liabilities: The Financial Economics Perspective," *North American Actuarial Journal* 6(1). Gutterman, S. 2002. "The Coming Revolution in Insurance Accounting," *North American Actuarial Journal* 6(1). Perrott, G., and W. Hines. 2002. "Fair Value Accounting Compared to Other Accounting Systems," *North American Actuarial Journal* 6(1). Wallace, M. 2002. "Performance Reporting under Fair Value Accounting," *North American Actuarial Journal* 6(1).		www.soa.org/bookstore/naaj.html. Has been part of the SOA exam syllabus. The February 2001 issue of *Risks and Rewards* provides a subset of this article ("The Bullet GIC as an Example"). This issue also includes "Beyond the Bullet GIC" by Stephen Strommen, and "The Cost of Capital Assumption in Actuarial Appraisals: An Application of Fair Value of Liability Concepts" by Gregory Goulding. The January and April 2002 editions of the *North American Actuarial Journal* contain several contributions from the 2001 Bowles Symposium.

Reference	*Level of Difficulty*	*Comments*
Girard, L. 2002. "An Approach to Fair Valuation of Insurance Liabilities Using the Firm's Cost of Capital," *North American Actuarial Journal* 6(2). Gutterman, S. 2002. "The Evolving Role of the Actuary in Financial Reporting of Insurance," *North American Actuarial Journal* 6(2). VanBroekhoven, H. 2002. "Market Value of Liabilities Mortality Risk: A Practical Model," *North American Actuarial Journal* 6(2).		www.soa.org/bookstore/naaj.html Has been part of the SOA exam syllabus.
Reitano, R. 1997. "Two Paradigms for the Market Value of Liabilities," *North American Actuarial Journal* 1(4): 104–134.	Intermediate	www.soa.org/bookstore/naaj.html 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.
American Academy of Actuaries Fair Valuation of Liabilities Task Force. 1998. "Fair Valuation of Life Insurance Company Liabilities," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Becker, D. 1998. "A Market Value Accounting Framework for Insurance Companies," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Griffin, M. 1998. "A Market Value Accounting Framework for Insurance Companies," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers.		This two-volume package contains several papers that were presented Dec. 7–8, 1995 at a conference held at the New York University Stern School of Business.

Reference	*Level of Difficulty*	*Comments*
McLaughlin, M. 1998. "Indexed Discount Rate Method," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Mehta, S. 1998. "Allowing for Asset, Liability and Business Risk in the Valuation of a Life Company," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. O'Brien, C. 1998. "The Derivation and Application of Accounting Standards to the Market Value of Liabilities," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Ostaszewski, K. 1998. "Is Paul vs. Virginia Dead?" in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers.		
Duran, J., and A. Vilms. 2000. "Modeling Fair-Value Financial Reporting Results for the Single-Premium Deferred Annuity," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Girard, L. 2000. "Market Value of Insurance Liabilities and the Assumption of Perfect Markets in Valuation," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Gutterman, S. 2000. "The Valuation of Future Cash Flows: An Actuarial Issues Paper," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers.		This book contains several papers presented during the conference on Fair Value of Insurance Business held in March 1999 at the Salomon Center of the Stern School of Business at New York University.

Reference	*Level of Difficulty*	*Comments*
Herget, R. 2000. "Considerations for Ascertaining Term Insurance in a Fair-Value Context," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Ho, T. 2000. "Market Valuation of Liabilities: Transfer Pricing, Profit Release and Credit Spread," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Michel, M. 2000. "Earnings, Historical-Cost Basis Book Values, and Fair Value Disclosures in the Valuation of Stock Life Insurance Companies," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers. Wallace, M. 2000. "Fair Value Accounting for Financial Liabilities," in *The Fair Value of Insurance Business*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers.		

References—Other Readings

Reference	*Level of Difficulty*	*Comments*
Asay, M., P. Bouyoucos, and A. Marciano. 1989. *An Economic Approach to Valuation of Single Premium Deferred Annuities*. Financial Institutions Research. New York: Goldman Sachs.	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, D. 1998. "The Objective (Function) of Asset/Liability Management," *Risks and Rewards*. January.		www.soa.org/library/monographs/other/m-as00-1/m-as99-1_v.pdf
Noris, P., and S. Epstein. 1991. "Finding the Immunizing Investment for Insurance Liabilities: The Case of the SPDA," *Strategy Notes.* Morgan Stanley & Co.	Intermediate	
Zenios, S., ed. 1993. *Financial Optimization*. Part II.5. New York: Cambridge University Press.		

Pension Liabilities

While much of the discussion of fair value and associated references in the Insurance Fair Value section are applicable to pension liabilities, the fair value of pension liabilities has received increased attention in recent years. Changes in accounting rules starting with the implementation of FAS 87 and followed by FAS 106 required that the pension liability be determined by using discount rates that "reflect the rates at which the pension benefits could be effectively settled." Thus, the accounting standards required that the fair value of the liability be determined and suggested that "the accumulated post-retirement benefit obligation would be equal to the current market value of a portfolio of high-quality, zero-coupon bonds whose maturity dates and amounts would be the same as the timing and amount of the expected future benefit payments." The use of the high-quality, zero-coupon curve will "ballpark" the fair value (settlement price), but needs to be adjusted for insurance company administration, overhead and investment management expenses, profits, balance sheet considerations and risk assumptions. Modugno and Ryan Labs discuss these adjustments in their papers for the Society of Actuaries research project, "30-Year Treasury Rates and Defined Benefit Pension Plans."

The accounting standards provide some latitude in their application, and the use of various indexes and rates such as Moody's AA corporate rate, as well as the expected return on assets have been used to determine the liability even though there are concerns with each. In June of 1993 the SEC sent a letter to all corporations indicating that the guidance provided in FAS 106 was appropriate and noted that the use of rates that could not be justified would be sent to the enforcement division for action.

While FAS 87 requires marking the liability to market each year, smoothing methods are permitted. FRS 17 in the UK requires similar marking to market, but no smoothing is permitted. International Accounting Standard 19, which must be implemented by 2005, is similar to FRS 17. These accounting rules are consistent with a movement to more fair value accounting. FASB Concepts Statement No. 7, "Using Cash Flow Information and Present Value in Accounting Measurements," will be the basis for future accounting standards, so it should be anticipated that even more emphasis will be placed on the determination of the fair value of pension plan liabilities. Marking both the assets and liabilities to market each year will increase the need for effective ALM. In addition to the increasing emphasis on fair value accounting, the significant loss of surplus in the 2000–2002 period with the subsequent impact on corporate earnings, balance sheets, contributions and credit ratings will increase the desire/need for effective ALM by plan sponsors

The methods used for determination of fair value vary from using a single discount rate for the projected cash flows to term structure models. Regardless of whether a single rate or term structure is used, the elimination of the 30-year U.S. Treasury bond and associated zero-coupon bonds raises the need to identify alternative portfolios that have long durations and are robust enough to determine appropriate discount rates. This issue is discussed extensively by Modugno and Ryan Labs in, "30-Year Treasury Rates and Defined Benefit Pension Plans."

The move to fair value accounting, which could cause a significant increase in the volatility of plan surplus, net income and contributions, raises questions about standard practices currently in use. The issues that surround the actuarial pension model and fair value are thoroughly discussed in the paper, "Reinventing Pension Actuarial Science," by Bader and Gold and other associated discussion papers.

Changing reporting requirements and the heightened awareness of corporate management, shareholders and taxpayers regarding the problems associated with surplus volatility are causing an increased focus on the methods to determine the fair value of pension liabilities. The methods developed to manage pension expense volatility will be different from those used to reduce the volatility of contributions and PBGC premiums. Single discount rates based on duration will not be as good as those based on the term structure. Consequently, it is important that the development of fair value be consistent with the goals of ALM.

References—Pension Liabilities

Reference	*Level of Difficulty*	*Comments*
Bader, L., and J. Gold. 2003. "Reinventing Pension Actuarial Science," *The Pension Forum* 14(2). Schaumburg, IL: SOA.	Intermediate	This can be obtained at www.soa.org/library/sectionnews/pension/pfn0301.pdf.
Financial Accounting Standards Board (FASB). 1985. "Statement of Financial Accounting Standards No. 87, Employers Accounting for Pensions." FASB.	Basic	Available from: Order Department, Financial Accounting Standards Board 401 Merrit 7 P O Box 5166 Norwalk, CT 06865-5116
Financial Accounting Standards Board (FASB). 1990. "Statement of Financial Accounting Standards No. 106, Employers' Accounting for Postretirement Benefits Other Than Pensions." FASB.	Basic	Available from: Order Department Financial Accounting Standards Board 401 Merrit 7 P O Box 5166 Norwalk, CT 06865-5116

Reference	*Level of Difficulty*	*Comments*
Financial Accounting Standards Board. 2000. "FASB Concepts Statement No. 7, Using Cash Flow and Present Value in Accounting," FASB.	Basic	Available from: Order Department Financial Accounting Standards Board 401 Merrit 7 P O Box 5166 Norwalk, CT 06865-5116
Society of Actuaries Pension Section and Committee on Retirement Systems Research. 2001. "30-Year Treasury Rates and Defined Benefit Pension Plans." Schaumburg, IL: SOA.	Intermediate	This can be obtained at www.soa.org/sections/dbpp.pdf

Performance Measurement and Benchmarking

Performance measurement is a fundamental tool used to determine whether various parts of an organization are meeting or exceeding their objectives, and it is also a critical element of pension fund and insurer ALM. Within an institutional framework, ALM is often practiced under explicit and implicit constraints. In order for it to succeed, the organization must be able to measure the extent to which ALM is accomplishing its goals. While performance measurement is most commonly associated with portfolio managers, it is just as relevant to other decision-making entities in the organization. In many cases, investment-related decisions made by other parts of the organization may have a more significant impact on profitability than the portfolio manager. In most organizations there is a hierarchy of investment-related decision-making, which includes:

- **Liability driven:** The strategic asset allocation, determined by the product manager or investment committee, is driven by the liabilities.
- **Firm driven:** The chief investment officer (CIO) may determine the tactical asset allocation. It includes consideration of the timing of portfolio rebalancing, timing of the investment of surplus cash or raising cash in anticipation of payouts, opportunistic investments in anticipation of market moves and hedging decisions.
- **Style:** The selection of investment styles, such as growth or value equity portfolios, and the associated portfolio managers. This decision may include the participation of an outside consultant.
- **Security selection:** The selection, purchase and sale of individual securities by the individual portfolio manager.

In order to evaluate the effectiveness of these investment decisions, the related performance must be compared with a standard or benchmark that is appropriate. Some examples of appropriate benchmarks to evaluate the asset allocation decision include:

- A portfolio that has very similar cash flow characteristics as the liabilities.
- Asset index returns allocated according to the strategic asset allocation. The performance for the tactical asset allocation decision can be the market index returns applied to the actual portfolio allocation.
- The style/manager selection performance can be evaluated by comparing the performance of style-specific or manager-specific benchmarks with the broad market indexes for the asset class chosen for the strategic asset allocation.
- Portfolio management can be evaluated against style specific or manager specific benchmarks. A good description of how to perform such calculations is outlined in AIMR's Performance Presentation Standards.

It may also be desirable to compare investment performance of individual managers with appropriate peer group averages to determine the quality of the manager versus others with similar objectives. It may also be desirable to calculate performance relative to other institutions with similar liability profiles in order to compare returns on the actual asset portfolio against a notional portfolio that has similar expected cash flow characteristics as the underlying liabilities to assist in competitive evaluation and pricing decisions.

While all of the investment decisions need to be evaluated, the following examples of portfolio manager evaluation and investment income allocation elaborate on particular issues associated with them.

Portfolio Manager Evaluation

The primary responsibility of the portfolio manager is, of course, selection of individual securities. A complete evaluation of a portfolio generally ends with an evaluation of how the choice of individual securities affected the returns achieved. This is calculated under hypothetical conditions where the influences of cash-flow timing, asset allocation, risk parameters and other factors have been removed. This evaluation typically involves attributing actual portfolio returns to a variety of factors by comparison with an ideal "benchmark" portfolio that represents an optimal strategy. The actual portfolio returns achieved can then be attributed to controllable and uncontrollable factors, with only the controllable factors being used to evaluate the performance of the manager(s).

One of the chief uncontrollable factors, from the portfolio manager's viewpoint, is the behavior of the benchmark itself. Security prices fluctuate with interest rates, foreign exchange rates and other macroeconomic values, as well as peculiar characteristics of the benchmark itself. A portfolio manager can often match his benchmark's return exactly by following the benchmark definition in his choice of securities. Typically, a manager is evaluated on the difference between actual returns and benchmark returns.

The timing and amount of non-investment cash flows are additional uncontrollable factors. For example, a need for cash to pay surrender benefits may come at a time when portfolio values are depressed, and after a subsequent recovery, additional cash may be made available for investment. When comparing the actual portfolio returns to those of the benchmark over the same period, the benchmark returns should be adjusted to reflect the invested balances at each point in time.

Investment strategies are often defined in terms of analytic parameters and allowable ranges. Fixed-income portfolios typically specify a duration target and an allowable range of durations, while equity portfolios are sometimes constrained to a specific style such as growth or value, capitalization size (large, mid or small) or an allowable range of betas (to measure volatility relative to the market in total). Additional risk characteristics and ranges may also be specified. These limits are adopted in order to prevent portfolio managers from assuming investment positions that are not consistent with the underlying objectives and overall portfolio strategy. In some cases, constraints are also imposed by regulation, or may be adopted voluntarily in order to achieve various ratings, even if the purpose is neither to reduce risk nor increase profits.

In these situations, evaluation for performance measurement purposes involves determining the extent to which the portfolio manager has deviated from chosen norms (such as target duration), and attribution analysis will be used to determine the extent to which actual returns would have been higher or lower had the norm been followed. Return excesses or deficiencies are properly attributable to the manager's skill.

Often portfolio managers are evaluated on their returns relative to their defined benchmarks, without regard to the source of the funds they invest, since they may not be aware of the underlying liabilities or are only responsible for a portion of the assets invested. In these cases the other decision makers, who could include the product manager, CIO or consultant, must be measured and appropriately benchmarked.

Investment Income Allocation

On the other hand, it is possible for an organization to do a good job managing its asset and liability functions independently and still perform poorly overall. This may result when investment strategies are poorly defined, improperly designed, or when funding costs exceed expectations due to policyholder behavior, insured events or mismanagement. A better approach than evaluating asset and liability managers independently is to include a component of overall organization performance in their reviews. This will encourage portfolio managers to respond to emergent behavior of the liabilities, even diverging from the benchmark when new information indicates it is appropriate to do so.

The primary measurement of organizational performance is the statement of profit and loss. Profitability determination depends on measurement or estimation of all marginal impacts of a particular activity. For financial intermediaries, the most important source of profitability is the investment margin, the measurement of which requires matching liability costs with investment income from the associated assets. A major theme of ALM, explored elsewhere, is that profits may be increased, and earnings variability decreased, when complementary asset and liability positions are maintained.

Many organizations have formalized the relationship between assets and liabilities by establishing multiple asset and liability accounts, and matching groups of assets to specific groups of liabilities. Insurance companies generally refer to these groupings as segments. In the most common form of segmentation, liabilities are grouped together if the optimal investment strategies for the liabilities share similar characteristics. The match between optimal investment strategies and

optimal funding (liability) strategies is identified through analysis during the product development and approval process.

The portfolio is managed based on these common requirements, compromising when necessary among competing objectives, and investment income from the assets is allocated based on the book values of the assigned liabilities.

A common alternative to segmentation is to use the investment generation method. In this approach, assets are grouped according to the time at which they were acquired, and liability cash flows are summarized for the same periods. The periods (investment generations) may be identical in length, but it is not required. In practice, the primary factor to consider in establishing the periods is that investment conditions are relatively homogeneous within the period, but may differ from those in the periods immediately before or after. Investment income is summarized for each generation, and the income for each generation is allocated to the various liabilities based on the investment cash flow provided by each product during the generation. Companies that use this approach may also find that the allocations are useful in establishing equitable crediting rates for various groups of policyholders. Generally, asset purchases are tracked for a limited number of years based on the portfolio's liabilities and then rolled into a portfolio segment.

A third method for allocating investment income utilizes transfer pricing. Transfer pricing requires that idealized investment strategies and crediting strategies be developed for each product. Accounting using transfer pricing typically involves establishing an ALM/risk management profit center. In each reporting period, the investment income would have been earned if the idealized investment strategy is determined and credited to the liability profit center. Similarly, the cost of funding that would have emerged had the idealized crediting strategy been followed is determined and charged to the investment unit. Any difference between these two amounts is credited as profit or charged as a loss to the ALM/risk management unit. In this way, the investment and liability units are evaluated independently of each other. The ALM/risk management area is free to hedge any mismatch between the asset and liability amounts, and is evaluated based on the marginal contribution to profits associated with its hedging activities.

Segmentation and the investment generation method are commonly used within the insurance industry, while transfer pricing, a relatively new approach, has primarily been applied in the banking sector.

The published work on performance measurement using asset-liability benchmark analysis continues to emerge. The references given below should be regarded as introductory in nature.

Reference—General

Reference	*Level of Difficulty*	*Comments*
AIMR Performance Presentation Standards. 2001.	Basic	Has been part of the AIMR exam syllabus. It is available at http://www.aimr.com/standards/pps/.

References—Portfolio Manager Evaluation

Reference	*Level of Difficulty*	*Comments*
Bennett, N., and M. Murphy. 1999. "The Use of Transfer Pricing in Asset Liability Management," *Risks & Rewards*. August.	Basic to intermediate	Provides a good introduction to the topic from actuaries who have implemented the concept of benchmarking assets using the underlying liabilities.
Rennie, E., and T. Cowhey. 1990. "The Successful Use of Benchmark Portfolios: A Case Study," *Financial Analysts Journal* (Sept.-Oct.): 18-26.	Intermediate	Has been part of the SOA exam syllabus.

References—Investment Income Allocation

Reference	*Level of Difficulty*	*Comments*
Attwood, J., and C. Ohman. 1983. "Segmentation of Insurance Company General Accounts," *Transactions of the Society of Actuaries* XXXV.	Basic	Very old material, but still provides a thorough discussion of segmentation issues.
Dietz, P., and J. Kirschman. 1990. "Evaluating Portfolio Performance," Chapter 14 in *Managing Investment Portfolios.* 2nd ed., edited by J. Maginn and D. Tuttle. Warren, Gorham and Lamont.	Intermediate	Has been part of the SOA and AIMR exam syllabus.
Reilly, F., 1994. " Evaluation of Portfolio Performance," Chapter 26 in *Investment Analysis and Portfolio Management*. 4th ed. Dryden Press.	Intermediate	Good introduction to some important concepts, including the notion of risk-adjusted performance and customized benchmarks.
Spaulding, D. 1997. *Measuring Investment Performance—Calculating and Evaluating Risk and Return*. 1st ed. McGraw Hill.	Intermediate	
The Journal of Performance Measurement.	Intermediate	www.spauldinggrp.com

Applications of ALM

Corporate ALM

How does a financial institution set up an ALM capability, and then once established, what ground rules need to be established? This section of the guide focuses on such aspects of corporate ALM. There is much discussion about where corporate ALM stops and corporate risk management begins. Some practitioners focus on interest rate risk when discussing ALM, while others include all financial risks in their discussion. Corporate governance is a related topic that is generating more interest. The Canadian Institute of Actuaries completed an ALM survey in 2001, with their practitioners painting a broad stroke of ALM. The references cited here will focus on interest rate risk.

While interest rate risk should also be managed by product, solvency is measured at the enterprise level. Measures such as duration and convexity can be calculated for the firm, allowing the management team options to manage interest rate risk. These measures show how sensitive the value of a block of policies or a company is relative to a change in interest rates. Simply put, a duration of 1.0 means that the value, or price, of a security declines by 1 percent for each 1 percent increase in interest rates (e.g., 3 percent to 4 percent).

The establishment of an ALM capability involves many important decisions that need to be made at an early stage and 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 have a senior-level ALM committee or working party that makes important ALM decisions on a regular basis. Decisions that need to be made in establishing such a committee include:

- How to set up such a committee;
- Who should be on the committee;
- What the committee should be responsible for; and
- What structure needs to be in place to allow the committee's decisions to be implemented.

Once a committee is in place, what ground rules need to be established? What are the considerations that need to be made when looking at ALM at the enterprise level? Such questions encompass many important elements:

- Corporate governance;
- Trading rules, e.g., no more than 5 percent of funds to be held in international investments or in a single holding;
- Rules for derivatives trading and bookkeeping; and
- Procedures for the reporting of ALM decisions and results across the corporation.

The amount of literature on corporate ALM and financial risk management is expanding continuously, and the reader should include an Internet search on the topic as part of their research.

Some of the newer texts by Shimpi, Culp and McKinsey look at both the role of the chief risk officer and economic capital allocation.

References

Reference	*Level of Difficulty*	*Comments*
Babbel, D., and A. Santomero. 1996. "Risk Management by Insurers: An Analysis of the Process." Working paper 96-16, The Wharton School, Philadelphia, PA.	Intermediate	A very good read for someone with good product knowledge looking to understand risk management issues. Available at http://knowledge.wharton.upenn.edu/PDFs/236.pdf
Babbel, D., and F. Fabozzi. 1999. *Investment Management for Insurers*. John Wiley & Sons.		Has been part of the SOA exam syllabus.
Babbel, D., and C. Merrill. 2000. *Valuation of Interest-Sensitive Financial Instruments*, Monograph M-FI96-2. Schaumburg, IL: Society of Actuaries.	Intermediate	Has been part of the SOA syllabus and provides a very good introduction to technical models used to value securities with options.
Canadian Institute of Actuaries. 1994. "An Overview of an Investment Policy Statement in an Asset/Liability Management Context." CIA Guidance Note, Ottawa, Ontario: CIA.		Has been part of the SOA exam syllabus.

Reference	*Level of Difficulty*	*Comments*
Canadian Institute of Actuaries. 1995. "Measurement of Exposure to Interest Rate Risk." Educational Note, Ottawa, Ontario: CIA.		Has been part of the SOA exam syllabus.
Canadian Institute of Actuaries Committee on Investment Practice—Working Group on Asset Liability Management. 2002. "Results of the Survey on Asset Liability Management Practices of Canadian Life Insurance Companies." Ottawa, Ontario: CIA.	Basic/Intermediate	www.actuaries.ca/publications/2002/202029e.pdf
Crouhy, M., R. Mark, and D. Galai. 2001. *Risk Management.* 1st ed. McGraw Hill.		
Culp, C., and M. Miller. 1999. *Corporate Hedging in Theory and Practice.* Risk Books.		
Culp, C. 2001. *The Risk Management Process: Business Strategy and Tactics.* John Wiley & Sons.	Intermediate	Focuses on integrating risk management with corporate business strategy, addressing practicalities along with the big picture.
Culp, C. 2002. *The ART of Risk Management*. John Wiley & Sons.	Intermediate	Focuses on the practical aspects of alternative risk transfer.
Daskais, R., and D. LeSueur. 1993. "An Introduction to Duration for Pension Actuaries," *The Pension Forum* 8(1).		Has been part of the SOA exam syllabus.
Laster, D., and E. Thorlacius. 2000. "Asset-Liability Management for Insurers," Swiss Re *Sigma* (June): 7-11.		Has been part of the SOA exam syllabus.
Life Office Management Association (LOMA). 2001. *Enterprise Risk Management in the Life Insurance Industry.* Atlanta, GA: LOMA Research.	Basic to Intermediate	One of a series of books that LOMA has created for its member companies. Member companies can download from www.loma.org, others can purchase the book for a fee.
McKinsey & Company Inc. et al. 2000. *Valuation: Measuring and Managing the Value of Companies*. 3rd ed. John Wiley & Sons.	Intermediate	
McKinsey & Company Inc. et al. 2000. *Valuation WorkBook*. John Wiley & Sons.	Intermediate	
Mercer Oliver Wyman, www.owc.com.		Source for corporate ALM at many global financial institutions.

Reference	*Level of Difficulty*	*Comments*
Panning, W. 1994. "Asset-Liability Management for a Going Concern," in *The Financial Dynamics of the Insurance Industry*, edited by E. Altman and I. Vanderhoof. Irwin.		Has been part of the SOA exam syllabus.
Satanove, H. 2000. "Investment Management of Retirement Plans in Canada." Study Note SN 6-32-00. Schaumburg, IL: SOA.		Has been part of the SOA exam syllabus.
Shimpi, P. et al. eds. 2001. *Integrating Corporate Risk Management.* Texere.	Basic/Intermediate	Illustrates different ways to view and solve financial problems and their effect on a corporate balance sheet. General business focus.
Society of Actuaries. 1994. "Finance Aspects of Corporate Governance." Professional Publishing Ltd. & Committee on Financial Aspects of Corporate Governance.		Has been part of the SOA exam syllabus.
Society of Actuaries. 1996. "Investment Strategy Formulation and Implementation," session 89PD in *Record of the Society of Actuaries* 22(3).		Has been part of the SOA exam syllabus.
Society of Actuaries. 1997. "Management of Insurance Company Risk," session 74OF in *Record of the Society of Actuaries* 23(2).		Has been part of the SOA exam syllabus.
Stapleford, R., and K. Stewart. 2000. "Introduction to the Formation of Investment Strategy for Life Insurance Companies and Pension Plans." Study Note SN 6-28-00. Schaumburg, IL: SOA.		Has been part of the SOA exam syllabus.
Strategic Asset Alliance at: www.saai.com.	Basic	A short introduction to the topic. This company Web site provides some readable introductions to ALM and surplus duration.

ALM in Product Development

Various regulators are turning to a company's internal stochastic models in assessing proper capital levels; in particular, the consistent usage between pricing, valuation and risk management. For actuaries, product development and ratemaking studies are included in the scope of Actuarial Standard of Practice (ASOP) Number 7, "Analysis of Life, Health, or Property/Casualty Insurer Cash Flows." Indeed, many of the new products offered by insurance companies have embedded options dependent on equity or interest rate performance. Other products have very long maturities dependent on policyholder behavior. Derivative instruments (such as options and futures) or other product features are being used to hedge some of these risks.

The following list, though not exhaustive, provides a snapshot of various insurance products and their characteristics.

References—General

Reference	*Level of Difficulty*	*Comments*
Griffin, M. 1992. "A Market-Value Accounting Framework for Insurance Companies," *The Financial Reporter.*15: 1–2.		
Hughes, M., R. Nelson, S. Gathje, and M. Davis. "Asset Liability Techniques for Product Design and Management," SOA Product Development Seminar, Reno, Nevada, September 4, 1996.		
Society of Actuaries. 1987. "Investment Considerations in Product Development," *Record of the Society of Actuaries.* 13(2): 939.		

Reference	*Level of Difficulty*	*Comments*
Society of Actuaries Dynamic Financial Condition Analysis Task Force. 1996. *Dynamic Financial Condition Analysis Handbook*. Schaumburg, IL: SOA. • "Analysis Game Plan: Issues, Considerations and Strategies." • "Liability Modeling." • "Analysis of Assets." • "Analysis of Company and Policyholder Behavior: Group Pensions." • "Analysis of Company and Policyholder Behavior: Group Life and Group/Individual Health." • "Analysis of Company and Policyholder Behavior: Individual Life and Annuities." • "Liquidity and Surplus Enhancements." • "Research Report on Selected Dynamic Solvency Testing Topics; Boundaries of Risk."	Basic	Primarily for solvency testing, of which, product pricing has a great influence.

References—Annuities

Reference	*Level of Difficulty*	*Comments*
The Actuarial Foundation and Nationwide Financial Services. 1999. "Risks in Investment Accumulation Products of Financial Institutions." Symposium proceedings, New York. Becker, D. "Risk and Policyholder Behavior in Separate Account Products." Boezio, N. "Risks in Accumulation Products: Insights from Investor Behavior." Chalke, S. "A Model of Persistency Behavior for Internet Distribution Channels." Claire, D. "Regulatory Considerations for Accumulation products."	Intermediate	A broad publication covering topics ranging from scenario testing to policyholder behavior to product management.

Reference	*Level of Difficulty*	*Comments*
The Actuarial Foundation and Nationwide Financial Services. 1999. "Risks in Investment Accumulation Products of Financial Institutions." Symposium proceedings, New York. (cont'd.) Craighead, S. "Risk in Investment Accumulation Products of Financial Institutions." Crozier, B. "The Practical Aspects of Managing Annuity Blocks of Business." Fridson, M. "What Went Wrong with the Highly Leveraged Deals? (Or, All Variety of Agency Costs)." Galochkin, V., and A. Kukush. "the Prediction of the Derivative Portfolio Price." Glacy, A. "Option Pricing in Action: The Case of SPDA." Hardy, M. "Maturity Guarantees for Segregated Fund Contracts: Hedging and Reserving." Mandelbrot, B. "A Multifractal Walk Down Wall Street." Rubenstein, M. "Comments on the 1987 Stock Market Crash: Eleven Years Later." Tenney, M. "Analyzing Interest-Rate Guarantees with the Double Mean Reverting Process.™" Vanderhoof, I. "Guarantees of Long-Term Interest Rates." Yu, O., et al. "Portfolio Analysis of Financial Market Risks by Random Set Tools."	Intermediate	A broad publication covering topics ranging from scenario testing to policyholder behavior to product management.

References—Equity-Indexed Annuities

Reference	*Level of Difficulty*	*Comments*
American Academy of Actuaries. 1997. "Final Report of the Equity Indexed Products Task Force." Washington, DC: AAA.		
Mitchell, G. 1996. "Equity-Indexed Annuities—New Territory on the Efficient Frontier," *Product Development News* (January).		The SOA uses this reference for Course I-441U in its examinations.
Tiong, S. 2000. "Valuing Equity Indexed Annuities," *North American Actuarial Journa*l 4(4).		

References—Group

Reference	*Level of Difficulty*	*Comments*
Markland, J. 1998. "Stable Value Investments," in *Pension Investment Handbook*, edited by M. Riepe. Aspen Publishers.		
Society of Actuaries. 1986. "Matching of Insurance Company Pension Assets and Liabilities," *Record of the Society of Actuaries* 12(1): 127.		
Stiefel, J. 1999. "The Guaranteed Investment Contract," in the *Society of Actuaries 50th Anniversary Monograph*, edited by J. Hickman. SOA Monograph M-AV99-1. Schaumburg, IL: Society of Actuaries.		

References—Single Premium Deferred Annuities

Reference	*Level of Difficulty*	*Comments*
Griffin, M. 1990. "Determining Interest Crediting Strategy Using the Excess Spread Approach," *Product Development News.* December: 12–15.		
Griffin, M. 1990. "The Excess Spread Approach to Pricing and Valuing SPDA," *Transactions of the Society of Actuaries* XLII: 231.		

References—Variable Annuities

Reference	*Level of Difficulty*	*Comments*
Brizeli, B. 2001. "Variable Annuities—'No Loss' Propositions." SOA Study Note 8V-313-01. Schaumburg, IL: SOA.		
Canadian Institute of Actuaries. 2002. "Report: Task Force on Segregated Fund Investment Guarantees." Ottawa, Ontario: CIA.		
Consiglio, A., F. Cocco, and S. Zenios. 2001. *Asset and Liability Modeling for Participating Policies with Guarantees*. The Wharton School, Philadelphia, PA.		

References—Life, Equity-Indexed

Reference	*Level of Difficulty*	*Comments*
Ho, B., and L. Sham. 1997. "Equity-Indexed Life Products," Update—Tillinghast-Towers Perrin.		
Moller, T. 2001. "Hedging Equity-Linked Life Insurance Contracts," *North American Actuarial Journal* 5(2).		

References—Retirement Plans

Reference	*Level of Difficulty*	*Comments*
Griffin, M. 1990. "Determining Interest Crediting Strategy Using the Excess Spread Approach," *Product Development News.* December: 12-15.		
Griffin, M. 1990. "The Excess Spread Approach to Pricing and Valuing SPDA," *Transactions of the Society of Actuaries* XLII: 231.		
Griffin, M. 1992. "A Market Value Accounting Framework for Insurance Companies," *The Financial Reporter*. 15: 1-2.		
Hughes, M., R. Nelson, S. Gathje, and M. Davis, "Asset Liability Techniques for Product Design and Management," SOA Product Development Seminar, Reno, Nevada, September 4, 1996.		

Reference	*Level of Difficulty*	*Comments*
Leibowitz, M., S. Kogelman, and L. Bader. 1992. "Asset Performance and Surplus Control: A Dual-Shortfall Approach," *Journal of Portfolio Management* 18(2): 28-37.		
Mitchell, G. 1996. "Equity Indexed Annuities—New Territory on the Efficient Frontier," *Product Development News* (January).		Has been part of the SOA exam syllabus.

Property and Casualty Insurance

Early ALM studies for P&C insurers focused on duration analysis, similar to the ALM studies for life insurance companies. Several characteristics of P&C loss reserves made duration analysis of only marginal relevance. More recent actuarial studies of ALM have used dynamic financial analysis (DFA) models.

Early Studies

Ferguson (1984) introduced ALM and duration analysis to casualty actuarial literature, applying the standard life insurance tools to P&C loss reserves. Noris (1985) used the same approach and popularized the term "duration gap of surplus" to reflect the expected change in surplus for a given change in interest rates. Noris recommends fixed-income securities to back loss reserves and equities to back policyholders' surplus. Policyholders' surplus is about a third of P&C insurance company assets, and the recommendation for greater equity investments is echoed by many subsequent ALM studies. Panning (1995), considering the high *de facto* retention rates for private passenger automobile policies, quantifies effective durations using a multi-period approach.

D'Arcy (1984), in a discussion of Ferguson's paper, notes that the inflation sensitivity of P&C loss reserves renders the traditional duration analysis improper. Butsic (1981) differentiates between accident date and payment date effects of inflation. He considers most casualty reserves to be inflation-sensitive through the payment date; most subsequent writers follow Butsic's view.

Butsic assumes a constant (Fisher) spread between long-term interest rates and inflation rates. Feldblum (1989), following D'Arcy and Butsic, infers that casualty loss reserves have very short durations. The inflation sensitivity of reserves along with the generally upward sloping yield curve makes traditional asset-liability matching a suboptimal investment strategy. Many subsequent writers adopt this view; see the exacting analysis by the CAS VFAC Committee (2002).

D'Arcy and Gorvett (2000) consider the types of P&C liabilities and the correlation between interest rates and inflation rates to quantify the effective duration of casualty loss reserves. They conclude that effective duration measures for casualty loss reserves are about 25 percent below their modified duration counterparts.

Term Structure of Interest Rates

Matching the short duration casualty loss reserves would require a portfolio of cash equivalents and other short-term securities. An upward sloping yield curve renders such strategies unappealing. Many casualty insurers have long-duration fixed-income securities.

Common Stock Durations

Fama and Schwert (1977) analyze the effects of inflation on common stock prices. They find a slight negative correlation that is insufficient to offset trading costs. They consider the correlation enigmatic, since it appears to be a CAPM anomaly. Subsequent studies in the U.S. and other countries have confirmed their results, though the correlation has become weaker and may be immaterial.

Until the mid-1980s, some writers viewed common stock like fixed income perpetuities with a duration of 1/d (d = dividend yield), giving extremely long durations. Leibowitz, Sorensen, Arnott and Hanson (1985) consider the inflation sensitivity of dividends and conclude that common stock have short durations; subsequent writers follow Leibowitz.

Dynamic Financial Analysis (DFA)

Most current ALM work by casualty actuaries relies on DFA analysis, either for determining an asset-liability efficient frontier or for optimizing an asset class mix for the investment portfolio. DFA analyses use either scenario testing or

stochastic simulation; see Feldblum (1995) for an overview. Many corporate financial analyses use scenario testing; most actuarial studies use stochastic simulation, from either an accounting (statutory earnings) perspective or a cash flow perspective.

The Finnish Working Party, as in Pentikainen and Rantala (1982) and Pentikainen, Bonsdorff, Pesonen, Rantala, and Ruohonen, (1989) illustrates the accounting perspective with a probability of ruin risk measure for measuring financial strength. Probability of ruin is common in European actuarial literature; Kreps and Steel (1996) is a North American study that continues this analysis.

The British Solvency Working Party illustrates the cash flow perspective, again with a probability of ruin risk measure. Daykin, Bernstein, Coutts, Devitt, Hey, Reynolds and Smith (1987) apply the analysis to government solvency monitoring; Daykin and Hey (1990) apply the analysis to internal company management. Daykin, Pentikaien, and Pesonen (1994) combine the analyses of the Finnish and British actuaries.

D'Arcy, et al (1997, 1998) show a case study of a DFA model, using interest rates as the linkage between assets and liabilities. D'Arcy, et al., use interest rate generators and cascading sets of stochastic differential equations; both of these are now common for both life insurance and P&C insurance DFA models.

Expected Policyholder Deficit

Butsic (1994) analyzes risk-based capital requirements using an expected policyholder deficit (EPD) analysis as an alternative risk measure to the probability of ruin. He compares the EPD to the value of a call or put option, and he quantifies the EPD using a Black-Scholes option pricing procedure.

Butsic's EPD measure has been used by several subsequent writers. Lowe and Standard (1996) use the EPD measure in a DFA model to determine an asset-liability efficient frontier for a property excess-of-loss catastrophe reinsurer. Hodes, Feldblum and Blumsohn (1999) use the EPD measure in a DFA model to determine the risk of workers' compensation loss reserves and the implied risk-based capital needs.

Coherent Risk Measures

Some actuaries have used coherent risk measures instead of probability of ruin, VAR or expected policyholder deficit. Philbrick and Painter (2001) use a tail conditional expectation to analyze capital requirements, capital allocation, reinsurance and asset allocation. Coherent risk measures are more commonly used in academic literature and European studies than in North American casualty actuarial literature.

Risk-Based Capital Requirements

The NAIC life insurance company risk-based capital formula has an interest rate risk component, as does the Best's capital adequacy ratio used for P&C insurers. The NAIC's risk-based capital formula for P&C insurance companies has no interest rate risk charge, relying on Hodes and Feldblum (1996), who argue that interest rate risk within a statutory accounting framework is minimal for casualty companies.

Federal Income Taxes

ALM for P&C companies is affected by the tax treatment of different securities; P&C insurers are fully taxable. Almagro and Ghezzi (1988) analyze the optimal mix of taxable vs. tax-exempt bonds. The proration provision of the 1986 Tax Reform Act raised the marginal tax rate on municipal bonds for insurance company taxpayers to 5.25 percent, rendering these securities of less use to P&C companies.

Asset-Liability Efficient Frontier

Several authors use DFA models to determine efficient investment strategies. The investment portfolios of the financial literature are replaced by management strategies for both investment and insurance operations. The variance and standard deviation measures of risk are replaced by a variety of cash flow and statutory accounting metrics.

Almagro and Sonlin (1995), Weinberger and Kaminski (1991), Lowe and Standard (1996) and many other studies use DFA modeling to determine an asset-liability efficient frontier. This frontier is the locus of management strategies that maximize some accounting metric for a given level of risk or minimize the risk for a given accounting metric. The accounting metric is generally surplus growth or pre-tax operating income; the risk measure is generally probability of ruin, value at risk or expected policyholder deficit. Scheel, Blatcher, Kirschner and Denman (2001)

question the efficiency criterion used in many such studies, concluding that sampling error may degrade the ability to effectively distinguish optimal and no optimal points in risk-return space. It is unclear whether these studies improve upon the financial investment literature, which also seeks to determine optimal investment strategies by type of investor.

Kaufman and Ryan (2000), using a DFA analysis, conclude that P&C insurers should invest more heavily in common stocks; see also Kirschner. Feldblum (1989) suggests that the statutory accounting valuation of bonds at amortized value and common stocks at market has led to an overemphasis by P&C insurers in bonds; see also Kirschner.

Staking and Babbel (1995) examine the effect of interest rate risk on insurance company market values, concluding that insurer equity value at first declines with increased interest rate risk, but then rises with high exposure to interest rate risk.

References

Reference	*Level of Difficulty*	*Comments*
Almagro, M., and T. Ghezzi. 1988. "Federal Income Taxes—Provisions Affecting Property/Casualty Insurers," *Proceedings of the Casualty Actuarial Society* 75: 95-161.		Optimal mix of taxable vs. tax-exempt bonds to maximize net after-tax income.
Almagro, M., and S. Sonlin. 1995. "An Approach to Evaluating Asset Allocation Strategies for Property/Casualty Insurance Companies," *Incorporating Risk Factor in Dynamic Financial Analysis,* Casualty Actuarial Society discussion paper. Colortone Press.	Basic	Introduction to the asset-liability efficient frontier approach for determining optimal investment strategies from the perspective of a P&C company. Considers the interaction of the underwriting and investment operations and their joint effect on financial risk. The same technique can be used to evaluate other business strategies, such as business mix and reinsurance decisions, in a consistent framework.
Balcarek, R. 1981. Discussion of "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," *Inflation Implications for Property-Casualty Insurance*, Casualty Actuarial Society Discussion Paper Program. 103-109.		

Reference	*Level of Difficulty*	*Comments*
Butsic, R. 1994. "Solvency Measurement for Property-Liability Risk-Based Capital Applications," *Journal of Risk and Insurance* 61(4): 656-690.	Advanced	Introduced EPD analysis to quantify the expected loss to policyholders/claimants per anticipated dollar of benefit payment. Butsic uses a Black-Scholes option pricing approach. Insurance company financial simulation using an EPD solvency yardstick may be found in Lowe and Standard (1996) and in Hodes, Feldblum and Blumsohn (1996). Part of the CAS Exam 8 syllabus.
Butsic, R. 1981. "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," *Inflation Implications for Property-Casualty Insurance.* Casualty Actuarial Society Discussion Paper Program. Arlington, VA: CAS. 51-102.	Intermediate	Seminal paper on the effects of inflation on P&C insurance operations differentiates between inflation affecting losses through the accident date vs. through the payment date. Butsic assumes a constant (Fisher) relationship between interest rates and inflation rates. Objective was to show that acceleration of inflation was not necessarily bad for P&C insurance operations, since the associated rise in interest rates generated increased investment income. Butsic's model is more commonly used now to assert that a rise in interest rates is more harmful to P&C insurance companies than to other financial intermediaries because the drop in fixed-income asset values is not offset by a drop in the loss reserve values.

Reference	*Level of Difficulty*	*Comments*
Casualty Actuarial Society Valuation, Finance, and Investments Committee. 2002. *Interest Rate Risk: An Evaluation of Duration Matching as a Risk-Minimizing Strategy for Property-Casualty Insurers.* Arlington, VA: CAS.		Duration matching does not appear to be the sole optimal strategy for most P&C insurers; on a statutory basis, longer investment strategies often yielded higher return and equal or lower risk.
D'Arcy, S. 1983. Discussion of 'Duration' by Ron Ferguson," *Proceedings of the CAS*. 70 (November).	Basic	Ferguson: Extension of life-insurance techniques to P&C insurance; D'Arcy: Inflation-sensitivity of P&C loss reserves.
D'Arcy, S., and R. Gorvett. 2000. "Measuring the interest rate sensitivity of loss reserves," *Proceedings of the CAS*, 87: 365-400.		Authors quantify the effective duration of P&C loss reserves by estimating the interest sensitivity of the reserves and the correlation between interest rates and inflation rates. They conclude that casualty loss reserves have effective durations of about one to three years.
Daykin, C., G. Bernstein, S. Coutts, E. Devitt, G. Hey, D. Reynolds, and P. Smith. 1987. "Assessing the Solvency and Financial Strength of a General Insurance Company," *Journal of the Institute of Actuaries* 114(2): 227-310.	Intermediate	British Solvency Working Party cash flow approach for solvency measurement
Daykin, C., T. Pentikaien, and M. Pesonen. 1994. *Practical Risk Theory for Actuaries*. 1st ed. New York: Chapman and Hall.	Advanced	Textbook on stochastic simulation approaches to financial modeling; uses Wilkie model for ALM analysis. Combined accounting approach of the Finnish Working Party with the cash flow approach of the British Working Party.
Fama, E., and G. Schwert. 1977. "Asset Returns and Inflation," *Journal of Financial Economics* 5: 115-146.	Intermediate	Empirical study on correlations of common stock returns with expected and unexpected inflation. Authors find that stock returns have a slight negative correlation with inflationary changes. Subsequent studies repeated their findings for other periods and other countries. Authors show that the empirical correlation is too weak to offset trading costs for common stock; this correlation has weakened and is now hardly material.

Reference	*Level of Difficulty*	*Comments*
Feldblum, S. 1989. "Asset-Liability Matching for Property/Casualty Insurers," in *Valuation Issues,* Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press. 117-154.	Basic	P&C reserves generally have short effective durations, particularly if the inflation sensitivity of these liabilities is considered. Holding a duration-matched investment portfolio necessitates a reduction in investment yield. Part of the CAS Exam 8 syllabus.
Feldblum, S. 1995. "Forecasting the Future: Stochastic Simulation and Scenario Testing," in *Incorporating Risk Factors in Dynamic Financial Analysis*, Casualty Actuarial Society Discussion Paper Program. Landover, MD: Colortone Press. 151-177.	Basic	A comparison of stochastic simulation and scenario testing.
Hodes, D., and S. Feldblum. 1986. "Interest Rate Risk and Capital Requirements for Property-Casualty Insurance Companies," *Proceedings of the Casualty Actuarial Society* 83: 490-562.	Intermediate	Measurement of interest rate risk in a risk-based capital framework; interrelationship of accounting system and ALM.
Hodes, D., T. Neghaiwi, D. Cummins, R. Phillips, and S. Feldblum. 1996. "The Financial Modeling of Property-Casualty Insurance Companies," *Casualty Actuarial Society Forum.* Arlington, VA: CAS. 3-88.	Intermediate	
Hodes, D., S. Feldblum, and G. Blumsohn. 1996. "Workers' Compensation Reserve Uncertainty," *Casualty Actuarial Society Forum*, Casualty Loss Reserve Seminar Discussion Paper Program. Arlington, VA: CAS. 61-149.	Basic	Stochastic simulation and expected policyholder deficit analysis in a P&C company; shows the effects an interest rate increase on assets and liabilities
Kaufman, A., and T. Ryan. 2000. "Strategic Asset Allocation for Multi-Line Insurers Using Dynamic Financial Analysis," *Casualty Actuarial Society Forum*, Arlington, VA: CAS.		DFA recommends a higher proportion of equities for P&C insurers.

Reference	*Level of Difficulty*	*Comments*
Kirschner, G. 2000. "A Cost/Benefit Analysis of Alternative Investment Strategies Using Dynamic Financial Analysis Tools," *Casualty Actuarial Society Forum*. Arlington, VA: CAS.		Uses a DFA model to show that 80 percent of the variability in overall results stems from three financial variables: interest rates, inflation rates and common stock returns, and 20 percent of the variability in overall results stems from loss reserve adequacy, future loss ratios and claim payment speed. Recommends higher proportion of equities to optimize investment performance.
Kirschner, G., and W. Scheel. 1997. "Specifying the Function Parameters of a Corporate Financial Model for Dynamic Financial Analysis," *Casualty Actuarial Society Forum* 2. Arlington, VA: CAS. 41-88.		
Kreps, R., and M. Steel. 1996. "A Stochastic Planning Model for the Insurance Corporation of British Columbia," *Casualty Actuarial Society Forum.* Arlington, VA: CAS.	Intermediate	Stochastic modeling for a government-operated automobile insurance enterprise, following the methods of Daykin, Pentikaien and Pesonen.
Leibowitz, M., E. Sorensen, R. Arnott, and H. Hanson. 1989. "A Total Differential Approach to Equity Duration," *Financial Analysts Journal* 45(5): 30-37.	Intermediate	Measures the effective duration of common stocks and concludes that the duration is generally short. There should be little correlation between common stock values and interest rate changes, unless the firm has significant fixed-dollar contracts.
Lowe, S., and J. Standard. 1996. "An Integrated Dynamic Financial Analysis and Decision Support System for a Property Casualty Reinsurer," *Casualty Actuarial Society Forum*. Arlington, VA: CAS. 89-118.		DFA model for a reinsurance company writing property excess-of-loss catastrophe treaties, using an expected policyholder deficit analysis to derive an optimal asset-liability efficient frontier.
Noris, P. 1985. *Asset/Liability Management Strategies for Property and Casualty Companies*. New York: Morgan Stanley.	Advanced	Application of life insurance ALM techniques to P&C insurance. Has been part of the CAS exam syllabus.

Reference	*Level of Difficulty*	*Comments*
Panning, W. 1995. "Asset-Liability Matching for a Going Concern," Chapter 12 in *The Financial Dynamics of the Insurance Industry,* edited by E. Altman and I. Vanderhoof. Irwin Professional Publishing: New York.	Advanced	P&C contracts are short-duration with high de facto retention rates for private passenger automobile policies; quantifies effective durations using a multi-period approach.
Pentikainen, T., and J. Rantala. 1982. *Solvency of Insurers and Equalization Reserves* (Two Volumes). Helsinki, Finland: Insurance Publishing Company.	Intermediate	Illustrates the Finnish Working Party approach, with a stochastic use of accounting figures.
Pentikainen, T., H. Bonsdorff, M. Pesonen, J. Rantala, and M. Ruohonen. 1989. *Insurance Solvency and Financial Strength*. Helsinki, Finland: Finnish Insurance Training and Publishing Company.	Intermediate	Illustrates the Finnish Working Party approach, with a stochastic use of accounting figures.
Philbrick, S., and R. Painter. 2000. "DFA Insurance Company Case Study, Part II: Capital Adequacy and Capital Allocation," *Casualty Actuarial Society Forum*. Arlington, VA: CAS.		Authors examine capital adequacy, capital allocation, reinsurance and asset allocation, using a coherent risk measure, tail conditional expectation, to measure capital adequacy.
Scheel, W., W. Blatcher, G. Kirschner, and J. Denman. 2001. "Is the Effective Frontier Efficient?" *Proceedings of the CAS*. 88: 236-283.		Authors examine the efficient frontiers used in dynamic financial analyses and conclude that sampling error may degrade the ability to effectively distinguish optimal and no optimal points in risk-return space.
Staking, K., and D. Babbel. 1995. "The Relation Between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry," *Journal of Risk and Insurance*, 62: 690-718.		Authors conclude that insurer equity value at first declines with increased interest rate risk, but then rises with high exposure to interest rate risk.

Pension Plan ALM

Because defined benefit pension plans are subject to a plethora of rules, regulations and employee relations concerns, ALM is frequently complicated by having one pool of assets and several liabilities which are defined by the various regulatory and administrative organizations, including the SEC, IRS, PBGC and FASB. Optimal ALM for one set of concerns will likely be suboptimal for other concerns, which leads to the need for compromise. While 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 may be more complex because of conflicting objectives with each based on a somewhat different definition of the liability. A plan sponsor concerned about adverse earnings consequences will have a different ALM model than one concerned about increased liabilities on the balance sheet or going to the capital markets to fund an unanticipated contribution. Because there is not a unique asset allocation that will meet all of the possible objectives, it is particularly important to identify the risk (liability) of particular concern to the sponsoring organization.

Pension fund ALM analysis helps the sponsor establish an asset allocation policy mix that comfortably balances the competing goals of reducing long-term cost (through higher portfolio returns) and reducing the exposure to the other risks in both the short term and the long term. In addition to the asset allocation policy decision, sponsors also have some discretion on whether to fund the liabilities more or less rapidly, within limits established by law. Pension plan ALM can also be useful in analyzing this strategic policy choice. As contrasted to life insurance companies where bad ALM can lead to bankruptcy, ongoing pension plans have 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. While pension plans are unlikely to go bankrupt, the sponsoring organizations can as a result of increases in the corporate liability to make future contributions resulting from poor ALM. Also, adverse capital market results and poor ALM can cause a painful increase in ongoing pension cost to the sponsoring organization, and can require increased premiums for the PBGC. Debt ratings can be reduced resulting in an increased cost of capital for the plan sponsor, and future corporate earnings can be reduced, leading to poor market performance. Additionally, executive compensation, which is becoming increasingly dependent on options, can be negatively impacted.

Pension plan ALM is carried out through mean variance optimization in conjunction with Monte Carlo-type simulations of plan assets, liabilities and costs over a relatively long time horizon—typically from 10-20 years. Key economic and capital market variables that need to be simulated are inflation, real wage growth and 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 investment consultants. Critical model features will be those that deal with the longer-term dynamics (i.e. 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 and the accountants in their annual valuations to determine plan cost for the sponsor and its annual reports. This will become increasingly important as accounting standards move toward greater disclosure and marking assets and liabilities to market annually.

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.

References—Pension Plan ALM

Reference	*Level of Difficulty*	*Comments*
Davis, R., and M. Sloan. 1993. "Pension Plans: A Risk Management Perspective," *The Journal of Investing* (Summer): 58-61.	Basic	
Jaeger, S., and H. Zimmerman. 1996. "On Surplus Shortfall Constraints," *The Journal of Investing.* (Winter): 64-74.	Advanced	Extension of the ideas presented in Leibowitz/ Bader/Kogelman ideas.
Kritzman, M. 1990. "Strategic Asset Allocation for Institutional Portfolios," (Chapter 5), and "Dynamic Hedging Strategies With Liabilities," (Chapter 6) in *Asset Allocation for Institutional Portfolios.* Irwin.	Intermediate	Good introduction to portfolio insurance techniques and efficient frontier based on surplus optimization.
Leibowitz, M., L. Bader, and S. Kogelman. 1996. *Return Targets and Shortfall Risks.* Irwin.	Intermediate	Collection of Salomon Bros. research pieces on asset allocation, using a static, interest-sensitive concept of liabilities.

Reference	*Level of Difficulty*	*Comments*
Peskin, M. 1997. "Asset Allocation and Funding Policy for Corporate-Sponsored Defined-Benefit Pension Plans," *Journal of Portfolio Management* (Winter): 66-73.	Basic	Good overview of the ALM process.
Ryan, R., and F. Fabozzi. 2002. "Rethinking Pension Liabilities and Asset Allocation," *The Journal of Portfolio Management*. 28(4).	Basic	Good overview of contemporary problems affecting the asset allocation problem in pension funds.
Wendt, R. 1994. "Strategic Asset Allocation: Asset/Liability Forecasting, from A to Z," Chapter 10 in *Global Asset Allocation, Techniques for Optimizing Portfolio Management*. Lederman and Klein, eds., Wiley.	Basic	

Accounting and Regulatory Issues Applicable to ALM

This listing identifies sources of information on some of the major accounting and regulatory issues.

FAS 133

FAS 133, issued by the Financial Accounting Standards Board (FASB), requires that derivatives, including those embedded in more general contracts, must be marked to market, and permits certain accounting techniques to facilitate meaningful reporting for specifically designated derivatives that are effective in hedging risk. Otherwise, the change in the market value of such positions flows through to income in each accounting period. Hedge design and effectiveness demonstration may involve ALM modeling. Information regarding FASB's Derivatives Implementation Group (DIG) is available at www.fasb.org/derivatives/.

AICPA Standards

Relevant GAAP standards are also issued by the AICPA in addition to FASB. Exposure drafts may apply to items such as guaranteed minimum death benefits (GMDBs), or fair value auditing standards. The AICPA Web site, www.aicpa.org, is a source of information.

U.S. Insurance Statutory Issues

The NAIC and the NYS Insurance Department are important sources of new laws and regulations. Their respective Web sites are www.naic.org and www.ins.state.ny.us.

International Accounting Standards

Legislation requiring the International Accounting Standards Board valuation basis for insurance has been passed by the European parliament effective in 2005. Valuation of equity at market may be delayed until 2007. U.S. GAAP statements may be filed in lieu of fair value statements until 2007. Two sources of information regarding international accounting issues are www.iasb.org.uk and www.iasplus.com.

American Academy of Actuaries (AAA)

The AAA provides guidance on many accounting and regulatory issues. The AAA's Web site is www.actuary.org.

Actuarial Standards Board (ASB)

The ASB establishes actuarial standards of practice. Standards that have been established, or are in the process of being established (exposure drafts or discussion drafts), can be viewed at www.actuarialstandardsboard.org.

European Union (EU)

The EU conducted a study into the methodologies to assess the overall financial position of an insurance undertaking from the perspective of prudential supervision. Related information is available at www.europa.eu.int/comm/internal_market/insurance/index_en.htm.

Enterprise Risk Management Commentary

Recent high-profile bankruptcies and shareholder lawsuits due to rogue traders, liquidity mismanagement, inappropriate accounting practices and corporate statements, has led to an increased emphasis on ERM from investors, regulators and senior management.

ERM is a structured and disciplined approach aligning strategy, process, people, technology and knowledge with the purpose of evaluating and managing the risks that a company faces. Financial, operational, strategic and hazard risks are reviewed from a company (or "holistic") perspective rather than a product (or "silo") level to enhance shareholder value through established risk limits, lower capital costs and improved resource allocation. ERM is, foremost, a corporate culture practiced by all employees.

An example of a formal definition of ERM is the following adopted by the Casualty Actuarial Society ERM Committee: "ERM is the process by which organizations in all industries assess, control, exploit, finance, and monitor risks from all sources for the purpose of increasing the organization's short- and long-term value to its stakeholders." This definition is detailed in the Casualty Actuarial Society's "Final Report of the Advisory Committee on Enterprise Risk Management," (December 2001).

ALM is an important tool of ERM because it can assess the financial impact of a specific management risk decision such as implementing a hedging strategy, completing an acquisition, opening a branch office or calculating a hurricane claim exposure. Two sources of much information related to ERM are the CAS ERM Web site and the SOA Risk Management Task Force subgroups Web site. Their addresses are included in the following list of references.

References

Reference	*Level of Difficulty*	*Comments*
Basel Committee on Banking Supervision. 2002. "Sound Practices for the Management and Supervision of Operational Risks."	Intermediate	Available at: www.bis.org/publ/bcbs91.pdf
Casualty Actuarial Society. 2001. "Final Report of the Advisory Committee on Enterprise Risk Management." Arlington, VA: CAS.	Basic	Available at: www.casact.org/research.erm/
Committees at the Bank for International Settlements. 1998. "Capital Adequacy Principles Paper."	Intermediate	Available at: http://risk.ifci.ch/143520.htm
International Actuarial Association (IAA). 2002. "Report of Solvency Working Party." Ottawa, Ontario: IAA.	Intermediate	Available from: www.actuaries.org/members/en/committees/insreg/documents/solvency_report_en.pdf
International Organization of Securities Commissions (IOSCO). 1998. "Risk Management and Control Guidance for Securities Firms and their Supervisors." Geneva, Switzerland: IOSCO.	Intermediate	Available from: http://risk.ifci.ch/143370.htm
Lam, J. 2000. "Enterprise-wide Risk Management and the role of the Chief Risk Officer," *ERisk* (March).	Basic to Intermediate	Available from: http://erisk.com/portal/resources/archive/011_lamriskoff.pdf
Lam, J. 2003. *Enterprise Risk Management: From Incentives to Controls*. John Wiley & Sons.	Basic to Intermediate	Comprehensive review of key factors and issues in ERM.
Office of the Superintendent of Financial Institutions Canada (OSFI). 2002. "Use of Internal Models for Determining Capital for Segregated Fund Risks MCCSR." Ottawa, Ontario: OSFI.	Intermediate	Available from: www.osfi-bsif.gc.ca/eng/documents/guidance/docs/insguide02.pdf
Secretariat of the Basel Committee on Banking Supervision. 2001. "The New Basel Capital Accord: An Explanatory Note."	Intermediate	Available at: www.bis.org/publ/bcbsca01.pdf
Society of Actuaries. 2000. *Dynamic Financial Condition Analysis Handbook.* Schaumburg, IL: SOA.	Intermediate	Available from: www.soa.org/bookstore/books.html
Society of Actuaries. 2002. "Bibliography of Published Materials on the Topic of Enterprise Risk Management." Schaumburg, IL: SOA.	Basic	An annotated bibliography of ERM references is available for download from this Web site. www.soa.org/sections/rmtf/rmtf_erm.html

Appendix

Reference	*Section of Guide*
Abbink, M., and M. Saker. 2002. *Getting to Grips with Fair Value*. London: Staple Inn Actuarial Society.	Fair Value of Liabilities: Theoretical Readings and Examples
The Actuarial Foundation and Nationwide Financial Services. 1999. "RISKS in Investment Accumulation Products of Financial Institutions." Symposium Proceedings, New York. Becker, D. "Risk and Policyholder Behavior in Separate Account Products." Boezio, N. "Risks in Accumulation Products: Insights from Investor Behavior." Chalke, S. "A Model of Persistency Behavior for Internet Distribution Channels." Claire, D. "Regulatory Considerations for Accumulation products." Craighead, S. "Risk in Investment Accumulation products of Financial Institutions." Crozier, B. "The Practical Aspects of Managing Annuity Blocks of Business." Fridson, M. "What Went Wrong with the Highly Leveraged Deals? (Or, All Variety of Agency Costs)." Galochkin, V., and A. Kukush. "The Prediction of the Derivative Portfolio Price." Glacy, A. "Option Pricing in Action: The Case of the SPDA." Hardy, M. "Maturity Guarantees for Segregated Fund Contracts: Hedging and Reserving." Mandelbrot, B. "A Multifractal Walk Down Wall Street." Rubenstein, M. "Comments on the 1987 Stock Market Crash: Eleven Years Later." Tenney, M. "Analyzing Interest-Rate Guarantees with the Double Mean Reverting Process.™" Vanderhoof, I. "Guarantees of Long-Term Interest Rates." Yu, O., et al. "Portfolio Analysis of Financial Market Risks by Random Set Tools."	Applications of ALM: ALM in Product Development; Annuities

Reference	*Section of Guide*
AIMR Performance Presentation Standards. 2001.	Tools and Techniques: Performance Measurement and Benchmarking
Albrecht, P. 1985. "A Note on Immunization, Under a General Stochastic Equilibrium Model of the Term Structure," *Insurance: Mathematics and Economics 4* October: 239-44.	Tools and Techniques: Immunization: Fixed and Certain Cash Flows
Alexander, C. 2001. *Market Models: A Guide to Financial Data Analysis.* John Wiley & Sons.	Tools and Techniques: Financial Market Modeling; Survey of Continuous-Time Term-Structure Models
Alexander, G., W. Sharpe, and J. Bailey. 1993. "Valuation of Risky Securities," Chapter 5, and "Bond Portfolio Management," Chapter 14, *Fundamentals of Investment.* Pearson Higher Education.	Tools and Techniques: Basic Risk Management Metrics; Fixed and Certain Cash Flows
Almagro, M., and T. Ghezzi. 1988. "Federal Income Taxes—Provisions Affecting Property/Casualty Insurers," *Proceedings of the Casualty Actuarial Society* 75: 95-161.	Applications of ALM: Asset-Liability Efficient Frontier
Almagro, M., and S. Sonlin. 1995. "An Approach to Evaluating Asset Allocation Strategies for Property/Casualty Insurance Companies," *Incorporating Risk Factor in Dynamic Financial Analysis,* Casualty Actuarial Society discussion paper. Colortone Press.	Basics in Financial Economics Relevant to ALM: The Efficient Frontier and Asset Allocation
American Academy of Actuaries. 1997. "Final Report of the Equity Indexed Products Task Force." Washington, DC: AAA.	Applications of ALM: ALM in Product Development; Equity-Indexed Annuities
American Academy of Actuaries Fair Valuation of Liabilities Task Force. 1998. "Fair Valuation of Life Insurance Company Liabilities," in *The Fair Value of Insurance Liabilities*, edited by I. Vanderhoof and E. Altman. Boston: Kluwer Academic Publishers.	Tools and Techniques: Fair Value of Liabilities; Theoretical Readings and Examples
American Academy of Actuaries. 2002. "Fair Valuation of Insurance Liabilities: Principles and Methods." Washington, DC: AAA.	Tools and Techniques: Fair Value of Liabilities
Anderson, N., F. Breedon, M. Deacon, A. Derry, and G. Murphy. 1996. *Estimating and Interpreting the Yield Curve*. John Wiley & Sons.	Tools and Techniques: Financial Market Modeling; Discrete-Time Term-Structure Models
Ang, A., and M. Sherris. 1997. "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* Vol. 1(2): 1-26.	Tools and Techniques: Financial Market Modeling; Interpretation of Financial Market Models

Reference	*Section of Guide*
Ang, A., and G. Bekaert. 2002. "International Asset Allocation With Regime Shifts," *The Review of Financial Studies.* 15(4): 1137-1187.	Tools and Techniques: Financial Market Modeling; Equity Models
Asay, M., P. Bouyoucos, and A. Marciano. 1989. *An Economic Approach to Valuation of Single Premium Deferred Annuities*. Financial Institutions Research. New York: Goldman Sachs.	Tools and Techniques: Fair Value of Liabilities; Other Readings
Attwood, J., and C. Ohman. 1983. "Segmentation of Insurance Company General Accounts," *Transactions of the Society of Actuaries* XXXV.	Tools and Techniques: Performance Measurement Benchmarking; Investment Income Allocation
Avellaneda, M., and P. Laurence. 1998. *Quantitative Modeling of Derivative Securities: From Theory to Practice.* Chapman & Hall/CRC.	Tools and Techniques: Financial Market Modeling; Discrete-Time Term-Structure Models
Babbel, D., and A. Santomero. 1996. "Risk Management by Insurers: An Analysis of the Process." Working paper 96-16, The Wharton School, Philadelphia, PA.	Basics in Financial Economics Relevant to ALM: The Efficient Frontier and Assets Allocation; Property/Casualty Applications of ALM: Corporate ALM
Babbel, D., and C. Merrill. 1998. "Economic Valuation Models for Insurers," *North American Actuarial Journal* 2(3).	Tools and Techniques: Fair Value of Liabilities; Theoretical Readings and Examples
Babbel, D., and C. Merrill. 2000. *Valuation of Interest-Sensitive Instruments*. M-FI96-2. Schaumburg, IL: Society of Actuaries.	Tools and Techniques: Financial Market Modeling; Discrete-Time Term-Structure Models Applications of ALM: Corporate ALM
Babbel, D., J. Gold, and C. Merrill. 2002. "Fair Value of Liabilities: The Financial Economics Perspective," *North American Actuarial Journal* 6(1).	Tools and Techniques: Financial Market Modeling; Theoretical Readings and Examples
Babbel, D., and F. Fabozzi, eds. 1999. "Asset Allocation for Property and Casualty Insurers," *Investment Management for Insurers.* John Wiley & Sons.	Basics in Financial Economics Relevant to ALM: The Efficient Frontier and Assets Allocation; Property/Casualty
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Back, K. 1996. "Yield Curve Models: A Mathematical Review," in *Option Embedded Bonds*, edited by J. Lederman, R. Klein, and I. Nelkin. Irwin.	Tools and Techniques: Financial Market Modeling; Discrete-Time Term-Structure Models

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Balcarek, R. 1981. Discussion of "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," *Inflation Implications for Property-Casualty Insurance*, Casualty Actuarial Society Discussion Paper Program. 103-109.	Applications of ALM: Property and Casualty Insurance; Asset-Liability Efficient Frontier
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Berkshire Hathaway. 2002. "Berkshire Hathaway Annual Report." Omaha: Berkshire Hathaway Inc. 13-15.	Basics in Financial Economics Relevant to ALM: Derivatives
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