Chapter 7

Applications of financial modeling to asset/liability management: advances, challenges, and future directions

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This chapter introduces and contrasts financial modeling and ALM approaches currently employed by financial institutions. It also discusses the evolution of the field of financial modeling, its advancement, challenges, and future directions as they apply to ALM. Best practices in ALM have become extremely important in providing a competitive advantage and ensuring survival during financial crises or in difficult market environments in general.

ALM in a financial modeling context

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 an ongoing sound financial management process of formulating, implementing, monitoring, and revising strategies related to assets, future investments, and liabilities in an attempt to achieve an organization's financial objectives, future cash flow needs, and capital requirements, given the organization's risk tolerances and other constraints.

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. Modeling seeks to gauge the impact of changes in value drivers (such as interest rates or equity indices) and to ascertain the value and sensitivity of embedded options granted or retained (such as guaranteed minimum investment benefit calculations, insurance policyholder lapse, depositor or bank loanee transfers between floating and fixed-rate products).

ALM is practiced in diverse settings.

- Derivatives dealers manage their long and short positions.

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- 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 make sure they can support competitive pricing and interest crediting strategies.

While each of these involves the application of ALM techniques to a particular financial problem, these techniques may bear little resemblance to one another. The derivatives 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 intent of this chapter is to provide a basic overview of financial modeling and concepts that are applied in ALM, and to 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. Bodie, Kane, and Markus (2002) or Forbes, Hays, Reddy, and Stewart (1993) provide excellent introductions.

Concepts from modern financial economics that are directly relevant to ALM include knowledge of the dividend discount model and common asset types, the term structure of interest rates, and dissecting the yield curve using bootstrapping techniques into forward and spot curves. The landscape is always changing, with new classes of assets being created as quickly as the quantitative researchers can think them up. What is important for ALM practitioners is to understand the cash flow optionality purchased or sold. Unintended consequences can leave the practitioner in worse shape after selecting an inappropriate hedge. Counterparty risk must also be considered.

Recently, there has been much discussion regarding the concept of enterprise risk management (ERM) which 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 enhance shareholder value and economic value while minimizing the effects of risk on an organization's capital and earnings, and to secure improved allocation of its resources and risk capital. The following definition was adopted by the Casualty Actuarial Society (CAS) ERM Committee in their *Final Report of the Advisory Committee on Enterprise Risk Management* (December 2001): '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.' Within the context of ERM, ALM can help 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.

Financial market modeling

The choice of financial market model depends on how the model is to be applied to the analyses of market phenomena, the data available for estimation, and the computing power available. 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 arbitrage-free. The Black-Scholes (1973) equity market model and the Vasicek (1977) bond market model are two of the earliest arbitrage-free models. Both models are single-factor models, 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 non-technical terms it means this: 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: (a) if a security in an arbitrage-free model pays US$1 with probability 1 in the future, it must have a positive price; (b) 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 has 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 a relatively efficient 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. Secondly, 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 assumes that percentage changes in stock prices are normally distributed, while studies of equity returns indicate that their distribution 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 (1985).

The problems with arbitrage-free models may be avoided with another approach, generally described as follows: 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 Wilkie 'stochastic investment model' (1986), publicly-available dynamic financial analysis (DFA) models such as Dynamo,[2] and other models developed by actuarial consulting firms use this approach. 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. There is 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 literature on financial market models is enormous and can be subdivided into models of markets for Treasury bonds, equities, currencies, corporate bonds, and their combinations. Most papers assume arbitrage-free models.

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 considerations such as 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 it is not feasible to provide much detail here. The reader should be aware that these issues pervade any attempt to apply any interest rate model. In this section the discussion is confined to arbitrage-free models of the default-free term structure. In non-technical 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 a later section and in other parts of this chapter.

The original classes of arbitrage-free interest rate models consisted of what are now called factor models. These include the Vasicek and Cox-Ingersoll-Ross models, which are now considered classical approaches to continuous time models. Other early models developed in discrete time, including the Black-Karasinski model (1991) and the Black-Derman-Toy model (1990). Discussions of these discrete time models and related tools have been numerous as have been the variations in efficient ways to implement the Black-Derman-Toy 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 the following.

1. An adjustment method based on tinkering with the short-rate process (Dybvig, 1998).
2. A numerical computation of parameter values involving integral equations (Hull and White, 1990).
3. Another approach to interest rate modeling with the feature that the initial yield curve is automatically produced was developed in the seminal paper by Heath, Jarrow, and Morton (1992).

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 normal 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. Principal components analysis can help in calibrating HJM models by reducing the number of factors in the system and imposing 'no-arbitrage' restrictions in combination with tractable and realistic volatility structures.

Another generation of sophisticated models has emerged and members have been referred to as random field models, Libor market models, or string models, among other names. Other types of models include:

- positive interest rate models;
- gauge models;
- quadratic interest rate models;
- non-linear models;
- non-parametric models; and
- regime switching models.

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

Interest rate modeling with default risk/credit risk models

Government bonds are in many ways the simplest fixed-income instruments. Bonds issued by the U.S. 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, but if both ratings are strong these countries are generally modeled in the same fashion, ignoring default risk. For example, U.S. government bonds and Canadian government bonds are rated AAA and may be considered to have no default risk. Such a convention is not merely a matter of convenience: there is no default data for U.S. 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 private placements. Default data and data on changes of rating class are available commercially. Bank loans and commercial mortgages have similar credit issues.

Numerous credit risk models are described in Duffie and Singleton (2003) and Ong (1999). The ISDA Credit Risk Working Group has been reviewing credit models and counterparty issues for the Basle II Capital Accord.

Quantitative credit scoring models

The best-known quantitative credit scoring models used for default predictions are:

- Edward Altman's Z-Score (1968) and a family of related models usually called statistical models because they are based on empirical studies of quantifiable default predictors based on fundamental financial ratios.
- Robert Merton's model (1974) and forms such as KMV's implementation (Vasicek, 1984) are commonly called structural models as they model the economic structure of the firm where debt represents a call option on the assets of the firm.

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. Richard Wendt has produced an interesting note on real versus nominal dividend yields (see Wendt, 2002).

Equity models

The first equity model was the Black-Scholes; 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. There are several approaches that have been developed to allow financial econometricians to allow accurate modeling of these effects, including:

- Generalised Autoregressive Conditional Heteroskedasticity (GARCH) volatility models;
- stochastic volatility models; and
- 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 capture empirical features of equity returns such as fat tails and stochastic persistent volatility. Stone (2000) provides an equity example for a guaranteed minimum death benefit (GMDB) model. 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 United States 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) considered the inflation sensitivity of dividends and concluded that common stock has short durations; subsequent writers follow Leibowitz et al.

Discrete time versus 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 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 in interpreting their results. 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%, a high of 12%, and averaged 5.6%. 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 reached a low of 0% of the benefit premium, a high of 5,000% of the benefit premium, and averaged 90% 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 (risk neutral measure).[3] 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, would be sufficient to cover all liabilities due under the GMDB. 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 naive delta hedging strategies require the most activity when the underlying is the most active. While an advanced issue, overlooking pricing and risk mitigation issues has been at the heart of the recent reversals in the fortunes of some insurers involved in the variable annuity business.

Practical considerations

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.

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.

Another practical problem that can confound interest rate models is, for want of a better term, outliers in the data. Recent low interest rate data in the United States provides an excellent example. The decision to use a non-stationary model or a regime-switching model involves a philosophical trade-off.

A universal issue in the implementation of all types of financial market models is acquiring sufficiently good quality data to model global interest rates, inflation, market spreads, market returns, indices, and economic variables. Yield curve modeling may require complex models to extract spot rates from market data, fit sparse on-the-run data, or use premium priced zero-coupon bond yields. Periods of ‘flight to quality’ demand can distort the ‘risk-free’ curve. The recent elimination of the 30-year U.S. Treasury bond and associated zero-coupon bonds has forced changes in many models. Also, a host of related problems arise 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.

Investment philosophy and investment strategy models

Risk-return trade-off 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 for ALM purposes. Index models form a second class and assume that systemic or market risk can be represented by a broad index of stock returns. 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 class and 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, single and multi-factor APT models do not assume that the same expected return to risk relationship holds for all assets.[4]

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 referred to as the optimal portfolio. The Markowitz (1952, 1959) and Tobin (1958) model of investor behavior is referred to as a mean-variance framework, since 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 can also be used to evaluate risk versus reward trade-offs for any ALM decision, such as testing alternative crediting strategies or product designs.[5]

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

Efficient frontier analysis is still a dominant practice used in pension plan asset allocation. In many cases the liabilities are not integrated into these approaches as well as they should be (see Chapter 18).

Performance measurement and benchmarking

Performance measurement is a fundamental tool used to determine if various parts of the organization are meeting or exceeding their objectives and, within an institutional framework, ALM is often practiced under explicit and implicit constraints that make it challenging to measure the extent to which ALM is accomplishing its goals. Performance measurement should be made relevant to other decision-making entities in the organization, especially those that may have a more significant impact on profitability. Most organizations already have a hierarchy of investment related decision-making, which includes the following.

- *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 (see Chapter 5). Some examples of appropriate benchmarks to evaluate the asset allocation decision include:

- a portfolio that has very similar cash flow characteristics to 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 indices for the asset class chosen for the strategic asset allocation; and
- portfolio management can be evaluated against style-specific or manager-specific benchmarks as 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.

Investment income allocation

It is possible for an organization to manage its asset and liability functions well independently and still perform poorly overall. This may result when investment strategies are poorly defined, or are 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 CIOs and asset managers to respond to emergent behavior of the liabilities, revising benchmarks 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 is that profits may be increased, and earnings variability decreased, when complementary asset and liability positions are maintained.

Segmentation

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.

Investment generation

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’) are not required to be identical in length, but may be. 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.

Transfer pricing

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 that would have been earned if the idealized investment strategy has been adopted 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 where it is known as Funds Transfer Pricing.

Fair value of liabilities

One dominant challenge surrounding ALM is the lack of price transparency that is available in the public securities market. Financial modeling can be applied to help determine the 'value' of liabilities and illiquid securities and their sensitivities to changes in value drivers.

Classical economic theory attempts to explain the interactions of buyers and sellers of goods, including capital and labor, which form a 'market'. The analyses of transactions occurring in a market permit an objective 'market value' of one good in terms of another. If market trades for a good are infrequent, or if the market for such a good is known to be illiquid, inefficient, or incomplete, it may be difficult to obtain a market value, but it may be possible to assign a 'fair value' using a market value model based on information known about the market values of similar goods. Liabilities often require use of the concept of 'fair value' because they often do not have a traded market value. (For an overview of fair value see Society of Actuaries, 1999.)

There is an active dialog between the actuarial, accounting, and financial regulatory professions regarding the fair value (or 'market value') of insurance liabilities due to a greater need for increased transparency in financial statements, an increased emphasis on risk management, and the convergence of the financial services industry. The International Accounting Standards Board[6] had spearheaded the implementation of fair value accounting treatment within the EU by 2005 and is issuing *Statement of Principles: Insurance Contracts* in 2003. In October 2002, the Financial Accounting Standards Board[7] agreed to work towards a 'convergence' of global accounting standards.[8]

The IASB is moving towards a 'balance sheet' (prospective) approach rather than an 'income statement' (deferral and matching) focus that has been the cornerstone of FASB. Both balance sheet alternatives being considered by IASB – the 'entity-specific value' and 'fair value' – 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 (ie, entity-specific) or must always use those consistent with an arm's length transaction between knowledgeable, willing parties (ie, fair value).

For life insurers, Gutterman (2002) provided an overview of the 'fair value' issue in *The Coming Revolution in Insurance Accounting.* Reitano (1997) outlined two actuarial valuation approaches: (a) the direct (or option pricing) method which discounts liability cash flows; and (b) 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 (2002) showed these methods produce the same results using consistent assumptions. Babbel, Merrill, and Gold (2002) demonstrated three methods to determine the fair value of liabilities via the direct approach. Debate persists on underlying assumptions, discounting methods (including credit spreads), market value of margins (MVM), and measurement/reporting.

ALM in insurance 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 provides a snapshot of various insurance products, some of their characteristics, and approaches used for ALM.

- Most current ALM work by casualty actuaries relies on dynamic financial analysis (DFA), 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. 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. DFA is required in Canada. Interest rate generators and 'cascading sets of stochastic differential equations' modeling assets and liabilities are now common for both life insurance and property-casualty insurance DFA models.
- Probability of ruin (POR) is a common risk measure in the European actuarial literature used for measuring financial strength, solvency monitoring, and internal company management.
- Expected policyholder deficit (EPD) analysis measured by a DFA model is an alternative to probability of ruin. EPD can be compared to valuing a call or put option by a Black-Scholes option pricing procedure. EPD can help determine the asset/liability efficient frontier for property excess-of-loss catastrophe reinsurers or workers' compensation loss reserves and implied risk-based capital needs.
- 'Coherent risk measures' have been used instead of probability of ruin, VaR, or expected policyholder deficit mostly in the academic literature and in European studies. For example, conditional tail expectation can help analyze capital requirements, capital allocation, reinsurance, and asset allocation.
- The National Association of Insurance Commissioners (NAIC) life insurance company risk-based capital formula has an interest rate risk component, as does A.M. Best's Capital Adequacy Ratio (BCAR) used for property-casualty insurers.[9] But the NAIC's risk-based capital formula for property-casualty insurance companies has no interest rate risk charge as interest rate risk within a statutory accounting framework is minimal for casualty companies.
- DFA models are used to determine an asset/liability efficient frontier. 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, and solved to maxi-

mize surplus growth or pre-tax operating income for a given level of risk as represented by probability of ruin, VaR, or expected policyholder deficit. There are questions about the efficiency criterion used in many such studies, as the sampling error may degrade the ability to effectively distinguish optimal and non-optimal points in risk–return space.

Recent valuation, equity bias, and portfolio rate assumption controversies

Recently some financial economists have pointed out biases in classic actuarial models that favor high-risk equity investments that they have blamed for some aspects of the 2002–03 pension fund crisis (see Chapters 17–19). In Vancouver in June 2003, papers were presented at the 'Great Controversy: Current Pension Actuarial Practice in Light of Financial Economics' conference where advantages/weaknesses of the different pension models were discussed. Still controversial valuation differences in actuarial and option pricing models were first eloquently presented by Bodie (1995) and excellently summarized by Wendt (1999) and in the Bader and Gold (2003) paper 'Reinventing Pension Actuarial Science', and discussion articles associated with it.

Since a major portion of ALM is identifying the 'risk of concern', the question being addressed by Bodie, Bader, and others will make the need to identify the risk of concern and its underlying liability more obvious. With so many vested interests (with different axes to grind) in pension plans, including the accountants, SEC, PBGC, shareholders, debt holders, management, and even the plan participants, there is no single solution. Recent suggestions by Peter R. Fisher, former Under Secretary of the Treasury for Domestic Finance under the Bush administration, to use a term structure of corporate rates and Warren Buffet's championing more realistic portfolio rates will add fuel to the fires.

Citing DFA analysis, some actuaries have suggested that property-casualty insurers should invest more heavily in common stocks. Alternatively, others have suggested that the statutory accounting valuation of bonds at amortized value and of common stocks at market has led to an overemphasis by PC insurers in bonds. Some have suggested a similar bias exists for life insurers.

Conclusions

While much has been accomplished by applying advanced financial modeling techniques to risk management and ALM, many challenges remain, especially with respect to balancing competing interests and combining subjective judgment and human knowledge with models of consumer behavior. Improvements in and feedback from the ALM process is needed to improve confidence in model reliability and to balance accuracy versus uncertainty. In practice there are many areas competing to model ALM:

- actuarial;
- product;
- investment;
- treasury/finance;
- risk management;
- trading; and

- regulatory.

Senior management must be helped to understand and interpret differences in assumptions and results from economic, CAPM, investment, actuarial, and statistical models, and in accounting/financial reporting over short-term and long-term horizons. Risk management should provide interpretations that appropriately contrast long-term and short-term economic valuation versus quarterly accounting/financial reporting, economic versus regulatory capital, and insurers additionally have to report both statutory and GAAP financials.

Some of the more complicated questions will remain a matter of investment philosophy within the industry.

- What is the appropriate long-term equity allocation?
- What is the optimal portfolio yield and reinvestment investment income relative to liabilities?
- Is it better to segment portfolios or manage a co-mingled general account in the insurance context?
- Maximizing yield with diversification, passive index, or active total return investment management?

ALM is a critical component in strategic management, such as allocation of capital and maximization of risk-adjusted return on risk-adjusted capital (RARORAC). Ultimately there is a philosophical ALM decision to match or consciously mismatch liabilities and what approaches best communicate economic and financial risks to senior management and the board of directors (see Chapter 11).

In summary, ALM and financial modeling is still a lot of art, but the science is advancing.

- Banks have proved that it is possible to produce timely and actionable ALM exposures.
- Insurance companies and pensions typically have longer horizons and also longer lags in capturing and evaluating liability data. Recent distributed computational advances can permit more granular data to be evaluated over numerous scenarios and underlying models can be very complex. And yet the reliability and confidence in models can vary significantly from product to product, firm to firm, and business to business.
- Competitive forces will continue to make companies squeeze out maximum value from both sides of the balance sheet and advances in ALM processes, liability products, and risk management solutions will advance ALM in all areas.

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[2] Casualty Actuary Society's DFA model Dynamo (see http://www.casact.org/research/dfa/).

[3] Another name for equivalent martingale measure is risk neutral measure and they refer to the probability distribution for which prices are discounted expected values.

[4] The Capital Asset Pricing Model (CAPM) was developed by Sharpe (1964), Lintner (1965), and Mossin (1996). William Sharpe was co-winner of the 1990 Nobel Prize in Economics.

[5] 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.

[6] International Accounting Standards Board (IASB) (see http://www.iasc.org.uk).

[7] Financial Accounting Standards Board (FASB) (see http://www.fasb.org).

[8] The American Academy of Actuaries published a public policy monograph on Fair Value Principles and Methods in September 2002 (http://www.actuary.org/pdf/finreport/fairval_sept02.pdf) and the International Actuarial Association has a comprehensive index of topics and issues (http://www.actuaries.org/public/en/committees/INSSTD/documents.cfm).

[9] A.M. Best's Capital Adequacy Ratio (BCAR) for Property/Casualty Insurers (see www.ambest.com/ratings/2001underbcar.pdf). A.M. Best is a rating agency.