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General Asset Modeling Issues

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GENERAL ASSET MODELING ISSUES
Practical Asset Market Values

MR. THOMAS W. REESE: Actuaries have considerable experience building financial projection models for insurance product liabilities. The requirements for cash-flow testing and asset/liability management have caused actuaries to develop their systems to include asset financial projections as well. My thesis is that the unique needs of insurance asset/liability management require a new perspective on the calculation of asset market values. My presentation focuses on the problems and solutions for calculating asset market values in insurance asset/liability models.

Of course, considerable thought has been given to the general problem of calculating asset market values. There are extensive systems available in the investment community for such calculations.

Interest Paths

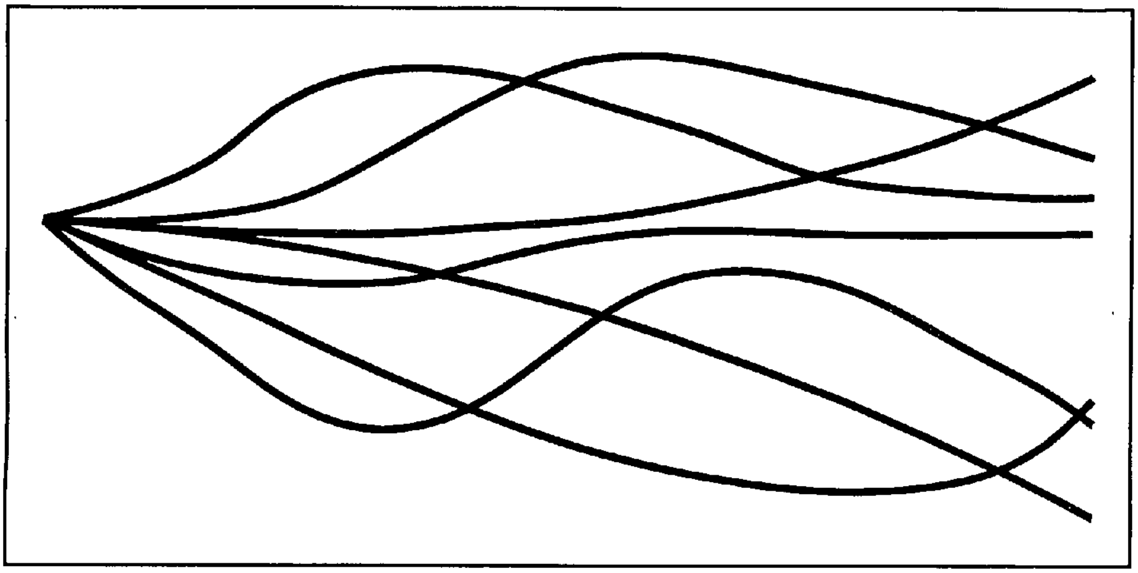
Chart 1 illustrates the asset market value concept. No one knows the future path of asset cash flows and interest rates. By projecting a large number of arbitrage-free stochastic interest scenarios beginning with the pricing date yield curve, however, you can calculate the average discounted value of asset cash flows along each path. That average is the expected market value of the asset.

This is a simple concept that can involve intensive calculations. Therefore, more efficient algorithms have been designed for the market value calculation.

Projecting and discounting asset cash flows along each of a number of interest scenarios is generally required for assets that are path dependent. That is, the asset cash flows at any time depend not only on the current interest yield curve, but also on the history of interest rates that have affected this asset. For example, the prepayment rate for mortgages depends on the past number of opportunities individuals have had to refinance at a certain interest rate in the past.

CHART 1

Present Value of Cash-Flow Alternatives
Interest Scenarios



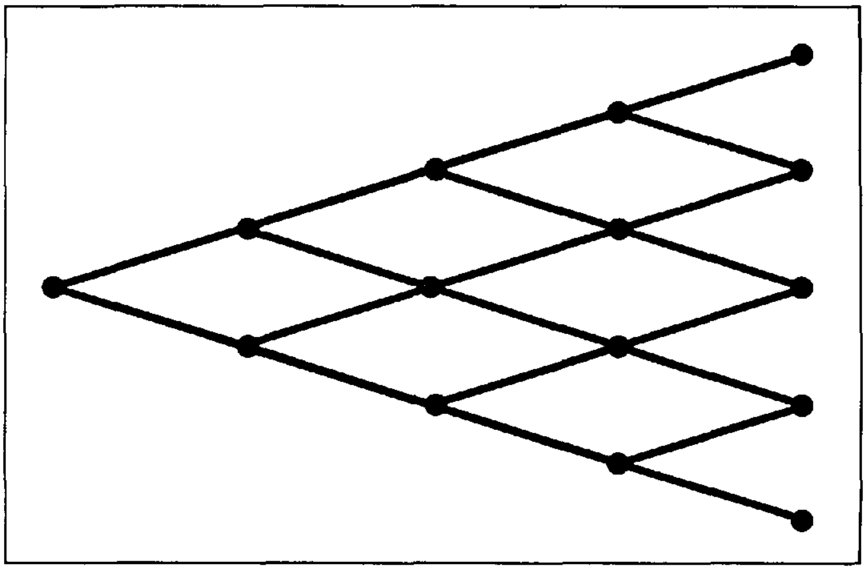
Interest Lattices

Many types of assets, however, are not path dependent. That is, their value can be determined at any point by knowing the current economic conditions without regard to past history. For these types of assets, much research has been done to make the calculation of asset market values more efficient.

Chart 2 shows a simple illustration of the concept of using a connected lattice approach to valuing assets. The assumption is that the interest rate at any point can either increase or decrease (or perhaps continue level) to the next time period, based on the volatility of interest rate changes. The lattice is constructed to present an arbitrage-free pattern of future interest rates. By following the potential interest rate movements through each of these nodes, an interest rate lattice simplifies the number of asset valuations that must be made. Since it is easy to value the asset at maturity, the market value of assets can be discounted back through the nodes of a lattice to calculate the market value at the current date.

CHART 2

Non-Path Dependent Assets
Connected Lattice



There is a diverse array of types of lattices and interest rate discounting models available. These models are commonly available in the marketplace, and have proven to produce market value results consistent with those observed in the marketplace.

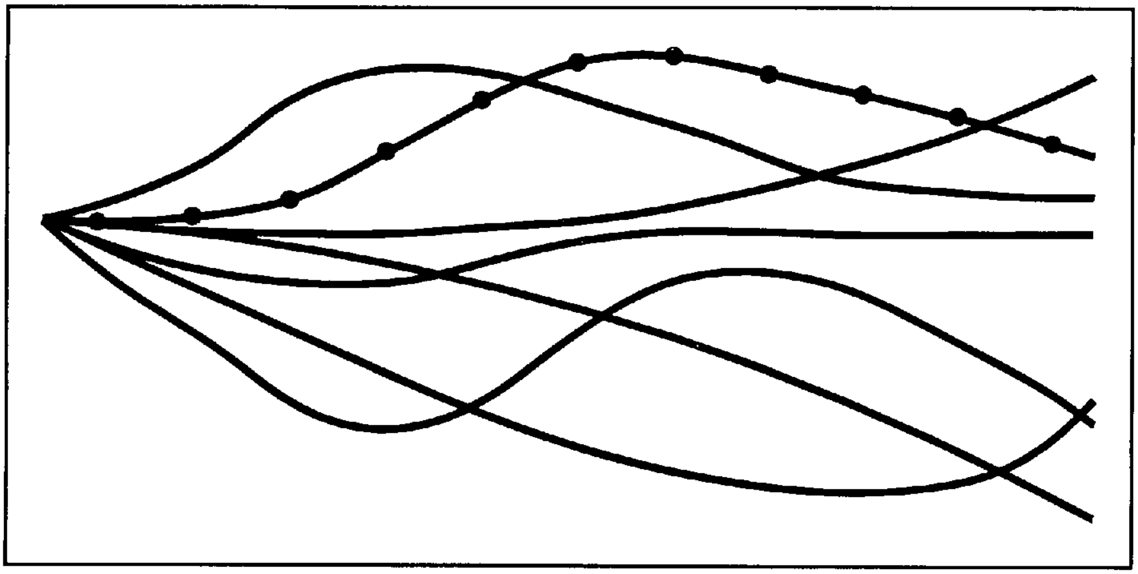
Insurance Asset/Liability Modeling Needs

Actuaries know about these asset market value calculation techniques. The problem is that we have to calculate so many asset market values! Chart 3 illustrates that asset market values must be calculated not only at the model start date, but also as of various time intervals along each interest path included in our asset/liability modeling process.

I believe this is a new concept in the calculation of asset market values. The existing asset market value algorithms have not had to solve this problem. They are concerned with calculating current asset market values. The concept of having to value assets at future dates along each scenario path is foreign to most uses other than insurance company asset/liability financial projections.

CHART 3

Multiple Compute-Intensive Processes
Interest Scenarios



We have a need that is unique within the investment community. We must project assets on a basis that includes insurance book value accounting of assets. However, we need to calculate asset market values whenever assets are sold to cover negative cash flows or to manage the investment portfolio as we simulate insurance company operations along each interest path. Further, we need to calculate asset market values at certain reporting intervals to show the liquidation value of assets to test reserves or surplus. Finally, the new accounting *Financial Accounting Standard (FAS) 115* requires assets to be valued at market value in some cases.

This requirement for so many asset market value calculations can be an overwhelming obstacle in the development of asset/liability model projections. The traditional asset market valuation techniques, which are proven effective for valuing current assets, fail for insurance asset/liability modeling because of the extremely long run time that would be required to implement them at so many asset valuation situations and dates.

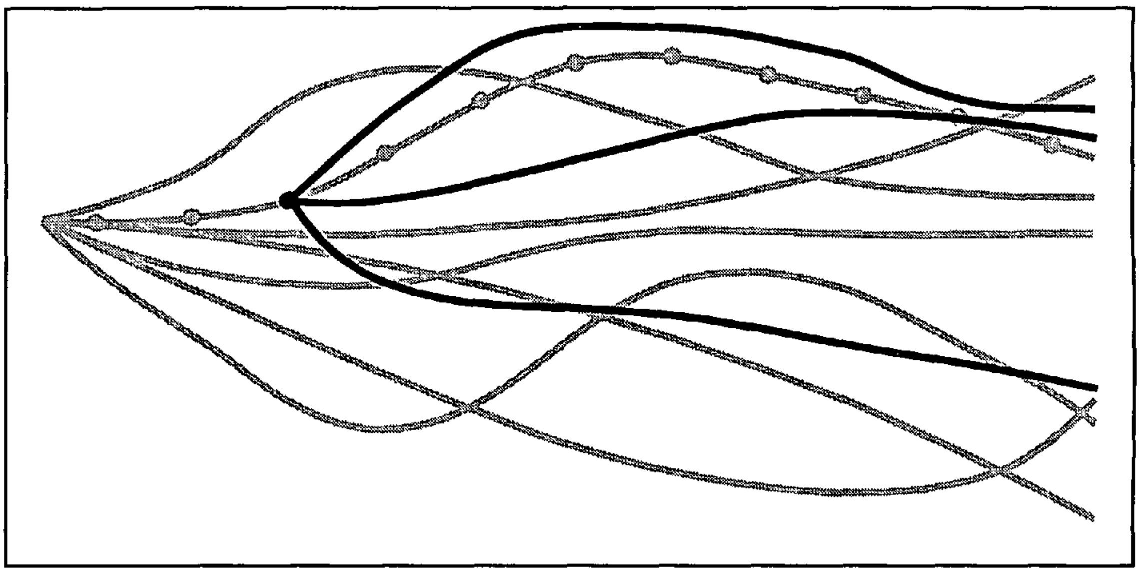
Instead, actuaries need to search for new solutions to the asset market valuation problem. Again, I believe our problem is unique. We are trying to solve a problem that the investment community has not had to address.

Solution 1: Few Paths

The first solution to this problem could be to calculate asset market values using a scaled-down version of the traditional asset market valuation techniques. This could involve the generation of a lower number of alternative interest scenario paths from each market valuation date, as is illustrated by Chart 4. Alternatively, it could involve the generation of a "sparse" interest scenario lattice with, say, annual instead of monthly time intervals.

CHART 4

Solution 1: Few Alternative Paths
Interest Scenarios



Whichever approach is used, the problem remains calculation time. The need to produce timely results will invariably drive this method to the use of so few alternative rate paths or such a sparse lattice that the accuracy of the results will be unstable. With today's computer hardware, I believe the calculation of asset market values by developing alternative interest paths is generally not feasible.

Solution 2: Simplify and Precalculate

A second potential solution is to precalculate the asset market values that would occur at different interest rate conditions through the remaining life of the asset. These precalculated results would be stored in a table so that asset market values could be interpolated from the stored results, given any interest conditions at any particular time in the life of the asset.

To make this method feasible, the economic interest conditions must be simplified. A one-factor interest model calculates the asset market values purely using the current Treasury spot rate. Of course, this method also assumes implied Treasury rate volatilities consistent with current asset market values. Using this approach, you could precalculate asset market values at various spot rates through each period in the asset's remaining life.

Table 1 shows a small portion of what such a table might look like. In actual practice, of course, values would be calculated at more values for the remaining years until asset maturity and at more spot rate values.

The method of calculating asset market values in this solution could be any of the established calculation techniques. The point is that they are all calculated at the model start date for existing assets and at the time of purchase for future assets. Then they are stored in tables for interpolation against the actual situations that occur through the model.

Of course, this one-factor interest model may not be sufficient for some types of assets. For example, mortgages are commonly modeled as having prepayment decisions governed by the current long-term (e.g., ten-year maturity) interest rate, while cash flows are discounted at the spot rates. In this case, a two-factor model can be used by adding a separate long-term-rate component to the precalculated stored tables. This results in a four-dimensional stored table (years/spot rate/long rate/market value) to be used for interpolation during the model.

TABLE 1

Solution 2: Simplified Precalculated Stored Table

Years	Spot Rate		
	2%	5%	8%
0	1,000	1,000	1,000
5	1,190	1,047	925
10	1,362	1,083	874

The drawbacks of this approach are obvious:

- The requirement for a simplified one- or two-factor interest model,
- The time required to precalculate the results, and
- The space required to store the precalculated results, which must be stored separately for each asset included in the projection.

Thus, this approach involves the same dilemma as I described for the first solution, namely that reducing the number of calculations to achieve acceptable run time and storage requirements is directly opposed to the accuracy of the calculation results.

Solution 3: Option-Pricing Techniques

Our research for a better solution has taken us to a third technique that might be surprising to some actuaries. This is the calculation of asset market values using the Black-Scholes option-pricing formula, modified in several aspects. I will explain how we have adapted this method for the calculation of bond market values.

The Black-Scholes method is a well-known algorithm for calculating the value of European stock options. It is a closed-form solution to a differential equation that defines the price movements of stocks. It is perhaps complicated to understand but is easy to calculate.

The Black-Scholes method is a well-respected means of calculating individual option prices. We have extended it to price American bond options through the following procedure.

The first step in using the Black-Scholes algorithm to calculate the market value of bonds is to convert the market value into a market yield rate that is used to discount planned cash values. The market yield is then separated into four components: Treasury equivalent yield, option-adjusted spread, option spread, and market spread.

Treasury Equivalent Yield

The Treasury equivalent yield is the market yield that would apply if this bond were a risk-free bond with no options, such as call or put options. There are two approaches to implementing this method.

The first approach is to calculate the weighted average life of scheduled principal payments. This weighted average life is used to identify the point on the Treasury yield to maturity rate curve to be used as the discount rate.

A second approach improves on the first approach, especially for uneven cash flows, by using spot rate discounting of each planned cash flow. This method takes account of all the portions of the yield curve rather than relying on one average rate.

Option-Adjusted Spread

With the Treasury equivalent part of the market yield established, the next step is to add an option-adjusted spread component that reflects the credit risks for the asset. With the option-adjusted spread included, the resulting market yield prices the equivalent noncallable and nonputable bond.

The appropriate option-adjusted spread assumptions can be determined by valuing groups of bonds in the market place without their call or put options. The option-adjusted spread varies by quality rating, years to maturity, and investment sector, such as oil versus utilities versus transportation investments.

Another characteristic of the option-adjusted spread is that it should increase as interest rates increase. That is, option-adjusted spreads would be expected to be wider in a 15% interest rate environment than they would in a more normal interest rate environment. This can be demonstrated by making a regression of bond market yield spreads over Treasury rates over historical years.

Option Spread

Now that we have calculated the market yield for an equivalent noncallable and nonputable bond, we can isolate the price of the option, which we will convert to a yield spread. For this purpose, we are using a modification to the Black-Scholes algorithm, made by Black. This option-pricing algorithm is applied at various different options available through the life of the bond.

The question is how to convert the prices of individual call options into the total option price for all the options. Our research has found that using the highest individual option price is a good approximation for the price of all the options as a whole.

With the option price determined, we then convert the option price into an option spread assumption.

Market Spread

The fourth component of the market yield rate is an additional spread to reproduce the current market yield rate. I will refer to this spread as the "market spread."

This market spread could be considered to be a refinement of the option-adjusted spread assumptions. That is, it is a correction of the spread assumption. For example, you might have assumed an option-adjusted spread for AA bonds. In actual practice, however, you may be modeling utility versus transportation versus oil AA bonds. The market spread in this case would adjust the overall average option-adjusted spread assumption to make it fit each individual asset.

Another view of the market spread is to consider it as a cheap/rich indicator. That is, the actual asset market values observed in the marketplace represent assets that are underpriced and overpriced. A consistent asset market value analytical tool can identify these pricing opportunities.

The market spread represents the balancing adjustment needed as of the model start date. The market spread could be kept constant through the model, usually interpreting it as a refinement of the option-adjusted spread assumption, or graded off to zero by maturity, usually considering it to be a cheap/rich indicator.

With the market yield rate determined, the asset market value can now be calculated as the present value of scheduled cash flows discounted at the market yield rates, where the market yield rates are calculated as the appropriate spot Treasury rate plus the option-adjusted spread, option spread, and market spread component.

Test Results

It is important to determine how well this asset option-pricing method works in practice. To measure that, we tested 21 callable Treasury bonds publicly quoted in the market. These bonds are 25- and 30-year bonds that were issued between 1974 and 1984, and are callable during the last five years before maturity. This collection of bonds gives a good test to the option-pricing methodology because it removes any error related to assumptions for option-adjusted spreads for nonrisk-free bonds.

Table 2 compares the pricing of this bond portfolio against the actual market values observed as of February 15, 1994. The first valuation was performed using the Integrative Bond System (IBS) available from Global Advanced Technologies (*GAT*). This system is widely used for calculating current asset market values.

TABLE 2

Testing the Theory
21 Callable Treasury Bonds

	Mean Error	**Standard Deviation**
GAT IBS	1.1%	6.0%
Black's Modified	3.9	6.9

The *GAT* system was able to price the bond option prices within 1.1% of the average observed market values. The standard deviation was 6.0%. This was compared against the modified Black formula results as I previously described, which produced an error for the option price of 3.9%, with a standard deviation of 6.9%. This error applies to the option price only. Of course, the error would be much less if it were measured against the total asset price.

The first two solutions I discussed above for calculating asset market values can, of course, produce accurate asset market value results if there is enough calculation time and, for solution number two, disk storage space available. None of these methods can be completely thorough, however, given the time and cost restraints available. The Black's formula approach that I have outlined is a means of obtaining the most accuracy with a reasonable amount of calculation time. Our goal is to achieve 90% of the accuracy while doing only 10% of the normal work involved in calculating asset market values.

GENERAL ASSET MODELING ISSUES

MR. MARTIN P. KLEIN: This presentation is made up of two distinct, though related, topics. In the first segment of the presentation will be a discussion of considerations in using deterministic versus stochastic yield curve scenarios. In the other part of the presentation will be a discussion of modeling issues in developing investment strategies, including how to define risk and reward criteria in the model, and the considerations in determining quantitative and qualitative assumptions.

Deterministic Versus Stochastic Scenarios

There are a number of advantages to using deterministic yield curve scenarios. One major reason is that deterministic scenarios are easy to develop. When engaging in cash-flow testing, the minimum required deterministic scenarios are already spelled out. Putting together other scenarios is not difficult either -- one merely stipulates what will happen to various key points on the yield curve: short, long, and perhaps certain intermediate rates. The results of modeling under such scenarios are also fairly easy to understand and communicate.

Another reason to use deterministic scenarios is that they are quick to put together and to model results under. And quickness has its virtues, although of course it can be fatally flawed if misleading results are produced.

Deterministic scenarios can be very useful in answering "what-if" types of questions. For example, an insurance company's management or investment managers may have a certain view on interest rates, and may want to base asset/liability or investment decisions on that view. Alternatively, there may be an interest rate scenario that management is fearful of, for example, an inverted yield curve scenario that might strain profitability.

Perhaps the most compelling reason to use deterministic scenarios is because you have to. When performing cash-flow testing for determination of reserve adequacy, there are, of course, certain scenarios explicitly spelled out, which the valuation actuary must use.

Despite all these reasons to use deterministic scenarios, there are drawbacks. One is that they can be arbitrary. Deterministic scenarios that are viewed as likely or as worst case represent only opinions as to what is likely or what is the worst case.

Even deterministic scenarios developed with the intent that they represent a wide spectrum of possibilities are limited. It is very difficult to capture the full and true risk profile of a company's business particularly given the complicated liability and asset structures that most insurance companies have. For example, trying to put together the worst case scenario for a particular type of liability or asset is very complicated, and becomes infinitely more so when trying to do so for several, potentially very different, liability types and asset types.

Given these limitations of deterministic scenarios, a strong case can be made to use randomly generated, or stochastically generated, yield curve scenarios. Certainly stochastic scenarios are less arbitrary than deterministic ones, and so they are less likely to be influenced by the views and biases of those developing them. Please note the use of the words "less likely to be influenced," as opposed to, say, "not influenced by." Given the many assumptions that must be made in generating stochastic scenarios, one can hardly say there is no arbitrariness or bias involved. But certainly compared to deterministic scenarios the magnitude of such influence is much less.

In addition, modeling under stochastic scenarios, by virtue of their random generation and sheer number, is more likely to capture the full and true risk profile of insurance company asset and liability structures. This can be very helpful not only in giving a better realization of what could happen, but also in managing the business to produce a more favorable set of potential outcomes. For example, as will be discussed in the next part of this presentation, stochastic scenarios can be very useful in developing investment strategies. Modeling under stochastic scenarios can provide a better measure of reward and risk, and different strategies, either on the asset side or the liability side, can be tested and compared.

Capturing this true risk exposure is very important, and while there are no regulations currently mandating that one has to use stochastic scenarios, one ought to. The appointed actuary is responsible for evaluating reserve adequacy, and is better equipped to make such an evaluation if he or she has the richness of information available under a stochastic analysis. Similarly, such information is also very helpful in the management of assets and liabilities.

Despite the advantages of stochastic scenarios, there are some difficulties around them that have kept them from being fully utilized, or sometimes from being used at all. Stochastic scenarios are certainly much more complicated to understand, explain, and develop. As noted earlier, there are a number of assumptions that must be made in producing them, and the determination of what assumptions are appropriate is not a trivial process. Assumptions need to be made with respect to interest rate volatility, the relationship between the short and long end of the yield curve and possible reasonable boundaries with respect to levels of rates. Assumptions even need to be made with respect to the general direction of rates. Such direction may involve following what is implied by the forward curve, or a certain shape and level of yield curve toward which rates have a tendency to move, or perhaps there is no explicit assumption at all.

Not only are stochastic scenarios more complicated to develop, they are more time-consuming to use. While the time generally is well spent, it can be an obstacle. During the process of putting together year-end financial statements, time is at a premium, and so the impetus to prepare stochastic scenarios and model assets and liabilities under them may not be great. However, with proper planning and management, the obstacle of time is not insurmountable.

Having discussed the value of modeling under stochastic scenarios, the next item to cover is obtaining a stochastic yield curve generator. There are two basic choices: buy one or build one. With respect to buying one, the major asset/liability modeling software packages generally include yield curve generators. While in some instances these may not be ideal from a theoretical standpoint, with some trial and error with respect to input assumptions, usually these generators can produce sets of scenarios with the desired characteristics. In other words, assumptions can be used which produce reasonable scenarios. This is preferable to developing what appear to be reasonable input assumptions, which when input in the generator and when in interaction with each other, produce unreasonable scenarios.

Of course, there are other choices that fall under the category of buying a generator. One is to hire a consultant to build one. Another is to use one provided by a Wall Street firm, where the cost may be in actual or else soft dollars.

How to build a generator is beyond the scope of this presentation and will not be covered here. This subject is a presentation unto itself. However, there are a number of worthwhile papers written on the topic, including some in Society of Actuaries publications such as the *Transactions*.

Developing Investment Strategies

Attention now shifts from the issues of deterministic and stochastic scenarios to a subject area where such scenarios can play an important role -- using modeling in developing investment strategies. Many actuaries here are so heavily focused on using asset/liability models for testing statutory reserves that they do not give much attention to using the models as a tool to manage business, including the development of investment strategies. But it is in fact the next logical step -- using modeling not only to measure risk, but also to help in managing it.

In the process of cash-flow testing for reserving purposes, there may be concern that in certain scenarios reserves are insufficient. In such cases the appointed actuary grapples with whether to increase reserve levels. All too often, however, a critical aspect of this problem is overlooked. That aspect is the investment portfolio and strategy backing the liabilities. By repositioning the portfolio or by changing the reinvestment strategy, the problem may be solved or at least mitigated. The suggestion here is not that cash-flow-testing results drive investment and asset/liability management decisions, but rather, that cash-flow modeling is an invaluable tool in making such decisions. As insurance companies have had to develop extensive models of their business for cash-flow-testing purposes, a logical extension of this tool is to use them in making management decisions. Granted, there are obstacles in many companies, often political ones. But perhaps the biggest obstacle is the tendency to stay so buried in one's specific responsibilities, that applications to other areas are never pursued. The valuation actuary may be so immersed in financial statement work that he takes a, "What, me worry?" attitude with respect to the investment side of the business. I hope the rest of this presentation will help those who are or can be in a position to lend some influence in the asset/liability management process. And for those who are not in such a position, I hope this presentation can be a starting point so they will at least be more aware of what can or should be considered in the process.

In using models in the development of investment strategies, it is important to develop criteria on which to define and measure risk and reward. In the context of cash-flow testing for determining reserve adequacy, risk might be defined in terms of the amount of surplus, perhaps on a market-value basis, at particular points in the future. This definition of risk might also be employed in using modeling to develop investment strategies.

Another definition of risk may be put in terms of earnings volatility. For example, over a particular time horizon, perhaps a year, perhaps five or ten years, there may be a desire to keep earnings volatility within certain bounds. Such volatility might be measured in a variety of ways. One measure might be the range of earnings results over a set of yield curve scenarios. Or, perhaps the measure might deal with only a lower bound rather than a range, e.g., earnings over the time horizon falling below a certain level. Another volatility measure might be in terms of the standard deviation of earnings results over a set of scenarios, or the mean result divided by the standard deviation.

The risk of insolvency might be another measure of risk employed in modeling for investment strategy purposes. Here the focus is on worst cases rather than volatility. These worst cases could be analyzed in terms of the probability or likelihood that surplus behind a line of business will be eroded away. Reworking this definition somewhat, risk could be measured in terms of the amount of target surplus that would be required in order to absorb the losses.

Reward definitions also need to be determined. Such definitions might be in terms of the present value of earnings, or the average earnings over a particular time horizon. Another definition might be the amount of surplus accumulated at the end of the period. The incidence of earnings may also be a factor, e.g., are all the profits up-front, or are they fairly well spread over time? Return on investment, where the "investment" reflects the associated level of target surplus, may be another definition.

Once definitions of risk and reward are determined, the assumptions must be set. Since the subject of this presentation is developing investment strategies, assumptions dealing with assets will be dealt with here, and liability assumptions generally will not be.

Asset assumptions are generally of the same types as made in cash-flow-testing work, although in the context of developing investment strategies the assumptions may be a bit different than those actually used in determining reserve adequacy. Assumptions in models for developing strategies might not have the conservatism that may be embedded in cash-flow-testing assumptions, or might tend to reflect current conditions more than longer-term averages.

Spread assumptions, that is, the yield of a security over that of the comparable maturity Treasury security, might be set to reflect current conditions. Note that in referring to spreads, this is the nominal difference between the yield on the security and the corresponding Treasury security -- not option-adjusted spread. Remember, in a cash-flow model, options embedded in securities will play out depending on the particular scenario. If current spreads are reflected, consideration should be given to having spreads move toward their longer term, more typical or usual levels at some point or time in the future. Spread assumptions in a stochastic scenario context are ideally determined not just as a flat spread to Treasuries, but rather in an approach that reflects the level of the underlying Treasury rates. For example, at a high level of rates asset spreads are often wider in an absolute sense than they are at a low level of rates. One function commonly used is of the "$ax + b$" type, so that the higher rates are, the wider spreads become.

As for spreads, defaults in a model used for developing strategies might be set, at least in the initial periods of the model, at levels more in line with recent experience, with a move in levels to longer term, more typical levels at some point. Unlike spread assumptions, however, it is uncommon to have default assumptions be a function of the particular yield curve scenario. Default assumptions tend to be set as a flat deduction, independent of what is happening with interest rates. Although a case might be made that defaults are higher, say, in a low interest rate environment, which may indicate a recessionary economy, it is very difficult to translate this type of default variability into a model. The good news is, when dealing with higher quality assets, that default variability is not a significant item next to other assumptions. The bad news is that it is very significant when dealing with lower quality assets.

Default assumptions should not be set in a vacuum. They should be set in the context of corresponding asset spreads, and the spread net of defaults should look reasonable across the quality spectrum. While, of course, asset spreads increase as quality decreases, the market view is that asset spreads net of defaults also should increase as quality goes down. In other words, the expected return, net of defaults, must increase to compensate for the additional risk.

Moving from spread and default assumptions to option assumptions, the option should be exercised consistent with what has happened to interest rates in a particular model.

With respect to call options on corporate bonds, calls are exercised when it is in the best economic interest of the issuer to do so (although some slight friction element might be incorporated, as the issuer must take certain steps to call its debt and perhaps refinance it, and also may give some, albeit small, consideration, to the holders of the bonds). However, it is generally a relatively straightforward matter to determine when it is economically worthwhile to call a bond.

Prepayment assumptions are a different matter. Mortgage prepayments generally do not follow what is in the best economic interest of the mortgage holder. Even if they did, what is in the best economic interest for one mortgage holder is not the same as for another, because, for example, their time frames in their respective houses may be different. Another complication, which is particularly relevant when modeling under stochastic scenarios with twists and turns in the yield curve, is the various types of mortgage loans available. Prepayment speeds are not only a function of the level of interest rates, but also of the relationship between the short and long end of the yield curve. For example, as the yield curve steepens, there is a tendency for 30-year-fixed-rate mortgage holders to switch to adjustable rate mortgages, which are generally indexed to short-term Treasury rates.

The point of these observations on prepayments is that, while some mortgage-backed securities are not as sensitive to prepayment speeds as others, extreme care must be used when modeling the more prepayment-sensitive instruments. Even with this extra care, one must realize that modeling results for these types of securities will not reflect the additional element of volatility related to prepayments. That is, for a corporate bond, there is really one fairly predictable outcome for a particular move in interest rates. However, for prepayment securities, there is a range of outcomes, and they are not as predictable, for a particular move in interest rates.

Market value assumptions are very important if there is significant negative cash flow in the business, in which case assets will need to be liquidated to meet the outgoing cash flows. Market value assumptions, of course, are also important when looking at market value of surplus. Market values, for securities with embedded options, are not the present value of future cash flows in a static environment, nor are they the present value of future cash flows in any one particular scenario. Rather, market values reflect the present values over a spectrum of yield curve scenarios.

It was just noted that, should there be negative cash flow in the model, assets will need to be liquidated. Other approaches are used by some in their models. Examples include borrowing to meet negative cash-flow needs, or purchasing "negative assets." Neither of these reflect reality for most insurance companies, though there are exceptions, such as companies with alternate sources of liquidability, such as a bank line of credit. However, generally the assumption that assets must be liquidated is the most realistic one. In cases where there is an assumption of continued incoming premium, care should be taken that this assumption is truly appropriate in a scenario where a company is under distress.

Shifting attention now to yield curve scenario assumptions, not only must the assumptions in generating stochastic scenarios be reviewed carefully, but also the resulting scenarios need to be reviewed for reasonableness. Due to the interaction of various assumptions, the resulting scenarios may not be reasonable, and so it is important to back-test them and perhaps revise the assumptions until a reasonable set is produced. In determining reasonableness, a number of characteristics should be considered. These include short, intermediate, and long-term interest rate volatility, the proportion of inverted yield curves, the length of time yield curves are inverted, maximum and minimum rate levels, and average rate levels, or more generally, the direction and magnitude rates tend to move over time. While the forward curve has proved to be a poor indicator of future rate movements, if the yield curve tends to move differently than is dictated by the forward curve, the scenarios are not arbitrage free. This means that the average present value of a security's cash flows over the set of scenarios will be different than the market value of that security.

In determining the initial asset portfolio and the reinvestment strategy, both aspects being part of developing investment strategies, the focus to this point has been on quantitative assumptions for the model. However, there are a number of qualitative aspects that must be considered and ultimately reflected. If these qualitative aspects are ignored, using a model to develop investment strategies could, for example, lead a company to the conclusion that making huge investments in junk bonds or commercial mortgages is the best risk-adjusted strategy. The point is that several qualitative aspects need to be factored in the model as additional constraints and considerations.

One consideration is asset liquidity. Private placement bonds, commercial mortgages, and certain prepayment-sensitive mortgage-backed securities are examples of asset categories that are or can be relatively illiquid. In a model these types of securities can look very attractive. However, in a scenario where a company is distressed and needs to liquidate assets, it could find itself in a liquidity squeeze such that, even if the company is solvent, it may not be able to liquidate assets in order to meet its obligations. Therefore it is important to consider liquidity needs, not just in normal circumstance, but in bad times as well, and to reflect liquidity needs in the investment strategy.

Asset availability is another issue to be considered. While a certain type of investment may appear to offer an ideal fit within a portfolio or against a liability, there may be practical limits on the availability of this type of security in the market. Availability needs to be considered not only in the near term, but also over the long term. It may not be realistic, or prudent, to assume a certain type of security is available far in the future, or at least at the spreads it may have currently.

Portfolio diversification is a third consideration. Again, certain asset categories may appear to be ideal from a quantitative standpoint, but if the qualitative aspect of diversification is not dealt with in a model, there could be instances where model results lead to a conclusion that the best investment strategy on a risk-adjusted basis is to invest 100% of all funds in one particular type of asset. Apart from the asset availability issue just discussed, for portfolios of significant size it is wise to diversify among types of securities, as well as among industries and among issuers.

Another set of issues to deal with are those with respect to external audiences, namely, regulators, rating agencies, customers, and distribution channels. Some issues may be hard and fast. Others may be matters of perception, but perception can be very important with these audiences. With respect to regulators, there may be explicit constraints on investments in certain securities. For example, New York has its restriction on the proportion of assets invested in junk bonds. Other regulatory considerations may not be quite as explicit, but can be limiting. From a cash-flow-testing perspective, too much of a duration mismatch between assets and liabilities, or too much negative convexity in the portfolio, will lead to scenarios where reserves need to be strengthened in order to be sufficient. Realizing that the discussion here with respect to investment strategies has been in the context of using asset/liability modeling as a tool to develop them, presumably strategies will not be developed which produce adverse results in certain cash-flow-testing scenarios. However, another regulatory consideration is risk-based-capital (RBC) regulations. If a company's RBC ratios are of concern, certain asset classes are preferable to others with respect to the RBC factors associated with them. For example, there are some insurers that invest less in equities than their managements would ordinarily like, because the RBC factors associated with equities are relatively high.

The rating agencies are another group that can bear some influence on a company's investment decisions. For example, in order to preserve a very high rating from A.M. Best or Standard & Poor's or Moody's, there are certain asset classes a company will avoid or else use very sparingly. Or, perhaps a company is seeking an upgrade, and so pledges to avoid making new investments in certain asset types. Like the regulators, the rating agencies have RBC criteria they look at, and certain liquidity criteria as well.

There may be further considerations with respect to customers and agents. If a portfolio is not responsive to rising rates, there is pressure on the insurer to hold the line on crediting rates, which makes customers and agents unhappy.

Finally, the characteristics of the company's investment managers are a factor. Staffing and the expertise of the staff have definite influences on investment strategies. A company without a sufficient credit analysis capability may want to limit its exposure to junk or lower quality investment grade paper. On the other hand, a company with a superior credit staff may bring access to certain attractive private placement issues not available to many other companies. A company with limited modeling and quantitative analysis techniques does not have the ability to properly manage certain mortgage-backed securities in its portfolio. A company without a commercial mortgage department will have limited access to that segment of the marketplace. Meanwhile, a company with an existing commercial mortgage department may feel some pressure to continue significant investments in that segment to justify the cost of the department. Another factor is that sometimes investment managers with specific expertise in a certain asset type or category may have a more biased (i.e., bullish) view of that market than others may have, and may try to influence decisions consistent with that view.