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# CASH-FLOW TESTING FOR PRODUCT ACTUARIES

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- Actuarial Standards Board (ASB) Guidelines and Guidance Notes
- Uses of cash-flow testing in product development
- Determining surplus requirements
- Setting investment strategies

MS. ANNE M. KATCHER: In the past, cash-flow testing was mainly the concern of valuation actuaries. Product developers have started to assume more responsibility in providing management with a better understanding of not only the liability side of products, but also the asset side and how it can affect their bottom line. Also, under Actuarial Standard of Practice No. 14, "When to Do Cash-Flow Testing," we now have a professional responsibility as product developers to share with management the effect that a product will have on cash flow.

Our panel consists of three distinguished speakers who all have extensive experience in both product development and cash-flow testing. Donna Claire will talk about the guidance notes that should help you in trying to write up your reports on cash-flow testing. Marty Klein will talk about investment strategies in product design. Finally, Dave Becker will talk about surplus requirements.

Donna has 17 years of experience in all phases of insurance work, including product development, expense analysis, asset-liability management, and determining investment strategies for various products. She now has her own consulting firm, Claire Thinking Inc., which specializes in corporate modeling, asset/liability analysis, and valuation actuary issues. She also teaches actuarial mathematics and investment topics at the College of Insurance. Donna has been very involved in both Society and Academy activities. She's a member of the Academy Committee on Life Insurance, is chair of the Practice Notes Task Force, and is past chair of the Product Development Section. Donna is a frequent speaker at many Society and Valuation Actuary meetings, and she has written several articles.

MS. DONNA R. CLAIRE: This session is technically called cash-flow testing for product-development actuaries. I'll address issues for both product-development actuaries and valuation actuaries. After a careful study, I determined that there are two related diseases that actuaries who aren't vigilant may fall prey to. The first I call clientitis: the desire to give the answer that the actuary thinks the client wants to hear. A related disease is I-wanna-eatitous: fear of being fired if unpleasant information has to be given to management. Unfortunately, both of these are legitimate fears. There is a lot of work that an actuary has to do when cash-flow testing, both on the product-development side and the financial side. The unpleasant information that you're giving the management may not be the bad results of cash-flow testing. It may simply be the fact you have to do it in the first place. Insurance companies, like all businesses, want to maximize profits. So the first goal is to convince your

management that cash-flow testing is a worthy goal and that there are certain things that you have to do. As Anne mentioned, Actuarial Standard of Practice No. 14 is important, as is No. 7, Performing Cash-Flow Testing. Other issues addressed in the Actuarial Standards of Practice include data quality, reinsurance, dividends (for traditional life insurance), and nonguaranteed elements. The Standards of Practice are legal requirements for actuaries to follow. All of them say, "This is what you should do, and if you decide to disagree, write it in your report." But all of them say, "Write your report," which actuaries may have been deficient on. Regulators are not as deficient. They are looking for the reports on the quinquennial or triennial exams in several cases.

Turning to a serious example, there is one actuary who was told by his boss, when requesting that experience studies be done on a block of business, because the claims seemed excessive, that it was not a requirement, and that further insistence by the actuary that such studies be completed could result in the actuary being terminated. In another situation, a consulting actuary was accused of being malicious and deliberately misleading when the data quality and asset adequacy of the company was questioned. The actuary must walk a fine line between his or her various constituencies. His or her own moral judgment takes precedence, and professionalism and duty to company and industry must be considered. Time and money are legitimate constraints that the actuary must work within.

So the Practice Notes Committee was formed to document current practice. Basically what we want to do is to say these are allowable practices. It's not to straightjacket somebody into what they have to do. It's to show choices and what can be done. Our committee would not object at all if both the Standards of Practice and these practice notes were shared with your management to show the extent of work that really does have to be done.

These practice notes were referred to as guidance notes. The name was changed at the American Academy of Actuaries Board meeting last month for two reasons. In Great Britain, the equivalent of the Actuarial Standards of Practice are called Guidance Notes. It was determined that a name change was needed to emphasize that the practice notes do not have the force of Standards of Practice. A second consideration was that it was felt that the name guidance notes may imply that all must be guided by them, as opposed to our purpose of letting people know what current practices are in certain areas.

Right now there are nine practice notes. We called the first one the Generalized Present-Value Model. These practice notes were deliberately written to the valuation actuary's point of view, but they apply to cash-flow testing in general. These practice notes were reviewed by some regulators. Option pricing is currently not an acceptable alternative to cash-flow testing for valuation actuaries. You can use option pricing within typical cash-flow testing. You can also use it for pricing. You cannot use it by itself for submissions to the regulators. Multiple interest rate scenarios are important for virtually every line of business; there are certain health insurance products where it is not necessary. The minimum suggested is the New York Seven, but it is current practice to do more scenarios. Stochastic testing is becoming the preferred method for the current standard of practice. It doesn't mean you have to do it for this year. The regulators, however, are beginning to prefer stochastically

generated interest rate scenarios. By the way, stochastic just means randomly generated interest rate scenarios. Of course, the volatility when generating the random scenarios has not yet been determined.

A second practice note of interest to product development actuaries is called alternative Methods of Testing for C-2 Risk. This considers the volatility of assumptions other than interest rates, such as lapse, morbidity, mortality, and expenses. What's currently in the practice note is to test what happens if mortality rates are 250% of base, lapses are 300% of base, or maintenance expenses are 200% of base. These are stress tests. You probably do not expect mortality rates to be 250% of base. The point is to see whether or not the company can withstand it, not that you price for it. If you price for it, you're not going to sell anything! It also mentions that you ought to combine lapse and mortality sensitivities.

An interesting note is the one on structured settlements. Right now it also contains a lot of extra information that is very interesting, including the theory of how many scenarios you should test. For example, it does point out that going from 100 to 400 scenarios only doubles your accuracy and that's presuming all the underlying assumptions are correct. It also gets into Generally Accepted Accounting Principles (GAAP) and statutory requirements. Most of you have to do financials under both methods. GAAP is really the best guess. You only have to pass 50-60% of the scenarios under GAAP. Under statutory, 90-95% is the number most being thrown around right now, that's what is in the current practice note. By the end, this will probably be part of the Generalized Present Value Model, because it does apply to things other than structured settlements.

Right now we have three practice notes on asset topics. One is Modeling Defaults, where the important points to consider are asset valuation reserve (AVR) and interest maintenance reserve (IMR) requirements and, depending on what type of assets you have, the effect of fluctuations on results. Another note is Modeling Collateralized Mortgage Obligations (CMOs). CMOs are currently a very hot topic with the regulators. They have seen certain companies that didn't buy the CMO tranches that backed their liabilities and have gotten into trouble. For certain liabilities, an interest-only (IO) tranche may be good. For others, planned amortization class (PAC) tranches may be good. If you have an IO, when you should have a PAC, you may be in trouble. More work is being done in the CMO area in terms of regulation, but right now the practice note is your best guideline on things you should consider if you have CMOs.

Another hot topic with regulators is modeling defaults on commercial mortgages and real estate. Many financial actuaries have done (New York) Regulation 126 testing and follow those rules. With a number of companies taking major losses on commercial mortgages and real estate, regulators want to make sure you are considering defaults, you are considering the information from the American Council of Life Insurance (ACLI), and you are looking at your own experience, not only on how much is defaulting, but on any restructures. And it is quite possible that New York will specifically address restructured mortgages in doing cash-flow testing.

Two interesting practice notes theoretically are directed to the appointed actuary. One is on accepting or resigning the position, which really applies to every actuary.

Make sure you are qualified to do the work and, if there are areas where you're not qualified (for example on the investment side), rely on somebody else. But you have to be sure that the person you are relying on is qualified to do the work. When writing your actuarial report, get a statement from that person and specifically state what you're relying on. Again, these actuarial reports may wind up in court, and you want to cover yourself as well as possible.

A related note is Wording for Actuarial Opinions. The Academy's lawyer wrote it, and the important thing is to be very careful with what you are opining on. Make sure that people realize these are representations and not warranties.

I want to mention a number of practice notes currently in the works. The first one is part of the original nine, Special Consideration for Group Annuities. A group is writing a note on health insurance topics. A third note is Analysis of Results. Okay, you have 12 billion different numbers. What do they mean? Do you have to put up extra reserves? Do you have to reprice? That's going to be a real interesting one. Unfortunately, there are so many different opinions that the note is not yet available.

The task force plans to continue writing notes as needed and, also, as people volunteer to write them. For example, a question came up in another meeting about what to do with stockholder dividends. That's one question we're going to try to address very quickly. These notes document current practices and will have to be reviewed and updated periodically when current practices have changed.

I distributed a questionnaire at the Valuation Actuary Symposium and got 20 responses from 630 people. Despite the limited number of responses, the answers are useful and some of the things that we found out were incorporated in the next draft of the practice notes.

One of the questions was how many scenarios to test for traditional insurance and how many for interest-sensitive business. There was a slight bias toward testing less on traditional than interest-sensitive but, frankly, I was surprised that there wasn't more bias. Many people felt you had to do an equal number of scenarios on both of them. The number of scenarios that you must pass affects the pricing actuary, because if your financial person thinks you failed, you have to put up extra reserves and you should have priced for that. Most people felt at least six of the New York seven had to be passed. The majority said seven of seven, and if you had stochastically generated scenarios, most people said 90-95% was passing.

Another question was, what was the size below which you did not have to do cash-flow testing. Valuation actuaries responding to the survey may not be a representative sample, but the majority of this group said you had to test everything. Others thought the model standard valuation law minimums, below which cash-flow testing does not have to be done, are adequate, and you could apply that if you're in a large company. Still others came up with formulas such as one-half of the surplus of the company, figuring any volatility in products less than that could have been covered by surplus.

Another question asked was, what else should be considered in doing cash-flow testing. The most popular answers were reinsurance, combination of risk, and C-4 risk, such as management changing the investment philosophy of the company.

What we're trying to do with the practice notes is give you something to work off of because there are so many questions, especially when you're first starting. There may be some conflicts between time, money, and doing the right thing. You have to make compromises and some are acceptable compromises and that's what we're trying to get to.

MS. KATCHER: Marty Klein is a partner and chief actuary with Analytical Risk Management. ARM provides asset/liability and investment-management services to pension plan sponsors, life insurance companies, and other institutional clients. Before joining ARM, Marty was a managing director of the ICH Capital Management Group and chief actuary at ICH's Constitution Life subsidiary. His responsibilities included accumulation product development and asset/liability risk management. Prior to that, Marty was with Capital Holding from 1983 to 1990. Marty currently serves on the Society of Actuaries Exam Committee for asset/liability management and speaks frequently on asset/liability-management and investment-strategy issues.

MR. MARTIN P. KLEIN: My part of the session covers the development of investment strategies behind products. First, I'll discuss why the development of investment strategies is important in the product-development process, and then I'll talk about the concepts of risk and reward and how they might be applied in the process. Finally, I'll comment on methodology and wrap up with an example.

I'm going to start out by discussing why investment strategies should be developed during the product-development process. There are a number of important reasons, and these revolve around the impact investment strategies have on what I call the three Ps: product, profitability, and perception. Many products developed and marketed today have interest-sensitive features, the dynamics of which are really not recognized in traditional actuarial pricing models, such as profit studies or asset-share tests. In these traditional models, the products typically are developed under a static interest rate assumption.

In reality, rates fluctuate tremendously, resulting in product cash flows that can also fluctuate tremendously. This is usually seen in the recent interest-credited rates for deferred annuities and universal life, but it also can include other product features that are usually incorporated in products, such as bail-out features or policy loans. Investment strategies need to be tested along with product features and the desired crediting-rate strategy. After several iterations of several different investment strategies, it may become apparent that there's no reasonable investment strategy that can produce a spread to an envisioned liability with certain dynamic features. The question that needs to be answered is, "Is there an investment strategy that can produce an acceptable spread or, at the very least, avoid an unacceptable spread over a reasonable range of product cash flows?" It's much better to realize the risk in product features during the development process before the features really become locked in stone or, even worse, before much of the product is on the company's books. Waiting until after the product is marketed to develop an investment strategy is a little bit like closing the barn door after the horse escaped. It's too late by then.

The horse is gone and what's left in the barn doesn't smell so good. So it's important to test and develop investment strategies while product features are being developed; otherwise, the product will be out the door, and you'll be stuck cleaning up the mess.

Part of the product-development process is to determine profitability. For some insurance products, the assumption of mortality and morbidity risk is the primary source of profit. But many other insurance products, such as universal life, guaranteed investment contracts (GICs), or deferred annuities, have interest rate spread as the primary, or at least a very critical, source of profitability. The product development actuary cannot accurately determine the level of profit on such products if he doesn't know what the investment strategy is and the spread that it will produce over the product cash flows.

In determining return on investment (ROI), the return depends on the spread. The other part of ROI is the up-front investment. This includes not only commissions and expenses, but also provision for target surplus. Target surplus is a function of the investment strategy and the resulting risk profit. Target surplus should cover default risk (C-1 risk) as well as asset/liability interest rate risk. But if the product is designed without an investment strategy, the appropriate amount of target surplus is unknown. So in the pricing process, the parameters of investment strategy have to be known if an actuary is to properly determine what the expected ROI on a product is going to be, because both the R and the I depend on it.

Finally, investment strategies have a big impact on perception. There are several groups where perception is important and the perception of each of these parties is really to some extent interdependent. These groups include regulators, rating agencies, customers, and investors.

The NAIC is putting in place regulations that will help it get a clearer perception of companies' risk profiles. These regulations include cash-flow testing and risk-based capital. For companies that continue to develop and market products without testing and develop investment strategies to go with these products, this is where they will "pay the piper," if interest rates or defaults don't get them first. If a product requires a large amount of credit-risk assets to make a spread, or a larger degree of interest rate risk, risk-based capital and cash-flow testing will send a flag to the regulators.

For companies in the institutional accumulation product business, such as GIC writers, or those writing many deferred annuities, the perception of the major rating agencies -- S&P's, Moody's, and Duff and Phelps -- is very important. Over the last few years, even buyers of traditional life insurance have asked about ratings, not just A. M. Best's ratings, but even S&P's and Moody's ratings. While the rating agencies don't have the direct power over insurance companies that the regulators do, they have a major impact just the same. If the rating agencies perceive a company to be a high risk, due to high degrees of credit risk or interest rate risk, the claims-paying-ability ratings will reflect this. And if the rating is too low, product sales will be too low as well. Even for the existing policyholders, perception is critical. Perceived problems can trigger a run on the bank, such as in the Mutual Benefit situation of the last year.

Over the last couple of years, an increasing number of customers and potential customers are not only more aware of rating agencies' perceptions, but also are aware of the problems embedded in insurance company assets. There's been a lot of publicity with respect to credit-risk assets, junk bonds, commercial real estate, and commercial mortgages. As Donna mentioned, the regulators are much more concerned about CMOs, and that concern is also finding its way in media like *The Wall Street Journal*. So there's more concern about CMOs, even though those are not really credit-risk assets, but really are more properly prepayment-rate risk assets.

If an investment strategy is receiving bad press, or if it's producing volatile returns, or even worse, if it's producing losses, investors will turn away, which is not a good thing. Given all these points, let's grant that developing investment strategies is important, not just for existing liabilities, but also in the product-development process.

There is a common investment tenet that there is a trade-off between risk and reward. More properly, this trade-off comes on what's called the efficient frontier. Risk and reward need to be defined when developing investment strategies. Some insurance companies seek to define reward in terms of investment return or total return, by attempting to optimize investment income or total return. Focusing on total return instead of profit is like a football coach focusing on how many points his team scores instead of the number of victories. What's critical for an insurance company is making a profit -- realizing that mutual companies may be searching for a little bit of a different spin on that. Assets and liabilities are interdependent, and their relationship determines the bottom line. So I submit that an investment strategy needs to be developed, not with the intent of optimizing investment return or total return, but really with optimizing spread or profit.

For a baby boomer investing money for retirement, risk could be defined as not having enough money to support himself or herself in 20 or 30 years when he or she retires. The concern is long-term return and whether the long-term return has a high probability of being sufficient. Many people recommend investing in common stock for this purpose, because in the long term, equity returns are thought to be greater than those of bonds, for example, and the short-term volatility of stocks is not too important. As in our baby-boomer example, an insurance company needs to define the risk that is important to it. The long term is important, but the short term is also important as well. If it doesn't survive the short term, there won't be a long term to worry about. An insurance company needs to make good in its obligations to customers, but if there's an asset-liability strategy that results in wiping out the company's surplus and more, it won't be able to meet those obligations. One definition of risk might be insolvency or the probability of insolvency. There are additional definitions of risk that can be factored into this particular process. Volatile earnings concern investors, customers, regulators, and rating agencies, so it concerns all of us as well. Therefore, another definition of risk for an insurance company may be earnings volatility, either year-to-year or perhaps over a time period of several years. For some companies the concern is quarter to quarter.

In summary, it's important to specify exactly what's meant by these terms, *risk and reward*, in this particular process. I've discussed defining reward in terms of optimizing profitability or spread. The risk constraints that I've discussed are at least twofold. One is the probability of insolvency, and the other is keeping earnings volatility within

acceptable bounds. Keep this in mind as we talk about methodology in developing investment strategies.

The primary methodology I'm going to discuss is cash-flow testing, which I refer to as stochastic risk analysis. But let me first talk about two other approaches: cash-flow matching and duration matching by insurance companies. These two approaches, although used historically by insurance companies that even bothered to use any methodology at all, are fraught with pitfalls. Cash-flow matching usually is not possible for many insurance company liabilities, given the complex options and resulting variable potential cash flows that many interest-sensitive products have. In cases where it is possible, such as for locked-in liabilities like structured settlements or bullet GICs, it generally allows for little, if any, profit, unless high credit-risk assets or highly illiquid assets are used. If there is a default or restructuring, the presumed cash-flow match disappears, as many GIC writers are now discovering; the commercial mortgages that they so carefully matched with their GICs don't seem to be maturing right on schedule with their GICs.

Duration matching can be a very powerful tool, but used in isolation has some pitfalls as well. Duration is only an accurate measure for very small changes in interest rates, and it's generally only good for parallel yield-curve shifts (although there can be other computations of different types of durations that address that). In reality, interest rates frequently change by more than a few basis points, and the yield-curve shifts are hardly ever parallel. The use of convexity, which measures the change in duration with changes in interest rates, is helpful in this process, but there's still a problem. Given how we defined risk and reward for an insurance company, it's difficult to determine earnings volatility or the probability of statutory insolvency by using duration and convexity measures. It's not to say that they shouldn't be used. They can be very powerful tools, but need to be used along with other tools.

Stochastic risk analysis involves modeling assets and liabilities under stochastic or randomly generated yield curves. The models simulate the dynamic cash flow behavior and values of financial vehicles in various scenarios, which include twists and turns in yield curves, not just parallel shifts. Under this analysis, the distribution of profits under a range of different yield-curve vectors is determined, which is very valuable in analyzing the risk/reward profile of the various investment strategies and product designs. Reward can be measured as earnings or spread, and risk can be measured by the standard deviation of those earnings and looking at the negative tail of the profit distribution, where comparison is made to target surplus.

To demonstrate this process, consider a plain vanilla single premium deferred annuity (SPDA) and how an investment strategy might be developed. This SPDA has a one-year interest rate guarantee, no bail-out features, a return-of-premium guarantee, and surrender charges that really run off after five years. The company targets a credited rate around 90% of the 10-year Treasury, and in the first year, credits a "teaser" rate of an extra 100 basis points. This is not necessarily a product structure that I would advocate, but it is common in the industry. We hope this design will tend to disappear with time. Most companies tend to aim their product and their interest rate at more intermediate rates, but for this particular example, we're looking at the 10-year interest rate.

Since we will test under several stochastic interest rates, we need to define an interest-crediting strategy. But what we have here is a reset rate that equals 90% of a 10-year Treasury index. The index is 75% of the then current 10-year Treasury and 25% of the 10-year Treasury rate one year prior. In addition, the rate is not allowed to increase more than 1% per year; it can go down more than 1%, but not up more than 1%. The weighted-average approach incorporates a lag factor that is typical of this company's competition. This crediting strategy doesn't come up magically. It needs to be tested iteratively to make sure it's workable with certain investment strategies.

The initial investment strategy we will test, an investment strategy that may or may not seem appropriate to many of you, is used by a variety of companies right now. In this strategy, basically all the assets are invested in longer-term securities. In this example, everything is in 10-year bonds, either A-rated or Baa (triple B) rated. With the yield curve as steep as it is right now, that produces a very attractive current spread, which in traditional actuarial pricing models looks good all the way through.

For this example we're modeling 40 scenarios of 10-year yield curves, where rates are changing quarterly. In practice, you need more than 40 scenarios. For iterative testing, 40 or 50 scenarios are okay, but as you begin to hone in on investment strategy or certain product features, more scenarios should be used. The initial yield curve can be critical. I've assumed here a "normal" initial yield curve. Rates in this normal curve are higher than current rates, and the yield curve is less steep. If your company will be selling products over a variety of different interest rate scenarios, you should try different initial yield curves to measure the impact.

Recall that we need to define reward and risk in specific terms. Reward is defined as an average annual pretax profit of 50 basis points a year. The risk constraints in this example are twofold. First, the 25th percentile annual pretax profit must be in excess of 10 basis points; i.e., in 75% of these scenarios there is some profit. The other risk constraint is that the minimum annual pretax profit must be greater than a 40-basis-point loss. Risk could also have been defined in terms of the amount of surplus left.

Chart 1 shows the distribution of the profit results over these 40 stochastic yield-curve scenarios. The mean profit is 59 basis points, which exceeds our profit target of 50 basis points. The 25th percentile is 26 basis points, which exceeds our 10-basis point risk constraint on the 25th percentile. The worst case is a 153-basis-point loss a year; this is the average over 10 years. This worst case fails the second risk constraint. A company with a significant amount of this product on its books could become insolvent, unless it holds well over 12% or 15% surplus, which not many companies are doing. These scenarios are fairly volatile. The volatility embedded in the scenarios is important, but they are not any more volatile than what we've experienced over the last 10 or 20 years.

Let's try another strategy. To save time, this is our second iteration, but in practice, it is more like iteration number 15. Table 1 shows the different categories of investments. Basically 70% of the portfolio is fixed-rate investments, although the maturity is shorter than the 10-year bonds of the first strategy. But 30% of the portfolio is in floating-rate securities to recognize the interest sensitivity of the crediting strategy for our SPDA. We have some adjustable rate mortgages (ARMs) and floating-rate

CMOs, and a hedging vehicle called interest rate caps, which are like an insurance policy. You pay a premium for the interest rate cap and define a "deductible," which is a strike yield out of the money. In this example, we have an interest rate cap that's 200 basis points out of the money on the short end of the curve off of London Interbank Offered Rate (LIBOR). If interest rates stay within 200 basis points of the initial rate, we never collect a claim on this insurance policy. But once interest rates in any quarter go above 200 basis points over the LIBOR rate at the beginning of the scenario, then we're incurring a claim and we get reimbursed dollar for dollar above this 200-basis-point deductible. It's a powerful hedging tool that insurance companies should use more commonly.

CHART 1
Investment Strategy I
Distribution of Annual Pretax Results

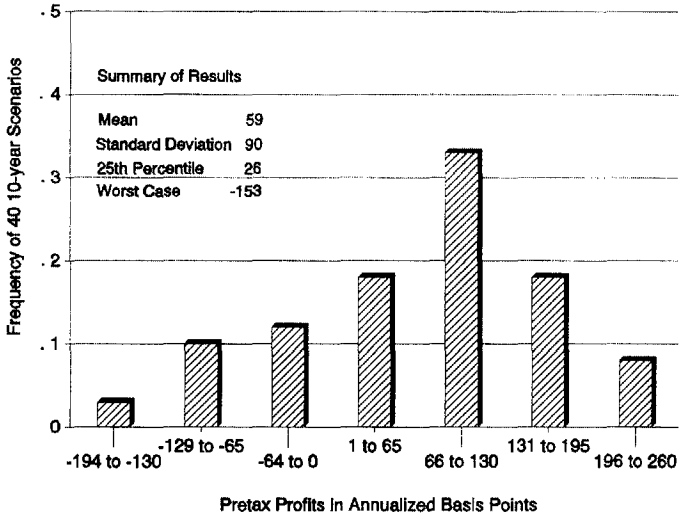
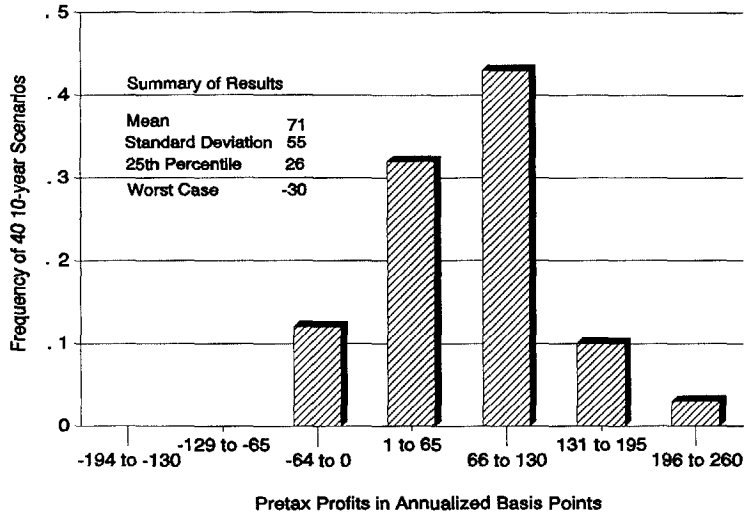



TABLE 1
Single Premium Deferred Annuity Example

| Investment Strategy II | | |
|---|---|---|
| Asset | Allocation | Assumed Spread |
| 10-year "A" bonds | 45% | 10-yr. U.S.T. + 100 bps |
| 5-year "Baa" bonds | 10 | 5-yr. U.S.T. + 100 bps |
| ARMs | 20 | 1-yr. U.S.T. + 150 bps |
| Floating-rate CMOs | 9 | 3-mo. U.S.T. + 130 bps |
| Structured mortgages | 10 | 3-yr. U.S.T. + 250 bps |
| 5-year "BB" bonds | 5 | 5-yr. U.S.T. + 350 bps |
| Interest rate caps on LIBOR | 1 | 200 bps out of the money |
| Note: UST = U.S. Treasury, bps = basis point spread. | | |

The distribution of profit results under the 40 scenarios is given in Chart 2. The 25th percentile is 26 basis points, which exceeds the 10-basis-point constraint that we had. Now the worst case is a loss of 30 basis points per year, which fits within our 40-basis-point-a-year loss constraint. The second investment strategy is much less risky. The tail doesn't go out nearly as far to the left, the distribution is much tighter, and the standard deviation is smaller. The mean on this second strategy is 71 basis points, and the mean on the first strategy is 59 basis points. We reduced risk and also increased reward. This means the first investment strategy is not on the efficient frontier. On a static basis with today's yield curve, the first investment strategy is going to look better today, but that's not the expectation over time. It's very important to realize that distinction.

CHART 2
Investment Strategy II
*Distribution of Annual Pretax Results*




Developing investment strategies is important, not just for existing liabilities, but also in the product-development process. It has a major impact on product features, on profitability, and on the perceptions of regulators, rating agencies, customers, and investors. To develop a strategy, we need to define risk and reward concretely. This is not something actuaries do by themselves necessarily, but through discussion with his co-workers and, most importantly, management. Reward as I've defined it for an insurance company is trying to optimize profitability or spread. Risk can be defined in a number of ways, depending on what's important to the company. I've talked about the probability of insolvency as well as earnings volatility. There are a number of methodologies used by insurance companies. Stochastic risk analysis is probably the most powerful and is a very powerful tool in developing products and also in developing investment strategies to go with those products.

MS. KATCHER: Dave is the chief actuary of Lincoln National Life and he has been very active in Society activities, too. He is a former chair of the Product Development Section Council, is currently a member of the Society Research Committee, and is chair of the Project Oversight Group on Option Pricing. Dave has published in the *Transactions*, various newsletters and *Best's Review*, and he was the winner of the 1989 annual prize for *Transactions* articles.

MR. DAVID N. BECKER: I've always felt there are problems with cash-flow testing, such as whether to use deterministic or stochastic scenarios, defining what pass/fail means for a single scenario, and what significance should be assigned to the results of a single deterministically chosen scenario. In other words, do you learn something from cash-flow testing that can actually tell you how to change management behavior if you've just picked a scenario? As Stan Tulin commented in the mid-1980s at a Valuation Actuary Symposium, "If you predict disaster by your assumptions going in, don't be surprised when it happens." To follow-up on Donna's comment on alternative methods of testing for C-2 risk, on every term product I've ever seen, if you price with 250% of the expected mortality, you don't have to bother to run the test.

How do we measure interest rate risk, and how do we set prices to reflect interest rate risk for new business, an existing block, or an entire company, and how do we analyze its experience? This list of questions isn't exhaustive, but the tool I'm going to present is an approach that will enable you to come to grips with this problem. For any fixed-income security, the risks in the product are embedded in the price, and if you take more risk, you should pay a lower price. Therefore, what we want to measure is price, or its flip side, return or spread, and what we need are the correct economic quantity to measure to obtain price, a correct present-value methodology to discount this quantity, and the stochastic methods from finance to assess the interest rate risk. By the way, this discussion focuses around options that are embedded in assets and liabilities from an interest-sensitive point of view, but you could extend that to options arising from other sources.

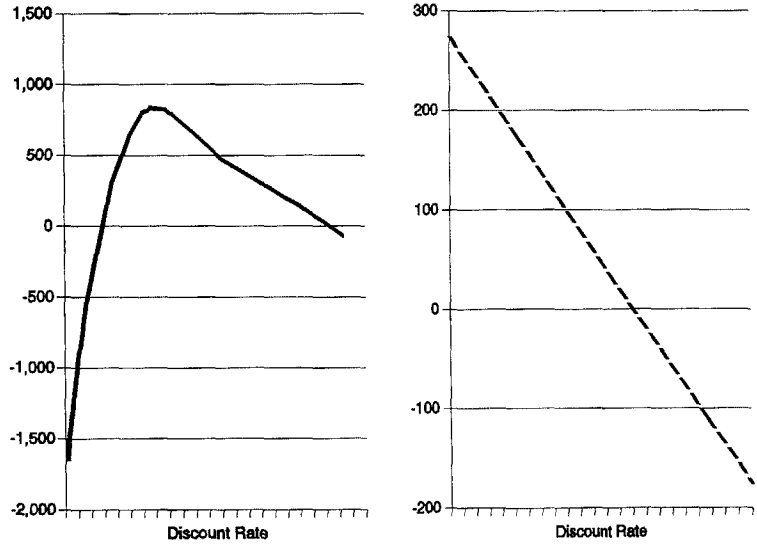
One of the prime methods of pricing a security is the capitalization-of-income method or intrinsic-value method; that is, the price of the security is the risk-adjusted present value of its free cash flows. A free cash flow is the money you get, with which you can do anything you want. For an insurance enterprise, the free cash flows to its shareholders are restricted by what can legally be paid, according to state insurance department regulations, and what can prudently be paid, given sound risk-based capital requirements. The quantity that does this we call distributable earnings. The definition will have to change in the future to allow for the IMR, and possibly the AVR, depending upon the capital situation of an insurance company when looking at the company as a whole. Basically, distributable earnings are the statutory gain, plus after-tax realized capital gains and losses, plus after-tax investment income, plus opening risk-based capital and change in risk-based capital. The paper that Anne referred to (*TSA* XL, 1988, Part I) demonstrates that the classical net present-value computations used to evaluate hurdle rates, judge the success of projects, or make go/no-go decisions, is very valuable, but it's flawed. If you have multiple changes in the sign of the cash flow (in our case, distributable earnings), or if you only have one change in sign, but the change in sign means you started out with positive numbers and they became negative, then classical techniques of discounting that stream

produce economically meaningless results. There was a famous project in finance in the 1950s called the Pump Project. I won't go into details, but this project has two internal rates of return: 25% and 400%. Many finance books, even today, say to use net present-value analysis when there's more than one internal rate of return. The problem is that the internal rate of return is a rate such that the net present value is zero, so if there are multiple internal rates of return, you effectively have a meaningless net present value as well.

Typically, fixed-income investments don't have negative cash flows. The price when you buy the security is the negative cash flow, and the future cash flows are positive. An insurance enterprise, however, can have alternating changes in sign of its distributable earnings.

Chart 3 shows the problem and a solution. The classical net present-value methodology is the graph on the left. You see zeros at 25% and 400%; to the left of the smaller zero there is an interest rate at which the net present value is negative. But between the two zeros is an interest rate used for which the net present value is positive. Think about that for a while and you realize that's why net present value doesn't make economic sense. By using the generalized net present-value method, however, you get the graph on the right, which shows a strictly monotonic decreasing net present value based on the discount rate.

CHART 3
The Pump Project




The methodology combining distributable earnings with the generalized net present-value method of discounting, I couple with a mechanism for coming up with the option-adjusted value of distributable earnings. That's described in the November 1991 *Product Development Section News.*

The stochastic method to assess interest rate risk is the average present value of cash flows computed over a set of arbitrage-free paths. The advantages of using arbitrage-free paths are that they will reprice Treasury securities, satisfy put/call parity so you don't introduce free lunches into the game, and provide for the relative valuation of securities on a consistent basis. At points on these paths, you may need to buy or sell a security. You can use the conventional techniques for calculating the price of a security, if the security is a noncallable bond and you're using the correct spot rates. But if it's a callable bond, a sinking fund, a mortgage pass through or a CMO, the conventional techniques don't work, and you have to use option-adjusted techniques, which help ensure that you buy the correct amount of each of these securities. It minimizes the risk of mispricing when you buy and, therefore, buying too much or too little from what the market would really have you do or, if you were to sell, what you would return. This method is used in finance to price things like call options or prepayment options in various securities. We will develop a set of future interest rate paths and their probabilities and measure distributable earnings along each path. Such earnings will reflect the exercise of options in both the assets and the liabilities and will discount along each path using the generalized net present-value algorithm.

Given a price target, you can obtain the option-adjusted spread or the option-adjusted internal rate of return or yield, because in addition to the spread over Treasuries, you can also solve for the option-adjusted yield in terms of a level amount over the horizon of the project. You can also calculate the statistical distributions of the spreads and yields. The flip side is that you can obtain the option-adjusted price and the distribution to prices for a given yield spread target. This might be pertinent in assumption reinsurance or buying an insurance company. For a given price target and a given spread yield target, you could try to determine strategies to optimize both.

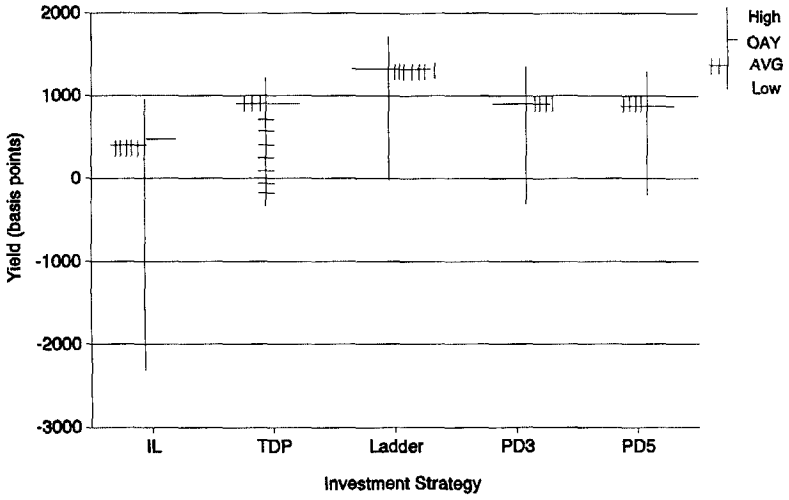
The first example is a simple SPDA. I just want to focus on the elements of what's happening. Its guaranteed interest rate is 4%, and the interest margin will be set so that with a flat yield curve, the internal rate of return on distributable earnings is 15% using the April 30, 1992 yield curve. The internal rate of return is static because it's a level investment horizon. To me a strategy is a triple combination of an investment and reinvestment strategy, a disinvestment strategy, and a crediting strategy. These are dials that you can turn. To make the example simple, I force the disinvestment strategy to be borrowing and the crediting strategy to be a portfolio-rate strategy. I will analyze five different investment strategies and then show how the computations yield results and how to interpret the results.

The first strategy is to invest long, the second is to purchase new assets with a constant duration of 4.5 years, the third is to ladder, i.e., to buy the assets in a constant proportion between two-, three-, five-, seven-, and ten-year maturities, the fourth is to maintain a constant portfolio duration of three years, and the last is to maintain a constant portfolio duration of five years. For the constant portfolio duration strategies, when we buy assets with positive cash flow, we will buy as much of the single assets (whatever the portfolio rate is at a given time) so that the total portfolio duration will come back to three or five. There's lots of numbers generated in this process, but we're going to summarize results graphically. We'll look at the distribution of spreads and the option-adjusted spread, the distribution of yields and the option-adjusted yield, and the distribution of distributable earnings and the option adjusted value of distributable earnings at various discount rates: the

risk-free rate (which is the one-period Treasury rate used on the arbitrage-free pricing); the cost of capital (a flat rate I assume is 12%); and a hurdle rate of 15%.

Chart 4 gives the distribution of the option-adjusted yield under these five investment strategies. The one that stands out as being best is the ladder, and the worst turns out to be the invest-long strategy. The option-adjusted yield is the yield that satisfies all paths simultaneously (as opposed to the average of the yield on each path). One interesting feature is that they all have long downward lines from the averages. The long negative tail is called negative skewness in statistics. In the insurance company environment, we call it very bad news. You can see that the interest rate risk is not symmetric and is mostly downside, which is a good reason for stochastic analysis.

CHART 4
Option-Adjusted Yield (OAY)
Distribution of Yields for Five Strategies



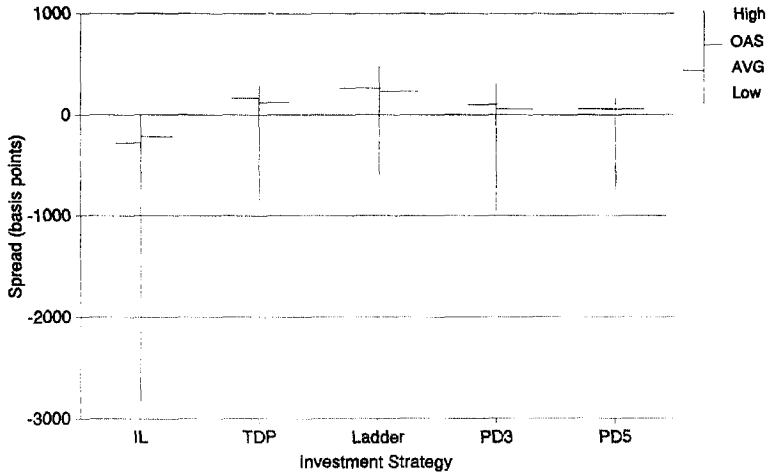

Generalized net present value algorithm used.

If we look at the return as spread over Treasuries, Chart 5, we see the long negative tail, and again, it's clear that the ladder is the superior choice. The option-adjusted value of distributable earnings discounted at the risk-free rate (Chart 6) confirms Chart 4 and 5; the ladder comes out the best. Finally, at 12% (the cost of capital), the ladder still comes out as being the best strategy (Chart 7). Of course, the 12% numbers are lower because you're discounting at a higher rate.

**INVESTMENT STRATEGIES**

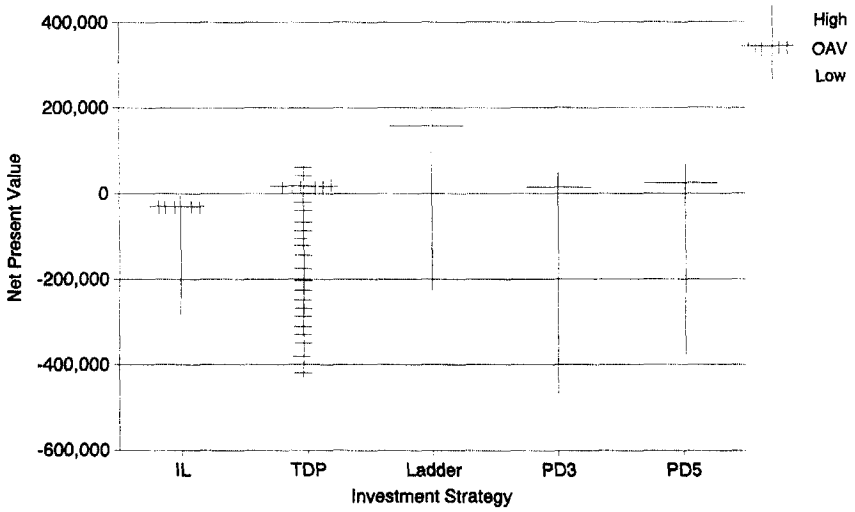
- Invest long (IL).
- Purchase new assets with constant duration, 4.5 years (TDP).
- Ladder (2-, 3-, 5-, 7-, and 10-year maturities) (Ladder).
- Maintain constant portfolio duration of 3 years (PD3).
- Maintain constant portfolio duration of 5 years (PD5).

CHART 5
Option-Adjusted Spread (OAS)
Distribution of Spreads for Five Strategies



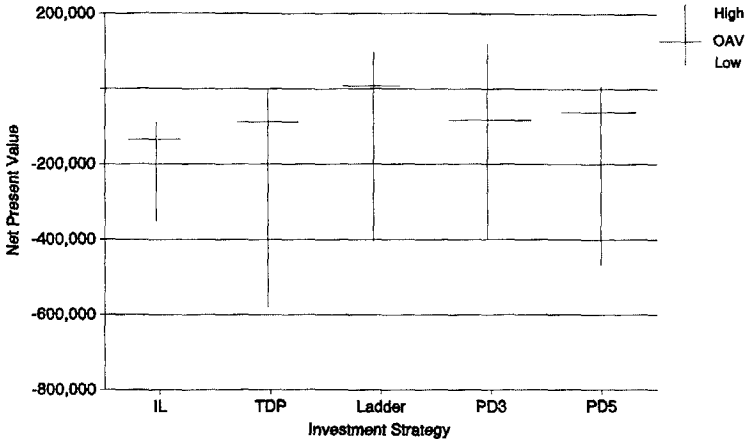

Generalized net present value algorithm used.

CHART 6
Option-Adjusted Value (OAV) of Distributable Earnings
Present Value of Distributable Earnings @ Risk-free Rate (RFR)




Generalized net present value algorithm used.

CHART 7
Option-Adjusted Value (OAV) of Distributable Earnings
Present Value of Distributable Earnings @ 12%




Generalized net present value algorithm used.

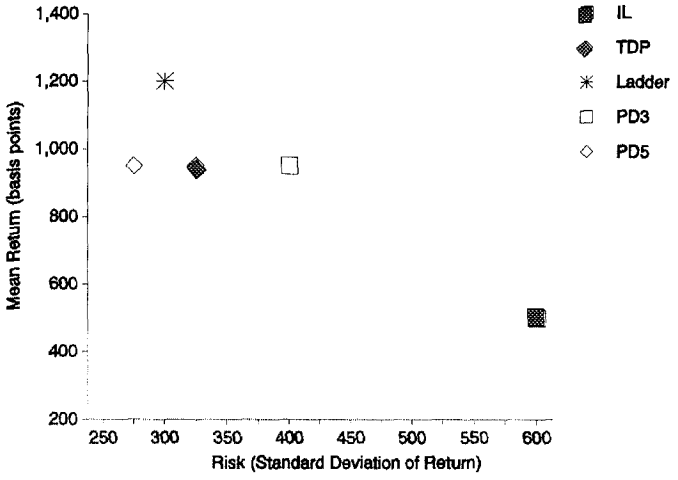
You can use mean/variance diagrams to utilize all this information. This is the Markowitz Efficient Frontier from finance theory (Chart 8), but note that it uses only the first two moments of the distribution. It's plotting mean return on the vertical axis, and it's plotting the standard deviation of that return on the horizontal axis. You then have to estimate the trade-off between risk and return.

Another way I prefer is using risk-adjusted value, which is in a paper by Coppolino (I think) published in the *Sloane School of Management Journal*. It's based on utility theory. You do need to estimate a company's aversion to risk, but it uses all the moments of the probability distribution, not just the mean and standard deviation. Risk-adjusted value linearly ranks all strategies, so there's no need to make the intuitive trade-off between risk and return. I do think it's good to utilize both techniques.

Chart 9 also shows what the five strategies look like under the mean/variance criteria and risk-adjusted value (also known as the risk-certainty equivalent). I've discounted at three rates, the risk-free rate, 12%, and 15%. Any of these rates would suffice, and you would analyze just one curve at a time. You can see that the ladder has the superior result, and there's no doubt about the trade-off between risk and return.

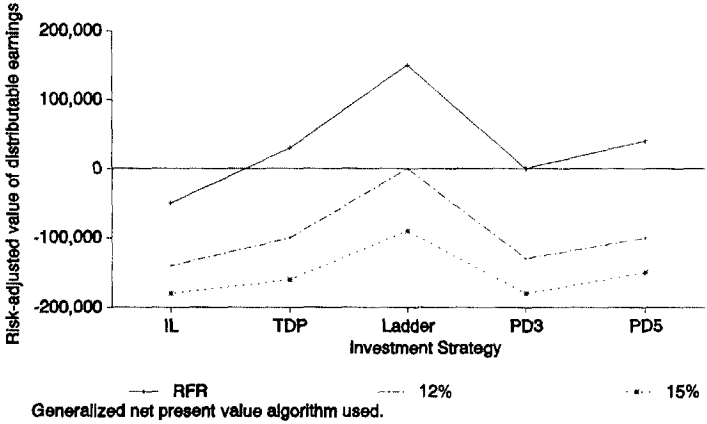
To use this to evaluate various liability designs, I'm going to start with my SPDA guaranteed at 4% (SPDA 4%). It's been represented to you that guarantees are important, and you have to raise the guaranteed rate. So it's proposed to look at 6% for five years and 4% thereafter [SPDA 6%(5)/4%].

CHART 8
Risk/Return Diagram
Mean/Variance Criteria
Markowitz Efficient Frontier




Generalized net present value algorithm used.

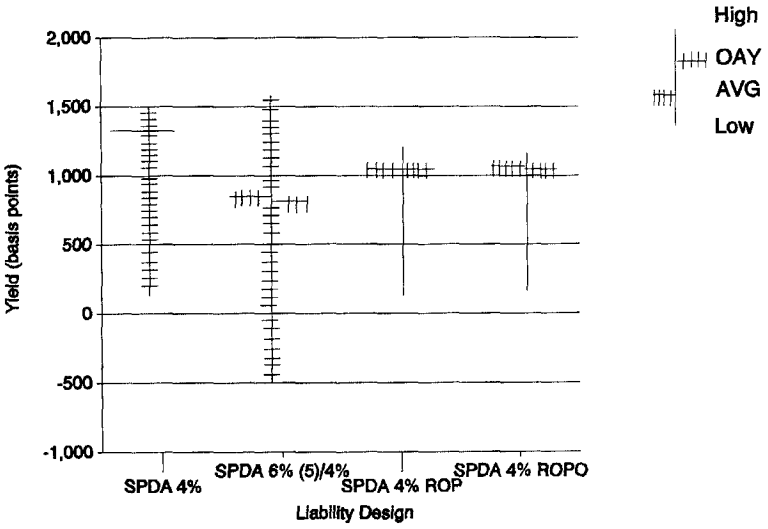
CHART 9
Risk-Adjusted Value
Risk-Certainty Equivalent




Generalized net present value algorithm used.
Risk aversion factor equal to 1/1,000,000

Another design is an SPDA with return-of-premium (ROP) guarantee and the interest rate margin adjusted for the cost of the guarantee due to the extra reserve required (SPDA 4% ROP). The fourth one is the return-of-premium guarantee, but calculated at the original interest margin (SPDA 4% ROPO). The return-of-premium guarantee in this example costs about 10 basis points. A yield analysis on these designs (Chart 10) reveals that there's a significant reduction in the option-adjusted yield of the SPDA 6%/4% and the average yield, and there's also a much greater dispersion of the results that occur under that scenario.

CHART 10
Comparison of Liability Designs
Yield Analysis

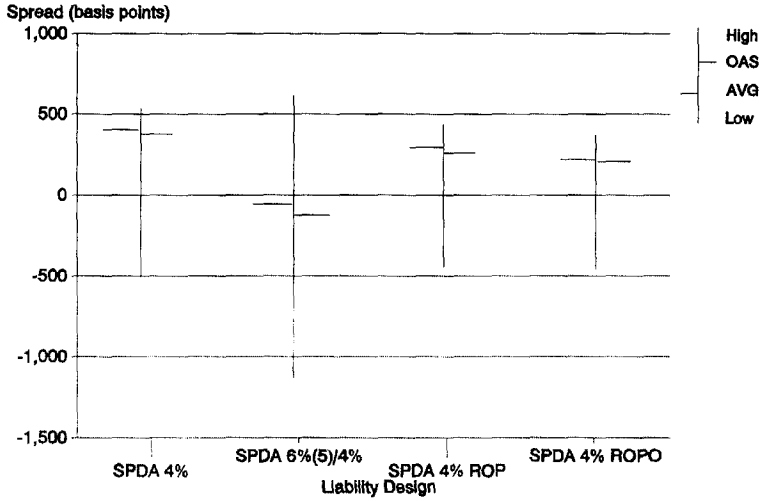



Generalized net present value algorithm used.

By the way, all these products, except for ROPO, are priced to return 15% on a static basis, even the 6%/4%. So if you priced the 6%/4% product to earn 15% by using the traditional method (i.e., just calculate the margin) you're going to take a real hit in your option-adjusted return.

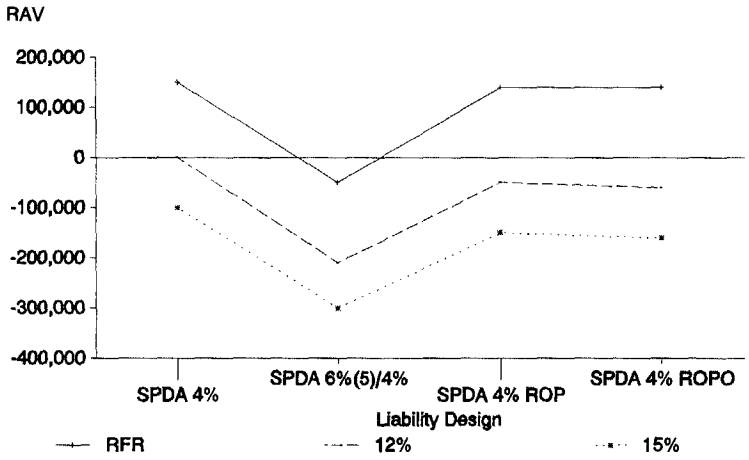
Expressing the return as an add-on to the one-period Treasury gives the same results (Chart 11). The risk-adjusted value of distributable earnings also show the 6%/4% taking a hit (Chart 12). Note that the ROPO has a slightly lower value than the ROP, because the ROP has 10 basis points more margin.

CHART 11
Comparison of Liability Designs
Spread Analysis




Generalized net present value algorithm used.

CHART 12
Comparison of Liability Designs
Risk-Adjusted Value of Distributable Earnings



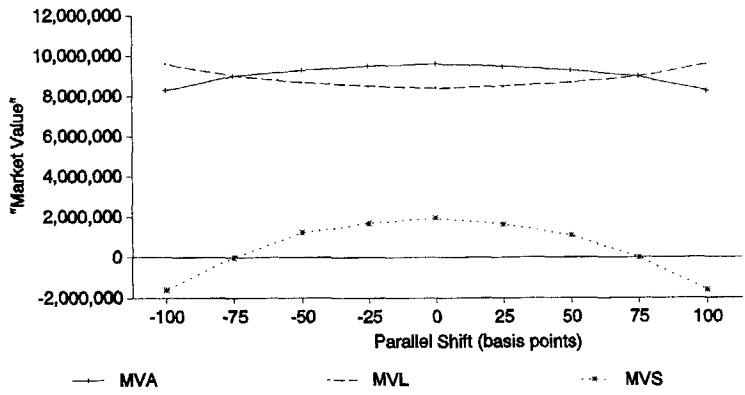

Generalized net premium value algorithm used.
Risk aversion factor 1/1,000,000

Some people use market-value diagrams, market value of assets (MVA) and market value of liabilities (MVL) calculated on an option-adjusted basis for analyzing the mismatch in assets and liabilities. The difference between the assets and liabilities is the market value of surplus. This leads to what I call the traditional smily face diagram, which shows you how things change as the yield curve does a parallel shift from whatever the yield curve is at the point in time that you're demonstrating. My problem with the label "market value of surplus" is that it is not a true market value. A market value is what a willing buyer would pay a willing seller, and it isn't this number, believe me.

In addition to market values, you can compute the option-adjusted duration and option-adjusted convexity of assets and liabilities. Chart 13 demonstrates the degree of immunization between assets and liabilities (or maybe the lack thereof).

This does require periodic rebalancing, however, as Marty pointed out earlier, duration and convexity are only good for really small shifts in the yield curve, and it only immunizes against parallel shifts. If you use techniques like Reitano's (for which he just won the annual prize), there's a way to look at what happens to different shifts. Limitations to market-value analysis are: there's no liquid or efficient market for selling them, and the diagrams fail to take into account federal income tax, the cost of holding reserves, and the cost of holding risk-based capital.

CHART 13
"Market Value" Diagrams
"Market Values"
Assets, Liabilities, and Surplus



**"MARKET VALUE" OF ASSETS, LIABILITIES AND SURPLUS**

- Market value of assets (MVA) computed using finance methodology described earlier.
- Market value of liabilities (MVL) computed by treating the product cash flows as those of a fixed-income security.
- Market value of surplus (MVS) computed as the difference between MVA and MVL.
- Goal is to have the graph of MVA above graph of MVL for a significant parallel shift in the yield curve.

If you have a graph with a mismatch of assets and liabilities, however, you can come up with strategies to change the MVA and MVL curves to more favorable shapes, indicating better immunization. We'll call that a hedge; it could be on the asset side, or another crediting strategy, or whatever. Any change to make that graph look better has a cost, and the graph doesn't reveal the cost. Therefore, if all you do is look at those graphs, you may be taking a very costly route to help improve asset-and-liability matching. We can use the option-adjusted value of the distributable earnings technique to supplement the graphs. First identify strategies that result in acceptable cash-flow management as determined by the diagrams. For each such strategy, compute the option-adjusted value of distributable earnings and determine how it changes for shifts in the yield curve. Finally, choose a strategy with the best option-adjusted value of distributable earning results; for example, by looking at the graphs or using a risk-adjusted value analysis.

Chart 14 is the market-value diagram for the SPDA liabilities. You don't see any assets because at the moment of issue, the assets happen to be all cash. It would be a horizontal line if I were to show it. You can see how much more expensive the liability of SPDA 6%(5)/4% is compared to SPDA 4%. You can also see the extra costs in ROP.

CHART 14
Comparison of Liability Designs
"Market Value" of Liabilities

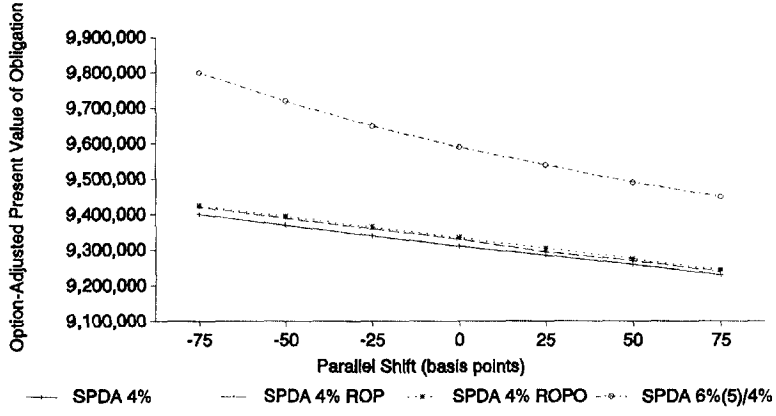
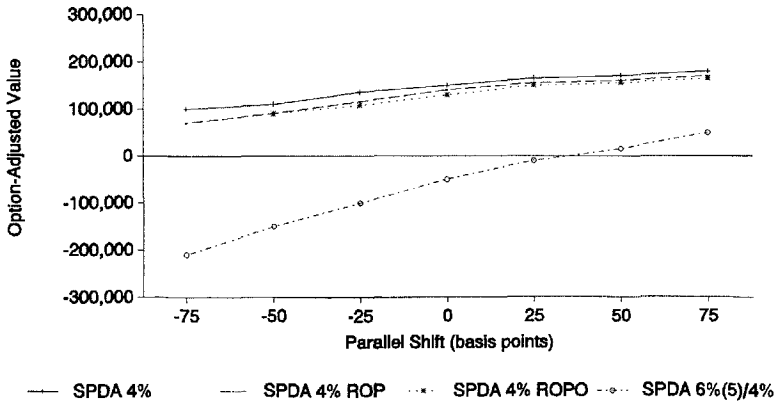


Chart 15 is the option-adjusted value of distributable earnings calculated for parallel shifts in the yield curve. By the way, you can use Reitano's techniques to do nonparallel shifts as well. This again shows you that the 6%/4% product is much more unprofitable than any of the other three designs.

You can enhance the technique for appraisals of company performance. The option-adjusted appraisal value equals the market value of assets supporting the excess of surplus and items in the nature of surplus over risk-based capital supporting the liabilities and related assets, plus the option-adjusted value of distributable earnings on existing business, plus the option-adjusted value of distributable earnings on future business, if any.

You can examine the change in this quantity from period to period. A second technique, which is a variant on the other one, is to look at the option-adjusted value added in excess of the cost of capital (or other hurdle rate), which equals the option-adjusted value of distributable earnings as of the end of the period, less the option-adjusted value of the beginning of the period, plus distributable earnings for the period, less cost of capital (or other hurdle rate) multiplied by opening present value of distributable earnings.

CHART 15
Comparison of Liability Designs
Option-Adjusted Value of Distributable Earnings




Generalized net present value algorithm used.

Last, you can analyze these numbers by source as they change from period to period: by external environment -- change in the level and shape of the yield curve, and change in the volatility of interest rates; by internal environment -- change in

investment/reinvestment strategy, change in the crediting rate strategy; by reinsurance; by new business versus existing business; and, by shareholder dividends paid.

FROM THE FLOOR: The committee that you're on said that option pricing was currently not useful for valuation purposes, but that stochastic interest rates were. Does that preclude using arbitrage-free stochastic interest rates?

MS. CLAIRE: No, the regulators' point is that they do not want a single option-adjusted price of liabilities versus assets.

MR. THOMAS J. MITCHELL: Valuation actuaries have a legal requirement to come up with one formal definitive report. For the pricing actuary, there's a different process. Number one, we aren't actually legally required to be in there. In iterative processes there are negotiations. With our new standards of practice, what's the impact when the president says, "I'd like the results at two o'clock today." Do you start running 100 scenarios, or do you start writing caveats for your report?

MS. CLAIRE: This is the time-versus-doing-a-good-job constraint I talked about. The president is paying your salary. If you can get a reasonable answer that you feel is in the ball park, give it to him or her at two o'clock, write the report after two o'clock, before you go home that night. But it is important to have a paper trail eventually.