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Session 38OF
Technology and the Actuarial Pricing Model—What Comes Next?

Track: Product Development
Key words: Asset/Liability Management, Pricing, Product Development

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Summary: This session offers a retrospective and prospective look at the development of actuarial pricing models. The skills of our profession have developed along with the capabilities of the technological tools available today. Will they continue to do so tomorrow?

Mr. Thomas W. Reese: Doug George is a partner at Avon Consulting Group. Mark Abbott is senior analyst at Global Advanced Technology, responsible for asset/ liability modeling and consulting. Shane Chalke is president of SS&C Chalke. Irwin Vanderhoof is Clinical Professor at New York University, Stern School. I'm a principal at Tillinghast-Towers Perrin's Atlanta office.

Mr. Douglas A. George: If I were to provide a quick review of where actuarial pricing models have come over the last decade, I'd say that they've come quite a long way. We started with simple asset-share unit-based models for new business pricing and layered on much more complex analysis and capabilities, to the point where we can now model our entire corporation through our actuarial pricing model.

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We started with new business and the next thing we added was in force. We added downloads from our administrative systems to look at our in force as well as our new business. On top of this, we've layered asset modeling, something that used to be relatively ignored in actuarial science—the whole second half of the balance sheet. On top of this we incorporated interest rate generators to model interest rate risk through explicit scenario testing. We included option pricing to do pure economic analysis. We added strategies and behaviors: corporate strategies for capital planning, for investment, and for in-force management; policyholder behaviors for interest-sensitive lapses, loans, and new production. Putting these all together, we're able to now model the complete corporation and do very complex analysis.

Well, the question is, Where do we go from here? We currently perform very complex analysis, things like value-added analysis and performance benchmarking, but these types of analysis are very difficult. They take a great deal of legwork to really implement and obtain a credible result. Even for something like cash-flow testing, we spend about four months developing, creating, and validating our cash- flow-testing models, and then we take four days to run scenarios and run analysis and interpret it. That type of time frame really needs to be switched. We really need to spend much more time analyzing our results rather than building the models.

To do that, I think we need to make our models more practical and more credible. We need more flexibility to be able to adapt to the different types of analysis that we need. We need to get more detail into our models, more liability features, and better asset modeling. I think liability models will eventually become not really models, but seriatims, where we model each individual policy one by one with its own assumptions and behaviors.

To achieve this, we're going to need more speed. We're going to need the high-speed computers that are coming out to produce the real-time results that we need to do models in this manner. The other thing we're going to need is more auto-mation and with automation will come consistency.

Through systems integration we can do a lot to improve the practicality and the credibility of our models. Right now, many of us are faced with a situation where we have dozens of systems that produce the financial information that we use. Each of these is independent and they're not well connected. Each of them produces a result that can be very inconsistent with a similar result or the same type of information that we're getting out of a different system. So in order to make our modeling and our pricing more practical, I think we need to integrate our systems better. Through the systems integration will also come a feedback mechanism where we can use our

results on our in-force business, and use our experience to better feed our pricing and our cash-flow-testing models.

I think another area we need to move forward with is asset/liability management for new business pricing. Right now I see some people doing some very simple and very crude asset/liability work when it comes to new business. But, once again, with systems integration, I think we'll get more capabilities to do asset/liability work when we do price our new products.

Right now I think our industry suffers from underpricing the options that we give away on our liabilities. We count on our policyholders to be relatively inefficient in the way that they exercise the options that we grant them, and that's how we make our spreads. Eventually, policyholders are going to become more sophisticated and they're going to exercise the options that we give them more efficiently. I think it's inevitable. Look at what has happened to the mortgage market, for example, with the explosion of refinancing over the last few years—most people never predicted this at all. People are getting smarter in how they exercise their options.

With systems integration, I think we will get a better handle on the real costs of our options, be able to more explicitly price them, and be able to get the feedback from our in-force experience to be able to see how our policyholders are exercising their options.

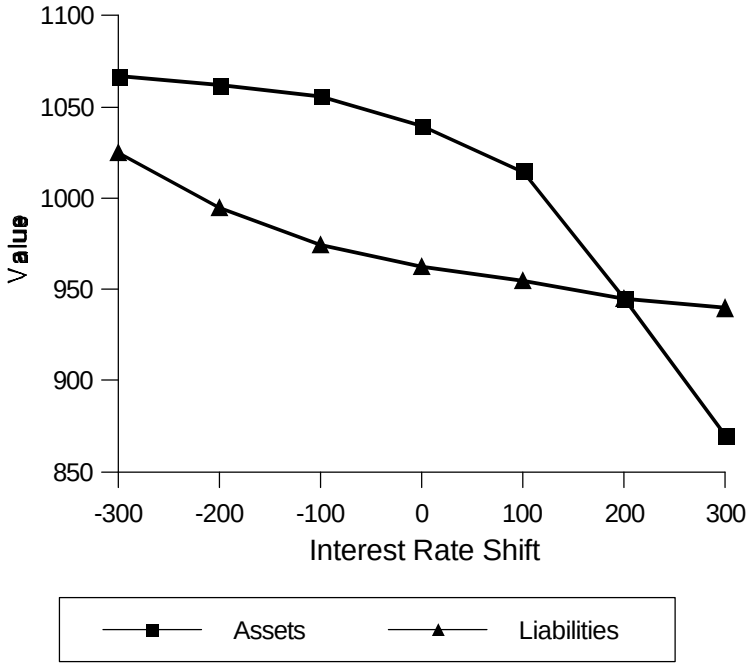
Also, in the area of asset/liability management, I think there's room to improve our algorithms. When it comes to cash-flow testing, for example, I know many people who feel like their cash-flow-testing models do an adequate job for the regulatory analysis, but they're really hesitant to use them to do real in-force management. I think one reason for this is we need to make our asset/liability models more realistic.

We tend to have rather simplistic strategies that we use going forward. For instance, consider our investment strategy. Our models tend to lock us into a given strategy that is used throughout all different types of scenarios and conditions. We need more dynamic strategies, things that will simulate more proactive trading—the way we really manage our portfolios to meet certain earnings goals or to meet tax needs. We'll also need better assumptions and, once again, if we're getting a better handle on our policyholder behaviors through better experience analysis, that will give us better assumptions to drive our asset/liability management work.

Another area is optimization. When we currently do asset/liability work, we often need to test thousands of different combinations of strategies and approaches to try to find an optimal way to manage our business for our company. We'll look at many

different types of investment strategies and crediting strategies. We'll look at hedging with derivatives and rebalancing our asset portfolios. We look at changing liability features on new products or the way we manage our liability in force. Through optimization algorithms, we can narrow the number of combinations that we need to test in order to get an optimal result to better manage our business. For example, Chart 1 is a relatively unhedged asset/liability risk position. Chart 2 might be more of a partial hedge, and Chart 3 is a full hedge.

CHART 1
PRICE CURVES



With optimization algorithms, we can narrow down the number of positions that we need to test in order to make the analysis more practical and find the optimal risk/reward profile for our company.

Finally, I think there are ways to improve our economic scenarios that we feed into our asset/liability models. Our current scenarios are really interest scenarios, not economic scenarios. We need to expand our scenarios to do more explicit accounting for changes to defaults and for changes to spreads as different asset sectors fall in and out of favor.

In the area of interest rate generators, I think we've just seen a first cut at what we're capable of doing with interest rate generators. Currently, I see a move from one-factor models to multifactor models, which I think is good. One-factor models can only go so far in explaining yield curve movements. They tend to give you

movements up and down, but don't really give good movements for yield curve shape changes or tilts and twists in the yield curve. Those are hard to really accomplish for the one-factor model.

CHART 2
PRICE CURVES

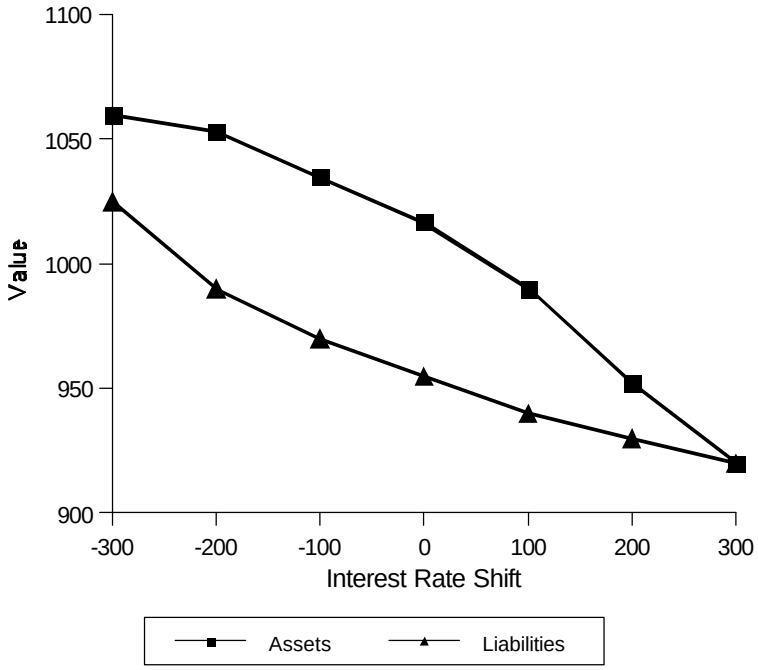
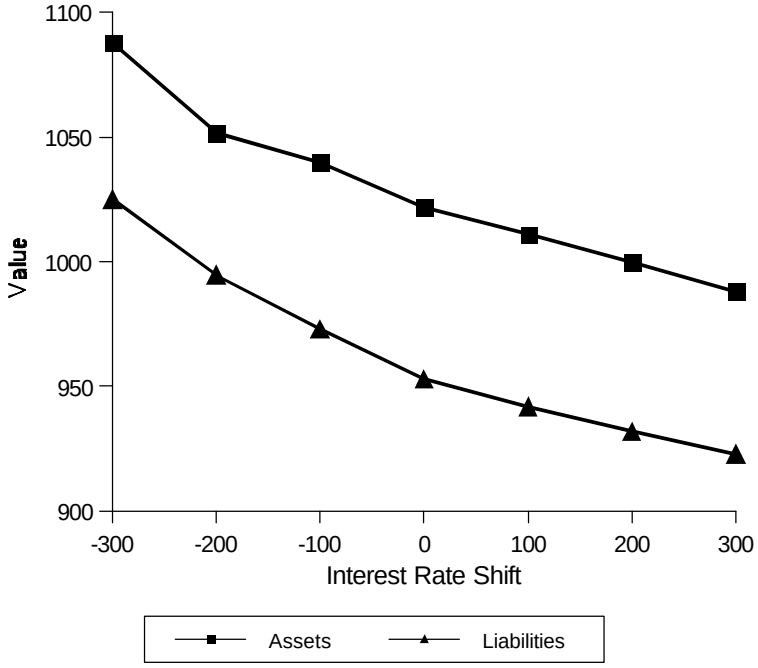


CHART 3
PRICE CURVES



Also, most of our models are currently based on arbitrage-free, risk-neutral approaches using the pure expectations theory where current rates or future rates are really based on implied forward rates coming out of the current yield curve. These types of models tend to produce rates that drift upward over time. They also tend to provide curves that invert quite a bit.

Now these types of approaches can be alright for pricing, but they can fall a little bit short when you want to do stress testing or when you want to do real scenario testing. When you do scenario testing using these types of models, you tend to get results that show that the best investment strategy is to go short on the yield curve. Because of the way the models are based, there's no real advantage of going longer, because the longer-term rates are really just the accumulation of the shorter-term rates. There's no additional reward for going out longer on the yield curve. By incorporating liquidity theory, like an explicit risk premium built into our yield curve, I think we can do a much better job of producing more realistic scenarios.

In conclusion, I'd just like to say that I do believe we do want to continue to push our systems and our models. We do want to push the edge of the envelope in actuarial science. We do want to continue to add new concepts, and develop new types of analysis, but I do believe there's also a great deal of room for improvement on the current techniques that we're doing and the current capabilities that we have.

Mr. Mark Abbott: I want to focus on the future of valuation technology. In some cases, to value a liability you have to consider the benchmark portfolio or investment strategy for the crediting rate in addition to the characteristics of the product. You can't divorce yourself from the need for one method of valuation of the liability and assets that may be backing the liability. We advocate a consistent-option- pricing framework to do this sort of valuation.

Obviously there has been tremendous change in technologies for doing valuation, and we expect more surprises in the near term. Computers have already increased their performance over 20-fold in the last four years. We need to be smarter in the way that we look at simulations for valuation. Certainly one scenario is inadequate today. I think everyone agrees you need to look at multiple scenarios of sets of risk factors. Similarly, the financial models, as well as the actuarial models, need improvement and better calibration to reproduce the actual behavioral considerations, prepayments, lapse behavior, and even the crediting rate of your competitors. These have been inadequately modeled and certainly deserve more attention. With advances in computer technology and different approaches, these problems can be overcome by respecting and then taming the uncertainties that confound us in terms of making this valuation.

In addition, the information that's going to drive the calibration of models will come from more dynamic feedback from the systems that have been used to collect policy information and aggregating that more quickly to make effective decisions. That feedback from marketing and sales success stories as well as failures will drive adaptive calibration of models in the future.

There are going to be dramatic changes in the way that the policy information is transferred from agent to office and then from company to consultant and in the way that services are sold and clients are supported. The Internet certainly is showing how efficiently international communication can be done.

Models are going to become faster and more sophisticated. Doug George just talked about the need for both arbitrage-free scenarios, as well as those that span expectations and maybe even replicate a distribution of historical scenarios. That requires an independence of the interest rate models for valuation or stress testing. You need an arbitrage-free model to determine the economic value of a liability.

Product features, risk factors, and interest rate scenarios are going to be scrutinized. Complex models are going to be better understood and the advantages and benefits of them will certainly be evaluated in an increasingly competitive environment. As a consequence, margins may reduce over the next couple years.

One of the problems that really hasn't been solved satisfactorily in the past is working with multiple currency curves. How do you properly simulate a multinational corporation or an insurance company? How do you simulate interest rate movements and other risk factors like currency exchange rates in a consistent way for valuation? We've been tackling this problem, but more work needs to be done in this area. By computing advances, such as distributed processing, we hope to do a more effective job modeling this in the near term.

Liability benchmarks is another area that deserves much more attention. You have a liability and determine a benchmark asset portfolio that replicates the behavior of that liability. For investment managers, this liability model can be translated into something that they understand—a portfolio of bonds and options.

Communication between the actuaries and the investment people is going to certainly change dramatically over the next several years. This is not turnkey by any means. People have set a targeted duration, and that has probably been inadequate for effectively managing investments against all the product features and the dynamics that are involved in a liability product or line of business.

Once investment departments understand the benchmark, they can do a better job of adding value, taking on risk, quantifying that risk, and improving their performance. What they should be tracking is their return performance over time versus this custom benchmark that is calibrated against the actual liability. Everything should come into sync much better in the near term in terms of being able to quantify performance of the liability product relative to the market and being able to sell it properly. The investment job of backing the liability and adding some value through the investment process should also improve.

That brings us to the details of liability modeling. We're more involved in the investment strategy and the analytics that one would use for the investment side at Global Advanced Technology (GAT) Corporation. But to better understand the liability, we still have to work on determining the fair value. We also need sensitivity measurements. To calculate the effective duration—the sensitivity of price with respect to parallel change of rates—we need several prices. We need a robust fair-value calculation and flexible liability models. Being able to feed them interest rate scenarios and get proper pricing by discounting among them is a way to effectively achieve this.

By cleverly perturbing the initial curve, one can come up with nonparallel interest rate sensitivities. Robert R. Reitano coined the term partial duration back in 1989. Thomas S.Y. Ho called this key rate duration (KRD) at the same time. You're looking for price sensitivity to twists and kinks in the yield curve. The value of the sensitivity is the fair value of changes in underlying interest rates at various parts of the curve. This is a summary of where we think technology's going, but I think knowing how we can better use today's tools is as important as building better and newer tools in the future.

Something that's becoming very popular for GAT is arbitrage-free bond canonical decomposition (ABCD). One part of ABCD is a "risk fingerprint" of the liability. It unveils what embedded options are in a liability product. It's also a way to produce a benchmark for measuring the characteristics of product features made up of bonds and other instruments that investment people understand.

Value-at-risk (VAR) is a term that was, up to about a year ago, primarily associated with off-balance-sheet instruments in banks. Now it's actually being talked about in terms of a useful measure for maximum downside loss for an insurance company. How can we take that same framework of looking at the risk, determining how much capital we need to have underlying a particular product line of business, and developing a risk-adjustment tool to measure total return? We need to look more intensely at the models that we have and the risk factors that are associated with various

characteristics. I think we really are at the tip of the iceberg. Many people have probably done some work in this area, but they've not made it very public.

I think efficiently shared knowledge is going to improve the way that people look at the behavior of insurance policies as in investments' prepayment behavior and the like. Specifically, this is going to evolve into a better understanding of what is at risk to the company. Understanding those risks as pertinent to liabilities will require an understanding of how well our models replicate the actual experienced lapse behavior. That's an adaptive calibration issue. These models will get better and better, but there's always something uncertain that can come up and send us back to the drawing board. So risk-factor analysis in this case will ask us to assume we're going to be wrong and see what it's going to cost us when that happens. And, finally, there is performance attribution—using the past to see how well our models actually did, how well our returns were, and what the sources of those returns were both for assets and the liabilities.

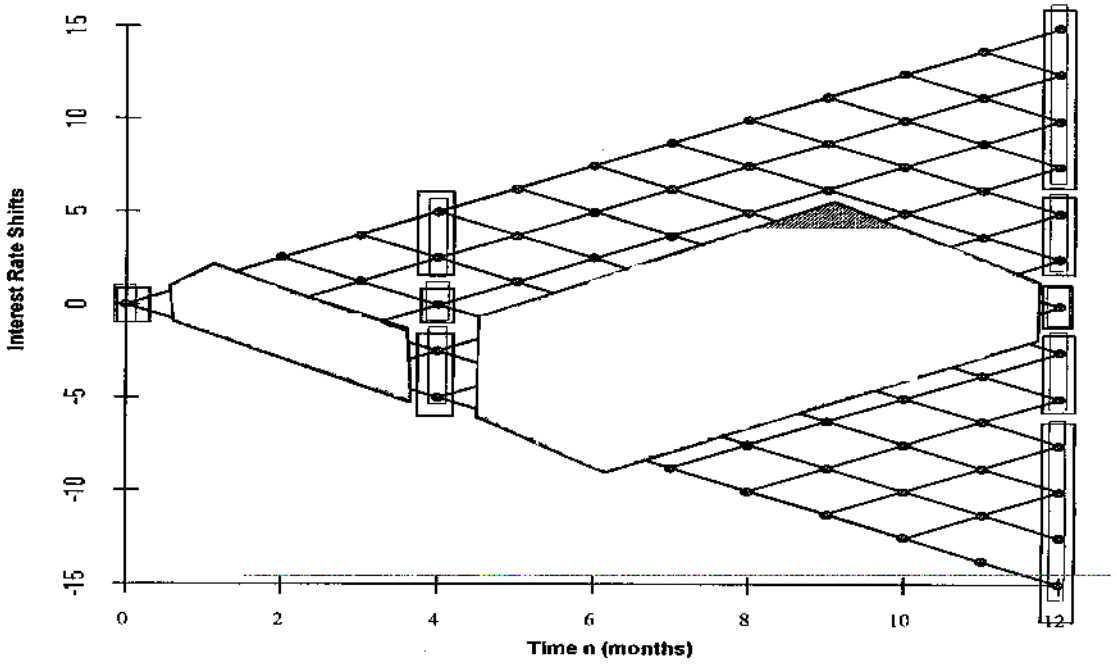
We believe a consistent framework needs to include a term structure of interest rates as well as a term structure of volatility. A binomial lattice that you would use to value American options using rollback techniques is the source for our one- factor interest rate model. Our latest edition is a two-factor model that also includes a term structure of correlations with the one-month rate. We are starting to apply to n-factor models where we simulate multiple currencies together to do global valuations.

We need to reduce the number of scenarios to be processed, and low discrepancy points is one method. Another method was developed by Tom Ho (GAT), through discussions with his colleagues at insurance companies. He developed the linear path space (LPS) in 1991, which is the first risk-neutral structured sampling methodology in the literature. LPS is not as statistically unbiased as the pure theory of low discrepancy points. But the mapping from the n-dimensional sample space to a univariate distribution for low discrepancy is nontrivial. LPS is well-defined. In addition, LPS has the advantage of being arbitrage-free at every point in the lattice and can shorten calculation time for asset and liability valuation for multiple periods.

The LPS framework is illustrated in Chart 4. *Tt* starts with an underlying binomial lattice, which has far too many paths to produce significant Monte Carlo simulation results for a small sample. LPS then incorporates the use of a trinomial representative path mapping and probability weighting from the underlying binomial distribution by counting the number of binomial paths that go through areas associated with the representative paths out of the total number of binomial paths. So by doing that we can actually achieve results quickly in under 50 paths that stay relatively stable as path

count is increased up to the total universe of about 2,000 paths. So LPS is a nice shortcut for valuation, and it has used all of GAT's analytical systems at present.

CHART 4
LINEAR PATH SPACE
BINOMIAL LATTICE PARTITIONS
ONE EQUIVALENT CLASS OF PATHS HIGHLIGHTED

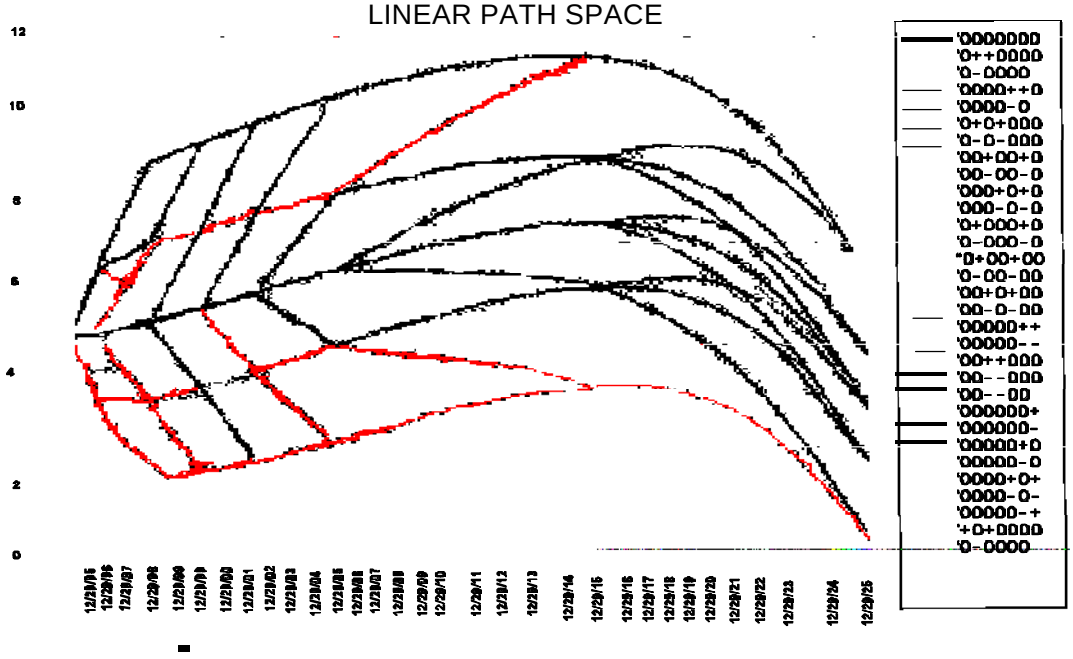


LPS does follow the shape of the implied forward curve which produces inverted yield curve movements because of the liquidity and risk premium that exists in the marketplace for longer instruments. There is much more work that needs to be done to unravel this problem. Chart 5 shows how we've added a two-factor rate model that produces twists in the yield curve. The average is still going to be roughly this implied forward shape in terms of valuation because we're keeping things arbitrage-free. We need to price various maturity bonds, collateralized mortgage obligations (CMOs), and long- and short-dated options all within the same framework. If you don't require the arbitrage-free conditions, you won't price a portfolio of bonds and options properly. Efficient interest rate modeling deserves a lot more attention and we certainly hope to focus on this in the future.

Our keynote speaker, Daniel Burrus, was talking about taking the technology and looking at it differently. When option-adjusted spread (OAS) analysis was invented, analysts just wanted that one statistic. Now, most folks are realizing that there's much more meat inside per scenario evaluation. We now look at linear path space scenarios, the probability weights that are associated with them, the liability products' economic fair value along with the assets' fair value and do comparisons on a per-

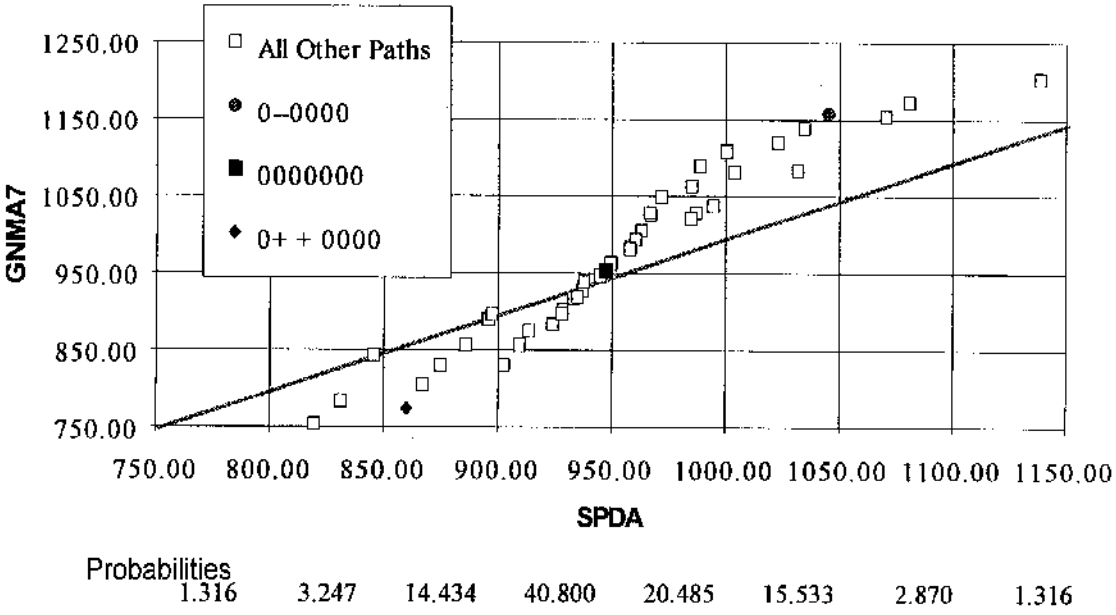
path basis. Obviously, the more diversified the scenarios, the more information you can determine about the embedded optionality and its value.

CHART 5
LINEAR PATH SPACE



Graphically you can plot the value of assets versus the liabilities and come up with what I'll call a pathwise profile (Chart 6). In this case we have a duration mismatch of asset to liability.

CHART 6
ASSET/LIABILITY PATHWISE VALUES



Note: High surplus duration implies profit when rates fall, loss when rates rise.

The mortgage-backed security value is much higher than the single premium deferred annuity (SPDA) liability in the case where interest rates fall, so it implies there's a profit when rates fall and shortfall losses when rates rise. A goal is to invest in assets and hedge in such a way that you profit in most if not all scenarios. We have several methodologies to do this and I think more techniques for this will be developed in the near term.

The current technology for KRD can be improved as well. We're doing linear interpolation from the underlying spot curve to come up with local shifts. Chart 7 shows an example of a KRD shift. An upward KRD shift of 25 basis points at the 20-year maturity ramps linearly from the unshifted spot curve at the 15-year point to 20 years and then back down linearly to 30 years. We need to smooth out the inflection points so we can increase the amount of rate shifts. Typically, we use about 25 basis points to do the KRD shifts because of the effect of the points of discontinuity on the forward rates. The beauty of KRD is that the sum of the KRD is equal to the effective duration. A systematic way of decomposing the interest rate sensitivity is by using KRD.

CHART 7
KEY RATE DURATION SHIFTS

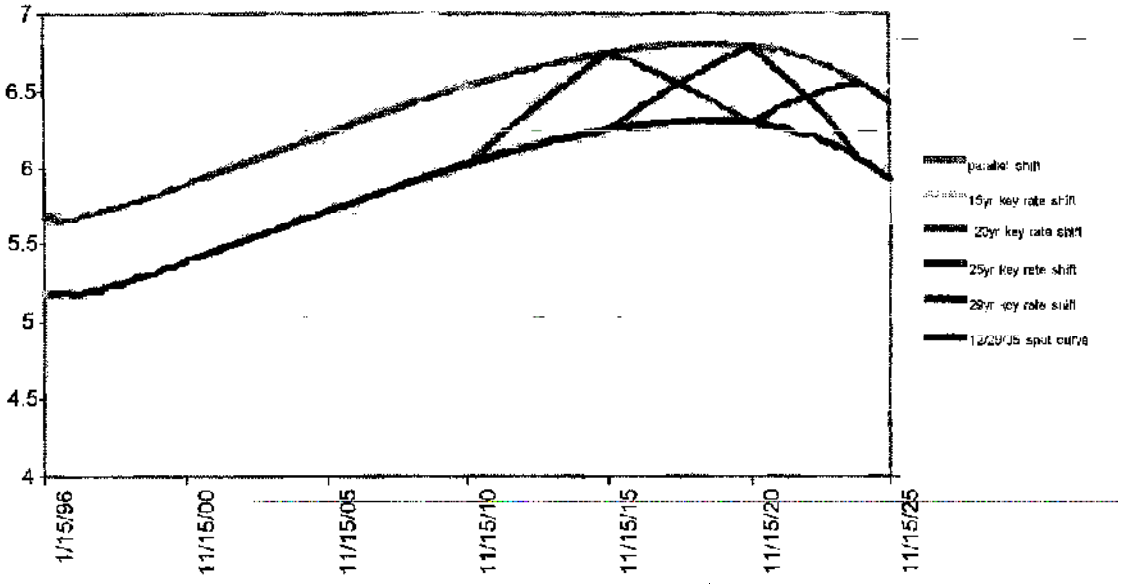


Chart 8(A) is the KRD profile for a zero-coupon bond of 20-year maturity. All of its duration sensitivity is to the single cash flow at maturity. As a consequence, its main sensitivity is to the 20-year rate. For a coupon Treasury bond [Chart 8(B)]), there's an even distribution of interest rate sensitivity. The principal has the largest duration bucket. For callable bonds [Chart 8(C) and (D)] the greater the chance of its being called, the shorter the distribution of KRD reflecting the uncertainty of when the call will occur.

CHART 8(A)
20-YEAR TREASURY ZERO COUPON BOND
KEY RATE DURATION (YEARS)

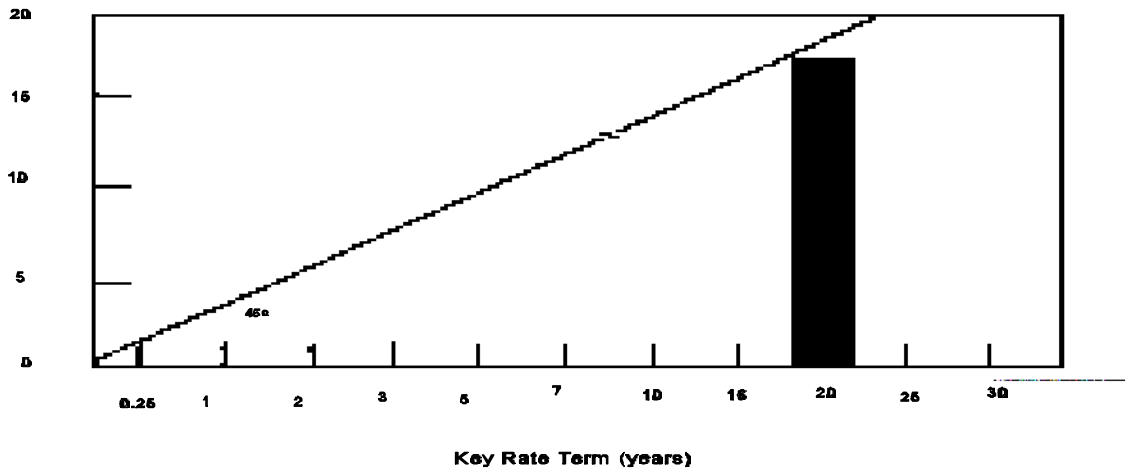


CHART 8(B)
30-YEAR 9% TREASURY COUPON BOND

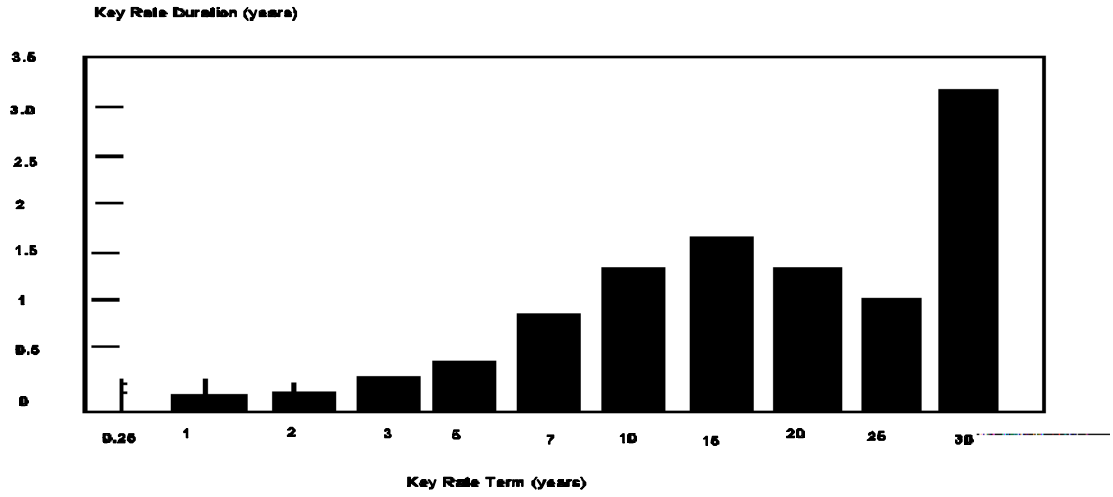


CHART 8(C)
9% VERSUS 8% 30-YEAR CALLABLE CORPORATE BONDS

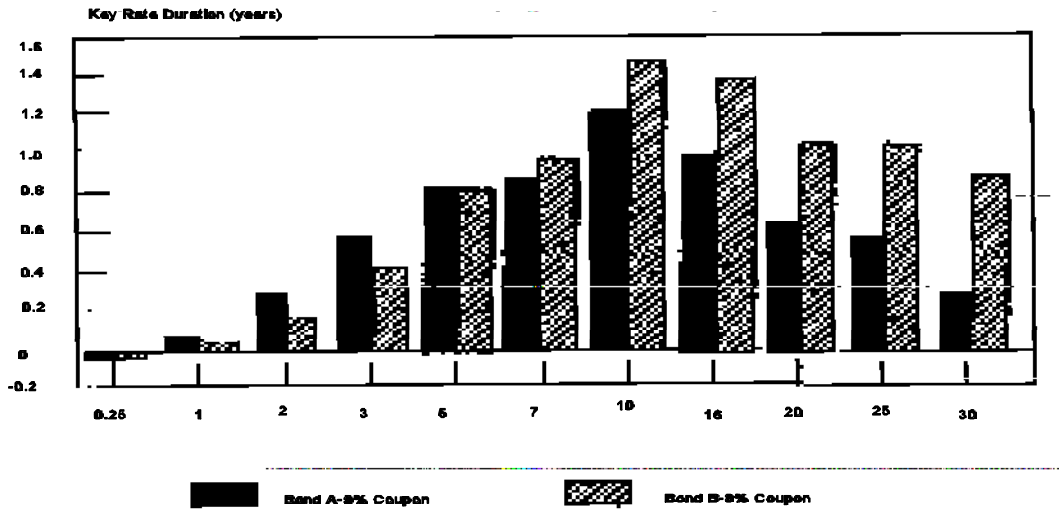
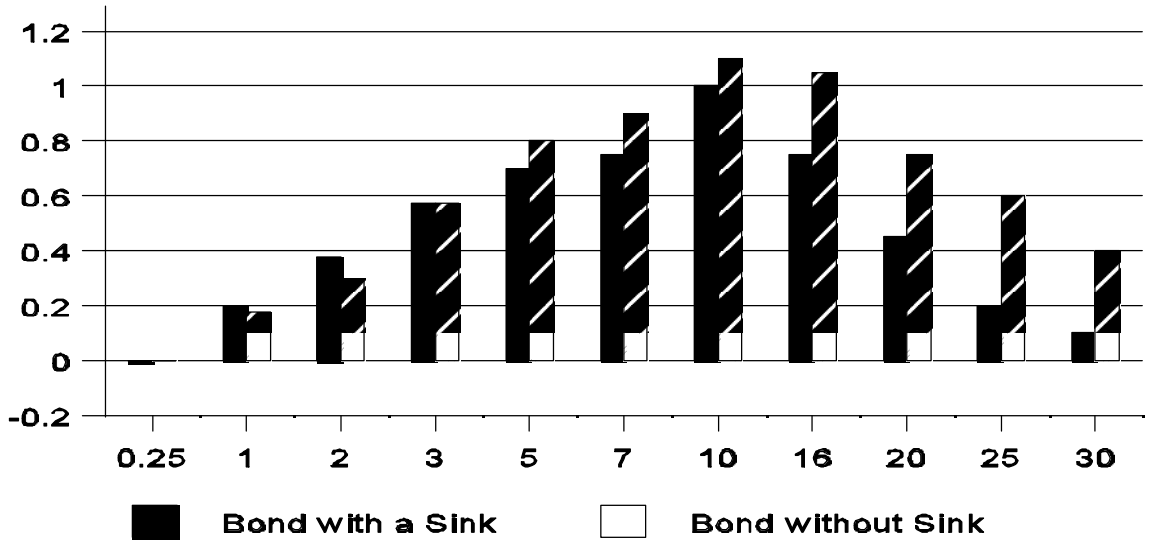


CHART 8(D)
CALLABLE BOND WITH/WITHOUT SINKING FUND
KEY RATE DURATION (YEARS)

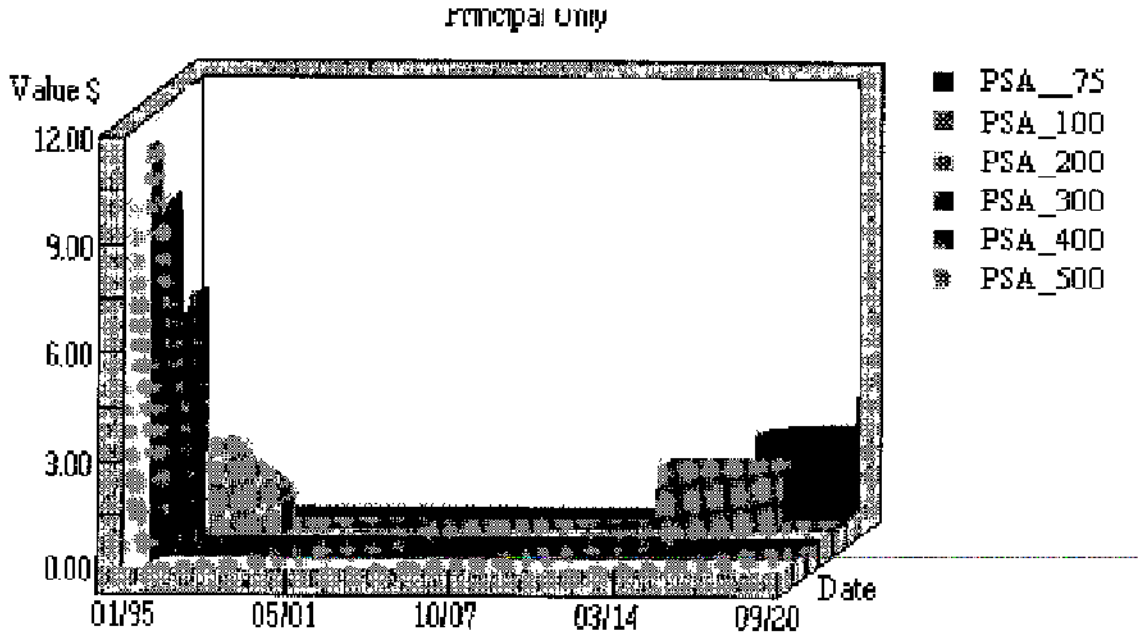


For options and basis or leveraged floaters, negative duration is very likely. What does negative duration mean? If interest rates rise and the value goes up, you have negative duration. For bonds, duration typically is positive because you're discounting a fixed cash flow. So when interest rates move up, the value goes down for a coupon bond. But in the case of something floating that's crediting maybe a higher rate than the discount, like a ten-year constant maturity Treasury, which is discounted at the one-month rate, you have the case where as rates go up, the value goes up. For example, you're getting a higher coupon and it's increase dwarfs the discounting rate that's in effect at that time. So you can see negative duration in various types of securities, derivatives, mortgage-backed securities, and especially annuities. For these, we have seen very complex negative KRD profiles.

Arbitrage-free bond canonical decomposition is a new tool to measure embedded optionality. The way that it does that is twofold. One—you can look at a liability versus an option-free replication of that liability. First you match cash flows along one interest rate scenario. Then you take a look at it over many scenarios versus the liability. Two—the main theorem says that if you have two-path independent instruments and if all the cash flows match for one scenario and if all the pathwise values match, then you have an equivalence. But I'll stress that this is for path independent. We have more research to do to apply to path dependent securities. But even now we can come up with a very nice replication of a liability or a complex asset like a CMO.

Chart 9 shows a CMO that has two risk factors—prepayment risk and extension risk of the cash flow. This is a cash-flow diagram under a range of prepayment speeds where there's a dramatic jump between these two extremities of early prepayments and late cash-flow extension of the CMO.

CHART 9
MONTHLY FH1747:Q CASHFLOWS PER $100 AT 6 SCENARIOS



The primary decomposition in ABCD (Chart 10) clearly shows this risk. To determine this, first determine the cash flow along the forward curve, and then match it with zero-coupon bonds that meet those cash flows. This first decomposition shows the prepayment risk and extension risk of the actual CMO relative to the benchmark portfolio of zero-coupon bonds. We can do the same thing with a liability versus a replicating portfolio. We've found, for annuities, that the best primary decomposition is not zero-coupon bonds but a synthetic instrument we would call an amortizing accrual note. This note accrues at a floating rate and the lapses for the implied forward scenario can be treated as an amortization schedule.

The secondary decomposition (Chart 11) requires an additional equivalence between the pathwise value for all paths of replicating portfolios and the actual liability. That is done by fitting forward caps and floors at various strikes. Now you have matched pathwise values right along this 45 degree line. This is a good benchmark for what was a complicated CMO using just Treasuries, caps and floors.

CHART 10
PRIMARY DECOMPOSITION

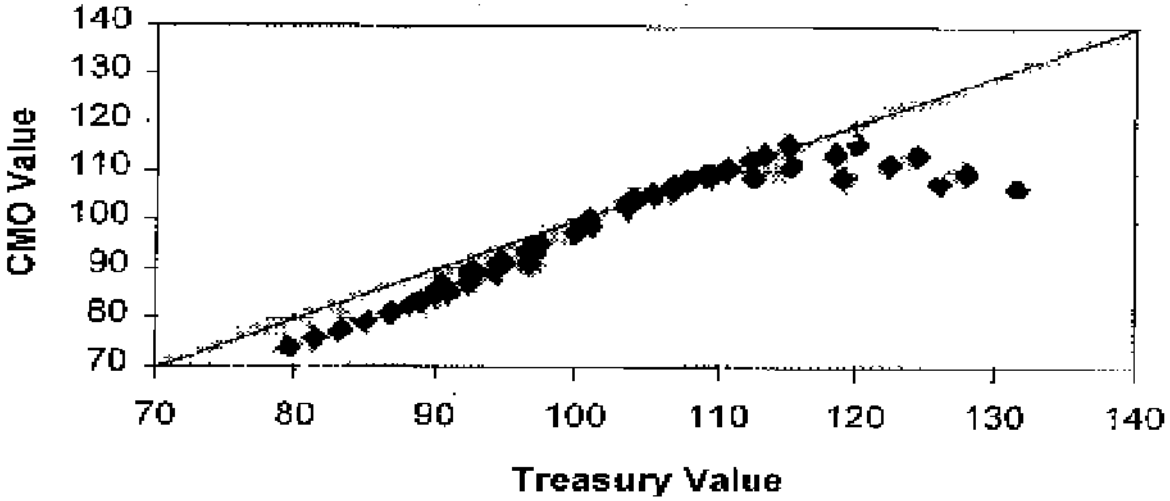
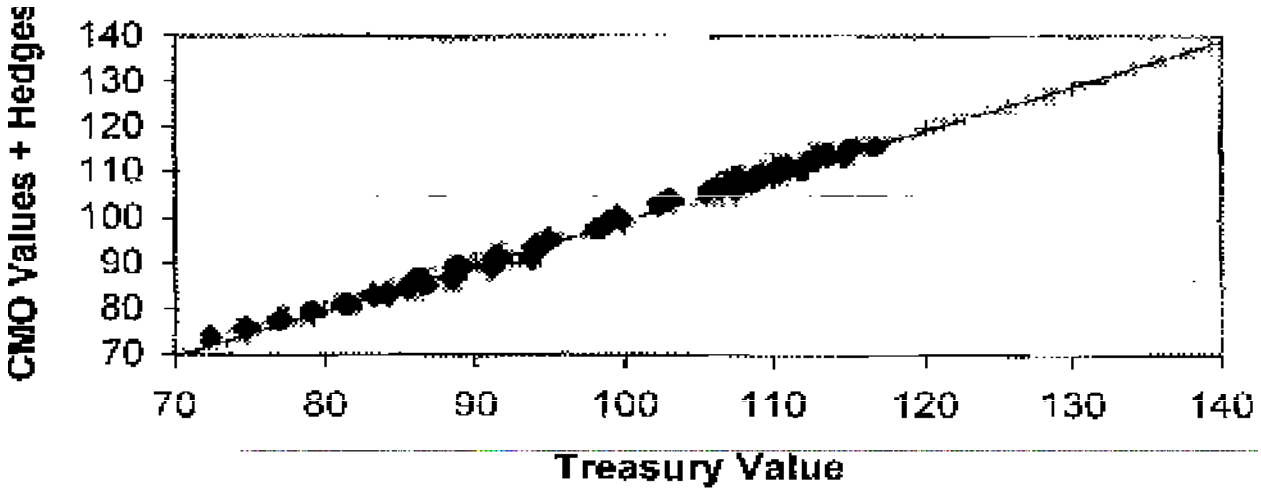


CHART 11
SECONDARY DECOMPOSITION AFTER HEDGES



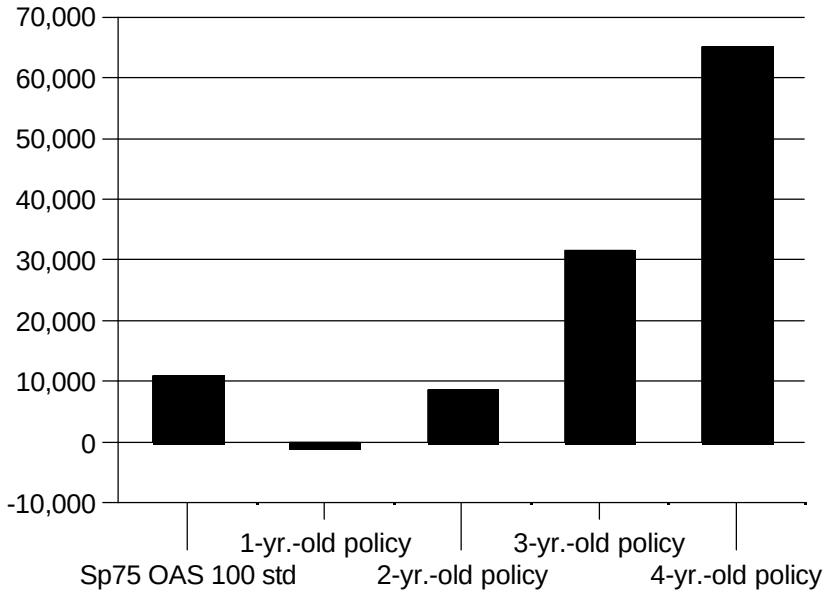
One of the new approaches to risk analysis is VAR, which is a concept that has been used by banks mainly for the off-balance-sheet instruments and originally applied to trading positions. The challenge is correctly applying it to handle insurance risks. Looking at VAR for asset/liability management is a current research problem that we're looking at with several large insurance companies. The main definition of VAR is the maximum expected loss over some horizon at a certain level of confidence. Management wants to know how much capital it needs to have in reserve to actually cover the downside risk. I foresee that the methods used for VAR will be adapted to more strategic management use for optimally allocating its capital.

The complexity of doing these calculations involves KRD for GAT's implementation of

the delta-normal valuation method for linear risk and key rate convexities for the delta-gamma method to calculate nonlinear risk. KRD is very computer intensive. For path-dependent-instrument market value, you need to do maybe 100–300 paths even with LPS. For KRD, multiply that by 23. Key rate convexity compounds that manyfold. This huge matrix of key rate convexity sensitivities are vital to determine the nonlinear risk associated with the embedded options.

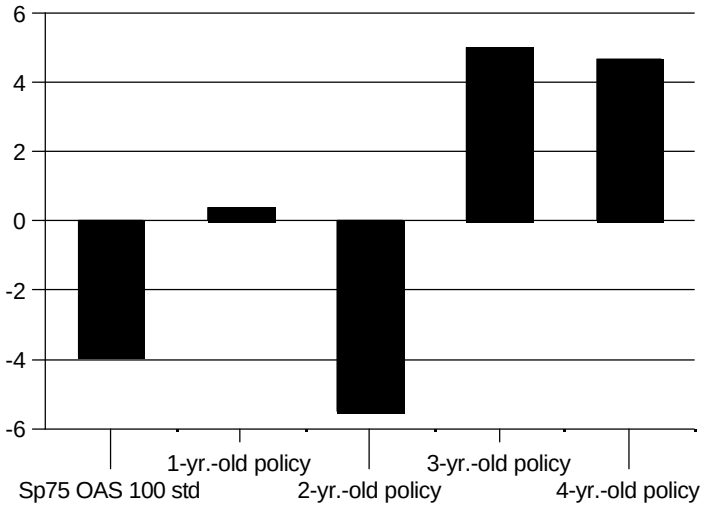
The other benefit to the VAR approach is defining an appropriate horizon for insurance. The trading VAR of one day is not appropriate in this context. Maybe a quarter or even a full-year horizon is required because of the illiquidity of the liability block of business. You can slice and dice across segments and risk sources and determine what each contributes to the total VAR. We could segment total risk by product lines instead of, in this case, by portfolios. We can roll up to look at the total VAR or drill down to ask what risk contribution is for each particular product line or portfolio that's backing it, how risk is diversified, and what risk capital needs to be allocated. And then maybe we can go even further and look at the return on that particular line. I think Bankers Trust coined the term risk-adjusted return on capital. You can also apply the sensitivity measure we call effective duration (which is a percent change) to other product features. For example, if we're looking at lapse and perturb our lapse model to give us a little bit more lapse or a little bit less lapse, we can determine the price sensitivity with respect to economic value. Chart 12 shows what happens to lapse duration for a new universal life policy when it is one year old, two years old, three years old, and four years old. Because the future premiums affect the market value so strongly, the results look random.

CHART 12
DOLLAR CHANGE IN MARKET VALUE FOR 10% CHANGE IN LAPSE RATES



Using dollar duration (Chart 13) instead of just effective duration it becomes much more reasonable and even systematic in terms of the behavior with respect to policy age. So good sensitivity measures combined with a total return and attribution framework can complete the set of thorough valuation tools that one needs.

CHART 13
PERCENTAGE CHANGE IN MARKET VALUE
FOR 10% CHANGE IN LAPSE RATES



In summary, I think that we're certainly going to have a lot more capacity for all of these calculations, all of this modeling control, through the changes in the way computing technology will be economically distributed across an entire network. Actuaries will be looking at not only what the value is today, but doing simulations to find out what the value is at various states in the horizon. Management will start to use this information to make strategic business decisions about how much capital to allocate to different lines of business and actually have more feedback into the "what if" scenarios that are used in testing, at the detailed level, the models and the product line characteristics.

Mr. Shane A. Chalke: I think, for the most part, Mark and Doug have talked about newer incremental technology solutions for an existing suite of products that exists in the insurance industry. I'm going to attempt to talk about something a little bit different.

I think that it's difficult to talk about emerging technology and new technology without taking a look at where we think the product is headed. I believe that product is entering sort of a golden age right now where we can expect to see some fairly dramatic changes in what kinds of products the services industry offers as a whole and, in particular, what insurers do within this universe. I'd like to take a step back

and look more at what consumers want; what humans want, let's say. And even though I am an actuary and you're all actuaries, we need to observe humans and study how they behave and act, so we can truly understand what humans desire in solutions to their financial picture. Without that, we run the risk of continually fine-tuning the point solutions that we offer the consuming public without looking at the broader picture of what, ultimately, is the need that we're trying to address.

Let's discuss the problem that humans face. This is, in fact, what I believe is the fundamental problem that we're ultimately trying to address. If we keep this in mind, we'll design different kinds of products to meet this problem.

Dual-income baby boomers, with their 1.7 kids, spend and earn money over their life span. I produced a picture that stripped out any accumulations of capital. I stripped out any financial engineering or financial services products that might be bought to help smooth these two aspects. This is the accretion of liabilities in the earned income of the baby boomer.

What happens is you don't really earn any appreciable amounts of income until you get out of school and then take a job. (I should also say I adjusted this to real dollars rather than letting it fly in nominal dollars.) Your wages increase very rapidly in real terms, for the first, let's say, 20 years of your working life. And then common wisdom says that wages go flat, in real dollar terms, once you reach your mid-40s to age 50. In fact, I do not believe that's true. That's only true in terms of dollar wages, but if you count, in fact, the aggregate wage that's paid, the whole package of employee benefits, that gets rapidly more expensive throughout your 50s. So although the rise in real wages tapers off, it does not go stagnant as is the conventional wisdom. Then at age 65 it goes down to zero, because, remember, I've stripped out all the financial engineering. In other words, there's no pension plan in here. The contribution to the pension plan made by the company is included in the wage line, so I presume that no financial services products have been bought at this point.

How you spend money creates a very different pattern than how you make money. This is one of the primary issues that humans face. I know actuaries never do this, but humans do. What happens is when you get out of the university, the first thing you probably buy is a car. And then very soon you start buying things like condos, houses, and children's education. You start making these fairly large lump-sum purchases that, of course, aren't supported by current income on a direct cash match basis. So what happens is you have all these spikes in the expense line. If you're a typical baby boomer now, it's not until your late 40s before you start buying education for your children. Then you replace each car every four or five years. Then, at age 65 or thereabouts, you retire and your expenses drop incrementally. Then,

should you live so long, you start being a major consumer of healthcare. So the major issue here is that the expense line doesn't look anything like the income line. This is fundamental to the problem that humans face.

The other dimension to this is that neither of these two lines is predetermined. Both of them are fairly fuzzy probability distributions. The way that you earn money can be interrupted by all the contingencies we're familiar with: disability, death, unemployment, and getting laid off. You don't really know if you'll follow the typical pattern of wage increases or not; it depends on how successful you are in making strategic moves in your career. On the expense side you just never really know when you're going to crash a car and have to buy a new car. Or you don't know when you're going to have a catastrophical medical problem. Therefore, the pattern of expenses is fairly unpredictable as well.

Now, I will outline the problem that we're trying to solve as a financial services industry. I put forth that the financial services industry as a whole only really does three things at the retail level. We do transaction processing. We sell a suite of products that does cash matching, and we sell a suite of products that does volatility reduction. And I think you can put everything financial services does at the retail level in one of those three categories.

First, consider transaction processing. It's really just moving money around. I think in each of these three areas we're going to see some very profound changes over the next few years. You look at what banks do. The major function of banks, at the retail level, is to move the pointers around. They consolidate transactions and net them bank-to-bank overnight.

In terms of the human level, I think we can expect to see some changes in the very nature of cash and in the way people view cash. Changes in the way they think about cash will have ramifications on the types of products that society will demand from us. If we look at this technology, it's not a bad technology, but we don't use it as humans very much anymore. There's only about 20 billion dollar bills in circulation in our economy. Every day that I hold one of these in my pocket, I lose money. We may be the first generation that actually understands this on an intuitive basis. I don't think our parents really understood this intuitively, but I think our generation now does. And you have companies like CyberCash and Verifone working very diligently to provide us with electronic cash known as smart cards or stored value cards. That's really just the tip of the iceberg.

If you think about what it means to have a dollar bill with a chip inside it, now it means that it's a very small technological leap to have these bear interest. That's

really, I think, very profound, and very significant for the way people view financial services. So it's a trivial process, for example, to have a fairly low guaranteed rate of interest, 2% maybe, programmed right into the chip. So every day you hold that smart card, the amount of Federal Reserve notes denominated on that card goes up by 1.02 to 1 over 365, or something like that. It's not a big deal to do this kind of technology. So I think what will happen is consumers will become very much more aware of what it means to store value, what it means to store purchasing power versus storing Federal Reserve notes. We may actually see a time when Federal Reserve notes even cease to be the unit of denomination. In a large part, compared to the traditional role, they're less relevant than they used to be.

On the other side of the fence, the place we're most concerned about is the cash matching and the volatility reduction. Those are the two things that we're involved in. What's cash matching? Well, the day that I get out of school at age 22 or 23 and I buy that first car I have a cash problem. Cars cost, say, $15,000. Let's say you don't have $15,000. That's a cash-flow problem, or a cash-matching problem. So what do you do? You go to the financial services industry and you buy a product, a cash-matching product, called a car loan credit product. At the time that you're doing it, at age 22, you don't necessarily think intuitively that you're buying a financial services product. But that's, in fact, what you're doing. When you buy that first condo, or some other form of credit, you buy another financial services product.
When you get into the middle part of the curve, where the income line is above the expense line, you start buying accumulation products. Again, they're cash-matching products. In today's environment, it tends to take the form of pension plans or certain types of personal savings. It can take the form of actually reducing your purchasing power or your store of credit products. But, in fact, what you're doing is storing up funds for later on. You are buying accumulation products. We, as an insurance industry, do participate very much in credit products at the retail level. We participate very strongly in accumulation products. So this is the cash- matching issue that we're faced with.

The third area is volatility reduction. Those are a suite of products that we offer that serve to control the volatility of either the income line or the expense line. For controlling volatility of the earnings line, we sell life insurance, we sell disability insurance, short-term disability, and long-term disability, and so forth. To control the volatility of the expense line, we sell personal lines, property/casualty insurance, and health insurance. These are the major point solutions that we offer.

The lesson here is that we require human beings to solve a very complex asset/ liability management problem, their own personal balance sheet. However, we've provided them with very little in the way of comprehensive guidance to do this. What

we provide them with is a suite of 80,000 or so point solutions that humans are intended to pull together on an a la carte basis in order to solve this problem. I believe that humans don't do a particularly good job at solving this problem.

So where this leads us, I believe, is that the future of product design will be more product integration; there will be more comprehensive solutions for this asset/ liability management problem at the human level. Why? The current wisdom in the insurance business, eight or nine years ago, was that this function, pulling the various selections from the a la carte menu to solve this asset/liability management problem at the human level, was done by the intercession of intermediaries, either insurance agents or financial planners.

The major problem here is that the economic conditions to have financial intermediaries or counselors or advisors perform this function are not right for two reasons. The first is that the intercession of human labor in any process is enormously expensive and most people in society can't afford the drag of the human intervention. The second issue is that you do have broad segments of society that have similar economic problems. You can put people in reasonably broad demographic categories where they face similar kinds of problems or a similar pattern. As a result, I feel that product design itself will perform more of the financial planning function.

I can draw a couple parallels to this—one very close to home, maybe one a little off the wall. Close to home would be health insurance. There was a time, years ago, when I was young when you bought things like an accident and sickness policy. I bought hospital, indemnity, and various kinds of a la carte coverages to put together health insurance. Now, we have migrated toward a more comprehensive solution where you buy one product and it is comprehensive in its nature.

Another maybe off-the-wall example is in home electronics. There was a time, about ten years ago, when if you wanted to buy something as seemingly simple as a home stereo system you went to perhaps a number of different stores. You had a lot of investigation to do. You had to read stacks of *Consumer Reports* and you had to talk to many people in the store. You'd end up buying seven different components, seven different point solutions and you ended up cabling everything together in your house. Well, now, just as an example, the most popular home theater system is the Sony System for idiots. You walk in the store. You make exactly one decision. They still load seven boxes in your car, but you don't have to be an expert. Now it would have been ironic if the home electronics industry ten years ago said the real solution is to train and recruit an army of stereo consultants. We'll give them a 62% commission and put them out into the world. That's how we'll really solve the problem. I don't

think that would have worked, and I don't think it's going to continue to work in the insurance world.

Where are the major advances going to occur? I believe in several different places. First there's the merging of credit and accumulation in a single product. Baby boomers have a big problem right now because they buy point solutions where they are simultaneously in debt and also own accumulation products. How many baby boomers have a home mortgage at the same time they have equity funds through a 401(k), or even through direct mutual funds, or even direct stock investments? Do these people realize that they're buying equities on margin? Do they realize how leveraged they are by simultaneously trying to play both sides of the balance sheet? If we can combine a product with both credit and accumulation under the same roof, then what we can do is give people the ability to have a less risky, more comprehensive, better managed personal balance sheet. I think this will come.

As a matter of fact, I think in the insurance business we should be concerned about people providing financial services from a number of different areas, places you wouldn't normally guess, such as a company like Fingerhut. Who would think that it would become a significant financial player? You probably don't even know who Fingerhut is. Fingerhut is a company that produces mail order catalogs. It doesn't actually make any particular product. All it does is package a bunch of products and sell them on credit. It's basically a provider of financial services disguised as a mail order catalog. All its prices are quoted as the monthly payment. It's not in the demographic category that all of you are in. It services lower income consumers, but this is an example of a company that is paying attention to what consumers want, rather than what we feel are traditional point solutions to consumer finance problems.

The upshot here is that we need to look at liability production as a derivative business. What we're really doing is producing derivative securities for end users. We can create a more complex derivative by combining credit and accumulation.

The other major advance that I think is already emerging is the provision of products that are more comprehensive, that store value better and that are mated better to consumers' risk aversion profiles. Consumers have a funny problem in that area. They have an asymmetrical risk-aversion posture. It is fairly well-known that consumers have a shifting profile toward risk, and they become more risk averse right after a loss event. This is why people buy homeowner's insurance after the house burns down or car insurance after they wreck the car. This is a fairly typical pattern of behavior. It also places people in a position, as personal investors, of tending to buy high and sell low. That causes them to be reasonably poor players at trying to solve this problem on the accumulation side. So if we can produce more complex

derivatives to shield people from their own asymmetrical risk profile, by producing products that have an asymmetrical payoff pattern, then we do a great service for the consumer.

We're already seeing the tip of the iceberg of this with these things known as equity-indexed annuities. I know many people in the insurance world think that these are a tad gimmicky. I don't share that view at all. I think we have created a very profound product with an asymmetrical payoff pattern to replicate the asymmetrical risk profile of the consumer. So these are a couple of advances.

Now if we're going to be looking at products as the production of derivative securities, that has a lot of ramifications on what kind of tools that we'll actually need. As Doug mentioned, we rely very heavily on consumers' inefficiency in electing options that exist within the products. Now the residential mortgage market has worked this way for many years. It's working this way less and less, but we do rely substantially on consumers not electing options when it's economically viable for them to do so.

Doug mentioned that consumers will become more sophisticated. I'd take that a step further and say consumers are already more sophisticated. It's simply a technology problem. Is the information about whether they should elect an option or not delivered to them in a cheap enough form? I think we want to design products and look forward to a day when options are elected on an economically efficient basis because entrepreneurs will deliver the information to them.

If you're in the annuity business, you have great entrepreneurial opportunities to seek out all other annuity holders that have an option to lapse in the money and show them a better way. And that's less expensive than finding new savings dollars. We see this happening in the mortgage market all the time.

The real breakthrough was, I think, in 1993 and 1994, when more proactive marketing of mortgages took place and broke everyone's prepayment model. Well, what's going to happen is all of our lapse models are going to break. I don't know exactly when they're going to break, but they're going to break. As a result of that, we're going to end up designing products that do not rely on inefficiency of consumer behavior, but rely more on the packaging of derivatives that consumers want. I'd call an SPDA a derivative. Universal life is a derivative security. It's essentially what we're doing, so we're actually gaining a fee for packaging

derivatives that map well at the retail level. We can take a bunch of wholesale tools that are available, repackage, design, and put them out into the world as a retail derivative.

Risks can be separated into diversifiable and nondiversifiable categories. For any risks that are diversifiable, like mortality, the main tool that we'll end up using is one of stochastic measurement. Whether that's pure Monte Carlo techniques, whether it's layered on top of Monte Carlo, some kind of value-at-risk concept, or whether it's a more rigorous stress test, I'm not sure where we'll end up. But I think we'll have to deal on a stochastic basis with risks that we attempt to control through diversification.

On the other side are nondiversifiable risks. You cannot diversify an option-writing program by writing more of the same options. It can't be done. I think our pricing methodology will be to disaggregate and hedge these risks through the pricing process.

This is very similar to what Mark was talking about in his canonical bond decomposition. We use simpler terminology—disaggregation—but essentially it's looking at the products of the derivatives that we structure at the retail level, looking at what the component parts are and pricing them on a capital market basis. What this means is that actuaries will no longer be allowed to quote in their pricing models gains from naked option writing. Now I'm using finance parlance, but, in fact, that's what actuaries have done for many years. When an actuary prices a product on a single-scenario basis, you cannot really tell what part of the gain is from the pure manufacturer of the derivative and what part of the gain is from naked option writing from unhedged options.

I think the mandate of product development actuaries will be to quote the returns on a fully hedged basis, on a fully risk managed basis. So we'll use the two techniques where appropriate. I think the major advance that's ahead of us in actuarial science is to merge these two techniques. This has some fairly profound ramifications, because it does speak to, ultimately, the merging of property/casualty actuarial science with life actuarial science. To me that's very exciting. Both disciplines do important things. When they're merged together, we'll have a much more cohesive framework to produce these derivatives at the retail level.

Let's discuss the metrics that senior management wants to see today on pricing. We rarely provide them. Does senior management really particularly care about statutory return on investment? I'd say no. But senior management wants to see marginal GAAP financials. They want to see capital cost and capital absorption. How much capital are you going to use in this project, and when are you going to give it back?

What is the GAAP earnings volatility? And at a more technical level, what about option-adjusted costs of funds? How efficient are you at bringing capital in the door on the liability side?

If you do this project at this level, what's the change in earnings per share? What's the change in GAAP return on equity? What's the change in return on assets? I think these are the suite of measurements or metrics that senior management wants. Management would have a much greater appreciation of us as pricing actuaries if we show up with these rather than what we usually show up with. And this is today, not three years from now. Although I'd say that three years from now this will become fairly standard in terms of methodology of quoting the results of the pricing process.

In the process itself, I believe we'll see a bifurcation of the pricing process from the actual decision mechanism. I believe for pricing itself we'll rely, at least in the accumulation products (which is where the action is at the moment), on disaggregation of the risks. This is the technique that people are predominantly using right now for equity-indexed annuities. It's a technique that perhaps should have been used for fairly exotic derivatives like guaranteed minimum death benefits and variable annuities, but has not been used widely. But in pricing we'll say, "Here's the derivative that we packaged; here's what it costs us to hedge it in the capital markets. What do we have left?" That's the pricing mechanism.

However, the decision mechanism will not be one based on this disaggregation and hedging. It will be based on simulation. We know in this business it is critical to be able to project and quote the accounting results, because we are an industry driven by accounting. We have at least three different accounting mechanisms, and the measures that I just discussed are all predominantly accounting based. What does this do to the financial plan? What does this do to GAAP results? What does this do to capital costs? I think that the actuaries will do pricing to understand what the price of the derivative ought to be. What's the fair price of the derivative? Then it will be wrapped into a financial plan and presented to management, who will decide whether we do this or not. I think that's where we'll end up.

I'll conclude with just a couple more concrete observations about where things are headed. First, as we make this transition from reliance and fairly inefficient behavior to a world where behavior becomes more efficient, that will happen from technology for no other reason. It's not that consumers will get smarter. They're just getting more information to be smart with. We will have much more burden placed on us as pricing actuaries to understand consumer behavior, and I think we'll spend more of our pricing technology dollars on behavior modeling and empirical behavioral analysis.

Second, as we move to a world where behavior becomes more efficient, we will put more of a premium on antiselection in that behavior. In other words, there's mortality deterioration. If consumers are more economically motivated in life insurance products, then people who have options in the money who don't elect them will have a reason why they don't elect them. It will be because their mortality has deteriorated.

Third, I think we'll see our systems, our actuarial systems, move from analytical platforms to operational platforms. I think it will become necessary to eliminate, for a large part, the collection of data process and the storage of data process. And I think we'll see our tools become more firmly integrated with liability management systems, with the transaction file, and with the master record, for example, so that we can do things like use a term the finance guys love—perturb. We can take an existing product, perturb it, and show what it looks like to do modifications of existing products on a more rapid basis.

And, finally, our technology is definitely headed in the direction that Doug talked about—fusing the planning process with the pricing process. Because, ultimately, what management wants to see is if you do this project, what does it do to the business plan? That's really the question that's being asked and we need to answer.

Mr. Irwin T. Vanderhoof: I would like to say a few words about the use of what are called low discrepancy points. I wish to make three points. The first is my relationship to this concept. I would like it on the record. Second, I'll tell you a little about what they are and how they work. There are more details in the September/ October 1996 issue of *Contingencies.* Third, I'll mention some results that have not been widely broadcast.

The reason for an interest in low discrepancy sequences is that they are a method of picking numbers for use in complex calculations, where only Monte Carlo approaches work; that is, they are more efficient than the use of random numbers normally used for such purposes. We are not talking a little bit more efficient. We are talking more efficient by a factor of 10 or 20 to 1.

My relationship to this methodology started in early 1992 when I read an article in *Science News* describing the work of Joseph F. Traub and H. Wozniakowski, both from Columbia, who had shown that low discrepancy sequences (LDS) should be more efficient in Monte Carlo calculations than in random numbers. I called them so often that they remembered my name and phone number when they had a student who wanted to explore the practical aspects for his dissertation. Professor Traub called and said that because I had been claiming that this technology would be useful in valuing financial instruments, they had decided they would like to try it out. I

cooked up a toy problem with a CMO, and the student, Spassimir H. Paskov, solved it very nicely and efficiently. We went down to Goldman Sachs that gave him a real CMO, which he used as the basis for his dissertation. He spent a summer working at Goldman Sachs and got his Ph.D. the following year.

In one of Spassimir's presentations at New York University (NYU), he gave the CMO problem he got from Goldman to a Japanese employee of IBM named Mr. Tazuka. Mr. Tazuka had previously done considerable work on LDS and had published one book on the general topic. He solved the CMO problem using his own set of numbers and IBM tried to sell the resulting methodology for $1 million per site. The whole point of this history is that the first recognition of the possible use of LDS on financial problems was made by an actuary.

To get an idea of how these sequences work, Chart 14 shows 1,024 points with random coordinates between 0 and 1 in two dimensions. Chart 15 shows 1,024 Faure points. Note the way the Faure points fill in the blank areas so that the whole area is covered. LDSs have the characteristic that if they are distributed throughout a unit hypercube, there will be a low discrepancy between the proportion of the number of these points within a given volume and the volume itself. In some sense they will distribute themselves evenly throughout the hypercube. The charts illustrate a hypercube of only 2 dimensions.

We can consider each dimension of the hypercube as being the values of a cumulative distribution function. If the CDF is of an interest rate generator, then each value of the CDF corresponds to a value of the interest rate. If the cube has 360 dimensions, then a point represents an entire scenario of a different interest rate for each month for 30 years. If the points are from an LDS, then the space is efficiently sampled and we would expect the interest rate scenarios to efficiently cover the range of possibilities.

Several different demonstrations of the usefulness of LDS for valuing complex investments were given at the May 25, 1995, meeting of the Society at NYU. Various kinds of options were valued. The following charts are illustrations from Mr. Paskov's dissertation that were also discussed at the meeting.

Chart 16 shows the convergence of the value of tranche A of a ten-tranche CMO using Sobol points versus random number generations. The random number generators produce obviously biased results.

CHART 14
1024 TWO-DIMENSIONAL PSEUDORANDOM NUMBERS

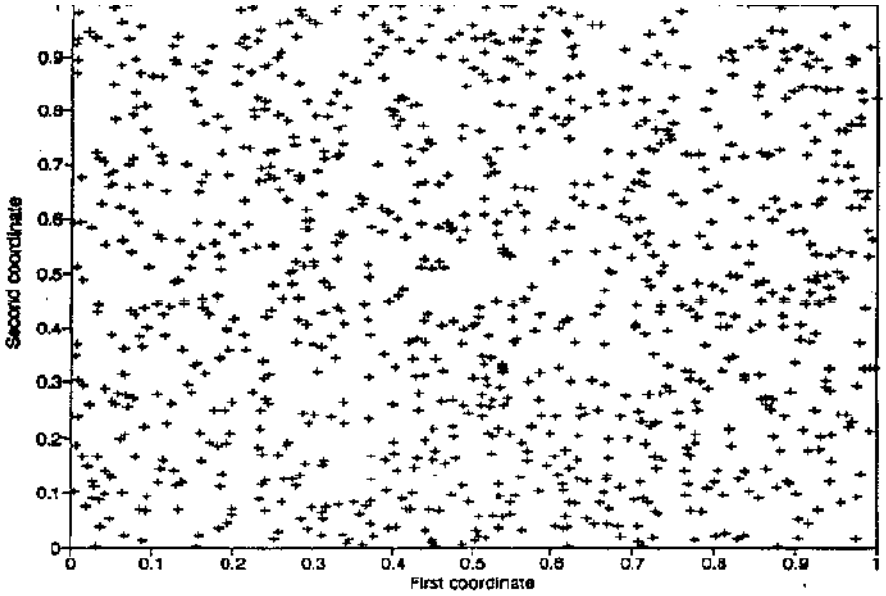


CHART 15
1024 LOW DISCREPANCY POINTS (BASE 3)

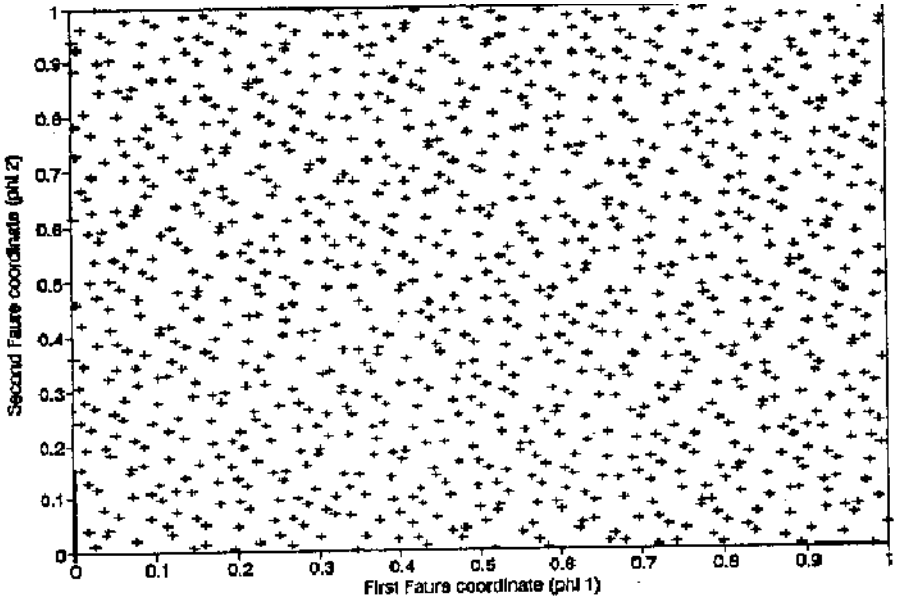


Chart 17 compares results using antithetic variables versus Sobol points. Chart 18 shows the comparison of the run with Sobol points versus the average of 20 runs using antithetic variables. Obviously, the Sobol points produce the average of the 20 runs with only 1 run.

CHART 16
SOBOL AND HALTON RUNS FOR TRANCHE A
AND FOUR MONTE CARLO RUNS USING RAN1

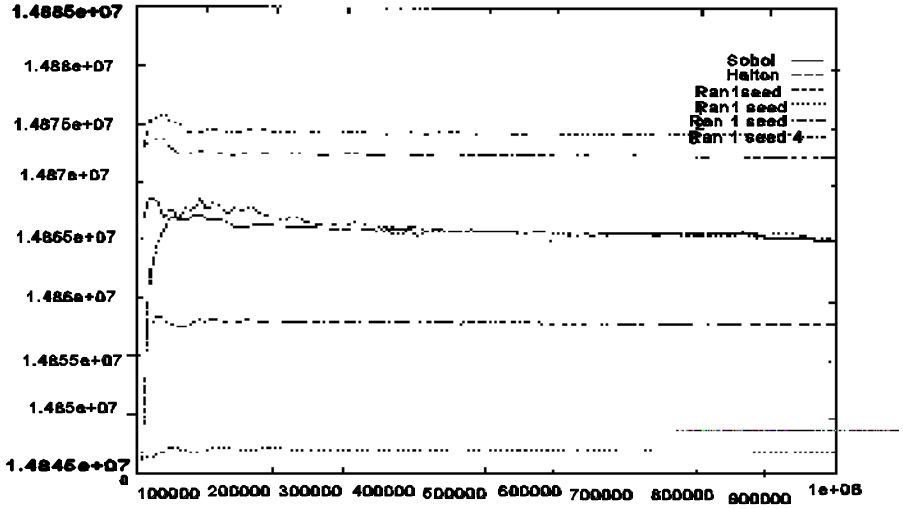


CHART 17
SOBOL AND HALTON RUNS FOR TRANCHE A
AND TWO ANTITHETIC VARIABLES RUNS USING RAN2

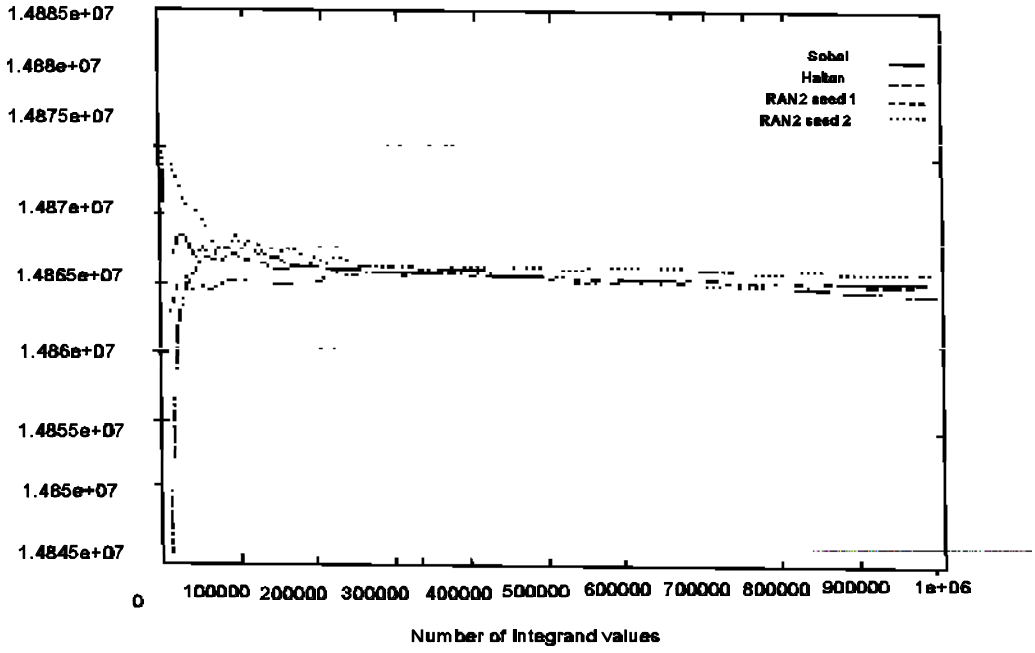
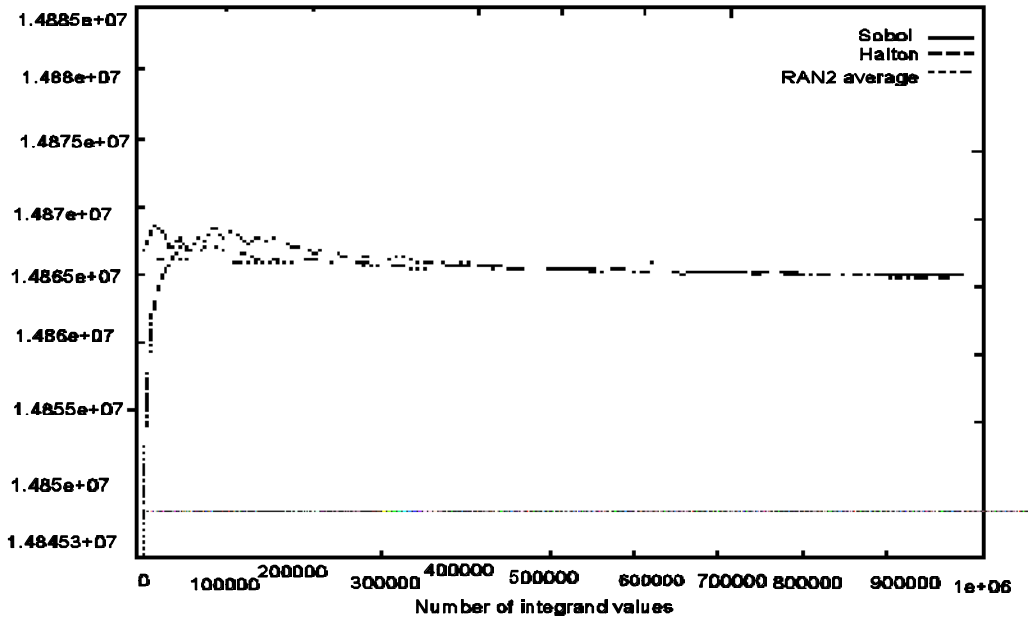


CHART 18
SOBOL AND HALTON RUNS
FOR TRANCHE A AND AN AVERAGE
OF 20 ANTITHETIC VARIABLES RUNS USING RAN2



Finally, very recent results from Professor Joseph F. Traub and Mr. Anargyros Papageorgiou are even more striking. In valuing the residual tranche from that same CMO (the most difficult tranche to value), they set up a criterion of accuracy such that a result was deemed accurate enough if the error was less than 1% and the error did not exceed 1% with additional calculations. Using the LDS called Faure points they needed 170 calculations to value the residual tranche—using random numbers they needed 2,700. There is some evidence that the advantage of LDS increases when higher degrees of accuracy are needed.

Unless there is some unrealized problem, it would seem that the use of these LDS in computation will become more common and certain important problems, like asset/liability matching, will be able to be solved efficiently.

From the Floor: I want to make a couple points about the issue of when we can value one liability independently of another and not have to value all the liabilities at once. That's sort of a fundamental problem of this whole subject. In principle you can't split up the valuation of liabilities.

Think about a simple example of a corporation, say an industrial corporation, with two zero, coupon bonds that mature at two different dates, and its stock. If those bonds are risky and have a significant chance of default, then you can't value those

three pieces independently of each other. The stock essentially depends on the probability that there's enough money to pay off the two bonds and what's left. The two bonds have to be reduced by the probability that they can't be paid. And the second bond depends on the face amount of the first bond.

In a general situation, you can't value the liabilities separately, which is a tremendous problem. You can't run a system like PTS or TAS where you project liabilities seriatim. You're really left with a big problem, and so you might be able to get around that in a couple situations. One is if the liabilities have high credit; then you can say that you don't have to worry about the default problem.

But with insurance liabilities you have this additional problem of the life insurance company having a crediting policy where it can sort of do what it wants. And so that's a problem, because what it's going to want to do is going to depend on how the whole company is doing. So unless you can argue that it doesn't really have flexibility there (and you can sort of argue it by saying it's a competitive market that's setting what the credit rate needs to be), then you can just use that competitive market rate and get an independent value. Or you're stuck with the problem that all these liabilities have essentially a credited rate that's going to depend on the value of the whole company, which means you have to simultaneously value the whole liability structure which seems to be a problem that cannot be solved.

Mr. Chalke: In general, I agree with what Mark's saying. However, I think we can decompose that into a number of different problems. There are two aspects of what he is saying, I think, that are quite relevant. The first is the credit risk problem. It is absolutely correct, in my opinion as well, that you cannot solve valuation of the credit problem without looking at the entire capital structure of the company, which involves all the assets and all the liabilities. However, as actuaries we're spending a great deal of time even trying to struggle with valuation of the optionality in the liabilities independent of credit risk. And so I think that the problem that's raised here is maybe a second-order problem for us at the moment, but will be a first order-problem in a very short period of time.

And, second, notwithstanding the flexibility that the company has in crediting interest, it is possible for us to value a liability assuming a certain set of normative rules for action or a certain set of behavior in valuing those liabilities from the company point of view. In the long run, I would predict that the whole era of products that have credits that are solely at the discretion of the company will die. I don't think they'll exist some number of years from now. We're unusual in the financial service industry because we may be the only group that produces significant accumulation products that work this way. I think that when consumers get more information they'll demand

more certainty in how they're treated and what the rules of engagement are. Right now, the rules of engagement in our contracts are extremely fuzzy.

Mr. Abbott: I'd like to address that a little bit also. I think one of the things that's most important that was brought out by Shane is how the companies are going to have to adapt to the marketplace as it changes. I think this adaptive nature is going to require continuous scrutiny and rebalancing of the feedback loop in this process. Within that you're going to have all of the different products segmented and portfolios that may back those products. In fact, synthetic options might be written from one segment to another offsetting one another. So you can look at this as sort of a macro problem and a micro problem. We're addressing most of these issues today at the macro level. Certainly there are other systems and methodologies that would be put in place to look at this in aggregate.

Mr. Alan L. Igielski: I'd like to try to get someone on the panel to reconcile two comments. One was that consumers are becoming more sophisticated and are having greater access to technology in order to get the information to make decisions. On the other hand, there's the idea that we're going to package more products together. I would think with increasing sophistication the consumers would have a better opportunity to mix and match different components.

Mr. Chalke: Because I made both comments, I'll try to address that. I don't think that consumers will become more sophisticated through their access to technology. I think what will happen is that other entrepreneurial forces will find consumers and deliver that information to them on a selective basis. In the residential mortgage market, it's not necessarily that consumers woke up and said, "Wow, this whole refinancing thing, there's something to this, I'm going to start calling around." What happened is mortgage brokers found techniques to locate people by looking at tax rolls and the dating of mortgage and home transactions. They found and sought out the people.

In terms of packaging, I think that, in general, consumers will pay a premium to have more comprehensive problems solved for them. That doesn't necessarily mean that we'll gain enormous value premiums in packaging those products. I think that we'll gain a fair return on capital for packaging products together. But I think consumers will pay that. I think evidence shows that consumers are willing to pay for what I call life simplification. We can take what used to be three invoices or three bills and distill it down to one bill. They'll gain some simplification.

Now one twist to that, however, is that this product consolidation doesn't necessarily have to happen at the institutional level. And one thing I struggled with is whether it's

going to happen at the institutional level. In other words, will we as XYZ insurance company come out with some comprehensive program or will the consolidation happen at the consumer level on their own personal computer through a package by Quicken, for example? Because all I care about, as a consumer, is my labor component and what I get as a comprehensive package. What is the leakage around the edges? If I have five credit cards, maybe I can get those all automatically consolidated in my home computer. So I don't know exactly how it's going to happen, but I think those two forces are very strong.

Mr. Abbott: I think I also want to add that as the sales agents or mortgage brokers become more sophisticated, they're also looking at themselves understanding the tools and understanding what clients want. And so, as this automation of information and knowledge coming to them develops over the next few years, they're going to be the driving force. In addition, the tools that are available to them from constituents such as ourselves will help them make better decisions on behalf of the clients, who are then looking at the different behavior of the available agents and evaluating them based on their past performance recommendations.

Mr. Reese: To close our session, I would like to refer back to what our keynote speaker said at the general session. Daniel Burrus talked about predicting the future by being able to recognize the things that are already here and how they'll be used in the future. I think I can make three predictions about the future. One is that actuaries will never have computers fast enough for them. Mark Abbott talked about KRD and key rate convexities. Shane talked about all the simulations needed for disaggregation of analysis. Doug actually even mentioned seriatim processing of liabilities! So no matter how fast they make computers, I'm sure we can use them up.

The second prediction I have is that actuaries will conduct a great deal of research. There is practically no end to the things we need to look at. I heard four main ideas from the speakers. First, we have to have better scenario generators. In particular, low discrepancy points for better simulations will be one improvement. Second, another area of research that Doug particularly mentioned was the need for dynamic assumptions with a better representation of strategies and behavior. The third area is the analytic selection of situations to test to cut down the number of scenarios that we have to look at. Finally, both Doug and Mark discussed arbitrage-free versus simulation scenarios and the need to resolve the distortions that each method presents.

My third prediction is that we are going to go through some rapid changes. As Shane pointed out, we are all going to have to react to the changing financial marketplace. I agree that there will be big changes in consumer behavior, and we need to take that into account in our thinking.

As our keynote speaker advised us, we cannot just ignore or be afraid of these coming changes. We hope the answer is instead that we're able to react to it. I'm confident that we have ideas here that will be used extensively over the next five or ten years.