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ARE WE PREPARED FOR INTEREST RATES TO RISE AGAIN?

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Although many actuaries probably long for the "good old days" of double-digit interest rates, are they really prepared to return to those levels? Some of today's risk exposures were not as prevalent a decade ago. This session will explore some of those issues, including what the maturity extension risk in mortgage securities (including collateralized mortgage obligations (CMOs) is and how we monitor and manage the risk.

DR. KRZYSZTOF M. OSTASZEWSKI: Let us begin by introducing the speakers. Our first speaker will be Shane Chalke, who is a Fellow and Vice President of the Society of Actuaries. He is a leading actuarial entrepreneur in this country and in the world, as the CEO of Chalke Incorporated, a provider of actuarial software. He is also known to many of us as the author of a very innovative paper entitled "Macro Pricing" published recently in the *Transactions of the Society of Actuaries* (Volume XLIII, 1991, pp. 137–230).

Our second speaker will be Mr. Thomas Godlasky. He is a Chartered Financial Analyst. He works at Providian Corporation, where he is responsible for fixed-income and derivatives and manages a $15-billion portfolio. His other responsibilities include asset allocation and certain risk management activities.

Our third speaker will be Dr. Tom Ho. He is the president of Global Advanced Technologies in New York. He holds a Ph.D. from the University of Pennsylvania. He spent 12 years as a professor of finance at New York University. He is very well-known as one of the leading researchers in the area of modern finance. He is the co-author of the Ho-Lee model and of the concept of key rate durations. You can study his work in the book *Strategic Fixed Income Management*, recently published by Dow Jones Irwin.

My name is Krzysztof Ostaszewski. The Polish spelling of my name may seem confusing; most people refer to me as Chris. I work at Providian Corporation, and I am an Associate of the Society of Actuaries. Providian is the new name of Capital Holding Corporation. I also hold a Ph.D. from the University of Washington and am a Chartered Financial Analyst.

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Just recently, Peter Lynch put out a book in which he explained that you should never buy stock in a company that changes its name because, as we all know, companies change names for the same reasons people do—they get married or they did something that they don't want you to know about. Clearly, Marilyn Monroe and John Wayne illustrate that there could be one more reason.

MR. SHANE A. CHALKE: In my portion of the program, I will really discuss the impact of increasing interest rates on liabilities, and within that context whether insurance companies are prepared for movements in interest rates. In fact, there's no particular reason to limit the discussion to increasing interest rates because decreasing interest rates can many times be just as harmful.

But, in fact, I start by asking, Who thinks interest rates rose? At the Orlando meeting recently and throughout this meeting I've heard many jokes about the prescience of the people who put this topic in the program—they really shouldn't be actuaries, they should be commodity trading. The yield curve went up 150 basis points. Big deal. Keep in mind that you don't have to go back more than three or four years to when the short rate was higher than the long bond is right now. And then, of course, that's without even going back to May 1981 when the rates were off the conceivable scale. I look around and many of you look too young to know that, but you don't have to go back to find some fairly dramatic movements in interest rates.

Well, let me start with a bit of a report card of where the industry is right now versus ten years ago. It's almost a cliche to say that so much has changed in the environment, with consumers, with financial awareness, and in the industry. If interest rates were to return to a period such as they were in 1979-81, we're in for very hard times, because many of the risk factors that exist now were not present back then; it's easy to get worked up about that. However, the industry is very different now than it was ten years ago. As a whole, the industry has done a lot of things very well during the past ten years. You can say that the risk factors are greater, but the level of preparedness for the risk factors is also commensurately greater as well.

Let's go over a few risk factors. By and large, insurers have far less duration mismatch than they had during the prior period. There is a fairly broad recognition that liabilities are either short or can be short, and this has just changed over the past three or four years. It would have been very common five years ago to hear even a prominent annuity writer say that his or her duration of liabilities are six or seven. At that time people confused duration with average maturity which can be slightly different or deadly different concepts. But now it's rare to talk to anyone in the annuity business that thinks that the duration of annuities is six or seven. There's a growing recognition that in a rising interest rate environment perhaps the duration of single premium deferred annuities (SPDAs) is as short as 0.9 or 1.25. So I think there's a very ingrained and perhaps even intuitive understanding of the problem now that simply didn't exist half a decade ago, and certainly not during the 1979-81 period. Having a great positive understanding of the risk that you face is about two-thirds of the battle.

Second, on the positive side of the balance sheet, product designs are much better than they were even five or six years ago. The options that we used to so freely imbed in our products with a band are being removed bit by bit. You see this mostly

in the universal life market and in the GIC market, or what's left of the GIC market. There's a retrenchment in effect with fancy features that allow money to flow more easily out of contracts. This hit the annuity side just a little bit with people tightening up on preferred which are all provisions and so forth. Let's say the products are somewhat less option laden than they were in years past. Another great positive.

Interest crediting strategies are quite a bit more rational than they were, and you don't have to go back ten years to see changes in most of these issues, maybe even only three or four years. Investment generation methods are more widely used. Most people now recognize that for many companies and many products you can't completely generalize, but investment generation methods are superior in terms of affecting the proper response, proper behavior from distribution systems and from consumers.

I'd say there's a less naive use of portfolio rate methods for crediting interest. Portfolio rate methods are still quite prevalent, but they're not used naively. What does that mean? Well, portfolio methods of crediting interest tend to be very effective. They provide a natural dampening mechanism which, in essence, exploits the relative inelasticity of our markets. It boiled down to its fundamental essence. If you're an interest-sensitive business within the insurance sector, you must take this fairly unwieldy business and make it profitable by moving your interest rate behind the market to some degree to take advantage of the fact that you have an elastic market. People don't take their money and run. We deal with a fairly inefficient market in comparison to the asset side of the balance sheet, and that's really the essence of the game. By using a portfolio rate method, you stumble into some of that proper effect, but I'd say that companies have shifted away from a naive use of portfolio rate methods in which they felt this was the right thing to do because we're cost plus prices and we believe in accounting to this is a good mechanism that has the right effect for some books of business and I think that's a real positive, although a fairly subtle, point.

The last big positive is that products are more profitable now. All the product people will say, "where?" There is marginal improvement and profitability that comes from a couple of different factors. First is the flight to quality and the obsession with ratings which I think has peaked and is taking a downturn. All in all, this has been a fairly healthy attitude for this industry. The products that we sell have long suffered from being viewed as commodities. It doesn't matter whether you buy it from company X or company Y; if you get 15 basis points more from company Y, it's a better product. We've suffered from this comparison only by price and that's in selling commodities for far too long and this industry cannot survive on a commodity business. We have very complex products. Complex products require expensive distribution, and expensive distribution pulls you out of the commodity business. And that has improved to a considerable degree and we can be thankful for that.

The second thing that has happened is many companies, through commodity selling, have really hit the wall in terms of profitability. More than a handful of companies see declining volume, at the same time they have thinner margins. Somehow the actuarial textbooks do not tell us about that.

So we have a whole array of factors that have improved remarkably over the past ten years, but of course, there are some things that are worse. We've been through a very long period of declining interest rates and that has caused the industry, I believe, to develop certain habits that could be destructive in the rising rate environment. The first is we've seen a fairly heavy reliance in some sectors of our business on traditional insurance products. Traditional insurance products are great, and I'm certainly a believer in them; however, I would dare say that many in the industry don't recognize that the resurgence of traditional products, the fact that they did gain a foothold in our powerful industry is largely a function of declining rates. If you peel back the layers of the onion and look inside you find out that the immense popularity of traditional products comes at least in part from the implied portfolio rate crediting. So in a falling rate environment traditional products are relatively stronger in the marketplace. And this is something I'm not sure the industry is broadly aware of, and this is going to cause some difficulties if interest rates spike up again. If you're running a large portfolio of traditional business, credit rates implicitly through your dividend structure using portfolio rate mechanisms, what are you going to do when interest rates rise? It's going to be very difficult. You'll be faced with many of the same decisions that traditional insurance companies were faced with in 1979 and 1980. Should you partition your portfolio and start a new portfolio so you can be competitive? Will you wonder whether it's ethical or not? You will find some risk with existing business, but that's something to reflect upon. If you look back in 1982 or 1983, most people predicted that traditional business wouldn't exist by now. Traditional business is very strong in our industry, but we must understand the causal factors as to why that's true and why that might bother us as interest rates rise.

Another problem on the negative side of the balance sheet is we have a very sophisticated consumer base. Times are different. Prior to 1979, people didn't make inflation-adjusted decisions. Now people do make inflation-adjusted decisions. They don't call it that and they don't know that's what that is, but, in fact, they do. They act as if interest rates matter and inflation exists.

If you asked a five-year-old 20 years ago, How much does a candy bar cost?, the answer would be 10 cents. Now if you ask a five-year-old boy how much a candy bar costs, he says, "Over what time series?" It's a different answer. In fact, one thing that I thought was very funny is that my daughter's kindergarten teacher reads *The Wall Street Journal* everyday to time the lock on her mortgage. Now this just gives you an example as to the relative level of sophistication in the consumer base. This is scary because I don't think that we're prepared for this. There's going to be very different behavior than we've seen in the past and we don't really have any empirical evidence over the past ten years as to how people are going to behave in an increasing interest rate environment. That's something that we should be very concerned about because, in essence, as I said before, we relied heavily in this industry on inefficient consumer behavior. If consumer behavior were to be efficient tomorrow, our business would be completely turned upside down because we offer cash on the book value with five to six year rates; that's our product and you can't sell such a product without inefficient consumer behavior. So if consumer behavior gets efficient, this industry is going to see some radical transformation.

Another negative is interest rates are too long. What do I mean by that? We sell immediately available funds and credit rates that are far out on the yield curve

compared with the annuity business; general account annuity business is four to five years out on the yield curve and life business is seven to ten years out on the yield curve. Those rates are long. We have had virtually no discipline in the past ten years to guide us toward the more proper competitive place to be in financial services. With a long period of declining rates, this behavior has been reinforced. Essentially declining rates make longer liabilities in this business because of the fact that our credit rates are longer than theoretically efficient behavior would dictate. The converse of that is that increasing rates cause shorter liability. That's maybe just a layman's way of saying negative convexity so that Tom can follow me. But that's really the crux of it and I don't know whether we can survive long rates again if interest rates were to spike beyond the little spike that we've had in the past couple of months.

The last big negative is that distribution systems are too expensive. What does that have to do with interest rates? In fact, it has a lot more to do with interest rates than we recognize in this industry. The amortization of distribution costs is dependent upon fairly long liabilities, and liabilities have been fairly long for the past ten years because of the declining-rate environment. When rates increase, liabilities get short. When the liabilities get short there's enormous pressure on distribution system cost.

I'll take you back to 1979 and 1980. If you came to the Society of Actuaries meetings during that time, at least one out of three sessions was about distribution system cost and why we were witnessing the end of the traditional distribution system. Well, that was at the root of the problem and precipitated by rising rates and shorter liabilities. You cannot pay a commission that needs nine years of spreads over which to amortize if liabilities have a duration of two. It's very difficult to do and even though it wasn't commonly analyzed that way back in 1979 and 1980, in my opinion, that was what was going on. So I would predict that if there were even moderate increases in interest rates, 200–300 more basis points, which I call moderate I guess, then you'll start seeing those seminars arise again. What are we going to do? How are we going to distribute insurance? This time the industry may be ready to try something different, but in 1979 and 1980 there were not any alternate plans. Thank goodness for Ronald Reagan.

This pressure that we see on the distribution system will have many ramifications that will go all the way back to product design. Those of you who work in the product side have heard many product actuaries say that products have been kind of boring for a couple years. I think you'll see that trend reverse again if interest rates move. Product design will get very exciting very fast and be high pressure.

So that's sort of my report card on where we are. Regarding net balance, I think the industry is far healthier than it was ten years ago far more prepared for a rise in interest rates. People generally have their arms around the problem at least intuitively, if not scientifically, and that is a major advance. In large part we can thank this profession for leading the charge that way. So in that respect I'm very proud of the actuarial community in paying attention to this issue even when it was unpopular. Who talked about asset/liability management two or three years ago when the only thing people cared about was default rates on commercial mortgages? But we kept it right in front and center, and we kept plowing heads with the science.

Let me talk a little bit about behavior models because that's really the crux of the message I wanted to deliver today. We've done a comparatively better job lately in sculpting and designing and playing with behavior models. When I talk about behavioral models, I'm talking about the assumptions that we make about the behavior of either agents or consumers with respect to changes in interest rates and all of the different ways that they can affect that behavior through the options in the contract through lapse, partial surrender, preferred partial surrender, zero cost wash loans, flexible premium payments, lapse and so forth.

When we first started printing these models back in the early 1980s, they were fairly simplistic. We generally had only one dependent variable, excuse me, one independent variable, creditor rate versus your competitor rate. The current models are much more sophisticated on the competitor's side. Many companies are doing regression analysis on competitor's rates versus the term structure to get a better handle on how companies behave, how your competitors behave and how they set their rates. Now the irony is that I'm aware of many companies that know more about how their competitors set their rates than how they set their own rates, because generally they'll set their own rates in committee on Monday morning. It's very subjective and intuitive yet these same companies will be doing some fairly scientific regression analysis on how their competitors move their rates and will come up with a pi R-squared function of the laws with all the spot curves and they will understand their competitor's behavior. My first suggestion is you're going to do the same analysis on your own rate setting committee and try to explain how they think, but that's a much better way of modeling. We're doing a much better job with competitor rates than in the old days when we simply said, we have new money rate competitors when rates go up. We have full rate competitors when rates go down. In fact, the market is much more sophisticated than that.

On the behavioral side, the models are now dependent upon the distribution system. Money temperature has emerged, in recent years, as perhaps the most telling factor or the most potent factor. Was it hot, cold or lukewarm money when it came on your books. That has a very high impact on subsequent behavior. And people are starting to bring that into the models now. When this product was sold was the rate of the 99 percentile or the 60 percentile. Subsequent behavior can be predicted with much better accuracy if you bring that in as a variable in your models.

The seasoning of the money. We routinely deal with that now and the elasticity is now sane in our models. Many of the analyses that you saw in the early years of Regulation 126 had insane elasticity in the models. Well, if you're 400 basis points off the competitor's rate, everybody lapses this week. I dare say there's probably not much that you can do to your clientele to get them to do that. Even sending them hate mail that gets them all to lapse in one month, so not that we're just looking at this as a better, more realistic fashion that this is not gold in the commodity market. People don't move their positions like day traders. It's a different world.

I'd say that as a profession, we are weakest in behavior model development, and that is where we should put most of our efforts. We've done a fairly good job in building high-quality, mechanical models of how insurance companies offer it. We've done a good job of looking at interest rate models. As a matter of fact, I'd say our profession has become semiobsessed with interest rate models which is good. But we're

not as obsessed as we ought to be with behavioral models. We know very little about actual behavior. In fact, in our industry all the research we've done doesn't compare to the rigor of research that has been applied to prepayment models in the mortgage market. Now you can sit back and say, "Well, it didn't help that much, did it?" However, I'd say that the continued study and the level of effort that goes into understanding the factors that affect behavior is far ahead of where we are in the insurance business. There are a couple things that prevent us from running out and doing this.

Why haven't all of us done analyses on statutory accounting principles (SAPs) or done something to figure out what the real behavioral models are? Well, it's difficult. First, we have a data problem. We cannot get homogeneous data across broad sectors of our industry. In fact, the homogeneity of the data is a bit of a misnomer. You can make any data homogeneous by reducing the number of variables. That's what happens in mortgage data. Most people feel very comfortable saying, "We only know eight things about each mortgage pool, so let's use those." Part of the problem is we have too much data. Just as an extreme example, if you cut down your data points to determine if they are alive or not alive, then all insurance data is homogeneous. So we could do a better job.

The other more serious problem though is that moving rates are a problem. Anyone who works in mortgage prepayment will tell you that developing a very good model for prepayment on adjustable-rate mortgages is far more difficult than developing a good prepayment model of fixed-rate mortgages. Why? Because you have another moving piece of machinery in the equation and almost all our products have that moving piece of machinery called the accredited rate. So it's difficult to get data points where companies are 500 basis points out of the money. We just don't have that kind of data. If anyone wants to volunteer to experiment and donate that data, it would be quite welcome. But, in fact, there are some things we could do. We could start analyzing behavior by geographical region. I know of some companies that do this, in fact, by agent sex, by other demographics or by seasonality. How many of you know your lapse rates by season? Are they higher in December than in June? Most companies don't really know that but putting that information back in through the rate-setting process could be quite valuable.

With all that said, where are we now? The thing that scares me the most is increasing elasticity in consumer behavior. The things that have hurt this industry have not been mechanically smooth events. The things that have hurt this industry have been discontinuities that were largely unforeseeable, things like the change in the junk-bond market, (although everyone now says that was foreseeable), and the drop in the commercial mortgage markets. Universal life profoundly dislocated this industry back in the early 1980s. There were also changes in tax laws, and these are the kinds of things that send little shock waves through our industry.

I'm concerned about discontinuities far more than I'm concerned about steady state behavior while interest rates rise. In fact, we all have models that predict some improvement or some increase in elasticity as interest rates rise. I feel comfortable that we can get a handle on that. We understand what will happen in a fairly smooth environment. But it's the discontinuities that concern me, especially the discontinuities that will affect efficient policyholder behavior. Much of the

discontinuity comes from technology. I don't know that we're prepared for where this market might go. Think way back to what money market mutual funds did to banks. Banks were unprepared for that discontinuity in the world. Now we're in an environment where's there's a little hint of disconnect. I don't know if it will go anywhere, but there are things like the wholesale insurance network which may or may not do well or the tax-deferred bank CDs. There was an article in *The Wall Street Journal* just a month ago about a bank out in Wyoming that's offering tax-deferred CDs. These things that are on the fringes concern me a bit. But the real concern is the interactive information explosion. Information is really the key.

Why are our policyholders inelastic in their behavior? There are really two root causes of that: the cost of information and the transaction cost. In economics both of those are a type of transaction cost. But to put it more simply, people don't know that they have a bad deal when they do and then if they do know they have a bad deal, it's a hassle to get a good deal. We rely on that. Those are staples of our industry. And if those two causes are removed, then we have different behavior which pushes us to very different products.

So I imagine a service like America On-line or Prodigy. You could sign on and key-in your annuity value from your statement. Up would come graphic comparisons of where you are compared to the five hot competitors at the moment together with maybe a nice little graphic of breakeven analysis. It would show that you could break even in month 17 if you make the switch. So we can reduce the cost of information, and we can reduce the cost of the transaction. And if both of those happen we'd better have our seat belts on because we will have a different industry.

Now we're in the mutual fund industry, and that impacts everything that we do. Things are going to be most stressed in the regulatory structure itself. If that comes to pass, we may see a total melt down of the nonforfeiture loss structure, because this intense reliance upon inelastic behavior is the root cause of the nonforfeiture laws which mandate that we offer cash at book-value products. If we end up with efficient behavior on the liability side, we will end up with short liabilities. Short liabilities mean short rates and short rates are essentially counter to the roots of this industry which is long-term security and long-term contracts. And like I say, a complete meltdown of the nonforfeiture law structure wouldn't keep me awake at night. That wouldn't be the worst thing to happen to this industry, but the pressure will be there.

What can you do to put your seat belts on and get ready for this? I have just a couple of suggestions. The first is stress test some discontinuities. We're all doing modeling, we're doing cash-flow testing. It would be very instructive to run at least one scenario where you assume radically efficient behavior. Not efficient behavioral leave in one month, but with efficient behavior as many as three-fifths of your client base may do the economically advantageous thing in a scenario. It would be very instructive to look at that kind of a scenario to see how bad the bleeding could be if we faced purely efficient behavior.

The second thing I'd suggest is let's start thinking about behavioral models differently than we think about them now. Right now every behavioral model that I've seen is continuous and I'd like to start thinking about discontinuous behavioral models. We

need practical analysis to start looking at behavioral models in a little bit different way where perhaps policyholders and agents are relatively inelastic within certain bands. Then you have significant or major disconnects and we tend to approximate that with S curves and slide and so forth. But to think about that in a different mindset, I believe, will help us in our modeling.

MR. THOMAS C. GODLASKY: It is a pleasure to be here to talk about a very timely topic. Some of my comments are going to overlap Shane's but I think it's good to reinforce those concepts. As I prepared for this speech, the market was reminding me almost on a daily basis just how timely the topic is, as interest rates seemingly increased unimpeded. There was a recent article in *The Wall Street Journal* that really captured the essence of what we've been going through. It talked about the bond market's stormy spring; I'm not sure if that means that the fourth quarter of 1993 was a lay up, but nonetheless it really began to capture the essence of what we've been talking about. I'm sure that all of us have some recent battle scars, if you will, reflecting our efforts to deal with today's rapidly changing interest rate environment.

I'm not an actuary, but rather I manage the fixed-income and derivative activities at my organization. Consequently, I hope to bring a slightly different perspective to this topic which I believe you'll find beneficial. The primary focus of my discussion is going to be on the asset side of the balance sheet and the effects that rising interest rates have on the asset side of the balance sheet and some of the risks inherent therein. However, I can't stress enough the importance of looking at these risks with regard to the assets in conjunction with a simultaneous changing risk profile of the liability side of the balance sheet as well. I'm a very strong proponent of an active integrated asset/liability management process; I will address this point later in my discussion.

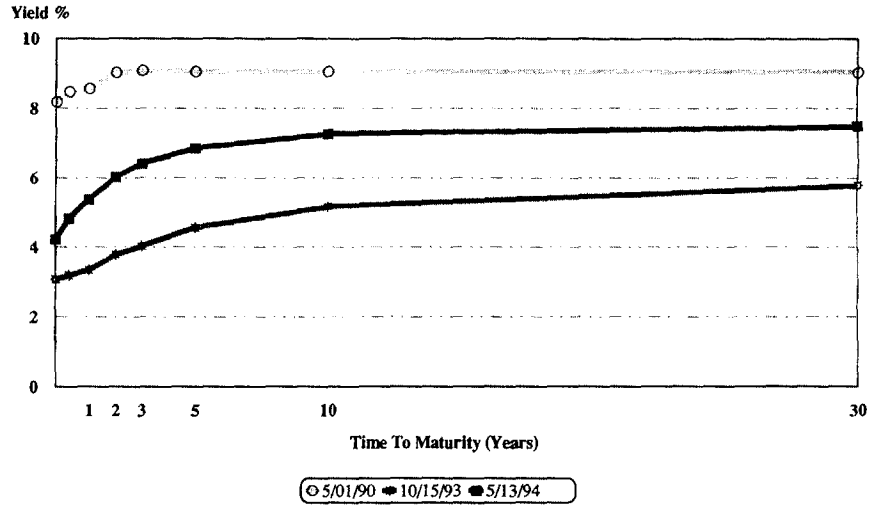
First, I'd like to spend a very short period of time taking a historical look at interest rates both from a short-term and a long-term perspective, again, reiterating some of the comments that Shane made earlier. Then I'd like to highlight some of the other risks that are associated with the move towards higher interest rates and touch upon what has become known as the short-straddle model. Then I'd like to illustrate the impact of these risks on certain asset classes in today's marketplace. Finally, I'd like to provide for your consideration some ideas on how you can manage and monitor these risks within your own organization.

So what has history told us about today's current rate environment?

Chart 1 illustrates three different yield curve configurations at various times in the recent past. As you can see, the top line indicates the last time that we've experienced a relatively flat yield curve in 1990. The bottom line reflects the lows in interest rates that occurred in October 1993, and the middle line shows the current interest rate environment that we're in. The three yield curves indicate a couple of important facts that I want to mention and bring to light. Not only has the absolute change in interest rates been rather dramatic, but the changes occurred over a very short period of time relative to most product life cycles. Furthermore, the shape of the yield curve has undergone a significant transformation—moving from what was a flat or slightly inverted yield curve to the steepest yield curve on record (close to three standard deviations from the mean) and now to what is a rapidly rising rate

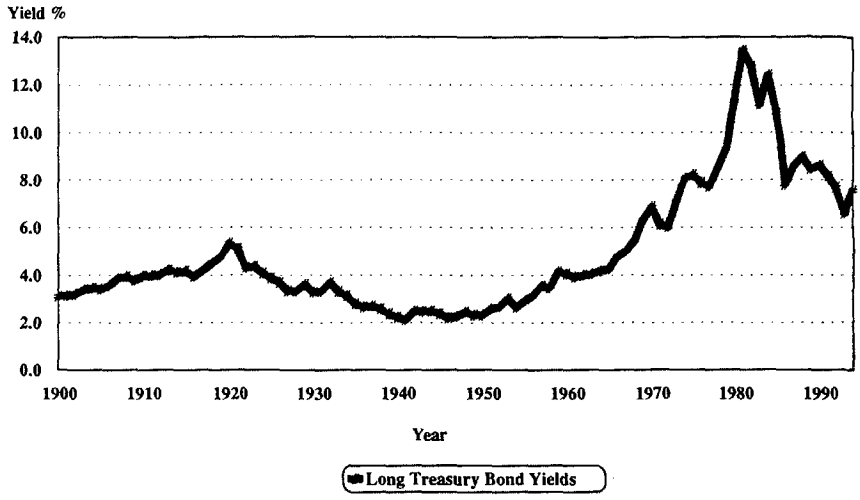
environment. Associated with each of these changing events is the everchanging risk profile of your balance sheets. Now the tendency, as Shane pointed out, may be to focus on the movement of interest from say October 1993 to the present, because it's the most recent occurrence. However, you may draw a different conclusion if you take a look at long-term yields.

CHART 1
YIELD CURVE COMPARISON



In Chart 2 I have charted the long-term treasury bond yield, or what was considered the straight long-term bond treasury yield at the time, from 1900 to the present. As you can see, rates were lower except for the perilous time of the late 1970s and early 1980s. Are we headed back to conditions of that time? If so, this recent move of about 200 basis points off the low is really a precursor of things to come. Or, was that period of time, the 1970s and 1980s just an anomaly and are we headed back to really what is more like the steady state environment similar to what occurred earlier in the century or in the last century? Well, if we on this panel had the answer to that question, we wouldn't be here. I'd be collecting my dividends, sipping on some tropical drink in the Caribbean, and calling my brokers to make sure that the movement of interest rates isn't affecting my net worth too badly. But, unfortunately, I don't have those answers. Now perhaps Mr. Greenspan had some insight when he suggested that a move was needed to dampen what he termed a "speculative bubble" that had formed in the financial markets. I have to believe, however, that even the Federal Reserve Bank didn't expect the dislocation that has occurred within the financial markets both at home and abroad. Consequently, we need to be prepared under any circumstance because each "blip," if you will, in interest rates, whether it is a move towards the higher rate environment of the 1970s or 1980s, or this recent 200-basis-point move in interest rates, can be fairly devastating.

CHART 2
HISTORICAL LONG TREASURY BOND YIELDS



What risk should be considered now that interest rates have begun to rise, but, clearly, could rise even further? A change in the interest rate environment and, in particular, a move towards higher rates captures the interest of many groups, the administration, the media, and Wall Street. Each proclaims the adverse impacts that a further move in interest rates will have. Unfortunately, very little attention is paid to the other risks that are associated with a move to higher interest rates. What are these risks?

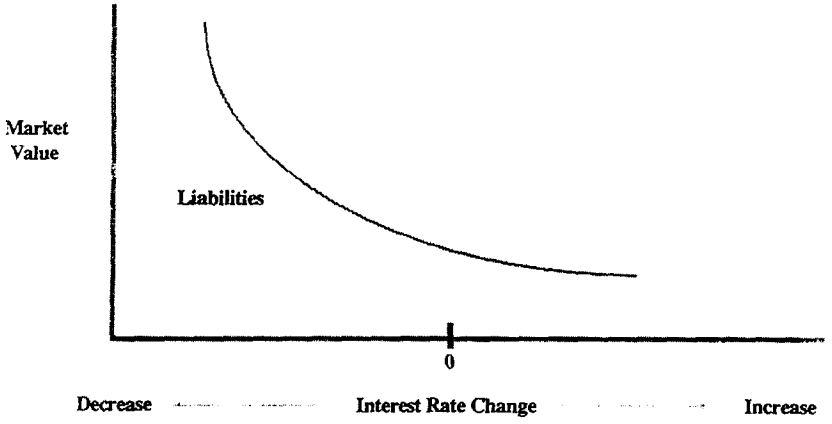
- A change in the shape of the yield curve (typically flatter)
- Negative convexity
- Increased volatility

The general public really doesn't understand the impact of these risks and all too often not enough attention is paid to these risks by professionals within our industry. It is imperative that these and other risks are considered in conjunction with the overall interest rates environment to get a total understanding of your company's risk profiles. My point is that these risks do not occur in isolation. The importance of understanding and fully considering not only the risk of higher interest rates, but these other risks as well can be best illustrated in what has become known as the Short Straddle Model.

Most financial services companies and, in particular, insurance companies, are either explicit or implicit writers of various options on both sides of the balance sheet. This strategy can be profitable if interest rates remain relatively stable. However, if a significant change occurs in either direction, significant losses may result. For

example, a policyowner can exercise a variety of options (many of which are interest sensitive in nature) at guaranteed values or "strikes" to the detriment of the company itself. Surrender features and policy loans are common options provided to the holder of traditional life policies, while owners of annuities and universal life policies are also offered a myriad of interest-sensitive options. It is generally agreed that policyholders tend to exercise these options more as interest rates rise leading to higher lapse rates and policy loans. Conversely, when interest rates fall, policyowners tend to hold on to their policies due to the attractive return versus other market opportunities. Thus, the market value of the liability does not decline as much under a rising rate scenario as it would if these options had not been made available. However, during the declining interest rate environment, the market value rises faster than it otherwise would. Consequently, a convexed shaped curve can best illustrate the changes of the market values on the liabilities (Chart 3).

CHART 3
SHORT STRADDLE MODEL



Given that policyholders have been provided with numerous options, a natural offset to this position would be to purchase options on the asset side of the balance sheet in order to mitigate the risk profile. Typically, however, just the opposite is done. Through the purchase of callable bonds and mortgage-backed securities, insurers tend to sell call options for increased yield at the expense of increasing negative convexity. The market value change of these assets is illustrated on Chart 4 and is reflected in a concave-shaped curve.

Moving to the market value of insurers' surplus—measured as a difference between the market value of the assets and the liabilities—it becomes quite evident that the insurer produces profits in a stable interest rate environment, but incurs risks in volatile market (Chart 5).

CHART 4
SHORT STRADDLE MODEL

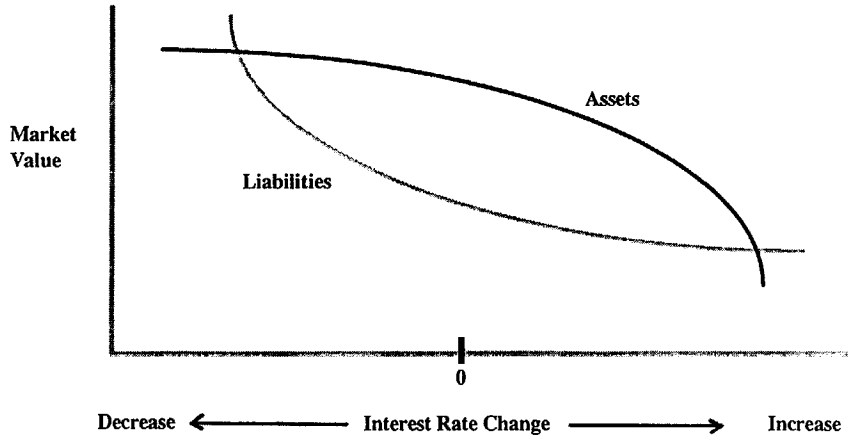
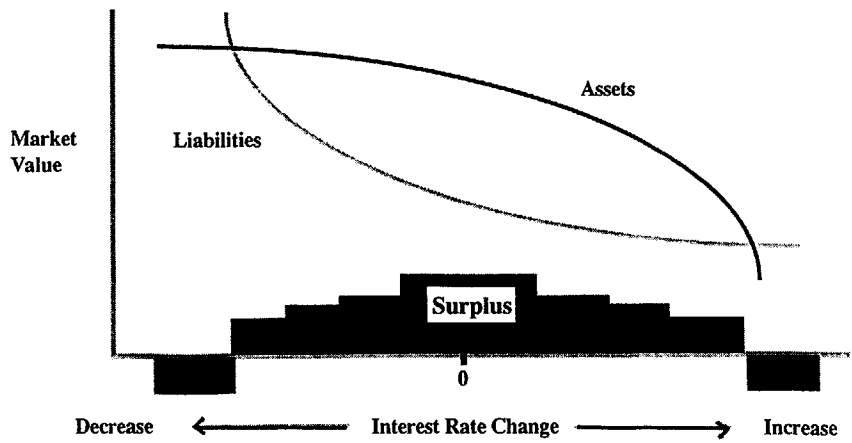


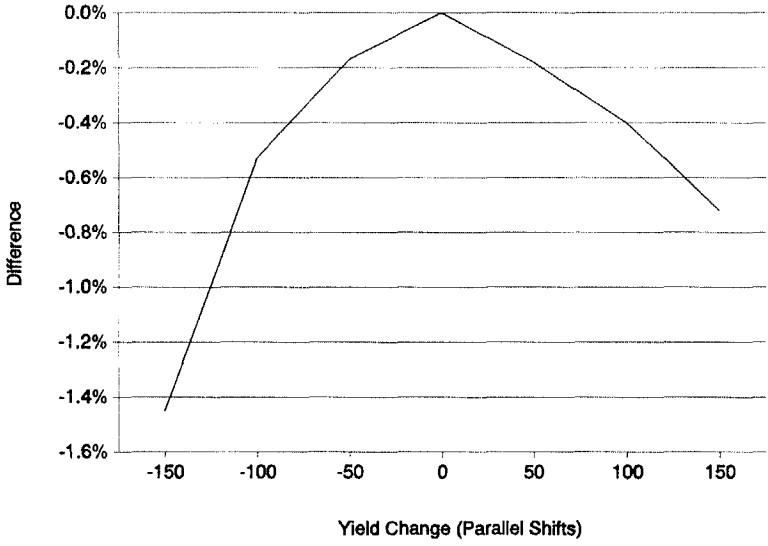
CHART 5
SHORT STRADDLE MODEL



The Short Straddle Model depicts the optionality in our business under parallel yield curve shifts. This optionality, however, is not only vulnerable to the absolute level of interest rates, but it's also vulnerable to increased volatility and twist in the yield curve. Typically volatility increases and the yield curve flattens during the initial stages in a move toward high interest rates much to the detriment of the short-option writer.

Let me illustrate these points just briefly with actual market examples. The first example is a relatively easy and straightforward depiction of the effects that the changing interest rate environment has on a callable corporate bond. In this particular case it was a Public Service Electric and Gas, 8.5% of 2002 callable in 1997, versus a similar duration U.S. Treasury security. The concave curve in Chart 6 represents the difference in the return patterns of the two securities and depicts the negative convexity of the callable security as parallel shifts in the yield curve occur. This return pattern is similar to that of most other callable bonds.

CHART 6
CALLABLE VERSUS TREASURY—TROR COMPARISON



I now want to illustrate the return characteristics of two portfolios—one with a barbell configuration (Chart 7) and the other with a bullet construction (Chart 8)—again these are under parallel shifts in the yield curve.

Despite the differences in the cash flows, both of these portfolios have similar duration, convexity and credit characteristics. With the curve depicting the differences in the return patterns of the two portfolios, Chart 9 shows that the bullet portfolio outperforms the barbell portfolio under most parallel shifts in the yield curve. It is important to note, however, the difference of the return profiles of the portfolios. The convexed shaped curve denotes the positive convexity characteristics of the barbell portfolio relative to the bullet portfolio. Why is this aspect important? It is important because, as we all know, the yield curve rarely moves in a parallel fashion.

CHART 7
BARBELL PORTFOLIO—CASH FLOWS

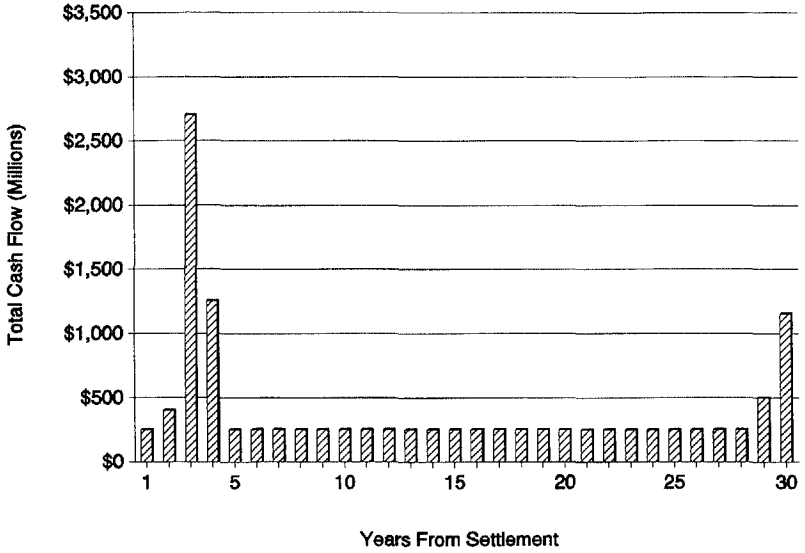


CHART 8
BULLET PORTFOLIO—CASH FLOWS

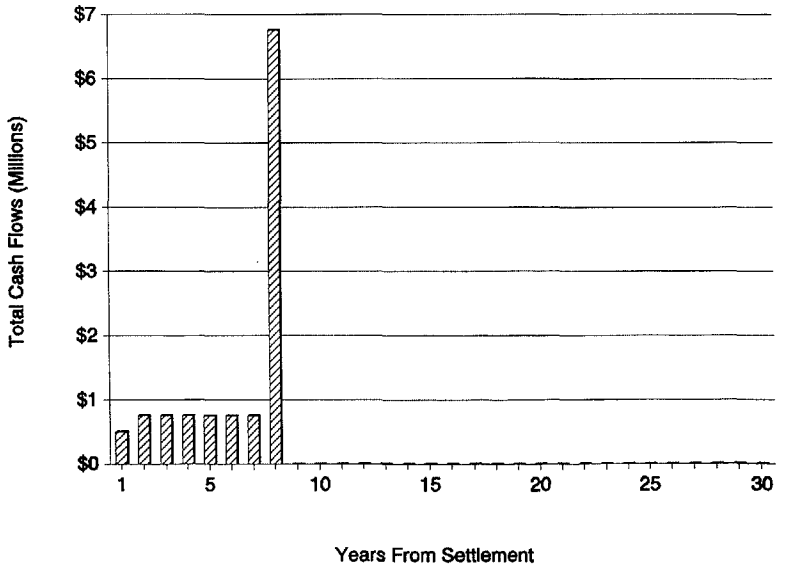


CHART 9
BULLET VERSUS BARBELL—TROR COMPARISON

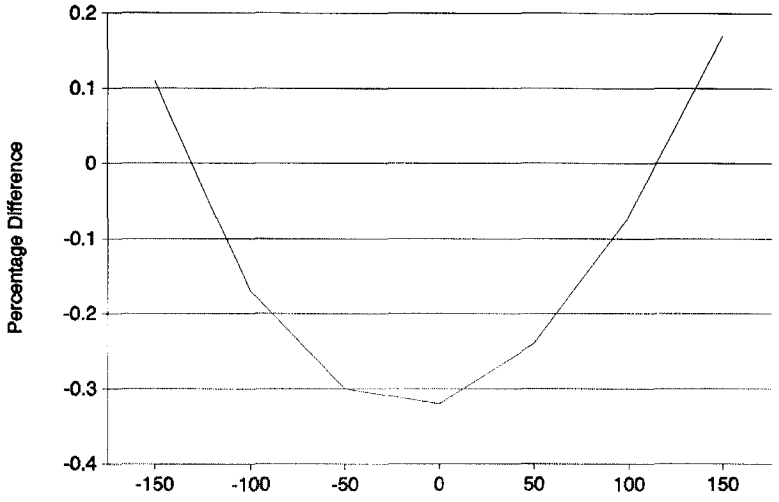


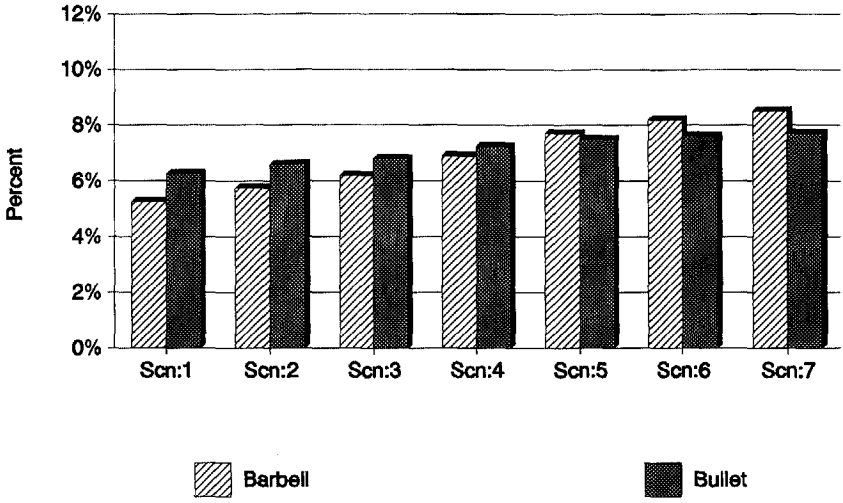
Chart 10 illustrates the return patterns of the same two portfolios given twists, i.e., flattening or steepening in the yield curve. For this example I have used the five-year area of the curve as the fulcrum for the twisting scenarios.

Scenario One represents the steepest yield curve with a two- to thirty-year spread of approximately 280 basis points. Scenarios Two through Seven depict the return patterns of each of the portfolios under progressively flatter and flatter yield curve configurations. The two- to thirty-year spread narrows to approximately 45 basis points under scenario seven. It is under these nonparallel yield curve scenarios that the differences of the bullet and the barbell portfolio return patterns are truly highlighted. (See Table 1.)

As you can see, the bullet portfolio outperforms under steepening yield curve environments while the barbell portfolio has a superior return profile under a flattening curve environment.

Why are these points important and how can you be considering them for practical application? Remember, financial services companies tend to be short sellers of options imparting a degree of negative convexity to the business. Additionally, the yield curve tends to flatten in the initial move upward in rates. Consequently, a move towards the barbell portfolio in a rising rate environment can add convexity to the business while providing a superior rate-of-return profile. It is important to note, however, that the barbell portfolio would generate lower current income than the bullet portfolio and, in addition, the yield curve itself must flatten more than the forward curve suggests in order for outperformance to be recognized. I will talk about forward curves in a moment.

CHART 10
BARBELL VERSUS BULLET—TROR (TWISTING CURVES)



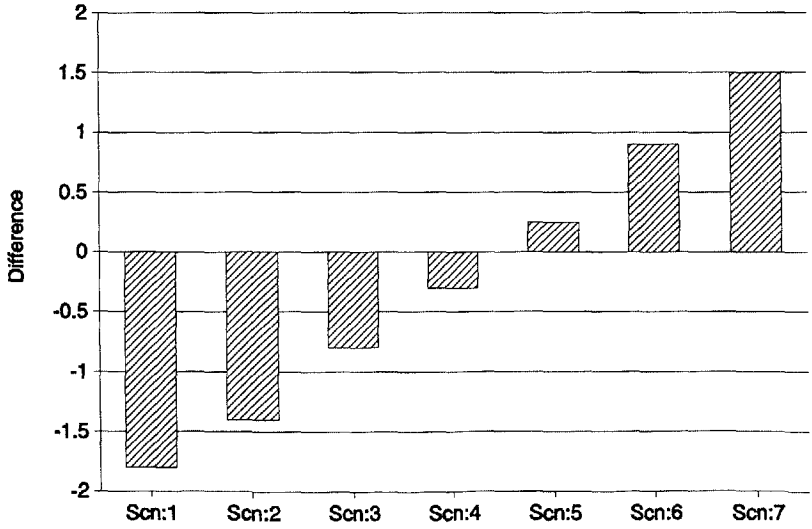


TABLE 1
BARBELL VERSUS BULLET—INTEREST RATE SCENARIOS

Years	Scn:1	Scn:2	Scn:3	Scn:4	Scn:5	Scn:6	Scn:7
0.25	3.21%	3.46%	3.71%	3.76%	4.21%	4.46%	4.71%
1.00	4.52	4.71	4.89	5.08	5.27	5.46	5.65
3.00	5.80	5.90	5.99	6.08	6.18	6.27	6.36
5.00	6.64	6.64	6.64	6.64	6.64	6.64	6.64
10.00	7.50	7.35	7.20	7.05	6.90	6.74	6.60
30.00	8.06	7.81	7.56	7.31	7.06	6.81	6.56

Notwithstanding the poor convexity characteristics of our business and the negative impacts that a rising interest rate environment and a flattening yield curve can have, there is an associated risk that I have not talked explicitly about and that is extension risk. Extension risk is one side of the negative convexity coin. With today's increased focus on mortgage-related products, I want to spend some additional time on this topic. I might add anecdotally that probably as much money was lost in mortgage-backed securities and related products as interest rates fell during 1992 and 1993 due to unanticipated prepayments, as has been best in this recent rise in rates. Much more attention has been paid to the extension risk than the shortening risk.

Nonetheless, I thought it would be interesting to look at one quick example of extension risks that recently received some notoriety. Earlier on I referenced a specific collateralized mortgage obligation (CMO) tranche. This was the Federal Home Loan Mortgage Corporation (FHLMC), 1579 PQ, a planned amortization class (PAC) tranche that makes up a CMO deal with a total of 29 tranches. I thought it would be interesting to model this particular tranche. I should mention that while CMOs are certainly subject to extension risks, not all CMOs have the same extension risks associated with this particular tranche.

Chart 11 is the first figure associated with FHLMC, 1579 PQ and shows the anticipated cash flows of the entire deal at pricing. It is important when analyzing a particular CMO tranche to understand not only the risk characteristics of the tranche you are interested in, but also the risks of that tranche relative to the entire deal.

Chart 12 shows the actual prepayment speeds of the tranche since October 1993—the low in interest rates. Not surprisingly, Public Securities Association prepayment standards slowed dramatically as interest rates rose. The actual speed should now be considered in context with the change in the average life of the tranche at different prepayment speed assumptions (Chart 13).

As you can see, as speeds fall below 150 PSA, the average life extends dramatically. Certainly, the buyer should have been aware of this risk, despite the fact that this tranche was considered a PAC tranche, if some modest analysis had been conducted. Concurrent with increased average life is a significantly longer duration as illustrated in Chart 14.

CHART 11
FHLMC GOLD 1579—TOTAL CASH FLOW

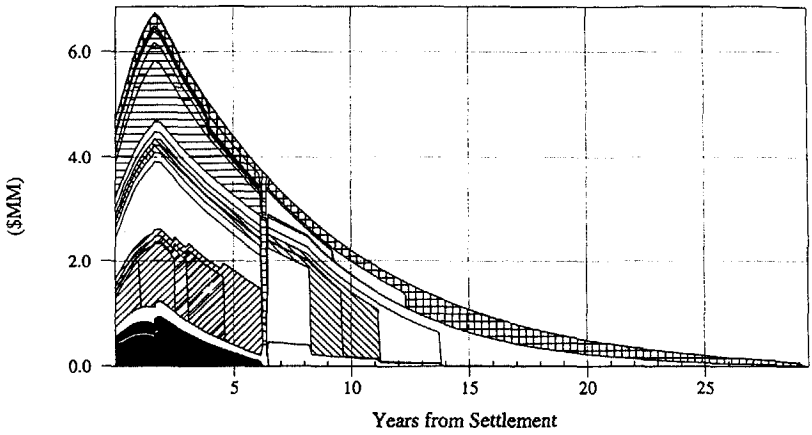


CHART 12
ACTUAL PSAs—FHLMC 1579 PQ

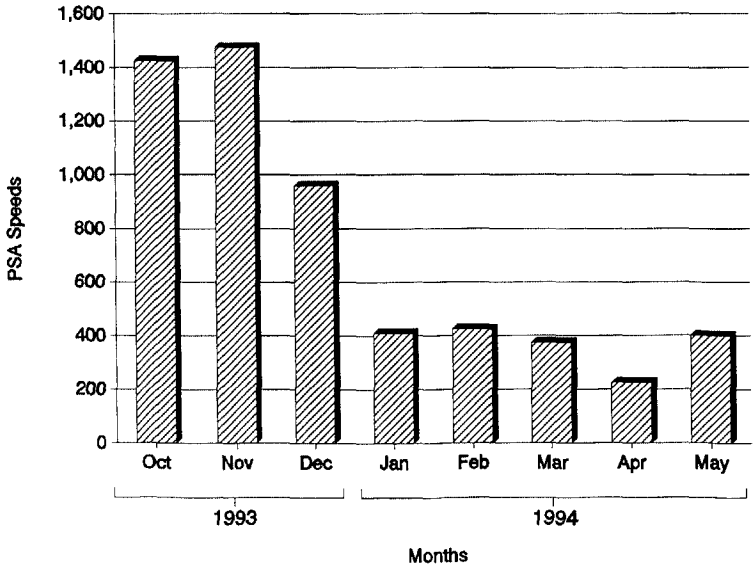


CHART 13
DURATION ANALYSIS—FHLMC 1579 PQ

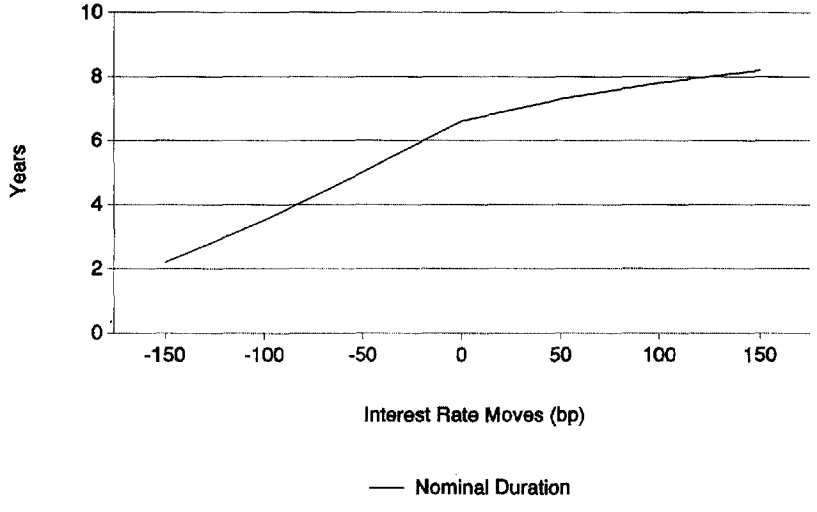
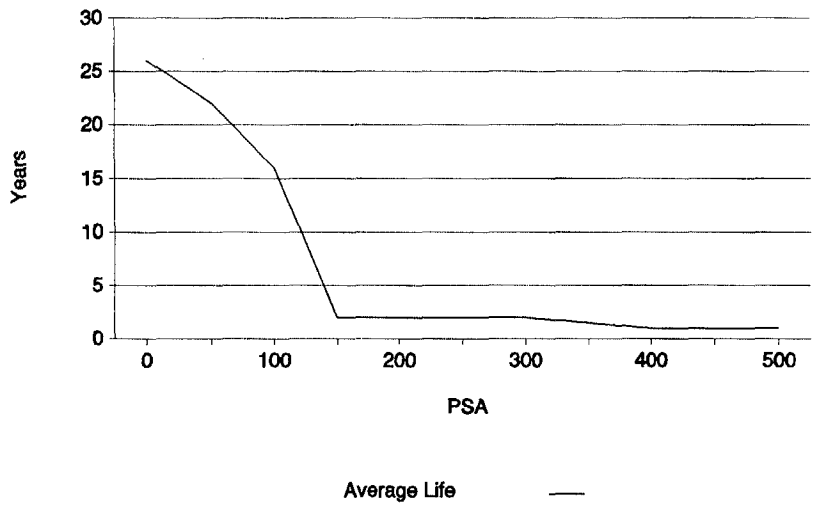


CHART 14
AVERAGE LIFE ANALYSIS—FHLMC 1579 PQ



As professionals within our respective organizations, we are charged with optimizing the risk/reward trade-offs of a very dynamic and complex business in pursuit of increased profitability.

What information would I hope you would consider as you monitor and manage your companies' risk profile? Let me offer some broad strategic suggestions. First, as simple as it may seem, it is imperative to have a full understanding of the risks of your business. I have discussed with you the risks associated with higher interest rates including negative convexity, twisting yield curves, volatility and extension risk. A great deal of work has been completed around persistency and lapse rates. It is also important to consider the risks associated with distribution channels, basis risk, and a risk that is most often overlooked and undervalued— liquidity risk.

Typically, when you have liquidity, you always feel you have too much. When you don't have liquidity and you really need it, you can rarely buy it at any price. If you take a look at history and look at some of the demise of some of the financial services companies across the country, the risk may have been germinated or generated from one specific aspect away from liquidity. But really the straw that broke the camel's back was the inability to have liquidity in some form or fashion. So this is a risk that I think is often overlooked and undervalued and one that I always like to highlight.

From an asset perspective I encourage you to analyze your risks by breaking down the risks into their component parts. I am fond of saying that I don't manage securities, but rather cash flows that are truncated by embedded options incorporated into a bond wrapper. For example, a callable bond is merely a noncallable security which is short the call option. When considering the component parts of a security, one needs to evaluate the duration option, the credit option, the call option, the liquidity option, etc. To the extent that I value out the options and arrive at a different value than you do, there is an anomaly created and the opportunity for one of us to prosper. What's important is this process gives tremendous insight into the risks one is assuming not only for that particular security, but cumulatively for the entire asset portfolio. This type of analytical review of one's risks becomes particularly helpful in assessing the numerous options embedded in a mortgage-backed security portfolio.

Second, continue to build your management information capabilities. The complexities of our business rapidly continue to increase within an extremely dynamic market environment. The risk profiles of our organizations are in a constant state of change. As managers you must have the appropriate and timely information to monitor and measure your risks. There are excellent management information systems both on the asset side and the liability side of the balance sheet that can be purchased off the shelf or can be built internally. The cost/benefit trade-off of understanding your company's risks better and being able to modify these risks when appropriate are tremendous. All too often companies rationalize away the incorporation of better systems due to cost which only subjects them to far more costly unknown risks within the business.

Third, consider the judicious use of derivatives when attempting to modify some of the risks embedded in your organizations. I understand that derivatives are extremely

controversial. Some believe that it is necessary to attach a Surgeon General's warning before derivatives could be incorporated in one's risk management activities. Clearly, a thorough understanding of the risks associated with any derivative strategy is required along with continuous management oversight and an understanding of the overall risk propensity of the organization as a whole. With these insights, derivatives can be a very effective tool to quickly offset the risks associated with a rapidly changing interest rate environment, such as we have experienced, or a changing business in general.

I would also ask those who say that they do not use derivatives or that derivatives are inappropriate to reconsider their position. Remember the Short Straddle Model? If your portfolios own callable bonds or mortgage-backed securities, you are definitely involved in the derivatives markets and making bets against the forward curves. This type of involvement in the derivatives may not be as intuitively obvious as if you were doing swaps, futures, and options, but you're clearly in the derivatives markets. Let me digress and talk very briefly about the forward interest rates and curves. It is widely understood that forward curves are a poor predictor of future interest rates. Nonetheless, every derivative, in some form, is priced off forward curves. To me, this creates an anomaly that should be exploited. Given that the term structure of interest rates and forward curves are mathematically generated, it would seem as if this would be a fertile area of investigation for this group.

The next aspect that I would like you to consider is another method to better understand and monitor your risks. It is the formation of multidiscipline product development teams. More often than not, the risks associated with a particular product and its related asset strategy can and should be recognized and managed in the earliest stages of development. The ongoing use of multidiscipline product teams can provide management with continued insight into the ever-changing risk involved with a particular product itself.

Finally, develop an integrated asset/liability (A/L) management process. This is not a new idea by any means. Yet, I often wonder whether the asset/liability process in many companies is truly integrated. In my organization the actuaries and the investment people are located on the same floor to encourage ongoing communication and interaction. We're fond of saying that some of the best discussions are in the hallway, or at the coffee machine, and as a result, both groups, I believe, as well as the company as a whole, have benefited. I'm continually amazed, as I talk to my peers in the investment community, by how many of them do not have ongoing dialogue with the actuaries in their companies. The actuarial and the investment disciplines have too much to offer to be worked in isolation. Our business is too complex. In many organizations a significant cultural change may be required in order to develop a truly integrated asset/liability process. Nonetheless, I think it can be accomplished. I am a member of the risk committee within my organization. This small committee comprises senior actuarial, investment, financial, and marketing people. We meet weekly to review the risk profile of the organization and to develop strategic plans to manage the risks. The exchange of ideas and information between the various groups has been extremely insightful.

As you can see my discussion has not only been on the impact of rising interest rates, but also on the many types of risks often associated with increased rates and methods to manage these risks from a macro level.

DR. THOMAS S Y HO: I'm going to talk about investment strategy and asset/liability strategy, using the SPDA product as example. There was a session at this meeting called "Stump the Investment Experts." The audience asked all the questions, and the speakers just answered them. In that session, investment questions were asked. One question was, how should we hedge our SPDA in this rising rate environment? It sounded like this discussion. So that's good. Another question is, if we use our short duration asset to hedge our SPDA, something like interest only (IO), what's wrong with that? The third question is, if we hedge our asset and liability by matching our durations, are we exposed to other risks? We have been told about caps, and floors, or swaptions, and all kinds of derivatives. Which one should we select and how do we put them together? So these are some of the questions that I will address.

There's no simple answer to deal with all these questions. The approach I will take, instead of giving straight answers to these questions, will be to present a methodology because the methodology is fundamental enough to help us handle all these questions as a core problem. The problem is that if we are really serious about managing the C-3 risk of our interest-sensitive product. We should not simply look at duration, key rate duration and convexity and say we're hedging. We have to have a process or a procedure of breaking down the products into building blocks of values: the cash flows, the options and so on. You know exactly what's inside the complicated product. And now you know how the assets should be put together to do the hedging. You heard Tom talk about the Short Straddle Model. If you have callable corporate bonds and mortgage-backed securities, you have negative convexity. SPDAs, as Tom described very carefully, can have a positive convexity. So you have a mismatch in convexity even though you're matched in duration. You might buy some options to eliminate this Short Straddle, and then you'll be hedged. These duration and convexity concepts are really useful if things just move slowly and continuously. But if next week or so, interest rates just move very fast or shift in a sudden way, the durations and convexities of the asset and liability will keep drifting apart. You will quickly find yourself mismatched.

All these duration and convexity matching strategies assume that you can keep buying and selling and changing the duration so that you can match up. But what if that is not liquid? You can buy and sell a period of time. You cannot adjust the portfolio all the time. Then you run into the problem as described in *The Wall Street Journal* articles which discussed how hedge fund managers found that at a certain time, the market moves too fast. They could not adjust the position; they found themselves exposed. If you cannot move further, big losses follow. Therefore, by hedging your interest rate risk of the SPDA using simple numbers, for example duration, in continuous hedging we face serious risk. And that is exactly the reason why we should think of something more fundamental. Can we truly hedge our SPDA in such a way that we can minimize the liquidity risk as well as minimizing the risk of this discontinuity of the market changes? And this static methodology, pathwise immunization, is exactly that. This idea really is very simple for us because

that's what we have been doing all the time, as it is really an extension of the stochastic cash-flow testing that we are doing.

Suppose we have a guaranteed investment contract (GIC). We know how to hedge it. We just buy a security that pays off at the same pay off line up with the GIC and we match the cash flow. The difficulty with the SPDA is that its cash flow changes depending on which scenario we take. So why don't we look at a set of scenarios and look at how the cash flow changes. Then we will be really matching on a cash-flow basis out of a set of scenarios. And if that's the case, you basically have replicated your product with security, as a security. And now this approach will give you insight into what you are dealing with on the liability side. Now I'm not advocating that that is the asset you should buy in this situation. But this is the first step to understand what you have on the product side. And then you can form a subsequent strategy.

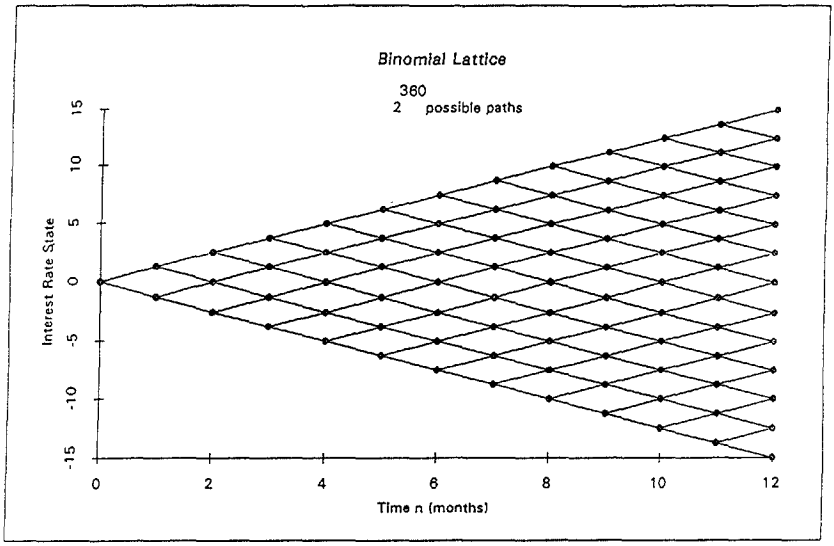
So, first find a set of scenarios and look at a cash flow, and then calculate each part, each interest rate and then find the asset portfolio that matches up the cash flow. How do you select the interest rate scenario? Very often we just use a computer and randomly generate interest rate scenarios. I have a problem with trusting the computer. What do those interest rate scenarios mean? Are they reasonable? Are 1,000 scenarios enough and so on. So the important thing is to look for spanning scenarios. We need a set of scenarios far apart enough to cover the wide range of interest rate scenarios that are reasonable. We must have a way of assigning probability to these spanning scenarios so that we add up to the expected market value. Then the whole concept of cash-flow testing, breaking down the security into its component parts, will be consistent with all the market valuation and, hence, consistent with all these duration and convexity concepts. So this is what is talked about in simulation strategy. How do you select a scenario? How do you calculate its duration numbers and how do you optimize the asset portfolio to match it up? Finally, the solution is how you break down the SPDA into its basic building blocks of value.

I'll show you a realistic SPDA block of business and how I can break it down into its building blocks of value: how much value comes from Treasury bonds, or what Treasury bonds do you need to buy to hedge, or what are the caps to put on top so that the portfolio looks like the SPDA block. (See Chart 15.)

We go first to the standard methodology in valuing assets. This is called the binomial method of arbitrage-free rate movement. We let the computer simulate the new curve going up and down, up and down every month into the future. It is very similar to our stochastic and cash-flow testing now. So in this stochastic cash-flow testing we simulate the interest rate going up and down into the future, and then follow a rate path. So in this case it would go up every month. And if we let the interest rate go up like this every month and calculate the cash flow of the SPDA and the present value of this cash flow, this scenario along this interest rate path is called the pathwise value of your SPDA. Count all the possible paths and get a pathwise value and the present value of the cash flow, add them up, and average them, then you get the market value or the fair value of the SPDA. This is a fairly standard procedure in valuing assets. Earlier we talked about all the methodologies in analyzing the CMOs and mortgage-backed securities—calculating duration and convexity. They

all follow this basic procedure. The procedure simply looks for all the interest rate scenarios in the future, calculates cash flow of the scenarios to get the average present value. It sounds simple, right?

CHART 15
BINOMIAL LATTICE



Well, the problem is that there are 360 interest rate paths as shown in Chart 15. Don't bother with any computer to do it. It's not possible. Basically we need to select scenarios that represent this picture. The idea is really quite simple. You might say "OK, let's take the representative paths. What are they?"

Consider 1, 2, 3, and through the 9 boxes? One gate here, one gate here, and one gate here and we pick an interest rate path that go through the middle of the first gate, that interest rate path goes through the middle of the second gate here, and if the interest rate path go through the middle gate here. And this interest rate path can be viewed as a representative of all the interest rate paths that go through this gate. So all of the paths that go through these parts will be represented by this path. All the interest rate paths that go through the middle gate were represented by the middle part and so on. So of all the paths in this whole tree, we can select representatives, and we know exactly how many paths each representative can represent all these paths that go through these gates and then assign weights. So you have a way of finding out the representative path of this whole tree and you can find the probability, the weighting assigned to each path. And now we can do all the analysis according to these representatives. Then we weigh the present values by these probability weighting, and we add them all up. We should get back the theoretically correct answer. So lets just repeat the procedure; the idea is very simple. Theoretically, the mathematically correct method is to use all the interest rate paths.

Certainly, we use all the interest rate scenarios, calculate present value, and add them up. That's the right answer. What is difficult is there are too many paths. So we want a spanning set, a representative set of paths that could deal with all these possibilities. I bring up all the rates that go constant, or go up say constant, or go up, they come down. And then you can assign probability to them by counting how many paths are represented by each representative path and divide that number by the number of paths. Then we derive the probability. And now all your analysis can be based on these representatives.

In Chart 16 I used June 24, 1993 with five-year interest rates. The five-year interest rate as of June 24, 1993 is 5.25%. One year later the rate is 5.85% according to this binomial lattice. Three years later it is 6.74% and so on. So an interest rate scenario will be represented by rates that go along the middle path. In the second representation, rates go up; so the rate goes up from 5.25% to 7.93% and then can stay constant. That's another alternative. Then I can calculate all the interest rate paths in the binomial lattice I showed you earlier.

CHART 16
FIVE-YEAR RATE FROM THE LINEAR PATH SPACE
AS OF JUNE 24, 1993

	12.86	13.18	13.30	13.43	14.76	12.13
7.93	8.76	9.21	9.45	9.77	11.74	9.78
5.25	5.85	6.74	7.24	7.55	7.97	10.24	8.62
3.80	4.74	5.30	5.66	6.18	8.75	7.46
	0.79	1.47	1.95	2.64	5.81	5.17

Here's the procedure. In Table 2, I'm using a ten-year zero-coupon bond. This shows the linear-path-space methodology. Let me explain why it's called linear path space. The first and most probable scenario is that the interest rate will stay constant: 00000 represents an interest rate path that stays constant in the future. This represented 6.47% paths. So it carries the weight of 6.47%. Along this interest rate path, we discount $100 back ten years. The result is 42.97. There's a number to modify this result—the probability weight of 2.78%. Next, you look at the 00001 path. I ranked the paths by the probability so that the 00000 path came out first. In this case, the interest rate followed the middle path and the rate came down after the

last gate. After five years, it came down. In this scenario, we carry the weight of 3.27%, and we discount $100 along the interest rate path. The pathwise present value is 43.28. The probability times this present value gives us 4.20. The number you get will convert to the theoretically correct answer of pricing a ten-year zero-coupon bond.

TABLE 2
LINEAR PATH SPACE SAMPLE PATHS

Code	Weights (%)	Present Value 10-Year Zero	Cumulative Value Sum
00000	6.47	42.97	2.78
0000−	3.27	43.28	4.20
0000+	3.27	42.97	5.60
000+0	2.58	39.73	6.63
000−0	2.58	46.71	7.83
00+00	2.57	38.16	8.81
00−00	2.57	48.65	10.06
0+000	2.54	36.60	10.99
0−000	2.54	50.72	12.28

So what have you accomplished? If you buy a ten-year zero coupon bond at $16, you can actually break down the $16 into which value was contributed from which scenario. What gives you that $16 that you paid for by these scenarios broken down. We can actually find out, if we pay $100 for these mortgage-backed securities, which scenario accounts for the value and we can bring it down into a pathwise level. The next procedure is, if you have an SPDA, you can finally lead to the path one contribution and determine which scenario will give you the value. And if I have a way of calculating the asset portfolio, the pathwise value asset portfolio matches the SPDA. I found a way of matching up the cash flow of assets and the liabilities under all scenarios, and I will show the answer.

So now I'm going to use an example, but let me just summarize the linear-path-space approach and the value of it. It gave us a very consistent scenario analysis. You now have an arbitrage-free way of valuing your assets, your liabilities and your interest in one consistent framework. Instead of focusing on just the market-value duration convexity, you actually focus on the pathwise value. Therefore, you're putting the cash-flow analysis and market-value analysis in one consistent framework. This way, you get yourself away from just simple duration numbers. Now you're actually putting in your cash-flow analysis. The procedure I just described will always be made consistent to all the market-value analysis. This linear-path-space approach is really a structured sampling approach; we really are just doing stochastic cash-flow testing when looking for scenarios. But what is different is that this an objective way of selecting these scenarios. We have a current probability weighting to the scenarios, so we can actually rank them and separate the important ones from the unimportant ones. By so doing, we can be more efficient when calculating value and doing analysis.

Monte Carlo simulation uses the computer to randomly generate interest rate paths. It will calculate a mortgage-backed security value. We find that you can reduce

3,000 paths of Monte Carlo simulation to 300 linear path spaces. Three hundred scenarios can represent over 3,000 simulations in the Monte Carlo method. By reducing all the scenarios, we can get to the right answer more quickly.

And how do we know it works? We use this methodology and test all the CMO agency deals issued in 1992 and we use all the computers available at our company and run them using the Monte Carlo method. Then we'll find how many paths using linear path space to converge to the prices derived by Monte Carlo simulation. You'll find that this method is very efficient and gets the same models as the Monte Carlo method and as efficiently. So by doing so we reduce the number of scenarios. We need to test a small, manageable number; we have a methodology of breaking down the SPDA into its component parts by looking for cash flow that matches up these pathwise values or matches up the market-value analysis to scenario analysis.

Let's now discuss the pathwise immunization example shown below. I use a model SPDA, which I don't need to go through it in any more detail because Shane did such a good job of talking about all the behavioral models, for example a lapse function. Your crediting rate relates to the market rate; you'll be partially adjusting to it. So in this model, I use a 50% partial adjustment rate. Next year you try to adjust 50% up. So a lapse function and your crediting rate will be, as I said, a partially adjusted credit rate. That means we'll have gone through a period of high interest rates. Much lapsing occurred and rates come back down. If it will go up again, the lapses will be lower because people have left. The hot money is already gone and you're left with colder money. So there's a burnout effect in the behavior model. We've built in a surrender charge. In this case, we have a 7% surrender charge increasing for seven years, and we have a guaranteed rate of one year. I will do this analysis on a block of business, so it's not just one SPDA doing the 5 SPDA would get for themselves.

- Based on February 1, 1994
- Asset portfolio consists of Treasuries, caps/floors (three year, five year, ten year)
- Liability is an SPDA block
- 51 highest probability paths
- $0 <= $ pathwise value (solution) $<= 20.5$
- Minimize market value of asset portfolio

In this analysis of the SPDA model we have most of the basic features that Shane talked about. I will talk about the pathwise feature. I'd look at February 1, 1994. Suppose we had this block of business, and we wanted to find out what is in this SPDA. What kind of things would we need to buy to hedge it? We look at the asset portfolio of all the treasuries and caps and floors, with a maturity of three years, five years, and ten years. Caps are those derivatives with strikes of 6%. In this case a reset takes place every six months. Every six months you look at a six-month rate. It is about 6%. Then you pay the difference, say 7%. So you have a 1% coupon for that six-month period and so on. When market rates go below the floor rate, you receive money. So these are all caps and floors, and I think of them as a building block of value.

Okay, so what makes SPDA the building blocks? Cash flows plus options. Options are represented by these caps on floors. So I put many of them in. Their liability is a

block of SPDAs. As I said, I look at the 51 highest probability paths. Remember I picked those interest rate scenario representatives and I have each representative by probability. I picked the 51 most important ones. Now I make sure that when I optimize using these assets, the pathwise value, that means the present value of the cash flow asset, has to be very close to the SPDA pathwise value for all 51 of them. The deviation of the asset and liability pathwise values are set very close, 20 for five years out of 4,000. Basically, let's call it 0.5% error. Okay, you only allow 0.5% error on mismatch of the present value of each part. So you're searching for all these assets so that the present value of each part is a match up with a very narrow band. And now I search for the optimal portfolio. What is the cheapest portfolio I can buy so that I'm totally immunized along each interest rate path? So it's a much more stringent condition than just matching up your asset/liability duration and convexity. Here you're matching no matter what interest rate scenario is going to prevail. According to these 51 scenarios, you are immunized.

Table 3 is your block of business. The first item is the new block just issued. Then we have one-year, two-year, three-year, and four-year business. So all five of them add up to 4,969.247. Each of these has a surrender charge. It's a whole block of business. And now we go through this optimization. Let the system pick out what bonds we match up in this block of business. The answer's really fascinating.

TABLE 3
ANALYSIS OF THE PATHWISE IMMUNIZATION RESULTS
FAIR VALUATION OF THE SPDA

New block	$903.500
One year	931.065
Two year	946.726
Three year	954.802
Four year	960.154
Total	$4,969.247

The solution is shown in Table 4. You can actually pick out these bonds for U.S. Treasuries a two year, three year, and then 2001 here. These are strips, and then you have your coupon bonds of 2006, 2015 and 2023. So the bonds are on this side. Now I'll give you the answer that is correct. It doesn't have one cap and certainly there would be no floors. As Tom explained, SPDA really is a cap for you. You are concerned about a rising interest rate. So your lapse is rising; therefore, it's a cap rather than a floor that you need to immunize. So the solution has no floor in it. It shows the SPDA is really some cash flow plus some cap. Now intuition tells us it's not one cap. It's a series of caps. We must replicate the SPDA. It's a two-year cap, at 2.2% and then a ten-year cap covers 5.7% and 3.7%. If you add up all of them, the sum is more than $400. So the answer is that in this block of business it's 10%. You have options and an embedded value of over 10% in this block of business. There is not just one simple answer. I give you duration convexity and the series of options to create that. So this is what I mean by breaking down a block of business into building blocks of values. What is more basic than cash flow and series of options? This shows me exactly what series or options they are and what cash flows are. Once you put these together to match against a block of business, an

SPDA, then you actually have immunized along all of the scenarios and immunized consistent with stochastic cash-flow testing. Now you actually add up all the values.

TABLE 4
OPTIMIZED ASSET PORTFOLIO

		Market Value
11/96	US Strip	$453.61
5/97	US Strip	675.15
2/01	US Strip	282.51
11/01	US Strip	1,029.71
2/06	T-bond	1,752.77
2/15	T-bond	84.91
8/23	T-bond	34.18
Cap 2 year 2.2%		$16.33
Cap 10 year 5.7%		5.74
Cap 10 year 3.7%		391.33
Total asset Value		$4,726.24

Here's the breakdown in Table 5. I calculated the asset portfolio for you. It's $4,726.24. On the pathwise basis, the SPDA is 4,719.18, so you pay $7 more in assets than in the pathwise value. I just calculated the SPDA pathwise value. It's the same number, $4,719. But in the actual value, all the paths are used. In this calculation, I only used 51 paths, but in reality there are many more paths. If you use the calculated value, you'll be off by a little. The first 51 paths already account for most of the value. That's the linear path space. It's important to pick the scenarios. Fifty-one paths can capture most of the value. They're off by a little bit. Only 229 out of 4,060. The asset value is only $29.96 of $4,000. It was a very small amount. So you can see very clearly what is an SPDA by breaking down these parts and all the dollars they cover.

Table 6 is a very useful picture for asset and liability management. You can actually see in which interest rate paths you are paying the higher price and in which interest rate path you're not paying a higher price. So you rank them. It shows that the rate goes up the first year, stays constant in the third year, and goes up again in the seventh year and then stays constant. You put in more assets than liabilities. The pathwise value asset is higher than the pathwise value of the liability by over $20. So these are the scenarios that you're putting bets on. So if you believe that these scenarios will happen, that's good. You're betting on these scenarios. If your pathwise value is small, that means you hope that it will not happen. So by ranking these pathwise values of assets and liabilities, you actually know which scenario you're really betting or not betting.

TABLE 5
SPDA VALUATION BREAKDOWN

Total asset value SPDA pathwise value	$4,726.24 4,719.18	
Pathwise surplus value SPDA pathwise value SPDA pathwise value	 $4,719.18 4,696.28	$7.06
Excess immunization value Total Surplus		$22.90 $29.96

TABLE 6
PATHWISE ANALYSIS

Term maximum profit $20.50	1	3	7	5	10	20	30
	+	0	+	0	0	0	0
	–	0	–	0	0	0	0
	0	–	0	0	0	–	0
	0	0	–	0	0	–	0
	0	0	–	0	0	0	–
	0	0	–	0	0	0	0
	0	0	0	–	0	0	–
	0	0	0	–	0	0	0
Minimum profit $0	0	–	–	0	0	0	0
	0	0	–	–	0	0	0
	0	0	+	0	0	0	+
	0	0	0	–	–	0	0

So what have we discovered? In this pathwise methodology we actually have a way of breaking down the embedded option value of SPDA holders. Oftentimes, we just talk about interest-sensitive products and how we have written too many options for our policyholders. It's time to really quantify and say what are these options? I have just told you. These are the caps you have actually sold to the policyholder. You can do the probability analysis of market valuation. You have sold SPDAs, and so beyond the accounting approach and income analysis you go through this way is that it was fully immunized this block of business by these caps and these cash flows. How much money are we making? How much more money can we make? We can assume we fully immunized this product. Is the profit left behind. So this approach can help you through that profit-analysis process.

We can do the recent return trade-off. We can actually look at each path and at each scenario. Are you taking the risk of each scenario and how much risk are you taking in each scenario.

How should we deal with interest rate risk. What kind of risk exposure are you facing? My answer is that you shouldn't go for just one quick answer. You need a methodology to find out what the building blocks of value of your product are and then decide what strategy you want to take.

So what is wrong with using interest only (IO) in hedging of an SPDA? Well, if you go through the pathwise immunization, you'll see that the path was totally mismatched because the matching duration always sums up the pathwise value. I want these two numbers to match up. But, if you can follow it different ways, they would mismatch.

I think IO is a very extreme example, but a less extreme example is Tom's which showed the barbell and bullet payment. If you match the barbell and bullet payment with duration, you're duration matched, but if you follow these pathwise scenarios, they're totally mismatched. The pathwise scenarios will tell you that you really immunized along all the paths and will protect you against the shocks of interest rates.

What's wrong with duration match? The implicit assumption of duration matching is that you can continuously trade and match up. These are very strong assumptions as we noticed recently. I think you should really look deeper into your product and not simplify yet.

We hear all these derivatives out there. You know the swaps, swaptions and so on. Which one should we use? What I've shown you is the breakdown of basic parts which are the caps and Treasuries. But now you look for what is cheapest. What has the best fit? You go through all the possibilities, do this optimization and find your best component fit to your portfolio. So the answer need not be very simple. You might not have just one type. You might have a combination of them that fits your needs and the cheapest way of succeeding it. After all, we are doing arbitrage business. We are selling products and then by assets and, hopefully, we can make a spread. So in some way we should exploit the derivative market to give us the cheapest way of protecting the risk.

DR. OSTASZEWSKI: I can't resist making two short comments. There was a question about matching duration—if you do match, are you exposed to other risks? This is really a first semester calculus problem. By matching duration you are actually maximizing other risk. You're not only exposed to it, but you're maximizing it. Recall how you maximize profit by having marginal revenue equal to marginal cost. It's the same reasoning. By matching durations, you're actually maximizing all other risks. That's just a comment. That's why those techniques are needed and I was worried when I was hearing this. Are we really certain that once we price all the options embedded in our product and in the assets we hold, that we are going to be able to find somebody foolish enough to sell them to us? I thought we were the only ones doing that. Of course, if we price them correctly, we should be able to do that.

MR. MATTHEW J. SHERWOOD: I have a question for Shane Chalke. Is the best way to manage this issue on the liability side to de-emphasize, from a marketing perspective, the importance of the fixed-interest guarantee. Obviously, for new business this would mean pushing variable annuities, pushing product features on the variable annuities such as automatic investment strategies and things like that. And for existing business, which has a fixed-interest guarantee, run kind of a 1035 exchange program into your new variable annuities just to make your customer base inefficient when it comes to the interest rate part of your product—to give them other things to think about—the variable funds, the product features.

MR. CHALKE: Yes, I think I agree with that. Ironically, the cash at a book value is not well valued by either our distribution system or the ultimate consumer. It's forced upon us by regulation. So you'd perhaps respond to that by saying, why doesn't the whole industry write variable business? Well, a really big part of it does, but the barriers to entry into the variable side of the business are fairly extreme; again, we have regulatory dislocation. I think de-emphasizing the embedded options is a healthy thing to do. As a matter of fact, we've seen many companies in the past few years reduce the value of options with virtually no marketing impact. Moving from a cumulative preferred partial withdrawal provision to a reset preferred partial withdrawal provision in annuities has virtually no impact on the illustration; there is no impact on the sales and marketing process, but it is enormously cheaper. Three or four years ago, did it really make much of a difference in life products whether you had a 4% or a 4.5% guarantee? I'd say that it didn't have a big marketing effect, but it was very costly. So I think there's much that we can do. Many industries have moved dramatically toward variable products. Many entries on the annuity side moved to market-value-adjusted annuities. I think the industry is doing a much better job at moving people over. But to summarize the irony of all this, if we were to price on an immunized basis (meaning what that option really costs), I don't think anyone would buy the product.

MR. DAVID J. ENGELMAYER: I want to ask a question of Professor Ho concerning the single premium deferred annuity. I'm not sure but I think the surrender assumptions are part of the C-3 risk. I was wondering how you saw or how sensitive the SPDAs are to the surrender charges compared to interest rate assumptions and how careful surrender assumptions are taken care of historically?

DR. HO: In this model, the lapse function depends on the competitive rate and your crediting rate adjusted by the surrender charge cost. We look at it from the policyholder side. What are all the costs that they have to pay relative to switching to the competitor. You find that when the surrender charge costs over seven years. The resulting lapse function has a big spike in the seventh year.

FROM THE FLOOR: But in the face of the recent and very volatile interest rate behavior, did these assumptions correspond to the actual behavior of the policyholders?

DR. HO: We did work this SPDA model with one of our clients very close to it. We tried to verify this lapse function behavior with what they observed. As Shane asked when the consumer gets more and more sophisticated, will this model hold? We have not built into the model increasing intelligence of the consumer.

MR. PAUL H. LEFEVRE: I wanted to second some of the things that Shane said about potential discontinuities in the single-premium deferred annuities by concentrating for a second on the bank market. A very large amount of SPDAs are being sold now in financial institutions. I have just a couple of thoughts on that. There are some completely different aspects there. Number one, most of the people that bought annuities or are buying these annuities are somewhat older. Number two, they are almost entirely ex-CD holders. Banking regulations have affected the way banks behave and the way banks set rates on CDs. The competitor rate in a sense is a CD rate as opposed to other SPDA rates. Changes in banking regulations, and

changes in the way that banks look at their balance sheets and the way they do business can create great discontinuities in this business. So I think it's very important to be thinking about the potential discontinuities that can occur.

MR. CHALKE: Paul, aren't annuities through financial institutions up to about 20% of the market now. I'd agree with what you said. The characteristics of the consumer base have changed as a result of that, and I'm not sure that's factoring into our current analysis. In fact, banks have a similar problem with their certificate of deposit portfolios. If you look at the average CD portfolio maximum penalty, it's typically one year's interest. They're not immunized either. They're in a little better shape than we are given consumer elasticity simply because CDs have been fairly short in recent years. Very few banks are going out beyond five years in their CD portfolio. So one-year's interest comes a little closer, but where is the comparison to an SPDA, seven-year CD. That gives us a little bit of a different dynamic to work with.

FROM THE FLOOR: I think we're paying the banks to let us take the risk.

MR. CHALKE: Right.

DR. HO: I just want to add that the distribution channel is a very important part of SPDA modeling; that's a behavioral model that has to change. It depends on which SPDA we're looking for.