

RECORD, Volume 31, No. 1*

2005 Life Spring Meeting
New Orleans, LA
May 22–24, 2005

Session 77 Seminar

Annuity Risk-Management Seminar: Variable Annuity Guarantees Modeling: Incorporating Derivative-Based Hedging

Track: Investment, Product Development, Financial Reporting, Risk Management

Speakers: MICHAEL J. O'CONNOR
MICHELLE D. SMITH

Summary: *Companies today in the annuity market, either in the fixed or variable-product markets, are facing ever-changing economic conditions. The risks associated with these products are well known, and the techniques applied by many companies have helped mitigate these risks, and in many cases have helped to find ways to improve profitability. This seminar takes a detailed look at the subject of annuity risk management and how this can be applied to new product development, as well as in-force product management. This session examines modeling results of variable-annuity hedging programs with a variety of alternative strategies. In addition, the panel discusses the proposed C-3 Phase II capital determinations for various guarantees with and without a hedging program. Emphasis is placed on static versus dynamic hedges.*

MR. MICHAEL J. O'CONNOR: Welcome to our session today on annuity risk management. We have two speakers. I'll be speaking first. The second speaker will be Michelle Smith. She's an FSA with Goldman Sachs. She spent 14 years with an actuarial consulting firm, Tillinghast, and joined Goldman this past January. She's in the Americas Financing Group where she works with equity derivatives and swaps trading desk. She'll be talking primarily about static hedging solutions for variable

*Copyright © 2005, Society of Actuaries

Note: The chart(s) referred to in the text can be downloaded at:
http://handouts.soa.org/conted/cearchive/NewOrleans-May05/077_bk_new.pdf.

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 2

annuities.

I'm a consultant with the Tillinghast unit of Towers Perrin. I'll be taking a broader perspective in terms of some other implications of hedging with respect to things like pricing, C-3 Phase II and, specifically, delta hedging. I'm going to be talking about modeling these for variable annuities, focusing on hedging, but also capital management, C-3 Phase II, how that comes into play. I'll also talk about the pricing reporting side, to give you a general operational overview of what's needed to establish a hedging program.

If you have C-3 Phase II, perhaps you factor this year in, and if you are in the hedging program and you want to get some capital offset, you have to do some analysis to determine what type of a hedge offset is applicable to your program. I'll get into that in more detail later on and go through a somewhat simplified example of delta hedging and the potential tracking error that can come about through that.

Now I'll discuss the pricing of product side. There is an approach that's being used by more and more companies these days — a combination of traditional actuarial pricing and some risk-neutral pricing of the underlying benefit guarantees. Outside of that context, companies will then have to determine what type of a capital offset is appropriate for their hedging strategy. Then they would typically haircut the capital requirements. Again, in a pricing context, if they're doing what we call a stochastic-on-stochastic capital projection, they do stochastic pricing, but at every year along the way, they redetermine their capital under the C-3 Phase II requirements. These days I see companies pricing them that way. So it's still a return on investment (ROI) type of a framework. But by reflecting the capital requirements under C3 Phase II, they end up committing a lot more capital to the product. Therefore, you need higher fee revenue to pay for your benefits and then pay for the return on capital. In a few examples I've been involved in, it's actually the ROI requirement that is the driver of the charges to the customer.

The risk-neutral charge that companies develop might be 35 basis points. For some companies, because of their ROI requirements, and they're reflecting the capital needs on a stochastic basis, they might determine they need to charge 50 basis points. More and more companies are using this because most companies in the United States still have to pay attention to return on capital. If you're a publicly traded company, one of the questions you have to be able to answer is what's my return on capital and what's my ROI?

On the financial reporting side, within the requirements of the last few years, the SOP 03-1 and FAS 133, how hedging comes into play is really under your deferred acquisition cost (DAC) calculation and under your revised estimated gross profit (EGP) stream. You have to incorporate a prospective view of your hedging offset, hedge effectiveness in effect, and then retrospectively, if you've had tracking error, you have to bring that into your EGP calculation as well.

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 3

In those types of hedge offsetters, regardless of whether you have a delta hedging strategy or a static one, I think you'd have to incorporate the hedge slippage historically and bring that into your true-ups on your EGP side. When you're doing a stochastic framework, whether it's developing the Greeks for a hedge operation or doing a pricing on a stochastic basis, it's obviously a balancing act between run time and model granularity. That is definitely more of an art than a science. Different companies have different opinions in terms of what constitutes a model that is still granular enough to get realistic results, yet can still run at a reasonable amount of time.

Let me describe some of the operational components to be able to come up with the Greeks, for example, for a variable annuity block of business. On the operational side, you have a lot of different components of data coming in, numbers being crunched, data going out and then executing trades. You typically would have some type of a live-market data feed to give you information in terms of the current risk-free rate curve. One of the more problematic challenges, frankly, is more on the implied volatility side, in terms of getting good implied volatility data going out more than just a few years. Typically, companies would have to go to some of the investment banks to get that type of information. Maybe it is one of the things Michelle can talk about, but I see companies getting at information typically with a simple "at the money" implied volatility term structure, maybe going out five or 10 years. And that's a start, but that's an area that I would expect companies to demand in the future. And then investment bankers will be able to provide more robust information about the implied volatility surface, going out more than just five or 10 years.

Another source of information, obviously, is in-force data. This is typically taken from a mainframe or some type of a data warehouse and that can, at times, be fairly problematic in terms of how frequently your data warehouse gets refreshed, things like money being transferred from bucket to bucket. New premiums and new sales are coming in. Some companies may not get all the information completely refreshed, and it may only be monthly. Supplier patchwork, on the operational side of the company, is figuring out how they can get information, especially if they're ramping up their hedging program for new business. A number of companies have been ramping up the hedging operations for a guaranteed minimum withdrawal benefit (GMWB) block of new business, or an accumulation benefit (AB) block.

We have your typical actuarial product assumptions in terms of lapse rates, both static and dynamic. Your scenario generator is key to this as well, and you can be feeding that into the model that is going to be used to generate the liability cash flows. You can then use that data to produce your Greeks. Most companies I'm aware of might be calculating several Greeks, but they may be using only one. They might be calculating delta, gamma, vega and rho, but they may be executing a delta hedging strategy only with the intent or the expectation that at some point down the road, they will enhance their hedging operation into more of the Greeks than just delta.

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 4

I think some of the information is very readily available. For example, with Bloomberg you can get intra-day yield curves very readily, and you can get some implied volatility data. The exchange rate is tough; it only typically goes out about a year and a half.

Based on those new economic factors, you have to regenerate your scenarios. And here, too, I think companies have a mix of practice. Some companies generate them externally and then feed them into the liability model. Some of them generate them on the fly, but the main thing is they want to make sure that those scenarios are consistent with the market. They want to calibrate them so that you'd be able to replicate some option prices in the market.

Once you have those scenarios, you have to feed that into your liability model to generate the cash flows. For product assumptions, lapse rates, static rates, lapses, as well as dynamic lapses, once you get them in the model, you're typically not going to adjust them in the future very often. What you want to have come out of this model are just the pure benefit cash flows. For example, if you're doing a WB or an AB hedge, at issue you would have to determine what is the fair value and the net premium charge so that the fair value of the liability is zero at issue. So somebody is going to have to go through that calculation periodically, like once a month or once a quarter, and say, OK, for this cohort of business, written during this time frame, the appropriate risk-neutral charge was 32 basis points. And then that charge would get locked in for that block and would be used in future valuations. Your future valuations then would be present value of future benefits, on a risk-neutral basis, minus present value of risk-neutral premium charge.

Once you have that in effect, fair value of a liability, calculating the Greeks is pretty straightforward. It's really the change in that fair value based upon one or more underlying factors changing — the stock price, the fund values, implied volatility, interest rates — and so you're looking at a change in that fair value of a liability based upon something else changing.

Once you have those Greeks, you then can go out and execute trades. Here, too, on the delta hedging, a number of companies are, in fact, generating more than just a delta. They might be calculating the other Greeks as well, but they may only be using the delta to actually execute today. Once you go beyond delta, you probably would want to look at some optimization routines to look at combinations of different put options to match the higher order or different Greeks, for example, like vega and rho.

I'll give you an example in more depth later on, but O'Connor Slide 14 is a very simple chart of looking at your risk profile. This is a rank-ordered cost of a benefit over a lifetime, expressed as a percent of fund value with no hedging, and there were a couple of other hedging approaches.

Let's talk about the risk-based capital (RBC) implications in general, and then we'll

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 5

talk specifically about the delta hedging. Under the C3 Phase II, if you utilize the alternative method, then you cannot get any hedging credit. You have to have a clearly defined hedging strategy, and I'll probably go through this pretty quickly, because I'm suspecting that you've probably already heard a lot of this over the last day and a half through some other sessions. It's worth repeating now, because with the delta hedging strategy, you've mitigated some risks and you've really transformed risks. Now, I'll get into it later, but your real risk winds up being: What's the actual realized volatility into the future?

There are a couple of different ways to analyze the capital offset. It's really whether you do it within your liability model or externally. And in a lot of ways, it's frankly the second method that is going to be easier, as we took a look at how to help companies evaluate hedge effectiveness. Part of the direction we're going is looking at simulating the hedge strategy, outside of the liability model, but focusing on the specific scenarios that generate the capital, the scenarios that wind up being in those 10 percent worst scenarios. We look at sampling points in those scenarios to determine if we're in this particular period of a scenario, and that's part of what's driving the capital requirements, how would the hedging strategy play out — the static strategy or a delta hedging strategy?

Clearly in the guidelines in the reg, they say you do need to recognize all the risks associated with the hedging strategy, including imperfections from the hedges and any mismatch tolerances you might have. There's a whole host of risks to varying degrees of any hedging strategy. You have basis risk; you have GAAP risk; estimating parameters; trying to estimate what the policyholder behavior functions might look like in adverse scenarios; and transaction costs. Part of what is required under the certification is that you need to adjust your hedge offset to the extent that there is more and more uncertainty around how your hedging strategy would actually perform.

First off, you calculate total asset requirement (TAR). It's called best efforts, and it's really a best-estimate approach to incorporate the hedging strategy. The second step is to calculate the TAR adjusted, which is to try to reflect the fact that you may not be modeling all the risks in this particular strategy, or you might be modeling them in an overly simplistic way. Then you get to your reported, which is really a weighting of the two. This is where you bring into it, in effect, a credibility factor. And this is where, not surprisingly, it gets fairly subjective in terms of whoever is going to be doing this certification is going to have to come up with that credibility factor. It has to be between 5 percent and 100 percent.

What else is going to be required of the actuary certifying this? You should look at any historical information. Although an example I'll show in a few minutes, the historical hedge effectiveness, depending on the strategy, may not tell you a whole lot. The economic environment we've been in over the last year or two has been fairly benign with respect to actual volatility. If you've been keeping logs of your hedge effectiveness in the delta hedging strategy, over a fairly benign, quiet period

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 6

of time, how do you extrapolate from that, if at all, into really severe scenarios, where actual volatility kicks up dramatically and the markets are in a declining situation?

Actuaries have to certify a number of things: Assumptions are reasonable for this particular purpose; they have to document their assumptions and their methods; and they must inform an officer of the company and certify that this is in fact their hedging strategy. An actuary has to maintain this documentation into the future.

Let's get into a delta-hedging example. This is a simple example, but I think it makes the point pretty strongly. It is a plain, vanilla, five-year European put option, and I'm looking at this over a one-month period where I'm adjusting my delta hedge daily, at the end of the business day, based upon what happened to the S&P during the day. I've chosen the S&P as more or less an illustrative proxy for the market. Now, during this lifelong period, I'm keeping my drift term; this is kind of a real-world scenario. I'm keeping it constant; it's around 8 percent. All I'm changing is the projecting different volatility levels — 17 percent, 25 percent and 35 percent to see what happens to my hedge slippage just by changing the volatility assumption.

Now let me look at my cumulative gain or loss over this month. I know the transaction costs express this slippage in terms of basis points of the option value because this is a simple European put option, and there is no underlying fund value or anything like that.

O'Connor Slide 24 is the ugly example. The top line is the example where I have rank-ordered 100 samples to a daily hedge over month. So how much money did I make or lose on a cumulative basis during that month? Now, the example where the market on average is going up at an annualized rate of 8 percent, with 17 percent volatility, the average is roughly zero. Half the time you win a little bit, half the time you lose a little bit. It's a pretty flat line, actually. But as soon as you start increasing the volatility, your average goes negative. I forget the exact number, but I think it was about 1.75 percent average loss during one month, just from a delta hedging strategy.

With the third one, the light line, I increased volatility to 35 percent. So it's the same economic environment, using the same risk-neutral assumptions to establish my Greeks, to reevaluate the Greek, the delta, daily, change my futures position, and see how I did for the day. The average for that one was almost 5 percent of the option value. There's no underlying fund value.

So the top line is arguably the type of situation that we've been in during the past year and a half. Delta and the others put up a few blips here and there in terms of the market, but it's been pretty benign for at least a year, or perhaps two years.

If you were the certifying actuary for a hedging strategy, the question that I have is

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 7

could I use that historical data to project in the future? I'll leave it as a rhetorical question.

This is in an environment where we get to an actual volatility of 35 percent over a one-month period, and the average was close to 5 percent loss. So a lot of these questions are really rhetorical. I'll try to answer a few of them myself, but especially when you get into situations like those two bottom lines, it's hard. The top line has nice symmetry, and it's nice that the average is around zero. But the bottom lines get to be such extremes. I don't know how you would use historical to project out in the future in terms of how your delta dynamic hedging strategy would operate in extreme situations. And extreme situations are going to drive your C3 Phase II capital.

It's not the top lines that are driving your capital. It's not those types of scenarios. It's the bottom line that's going to be driving your capital requirements. Again, this is a plain vanilla put option. There are no policyholder behavioral assumptions in here at all. And we can all probably guess what would happen to those bottom curves if there were policyholder behaviors introduced. They would dramatically have to shift the line, to be even more skewed.

In an ideal world, if I'm doing a certification for a company in terms of the hedge effectiveness, what other components should be reflected? In the examples I did, I kept implied volatility constant. In real life, that's not a realistic assumption. It's very problematic to figure out how to project out implied volatility. Beyond, for example, very short-term implied volatility, you can go out and do calibrations on the DIX index, which is a very short-term, implied volatility type of a number, and you can do some correlations about how that index, the implied volatility, compared with actual volatility over time. You can get some very high correlations, but the implied volatility behind a delta hedging or any type of hedging strategy for a variable annuity block has to be looking at implied volatilities five, 10 or 15 years out.

There probably would be some pretty simple ways to reflect transaction costs. Trading collars are a little bit more problematic because you're not going to trade on every little movement in the index. If things aren't moving much, you can have a little bit of a collar around your hedge position, your delta, before you're actually going to trade.

How would I quantify basis risks? This basis risk is in terms of the difference between the actual underlying funds movement versus the way you're modeling them. This might actually be a thing that would be very worthwhile to keep track of historically. Regardless of what type of a hedging program you have, this probably would be something you'd want to track explicitly because that could be something that would be very easy to model in the future, just as an error term that you would introduce into your modeling.

What are the drivers of tracking error in a delta-hedging program? Now the

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 8

example I gave, the option was five years out and it was "at the money." Now, if the option were way "in the money" or way "out of the money," you would have a different profile. Actually, the profile in terms of basis points of the option value looks worse for the put option that is way out of the money, but the absolute dollars would be very small. If the put option is way out of the money, the dollar value of that liability is very small. But for delta hedging, the primary risk is going to be the realized volatility. If we get into those periods of time, the volatility does shoot up periodically. It's not a smooth function at all in the market. That will be probably the main driver of your tracking error.

Another thing that will be probably a second order effect is the implied volatility surface of your liability calculation. So to the extent that that surface of the implied volatility moves over time, that will affect your delta, and it could affect your tracking error. That is probably more of a second-order driver.

Especially if you're using a delta hedging strategy, your assets should be predominantly in cash. Now for some companies, for a variety of reasons, the assets backing their delta hedging strategy might be in five- or 10-year bonds. If that's the case, then you have some duration mismatch between the assets and liabilities. For some companies, their hedge program might be de minimus, and it's probably not worth the effort for them to split out another portfolio of just cash.

The final component is policyholder behavior. To the extent that if you're in the variable-annuity market, you do have products that have a lot of policyholder behavior aspects to them. Those dynamics are going to exacerbate this type of a tracking error from a delta hedging program.

I tend to think in terms of the analogy between delta and gamma, for example, the variable annuity to duration and convexity. And so the policyholder behavior is going to give us a lot more gamma to the equation, and it's like having a lot more convexity. A lot of companies' policyholder behavior functions are like a cliff function. It's not a cliff; it's a hockey stick. Depending on the economic environment, you may not anticipate much in the way of changing behavior, but it's some threshold — behavior will change dramatically. The utilization will increase dramatically. Different companies will have different points at which that will kick in, but that is a component that will radically change the picture potentially of any hedging strategy, but particularly of a delta hedging strategy.

MS. MICHELLE D. SMITH: Mike spoke a lot about delta hedging strategies, and I'm going to focus mainly on the long-term derivatives market and static hedges. I'm going to look at some examples in this presentation of a GMWB, look at hedging it with some straight vanilla options, which means straight five- or 10-year puts and longer. We're also going to look at what happens if you, instead of hedging with vanillas, hedge with something more structured.

The market I want to talk about in that section is the long-dated derivatives

Annuity Risk Management Seminar: Variable Annuity Guarantees ... 9

market. I'm going to discuss some of the recent trends we've seen in the long-dated derivatives market and particularly, what are some of the drivers on the demand side and what are some of the drivers on the supply side.

We'll look at an example, like I said, of a GMWB, hedging with a vanilla and with vanilla puts, and then with more structured long-dated options. If we have a chance at the end, we'll look at that example and compare what we've learned about delta hedging or short hedging strategies versus long-dated hedging strategies.

One of the things we've seen in the past year or so has been a real pick up in the long-dated derivatives market. Both in vanilla puts, which started about a year ago when we started seeing a real pick-up in demand for 10-year put options, and then later on, about this year, we started seeing a higher activity in the long-dated, structured derivatives. In this section I'm going to talk about what's driving the demand that caused that to happen last year and this year and some of the supply things that are going on. What's going on on the supply side in response to that demand?

Some of the drivers of demand include the rating agencies. I see that Moody's is here, so I'll have Scott correct me if I say anything wrong. The rating agencies, from what we can tell, are a little nervous about delta-only hedging strategies. As Mike pointed out, they really haven't been tested. If you think about when companies started to delta hedge, it was after the reinsurance market dried up in 2001. Delta hedging came along more toward the end of 2002, the beginning of 2003. I'll show you some graphs in a few minutes, but look at what's been happening to volatilities during that period where companies have been delta hedging and there have been volatility spikes since that time. So the phenomenon that Mike talked about and illustrated in his presentation really hasn't been seen yet in the delta hedging strategies.

So rating agencies looking at companies is one driver. The changes in the supply side are another driver, and what I mean by that is that the big broker/dealers now will participate in the long-dated derivative market. Supply has picked up in response to demand, and hedge funds will also participate in this market. So there is more accessible and more reasonable data out there now for the term structure of volatilities. I'll talk about this more in a minute, but I think what that's going to mean is a change in some of the GAAP valuation practices on the FAS 133.

The other driver that we know is a big deal now, of course, is the pending C3 Phase II regulations. Just within the past month, and even within the past week or so, in the past few days, we've seen a lot of activity pick up in the long-dated derivatives market. The other thing I want to touch on is that risk return profiles can be significantly improved by product design and in long-dated hedging. We're seeing a change in the way companies are approaching product design. In the past, they've designed the guarantees and then worried about how they're going to hedge them. More and more what we're seeing is companies going to broker/dealers during the

Annuity Risk Management Seminar: Variable Annuity Guarantees ...10

product design phase and saying: What's available in the long-dated derivatives market? Then they're designing their product around what's actually available, how good the available derivatives are at being effective against a wide range of policyholder behavior and then structuring the product design around where the hedge is or isn't effective.

One of the things to think about is that a long-dated hedge is not going to be effective around the policyholder selecting different fund allocations. All of a sudden, you hedge against a certain proportion of equities and then the policyholder changes the allocation. Those are the things that you might want to control in product designs. Other things we found in some of the structures of the hedges are effective at dealing in a wide range of withdrawal behavior on the GMWB. So you can allow that range of behavior and you don't have to restrict it or tie it to more for certain types of behaviors.

I'd like to just talk a little bit more about the drivers of demand. I'll talk a little about how we think the rating agencies are looking at this and, like I said before, I think they have concerns about delta-only hedging strategies because they haven't been tested yet.

One thing I would like to say in addition is that with the coming C3 Phase II regulations, all that is going to do is set company action level RBC. This will mean different things from different rating agencies. What we don't know is when you have a CTE90 measure, you have all the calculations there for tail risk and the rating agency is going to be looking for CTE90 plus something, CTE98 or CTE96, depending on what rating you're trying to achieve. Are they going to be looking for a multiple of CTE90? We don't yet know the answer to that, but that's a very critical issue that drives when you price these products. What are you showing for your target surplus assumptions, your reserves plus target surplus? And I think the answer to that will also likely impact the long-dated derivatives market.

Let me talk more about these GAAP accounting issues. I think these have been discussed several times in the past few days. We know that generally under FAS 133, the AB and the WB are considered in better derivatives than mark to market.

Death benefits (DBs) are scoped out of FAS 133 because they are considered insurance. And income benefit (IB) is scoped out for a different reason, actually a little bit of an unusual reason, but it is scoped out and accounted for under the SOP 03-1. What you can see in the market is going on with DBs and IBs is that they tend to be relatively under-hedged compared to WB and AB, and it's going to be interesting when C3 Phase II does come in. Some of the IBs that are out there are likely to see significant capital requirements, and that's also likely to drive some extra demand in the long-dated derivatives market.

The FAS 133 issue that I was talking about before, is that because say, prior to last year, the long-dated derivatives market wasn't as liquid as it is now, and the data

Annuity Risk Management Seminar: Variable Annuity Guarantees ...11

you could get on the implied volatilities out at the long end of the bell curve was Variable depending on which broker/dealer you called. Companies were reluctant to use implied volatility in the FAS 133 mark to market of WBs and ABs. What a lot of companies did, and I think are still doing, is using a term structure volatility that starts with implied volatility at the short end of the curve, and gradually grades to historical volatility. What that does to your GAAP earnings is not recognizing the fact that you have volatility exposure on your books. So there hasn't been a great deal of incentive to hedge to volatility risk. Mike talked about the fact that the delta hedging hasn't been tested yet, but even if it had been tested, it's not necessarily going to show up so much on your GAAP earnings because companies are using historic volatilities.

Because the supply side is changing, and long volatility data is going to be more accessible, it's going to make more sense that there are more data points out there. This practice may very well change, so companies will actually use implied volatilities for the full term structure of volatilities in their FAS 133 calculation. And that in itself will be more of an incentive for companies to use long-dated derivatives.

I'm sure you've heard quite a lot about C3 Phase II in the last couple of days. The one thing I wanted to say here in terms of comparing a short-term dynamic strategy to a static hedging strategy is that if you want to take your static hedge and model how much credit you should get under C3 Phase II, it's very easy to do. It's easier than even modeling a single variable annuity because you know the terms of the contract on your books. You know exactly what the behavior is going to be. If you're buying a long-term option, you are going to get a significant amount of credit under C3 Phase II, but you've also paid to get that credit.

To try to prove the case of dynamic strategy, you start to get into needing the stochastic-on-stochastic models. You start to get into needing modeling capabilities that a lot of companies don't yet have, and may not want to build up internally, in terms of the actual technology that's required and the amount of resources you have to devote to that. If you use a static strategy, you don't have to allocate those resources during that kind of modeling of dynamic strategy. The proposed standard scenario doesn't give credit for future hedging and of course, we don't know what the fate will be of the standard scenario yet, but we should know in a couple of weeks.

On Smith Slide 10 (slide not available), the graph on the left is a graph of implied volatility over the past three years, and what it's trying to show you is the term structure of volatility over that period. The blue line is the volatility for one year at the money put. The green line is volatility for a five-year at the money put, and the gray line is volatility for a 10-year at the money put.

So it's kind of hard to go back further than about 2002, because there are really not very many data points there. You can see at the right-hand side of that left graph

Annuity Risk Management Seminar: Variable Annuity Guarantees ...12

that there was a more normal term structure over the past year or so. It's the term structure you expect that as you go out longer, implied volatility is higher. In this graph, over that year also there's been about a 200-basis-point difference between a 10-year and a five-year, and then a five-year and a one-year. Another interesting thing on that graph is that there are actually periods called back gradation, where just before July 2004, there is so much demand for one-year instruments that there is really no difference between volatilities in a one-year instrument and 10-year instrument. And as Frank Sabatini said yesterday, a lot of broker/dealers will go out to about 20 years, so that's a more recent development, but I don't have 20-year volatilities here.

To reiterate this whole point, that delta hedging strategies have not been stress-tested yet, if you look at this graph at the point of early 2003, at the time that most companies started doing their delta hedging strategies, there have been no significant spikes in volatility in that period. The right-hand graph is showing you the actual S&P index on the green line and one-year volatilities on the blue line. It's been a nice time to be delta hedging. Of course we don't expect that that will always be the case, and we have three volatility spikes showing there, the first one being the green spike on the right-hand graph. The first spike is long-term capital, the second one was Sept. 11, 2001, and the third one was one of the recent wars, but I can't remember which one it was. There are so many.

Smith Slide 11 is showing you rate volatility, which of course is a lot less than equity volatility. There are sometimes small movements, and rates can actually move the tail risk and the mark to market of certain benefits quite significantly. Guaranteed minimum income benefits (GMIBs) are probably the main examples there. The graph on the left-hand side is showing you the flattening of the yield curve. I was just looking at the yield curve last night where it ended up yesterday, and there's only about a 75- or 80-basis-point difference now between the rate on the two-year swap and the rate on the 30-year swap. So the current yield curve is very flat, which is actually increasing the mark to market on all of these benefits. And it's particularly doing so on the IBs.

The example we have is a GMWB, and I didn't put up all the details about the base product. It has normal mortality and expense (M&E) fees, investment advisory charges, commissions, surrender charges and so on. The more interesting thing is the GMWB rider. It's a 5 percent withdrawal benefit. The guarantee rose up at 5 percent a year, capping out at five years. So if the policyholder delays withdrawal until year six, his guaranteed benefit will be 125 percent of the original premiums. There is also a three-year step-up feature so that the policyholder can, if the account value is higher, every third year reset the guarantee. For some products that can be a big deal if you charge on the guarantee and not on the account value, so that step-up feature is a less costly feature for the company.

We have some results on the next page, but before we get into those I should mention the assumptions of policyholder behavior. We're showing here that we've

Annuity Risk Management Seminar: Variable Annuity Guarantees ...13

assumed a 70 percent allocation to equities in this particular example, and I'll change the allocation in the next example. We've assumed that the policyholder takes maximum advantage of the bonus feature and starts withdrawing in year six. We've assumed that once the policyholder starts withdrawing, he keeps withdrawing at 5 percent at the maximum amount once he actually starts withdrawing. We find that is the most conservative assumption because of the lost M&E fees.

We have also a dynamic lapse assumption in this example. As the benefit's more and more "in the money," we apply a multiplier to reduce the lapses. I think that multiplier is floored at about 25 percent. We also assume that the policyholder elects to reset whenever it makes sense for him to reset.

In Smith Slide 15, we compared the results like the present value of cash flows and a risk measure where we've selected a CTE90 calculation for the risk measure. We're trying to approximate a C3 Phase II-type company action level RBC in that CTE90 measure. I should note, however, in case you're falling off your chairs worried about how high that CTE number is for a fairly common WB product that's out there, that these are pre-tax numbers. You can tax-effect the present value numbers and the CTE90. We just ignored tax for simplicity. The mean numbers are shown under a risk-neutral scenario and a real-world scenario set. As Mike said, companies really like to look at their results under both sets of scenarios and particularly they like to do that for what they're going to make on the base product, ignoring the rider.

The present values of cash flows showing in the first two rows are for the whole product. It's not just the rider; it's the whole product. So it's the base product cash flows plus the rider cash flows. Under the risk-neutral scenario, your means are lower than under the real-world scenario set because of the equity risk premium. But of course, what happens under the risk-neutral scenario set is when you go out and buy a hedge, you don't lose very much present value at the mean because you're paying for something at a market price. Which is calculated using risk-neutral scenarios, and your models are valuing all your cash flows from that hedge, using risk-neutral scenarios. So that the slight drop in value is basically bid/offer spread.

Under the real-world scenarios, your mean values are higher. When you go to put on a hedge, as anyone who does embedded-value accounting knows, you lose value at the mean. This is because you're buying a hedge, which is valued using risk-neutral scenarios, but you're valuing hedge cash flows using real-world scenarios.

And then the CTE90 measure, as I said before, is trying to get a proxy for C3 Phase II, RBC level capital. What's not showing here is how much you would have to invest in the hedge, and I'm going to tell you what that is in our models. You may want to write it down for comparison purposes. Then we'll talk about comparing,

Annuity Risk Management Seminar: Variable Annuity Guarantees ...14

once you know that cost of the hedge, that what you're going to have to invest in the hedges if you go out and buy long-dated derivatives, you can start comparing it to your own hedge situation. How much does it cost me to go out and buy a hedge and reduce my capital a lot versus having to put up a whole lot of capital in the unhedged situation?

In the CTE90 calculation, when I put on a vanilla, completely unstructured hedge, a 10-year bullet put, I can reduce my CTE90 by about half or a bit more than half. When I put on something that's more structured to match the WB cash flows, I can reduce it by about three-quarters, or get to 25 percent of my unhedged CTE90.

The cost of the bullet put in this example is 3.4. The cost of the structured hedge is 3.5. How does that compare with what I'm actually charging the policyholder for this benefit? In this example, the risk-neutral value of the GMWB fees is 3.8. So the 3.4-3.5 cost of the hedge compares well with what you are charging the policyholder for this guarantee. However, even under the structured hedge example, you still have some residual tail risk. Presumably then what you would have to do is invest in this hedge, but you'd also have to set up a little bit, the 1.1, to cover the tail risk.

One thing I would say is there are a few little things going on here. You're not going to hold capital at CTE90. You're going to hold it at something higher than CTE90. I was just doing some rough calculations myself this morning and saying well, what if I say I tax-effect the CTE90, and then I'll just make some kind of wild assumption that for an A-level company, I'm going to have to hold 150 percent of CTE90. And I basically get back to these same capital levels that I'm showing here. So I can say from my structured hedge case that what this example shows is that because the cost of the vanilla put and the structured hedge is about the same, the reduction in capital under the structured hedge is much greater; it's a much more effective hedge. So of course, in this case, if you felt comfortable with the structured hedge, you might consider that because it's the same level of investment, but it gives you a higher capital reduction.

Compared to the unhedged case, for the structured hedge you might have to invest about 3.5, plus put up 1.1, so it compares with the 4.4 that you'd have to set up for the unhedged case. But the big difference is that you're likely to never have to go back to your shareholders to ask for more capital in a structured hedge case. Whereas, for the unhedged case, next year that capital number could be 8.8, and you'd have to go back to the shareholders and ask for more capital.

The other thing that companies often ask about are returns on equity (ROEs). What are my ROEs under these different examples? If you go out and buy a structured hedge, if you'd buy it on day one, then obviously your GAAP equity is going to be whatever you invest in the hedge, plus any additional capital that you have to put against the residual tail risk. The reason for that is because your FAS 133 liability for the GMWB is zero on day one, because the policyholder is financing the

Annuity Risk Management Seminar: Variable Annuity Guarantees ...15

guarantee. So if you want to reduce your GAAP equity that you have to contribute to this business, you could also consider financing the derivative so that you're not investing 3.5 up front. You're actually going to try to finance the derivative in a way very similar to the way the policyholder is financing the derivative with X basis points per year. That's something that most broker/dealers will do. Obviously, that would improve ROEs.

Smith Slide 16 shows what happens to those return-on-risk measures if I reduce my equity allocation. Of course, all my risk measures go down on the risk-neutral scenario. Except my means actually go up because volatility has gone down. On the real-world scenario it looks like my means go down because I've lost equity risk premium.

The important thing to note about this is obviously if a policyholder has one type of fund dollar allocation and I go and put on my hedge on day one, and then he turns around and invests in more equities, then my hedge is no longer that effective. We've seen an increasing trend toward companies putting restrictions on fund allocations for that very reason. If you put those types of restrictions on policyholder behavior, it makes it a lot easier to hedge. One thing you can do is say, you can't do this, or you have to get this guarantee provided you're invested in these types of fund allocations. The other thing to do is if you want to change a fund allocation, if you want to increase your proportion of equities, we have the right to increase the charge for this guarantee. And that gives you the ability to go out and buy the appropriate hedge or just adjust the hedge appropriately.

Another example of policyholder behavior is withdrawal behavior. One thing that's good to look at is the risk return — risk plotted on the Y axis and return or mean present values plotted on the X axis. Look at where if I'm unhedged or hedged, the different types of instruments, where do different policyholder behaviors fall on that graph? In that way, you can see if the policyholder instead elects to start withdrawing earlier than you expected when you were modeling this hedge. What does that do to my hedge effectiveness? One thing we have seen with some of the structured hedges is that the structured hedges can be very effective at dealing with most types, but they continue to be effective against a whole range of withdrawal behaviors. The one that they're probably not effective against is when the policyholder starts withdrawing in year one. But if he starts withdrawing in year three onward, the hedge will be effective. If I know that and I'm factoring all this into product design, maybe I can put restrictions on the policyholder starting to withdraw in year one, or maybe I can charge extra for that type of behavior.

The one behavior I haven't touched on here is lapse. Lapse doesn't affect the design of a hedge of a long-dated derivative. It only affects the notional that you decide to buy. So the issue there is: What if I go out and I buy this long-dated derivative, and then more policyholders lapse than I expected, then I've overhedged and wasted all this money on the long-dated hedge. There are several ways of handling that. One is as policyholder behavior emerges, you can adjust the

Annuity Risk Management Seminar: Variable Annuity Guarantees ...16

notional amount of your long-dated derivatives accordingly. Of course you may end up having to do that at times that you least would like to do that. Another way of dealing with the lapse risk is to invest in a long-dated derivative or finance a long-dated derivative for the lower end of where you expect consistency to be when the products are eligible for the guarantee and then delta hedge around the rims.

FROM THE FLOOR: What's the difference between Slide 15 and Slide 16?

MS. SMITH: I dropped equity allocation to 50 percent from 70 percent, so the volatility has gone down. These are present values of cash flows. The mean numbers are present values of cash flow, so when I move from this situation on the risk-neutral scenario set to this situation, the mean returns are still the same if I follow the forward curve, but the volatility has decreased in going from this one to this one. So the cost of my WB in going from the 70 percent allocation to the 50 percent allocation has gone way down.

What you're trying to do is see if I stress policyholder behavior, unless I've already gone and invested in that hedge, is it still effective? Because I don't want to have to reposition myself and that's what you're trying to test for — what policyholder behaviors are going to cause you to reposition yourself and therefore, what should you maybe be either restricting or charging extra for so you do have the money to reposition yourself?

MR. MARK D.J. EVANS: I have a couple of comments on the delta hedging. First of all, at least some companies have been delta hedging some products for years. That would include the Sept. 11, 2001 situation. It's pretty easy to calculate what would happen with a delta-hedging program on, say, Oct. 19, 1987. So I don't think there is any big mystery on what would happen with delta hedging in the case of a spike, or in the case of prolonged high volatility. So those numbers are all fairly easily estimated.

MS. SMITH: Mike, do you want to comment?

MR. O'CONNOR: The tough question gets to be: What's the capital offset? I think that's the unknown question to me. There's no clear answer. I mean, it is pretty clear. You pointed out 1987, and I think there are a couple other examples of periods where delta hedging didn't work, so I'm not quite sure what your question is.

MR. EVANS: My point is that you can figure out what's going to happen to you in those situations. It's not an unknown.

MR. O'CONNOR: I agree with that.

MR. EVANS: I was really addressing some comments that Michelle made in that regard. You were talking about the fact that recently we've had fairly well volatility,

Annuity Risk Management Seminar: Variable Annuity Guarantees ...17

true, so delta hedging really hasn't been tested well, that's true. But that doesn't mean we don't know what it would be like if we moved into high volatility.

MS. SMITH: Right, yes. I mean hedging being tested in an environment where it's been experienced and then you've had a reaction from shareholders and agencies and so on.

MR. EVANS: With your model up here, are these stochastic interest rates in your model?

MS. SMITH: Yes.

MR. EVANS: How did that impact the cost of the reset, particularly in the strong down environment for interest rates? Related to that, was your customer behavior assumption reactive to the interest rate environment at the point of reset?

MS. SMITH: No, it wasn't. Just for simplicity, we didn't take that into consideration. That is one way you can think of WB behavior is that policyholders will compare the WB itself to what they can get in the market if they've gotten in by a SPIA. But we don't have a dynamic assumption for interest rate behavior. We think, unless you have the more sophisticated players coming in, it's not something that we necessarily take into account. We know a lot of companies aren't modeling interest rate behavior and for simplicity we didn't model that in this particular model.

MR. DANIEL STEVENS: Earlier you talked about sources of demand for long-dated options. Are those sources exclusively insurance companies?

MS. SMITH: Insurance companies and pension funds basically. And that's it as far as I know.

MR. STEVENS: The investment bankers that are selling these options, what are they doing to hedge?

MS. SMITH: I knew someone was going to ask me that. To me that's actually a bit of a mystery because I'm a lone actuary in the whole organization. There are a few of us, but here's the answer that they always give me. Maybe they don't really want to tell me the answer, I don't know. These risks are getting thrown into a pool of all kinds of risks from all kinds of industries and different counterparties, and they do whatever they do to look at the value at risk, and so on. Presumably they're also doing some kind of delta hedging as well. One big difference for a broker/dealer is in all of this stuff when they've gotten hedged. The accounting is very simple, so they're all doing mark to market and they're also governed by different capital rules. So in some ways, they have less complicated regulations to deal with, but you can imagine that they're doing some of this dynamic hedging as well.

Annuity Risk Management Seminar: Variable Annuity Guarantees ...18

MR. DAVID TAUBER: We're talking about derivatives of the underlying securities, duration — delta, vega, rho, all the things here, those aren't matching cash flow to cash flow. You know you can take on the fixed-income side and you can say, I'm duration-matched, but I have this barbell strategy and cash flows come in and now I'm going to have to all of a sudden have a huge cash outflow in a given time period and a high-volatility time period. Could that also occur with these kinds of scenarios? Will hedging strategy on a delta strategy be able to insure the insurer against that, or are they going to need to vega and rho to match that? Are they going to have to use full options to be able to get that value instead of just using futures? Can you talk a little bit about the types of strategies?

MS. SMITH: I can talk about it from the long-dated derivatives, from the structured hedge perspective. I'm not sure, but I think the structured hedges for these numbers here, the payout would be in the year 15. When we look at WBs and you look at when the account value starts to go negative, it's around that time point. What we've tried to do in the structuring of the hedges is tie them as closely as possible because the other thing is, you don't want to get too exotic and have people's heads spinning when you're trying to explain the hedge. But you need to try to structure it so that the cash payout under the hedge is similar to the timing when you're going to need cash to pay the policyholder benefits. But you know if your timing is a bit off, you can liquidate it at certain time point and so on. By definition the structured hedge is trying to get at cash flows as well.

MR. O'CONNOR: You can have a vega mismatch, similar to having a duration mismatch. We're looking at one company right now that has a very sophisticated rolling hedging strategy, and they roll contracts that are relatively short and kind of intermediate term. You would get into an accounting mismatch at least, perhaps economic mismatch, if you have a bunch of liabilities that are really 10-year. Take an AB for example. That's a very simple example. The liability valuation for GAAP purposes would be tied to the 10-year volatility, whereas their basket of options on the asset side might be two-month or one-year options.

MR. WILL MITCHELL: In Mike's presentation on run-speed considerations, one was the degree of stochastic on stochastic. I was wondering what some different degrees of stochastic on stochastic had been commonly used? Does that mean you have a full stochastic on stochastic, or none at all, or there are some levels in between when you say the degree?

MR. O'CONNOR: Let me give you one example, to calculate C3 Phase II on a stochastic-on-stochastic basis. Let's say you're doing 1,000 scenarios going out for 15 years or so. If at every year along the way you ran another 1,000 scenarios, that would result in a huge amount of run-time implications. But you can choose scenarios so that you have a pretty high confidence level of picking up the tail, which is the main thing you're interested in. So at each point along the way, you may only need to run 50 scenarios to recalculate capital. So that's stochastic on stochastic, but you don't necessarily need the full 1,000 at each point along the

Annuity Risk Management Seminar: Variable Annuity Guarantees ...19

way for 1,000 scenarios.