

# RECORD, Volume 31, No. 1\*

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

## Session 3PD

### Financial Economics vs. Traditional Actuarial Methods/Back to Basics: Risk Neutral vs. Real World

**Track:** Investment

**Moderator:** JULIA LYNN WIRCH

**Panelists:** TAMARA LOIS ANN BURDEN  
GRAHAM D. IRELAND

*Summary: This session examines financial, economic and traditional actuarial methodological approaches used for solving investment-risk problems. The following topics are discussed: What is the theoretical basis for each approach? What are the types of problems that would warrant using one approach vs. another? Can both approaches be used? And if so, how can discrepancies in the results be interpreted? What are the challenges involved in implementing either approach?*

**MS. JULIA LYNN WIRCH:** We've been given the opportunity to evaluate our current modeling processes and capabilities and determine where we should make changes in order to prepare our systems for the challenges facing us in the 21st century. I would like to find out what each of you sees as our greatest concerns. Hopefully, we can address these issues and develop an action plan for the coming year.

**MS. TAMARA LOIS ANN BURDEN:** My specialty is derivatives trading and financial economics. In the work that I do, I feel that the only method that gives an appropriate measure of the value of a liability is the value obtained through risk-neutral pricing. The risk-neutral pricing method produces market-consistent prices, which are necessary for determining the cost of hedging; accounting regulations

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**Note:** The chart(s) referred to in the text can be downloaded at:  
[http://handouts.soa.org/conted/cearchive/NewOrleans-May05/003\\_bk\\_new.pdf](http://handouts.soa.org/conted/cearchive/NewOrleans-May05/003_bk_new.pdf).

require them as well. I am quite uncomfortable with using assumptions that are not derived from the market.

**MR. GRAHAM D. IRELAND:** As an actuary, I'm concerned with the solvency risk of the company. My focus is to ensure that the company has enough capital to weather the worst-case losses. For that, risk-neutral pricing tells me very little. I need to know what really could happen. The market seems to change its mind so much that I am uncomfortable with assuming that the market knows what's best. I prefer a long-term approach to modeling.

**MS. WIRCH:** I am a senior risk officer. I need to have a consistent, integrated risk-management system. How to measure your risk doesn't matter, as long as you can show me why your answers are right and when I should use which methodology. I would like for each of you to explain the preferred methods. Then, I'll understand how they can be used to respond to my enterprise risk-management needs.

**MS. BURDEN:** Let me start by explaining what risk-neutral valuation is and why it gives us the fair value of a liability.

**MR. IRELAND:** Can you explain what you mean by "fair value"?

**MS. BURDEN:** Fair value means that two portfolios with identical payoffs will have the same price if the market can set that price. Otherwise, an investor could sell the more expensive portfolio, buy the cheaper one and make free money. The fair value is the price that the market naturally assigns to any tradable asset.

**MR. IRELAND:** You said that the market can set the price, and you mentioned tradable asset. If I'm looking at an insurance liability like a long-term life-insurance contract, neither of those phrases applies. The market can't set the price, because the market can't invest directly in an insurance liability.

**MS. BURDEN:** That is completely true. But let's say that you're an insurance company, and you've sold a guarantee on the performance of a mutual fund. Now you want to buy a portfolio that's made up of tradable assets that replicates the payoff of that guarantee exactly. The price of that replicating portfolio will be set by the market. That's the real purpose of calculating a fair value. It's not so much to tell you what the market would pay for your liability if it could buy it; it's to tell you what you would have to pay for the same payoffs in the market.

**MS. WIRCH:** Tell me why I would want to buy the same payoff in the market, particularly if the market price of the replicating portfolio is more expensive than my expected guarantee.

**MR. IRELAND:** Over the last decade, a lot of insurance companies asked that question. They decided not to buy the replicating portfolio. And they didn't price using risk-neutral methods. The idea behind this was that the company is in it for

the long term, the expected cost should equal the cost of the guarantee, and the company would have reserves and capital left to weather the wide swings in experience. They found out that the guarantees on equity products were different from guarantees on mortality. There were several years of high claims in a row, and the stock market was going steadily down. The reserves were much too low to cover claims.

**MS WIRCH:** Can you explain why guarantees on the capital markets are so different from guarantees on mortality?

**MS. BURDEN:** In the past, insurance companies have profited from risks like mortality and longevity, for which random fluctuations from cohort to cohort or from time period to time period likely will offset each other. This results in a risk that, in aggregate, becomes fairly predictable. This is the type of risk that insurance companies are most experienced with and are best equipped to handle at this time. But, say you're an insurance company, and you've sold a guarantee on the performance of a mutual fund, and your customer has paid you a fixed amount in return for protection against losing more than his initial investment. If the mutual fund goes down by 10 percent, you, as the insurance company, are now on the hook for 10 percent of your policyholder's initial premium. If you sold 1,000 of those policies all on the same day, you're going to be on the hook for 10 percent of everybody's initial premium. There's no diversification in the risk that you've just sold. But if you could do what the policyholder just did, and transfer your risk in exchange for paying a fixed amount and not having to pay the guarantee if it expired "in the money," then you can give that risk to the market. The market is best equipped to handle that type of risk.

**MR. IRELAND:** It sounds as though the insurance company is really nothing more than a "go between." If the company is not taking on any risk, how can it expect to make a profit? Why wouldn't the policyholder bypass the insurance company and go directly to the market?

**MS. BURDEN:** Theoretically, that would be possible. But this is where the economies of scale of an insurance company really come into play. The risk could be transferred to the market by the policyholder. But in order to transfer that risk, you'd have to contact a broker. He would expect payment for his services. Those transaction costs at a single-policyholder level are prohibitively high. When those costs can be spread out among many policyholders, that technique becomes affordable. On top of that, the public only can invest easily in exchange-traded assets, which aren't the instruments that insurance companies typically use to hedge these types of guarantees. Because of these reasons, the policyholder generally is willing to pay the insurance company a higher amount than the insurance company would have to pay the market. That results in a profit for the company. But smart companies understand their customers. They can understand what risks they want coverage for and how much they're willing to pay for those

risks. The company can decide internally what risks it wants to lay off to the market and what risks it wants to handle internally.

**MS. WIRCH:** I agree that purchasing and replicating a portfolio in the market is a way of transferring my capital-market risk back to the market. That's clear. And in doing so, we still can offer a valuable product that the policyholder is willing to pay for. The problem is, I think that a lot of people may not be familiar with risk-neutral valuation. Could you start by explaining risk-neutral valuation?

**MS. BURDEN:** The seed of risk-neutral pricing was the need to price a derivative contract. A derivative contract, very simply defined, is an asset with a value that depends on the value of another underlying asset. The key is that the value of the derivative only depends on the value of that asset. It does not depend on the particular risk preferences of the person who's buying it. For example, we could have a put option on a stock price. The value of that put option is going to be determined by whether or not the stock expires at or above the strike price at maturity.

It doesn't matter who's buying that put option. The value of the put option should be consistent. This means that when we're valuing a derivative, we can use any risk-preference assumption that we want. When I'm saying "risk preferences," I'm referring to the fact that an investor, depending on his risk preference, may require a higher-expected return to take on risk—and in this case, for valuing derivatives. If we talk about risk-neutral pricing, we're saying that we're looking at investors who are risk-neutral. This means that, regardless of the risk of the product, they're only interested in the expected value. They would see the same value from a 100 percent chance of getting \$100,000 or a 10 percent chance of getting \$1 million, and 90 percent chance of getting nothing at all. But mathematically, it is convenient to assume that investors are risk-neutral, because then we can assume that no matter what the asset is, the investor only will require the risk-free rate of return.

**MS. WIRCH:** So, the powerful conclusion of risk-neutral valuation is that you project market movement along a risk-neutral random "walk," and you discount the payoffs of your complex asset at the risk-free rate, and you get the fair value of that asset.

**MS. BURDEN:** That's exactly right. Slide 12 shows a simple equation to explain what we mean when we say "random walk," and what we mean by "risk-neutral random walk." The movement of the stock price has two components. It has an expected value and some random noise. In this equation, the  $\mu$  (which is also called the "drift term") is the expected return over a small time interval,  $dt$ . And the part with the  $\epsilon$  (and  $\epsilon$  is actually a random draw from a standard normal distribution) can be thought of as a shock to the return. Since the  $\epsilon$  is from the normal distribution, it's zero, on average. This means that this does not affect the expected return. But the size of the shock is proportional to the volatility and to the square root of time.

**MS. WIRCH:** You're saying that, over time, the asset drifts. And around the drift, there's a random noise. That's where it gets the name "random walk."

**MS. BURDEN:** Under the risk-neutral framework, we use the same equation. But the expected drift is the risk-free rate. This often is calibrated to the London Interbank Offered Rate (LIBOR) swap curve. When you talk about risk-free rate, theoretically, that definition would be the definition of the rate offered on government bonds. In practice, we would use the LIBOR swap curve, because it also has very low risk and it doesn't have the occasional liquidity issues that surround government-treasury issues. Again, we have an expected drift rate, and we have a random component that's modeling the noise around this drift.

**MS. WIRCH:** Are you saying that risk-neutral models are market-consistent?

**MS. BURDEN:** Market consistency is a function of how you set your input parameters. You can have a market-consistent model if you feed in an appropriate drift and a volatility structure that reflects the current market condition.

**MS. WIRCH:** So risk-neutral, by definition, doesn't mean market-consistent, But if your parameters are right, your risk-neutral model gives market-consistent values.

**MS. BURDEN:** Let me give you an example of that. Let's say that we calculate 1,000 stochastic stock returns with a random walk. We're using a constant risk-free rate and a volatility. The resulting distribution looks very symmetrical. It looks like the normal distribution. This is the standard assumption that underlies the Black-Scholes model. But if, instead, we calibrate our stochastic random walk to the current term structure of interest rates and to the current implied-volatility surface, then the distribution of returns that we actually get is very asymmetrical. When I'm talking about the implied-volatility surface, what I'm saying is that the implied volatility is a function of not only time, but also of the stock price. Typically, in practice, if you had a recent drop in the stock market, the volatility of your stock price is now higher. If you don't capture that switch in volatility or that change to a higher volatility, you won't be able to price appropriately such things as in-the-money and out-of-the-money options.

**MS. WIRCH:** And you have an example of this, don't you?

**MS. BURDEN:** Slide 17 shows the results for three European put options on the Standard & Poor's (S&P) 500. I've priced them in three different ways. First, I used the Black-Scholes formula with a constant  $\mu$  and a constant volatility. Next I used a Monte Carlo methodology with a constant  $\mu$  and volatility. And finally, I used a Monte Carlo with the current term structure of interest rates and a full implied-volatility surface. I've shown an at-the-money, a 20 percent in-the-money, and a 20 percent out-of-the-money put. The part in brown shows the actual market prices. (This came from some sample pricing by Bear Stearns.)

The Monte Carlo and the Black-Scholes, with the constant  $\mu$  and  $\sigma$ , are able to replicate the price of the at-the-money put. I've calibrated the  $\mu$  and the  $\sigma$  to do that. That was the current 10-year, risk-free rate, the implied volatility at the at-the-money put. The Black-Scholes price on the Monte Carlo methodologies with a constant  $\mu$  and  $\sigma$  replicate each other. They should, because the Monte Carlo simulation is simply a simulated version of the analytical formula that Black-Scholes is. If we compare those to Bear Stearns prices, although the at-the-money seems right, the in-the-money and the out-of-the money are both quite far away from what the market actually is going to be selling that option for. However, if you take the Monte Carlo, and you use an interest-rate-term structure (and in this case, we used the local volatility model, which would translate the implied volatilities into a simulated path that you can follow), you see that you come back to the market prices of all three, with a single model quite closely.

**MR. IRELAND:** Making sure that your parameters are right really makes a difference on how accurate your model is.

**MS. WIRCH:** I understand the importance of calibration. So far, we agree that risk-neutral pricing helps determine the cost of the portfolio that replicates our liabilities. To summarize, we need to use risk-neutral pricing with appropriate parameters to calculate the cost of buying the asset portfolio that matches liability. Put another way, buying an asset that matches the liability that I've sold is the most basic definition of hedging. What you're saying is that if I'm hedging my liability, then I should use risk-neutral valuation, especially to determine the cost of the hedge itself. Are there any other reasons within our business to use risk-neutral valuation?

**MS. BURDEN:** Accounting regulations require it. Financial Accounting Standard (FAS) 133 requires risk-neutral, market-consistent valuation for embedded derivatives in insurance products. This is applied to variable annuity guarantees, equity-indexed universal life and equity-indexed annuities (EIAs), but also to things like synthetic guaranteed investment contracts (GICs) and to stable value wrappers for corporate-owned life insurance/business-owned life insurance (COLI/BOLI) contracts. A lot of people will have to use risk-neutral valuation. From a company perspective, the issue is that your company's quarterly GAAP statement under FAS 133 is going to reflect the risk-neutral value, not the real-world value, even if you're not hedging it. Some statutory valuation rules also require this type of risk-neutral market-consistent valuation.

**MR. IRELAND:** I want to ask you some questions that actuaries often have when they're listening to discussions of risk-neutral valuation. It seems to me that investment departments—and not just investment departments in insurance companies—make a lot of investment decisions that are not based on risk-neutral valuation. For example, we run a multi-line insurance company. We sell a lot of life insurance, and we sell a lot of annuities. We sell single-premium deferred annuities.

We sell market-value-adjusted annuities, and we sell indexed annuities. All of these annuities have some minimum-rate guarantees. They all have other embedded options now. The life-insurance products have guarantees as well.

When we're backing these liabilities, we're taking on interest-rate risk and credit risk on our fixed-income portfolios. We expect a risk spread over the risk-free rate along these portfolios, which are the bulk of our assets. The way that I see risk-neutral valuation is that you could use it to price all types of assets. But if we actually price our assets this way, we would end up indifferent, earning a risk-free rate versus earning a risky spread. Since we are taking on extra risk in the expectation of earning a decent spread, we are not using a risk-neutral valuation. Put another way, if risk-neutral valuation is right and we are wrong, why are we in these lines of business for which we're trying to earn risky spread?

**MS. WIRCH:** These comments of risk-neutral valuation are not at odds with the investment behavior you describe. In practice, insurance companies take a strategic view of the risks that they take, especially the ones that they want to control through hedging, which require a risk-neutral framework. In practice, insurance companies take a strategic view of what risks they want to control through hedging and what types of risk they're comfortable with absorbing in hopes of getting a higher return. So you have the two different types of risks: ones that they want to give away and ones that they want to manage. When risk preferences differ among investors, they have different opinions on the risk within the investment. They also might have differences in how they're able to manage that risk. Both of these things contribute to investors making different investment decisions.

**MS. BURDEN:** A risk-neutral price gives the price of hedging, which, very specifically, is the price of a portfolio that dynamically replicates the liability through continuous rebalancing. Hedging is not the same as the long-term risk-management approach that you've described. Hedging means that you're protected in the short term against small moves in the market. If the market goes down by 1 percent, your liability value will increase by \$500. If you're hedged, you will own an asset that also increases by \$500 when the market goes down by 1 percent. The thing about hedging with a replicating portfolio is that if the market goes up by 1 percent, your liability goes down. This is good, but at the same time, you've lost money on your asset side. In hedging, you're getting rid of your downside risk at the cost of sacrificing your upside potential.

**MR. IRELAND:** When you hedge, you are trading your expected-future spreads for a return that you can earn with certainty.

**MS. BURDEN:** In effect, hedging translates your risky cash flows into certain cash flows, and the value of those certain cash flows is the value obtained through risk-neutral in a risk-neutral world, which is not the same as the value obtained necessarily through a real-world expectation.

**MR. IRELAND:** If I'm willing to take on extra risk, why do regulators insist on risk-neutral valuation?

**MS. WIRCH:** They only insist on risk-neutral valuations for derivatives, not all assets. This is because risk-neutral pricing has been shown to be fundamentally true for derivative valuations. But this does not extend to all assets, unless you're hedging them.

**MR. IRELAND:** One of the things that I like about risk-neutral valuation is that it is fairly objective. One of the most difficult parts of my job is to familiarize myself with the assumptions used throughout the company. The problem is that I still have to sign off on the assumptions that we use. What if I am uncomfortable with the assumptions that the market suggests? Risk-neutral valuation replicates prices of easily tradable assets, but it doesn't say anything about tail risk. My concern is that we have to price competitively, but we have to stay profitable. If there's a big change in the capital markets, my company might lose more money than we have in reserves and capital to weather. In order to know the tail risk, I need to use a model that reflects not only the potential outcome but the full breadth of potential outcomes, and that requires real-world valuation.

**MS. WIRCH:** If risk-neutral stock returns are generated using Brownian motion and the risk-free forward curve, how do we model real-world returns?

**MR. IRELAND:** First, use random walk of asset prices, but the input parameters are different. Instead of the risk-free rate, you use a reasonable expectation of actual turns for each asset. For example, you might use your drift rate based on historical averages. For volatility, you will want to incorporate the skew. Typically, you might use a Generalised Autoregressive Conditional Heteroskedastic (GARCH) model, a regime-switching model or something called a jump-diffusion model. In addition, you want to examine the risk of anti-selective policyholder behavior. You also want to examine the risk of potential credit default. In doing all of these models, you must produce reasonable assumptions, including assumptions regarding correlations and how the correlations move over time.

**MS. BURDEN:** The result of your real-world valuation, typically, is going to be a lower-expected payoff path for the guarantee that you sold, because, on average, the asset return will be higher than a risk-free investment. But there will be more variability of profit by scenario. Since you care about that variability, you're going to require a higher-expected return just to consider not hedging. Depending on your level of risk aversion, you could be indifferent to hedging—which has a higher-expected cost but a lower-expected volatility.

**MS. WIRCH:** Depending upon how bad your tail risk is and how much capital you have to support this product line, you may prefer the higher-expected cost of hedging.



**MR. IRELAND:** From what you've said so far, if I want to measure tail risk, I am right to use real-world valuation. This is because risk-neutral valuation projects averages but not the full distribution of returns. If I want to look at averages, risk-neutral and real-world averages are not the same. I could choose risk-neutral if I wanted very little variability. I could choose real-world if I wanted more variability. I would choose risk-neutral if I want very little variability, and I'm planning to hedge; real world if I want to accept the variability and don't want to hedge.

**MS. WIRCH:** There are external reasons to use risk-neutral valuation, like FAS 133, which requires fair-value reporting for guaranteed minimum accumulation benefits (GMABs) and guaranteed minimum withdrawal benefits (GMWBs). These require market consistency. The good thing about this methodology is that it lends itself to hedging strategies. This can reduce volatility in your income statement. Are there reasons like this to use real-world valuations?

**MR. IRELAND:** There are accounting regulations that require the use of real-world stochastic valuation. Risk-based capital (RBC), C-3, Phase II, requires them for tail risk. The proposed variable annuity commissioner's annuity reserve valuation method (VA CARVM) outlines real-world stochastic methodologies to calculate the variable annuity reserves. You have to use these whether you're hedging or not.

**MS. WIRCH:** Each of you has given me valuable information regarding the appropriate use of real-world and risk-neutral models for valuing my complex option. I'd like for each of you to explain how these methodologies apply to the valuation of embedded options in insurance contracts versus just the financial market. Two differences come to my mind. One is the effect of suboptimal exercise by our policyholders. The second one is the long-term nature of some of our liabilities. In the financial market, the price of an option that allows that holder to choose when to exercise is determined by assuming optimal election. The entities that buy these options typically are well-versed in how to evaluate their choices and have the ability to maximize their value through optimal election. But in insurance contracts, this isn't the same. There's evidence showing that policyholders do not elect their options optimally.

**MR. IRELAND:** If we look at the flexible-premium deferred-annuity market, policyholders have an option. They can surrender their policy and get a new contract if interest rates rise. But some of the policyholders never exercise that option no matter what. Interest rates can go up, down, whatever. You're always going to have some cohort of policyholders who are around forever.

Let's look at variable annuity or variable life policies. They have a contract that gives them a performance guarantee. They ought to be buying the most aggressive funds that they can get, because more risk means more return and the insurance companies picked up the risk. There's evidence that says that they do nothing of the sort. They do not buy the most aggressive funds that they can. On the other hand, there's some evidence that, with the help of their agents, policyholders are

becoming more optimal in their work. For example, we've noticed this with our fixed-annuity block. In scenarios of rising rates some agents pursue a 1035 exchange, move the contract over to another insurance company, and get a higher rate for their customers and a new commission on the way. That sort of phenomenon is making the election of these options more optimal.

**MS. WIRCH:** How would you model this?

**MR. IRELAND:** If you go back to the basis of Monte Carlo valuation, we project all of the market movements and determine the option payoffs at each step. It is the same methodology as if you were doing a risk-neutral valuation. However, if the option payoff is determined on the actual decision of the policyholder to annuitize, and that choice is affected by current market value at that time step, then you can build that assumption into the model. Similarly, you can reflect the probability of lapse or free partial withdrawal the same way. Typically, you're not going to use optimal behavior, but you're going to look at patterns of behavior in the past, and you're going to support that with actuarial judgment.

**MS. BURDEN:** Conceptually, policyholder-behavior models can be implemented in risk-neutral models quite similarly. Typically, you would calibrate your market parameters to a tradable option. Then you'd add policyholder behavior into a Monte Carlo stochastic projections. There is a school of thought among risk managers that are uncomfortable with this methodology. If you're using your risk-neutral account value to set your policyholder-behavior assumptions, under a risk-neutral framework, that guarantee may be more in-the-money because the growth rate on your account value is lower.

You may be modeling dynamic policyholder behavior that's going to have a greater effect on the option values than it would in the real world, but your policyholder behavior is going to be set on the true account values that they're seeing in the real world. There's not really a solution to this. One that's been proposed is to create two sets of scenarios running in tandem, one risk-neutral, one real-world, and set the policyholder behavior on the real-world scenario in your risk-neutral valuation. No one is quite sure exactly how that would work or if there's justification for it. But in practice, a company may want to estimate its cost of hedging using this methodology or another methodology to reflect what they believe is the most appropriate way of thinking. To the extent that they are wrong in their policyholder-behavior models, it'll probably reflect in leakages in the hedge program down the road.

**MR. IRELAND:** I think that the point of running a model of this kind is that if you're trying to get tail risk right, the correct model of policyholder behavior that you'd need in risk-neutral space is a lot less important than conservative measures.

**MS. BURDEN:** But if you're hedging, particularly if you're pricing your upside potential, you really don't want to use a conservative model, because you'll be continuously overhedged, and that could be quite costly.

**MR. IRELAND:** What happens if you're hedging, and your behavior model isn't perfect?

**MS. WIRCH:** Risk-neutral valuation tells you what it would cost to buy the asset that will match the certain cash flows that you've estimated for your liabilities. Remember that's certain cash flows that you've estimated for your liabilities. Most of us know that they're not quite "certain." For insurance benefits, you could try to estimate those certain cash flows using the law of large numbers. But if you're not accurate in your estimate, because you don't have enough policyholders or you've had to adjust your assets, the cost of buying the same payoffs in the market is the price to hedge the certain-liability cash flows. It's not a good estimate of the actual gains and losses that you might experience if you don't lock in your cash flows.

**MR. IRELAND:** If you don't lock in your cash flows—and you can't when you're selling insurance contracts—you're, in effect, unhedged.

**MS. WIRCH:** Put another way, you're imperfectly hedged.

**MR. IRELAND:** In deciding whether or not to use risk-neutral valuation for market-consistent values, let's think about the long-term nature of insurance contracts. If you are trying to buy a financial contract from a dealer, in the case of equity markets, you can get call options that go out a few years. If you're trying to buy an interest-rate swap, you can get a swap that runs as long as 30 years. But life-insurance contracts and such structured settlement contracts easily can be enforced for 40 years. There are companies for which long-term care is projected to be in the business for up to 80 years. What do you do when financial instruments are not available to determine long-term risk-free rates accurately? How do you model all of this?

**MS. BURDEN:** This is a problem. There are a number of assumptions that you can use to model the risk-free rates beyond 30 years. Perhaps the most common one is to assume that the 30-year spot rate would continue into the future. There is some sparse data from longer-maturity instruments that have traded. You can use it, comparing it to the 30-year spot rate doing some regressions, trying to build out that part of the yield curve. The real problem is that if you wanted to buy a bond or a swap or something that you will use for hedging, the spreads that you'd have to pay probably would make it undesirable.

**MS. WIRCH:** Suboptimal policyholder behavior can be modeled through Monte Carlo simulation. But if my assumptions are not realized, that will affect my actual costs. There really is no appropriate instrument to hedge the long end of the yield

curve, but there are many tests that I can do to test the different assumptions and illustrate the volatility that might result from not hedging my risk that far out.

**MR. IRELAND:** Does anyone have any questions? We're going to get into more applications, some stochastic in stochastic, and some discussions about what you'd do in certain instances.

**FROM THE FLOOR:** You're saying that if you're hedging, you'd use risk-neutral valuation methods. But if you're not hedging, it's appropriate in some cases to use real-world valuation methods, even for embedded-derivative contracts.

**MS. BURDEN:** Actually, I think that the point that we were trying to make is that you'd always want to use risk-neutral valuation, regardless. FAS 133 says that financial theory has shown that risk-neutral valuation is the appropriate method for derivatives. But if you're talking about modeling things like credit risks in bonds and stuff like that, you may or may not want to use your risk-neutral method to do that. Typically, if you were hedging, you would want to use risk-neutral.

**FROM THE FLOOR:** But if you have an embedded guarantee in your variable-annuity product, and for some reason you're not hedging that, it should still be valued with risk-neutral.

**MS. BURDEN:** Yes, because it's a derivative.

**FROM THE FLOOR:** I'm trying to understand why you're talking about analyzing policyholder behavior in a risk-neutral calculation. In my mind, doing a risk-neutral calculation will give you a market value of some asset. But I don't see why you would try to look at policyholder behavior in that situation. You have the value of your hedge, and you project along some real-world scenarios. You know what your behavior will be. You could do sensitivity tests to find out if your assumptions are really wrong. It's like what you said before. Your hedge ends up being imperfect. I don't understand why policyholder behavior comes into a risk-neutral framework.

**MS. WIRCH:** If you had this product, how would you determine the payoff that you're hedging against?

**FROM THE FLOOR:** That would be determined by if you're going to have some strike level and whatever your scenario says at maturity—whether it's a real-world or a risk-neutral framework. I'm going to have some payoff that's based upon, say, a put—so the strike minus whatever the index level ends at.

**MS. BURDEN:** You raise a good point. You've described that well. But the key is for things like variable annuities. I will speak from the direction of variable annuities, because that's where most of my experience is. Say that what you have is a guaranteed minimum income benefit (GMIB). You've sold them a put option on the fund. It has a strike price that's equal to something that you've calculated, but the

issue is that the person can choose whether or not to elect. At any point in time, your payoff is not only dependent on a particular time to maturity, but whether or not at any of these years that the policyholder could elect, he does elect. In order to appropriately decide what sort of hedge assets you need or the sensitivity of those expected cash flows to changes in the market, you have to make a basic assumption of whether or not the policyholder will elect it this year or not. Financial economic theory tells you risk-neutral valuation for derivatives based on market prices. It doesn't talk much about policyholder behavior or the appropriate way to use policyholder behavior. But when you're trying to value a GMAB or GMWB through FAS 133, you must have some assumption regarding that.

**MR. MARK EVANS:** I'm responsible for hedging equity-related risk for Aegon USA, Inc. I will address this gentleman's question. If you're hedging, you will be using risk-neutral scenarios. If you use customer behavior based on a real-world scenario, then if you actually exhibit a given path, you'll be under-hedged. If you are hedging, you want to use risk-neutral account values to drive your customer behavior. Let's say that customer is 10 years into the future, viewing even further out into the future, say another 10 years out. That customer, at that point in time, is going to have a real-world view of the future. If you want to put that into your hedging model, fine. That's purely a matter of judgment. However, when that customer is 10 years into the future, and you're hedging, he needs to have a risk-neutral account value, not a real-world account value. What is the reason for that? The reason for that is that if you assume real-world behavior along that given path, which is a risk-neutral path, then whatever path you actually experience while you're hedging will be mishedged. No one knows. And that's a fair statement about what view the customer will take when looking into the future. When you're hedging, there's no unknown. The customer's behavior needs to be based on his risk-neutral account value at that node. Expectation beyond that is an area of judgment.

**MS. BURDEN:** That's a valid point. When we're using policyholder behavior in our models, we're calculating the in-the-moneyness of the guarantee. The determination of the in-the-moneyness as a guarantee definitely could be set on the policyholder's expectation of his payoff in the future, which is not necessarily a risk-neutral expectation of that payoff. I agree with that. I find your comments interesting and valuable, because I'm in the process of doing some analysis of running shadow scenarios and determining results that you get. More disagreements with that are welcome. I'd like to hear what people have to say about it.

**MR. DOUGLAS L. ROBBINS:** I have thought about this quite a lot. Actually, in a session that I'm going to, I'm going to use a crazy example to show what goes wrong, either way you look at it. Talking about a GMAB instead of a GMIB, I think that you can shed some light on what the market would be valuing. A market typically sells just a put option guaranteed to be exercised at the end of the period. I think that you said that. A GMAB only is exercised if the policyholder is still around

or if his entire fund is still around. So the question is: What premium would the market put on the lapse option? That's the behavior that we're trying to determine when we are valuing it at the beginning of the waiting period or anywhere in the intermediate. I think that it's fair to say that, although this isn't necessarily a good thing from a GAAP standpoint, if you do risk-neutral valuation on the behavior function, you're conservative. Your liability will be higher. If anything, it will be higher than it needs to be, not the other way around. That said, can I ask you just one question? When you are modeling that sort of behavior in a GMAB, beyond the aspect that the policyholder has to stick around long enough to collect the guarantee, do you see any uncertainty in the fact that they can move funds around into various sub-accounts that perform differently than indexes you are hedging with?

**FROM THE FLOOR:** Yes, there is. It's more irrational policyholder behavior. I don't know that there's a lot of that going on between the different options, at least from what we see.

**ROBERT NELSON:** I have spent the last 10 years on the dark side, because I'm in investment banking and securitizations. One of the things that's a little confusing in the conversation is that we keep mixing up liquidity with price. When you say whether or not someone would exercise the option, you're not saying that the person has to exercise the put and demand their money. That would be a liquidity event. But the value is still the same. He may choose to hold that instead of taking his cash. So when you have a policyholder that has an in-the-money put, it's a perfectly rational choice to keep that vehicle. To me, there's a big difference between the liquidity and the price. If you're saying that you're trying to protect liquidity, and you want to do a worst-case scenario, what if everyone exercised? How much commercial paper would I need? That is a different exercise than saying what the value is.

**MR. IRELAND:** The particular nature of the option policyholder is having isn't necessarily European. It's really an option that they can exercise virtually any time over the life of a very long contract.

**FROM THE FLOOR:** They can exercise it at any time they want. It doesn't mean that I can't value on a risk-neutral basis. It's not to say that everyone will turn in their mortgage because rates went up. That's not the assumption. You need to know that before you do your investment strategy. If you're picking an investment strategy, that may mean that you have a call of \$7 billion. You should know that.

**MR. IRELAND:** Isn't a lot of that related to the fact that there's been so much securitization of mortgages that the people who work in that business are highly competent in terms of the way cash flows will change in response to changes in interest rates?

One of the things that we haven't touched on, so far, is the need for stochastic-on-stochastic models. We know that these are required for C-3, Phase II, RBC. And we know that they will be used for VA CARVM work. I hope you could explain for us the purpose of a stochastic-in-stochastic model.

**MS. WIRCH:** "Stochastic-in-stochastic" means that you project your liability along the scenario. At each time step in that scenario, you complete a nested stochastic valuation of that liability. For example, I want to know what my mark-to-market liability value is one year from now. First, I have to project the liability forward for one year. This projection has to be stochastic, because the ending-fund value depends upon the dynamic behavior of the policyholder and upon the random market movements. You have to do that stochastically. For each of these one-year projections, I have to perform a stochastic valuation to get my mark-to-market liability value.

**MR. IRELAND:** Do we need this for every line of business? Are there some applications for which a simple model is good enough?

**MS. WIRCH:** Slide 35 shows a chart that helps to identify some of the applications that should be done using stochastic-in-stochastic models. To support this type of modeling, distributed computing really is a must. Many companies in the United States already are supporting this with distributed processing.

**MR. IRELAND:** Are these stochastic scenarios real-world or risk-neutral?

**MS. WIRCH:** It depends upon whether or not you're hedging. If you aren't hedging, you would project your block of business along a real-world market path, and you really don't need stochastic-in-stochastic for this. Although, if accounting regulations require a risk-neutral determination of these cash flows regardless of hedging, you probably would use risk-neutral. If you are hedging, you would use a real-world on the outside loop to project your liabilities. And then, as the internal loop, you would use risk-neutral to determine the cost of your hedge.

**MR. IRELAND:** But, say I wanted to use stochastic-in-stochastic to evaluate whether I should use one hedging strategy over another. The way that you've just described it, that wouldn't be possible, because risk-neutral value doesn't depend on the hedging strategy. It assumes constant rebalancing, no transaction costs, i.e., perfect hedging.

**MS. WIRCH:** I agree. Fundamentally, risk-neutral valuation relies upon the concept that there exists a portfolio that will replicate exactly the payoffs of the option under all possible scenarios. This assumes complete and efficient markets, no frictional costs, and the ability to rebalance continuously.

**MR. IRELAND:** I think that, in a way, that's my point. Perfect knowledge of demographic changes or the existence of risks that can't be hedged means that

risk-neutral price is an imperfect measure to value the guarantee. There are a number of risks that can't be hedged easily. Any nonfinancial risk, such as the risk of fraud or mismanagement, cannot be hedged. But there also are insurance risks, such as mortality and persistency risk, that are not hedged easily. Risks that cannot be hedged will affect the ultimate cost of our liability. Risk-neutral valuation can't account for this extra cost easily.

**MS. WIRCH:** Minimizing the net gain and loss is done by selecting the appropriate hedge asset and the appropriate trading strategy for those assets that will offset best the market-related movements of the guarantee value. However, the net gain or loss still will be affected by the unrealized policyholder-behavior assumptions and changes in the guarantee value, due to unhedgeable risks. What I see is that the real cost of hedging is not just the risk-neutral value, but also the remaining variability that comes from not having a perfect hedge. If I want to analyze what this remaining variability is, I would need to look at how the hedging program actually performed in the real world over time. For example, say you have sold the liability with an embedded option, and I plan to calculate the sensitivity of that option value on a daily basis and purchase an asset portfolio that has the same sensitivity. To analyze this program, I must simulate all of these steps.

**MR. IRELAND:** That sounds like a complex objective. You also have to take into account transaction costs.

**MS. BURDEN:** As well, in a real-life hedging program, you would have tolerance levels for your sensitivity mismatches. Within those tolerance levels, you wouldn't execute any trades. This would help control the effect of your transaction costs.

**MS. WIRCH:** All of those are important. The type of projection model that I'm thinking of must be stochastic-in-stochastic. That simulates real-world stock prices, interest rates, and volatility movements, in addition to the actuarial assumptions that control the roll-forward of the in-force. At each time step, several full stochastic, risk-neutral liability-option valuations are needed. You have to calculate the appropriate sensitivities of your liability to market movements. This is because you have to simulate the purchase of hedge assets. If you're going to base your hedging program on using futures contracts to manage the delta (the risk of the move in the stock price), maybe you'll use the five-year at-the-money put options to manage vega (the risk that there's a change in the volatility of your stock). You would have to know the delta and the vega of the liabilities and of your hedged assets. You would want to simulate tolerance limits—an equity market move of 5 percent or a vega mismatch of, say, \$100,000—and transaction costs. If your liability and assets had a delta or vega mismatch outside of those tolerance levels, then you would purchase appropriate balancing assets, incur transaction costs, and rebalance. Over the next time step, the markets would move in some fashion. And both your assets and your liabilities would change in value. The difference in this change in the perfect hedge would be zero. In reality, we would have some non-



zero value. These gains and losses, combined with the transaction cost, is your real hedge cost.

**MS. BURDEN:** This is interesting, but financial economics says that you would have to value this very frequently. What time step do you have in mind for this?

**MS. WIRCH:** For this type of an application, you'd need frequent rebalancing. I would say, probably, no less than weekly.

**MR. IRELAND:** How do you revalue your hedge-asset positions?

**MS. WIRCH:** Asset positions must be revalued at current market conditions. The volatility surface must be projected, as well as the hedge strategy that includes options. Transaction costs have to be incorporated, as well.

**MR. IRELAND:** How do you select the hedging strategy?

**MS. WIRCH:** You would select the hedging strategy based on a risk/reward tradeoff. You want to trade off cost versus a reduction in volatility. We use graphs to show the comparison of the variability expected in our quarterly profit-and-loss (P&L) statement for one of our products under the three hedging strategies. For a different product, we directly were able to show the difference in the net present value and in the variability caused by the implementation of a hedging program.

**MR. IRELAND:** How are you analyzing the income-statement P&L? For FAS 133 liabilities, I have to write down any change in the fair value of my liabilities into my earnings. But Standard of Practice (SOP) 03-1 is different, and several of my liabilities fall into that category. How will hedging affect those liabilities?

**MS. WIRCH:** SOP 03-1 introduces a mismatch between the value of the liability written into the accounting statement and the market-consistent fair value. Typically, SOP 03-1 liability is less sensitive than the fair-value measure. You should model all of the market-sensitive elements of the income statement, including the deferred-acquisition-cost unlocking and fund-management fee revenue, in addition to the change in the SOP reserve. Then, you can analyze the net effect of hedging on a GAAP income volatility. Some companies choose to hedge the economic value of the liability and accept the GAAP statement volatility, because, really, they're most interested in having the right amount of money when the payout is triggered. Other companies are more concerned about the GAAP volatility and have chosen to hedge only 50 percent of the market movements in order to match the hedging strategy to the income statement better.

**MR. IRELAND:** C-3, Phase II, is a big concern for companies issuing variable annuities with guarantees. It's been suggested that these methods that have been applied to these products may become a reality for other lines of business. The purpose of C-3, Phase II, is to identify the tail risk in the product, not just the

guarantee. The NAIC gives us this set of prepackaged roll-up scenarios, along which we calculate the accumulated surplus for each year in the life of the product. For each scenario, we take the present value of the lowest accumulated-surplus measure at the end. The average of the lowest accumulated-surplus measures in the worst 10 percent of scenarios becomes their RBC contribution. How do I reflect hedging in the RBC calculation?

**MS. WIRCH:** If you reflect hedging, you will likely reduce your tail risk and therefore reduce the level of volatility of required capital. Now, how to do it: If we look at C-3, Phase II, without hedging, the accumulated surplus measure is going to depend upon the cash flows in each period along a real-world scenario. Stochastic-in-stochastic models aren't necessary. If we include hedging, what we are including in the surplus calculation are the cash flows that are coming out of the hedging program. In order to calculate these, we have to illustrate setting up a hedge-asset position at each time step and then calculate the payoffs and transaction costs associated with these assets. To do this, we have to calculate the appropriate sensitivities of the liability to market movements—that means your delta, your rho, and your vega, and things like this. This requires a stochastic-in-stochastic projection. The outside loop shows the prepackaged, real-world scenarios from the NAIC. The inside loop shows enough risk-neutral valuations to calculate the appropriate delta, vega or rho measures of the liability.

**MR. IRELAND:** Have rating agencies or regulators issued any guidelines in terms of how much they'll reduce RBC if a program is in place? Can we get full recognition of our hedge?

**MS. WIRCH:** Full recognition, no. There is no written guidance at the moment. However, at a recent C-3, Phase II, seminar, this topic was addressed. Any current hedge position must be reflected in the RBC calculations. Future hedge positions expected to be held may be reflected under certain criteria. You must have a clearly defined hedging strategy, which means three things. It must be defined in an investment policy adopted by the board. It must have been implemented effectively for at least three months, although you can use mock hedging to cover that. And it must be within the guidelines regulating the use of derivatives for hedging. The amount of credit you may take for your hedging strategy will be made on a company-by-company basis. The regulators are going to expect that you will perform both stochastic-in-stochastic valuation as well as test a variety of stress scenarios. For example, you might test actual market conditions on "Black Monday," October 1987, or from September 11. You might make up severe, longer-dated scenarios to see how your program performs over the long term. If you rigorously test your hedging program and find that, in all cases, it's between 87 percent and 96 percent effective, you might choose to reflect about 85 percent of your hedging in your RBC calculation. Ms. Burden and I have been working on a number of examples of this methodology. I'll let her explain some of the applications that we've looked at.

**MS. BURDEN:** We took 1,000 scenarios, and calculated the average P&L over 30 years. Slide 48 shows the results. And this would be an example of a stochastic-in-stochastic calculation. This would be backed up with some statistical measures. It's important to note that this model is of the entire product. It's not just the embedded option. C-3, Phase II, requires that you model the entire product as a whole. The hedging cash flows are only one part of the projection.

Slide 49 shows an example of a stress-test scenario. At the bottom, we have an equity market return that was negative 25 percent for four years. On top of that, we had a 200-basis-point decrease in interest rates. This should be a worst-case scenario. The goal was to see how the fair value of the liability would have changed, versus how the futures and swaps that were being used for hedging would have changed. The orange line shows the increase. The fair value of the liability would have gone from about \$10,000 to more than 10 times that. The company, at that point, probably never would have recovered from that. But they were testing a strategy that was semi-static. They had large options and swaps holdings, too. They were using dynamic hedging. We see some futures in there, as well. We see that this would have worked extraordinarily well even in this very bad scenario, showing that an appropriate hedging program is truly robust enough to withstand even very dire situations.

If you perfectly could reflect your hedging program, what would they have expected to see for total reserves in capital for the RBC? Based on a variety of statistical tests, such as the ones we've described, they had determined that they could take credit for about 80 percent of this hedging program.

**MS. WIRCH:** Are there any questions or comments?

**MR. ROBBINS:** I just want to clear something up. The statement was that if you have RBC, C-3, Phase II, testing and you're hedged, you need to do stochastic-in-stochastic. But if the situation is that your hedging program is to buy static hedges at product issue and not do anything else, that's not really true.

**MS. BURDEN:** You are correct. The C-3, Phase II, reads that if you have a current hedge position, you must reflect it. But if you can reflect it without stochastic-in-stochastic, that's fine. If you want to do a dynamic strategy to reduce your RBC, then you have to.

**MR. EVANS:** Actually, the RBC requirements do not require stochastic-in-stochastic modeling even with dynamic hedging.

**MS. BURDEN:** That surprises me.

**MR. EVANS:** If you read the main document carefully, in the modeling of hedging section, it talks about two different approaches to modeling hedging. One is stochastic-in-stochastic, but it also mentions that you can use other methods. A

specific alternative will be proposed in the practice note, and it does not involve stochastic-in-stochastic.

And it's not really complex. The basic idea is, as you were mentioning, you have your hedge effectiveness. If you have 80 percent credit, you simply would run your American Academy of Actuaries scenarios through your RBC models and ignore 80 percent of your claims that are related to minimum guarantees. Take that out of your model, and, at the end of the process, simply add your option cost to your total asset requirement (TAR). There are a few additional details, but that's the basic concept. And that will be an acceptable method for getting credit for hedging under RBC.

**MS. BURDEN:** One of my colleagues spoke with Larry Gorski at the C-3, Phase II, seminar, and he explained that the determination of the appropriateness of the hedge and the effectiveness of the hedge was going to be done on a company-by-company basis and that some level of modeling would have to support their assertion of the effectiveness. I'm not that familiar with all of the details. I will find it interesting to see what methodologies companies used over the next few years and how successful they are with the regulators using the alternative methodology versus a stochastic-in-stochastic methodology. Can they predict appropriately their effectiveness and have it recognized?

**MS. MARY HARDY:** The two-tier stochastic simulations, computationally, are very intensive. I wonder if you wanted to make any comments about the use of variance-reduction techniques. Or do you just slam through it? Do you cut down the number of scenarios?

**MS. BURDEN:** That is a good question. We use distributed computing to support all of our projections, so that we have analyzed the use of a variety of variance-reduction techniques. Control variant technique was one that we looked at. Say we have several thousand options that you're trying to value. We simply use a crude Monte Carlo and different scenarios for each option. We get a price that converges very quickly over a block of options, much more quickly than you would get if you actually were trying to value each option separately. If you look in aggregate, and you're trying to hedge in aggregate, we found that crude Monte Carlo was perfectly sufficient for our needs without introducing any of the headaches that can come with reduction techniques. Through the use of distributed computing, you always can throw more computers at the problem. At some point, that might stop working. But at the moment, we don't use them.

**MS. HARDY:** In your slide presentation, you have shown everywhere the net present value of the hedge approach to be lower than the net present value of the unhedged approach. I'd agree in terms of the expected present value. But if you're allowing for the cost of capital, if hedging reduces your tail risk, which it should do and therefore reduces your capital requirement, then, if capital costs you money, surely the balance will depend upon your risk-discount rate and the cost of capital.

**MS. BURDEN:** That is true, and the examples that we showed did not reflect that. The difference really is coming from the purchase of options having transaction costs. But we weren't reflecting the different discount rates.

**MS. HARDY:** I didn't want to give the impression that you always lose by hedging.

**FROM THE FLOOR:** I'm in a group that looks at the education strategies. You may know that Black-Scholes financial economics has been removed from the syllabus. We're trying to put it back in. Can you tell us what you think all actuaries would need to know about financial economics?

**MS. WIRCH:** In my work, I have to know it all. There's no aspect that I have been able to forget about or ignore. I was an academic for five years. I've only been at John Hancock Financial Services for about a year-and-a-half. In my year-and-a-half, I have had to evaluate all of the stochastic models that are available outside, as well as inside John Hancock.

Manulife Financial has purchased it. So now, I've had to go through most of that company's stochastic models. In a group that I joined, we do studies on credit derivatives. We look at our credit risk. We look at our mortgage experience. We look at everything. So in terms of my knowledge of any kind of financial economics, if I had a hole in what I knew, I had to find out what it was. SOA Course 8 and Course 6 help a little bit. But based on what I needed to know or what I now know, with a year-and-a-half-in the industry, it would have been nice to have a whole lot more.

**MR. IRELAND:** I think that all of the types of products that insurance companies sell, basically, are loaded with embedded options. I think that for an actuary to apply financial economics successfully, he will have to be able to identify those options and measure them. Whether or not the company chooses to hedge all of those options is another question all together, but they should know that they exist, because, in my experience with insurance companies, I don't think that there's a company in the world that has enough reserves and enough patience for income volatility to ignore the problem and figure that it all will work out in the long run.

**MS. BURDEN:** I'm working with Milliman, Inc., to bring variable annuities into the European marketplace. I'm seeing a different perspective over there, but probably an exacerbation of some of the problems that we first encountered when we were talking about risk-neutral valuation and hedging of embedded guarantees five years ago when the markets were still strong. Even at a very high level in the company, people are not familiar with the concepts of risk-neutral valuation. They don't understand its applicability, have a lot of difficulty believing that it's essential to hedge these types of guarantees, and, in the United States, we've gotten past that point. In the longer run, if similar situations come up for which there is new financial-economic theory and we have a set of actuaries who have not learned it

and don't have the background to understand it without doing a lot of research on their own, that's not good. Twenty years from now, the student actuaries will be in senior management positions. I find a lot of value not only for the people who actually will be working with these embedded options or who'll be running hedging programs, but, in general, to train the population of actuaries in these concepts, to teach them about their availability, about the theory of it, so that 20 years from now, they have a good foundation and a good background.

**FROM THE FLOOR:** Is it possible to incorporate a regime-switching model with a risk-neutral model?

**MS. BURDEN:** It is. Typically, if you're trying to get prices that are completely consistent with current market prices, you're trying to price a block of options with market-consistent prices, as of today. You, typically, would take an implied-volatility surface, and use a local-volatility model, if you're running a Monte Carlo simulation, because that would be the easiest way to reflect the current volatility structure without substantial calibration. You definitely can use regime-switching lognormal models, even in a risk-neutral framework. The goal is to set your parameters for switching between regimes and your volatilities of each regime to calibrate back to market price.

**FROM THE FLOOR:** We're all dealing with a lot of stochastic models, a lot of "black boxes." In your real-world work, how do you see ways to make things more open, visible, in terms of what's going on with the models? What are you doing?

**MS. WIRCH:** I think that we all will have to use them. I think that there are some models that are a little more transparent than others. The one-factor model is a lot easier to explain than a two-factor model, so some people like that better. But in terms of if you want to get the right answer, I think that the best thing to do is to have an expert, someone who understands these models, explain them to people who don't understand them. I don't think that it's good to have black boxes, but sometimes not everyone can know everything. We need to have a basic knowledge of the different type of models that we could use and then have an expert explain what it does and the key underpinnings of the model. I think that's the most important.

**MS. BURDEN:** Say, for example, that you were using some Monte Carlo local-volatility model. It was too difficult to look into the model or read the code and understand, but you can price a variety of things, and you can test, one-by-one. If I add this lapse function, I would expect that it would increase my hedging cost. Does it really increase the hedging cost? By how much? Is that realistic? An extensive variety of tests of the model can help you look into a black box without actually trying to read the code.

**FROM THE FLOOR:** I wanted to comment on this whole real-world topic, for a moment. We keep talking about real-world assumptions like there's something

carved in stone or they have magic attached to them. But let's view real-world assumptions for a moment as risk-neutral plus risk-premium. Is that a fair way to look at them? Nobody really knows what that risk premium is. A lot of people have said that since we don't know what that risk premium is, let's use historical returns. Let's drop historical equity returns into our real-world models. The point that I would like to make is that if you go with this risk-premium idea for a moment, we're looking past history. Recent historical periods have much higher risk-neutral interest rates than what we have today. Because of that, is using historical returns for today's real-world modeling assumptions standing on shaky ground?

**MS. WIRCH:** Actually, it is a great concern, when you're looking at parameterizing real-world models. You have to answer a lot of questions about what data you use. What are your assumptions, and what are they based on? Some of the biggest problems that we have is that there isn't enough historical data on some of these things.

When setting long-term investment assumptions, if you look at a block of business like long-term care, you project out about 80 years for some of this business. In your projections, you are going to assume some alternative assets. You're going to have some equity. You might have some private equity. You might have some hedge funds. If you take hedge funds, for an example, are you going to assume the 11 percent that some of these things have had? These hedge funds are supposed to have no risk. In a very recent history, they appear to be returning a risk-free rate. It's not guaranteed. You have problems there. And if you also take a perspective of 100 years back, you have significant differences in the indices or how the indices were created, what the indices are comprised of. The markets have changed considerably. If you look at the way real-estate indices were calculated 20 years ago, the information in them was a lot less than what you have now. So using the whole history on that index makes it very difficult to get a grasp for what you should put into your model in today's world.

**FROM THE FLOOR:** I think that any realistic evaluation of, say, the NASDAQ index at the peak of the bubble, would have to argue that, at that point in time, risk premium was negative. I'm not saying that it was negative because of what's happened since then. I'm just saying that for any reasonable stock valuation, how are you going to come up with a zero-to-positive risk premium? That didn't make any sense. I want to emphasize that this whole concept of real-world scenarios is a big guess. I'm not saying that a risk premium doesn't exist. But if you will sell these things, you better know what will happen if, for some reason, risk-neutral ends up applying to you. If you have to hedge all of the risk, what's that going to mean to you? In those situations, real-world will not do you any good.

**FROM THE FLOOR:** My reaction is to the transparency issue. Say, for example, I price an annuity product, and I did the risk-neutral valuation. My computer determined the discount rate that I have to add to LIBOR so that the whole thing works. The cash that I still had left in hand after paying the commission is great. I

came back to the chief risk officer and said that we're making promises that are LIBOR plus 220, so we're a little bit like Champion Mortgage, that's how sure we are. I don't think that the chief risk officer wants to hear that the commitments that he is making to his policyholders are no more secure than a junk bond. But you have to give them that. You have to tell them the duality of the discount rate used. In today's world, that's like being a junk bond. You might want to sell that product. The president may say, "That's who I am. I make promises, and I keep a lot of them." And it's not wrong, but I think that we need to do a better job of communicating to people what the tradeoffs are.

**MS. WIRCH:** It sounds to me, in that example, that the investment division is not telling how to price.

**FROM THE FLOOR:** Once you price the annuity, and you decide how much cash you will collect for the promise, everything is done on that side. Whether the investment department can save your butt or not, I don't know.

**MS. WIRCH:** How often do you reprice?

**FROM THE FLOOR:** Every time you come out with a new product, I assume you do.

**MS. BURDEN:** Earlier, we had a brief discussion about using risk-neutral, versus real-world valuation in things other than equity-type embedded options. There are companies that are looking at hedging the types of interest-rate guarantees. Guaranteed-minimum credited rates can be thought of as an option on the interest rate. So there are companies that are looking at hedging that and stepping beyond the current risk-management framework with taking interest-rate and credit spreads.