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Session 34PD
Generating Economic Scenarios

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David E. Martin
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Summary: A fundamental step in stochastic asset/liability modeling is to choose an appropriate underlying economic scenario generator. In this session, panelists discuss various scenario generation techniques and theories, assumptions underlying interest and equity scenario generators and choosing suitable economic scenario generators for different applications.

MR. MARC N. ALTSCHULL: We're going to be talking about generating economic scenarios. Unlike past years, when we've just talked about generating scenarios, we're going to start off with Ellen Cooper who will speak from the viewpoint of an end user. She's going to demonstrate the need as well as the use for economic scenarios. From there, we're going to hear from David Martin who is going to look at generating scenarios. He's going to start by reviewing the types of models that are out there. He's going to talk about the considerations and methodology in developing long-run assumptions. He will finish with an evaluation of a real world economic generator. Finally, Bill Pauling will talk about modeling credit spreads, including a discussion of defaults and credit events.

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Note: The chart(s) referred to in the text can be found at the end of the manuscript.

We'll have some time for questions and answers. We're going to start with Ellen Cooper who is a senior consulting actuary in the North American Actuarial Services practice of Ernst & Young and is based in the firm's Philadelphia office. She is part of the risk management and value optimization practice and serves as a project manager for Ernst & Young. In her 16-year career, Miss Cooper has developed a broad base of insurance industry experience. She has had extensive experience with variable and fixed annuity, product development, and risk assessment, as in liability modeling and economic scenario generation. Prior to joining Ernst & Young in 2000, Miss Cooper was the unit leader for Towers Perrin's asset simulation unit, which was directly responsible for the development of global CAP:Link, a multicurrency, economic scenario generator. Prior to that, Miss Cooper worked for ALICO, a subsidiary of AIG where she built asset/liability models for ALICO's international blocks of business in Asia, South America, and Europe.

Miss Cooper has extensive experience in areas including project management of software development initiatives including asset/liability modeling, asset/liability management risk assessment (which focuses on evaluating a company's exposure to financial risk through the use of various approaches to measurement), variable annuity risk assessment designed to address revenue volatility and guaranteed benefits exposures, variable annuity product development, and investment strategy development.

MS. ELLEN EICHENBAUM COOPER: Although I do have economic scenario generation building in my background, I'm going to talk about the question that I frequently ask myself and that our clients frequently ask us. It is how do I know that I'm pushing the right buttons? What happens if I push a different button? Am I getting the right answer? How do I know that I have a result that is credible? So what I'm going to look at are two examples of the ways that we can use scenario generation. What I want to focus on is thinking about the fact that we generate scenarios as a tool, not necessarily as the answer. If we come up with a duration that's three, it doesn't necessarily mean that it is set in stone that our duration is three. It's a tool. We have to be careful to make sure that we analyze the tool and use it appropriately. So if you come away with that, then you've basically heard the lesson.

I'm going to spend the most amount of time just talking about how I calculate the effective duration of a deferred annuity portfolio. We're going to look at some examples of that, and how the result changes if I change assumptions in my economic scenarios. Then we're going to move to just a quick example for completion, because I wanted to talk about equities as well. How would we look at the embedded value of a variable annuity portfolio on a stochastic basis.

How am I going to know which buttons of my generator I push? For one thing, I'm going to call David, and I'm going to call Bill. I'm going to say, "You guys have the experience; can you help me out here?" Do I want to use risk neutral or real world scenarios? What is risk neutral anyway?" I feel like we all constantly struggle with this. What does it mean? I see this button that has mean reversion. Do I want to use it, and if I do, what am I reverting to? How strong should my mean reversion be if I use it? How many scenarios do I need? If I use 100 is that enough, or do I need 500 or a 1,000 and how do I know? I see this button in most of the generators that are proprietary that I can use to change my random seed. What is that? I'm going to look at some examples of that but David especially is going to address some of the answers to the questions. I'm just going to ask the questions. David is going to answer them. Right David?

MR. DAVID E. MARTIN: Yeah.

MS. COOPER: We need to understand the impact of what we're going to call initial conditions. I've got a starting yield curve. That starting yield curve is going to help me to produce some result. When I do my analysis again, I have another starting yield curve. A piece of my result is going to change, simply because my yield curve has changed. I'm generating scenarios from a different starting place. I need to understand what's going to happen and why when I go from point A to point B. My credit spreads are going to change. I have prepayment speeds, and in the case of a deferred annuity, I have a crediting spread. That's also going to have some impact on my results. To understand the result, I'm going to have to understand the inputs.

We're going to look at just a simple product, assume a new business pricing analysis, where I've got an asset portfolio. I've got 75% of my assets in noncallable corporate bonds. Let's just assume that most of them are investment grade. Some of them are high yield, and I've got a bunch of mortgage-backed securities. So that means I'm going to have to deal with prepayment risk. We're not going to talk about convexity today, but we're throwing in some negative convexity as a result of having mortgage-backed securities in there. On my deferred annuity side, I just have a very simple basic product. I've got a seven-year surrender charge, and I have an initial crediting rate that's pegged to a five-year Treasury plus a spread. Then, as I move forward, my renewal crediting range is going to change as some combination of new money rate and portfolio rate.

For those of us that haven't taken exams in a while, we're going to quickly take a review of what is effective duration, because we're going to move into the world of effective duration soon. What is effective duration going to tell us? It's a measure that is going to basically look at the change in my value of my portfolio. If my duration is three, then I can expect that my value is going to change by approximately 3% if I take a one-basis-point drop.

We're going to look at a starting yield curve scenario, which is what we're calling P not, and I'm going to come up with some initial 25-50 basis point yield curve shift up and down. I'm going to shock the entire yield curve up and down, and I'm going to regenerate my scenarios. Then I'm going to calculate duration based on the formula in Equation 1.

$$\text{Effective Duration} = (P_- - P_+)/(2 \times P_0 \times (\Delta y)) \qquad \text{[Equation 1]}$$

Where:

Δy is a small change in the yield of the security
P_0 is the initial market value
P_- and P_+ are the prices where the initial yield curve is shocked up and down, respectively by Δy, the same number of basis points in both directions.

Let's do a review of durations, so that we can make sense of the results that we're going to take a look at. The duration of a zero-coupon bond is equal to its term to maturity. If my zero-coupon bond is five years until maturity, then my duration is also going to be equal to five. A bond with coupon payments will always have a duration less than its term to maturity.

There's an inverse relationship between a coupon rate and a duration, so if I have two bonds, everything else is equal. I have a high-coupon rate on one and a low coupon rate on the other.

I'm going to have a lower duration on the high-coupon rate because it's going to pay off faster. There's a positive relationship between duration and term to maturity. The longer the term to maturity, the longer the duration.

The next topic is limitations of effective duration. Basically, this is just showing us that we have to take into account cash flow. An instrument would be, for example, the expected amount of cash flow under a level scenario, plus an adjustment for any interest sensitivity. In our case, we have interest sensitivity in our mortgage-backed securities because we have prepayments. If we had callable bonds (which we don't in this example), and deferred annuities, we can expect that will have a negative impact on our duration. It's going to shorten because of prepayments. Finally, regarding effective duration, we're going to look at scenario generation. However, when you look at effective duration, you need to remember that there are some limitations in terms of its measurement. First, we talked about the yield curve and shock up and shock down. That's a parallel shift and we know that that's not realistic. It's not really the way that it happens. You need to worry about whether or not the shape of your yield curve is going to change and whether or not you have to worry about convexity. In this particular example, we're going to assume that credit spreads are fixed from the beginning of the projection period. Bill is going to address the fact that it's not realistic. Credit spreads don't stay fixed. Bill is going to talk about dynamic credit spreads and how they can change as your yield curve is changing and moving forward.

Table 1 is a simple example. If we focus on the top piece of the duration of sample Treasury bonds, this just drives home some of the points that we just reviewed. As yields increase, duration decreases. For example, from the first quarter term to maturity of five years to the second quarter, the yield curve actually increases. Then, the term to maturity actually will decrease. It is an inverse relationship.

TABLE 1
Duration of Treasury Bonds from Quarter to Quarter

BEY Term	1Q01	2Q01	3Q01	4Q01
5	4.62%	4.97%	3.93%	4.38%
10	4.93	5.42	4.60	5.07
20	5.60	5.91	5.45	5.74

Duration of Sample Treasury Bonds

Term to Maturity	1Q01	2Q01	3Q01	4Q01
5	4.43	4.39	4.51	4.46
10	7.86	7.69	7.98	7.81
20	12.09	11.80	12.23	11.96

1) Note that as BEY increases, duration decreases.
2) A 100-basis-point change in five-year yields changes modified duration by 0.12.
3) A 12-basis-point change in 20-year yields changes modified duration by 0.13.

Duration of Sample Weighted Average Portfolios

	1Q01	2Q01	3Q01	4Q01
20% 5 year/80% 20 year	8.26	8.10	8.37	8.21
3.3% all 3	8.05	7.88`	8.16	7.99
25% 5/50% 10/25% 20	8.06	7.89	8.17	8.01

1) A portfolio of assets keeps the duration more stable from period to period.
2) Change in 10-year rate is the most likely driver of changes in duration from period to period.

We talked about term to maturity and its impact. A 100-basis-point change in the five-year yield will change the duration by as much as 12 basis points in a 20-year yield. So that means that as our yield curve is changing from point A to point B, we have to focus on which part of the yield curve has changed the most and how that will most impact my duration. If I have a bunch of long-term bonds, and I have a small change in my long-term yields, I'm going to see as much of an impact as if I see a large shift in shorter term assets.

Chart 1 shows prepayments from mortgage-backed securities. The line that is on top shows you the increase in cash flow from a 100-basis-point drop. Again, what is the impact here of duration? It's going to shorten the duration of the mortgage-backed security, as we lower interest rates. We expect more people are going to refinance, and we're going to prepay faster.

I'm going to generate my yields. We're going to use a risk-neutral process. We're going to assume 100 scenarios. There is the mean reversion rate and the strength to probability rate. I'm only going to use these pieces when I do a duration calculation, if I want to attempt to weight my scenarios. If I don't want to use an equal weight, I can use some kind of an algorithm to put in my mean reversion rate and my strength to probability. I can come up with a probability weight of scenarios. I'm going to assume a shift size of 50 basis points. David is going to answer all the questions about why I chose those answers. From now, I'll say David told me to as the reason why I did it.

I'm going to calculate the duration of my asset portfolio. It is a plain portfolio. The first thing I do is take my base scenario. I have a starting market value, so I already know my market value is $108,426. I'm going to shift my yield curve up, parallel, and I'm going to generate new scenarios. I'm going to come up with the average market value. If I'm not probability weighting, I'm going to look at my 100 scenarios, and I'm going to come up with, based on my shift up, an average market value of $106,419. I'm going to do the same thing for a shift down. Then I'm going to plug the numbers into the formula and come up with a duration of 3.78. I don't really know yet what that means, but we're going to find out.

We would do a down scenario and take it based on the initial yield curve minus the 50 basis points at the model start date. We're only going to look at the asset portfolio at the model start date. We're going to do something a little bit different for liabilities. Does that answer your question?

It's a 50 basis point shift up and down and a new generation of scenarios. Yes. The initial curve has shifted.

We're going to do the same thing for our liability duration. The difference here is that we're actually going to project the liability cash flows along the paths, and we're going to discount them back at the short-term Treasury rates or short-term risk-free rate and come up with an average value. When we do this, we come up with a duration of 2.66. Now I have to analyze these results. I have a 3.8 duration of my assets and a 2.66 duration of my liabilities. Is this reasonable, and what does this mean?

We talked about going from Point A to Point B. I changed my yield curve. We've got a duration of 3.78. I changed my yield curve from Point A to Point B. The duration goes up. So what does that tell me? It tells me that I've got a yield curve that must have gone down somewhere. I need to look at it and determine whether it makes sense? I'm going to go from point A to point B. Does that make sense? Is that reasonable? I refresh my asset credit spreads to current spreads, and I refresh my prepayment assumptions. Again, I increase my duration, so I've decreased my credit spreads. Is that really what happened? Is that my input, and can I properly interpret this result?

Likewise, I'm going to do the same thing on the liabilities. I've changed my yield curve from last quarter to this quarter, and I see the impact there. I revised my asset credit spreads and my prepayment assumptions. My prepayments, in the low-yield environment, have become so low that my prepayments are very quickly prepaying. As a result, I'm re-investing in lower yielding assets. I've got a lower portfolio yield. Therefore, I'm crediting less. I have lower liability cash flow. As a result, I have a much lower duration. Is this a reasonable result? Do I agree with this or not? In this particular example, my prepayments are happening so quickly that maybe this environment isn't an appropriate environment for mortgage-backed securities. Maybe I need something that can give me more certainty in my cash flow. That is because I can't work with a duration mismatch that is so wide.

The other question is, do I have the right scenarios? Have I produced the right set? Table 2 demonstrates that if I want to probability weight my scenarios, and I use different reversion rates and different reversion strengths, I can come up with really an interval of duration numbers on my liability side. If I shift the parallel yield curve up 25 and down 25, or up 100 and down 100, I'm going to get a different answer. My boss wants my duration target to be less than one. So I'm going to have a shift size of 25 basis points instead of 50. Then I'll have the right answer. Have I really produced the right result? Is there a right answer? Do I need to look at an interval rather than a point? Likewise, when I discount back my liability cash flows, should I assume an option or just its spread? What should it be? If I assume nothing or 60 or 120, I'm going to get a different result. Which one is the right answer? I'm not going to try to answer the question today. I'm just going to ask the questions.

TABLE 2
Effective Duration as an Interval Rather than a Point Estimate—Some Sensitivities

Mean Reversion Rate	Reversion Strength	Annual Volatility	Duration
2.00%	10.00%	18.00%	3.05
4.00	10.00	18.00	2.89
5.00	10.00	18.00	2.84
1.70	10.00	18.00	3.09
1.70	0.60	18.00	3.25

Shift Size	Duration
25 basis points	3.06
50 basis points	2.84
100 basis points	2.64

Spread	Duration
0 basis points	2.94
60 basis points	2.84
120 basis points	2.71

In the interest of time, I'm going to move to a quick example on the variable annuity side, just so that we can hit on equities. Bill is going to touch lightly on equity, as well.

In this particular example, I have a whole different case entirely. Now I'm going to look at what my boss wants to know: what is the value of my variable annuity block? Should I look at it stochastically or deterministically, and how different are the results? If I look at it stochastically, and if I look at a range of different possibilities over a period of time, how does that compare to my deterministic projection based on some deterministic interest rate going forward of my separate accounts and discounting back at some constant rate? How is it different? When I look at that, have I looked at it under the proper set of scenarios? If I change my scenarios, does my stochastic set still fall within a reasonable range compared to my deterministic or does it not? In this particular example, I'm going to use 500 real world scenarios because this model runs faster than the deferred annuity models. I can produce more scenarios. I'm going to use long-range conditions, so I'm going to use mean reversion, and I'm going to revert to some kind of long-term average. What should the long-term average be? David is going to talk about that too. Should I look at a long-term average of the equity markets over the last two years? Should I look at it since 1926? What should the answer be? How does it reflect my results?

Table 3 shows my assumptions. These are the assumptions that I used to do some historical time series. I picked a time interval. I've gotten standard deviations and total returns and a correlation over a ten-year period. If I did this over a five-year period, or a 20-year period, or I looked at rolling averages of standard deviations and total returns, I would get a different answer. That's where I'm going to get a different result. I'm not suggesting that there is a right or wrong answer; I'm just suggesting that we need to understand what we're putting into the model, so that we're comfortable with what's coming out.

TABLE 3
Capital Markets Assumptions

	Standard Deviation	**Total Return**
Stock	14.40%	8.75%
Bond	8.54	6.02
Money Market	0.79	4.75

Correlation Matrix	**Stock**	**Bond**	**Money Market**
Stock	100%	34%	–5%
Bond	34	100	20
Money Market	–5	20	100

- Present Valuing done using static 8.75% discount rate.
- Capital Markets Assumptions for stochastic runs shown above.

Here's my result in Chart 2. The horizontal line is my deterministic result. I've made an assumption. I'm going to project at X%, and I'm going to discount back at a static 8.75%. Here's my range of stochastics based on the assumptions on the previous table. So my mean is lower than my deterministic result. Am I comfortable with this, or should I look at alternative scenarios?

Chart 3 shows my results on a year-by-year basis. The grey line represents my mean and the black line is my deterministic result. My mean is basically done on a year-by-year basis, always below my deterministic. Do I need to change my deterministic, or do I need to change my assumptions?

I chose some stochastic scenarios to take a look at. There are a whole spectrum of things that we could have looked at and tested, but just as an example, some of what I *focused on* was changing the mean equity growth. Instead of assuming, on average, equity was going to grow at 8.75%, I looked at shifting it up and shifting it down, so that, on average, my scenario is going to give me 9.75% versus 7.75%. In Chart 4, we see that the black line, especially on the poor scenarios, gives us a much better result. It gives us a tail that's nearly as severe. The yellow line gives us a much worse set. The question is, how do I rely on my results? What kind of conclusions can I draw? I'm going to leave it to David and to Bill to try to answer some of those questions.

MR. ALTSCHULL: Next we're going to hear from David Martin. David is an assistant vice president within the Insurance Advisory Service Unit of Conning Asset Management, where he's involved in the development of models, in particular, capital markets, economics and simulation models used for asset/liability management (ALM) and dynamic financial analysis (DFA) applications.

Prior to joining Conning, Mr. Martin was an assistant vice president with Swiss Re Investors Asset/Liability Management Unit. Mr. Martin is a graduate of the University of Michigan, with a BS in actuarial science. He's an Associate of the Society of Actuaries and a member of the American Academy of Actuaries, as well as a Chartered Financial Analyst (CFA).

MR. MARTIN: As Marc said, I work for Conning Asset Management. We are a third-party asset manager. I work in our investment advisory division where we offer asset/liability management (ALM) solutions for life clients and DFA analysis for property/casualty clients as a value-added service for our existing asset management clients.

I'm in charge of our asset model, our economic simulator. It's a proprietary model that feeds scenarios into our actuarial systems for both life and P&C work. I'll give a brief overview of the model. It's a cascade model, where we project out economic variables such as inflation, real GDP, government interest rates, corporate spreads municipal yield ratios, and economic variables that produce stock returns, such as price/earnings (P/E) ratios, earnings growth and dividend payout ratios. With those underlying economic variables, we can produce capital market returns. One of the salient features of this kind of model is that the underlying economics are consistent with the capital market returns. If you use a mean variance model, sometimes the economics that are implied are unrealistic. But my presentation mainly addresses the aspects of scenario generators that actuaries should consider when they use them.

I will go through a brief review of two model types—pricing models—and real world models and discuss their differences. The main topic that I want to talk about is how to develop long-run mean assumptions for economic variables and capital market returns. I'll go through our assumption "buildup" process as of December 31, 2001. I'll step through that a little bit. Then, after we've developed our assumptions and generated our scenarios, I'll talk about ways to evaluate the quality of the scenarios.

The two most common applications for which people use scenario generators are pricing and risk analysis. These are two different applications, which require different types of models. It's important to use the right model for the specific application. Pricing models are used to price both assets and liabilities. Risk analysis models are used for ALM, investment strategy, regulatory solvency, and capital adequacy.

Pricing models are used to value interest rate derivative securities, calculate market values, and can be used for duration analysis. They focus on today's current value at time t equal to zero. Pricing models are calibrated to replicate a set of traded bonds and options in the market. They are arbitrage-free and risk neutral.

Risk analysis models are used to project economic capital market scenarios out into the future. We are concerned with the distribution in the future. It could be a distribution of scenarios or a distribution of cash flows that you are interested in. We are interested in the full distribution, unlike pricing, which looks at the average of the distribution.

As Ellen said, she uses them for her embedded value for variable annuities. The important features of risk analysis models is that they produce realistic scenarios. The parameters that are used to calibrate them are based on statistical regularities in the historical data. We look at the historical data of the variables we are modeling to understand the dynamics and the distribution of these variables over time. Then we parameterize the model so that the simulations reflect these dynamics.

Before we move on, I'd like to make a brief comment about risk-neutral scenarios. Essentially risk-neutral means that every asset class has the same expected return as opposed to the real world in which people are risk averse and require more return for taking on more risk. Different assets have different expected returns and different risks. Think of it simply as a convenient mathematical environment that prices securities fairly. The problem with using these scenarios for risk analysis is that the scenarios it generates tend to follow the forward rate curve, so it produces flat yield curves on average in the future. If you look historically at yield curve shapes, they generally exhibit an upward sloping shape. So risk-neutral scenarios may be good for pricing, but not necessarily good for risk analysis. The key point is to choose the right model for the job.

Now that you've chosen your model, how do you parameterize it? Our goal is to figure out what we want these yield curves to revert to over time. Before we do this, we must take a look at where we are today. At December 31, 2001, we were in a pretty steep yield curve environment (Chart 5) where the term premium, which is the long government rate minus the short rate, was about 3.75%. So that's a little bit wide on a historical basis. I don't show an inflation rate, but in 2000, the inflation was around 1.9%. If you used that as an expected level of inflation, the real returns on the short end would have been negative. Both these features tell us that things are not necessarily in equilibrium.

The actuary is left to choose some long-run reversion targets for economic variables. It depends on the purpose of the analysis. Looking at pricing scenarios the long-run expectations are already chosen for you, and the scenarios follow the forward rate curve. It might not necessarily be what you want for your risk analysis models. For ALM and strategic asset allocation, the challenge is to minimize bias in the scenarios. That's really hard to do, because no matter what you choose as a reversion target, you bias the scenarios. So your choices are to revert to the way things are today (initial conditions), or to revert to something different.

The "initial conditions" argument states that today's value goes to the best estimates for future values. Practitioners used to think that if you revert to initial conditions, then you're not making a call. You're not saying rates are going up, and you're not saying they're going down. Today's environment is just as good of a guess as any, so why not use it as your long-run target. That was thought to be unbiased. The problem with this approach on December 31, 2001, when yield curves were abnormally steep, is that your simulations would have steep average yield curves.

The "initial conditions" approach may be a nice sensitivity test, but for the baseline run we would revert to more normative conditions and take a market-neutral perspective. When setting our expectations for the future, we combine an historical perspective with the consensus forward-looking viewpoint.

I'll just go through our process quickly. We call it our "buildup" approach. Instead of focusing primarily on interest rates and returns, we focus on inflation real return, which is the short rate minus the expected inflation rate, term premium, which is the spread between the long government bond yield and the short government bond yield and the equity risk premium. We try to stay consistent with valuation adjusted historical data. I'll talk a little bit about what we mean by that later. Basically, we attempt to de-trend the historical data. For example, equity returns in the last 25 years have been fueled by a P/E valuation growth that may not be sustainable.

We also try to reflect a forward-looking view of economic and capital market expectations and uncertainty. We don't rely on history alone.

Let's start with our buildup approach. The first thing we target is the expected level of inflation. We use 2.5% as our baseline inflation target in Table 4. The historical data indicates that inflation rates have been quite a bit higher than the 2.5% expected rates. This is a case where you can't use history solely as your guide. You have to impart some forward looking viewpoints. It can be argued that the Federal Reserve Open Market Committee (FOMC) practices indirect inflation targeting through monetary policy, with a goal of keeping inflation in the 2-3% range—a range thought suitable to encourage a healthy, growing economy. That doesn't mean inflation can't go to the moon, but remember, we are talking about expected levels.

TABLE 4
Developing Long-Run Assumptions

	12/31/01	Expected Levels	Historical		
			1961-2000	1981-2000	1991-2000
Inflation	1.90%	2.50%	4.40%	3.58%	2.66%
+ Real Returns	–0.16	2.00	1.80	2.78	2.12
Short-Rate	1.74%	4.50%	6.20%	6.36%	4.78%

Next, we look at real returns which is the short rate minus expected inflation (Table 5). We target a 2% real return. If you look at history, you'd conclude that this is a reasonable target. We're not saying that this is the only choice; anything between 1-3% could be justified. Two percent sounds good. There is an economic theory that supports having a positive real return. If real returns were zero, investors would basically consume now and buy things because their investments aren't going to keep up with inflation. That would drive the prices down and drive the yields up. It would get you back to higher yield and higher real returns. So you add the 2% to 2.5% and you get a short rate of 4.5%.

TABLE 5
Developing Long-Run Assumptions

	12/31/01	Expected Levels	Historical		
			1961-2000	1981-2000	1991-2000
Inflation	1.90%	2.50%	4.40%	3.58%	2.66%
+ Real Returns	–0.16	2.00	1.80	2.78	2.12
Short-Rate	1.74%	4.50%	6.20%	6.36%	4.78%
+ Term Premium	3.74	1.75	1.10	1.81	1.70
Long-Rate	5.48%	6.25%	7.30%	8.17%	6.48%

Now we have to come up with a term premium. This is the long government rate, which is the 30-year government yield, minus the short rate (three-month yield). You might want to use the swap curve or a maturity shorter than the 30, because 30-year government bonds are no longer issued. We assume a term premium of 1.75%. Again, this value is in line with history. This is a market-driven variable, as investors demand a term premium to compensate for liquidity and inflation risk. There are a lot of theories about what the compensation is for, but as strategic modelers, our job is not to theorize, but to come up with a reasonable expectation that generally reflects history and is in line with consensus.

This is what our yield curve progression would be in our model, starting at the initial yield curve. You can see the short rate has reverted pretty quickly to four, over three years, and then it kind of drifts off (see Chart 6). Our model has dynamics that control the mean reversions, and I'll talk a little bit about dynamics that you need to look for in a model later.

The last piece of our buildup approach is the controversial equity risk premium (Table 6), which, when added to the risk free rate produces equity returns. Our risk premium that we're using is 3.75%. What is equity risk premium? It's the incremental return you get for going into the stock market vs. bonds. We're using the S&P 500 for our equity proxy, and the long government rate for our risk-free rate.

TABLE 6
Developing Long-Run Assumptions

	12/31/01	Expected Levels	Historical 1961-2000	1981-2000	1991-2000
Inflation	1.90%	2.50%	4.40%	3.58%	2.66%
+ Real Returns	–0.16	2.00	1.80	2.78	2.12
Short-Rate	1.74%	4.50%	6.20%	6.36%	4.78%
+ Term Premium	3.74	1.75	1.10	1.81	1.70
Long-Rate	5.48%	6.25%	7.30%	8.17%	6.48%
+ Equity Risk Premium	N/A	3.25	5.00*	7.75	11.38
Equity Return	N/A	9.50%	12.30%	15.92%	17.86%

* Historical equity risk premium drops to 3.7% after removing the impact of non-sustainable increases in equity valuation levels.

If you relied solely on the history, you would argue for quite a large equity-risk premium (Table 6). Closer inspection of the historical data indicates there are characteristics of P/E ratios that have accompanied the bull market of the last 25 years that may not be repeatable (sustainable) in the future. In particular, over the past 25 years, P/E ratios have increased dramatically from 8 to 30, and they're in the 30s and 40s now. To have the same type of returns in the future, really would say that P/E ratios have to go from the 30s now to 60 in the future or earnings must increase tremendously. I don't think anyone really wants to put that in a long-run expectation. We try to strip these nonsustainable trends out of the data.

After we remove those nonsustainable increases, the historical equity risk premium is about 3.7%. Add this to the long rate and you get 9.5% for an equity return.

Finally, we come up with the rest of the assumptions for the model (Table 7). We have a real GDP growth. And the variables that generate our equity returns: P/E ratios, equity earnings growth and dividend payout ratios. We also have corporate spreads. They all have reversion targets, as well.

TABLE 7
Developing Long-Run Assumptions

		Expected	Historical		
	12/31/01	**Levels**	**1961-2000**	**1981-2000**	**1991-2000**
Inflation	1.90%	2.50%	4.40%	3.58%	2.66%
+ Real Returns	–0.16	2.00	1.80	2.78	2.12
Short-Rate	1.74%	4.50%	6.20%	6.36%	4.78%
+ Term Premium	3.74	1.75	1.10	1.81	1.70
Long-Rate	5.48%	6.25%	7.30%	8.17%	6.48%
+ Equity Risk Premium	N/A	3.25	5.00*	7.75	11.38
Equity Return	N/A	9.50%	12.30%	15.92%	17.86%
Real GDP Growth	N/A	3.00%	3.45%	3.23%	3.25%
P/E Ratios	25	18	16.5	18.29	24.00
Equity Earning Growth Rates	N/A	6.00%	7.70%	7.67%	10.48%
Dividend Payout Ratio	40%	50%	49%	48%	48%
Corporate Spread					
– Short Spread	80 bps	75 bps	N/A	N/A	74 bps
– Long Spread	120 bps	125 bps	121 bps	142 bps	120 bps

* Historical equity risk premium drops to 3.7% after removing the impact of nonsustainable increases in equity valuation levels.

I have one point on the earnings growth rate assumption. We are assuming a 6% equity earnings growth rate. There are a lot of economists who say that earnings in the equity market cannot grow faster than the economy (as proxied by nominal GDP) in the long run. If you add our 2.5% inflation rate to our 3% real GDP growth rate, we get approximately a 5.5% nominal GDP growth rate. Compare this to our 6% earnings growth rate, and we believe we are consistent in our assumptions.

Now that we have come up with the long-run expectations, we're ready to run the scenarios. Once the scenarios are generated, how do we know they make sense? You can't just buy into what I've been saying or blindly trust actuarial software manufacturers. So you want to try and verify these scenarios for yourself. There are three questions that need to be answered. Are the distributions and dynamics of the variables reasonable? History is a good guide for the dynamics. Are the interrelationship between variables, plausible realizations of events. For example, in a particular simulation, if your inflation rate is high and volatile, but the short-term interest rate is low and steady, you may have a problem. This would not be plausible. The third question is, does the range of variables span all conceivable economic environments? For the most part, the distribution should look similar to the historical distribution. Even though inflation is targeted at 2.5%, inflation should be able to go negative in some scenarios.

Now two methods I use to calibrate our model are methods you can use to evaluate your scenarios. The first method is to choose a basic set of statistics that describe the important properties. We use 500 statistics, and we weight them according to importance. The key statistics are volatility, correlations, and serial correlations. But you don't want to just rely on statistics alone. So what you also want to do is look at the scenarios that you're simulating. I like to look at them string by string sometimes. So eyeball them, compare them to the history, and make sure that the dynamics are making sense.

Chart 7 shows historical yields from 1960 to 2001. It shows the three-month yield and the 30-year yield. It just gives you a feel for what the short and long interest rates have looked like historically. You can see that they kind of meander around. The high is 17.2%, and the low is

2.3%. The 30-year distribution is tighter than the three-month distribution. So you have to reflect some of these dynamics in your simulations.

In Chart 8, I've plotted nine strings from our simulator, and one of them is the actual Japanese short rate—the Gensaki. You want the scenarios you are generating to look a lot like the actual historical time series of the variable you are interested in validating.

Can you guess which string is the actual Gensaki time series? There are a couple of characteristics that would give it away if you know anything about the Japanese economic environment (Chart 9). What really gives it away is the last five years of 0% interest rates. Our model shouldn't generate rates below zero, but they should generate some scenarios that approach zero. Chart 10 shows another scenario from our model. It shows a scenario that has a dynamic that we like to see, especially for our Japanese calibrations. In one scenario, interest rates might go really low and stay there because volatility levels are a function of interest rates in our model. The lower the interest rate, the lower the volatility level. Again, this is a dynamic that you may want to see in your model.

Finally, Chart 11 shows what can go wrong when you just look at target statistics. This again is a short interest rate. The mean is 4%, and the variance is 3%. You would probably never use a mean variance model to simulate interest rates, but we'll just use this as an example. If you're just targeting mean and variance, and if you just broadly look at target statistics, you may miss something. Obviously, you've missed the fact that the dynamics of interest rates are not that choppy, and you wouldn't want that to come out in your scenario generator.

In summary, there are three things I've talked about. One is understand the objective of your analysis and choose the right models for the job. There is pricing versus real world. Second, you need to decide on a set of long-run expectations. The goal is to minimize bias. Sensitivity tests can alleviate some of your concerns with that. Finally, once you have the scenarios, you really should analyze the scenarios and check for reasonableness and not just blindly use a set of scenarios given to you by some consultant.

MR. ALTSCHULL: I'll hand things over to Bill Pauling. He's a consultant in the Towers Perrin assimilation unit located in Philadelphia. He oversees the development of the Towers Perrin global capital market scenario generator, Global CAP:Link, and the Towers Perrin Risk Reward Optimization System, OPT:Link. In addition to the research development in support of these systems, Bill is responsible for the integration of these systems with other Towers Perrin and Tillinghast systems, such as the retirement financial management system, TAS, and TAS PC. Bill has assisted in many asset/liability modeling and asset allocation studies for pension plans and insurance companies in the United States and other countries.

Bill holds a bachelor of science degree in finance from Drexel University in Philadelphia. He's a chartered financial analyst, a member of the Association for Investment Management and Research, and a member of the Financial Analysts of Philadelphia.

MR. WILLIAM PAULING: I'd like to talk about some credit spreads and how we can model them. First, we'll look at the credit spreads and yields and get a sense for the historical record as well as the current environment. Next we'll look at a simple model for modeling the AA credit spread. Finally, we will look at the impact of defaults and credit events on fixed-income portfolios, and we'll have a discussion about how they affect our fixed-income portfolio.

Looking at the historical record in Chart 12, the graph on the left is the credit yield as reported by Moody's. It covers the time period of January 1947 through June of 2002. The credit spreads are shown in the graph on the right. The credit spread is defined as the difference between the credit yield and the yield on the 30-year Treasury bond. That graph covers the historical period, February 1977 through June 2002.

Looking at these graphs, we see that credit yields are near their lowest levels in the last 25 years. Whether you consider that to be a low-yield environment depends on the length of your memory. We see that going way back into the 1940s and 1950s, credit yields have been below 4%. The other observation is that while credit yields are low, credit spreads are relatively high. They're near their highest levels over the last 25 years, and that's a bit of a contrast. Relating this to the current environment, in the second quarter of 2002, we saw the total volume of defaulted debt reach a new high. Some good news is that the total number of defaulting issuers is lower than it was a year ago. In the first half of 2002, we saw four issuers default within one year of holding an investment grade rating. The pace at which the market has been moving has been quite rapid.

There's some bad news out there. Many economists are fearing a double dip recession scenario. The corporate accounting scandals have shaken the public's trust in our business institutions. Unfortunately, there's a threat of terrorism out there, but all the news isn't bad. There are other economists who expect stronger growth in the second half of 2002, and they're saying that the worst might be behind us. The bottom line is that the credit markets are reflecting this uncertainty in the economy and reflecting that through the high credit spreads that we currently observe.

With that as background, I'd like to take you through a brief example of building a model for the Aa credit spread. First, we want to look at the Aa credit spread, which is what we are attempting to model (Chart 13). I've analyzed history, and drawn out some summary statistics. I observed a mean credit spread of 1.08%, a standard deviation of 0.41%, a minimum of 0.39%, and a maximum of 2.09%. Again, this credit spread is the difference between the Moody's Aa rate and the 30-year Treasury yield.

Next, we look at the fitting of the basic equation to model the credit spread. The equation I've chosen models the change in the credit spread. That's the DS on the left-hand side. The first term in that equation is a mean reversion term, where the S bar is the mean reversion target, which is the level to which we're reverting. Kappa is our mean reversion strength. That's the speed at which we'll move toward our target. So in each period, this model will move some proportion of the difference between its current level and its target level, as determined by our strength parameter kappa. The second term in that equation describes the volatility of the model, and that's given by the parameter sigma. The z term is a random term or Brownian motion. Finally, the t, the time step, is one month. You'll see that this equation uses what's called a square root volatility process, and it just means that the volatility is proportional to the square root of the level of the spread.

$$ds_t = K(s - \overline{s}_t)\, dt + \sqrt{s_t}\; \sigma dz_t \text{, where} \qquad \text{[Equation 2]}$$

s	=	credit yield spread
$\overline{s}$	=	mean-reversion target
K	=	mean-reversion strength
σ	=	volatility
Z	=	Brownian motion
T	=	time (1 month)

So I worked with the historical data and that equation, and through regression I determined the model parameters. The regression returned values of kappa 0.0468 and sigma 0.0117. I set the s bar parameter to a forward-looking expectation, as opposed to the historical average. The value I chose of 1.35% is somewhat higher than the long-term historical average, but it is lower than the current level of credit spreads, which is 1.56%.

Finally, I ran this model for 10 years, on a monthly basis, for 100 scenarios. Chart 14 is a summary of the distribution of the results that the model produced. The upper line is the 90th percentile result. The second line is the 75th percentile, and the two middle lines are the mean and median. The bottom two lines are the 25th and 10th percentiles.

To help evaluate this model, I've graphed our simulated results together with the historical experience to help validate the model results (Chart 15). We observe a mean of 1.38%, which is basically what we'd expect, starting out at a relatively high credit spread and going towards the assumed level of 1.35%. The standard deviation and minimum and maximum fit well against the historical results. Ninety percent of the time the credit spread is expected to be below the 2% level, and 90% of the time, it's expected to be above the 0.8% or 0.9% level. So it looks like a fairly good fit to history. To do further validation, we could go through some exercises like David was showing. We could do more investigation on these scenarios, but on the surface this looks like a good fit.

Finally, I would like to discuss defaults and credit events, and consider their impact on fixed-income portfolio returns. A very useful tool for helping us to analyze this is a transition matrix. Moody's publishes a transition matrix in their annual default study. The left-hand column in the matrix describes the original quality of the bond. Each column in the matrix describes the quality of the bond at the end of the year. This is the one-year, long-term average matrix, which is one of a number of matrices that Moody's publishes. This matrix describes the transition probabilities over a one-year horizon. If we have a A bond, there is an 89.01 chance that it will remain a A quality. There's a 4.68% chance that it will be downgraded to a Baa, and there's a 0.01% chance that it's going to default.

There is a column for ratings withdrawals. Those usually happen due to mergers or acquisitions. We could adjust the matrix for withdrawn ratings, but in my examples, I haven't done that just to make all the numbers match. Many practitioners would use an adjusted transition matrix for their analysis.

The transition matrix for 2001 demonstrates that it was a particularly bad year, especially for the A and lower qualities. Default rates reached decade highs in the year 2001. The all corporate rate reported by Moody's was 3.7%. For speculative great debt, the default rate was 10.2%. However, as bad as it was, the probability of default on investment grade debt was just 0.17%. That's an exceptionally bad year. Looking at the transition matrix can help us understand where the risks are in our bond portfolio. Another point to make is that bonds can upgrade as well as downgrade, and we can see the associated probabilities by looking at the matrix.

With that tool, we can think about how different credit events impact portfolio returns. I may define the term credit event differently than some others might. A credit event is any change in the credit quality of an issuer. The worst type of credit event is a default. When we have a default, the impact on the portfolio is due to the price of the bond, which will fall dramatically. Depending upon the portfolio manager's expectations, he might choose to realize the loss. If he does, a significant capital loss will impact the portfolio that period.

Another type of credit event is a downgrade to a lower quality rating. In that case, the bond price will fall. A capital loss will be produced, and it will be to the portfolio manager's discretion and the investment policy as to whether that loss will be realized or not. Of course, the news isn't all bad. There is also some possibility for an upgrade to a higher rating for all but the highest quality level. In that case, the bond price will rise, and we'll have a capital gain.

I wanted to look at a comparison of a couple of credit risk metrics that are commonly used. The first credit risk metric is called the credit loss rate. You may already be familiar with this statistic. It is a basic downside risk statistic where the credit loss rate is defined as the default frequency, which is the probability of default, multiplied by one less the recovery rate, which is the loss on default. This statistic gives us an indication of the loss of principal due to defaults.

Let's review an example of calculating a credit loss rate on A-rated debt. This example uses the Moody's 2001 transition matrix. The result is the credit loss rate for a pretty bad year. I'm assuming also a recovery rate of 40%, which is close to the long-term historical average. For the year 2001, assuming a recovery rate of 40%, we would see a credit loss rate on A-rated debt of 10 basis points.

The next statistic is called credit event risk. This is defined as the sum of the product of all the transition probabilities, the credit spreads, and the portfolio's duration. The second term in the equation is the same as the credit loss rate. You can think about credit event risk as being an extension of the credit loss rate, where we are considering all the transition probabilities. So the credit event risk gives us a measure of loss associated with downgrades, as well as defaults, net of the gain associated with upgrades.

Let's review an example of calculating credit event risk. We will assume a five-year duration, a A-rated portfolio, the use of the Moody's 2001 transition matrix, and spreads as reported by Lehman Brothers. Your handouts have an appendix that gives you more background and details on the actual calculation. The credit event risk works out to 65 basis points. We know that the credit loss rate was 10 basis points, so there's another 55 basis points of losses associated with credit events that are not captured by the credit loss rate. These losses are attributable to downgrades. This calculation uses a more complete set of information from the transition matrix than just the probability of default alone.

To sum up, credit spreads are near the highest levels in the last 25 years, and reflect the uncertainty of the current economic environment. I presented an example of modeling credit spreads. Possible applications of such a model might include calculating an effective duration or projecting the performance of an asset portfolio. Finally, we looked at the transition matrix, and we saw that while defaults are a concern, downgrades are actually a more significant risk to investment grade portfolios. We can use the transition matrix to better understand those risks.

MR. ALTSCHULL: Thanks Bill. And now we get to the audience participation part of our program. I have one question. Many of my clients always have a question about the deterministic versus stochastic scenarios. You mentioned it a little bit in your session. What are your feelings on projecting across deterministic and stochastic scenarios? Which one do you use when?

MS. COOPER: I think the time to use stochastics is when you need to understand your volatility. If you have a traditional nonparticipating life product, and you do stochastic analysis, you're probably not going to get a very interesting result. If you have a variable annuity product, and you have 12 different classifications of sub funds (international, small cap, large cap, bonds, money market), and you have risk in things like guaranteed minimum death benefits (GMDBs) and guaranteed minimum accumulation benefits (GMABs), you'd probably want to understand how volatility is going to impact your result. I think it always helps your perspective to look at some deterministic scenarios in terms of answering what if questions and in terms of making a best guess. It helps to understand the range of stochastic scenarios that you've generated. It is sort of like the example that I showed.

MR. PAULING: I would add that it is helpful to look at deterministic scenarios first. You can build a model, and you can run some deterministic scenarios through it, but if you don't understand those deterministic scenarios, there's no way you're going to understand what goes on when you switch the model over to stochastic. It can be good to actually validate the model, and help get a basic understanding of the dynamics and set you up for the next step, which is stochastic.

MR. MARTIN: In our work, stochastic simulations are used for ALM work. Stochastic is not the only way, but we use that predominantly. When we pick strategies off of the efficient frontier, for instance, risk and reward may help you pick the optimal strategy, but you also want to look at downside risk. Many of our clients are concerned with what kind of scenario is going to make them insolvent. So I think it's pretty important, at least in our work, that you focus on the distribution of results from stochastic simulations. As Ellen said, it is nice to look at a particular scenario and see what's driving your results. When looking at the tails of the distribution, you can dig down and you see what scenario is causing that, and that can be pretty useful.

FROM THE FLOOR: I used to work with Accept RE Life Insurance Company as the risk manager of the company, and I've been using stochastic modeling and stochastic scenarios. In my work as a risk manager, I use the stochastic scenarios for pricing, for calculating the readjusted capital, embedded values and so on. If I want to understand the product, I use a deterministic scenario. If I want to stress test all my results, I use the Nikkei Scenario, the 1987 scenarios, and the historical scenarios of 1926 to 1936. These scenarios help you to fully understand what would happen if this kind of scenario would occur in the future.

FROM THE FLOOR: Do you have any suggestions on how to pick representative scenarios in cases where you have complex modeling and where corporate integration and leverage has to be considered?

MR. PAULING: That is something that we have looked at on the pension side. We have something that we have developed that looks at matching summary statistics for a set of 5,000 scenarios and tries to get a best fit to those by using 100 scenarios of the 5,000. It's something that we continue to research.

FROM THE FLOOR: Are you focusing on the economic scenarios themselves as representative or the impact that they have on say product loads?

MR. PAULING: The primary focus would be on the asset class returns, and to a lesser degree, the economic scenarios.

MR. MARTIN: Are you asking, how do you choose a good set from 1,000 scenarios, for instance, that represents the thousand? How do you get the same distributional characteristics of the thousand?

FROM THE FLOOR: Do you focus on rates themselves, or do you focus on the impact that you have on those matrices versus the impact on the liability?

MR. MARTIN: To some extent, you focus on the actual economic scenarios and capital market returns, as Bill was saying. It comes down to doing enough work with the particular problem you're looking at or to see when you get a convergent solution. If you use a different random seed to produce another 500 scenarios and you start to get a similar solution, then you might have the right number of scenarios. For every application, there might be a different number of scenarios. There are techniques to get a better set of distributions, like a quasi-random number or low discrepancy sequences. You can get a representative set, but you still need to run the whole model to really get a good view of whether it's the right amount of scenarios.

FROM THE FLOOR: I have a question for David. It's about the generation of interest returns and equity returns. Thank you for informing us about the components of these returns. You have an inflation rate, the real return, the shorter term, and you add the risk premium for the long rate to get the long-rate return. Then, to get the equity return, you add the equity risk premium. My first question is, do you generate each component using a stochastic differential equation separately, or do you just equally generate the short rate and then the long rate and then generate by using a differential equation or the equity risk premium to generate the equity return? What's the process?

MR. MARTIN: The real returns and term premiums aren't actually the variables that are stochastically projected. Inflation, interest rates, the equity earnings growth, the P/E ratio, and the dividend pay ratio are simulated. These are the outputs of the model. Our goal is to produce real returns, term premiums, and equity risk premiums that make sense on any expected value basis. Our initial short rate at December 31, 2001 was 1.9%. It reverts to 4.5%. Our initial long rate was 5.48%. It reverts to 6.25%. These rates are going to revert to those expected values over time. After you've reached equilibrium, the expected risk premiums will come out as output of your model. Actually, in the reversion process, when the interest rates go up, P/E ratios go down. This is a relationship between rates and P/E ratios that has been built into the model. So what happens is, when the rates go up, your bond returns kind of get hit but so do your equity returns. This helps to maintain the appropriate correlation. They're consistent, and that's the key I guess. I'm not sure if I answered your question.

FROM THE FLOOR: My question is, when you generate your scenarios, do you use a stochastic generator to generate inflation?

MR. MARTIN: Yes.

FROM THE FLOOR: And you do that also for real terms?

MR. MARTIN: We project the short rate. We don't project the real returns.

FROM THE FLOOR: You're also projecting the term premium?

MR. MARTIN: Again, we're projecting the long rate, and the term premium comes out of that.

This is more about how we build a nice rationale for our expectations, but we don't actually simulate a real rate or term premium. We simulate inflation, interest rates, and equity variables.

We actually simulate those three variables: P/E ratios, the earnings growth rate, and dividend pay ratios. When you combine the three, you get a return. So, if P/Es and growth rates are going up, you can mathematically get an equity return. Those three are stochastic, and they're calibrated to historical data. When you keep P/E ratios constant, on average, equity returns are mostly composed of the earnings growth rate and the dividend yields. Our earnings growth rate is 6%. If you take an average P/E of 20, 1/20 would be your earnings yield, and it would be 5% times the payout ratio of 50%. So you get about a 2.5% dividend yield. When added to the 6% earnings growth, you get a median return of 8.5%. That is what our equity returns would be.

Because of the stochastic nature of returns and the lognormality of equity returns, you get a higher mean. That is basically it. We don't stochastically generate risk premiums. It's easy to target an equity return, but we feel it makes more sense to follow a risk premium type of approach. It ties things together. A 2% real return is kind of a risk premium for going into a short rate. A 1.75% return over the short rate is a risk premium for going long.

FROM THE FLOOR: I understand that. The next question is, how would you differentiate the process of generating the risk-neutral scenarios and the real world scenarios?

MR. MARTIN: The long-run expectation that the risk-neutral scenarios follow is the forward rate curve. That's just by definition. If you have an upward sloping term structure, the short rate is going to start to rise and follow the forward rate curve. So what is going to happen is you're going to have flat yield curves in the future, and it works out great for pricing, but you'll miss some things if you use them for a risk analysis. It just doesn't make sense to have flat yield curves on average.

FROM THE FLOOR: I understand the process of generating interest rate risk-neutral scenarios. Is there such a thing as a risk-neutral equity return?

MR. MARTIN: Risk neutral basically means that every asset class, regardless of real risk, has the same return. There's something called the market price of risk, which is a factor that describes the incremental return, given the level of risk. The market price of risk is zero. So even if you have a risky security (like an equity) or one that is not so risky (like a corporate), they all, in this environment, return the risk-free rate. They don't return zero. But the market price of risk is zero, which is not really the real world, it works for pricing. You have discount rates which are the risk-free rate or risk-free rate plus the spread. The growth rates are the risk-free rate. You grow and you discount at the same rate. Although the growth rate is unrealistic, and the discount rate is unrealistic, the beauty is that they cancel each other out and price securities fairly. In this case, "two wrongs do make a right."

FROM THE FLOOR: The reason why I asked the question is because many of us are pricing variable annuities with guarantees. Most of the assets supporting these products are probably equally related. When you price them, they usually say, use risk-neutral scenarios. When we actually project the account values (the current values using equity returns), are we going to use risk neutral equity returns or real-world equity returns?

MS. COOPER: We've done it, but I'm not sure that I'm comfortable with what we've done. Yes, you can come up with some kind of a methodology to determine what is a risk-neutral process for an equity return. But do you have the right answer? I'm not convinced. I think that you're getting into a conflict between option pricing versus actuarial pricing. How can you really compare and contrast the two? This is a topic for a different session. It is something that I personally struggle with, as well. I don't have an answer for you.

CHART 1
Cash Flows of MBS with Parallel Shock Yield Curve

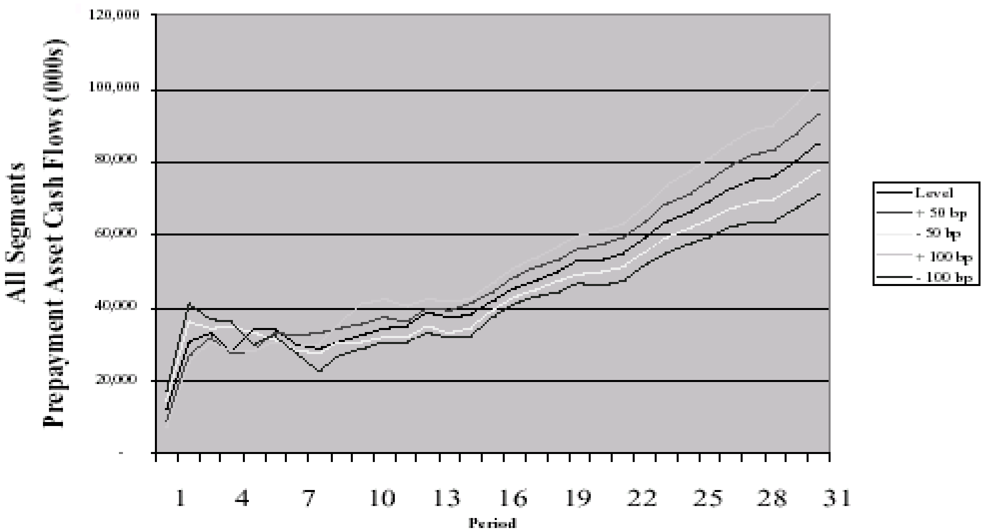


CHART 2
Stochastic Embedded Value

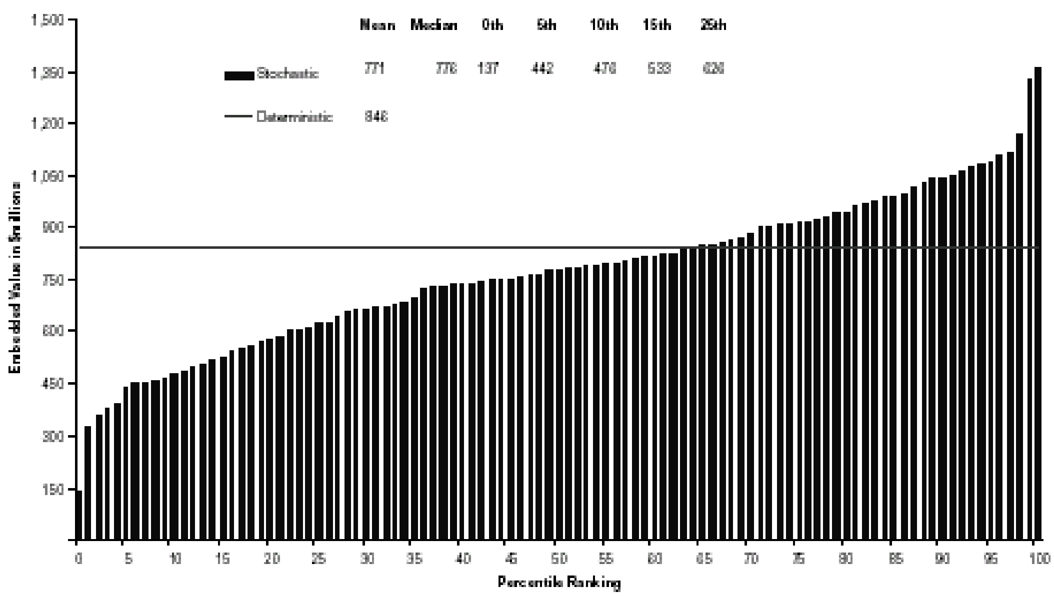


CHART 3
Stochastic EV Results Year-by-Year

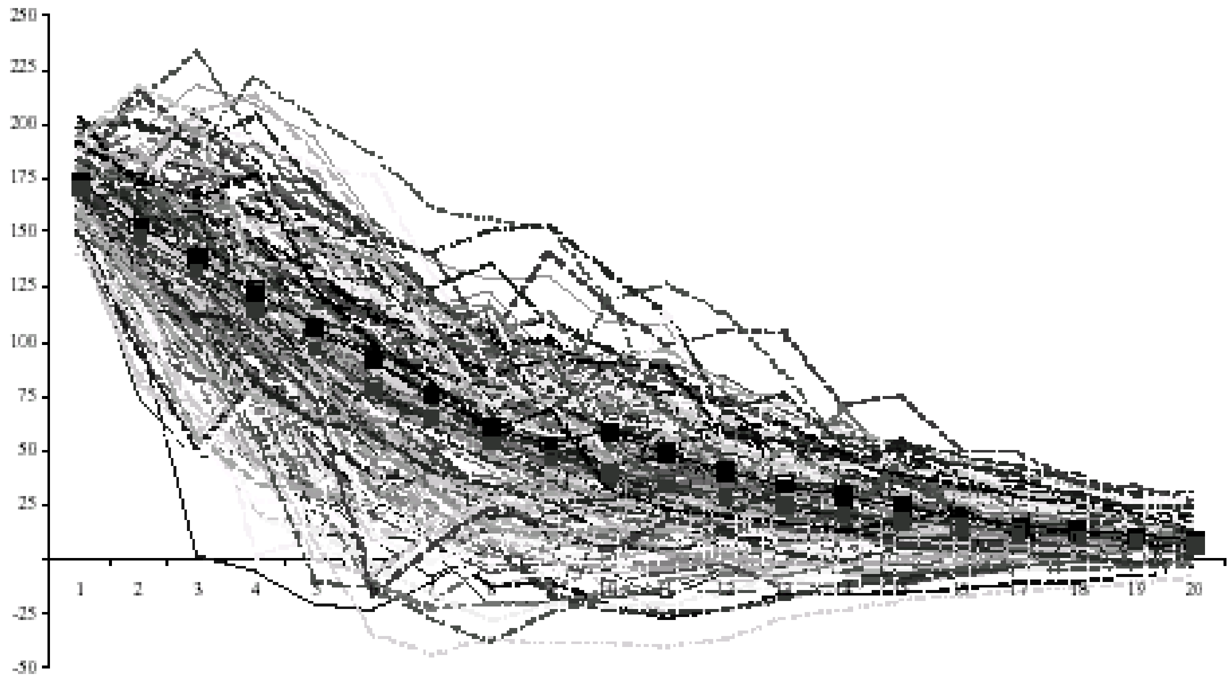


CHART 4
Stochastic Sensitivity Chart

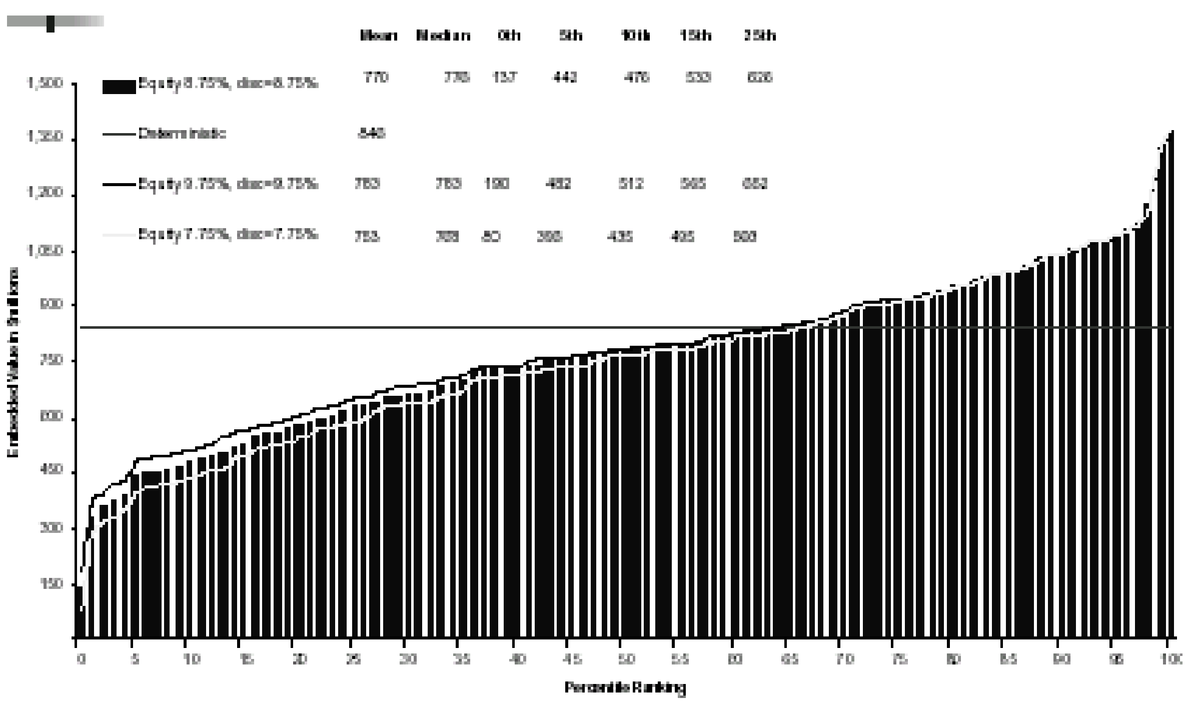


CHART 5
December 31, 2001 Yield Curve

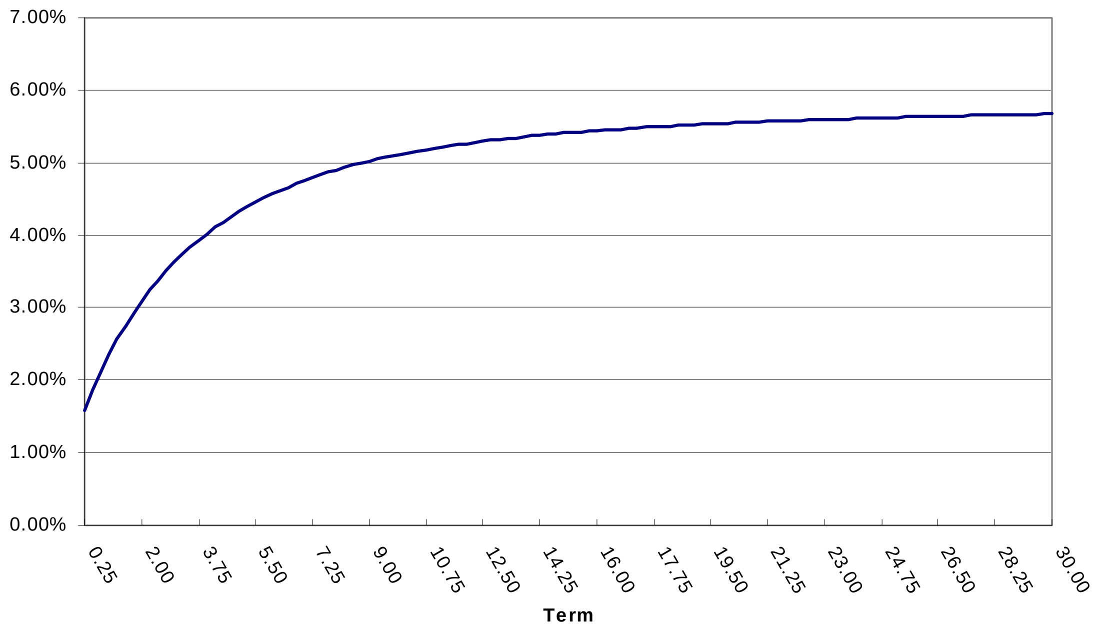


CHART 6
Yield Curve Progression

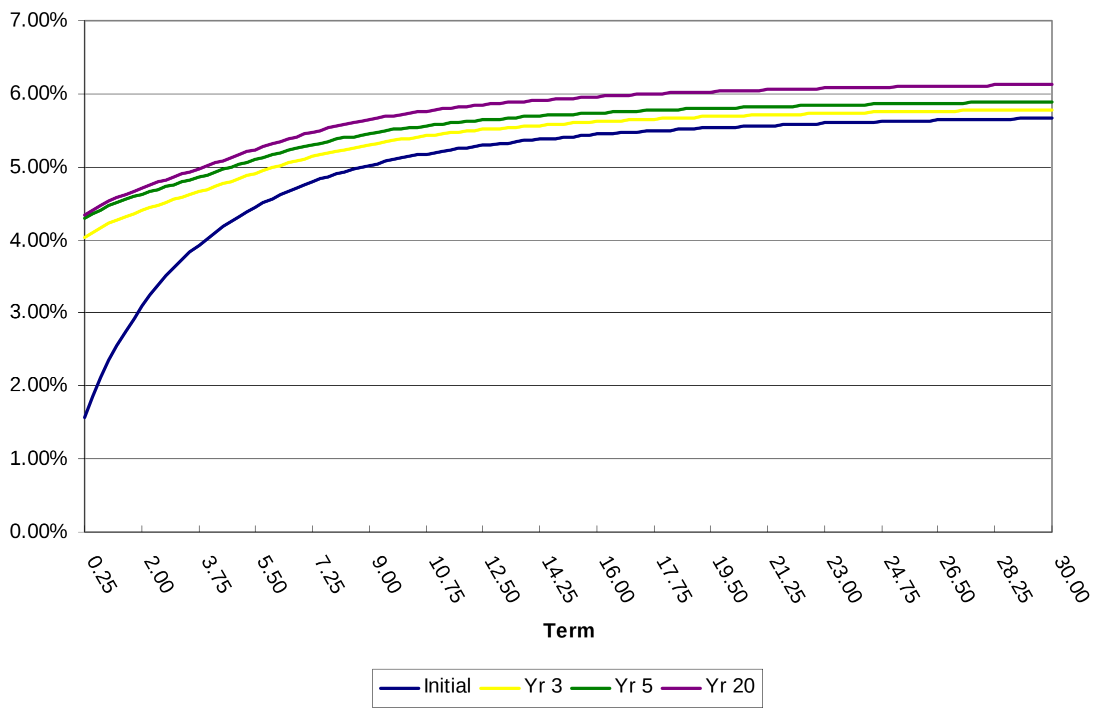


CHART 7
Historical Yields
1960–2001

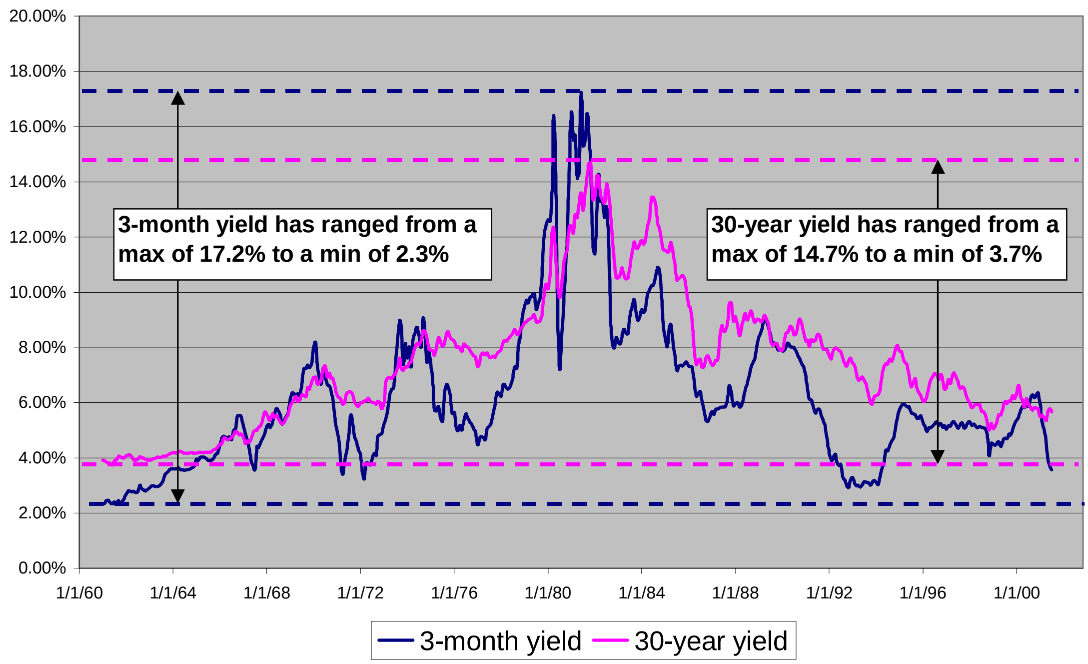


CHART 8
Japan Short Rate–Gensaki

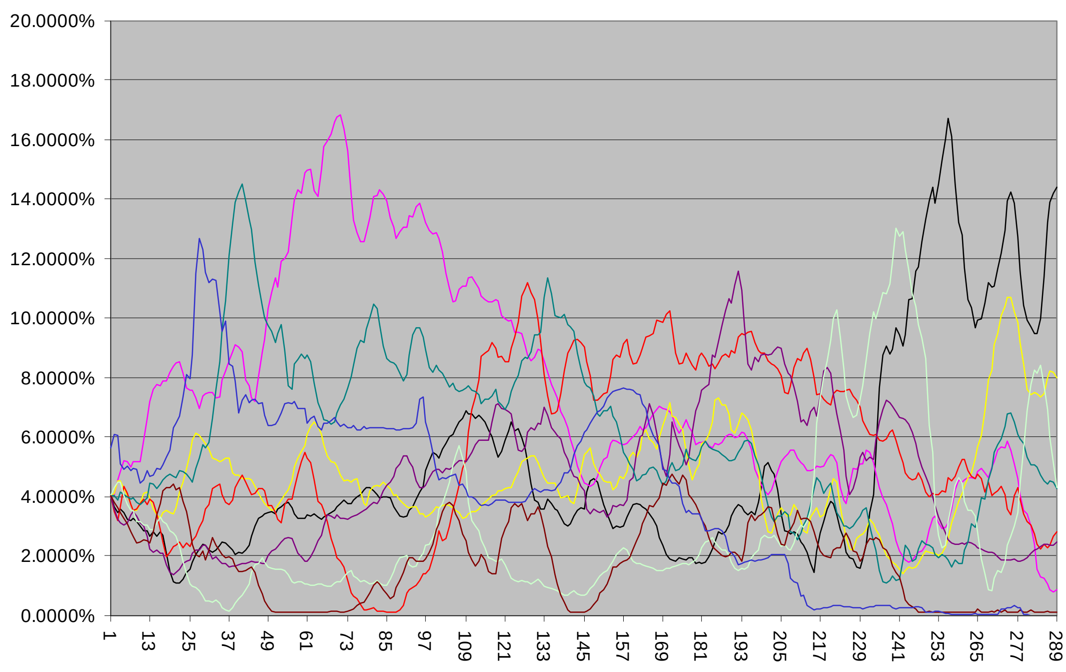


CHART 9
Japan Short Rate–Gensaki

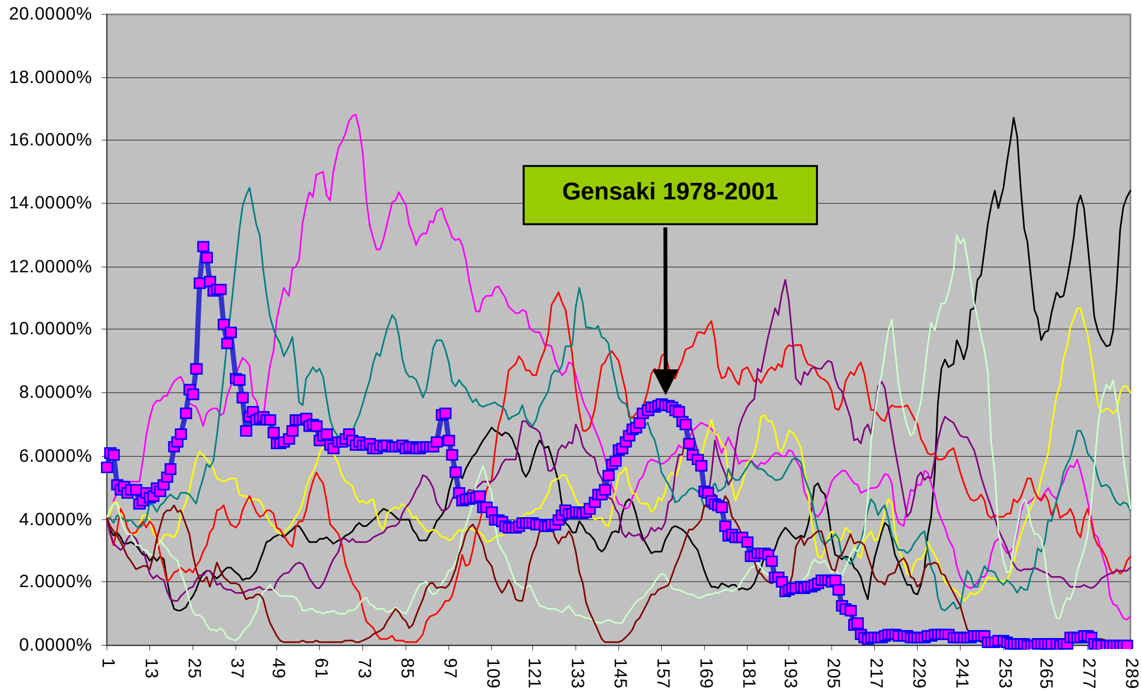


CHART 10
Japan Short Rate–Gensaki

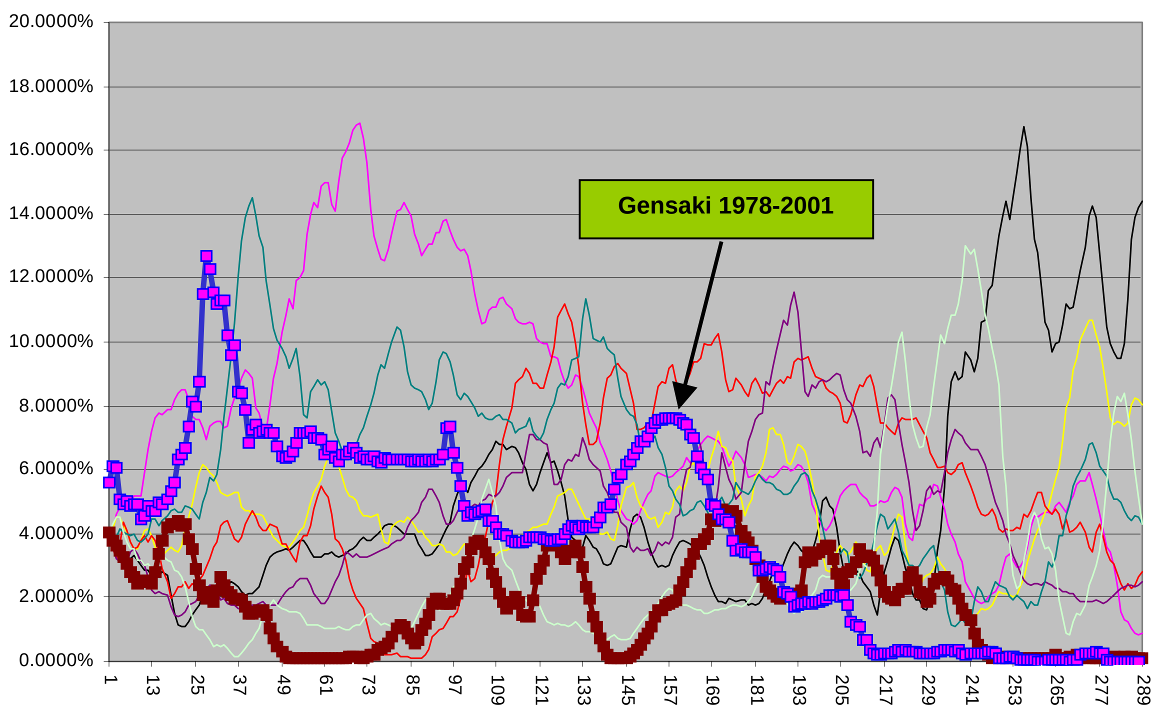


CHART 11
Mean–Variance Model

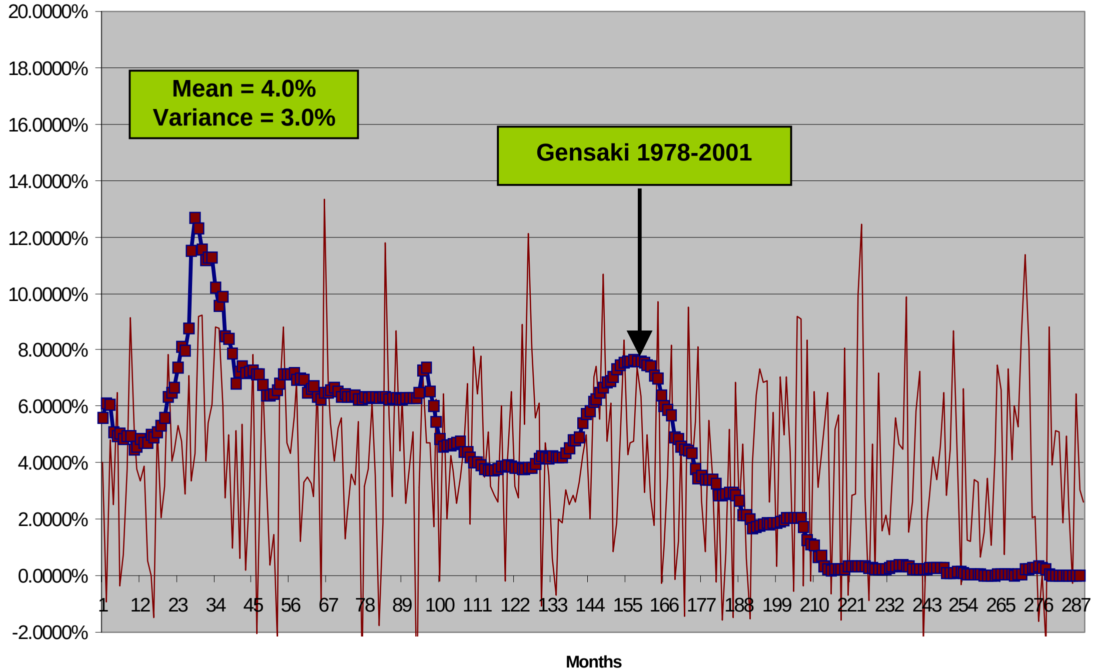
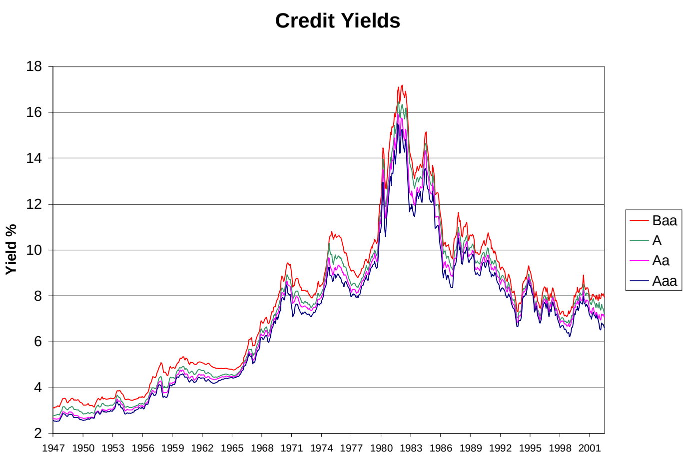


CHART 12
Credit Yields & Spreads: The Historical Record



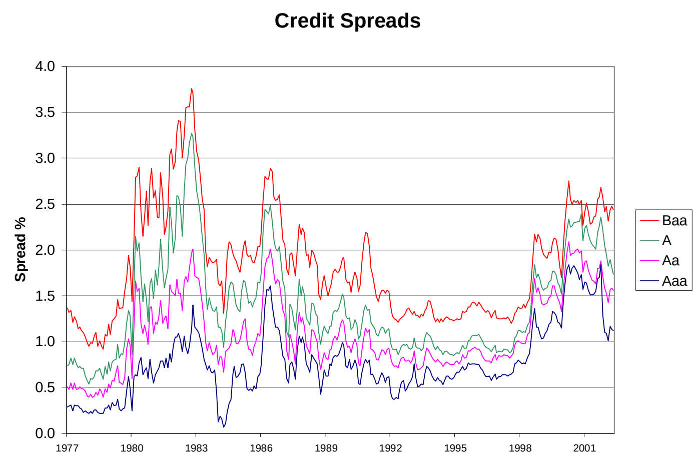


CHART 13
Aa Credit Spread Model Example
Historical Analysis

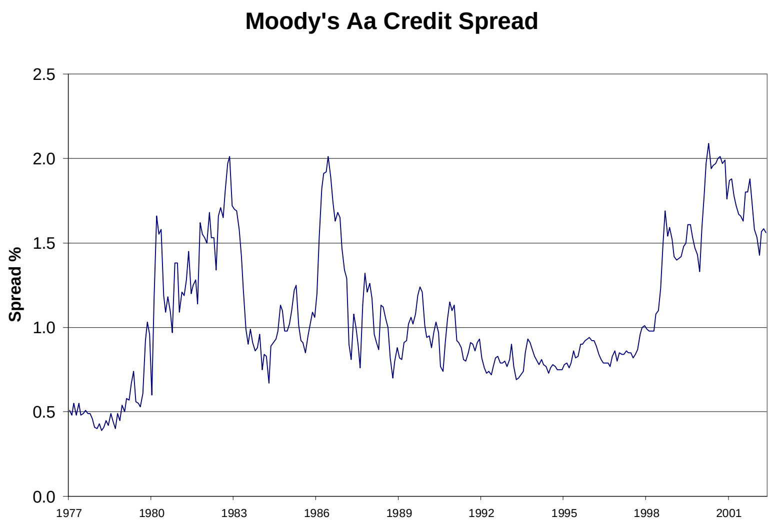


CHART 14
Aa Credit Spread Model Example
Model Evaluation

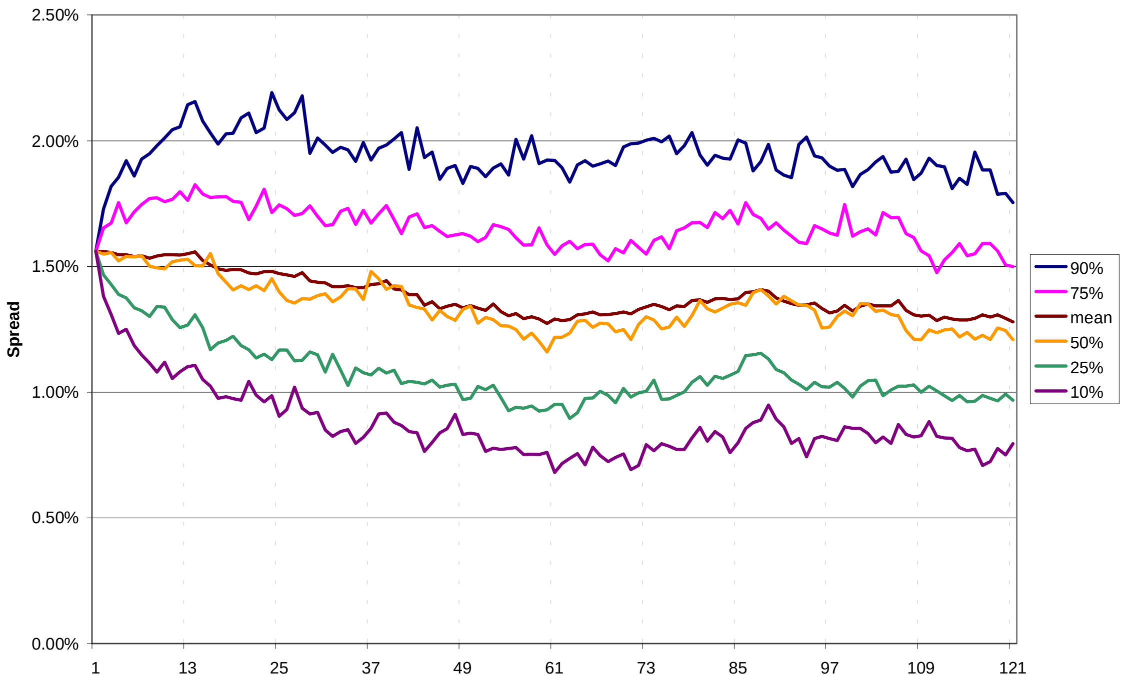


CHART 15
Credit Spread Model Example
Model Evaluation