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Specific Asset Modeling Issues and Applications Beyond Cash-Flow Testing

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SPECIFIC ASSET MODELING ISSUES AND APPLICATIONS BEYOND CASH-FLOW TESTING

Modeling Commercial Mortgages

MR. JEREMY J. BROWN: The collapse of the real estate market in the early 1990s created many new problems for both pricing and valuation actuaries. Profitability problems resulted from nonperforming assets. Real estate could no longer be ignored, and commercial mortgages could no longer be modeled as noncallable bonds.

My first exposure to commercial mortgages was in the mid 1980s. I was running a large GIC business and viewed mortgages as a superior alternative to bonds. My company had never lost a penny with mortgages, and these offered a significant yield spread over public bonds. What could be easier than selling GICs by the millions of dollars at 100 basis points over Treasuries and writing mortgages at 250 basis points over?

In the early 1990s, major changes in real estate values changed the landscape considerably. It became clear that a very significant portion of the incremental yield provided by commercial mortgages was related to credit risk, proving the adage that there is no free lunch. Rating agencies zeroed in on companies with significant mortgage positions, and continued the downgrading trend that began a few years earlier with junk-bond troubles. Even companies with well-performing portfolios were at risk to lose their ratings.

Most insurers have taken substantial write-offs on both their commercial mortgages and real estate. After a few years of refining these and some firmness coming to real estate values, many companies are now comfortable that their book values are in line with market.

Fortunately, conditions in the real estate market have recently improved. Fundamentals for most property types are beginning to turn positive, even if at a very slow rate. The major contributing factors are a dramatic reduction in new construction and a slow, but steady, increase in demand that is dependent on continued economic growth. Given these improving fundamentals, value may finally be coming to this asset class.

The calamity in the commercial mortgage market had a significant impact on the way valuation actuaries have treated this asset class when performing cash-flow testing. In addition it introduced many of us to a new asset class we had not planned to use to back our liabilities, namely real estate in various states of foreclosure.

Many companies have taken the easy way out and assigned real estate, particularly home office property, and problem mortgages to surplus. This same approach is often used for other equity investments, such as common stock. Because troubled real estate and mortgage accounts have grown over the last five years, many companies have more problem assets than surplus, so this approach is not feasible. Accordingly, these assets must be used to back liabilities in the cash-flow-testing exercise.

Historically, mortgages have been modeled as fixed-income, noncallable bonds, with very modest (sometimes zero or lower) sinking fund payments. Defaults were projected as a few basis points on the outstanding balance. If the mortgage had an interest rate reset feature, these could be modeled, or assumed to pay cash at the reset date, depending on the nature of the formula underlying interest rate reset.

Commercial mortgages were treated like noncallable bonds because they usually include "make-whole" provisions if they were paid off early. These allow the insurer to recover the interest income shortfall should rates fall, typically assuming reinvestment in Treasuries. Upon delinquency/default/foreclosure/and so on, insurers have clearly not been successful in recovering these amounts. This has an adverse impact on cash flow in declining interest rate scenarios.

With the significant growth of assets allocated to the commercial mortgage sector, this asset class now needs more attention in the cash-flow test. Many new issues arise as a result of the relationships between the interest rate scenarios and the cash flow produced by these securities. While earlier work has focused on the C-1 risk, more attention is now given, in addition, to the C-3 risk.

At their peak in 1986, commercial mortgages totaled one-third of new investment commitments by life insurance companies, with many of the major GIC and single premium deferred annuity writers well above this level. As problems began to unfold in the late 1980s/early 1990s, many companies began to pull back from this asset class. As a result, when mortgages come due, there are fewer lenders willing to finance the property.

A significant concern with mortgages from both a profitability viewpoint and a cash-flow-testing perspective is the disposition at maturity. In the mid-1980s many actuaries were comfortable projecting bullet maturity or rate reset commercial mortgages as if they would be paid in cash or reset pursuant to the terms of the mortgage note.

Recent experience shows less than one-third are paid off. This situation seems to be improving as many companies are now getting back in, because of the attractive returns available. While some maturing mortgages are refinanced at current market rates, many more become forced roll over situations. For cash-flow-testing purposes, we can no longer count on being paid off when we had expected. A typical approach is to assume a percentage distribution of payoff, market interest rate refinance, below market refinance, or foreclosure, based on the companies underlying or projected experience.

An important factor in the cash-flow-testing process is the impact of the interest rate scenario on the cash flow produced by the mortgage. Borderline properties may support mortgage service costs at the current interest rate, but may not if the note is subject to interest rate reset at a point in time when rates are above the current rate. Even well-performing properties may become problems if interest rates rise to high enough levels.

Delinquency is clearly one of the early indications of potential problems. Delinquent mortgages (typically 60 days) need to be carefully considered. These may still be categorized as "in good standing" on your database, depending on the responsiveness of your updating process. Part of the data-checking task should be to make sure that these are correctly classified as of the valuation date. Separate assumptions on future cash flow for these mortgages should be made. One approach is to assume that a small percentage of these mortgages recovers, and the balance moves to the "in foreclosure" status, and finally to the problem real estate group.

Another group of problem mortgages to address would be any restructured mortgages. In many cases these do not have strong loan to value ratios, and the underlying quality may be below average, so future default assumptions need to be carefully considered. Other factors to consider would be any of the typical protections that may have been negotiated out. For example, high interest rate modified mortgages may no longer have "make-whole" provisions on early payoff.

Modified loans may also have negative amortization. This results when the interest rate is set at a level above the mortgage payment level, with the additional interest added to the current balance. This additional interest may or may not turn to cash, depending on the borrower's ability to sell the property in the future at a high enough price to recoup the accrual.

Another common feature of modified mortgages is to schedule future interest rate increases, on the basis that the underlying fundamentals of a property will improve. To the extent these improvements do not materialize, the additional interest may not turn to cash, rather, the note will simply be modified again or foreclosed upon.

As insurers increase pressure on their investment staffs to remove troubled loans from their portfolios, many creative financing alternatives have arisen bringing new uncertainties to cash-flow projections. In some cases mortgage payments have been tied to property income, apartment unit sales, and the like. Actuaries need to be cautious in assuming vacancy rates will decrease or that rent rates will increase. A good understanding of the local market for the specific property type is required to make sound projections on either of these assumptions.

Most companies have done extensive analysis of their mortgage portfolio, either for the various rating agencies, or to address management's profitability concerns. These data should be used to make property-specific or portfolio assumptions on these assets.

Prior to the real estate crunch, products tested for disintermediation risk were not generally backed by real estate. To the extent they were, performing real estate was typically modeled with both projected net rental income (probably with inflation-plus annual increases) and projected capital gains at some projected point in time.

Problem real estate presents its own set of challenges both to the profitability of a block of business and to the ability to accurately project cash flow. Most of the recently acquired real estate would be classified in various states of under- or nonperforming. Income is much less stable; many properties will have vacancy issues and possibly rent concessions. Also driving both income and net cash flow will be expenses to repair and maintain properties as well as leasehold commissions, utilities, and tenant improvements. In the short term, cash flow may well be negative.

Cash-flow projections for real estate are best handled by carefully reviewing each property. Again, you generally need to rely on the analysis of your real estate staff for this information. This may not be practical if a very large number of properties are in the portfolio. On the other hand, if the portfolio of real estate is large, it is especially important that this be properly analyzed. By considering each property on its own merits, local occupancy rates, economic factors, and specific lease expiration schedules can be considered. Assumptions need to be made regarding future vacancy rates, improvement expenses, rent rates, and related items. The critical assumptions for cash-flow projections are the projected sale price and date of sale. Again, most companies have carefully analyzed their real estate portfolio and should have some indications to establish these assumptions.

Some properties may be classified as investment real estate. These may have been purchased as such, or possibly totally transformed from the foreclosure process. These properties may actually fit well with your very long liabilities. It's worth being cautious in assuming well-performing properties will continue so indefinitely, with ongoing compound net rent increases.

Depending on the relative size of the real estate and mortgage portfolios, stress testing is definitely worthwhile. Sensitivity tests should be performed, recognizing the potential adverse impact each interest rate scenario may have on each of the various assumptions.

Extensive communication with your investment staff will be necessary. In some cases this may be a new way of looking at problem loans. Investment people may be more comfortable analyzing property under various sets of economic data than under various interest rate scenarios.

Additional concerns with commercial mortgages and real estate include the underlying liquidity of these assets. If these need to be liquidated to meet policyholder liabilities, bids, if available at all, may be well below the underlying value. In addition, concentration concerns should be reviewed if the portfolio includes any unduly large single assets.

Default assumptions need to be selected carefully for both real estate and commercial mortgages. If your company has an internal quality rating system for mortgage assets, this will be helpful in setting default assumptions. If the asset valuation reserve is included in the cash-flow test, only those assets needed to cover projected defaults may be included.

It may be a good idea to exclude properties with especially uncertain cash flow. If these can't be excluded, you may want to provide for additional conservatism to reflect this uncertainty.

Problem mortgages and real estate have brought many new complexities and uncertainties to cash-flow testing. The key to success in understanding these is very close working relationships and communication channels with your investment staff. You need to develop an understanding of how sensitive these assets are to minor changes in your projection assumptions. Stress testing is certainly appropriate.

SPECIFIC ASSET MODELING ISSUES AND APPLICATIONS BEYOND CASH-FLOW TESTING

MR. DOUGLAS A. GEORGE: I'd like you to consider three scenarios. First is a building developer. He buys a plot of land and designs an office park. He lays the foundation and begins construction, but then he runs out of money and the property lies there unfinished. Second is a baseball team. They play three quarters of the season and work hard, and they're in first place. They have a good shot at the world series, but then they go on strike and forfeit the rest of the season. Finally, consider IBM, which in 1981 developed the first personal computer but decided to continue to focus on mainframes, and hasn't eaten its own lunch since.

Now, what do these scenarios have in common? Well, they all represent missed opportunities where a lot of resources and effort were spent with little to show in return. And this is exactly what we do with our cash-flow-testing models. We devote significant resources to them September through February. We design, construct, and validate our models, but then we toss them aside in March with little to show in return. Sure, we use them to meet our regulatory requirements, but are we really getting an adequate payback for the capital that we've spent?

I'm going to talk to you about the state-of-the-art asset/liability model and its applications beyond cash-flow testing. I believe that our cash-flow-testing models represent valuable tools that we can get much more out of than simply meeting year-end requirements. It starts with a properly constructed model.

When I look to build my model, at first I look to my actuarial software, and I have some concerns. First, the interest rate process is rather simple. I wonder whether it really captures the nuances of my assets and my liability options.

Second, the asset modeling is very basic. It has limited capabilities for collateralized mortgage obligations (CMOs). The prepayment models are also limited. It doesn't take into account important factors like seasonality and burnout. It also doesn't have an updated database, so I have to go to other sources to get current collateral information and recent prepayment speeds. As a result, model creation is very difficult. Computer run time is also an issue. Actuarial models are often written in APL, so they're very slow to run.

Finally, the analysis can be inconsistent. It's inconsistent with the analysis that my investment people do on their assets. For example, if my actuarial software tells me that an asset has a duration of 4.5 but my investment people says it's 4, what do I do?

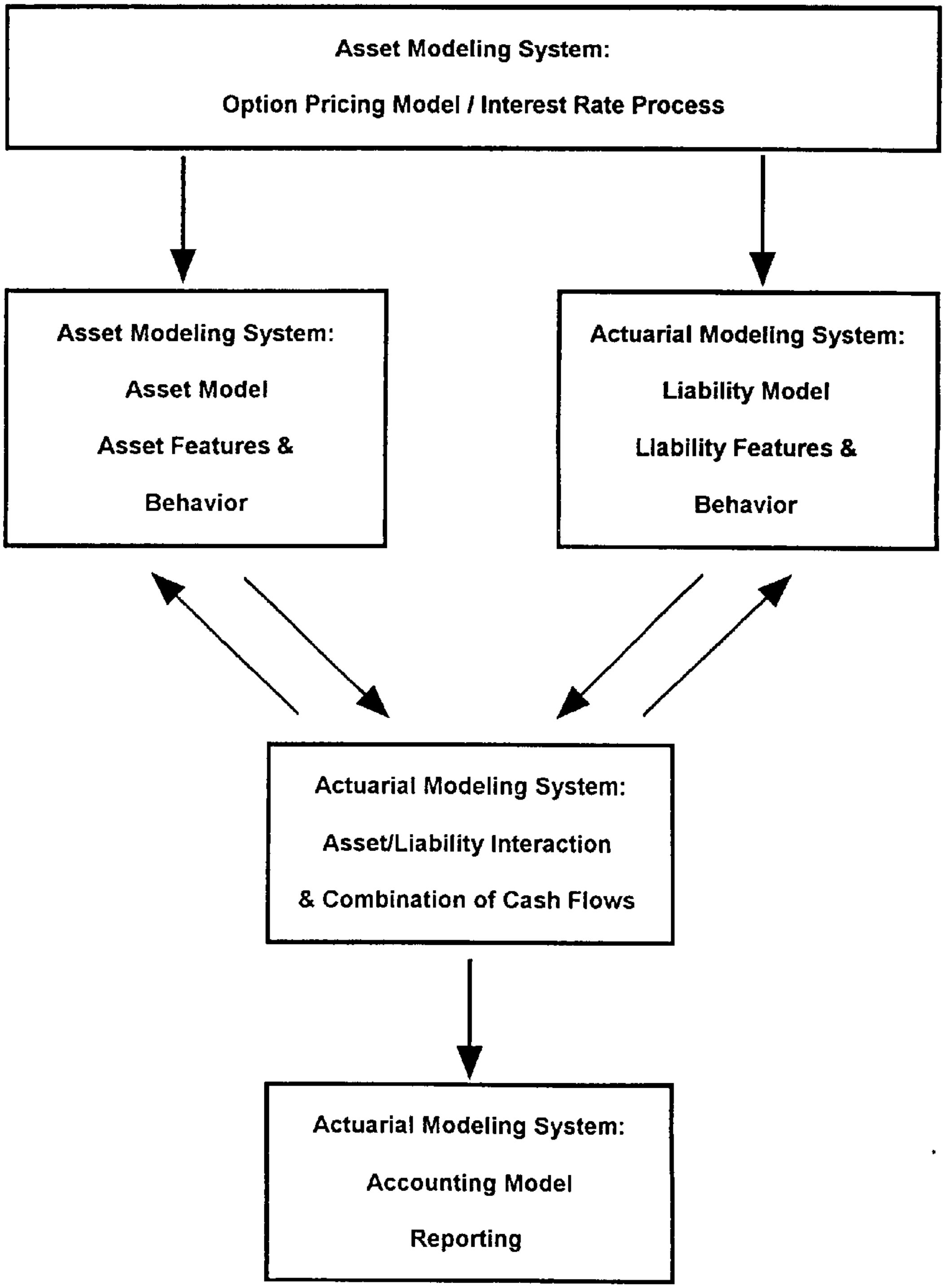
Next I look to my asset modeling software, and I also have some concerns. First, it's tough to model liabilities through asset forms. You don't really capture the product characteristics or the underlying demographics. Also, the accounting is very limited. It doesn't have statutory, GAAP and tax reserve calculations, or financial projection capabilities. Values for the asset valuation reserve (AVR), the interest maintenance reserve (IMR), and risk-based capital aren't calculated. Asset/liability interaction is also an issue. Trying to do model asset/liability interaction such as a crediting strategy based on portfolio rates is difficult. Finally, future trading and new business are tough to model.

Realizing that neither my asset nor my liability software is adequate, I look to a combined approach. The method I use for corporate modeling is systems integration (Chart 1). Under this approach, we take the best of both the investment and actuarial systems and merge them together to create our models.

I start with the option-pricing model and interest rate process. I generally take it from the asset modeling system. I usually take it from there because the asset models tend to be more robust. They give you both up and down scenarios and scenarios that zigzag. They've been proven to reprice both short and long options.

CHART 1

Systems Integration



In practice, I've used investment systems from Capital Management Sciences (CMS) and also from Global Advanced Technologies (GAT). You can also use internal asset systems.

We connect the interest rate process to our asset model, which we create from our asset modeling system. From this, we access the asset database, so we can get the current collateral. This saves us time and effort spent recreating asset models in actuarial software. We also get the advanced prepayment modeling and all the modeling algorithms that go with it. We connect this to our liability model in our actuarial modeling system. Here we can pick up the product features, the underlying demographics, as well as the actuarial assumptions for parameters like mortality and persistency.

Now, what we need is a system to connect the two, and here I usually use the actuarial system, although the investment system can be used as well. The actuarial system tends to have better capabilities for interacting cash flows, determining what your future cash-flow needs are, and modeling things like portfolio or investment generation crediting strategies. The investment system can be used for this purpose as well for some applications, which we will review later.

Finally, we need an accounting model and a method for reporting results. Here, once again, we go to the actuarial system so that we can pick up the statutory, tax, and GAAP models. We also pick up the cash flows or whatever results we need depending on the specific application.

Now, there are a few concerns with the integrated system. One is we need to model asset defaults for some applications (such as cash-flow testing), and our asset models don't typically do that. We also need to make sure that interest rate definitions are consistent. Some models are based on a par curve. Others are based on a spot curve. Cash flows also need to be consistent. One model might have quarterly cash flows.

Another might have monthly. Even if they're both monthly, one might be the middle of the month, one might be end of month. Finally, accounting needs to be consistent.

In practice I've seen that each of these concerns can be overcome. A default calculation can be created and put into our asset model. It's actually very simple, and most of the ones in the actuarial models are pretty simple anyway. We can actually do a better job than the actuarial models, and we know how important it is to model defaults properly. Accurate default modeling is very important. We can also make sure that interest rates are consistent. If they're not, we can convert from spot to par or vice versa. We can also accumulate cash flows to make them consistent. If they're middle of the month, we can accumulate them to end of month. Finally, we can take measures to make sure that accounting is consistent as well.

Now that we've satisfied our concerns, I see a number of advantages with the integrated system. We're getting the best analytics for both sides of the balance sheet. Not only are we getting the best analytics, but also we've achieved credibility by doing this. We get buy-in from the investment people. Because we use their system to model the assets, they will buy into the results that come out.

The interest rate process is also the best one available. Not only is it a quality model, but also it's consistent. So if we calculate effective durations for both assets and liabilities, we're sure to have an "apples-to-apples" comparison.

Model creation and maintenance is easy because the models already exist in the different systems. The asset model is easy to create in the asset system. It's quicker and easier than trying to reconstruct it in the actuarial software.

The models are flexible, and we'll see that, as we talk about the applications for which we can use our system.

The models are also consistent. They're consistent with the independent analysis that we perform on the liabilities as actuaries, and that the investment people perform on the assets.

Finally, computer run time is often improved because the asset models are written in compiled code whereas the actuarial models are in APL.

So, what do we do with a system like this? Well, for one, we can calculate option-adjusted-spread analysis on liabilities similar to what is done with assets. Once again, we can do this because we have the integrated system and we'll get an apples-to-apples comparison of asset/liability option-adjusted-spread values.

Here I demonstrate the technique on a single premium deferred annuity (SPDA) (Table 1). Under my base run, I have features such as a surrender charge that grades from 7% down to 0% over seven years. The crediting strategy is based on the five-year Treasury. The initial rates equals the five-year Treasury, and the reset rate is based on a combination of the previous rate and the five-year Treasury at the time of the reset. I also have a bailout that lasts for five years and is initially set at 1% below the initial rate.

First, I calculate our static spread. The static spread is found by projecting cash flows forward along the current yield curve. These are the all in cost cash flows. They include expenses, commissions, and benefits. To calculate the static spread, I equate the present value of the cash flows along the static yield curve with the issue price of the annuity. When I solve for a spread, I find that 73 basis points above the Treasury rate equates these values.

Next, I calculate an option-adjusted spread. Here, I expand the analysis to cover a full range of future interest rate space. When we include our up and down scenarios, we find that 104 basis points above the Treasury curve equates the present value of cash flows along all the paths to the issue price.

TABLE 1

OAS Analysis - SPDA

Run	OAS	Static Spread	Option Cost
Base	104 bp	73 bp	31 bp
Increase Initial Rate 50 bp	128	95	33
- Difference	24	22	2
Reduce Surrender Charge 1%/yr.	118	82	36
- Difference	14	9	5
Remove Bailout	93	73	20
- Difference	-11	0	-11
Remove Bailout (in force)	100	73	27
- Difference	-4	0	-4

So, what does this tell me? Well, first, I know what my hurdle rate is for my assets. I need to earn an option-adjusted spread of 104 basis points on my assets in order to break even on a cash basis averaged across all interest rate scenarios for this liability.

Second, I can calculate my cost of options. The cost of options here is 31 basis points (104-73).

I can also test different strategies. I can look for crediting strategies that minimize my option-adjusted spread on my liabilities. I can also test combinations of investment and crediting strategies that maximize the difference of my option-adjusted spread on assets and my option-adjusted spread on liabilities.

Finally, I can explicitly calculate the cost of some of my liability features. When I increase the initial credited rate by 50 basis points, I see that my option-adjusted spread goes up to 128. So it has cost me 24 basis points of option-adjusted spread to offer 0.5% more initial rate. Similarly, reducing the surrender charge increases the option-adjusted spread to 118 basis points. So it costs me 14 basis points of option-adjusted spread to reduce my surrender charge. Notice how the static spread does not change by the same amount as the option-adjusted spread, so there is actually an option cost to changing these features.

Finally, I can value my bailout feature. If I remove my bailout, I see that I can save 11 basis points of option-adjusted spread. So what can I do with these values? Well, for example, if I have two SPDAs in my portfolio and they're identical except one has the bailout feature and one does not, I know my bailout is worth 11 basis points and the increase in the initial credited rate by 0.5 of 1% is worth 24 basis points. Eleven is about one-half of 24, so the "fair" rate to offer on the SPDA without the bailout would be about 25 basis points of initial rate more than the one with the bailout. This would produce similar expected profitability, averaged across all interest rate paths.

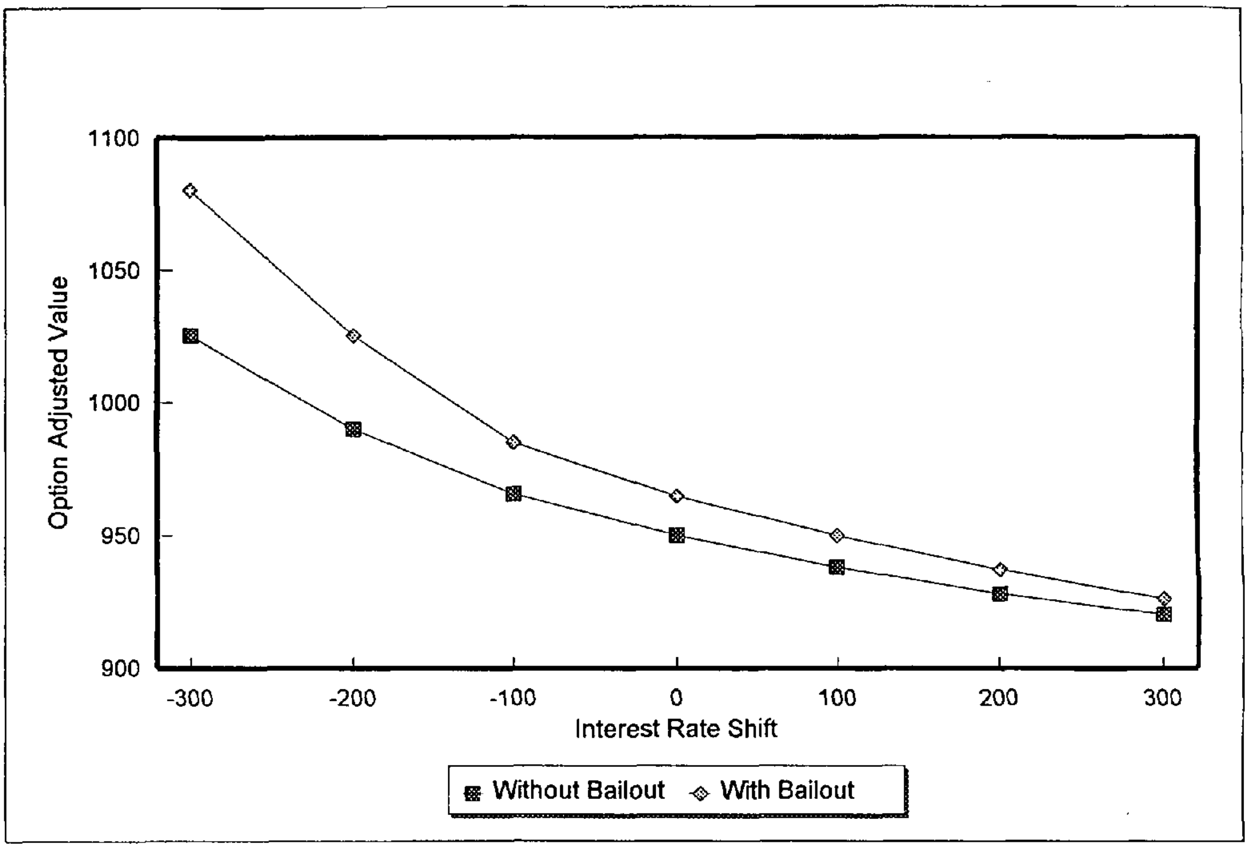
Notice, also, how the static spread doesn't change when I remove my bailout from my base product (both are valued at 73 basis points). That's because under the static scenario, the bailout is not triggered, so there's no "cost" to it. This makes sense because the option-adjusted spread is 11 basis points, the same as the option cost. That's because the bailout is a pure option. So the option-adjusted-spread change is completely made up of the option cost.

Finally, you can look at an in-force SPDA. Here, I test one that's three years in force. Remember that the bailout lasts five years from issue. So, in this case, all else being equal, the option is worth a lot less than a new bailout would be worth, and that's because we're getting near the end of the bailout. This is also true of asset options, although our systems don't typically price them that way. The option-adjusted spread should change over time as options come closer to starting or ending.

Next, we can expand this kind of an analysis in the form of price behavior curves (Chart 2). Once again, we can do this because we have an integrated system and we can get an apples-to-apples comparison of asset/liability values. Price behavior curves provide

CHART 2

SPDA Price Behavior Curves



	No Bailout				Bailout		
Rate Shift	Value	Duration	Convexity		Value	Duration	Convexity
-300	1025	3.4			1080	5.1	
-200	990	2.4	1.11		1025	3.9	1.46
-100	966	1.7	0.83		985	2.0	2.03
0	950	1.3	0.42		965	1.6	0.52
100	938	1.1	0.21		950	1.4	0.21
200	928	0.9	0.22		937	1.2	0.21
300	920				926		

a good picture of our C-3 risk. They're a great way to conceptualize C-3 risk because they're a graphic representation of it. They are a good way to present results to senior management because you don't need to understand the complete calculations behind the curve in order to get a good feel for what the curves are telling you.

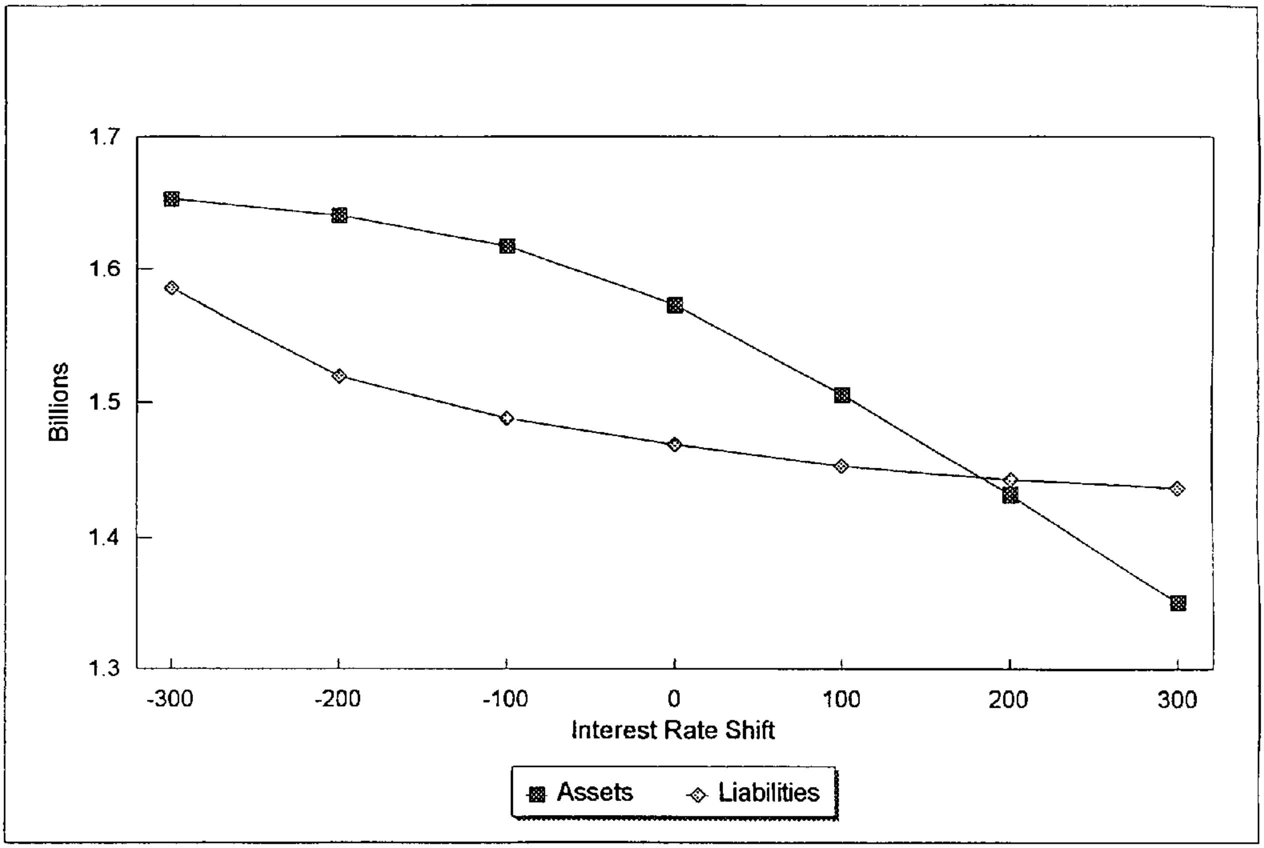
In my example, I illustrate my SPDA with and without the bailout. The duration of the products can be found by looking at the slope of the graph, and the convexity can be found by looking at the curvature. We begin by analyzing the zero interest rate shift (i.e., the current yield curve). Our SPDA with the bailout has higher duration (more steep slope), as well as higher convexity (more curved) than the SPDA without bailout.

When we apply this technique to our whole portfolio of assets and block of liabilities, we might see a graph that looks something like Chart 3. Economic surplus is found by looking at the difference between the lines, and we can see how it changes as interest rates go up and down as we go right and left from the zero interest rate shift on the graph. In our example, the asset duration is 4.3, and the liability duration is 1.1. Assets also have negative convexity, and liabilities have positive convexity, as can be seen by the general curvature of the lines. You can see how the graphic demonstration is a good way to picture your C-3 risk, and why asset/liability duration and convexity mismatch are a problem. You can show senior management how the slope and curvature of the lines will reduce economic surplus under interest rate changes.

Price behavior curves also provide a good way to do things to fix your C-3 risk. The general idea is to try to preserve economic surplus. This can be accomplished by lining up your asset/liability price curves. It's quite easy to do because the lines are additive. If we add a new asset to a portfolio, the new portfolio price is simply a weighted average of the previous portfolio plus the new asset.

CHART 3

Price Behavior Curves



	Assets			Liabilities		
Rate Shift	Value	Duration	Convexity	Value	Duration	Convexity
-300	1.653	0.7		1.585	4.1	
-200	1.641	1.4	-0.67	1.520	2.1	2.21
-100	1.618	2.8	-1.36	1.488	1.3	0.82
0	1.573	4.3	-1.40	1.469	1.1	0.21
100	1.506	5.0	-0.53	1.452	0.7	0.42
200	1.431	5.6	-0.35	1.442	0.4	0.28
300	1.351			1.436		

In Chart 4 I've added two hedges to the asset portfolio to help "fix" my C-3 mismatch. I've added a swap to help decrease the duration of my assets, and an interest rate cap to help correct the convexity. Other management action can be modeled as well. You can rebalance your asset portfolio as opposed to adding hedges. You can also look for liability "fixes" such as changing crediting strategies or product features. This will reshape your liability price curve as opposed to your asset price curve. You can certainly do combinations where you try to do some asset fixes and some liability fixes, and you can also perform partial hedging. Our example demonstrates a full hedge where you try to line up the curves as best as possible. A partial hedge would ameliorate some of the risk without lowering earnings as much.

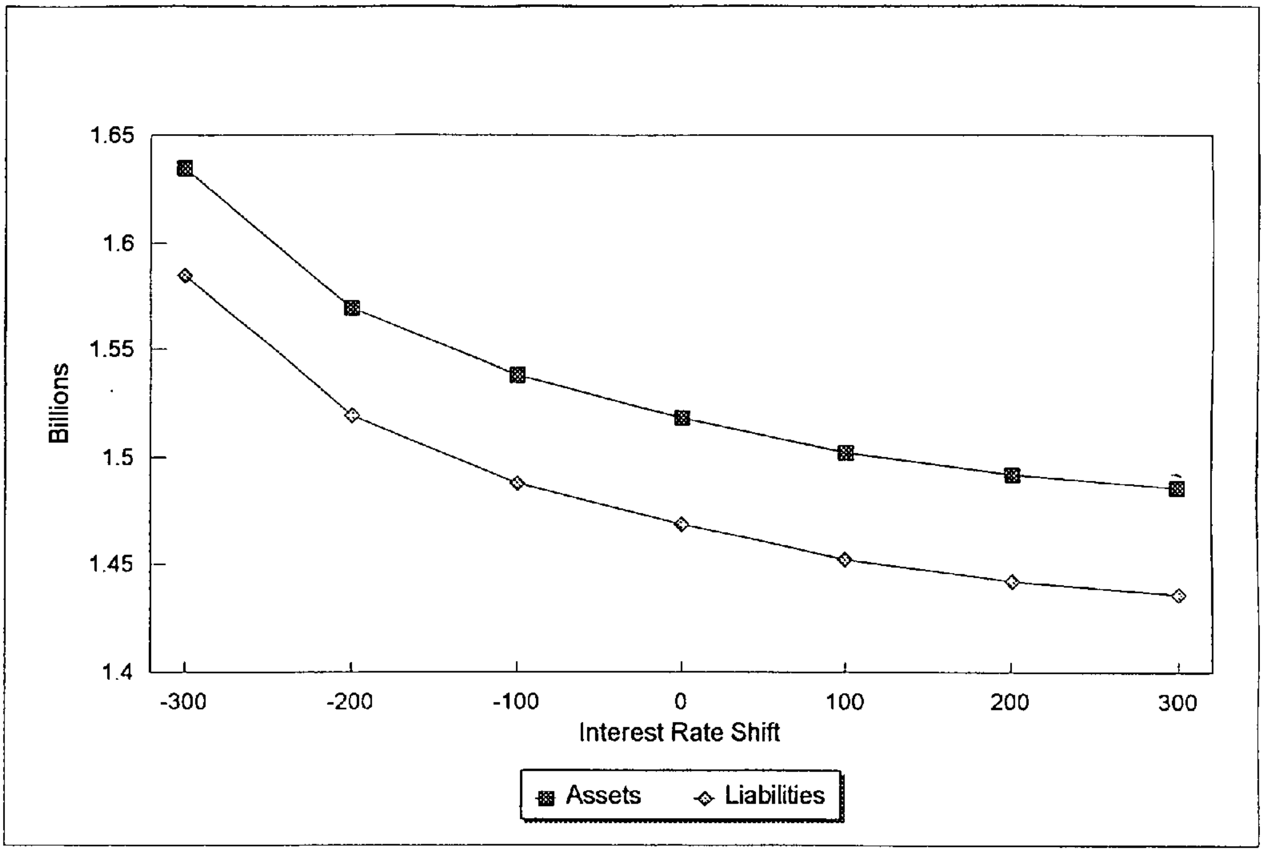
There are concerns with analysis such as this. One is the liability discount rate. The appropriate rate for discounting liabilities has never really been determined, and there's much debate as to what to use. The liability discount rate can have a big effect on the shape of the liability line. The duration and the convexity can change based on the discount rate that is used. It can also move the line up and down. In our example, we can't be sure that the liability curve isn't sitting right on top of the asset curve so that our economic surplus is basically zero.

Finally, we can't measure yield curve risk. This analysis is fine for a parallel shift, but it's not going to help us look at the risks associated with a nonparallel shift in the yield curve.

To analyze yield curve risk and to also lessen the effect of the discount rate on our liabilities, we can perform key-rate duration analysis (Table 2). A key-rate duration is a measure that represents the price sensitivity of an asset or a liability to each key-rate shift. Now, a key-rate shift is defined by breaking down a parallel shift into different segments along the yield curve so that the sum of the key-rate shifts equals the parallel shift, and the sum of the key-rate durations equals the effective duration. If we start with the spot curve and we define our interest rate process to compound continuously, the

CHART 4

Price Behavior Curves



	Assets			Liabilities		
Rate Shift	Value	Duration	Convexity	Value	Duration	Convexity
-300	1.635	4.0		1.585	4.1	
-200	1.570	2.0	2.14	1.520	2.1	2.21
-100	1.538	1.3	0.80	1.488	1.3	0.82
0	1.519	1.1	0.20	1.469	1.1	0.21
100	1.502	0.7	0.41	1.452	0.7	0.42
200	1.492	0.4	0.27	1.442	0.4	0.28
300	1.486			1.436		

TABLE 2

Key-Rate Duration Analysis

Security Durations

Security	Effective Duration	Key Rate D(1)	Key Rate D(2)	Key Rate D(3)
2 year zero	2.00	2.00	0.00	0.00
6 year zero	6.00	0.00	6.00	0.00
10 year zero	10.00	0.00	0.00	10.00

Portfolio Durations

Portfolio	Effective Duration	Key Rate D(1)	Key Rate D(2)	Key Rate D(3)
#1 (6 year)	6.00	0.00	6.00	0.00
#2 (2, 6, and 10 year)	6.00	0.67	2.00	3.33
#3 (2 year and 10 year)	6.00	1.00	0.00	5.00

Change in Value (%)

Portfolio	Scenario A	Scenario B	Scenario C
#1 (6 year)	- 1.50	- 0.60	0.00
#2 (2, 6, and 10 year)	- 1.50	- 0.37	0.27
#3 (2 year and 10 year)	- 1.50	- 0.25	0.40

effective duration of a zero coupon bond equals the maturity. In this example, I break down my parallel shift into three key-rate shifts, and those are listed across the top of the matrix.

My first key-rate shift is at year two. My second is at year six, and my third is at year ten. I've done this for a reason. Obviously; I've chosen a two-year zero, a six-year zero, and a ten-year zero bond. I define my first key-rate shift by increasing the two-year rate by ten basis points, and the six-year rate by zero basis points, and the ten-year rate by zero basis points. In between years two and six we have a pro-rata increase from ten to zero basis points. For my second key-rate shift, I increase the six-year rate by ten basis points. The two-year rate and the ten-year rate are each set at zero, and we do a pro-rata increase in between. Finally, for my third key-rate shift, I increase the ten-year rate by ten basis points. The two year and the six year do not move, and we have a pro-rata increase from year six through year ten.

In this way, I've broken down a parallel shift into three key-rate shifts. In the case of the two-year zero bond, the full effective duration of two is felt at the first key-rate shift. All the cash flows are at time two. When I shift to ten basis points, I get the full change in value. When I perform my last two key-rate shifts, there are no cash flows, so I get no change in value and no key-rate duration. Similarly, the six-year zero has a second key-rate of six with the first and third key rates equal to zero. Finally, the ten-year zero has zero key-rate duration at years two and six, and a duration equal to ten in year ten, the third key-rate shift.

With these bonds, I can show you three portfolios that have the same effective duration but different yield curve characteristics and different key-rate durations. First, we have a portfolio made up of just six-year bonds. Second, we have a portfolio made of one-third each of the two-year, six-year and ten-year bonds. And third, we have a portfolio that's half two-year zeros and half ten-year zeros. As you can see, each has an effective duration of six, but they have very different key-rate durations. Key-rate durations are easy to calculate for a portfolio. They're simply the weighted average of the key-rate durations of the individual securities that make up the portfolio.

So, what happens under different interest rate scenarios? In Scenario A, I illustrate a parallel shift. I shift 25 basis points higher all along the yield curve, and I can see that each portfolio goes down by 1.5%.

Scenario B is a nonparallel shift, and here I increase 25 basis points at the two-year rate, ten basis points at the six-year rate, and zero basis points at the ten-year rate. As you can see, the values of the portfolio change from -60 basis points to -25.

Finally, in Scenario C, I show you a rotation around the six-year rate. Here we have a ten basis point increase at the two-year rate, zero increase at the six-year rate, and minus ten at the ten-year. Here the value change varies from zero to 40 basis points.

What we can do is extend this analysis to our whole portfolio. We can do this, once again, because we have the integrated system. In practice, you would typically look at more key-rate durations than this. I usually use from five to 11, say, key-rate durations rather than just the three that I used in this example. And you can see that a small duration mismatch can really produce rather large key-rate duration mismatches even though there's only a small effective duration mismatch.

All the analysis up to now has been based on cash. The question remains, how does this effect my financial performance? What is the effect on my statutory and GAAP earnings of doing the different types of cash hedging and analysis, and in changing my portfolios and my crediting strategies? Furthermore, is hedging cash the same as hedging earnings? If I hedge cash, oftentimes the effect on earnings is the opposite. We often produce more fluctuations in earnings when we include hedges in our portfolio.

What are the differences in accounting? For example, if I rebalance the portfolio and my price behavior curve comes out one way, I can add a hedge and have the price behavior curve come out the same way, but each can have very different accounting effects.

Finally, what's the utility of doing this? What is my risk/return tradeoff? How do I know what I'm getting for my money, and what are my financials going to look like if I add a hedge or if I change crediting strategies?

To answer these questions, I can perform stochastic analysis (Chart 5). Here I show a mean-variance type of approach. My example here is for new business, but you can also use this for in force. Here I've demonstrated the same hedge as before. First, I start with the static pricing, and I just use this as a reference point where I have no hedge and I run the static scenario. I can reach my ROI goal of 12%. And I "think" there's no volatility because I'm just running one scenario.

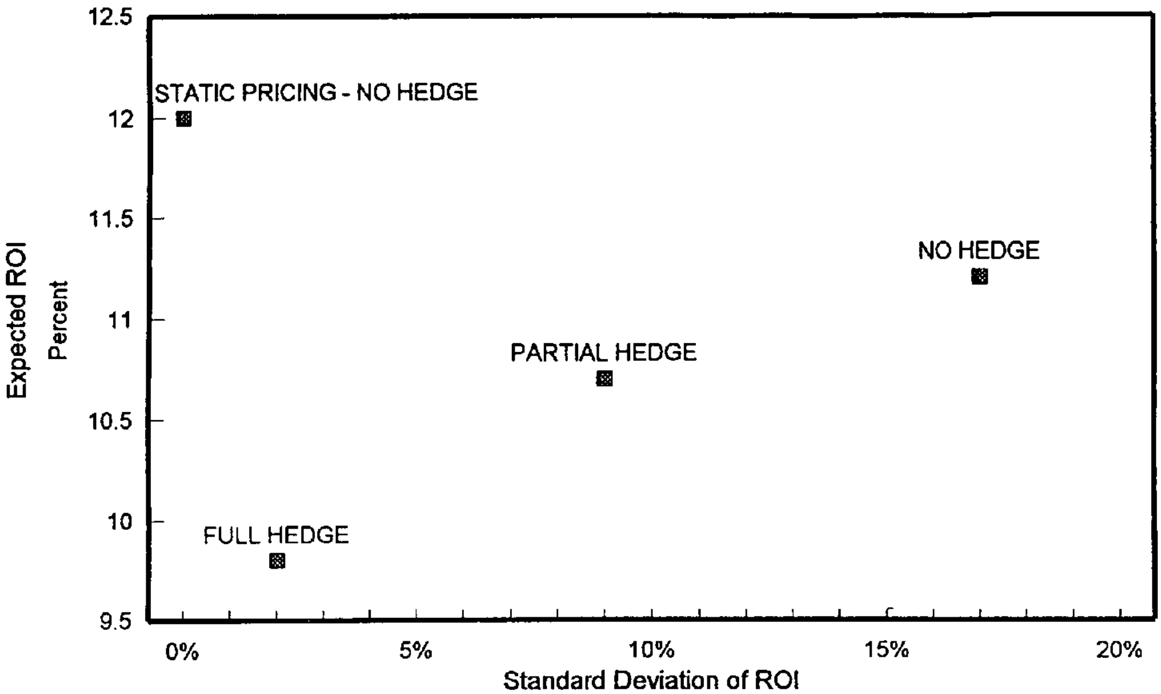
What happens when I include stochastic scenarios is I move over to this point on the far right of the graph. Here I still have no hedge, but the results include my different scenarios. Not only does my expected ROI drop, but also the volatility increases because we have many different returns over different interest rate scenarios. When I go to the other extreme, I include my full hedge, and that's in the bottom left corner. Here I can decrease the volatility of my ROI, but it's at a significant cost to my expected ROI. With this type of analysis you can try different crediting strategies, different investment strategies and analyze hedging options.

What you're really looking for is the best ROI you can get with the least volatility. Actually, the points illustrated here are pretty conservative. I've done this kind of analysis where the full hedge ends up pretty close to zero, and you can really see the cost of hedging. As competitive as things are today, it's really tough to hedge completely and make a profit. You really need to take some risk in order to achieve an adequate expected return. Of course, the other thing you can do when you do scenarios is look at the earnings patterns along the different scenarios, and that's definitely a desirable exercise.

Now, none of this analysis is going to guarantee your financial performance. None of it locks you into a given result. What you're really doing is, you're effecting the distribution, or the possible distributions, of your results. It's the kind of thing that needs to be repeated periodically. Also, we need to consider what the limitations are.

CHART 5

Risk/Return Opportunity Set



First, current models do not allow us to model future management action along scenarios. We lock in the time zero strategy for crediting and investment, and we are forced to use that in our models going forward no matter what the interest rate conditions. Obviously, in reality, as interest rates change, we will change the way we act, and our models won't account for this.

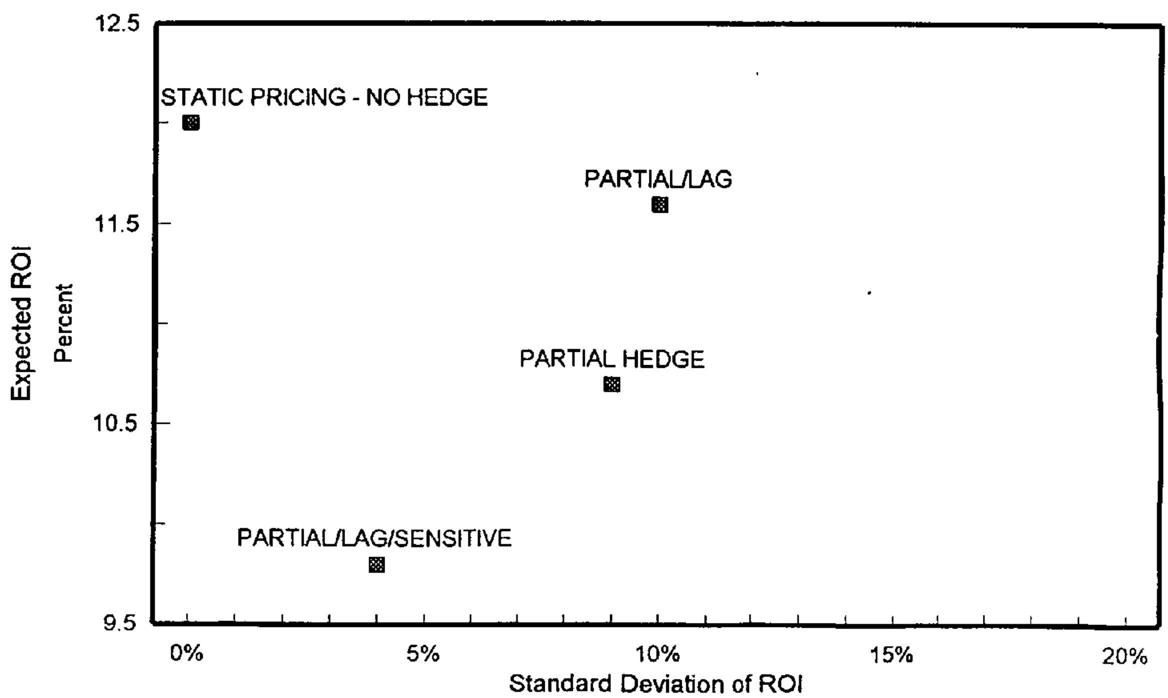
Second, our models can't take into account indirect effects of our actions, or at least, it's tough to model the indirect effects. If we lower our crediting strategy dramatically, how is our field going to react? These are the kinds of things that are tough to quantify in terms of the model. So we need to make sure we interpret this kind of analysis with the limitations in mind. The model's not going to give us all the answers. It's not going to run our company, but it's going to give us good insight into the C-3 risk and other types of risks.

Finally, we're not sure about some of the assumptions we use to create these models, and that's especially in reference to policyholder and agent behavior.

Here, I illustrate my partial hedge situation and include a lag component to my crediting strategy (Chart 6). And under my base policyholder behavior assumption, it looks like I could increase my ROI with only a slight increase in the volatility of my ROI by lagging interest rates when they go up, but following them quickly when they go down. However, if I'm wrong about my policyholder behavior assumption, then I end up with the result down in the left corner of the graph. And here I've increased the sensitivity of policyholders, and what I end up with is a big decrease to my expected ROI because I was wrong about the way my policyholders would behave.

CHART 6

Risk/Return Opportunity Set



The point here is to perform sensitivity testing. Now, some people argue that because we don't know about agent and policyholder behavior that we shouldn't even bother performing this kind of analysis. But I say that we should do more. We should perform more analysis because we don't know rather than perform less. We can perform the sensitivity testing to see what the effects are if we're wrong with our assumption about our policyholder and agent behavior.

We can also look for strategies that minimize the effect of being wrong about the behavior assumption. We can look for ones that don't vary too much over a wide range of policyholder behavior assumptions. We can also use it as a reason to develop the kinds of systems to track policyholder behavior. We have the data, we just need to access it. Our administrative systems have the cash-flow information. It's really a matter of getting at it and being able to analyze it and developing the systems to do that. The companies that do that, those that develop these systems and learn about their agent and policyholder behavior, are going to be the ones that succeed over the next ten years as interest rates increase.

Finally, I have one concern about my stochastic scenario analysis, and it's that you need hundreds of scenarios in order to get unbiased coverage of future interest rate space. Because the interest scenario is a randomly determined, you have much more duplication of scenarios. And to fix that, I use a deterministic approach.

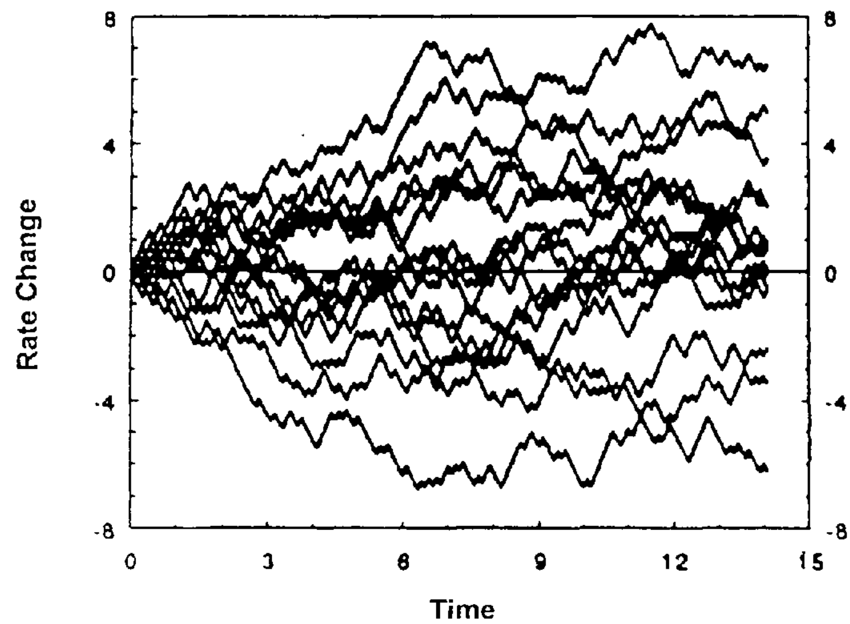
Chart 7 shows you an example of the deterministic representative path structure that CMS uses. The graph illustrates how the deterministic paths cover a full range of future interest rate space where many, many stochastic scenarios would be required in order to provide the same coverage.

Table 3 illustrates how various CMO tranches are valued under the deterministic path structure. Only a limited number of paths produce effective durations, which converge to actual values for many different CMO class types. Actually, I've seen results that are

CHART 7

Stochastic versus Deterministic Paths

Stochastic Scenarios



Representative Paths

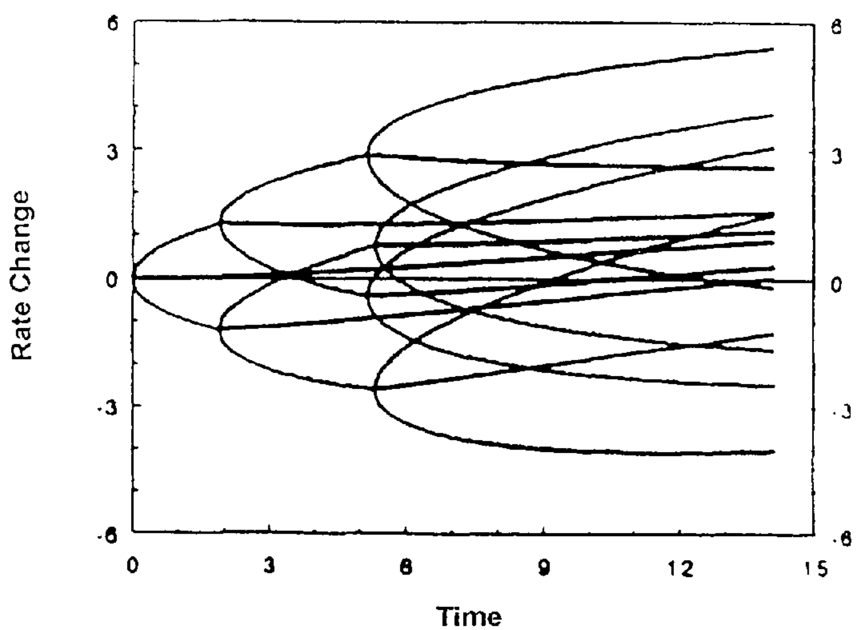


TABLE 3

Representative Path Accuracy
CMO Tranche Durations

Tranche	32 Paths	256 Paths
PAC	1.94	1.93
AD	4.91	5.00
2PAC	3.93	4.14
Floater	0.30	0.26
Sequential	5.37	5.39
PAC Z	8.05	7.85

pretty good even with only 16 paths as opposed to the 32 demonstrated here. Because of this we can use this handful of paths and/or scenarios to replace essentially our hundreds of stochastic scenarios that we would need to provide the same future interest rate coverage.

And we can do this because we have the integrated system. We have an apples-to-apples comparison of asset/liability results. This makes the whole project more manageable. It makes it more efficient. Run time is improved. Summarizing results and accumulating data are much easier with only a handful of scenarios versus hundreds.

It's also easy to review the earnings patterns over a handful of scenarios. You can look at each one explicitly, and because we've covered all possible future interest rate space, you will see whether or not you have problems under pretty much any condition.

Finally, there are many additional applications for the integrated system. There's financial forecasting. We can add new business to the model and get financial projections. We can look for optimal capital structures that meet our risk-based capital requirements, our rating requirements, but still give us good return. We can do the surplus management. We can determine the optimal capital structure for a mutual company planning to demutualize.

For pricing, I've talked about a few applications. But if we have an integrated system in place with our pricing system, we can look for products where we design the product features to ameliorate some of the C-3 risk. We can support the macropricing algorithm. Having a corporate model is really the true way to implement macropricing where you put in the marginal expenses at the appropriate level in the model. At the product level, we put in the marginal product expenses. At the line-of-business level, you put in marginal line-of-business expenses that are usually thought of as overhead.

You can do performance assessment such as the total return approach that's advocated by many people. The approach attempts to tag liabilities to market value and generates internal performance measurement analysis based on it. "What if?" analysis can be performed, like asset sectors falling out of favor, such as commercial mortgages. Using tax law changes, rating changes, or whatever, we can shock the model and see what the effects are.

Finally, we can do merger and acquisition (M&A) appraisal, and I can argue that this is the best system for doing an M&A job. M&A jobs are characterized by having quick time frames and hard deadlines. They need to be performed quickly. Because the assets are built in the asset system and the liabilities in the liability system, the model becomes easy to construct and validate. It's much easier than constructing asset models in actuarial systems or vice versa. We also get the best analytics for both sides of the balance sheet, so we can do quite a bit of financial analysis within a limited time frame.

Before I conclude let me just summarize quickly. Let's use our models to do a lot more than just meet cash-flow-testing requirements. We have additional C-3 risk applications as well as many others. We want to perform sensitivity analysis on the unknown assumptions, especially policyholder and agent behavior. Because we don't know that much about the policyholder behavior, we want to look for strategies that minimize the risk of policyholder behavior. We also want to build the databases that track policyholder behavior so we can learn more about it. We also can't use the models to dictate how we act; we can use them to provide insight. They won't give us all the answers, but we can use them to provide insight about our risks. Finally, the best system to create our corporate model and perform financial analysis is the integrated system. It offers the best analytics, easy model creation, credibility, flexibility, and fast computer run time.

SPECIFIC ASSET MODELING ISSUES AND APPLICATIONS BEYOND CASH-FLOW TESTING

MS. CATHERINE E. EHRLICH: I have heard many speakers and read many papers on asset modeling issues for insurance companies, but I have never heard anyone suggest any magic formula to make the process easy. Unfortunately for you, I am no exception. In my opinion, there is both good news and bad news about the state of the art of asset modeling.

I will give you the bad news first: Slimmer margins necessitate more precise modeling. Short cuts and approximations will involve some error, and that error may make the difference between profit and loss.

There is a lack of standardization of fixed-income vehicles. The proliferation of fixed-income vehicles from Wall Street has further complicated the situation. It is impossible to take some descriptive data, like maturity date and coupon, and accurately model cash flows. Collateralized mortgage obligations (CMOs) have made it difficult to model cash flows under one set of assumptions, let alone the variety of scenarios that today's valuation standards require.

Now I will give you the good news: Computers are much faster and the analytics are much better. We can now perform Monte Carlo simulations in minutes rather than overnight. This is due both to the speed of the computers and the development of methods such as the representative path method, which apply intelligence and probability to the generation of random scenarios.

Asset databases are readily available. You now have the option of using an independent third party to project cash flows and supply prepayment assumptions.

Change in Composition of Life Insurance Company Asset Portfolios

The composition of insurance company investment portfolios has changed over the years. Although still largely invested in fixed-income assets, the various weightings of the different classes of fixed-income assets have changed.

In the not-too-distant past, insurance company portfolios were largely invested in assets such as lower quality corporate bonds, commercial mortgages, and private placements. These assets provided a yield premium over similar duration Treasuries. This yield premium can be divided into two components.

The first component is the liquidity premium. For those assets that aren't publicly traded or for which the market is not particularly deep, the holder is compensated for the lack of liquidity. These assets were attractive to investors who were immune to liquidity risk, because their liabilities were predictable and they, therefore, anticipated no need to sell the asset.

The second component is the credit risk premium. This premium rewarded the investor for the risk that the issuer may be unable to fulfill the obligations of the contract and that either the interest payments or principal payments would not be made. These assets were attractive to investors who could do credit analysis that was superior to the average market participant.

The cash flows generated by these portfolios were not particularly susceptible to systematic risk, like interest rates. From an analytical standpoint, the cash flows are interest rate independent, and traditional risk measures like Macaulay and modified Macaulay duration worked very well for immunization purposes.

As policyholders and pension plans became more investment oriented, the products offered by insurance companies also become more investment oriented. The timing of liability payouts was less predictable since the marketplace demanded more cash-out options and the marketplace was quick to exercise those options.

The marketplace was also demanding proof of financial solvency. The need to improve the average credit quality of portfolio and the need to increase risk-based capital dictated a flight to quality. However, competitive investment returns were also of paramount importance, since insurance company products were being sold against bank CDs and mutual funds.

In order to satisfy these new demands, portfolio managers turned to investments such as mortgage pass-throughs and their derivatives, CMOs, that were publicly traded, liquid, and AAA or higher quality and that also have high yields relative to Treasuries. The risk that these securities carry is related to the timing of the cash flows. There is no, or virtually no, risk of contractual default of payment of principal and interest, only risk to the timing and, therefore, the amount of interest paid.

From an analytical standpoint, the cash flows generated by these assets are interest rate dependent. This type of risk is not captured by modified duration, which ignores the value of the short call option. New measures, such as effective and option-adjusted duration, needed to be developed and employed.

Need for Consistent Asset Modeling Methodology

There are a variety of groups that use asset modeling in insurance companies today.

<u>Portfolio and Asset/Liability Management</u> -- Portfolio managers and those responsible for asset/liability management are really on the front line of the battle to improve earnings, solvency, and competitive position. Individual security buy and sell decisions and determining the strategic direction of the total portfolio require state-of-the-art modeling techniques.

Portfolio managers employ analytical techniques to measure risk and reward. As we discussed, the introduction of embedded options into the asset side of the balance sheet has made traditional measures of systematic risk less useful. These measures, average life Macaulay and modified duration, only use the scheduled maturity payments in the calculation and do not take the call or prepayment options into account.

A different way of measuring duration, or the price sensitivity of assets to interest rate changes, is to back into it by calculating the effective duration. Effective duration explicitly solves for the actual percentage change in price for a movement in interest rates using central differences. This measurement requires the accurate calculation of the price change of a security, and therefore, the accurate projection of asset cash flows including the embedded option in different interest rate scenarios.

The reward is usually measured by calculating the option-adjusted spread. This is defined as the yield of the underlying asset stripped of its embedded options less the yield of the duration-matched Treasury -- or the risk premium on the security without the premium for the short call option.

The use of a consistent modeling philosophy across all asset classes in the portfolio allows a determination of the portfolio's effective duration and effective convexity for asset/liability management with consistent interest risk level and volatility assumptions.

Balance Sheet Management -- Financial Accounting Standard (FAS) 91 introduced volatility into book values and FAS 115 introduced market volatility into the asset side of the balance sheet during a time when risk-based capital and public scrutiny increased pressure on capital. Market values of assets and their relationship to the book values of liabilities are newly visible constraints in asset/liability management.

Compliance with Regulators and Rating Agencies -- The last and certainly not the least use of asset modeling in an insurance company is for compliance with regulators and rating agencies. Most companies that began cash-flow testing for regulatory reasons, now consider it an integral part of their asset/liability management process.

Rating agencies required more testing of interest rate sensitivity. A.M. Best, for example, now requires a report for the mortgage portion of the asset portfolio of market values, average life, and modified duration numbers for shifts of up and down 300 basis points by 100 basis point increments.

In summary, projecting market values for financial statement and regulatory purposes using a different set of models than for portfolio management can be counterproductive since these applications are very visible and impact the company's competitive position. Certainly, the sensitivity of results to different assumptions should be tested. But if any one group uses a model that is less sophisticated than others, the outcome will be unsatisfactory.

Fixed-Income Asset Modeling Needs

Having established the need for good consistent asset modeling techniques, we need to outline what that entails.

Database of Security-Specific Asset Descriptions -- The major asset categories of the database are Treasuries, Corporate, Private Placements, Mortgage Pass-Throughs, CMOs, ARMs and Asset-Backed Securities.

Issuer	Coupon Payment Date
Quality	Coupon Frequency
Sector	Price
Coupon	Call, Put or Sink schedule
Maturity	

Private placements require a pricing method and liquidity premium. Mortgage-backed securities also require a pricing weighted average maturity, weighted average coupon, and prepayment speed.

CMO cash-flow modeling is primarily an algorithmic logic problem. The rules are given in the prospectus. The difficulty is in translating these into a computer program. In general, the entire deal needs to be reverse engineered in order to model any one specific tranche.

Adjustable rate mortgages require a significant amount of additional information: Reset frequency, reset date, reset cap, lifetime rate cap, lifetime rate floor, index name, look back, index spread, collateral bucked, and convertible feature.

Asset-backed securities require structure, first principal payment, clean-up call, annual percentage rate (APR), and the prepayment assumption.

<u>Models</u> -- Many fixed-income securities provide the issuer the option to prepay. I separate these securities into those that involve one decision maker and pooled securities that involve multiple decision makers, like asset-backed securities and mortgage-backed securities are backward looking or path dependent. The anticipated cash flows at any given time will depend on previous prepayments.

There are path independent models. Corporate debt securities are the primary example of an optionable security with a single decision maker. They are typically callable, allowing corporate treasurers to refinance their firm's debt when prevailing interest rates are sufficiently low. Most corporate treasurers maximize the value of the firm's equity by minimizing the value of the firm's debt and call the firm's debt when the debt's market price reaches its call price. Using this methodology it is important to have a valuation model that will allow the embedded call option to be priced at every point in future economic scenarios.

Valuing options has been the subject of research for years, and there are a variety of approaches from binomial lattice option models to modified Black-Scholes approaches. At Capital Management Sciences (CMS), we use a model which is a way of approximating a differential equation, a moving boundary problem. The model uses a "grid" to evaluate the price of the bond today, given its possible prices at each subsequent critical date in the future. Working backwards from the maturity date to the pricing date, the price of the underlying bond at each coupon payment date is compared to the call price at each point on the grid, similar to a binomial lattice. The difference is that the CMS model also incorporates the "adjacent" values of the bond, based upon small deviations of the forward curve. This keeps the valuation error from growing with time.

There are path dependent models. Mortgage modeling of individual level pay self-amortizing loans is straightforward. Standard annuity formulas produced the cash- flow streams. The critical issue in modeling mortgage-backed securities is estimating the prepayment behavior of pooled loans. Unfortunately, the rational value-maximization behavior of corporate treasurers does not appear to characterize homeowners, who also have the option to prepay their home mortgages. For example, some homeowners prepay their mortgages when it is financially disadvantageous due to relocation or divorce. Conversely, some homeowners don't prepay their mortgages when it is financially advantageous perhaps due to falling real estate values.

A successful prepayment model must be flexible enough to handle all of the variations in the mortgage market, simple enough to emphasize the most important elements (and de-emphasize noise), and explanatory enough to disclose the underlying assumptions so that the user can understand the basis for prepayment behavior.

At CMS, we use a five-factor model to describe homeowner prepayment behavior. The factors explained below are refinancing incentive, burnout, seasoning, seasonality, and collateral type.

1. <u>Refinancing incentive</u> -- Lower refinancing rates increase the homeowner's financial incentive to prepay. The relationship between the financing rate and the prepayment rate is nonlinear. If new mortgage rates are only slightly lower than the old mortgage rate, the cost of refinancing may be greater than the interest savings. When the differential approaches 200 basis points, prepayment increases dramatically.

   It is important to recognize that the homeowner's financial incentive to prepay depends on short-term adjustable rates, as well as long-term fixed-rate refinancing alternatives. In effect, homeowners believe that they can predict interest rates and will opt for an adjustable rate mortgage when long-term rates are too high.

2. <u>Burnout</u> -- Homeowners are individuals in their response to the refinancing incentive. Some homeowners will respond slowly. This could be the result of varying levels of financial sophistication or different access to financial information.

   A mortgage pool is burned out once all the quick respondents have refinanced. Once a pool is burned out, the remaining homeowners would not prepay as quickly with a similar refinancing incentive.

   The burnout function measures what fraction of its expected speed a pool will prepay as a function of its factor ratio, or percentage of the original balance outstanding. The lower the factor ratio, the more burned out the pool and so the lower the speed of prepayment.

   There is an argument that the burnout effect may become less important for future fixed-rate pools as all borrowers become more informed and there is a relaxation of refinancing requirements and cost.

3. Seasoning -- Seasoning is the aging of the mortgage. As anyone who has recently bought a home or refinanced a mortgage knows, having just completed a closing, the probability of refinancing is slight. In other words, prepayment speeds are expected to be slow for newly originated loans. As the mortgage ages, the probability for the occurrence of relocation or another event that triggers a refinance increases. However, at a certain point, the probability levels off. After becoming established in the house, the homeowner is less likely to be subject to a job relocation, for example.

4. Seasonality -- Seasonality simply refers to the fact that home sales are significantly higher in the spring and summer months and lower in the fall and winter months. As a result, there is a corresponding seasonal pattern in prepayments. This pattern is ignored for long-term projections, but can be important for short horizons.

5. Collateral -- Prepayment rates vary across issuing agencies. Government National Mortgage Association (GNMA) securities, which are Federal Housing Authority (FHA)-insured and Veterans Administration (VA)-guaranteed and, therefore, have income and other constraints, typically prepay slower than corresponding Federal Home Loan Mortgage Corporation (FHLMC) or Federal National Mortgage Association (FNMA) securities. We separately estimate the parameters of the prepayment model for mortgage securities issued by different agencies. Whole loans, which are generally nonconforming loans, such as jumbos, are characterized by a much higher level of prepayment and are also separately estimated.

The same factors also apply to modeling adjustable rate mortgage loans. However, these loans generally have coupons that are closer to the rates offered on current refinancing opportunities. Caps and floors and time to reset can keep the actual coupon from being the fully indexed coupon for a period of time.

Some adjustable rate mortgages (ARMs) have a convertibility feature. The presence of this feature dramatically increases the prepayment sensitivity.

Asset-backed securities, including home equity loans, have prepayment rates that are not significantly impacted by changes in interest rates.

Modeling stochastic interest rate scenarios is important for good valuation and analytics, but not particularly important for cash-flow testing under deterministic scenarios.

Models are differentiated by the number of functions modeled, volatility assumption, and mean reversion.

Models can model a single factor or have multiple factors. Single-factor models are more efficient and give good results for securities whose cash flows depend on the general level of rates. Multiple-factor models need many more inputs. A two-factor model needs five inputs: level and volatility for each factor as well as covariance. These models are more cumbersome but do model the real world more accurately. They give more reasonable results for dual-index securities.

Volatility can be assumed to be constant over time or a function of time, rate level, or maturity.

The specification of an interest rate process generally requires mean reversion or the model would imply that interest rates could grow without boundaries. Inclusion of mean reversion dampens the impact of the volatility assumption because it reduces the variation of the short rate around a long run value.

Analytics -- Cash-flow testing gives you a good way of measuring gain and loss in specific scenarios, since existing summary risk measures (like modified duration) have been inadequate for interest-sensitive securities.

Cash-flow testing under random interest rate scenarios can be used to generate summary risk measurement numbers for securities with embedded options (like effective duration) as well as summary reward numbers like option-adjusted spread. These measures can help with ongoing asset/liability management. Since these summary numbers are averages, it is important to analyze the distribution of results and specific scenarios that produce "outliers."