1996 VALUATION ACTUARY SYMPOSIUM PROCEEDINGS

SESSION 32

Asset Modeling II

John E. Heinmiller

Peter Fitton

Joseph M. Rafson

ASSET MODELING II

MR. JOHN E. HEINMILLER: Peter Fitton will begin the second asset modeling session by talking about securities with options and derivatives. I will be talking about corporate government debt, mortgage-backed securities, and collateralized mortgage obligations (CMOs). Joe Rafson will be covering real estate equities and investment and disinvestment strategies.

Peter will now discuss the securities with options.

MR. PETER FITTON: Modeling securities with options could be the most general of topics. In particular, I'm going to focus on optionable corporate law. When I'm talking about options I mean not only the call-and-put options that are embedded in corporate bonds, but also sinking funds. Sinking funds often have option characteristics in the sense that the company sinking the corporate bond has the option to buy bonds in the market or retire the security with cash at par value. There's often an option to double or triple or pay one-and-a-half times the sink amount. That represents basically a call at par for a portion of the bond's outstanding face value.

Our goal in producing asset models for corporate bonds is twofold, and I'll call one goal the easy one and the other the extremely difficult one.

The easy one is to calculate a current fair price, that is, a fair market value for the corporate bond. The extremely difficult one is computing the horizon price at some point in the future along some scenario of interest rates.

I refer to the current fair price as the easier one because for most liquid, actively traded corporate bonds, there exists a market price that we can simply look up. For the less liquid corporate bonds where we want to use a model to assess a price, the approach has been to price by simply applying a certain spread over treasuries, either previously calculated from the same bond or estimated by looking at bonds with similar characteristics in terms of credit risk, and sector, and perhaps by adding a small premium for illiquidity.

On the other hand calculating the horizon price for a corporate bond, or any interest rate dependent asset, is quite a difficult job.

Let's assume five years from now along a certain scenario of interest rates, we're going to have a prespecified yield curve, or we're going to have some yield curve that is randomly generated. What will the value of the corporate bond or other security be at that time? This is a difficult question primarily because of our lack of knowledge about spreads.

There's an issue of calculational complexity. If we want to price the security at quarterly intervals, each price demands its own involved calculation. For horizon pricing of Treasuries we have to take the time to do that. But that's less of a consideration than simply not knowing what the spreads are.

We have good reason to believe that the spreads will change in the future. For one thing, if a corporate bond has a certain credit spread today, we expect that spread to decline as that bond approaches maturity. Whether the bond will pay back principal becomes more certain.

Also, we have no idea what kind of market changes there are going to be, or what the position of the corporation is going to be five years from now in terms of its future credit quality. There aren't good reasons to believe that the spread at which it's priced over Treasuries is going to be constant.

What to do about this is a difficult question to resolve. On the one hand we may decide that it's simply not important; that is, we may think when we're projecting ten years into the future, even though we're required to do it, it's a ludicrous exercise. So making gross approximations of things five years or more in the future is acceptable.

On the other hand, we can increase the complexity of our model by introducing for corporates, a model of spreads. A simple one would be the one that Joe mentioned earlier, where we induce a dependence on interest rates in the sense that as interest rates go up, spreads tend to widen.

A more complicated one is an extra random process for credit quality, where AAA bonds have certain probabilities of becoming AA or A rated bonds in the future.

The inputs to modeling securities with options, in particular corporate bonds, are the instrument characteristics themselves that derive from the prospectus but more likely are taken from a data service or accounting information, as John mentioned earlier.

We need a set of input market prices: an initial yield curve that we fit our interest rate model to and a set of corporate bond prices that we fit our spreads to. We also need the valuation model itself which projects interest rates, produces cash flows, and discounts them to today at the appropriate treasury rate plus spread.

Let's examine the components of the valuation model itself. There is a random process for the yield curve for the term structure of interest rates as we discussed at the end of the Asset Modeling I session. The routine for generating cash flows can be at a level of high complexity or low complexity.

I mentioned sinking funds. Many models of corporate bonds that are in use either ignore sinking funds completely or assume that they'll always be sunk at par. Some others make approximations because a sinking fund is the optimal sink policy that a corporation might follow. If it does sink the bond optimally, it is quite complex. And the software routines to do so are sold to the corporations who make the sinking fund decisions at fairly high-price points.

That sort of approximation is common in modeling corporates. In addition, suppose we use a scenario basis for modeling; we may have bond options that are Bermudan or American in nature, where they can either be continuously exercised or exercised at a number of different dates over the life of the bond. These are the most common bond options. Here the exercise decisions depend on having a model of the future. You must be able to compare the discounted value of future cash flows if you don't exercise the option with the value you're going to get by exercising the option.

At each stage along the scenario, calculating the discounted present value of cash flows is a heavy computational task. We often make a very crude approximation to optimal exercise decisions for these kind of options. For example, we set a price at which an option will always be exercised, regardless of the indications of the interest rate model for what the future might hold at that point.

The fitting routines for matching current market prices also come at varying levels of quality. There are very simple methods of looking at an initial yield curve and, say, boot-strapping out a set of spot rates. The boot-strapping routine starts at the short end of the curve, figures out the first spot rate, and then uses that to figure out the next one and so on for each of the maturities available in the on-the-run or Constant Maturity Treasuries.

Proceeding in that manner doesn't tell us anything about the spot rates in between the points at which we have Treasury maturities. So we have to use some sort of smoothing routine to figure out these rates. Software products like PTS and TAS do this.

Now the problem is that the smoothing routines come in varying levels of quality. For instance, if you draw straight lines between points on the yield curve, and use that as if it was your actual yield curve, then when you derive spot rates from that curve they still look fairly smooth. But, when you move to forward rates, you very often get a huge difference between the rate at the time period just before the five-year maturity and the rate at the time period just after the five-year maturity. So more complex smoothing routines for fitting a set of spot rates, which are going to be the basis of the interest rate model's fitting to an initial yield curve, are required in order to get a well-behaved forward rate function. Usually fitting spot rates or forward rates, rather than fitting yields, is the preferred way to go.

What are some pitfalls that can happen in asset modeling of optionable corporate bonds? One is a lack of completeness or a lack of correctness in structural information about the bond. This is a particularly potent problem when obtaining data from a market data service.

Now the market data services try very hard to represent corporates in a manner that captures most of their important characteristics in a set of fields in a database. However, they're not able to anticipate every feature that might be built into a corporate and include those fields in their database on a real-time basis.

Routines that take those features and then put them into projection software cannot keep up with the frequent changes in the database that would occur. So what you end up seeing is that you're almost always lacking complete information on the structure of the bonds, and that lack of information can sometimes be significant.

So if you're modeling assets on a seriatim basis, you may find that your projection doesn't capture some of the features of some of the bonds. On the other hand, given the abstract and simplistic characteristics of the model in the first place, this is not a problem as long as one realizes it. Whatever features are not modeled that actually exist in the bond, and which affect the market price are simply going to become impounded in the spread.

This is another good reason for not trusting that spreads are necessarily going to hold from now into the future.

I mentioned some problems in fitting the process to Treasuries. There can also be problems in the fitting process of spreads to supposed corporate market prices. Most of what's available for market prices for corporates aren't market prices at all. If you get them off the market data services or Bloomberg or EJV, most of the prices that are being quoted there even referred to as prices. They call themselves valuations, or indications, or matrix prices. Prices for a small number of corporates are obtained from a selection of dealers, and are fit with some sort of regression model on the characteristics, including the sector characteristics and the credit quality characteristics. They regress on the kinds of structural features, what industry are they, and so on. This model is used to predict prices for the rest of the corporates for which no traded price is available.

So when fitting spreads to such prices, what you're doing, in essence, is going back through whatever model has been used to create those prices in the first place, reproducing those model spreads, rather than some actual market spreads.

The final pitfall I wanted to talk about was the pricing model not handling some characteristics. I already mentioned sinking funds in this regard. Others are the default risk and liquidity risk. One of the most important things that many pricing models for assets disregard is correlation effects. For example, what if you have a floating rate corporate that's paying off something like a Constant Maturity Treasury rate or Constant Maturity Swap rate? The most important effect on the valuation of that bond is really the correlation between the longer term rate, the Constant Maturity Treasury or Constant Maturity Swap rate, and the discount rate used to discount cash flows.

And this goes back to the interest rate model. If you have an interest rate model in which there's only one factor, so there's perfect correlation between those two different sets of rates, you're going to see a different impact on price and a different impact on the valuation of risk than if you have one where you have multiple factors. With a multiple factor model you have some level of less-than-perfect correlation between longer term and shorter term rates.

The next topic is interest rate derivatives where your data is usually much better. You have a small number of positions and you have contracts for them. Since they're over the counter, you know what the characteristics of your instruments are. They tend to be for large dollar amounts so it is important to model them on a seriatim basis. Modeling their characteristics properly in order to capture all the value is important.

Since they're highly illiquid instruments, of course, they don't appear in investment and disinvestment strategies. Thus, a horizon price at every point along your projection is less important. Having a good one is really only important at the liquidation point, usually at the end of ten years.

Swaps can become liabilities. They may start as assets, and they may start as a zero-value position, but in the future, a swap can go the other way and become a liability. And since it's a swap, it's duration (it's interest rate sensitivity) is so high, the effect of a swap becoming a liability on the evolution of your portfolio can be significant.

One of the important implications of what I said about interest rate derivatives, for modeling purposes, is that it's important to model them on a consistent basis with other assets and liabilities.

It is really not a good idea to be using a different interest rate model and a different approach to model interest rate derivatives than are used for corporate bonds, but this is common practice. Interest rate derivatives are much more sensitive to certain characteristics of the interest rate process, such as volatility, than corporate bonds. A different modeling process and a different interest model is used for interest rate derivatives than for corporate bonds, in order to better capture this extra sensitivity.

However, if you want to compare things on a reasonable basis, using your best model for all of these assets is pretty much a requirement.

Let's talk just briefly again about the interest rate model since it has so much of an effect on interest rate derivative valuations. I talked about the difference between the risk-neutral and realistic interest rate models at the Asset Modeling I session. This is a completely separate dimension that I'm going to talk about now which is arbitrage-free versus equilibrium.

In an arbitrage-free model one goes through the process of creating a statistical model for interest rates, and then projects interest rates for producing cash flows and discounts to today to get a fair market value. One then goes on to take a certain set of assets, usually Treasury bonds, and compares those fair market values to the market prices of the Treasuries. We then adjust the model of interest rates, until there's an exact match. Thus you have an arbitrage-free model.

If, on the other hand, we have a model that's in equilibrium form, we're creating a statistical model for interest rates that works approximately well over time, but doesn't match exactly to some initial set of market prices. In other words, it's really a pure statistical model rather than a statistical model that has been shoe-horned into a particular behavior at a particular point in time.

This is relevant because we might consider using an equilibrium model that hasn't been calibrated to a set of initial market prices to value some interest rate derivatives. We would really be making two bets. One is that the interest rate model is reproducing the underlying price properly (or reproduces the underlying rate properly when valuing caps, floors or swaps). And two, is that the model is valuing the derivative properly.

Whereas in the arbitrage-free case you force your model to do the underlying properly; that is to exactly match prices or rates underlying the derivative. You're making only one bet that you're getting the derivative portion of the cash-flow routines correct.

On the other hand, there is a role for the equilibrium model in interest rate derivatives. The reason for that is that in some cases data on the underlying is not available. If you have an option on a long-dated cap, you know that observed prices for long-dated caps are simply not available. There's no one who can give those to you, because there is not even an inter-broker dealer in that market. So, if you end up using an equilibrium model in that case, you're avoiding the situation in which you fit an arbitrage-free model to a set of bogus prices.

MR. JOHN E. HEINMILLER: Peter's topic on pricing securities with options covered much common ground with my next topic. The two areas of focus will be bonds and mortgage-backed securities. One common criteria for success is comparing prices from the model with prices from other models. I think it is very important to understand the investment culture and how these prices are generated.

In the years that I have been involved to help introduce actuaries to asset modeling, I have found that it is important to help them understand that the culture in valuing assets is very different than the traditional actuarial culture or model building. Most actuaries receive an initial exposure to modeling in an insurance product pricing context. The criteria for a successful asset model is very different than these other asset models.

A primary difference is the attention paid to details. When actuaries start exploring the asset side of the company, they find there can be millions of dollars invested each day without regard to a detailed understanding of the securities purchased. It can come as quite a surprise to find that many investment decisions are made without an independent pricing model. It is amazing to see the volume of dollars that are purchased without an independent analysis of the securities, or without a basic reading of the securities prospectus.

This is an example of the cultural differences between the actuarial culture and the investment-trading culture. If you ever want to have an interesting day, run down to the trading department with your own calculated prices, and second guess the prices paid by the trading department. Such questions will result in a quick escort to the door.

A light book that I recommend to actuaries that want to learn about the investment culture is titled *Liar's Poker*. This book provides background of the life of a bond trader and the development of the mortgage-backed security markets. The investment sales process to institutional investors appears to mirror the used car market. When selecting a car from a used car lot, the opportunity of matching poor quality cars with unsuspecting customers exists. Both used car salesmen and bond salesmen appeal to the customer who trusts that the products sold have the quality advertised.

The brokers have a superior vantage point to understand the collateral backing corporate and mortgage-backed debt. The brokers also make the time to carefully analyze the embedded options in the security, and place these options through rigorous analytics.

Peter mentioned how many quoted security prices are indicators or valuations. There are a number of companies that sell data on securities. These data include both descriptive information about securities and their prices. But I have never found a dealer in security pricing who will disclose his or her pricing methodology. Many securities are not modeled, but simply matrixed priced by being compared to a similar asset that was modeled. When working with investment data from the portfolio manager, it is key to question the source of the pricing information.

Once you have decided on a data source and a calculation engine, you are ready to calibrate your model. The place to start is with a simple asset, like a treasury bond. Because these securities don't have risk, and typically have a simple structure, they are good starters. More advanced bonds like junk and CMOs are complex to model. The default and prepayment characteristics add a tremendous amount of complexity to the modeling process.

Asset models and the ability to rigorously price securities continues to improve. Better algorithms, better data, and faster computers are all contributing factors. It is possible that in the not-too-distant future we'll see trading quality portfolio analysis taking place on desk-top computers. This presents an opportunity to actuaries.

While bonds largely rely on interest rate models, mortgage-backed securities add the complexity of modeling complex and inefficient prepayment behavior. The common practice in the insurance industry is to look at the Bloomberg dealer prepayment estimates. This provides a very simple model of prepayment behavior. Basically the only considerations in these simple models are the type of issuer, the coupon, and the term of the mortgage. Better prepayment models look at additional factors, like burn and healing. The burn phenomenon occurs when a pool of mortgages do not refinance when obvious prepayment opportunities exist and we assume that the majority of mortgages can be prepaid. The remaining population is now characterized as price indifferent or financially impaired to the point that refinancing the original mortgage is not an option.

One of the best periods for studying prepayment history occurred as recently as 1993. In that year, there were two precipitous falls in market interest rates. A common rule of thumb is that when rates drop 150 to 200 basis points, refinance behavior is triggered. In 1993, we had two falls in interest rates which triggered a large volume of prepayment activity. There was substantial money from reputable investment firms that bet heavily on interest rate movement after the initial fall. These bets would pay off if interest rates rebounded. When rates continued to drop later in the year, the money managers lost substantial sums. One point is that the prepayment activity, together with the interest rate volatility, can make mortgage-backed securities much more difficult to model. The second point is that some of the companies that lost substantial sums were naive about the risks they were exposed to. Even some firms with the best reputation in modeling prepayment behavior lost by betting the wrong way.

Joe Rafson will now conclude with a talk about modeling real estate and equities.

MR. JOSEPH M. RAFSON: The most common approach to modeling real estate is to exclude it from the test, which is a fairly easy way of handling it. Of course, you must have enough surplus to cover your real estate to be able to exclude it.

The other ways of modeling real estate are generally very simplified approaches. Assume you're currently earning a 5% cash and cash return. You can simply assume 5% cash on cash return going forward.

Or perhaps your real estate department suggests that you will in the future get an 8% cash on cash return. You can grade to that and assume that will be a long-term return.

Sometimes real estate returns are modeled on an accrual basis only. You can assume you will get an 8% internal rate of return (IRR) on real estate. You can accrue 8% on the real estate, although that's an approach with particular problems. Some combination of cash return and appreciation is sometimes modeled on a very simplified basis.

Occasionally we see deal-by-deal projections. Real estate professionals sit down and go through each deal and lay out what they think the returns and the cash flows will be. They add them up and input them into the model on a one-line basis.

When we go to the equity side we'll see similar approaches. It's typical that unaffiliated equity is excluded from the model. Sometimes a simple assumed cash return is given; sometimes it's just accrual. Sometimes a combination of dividends and accrual is assumed.

Affiliated equity is almost always excluded. You have particular problems trying to model investments and insurance subsidiaries. You would have to pass through the results, modeling subsidiary performance in a pop-up scenario, etc. That can be a fairly onerous process. Again it's typically just excluded from the test.

There are some problems with some of these approaches. I have mentioned excluding these sorts of assets and perhaps your most troublesome CMOs because they're difficult to model, or because you don't like the pattern of earnings that they give you. You end up with a group of nonmodeled assets which must be less than your surplus. But if that bucket exceeds surplus, you have your nonmodeled liabilities being backed by things like real estate, which is not always appropriate.

Unrealistic real estate expectations are common when they are modeled. Sometimes actuaries get real estate projections from their real estate department. There may be some conflict of interest; for instance, the real estate professional may not want to give you the bad news all at once.

Sometimes when you get your real estate through foreclosure, the reason the property is foreclosed in the first place will give you subpar returns on a going-forward basis. Obviously there's also a problem with lack of correlation of the interest rates, and that makes the modeling somewhat problematic.

Sometimes we have a problem in a block that is in run-off. When you have an accrued return or when you do not have a declining principal balance in a real estate or equity portfolio, these assets grow as a proportion of what's in the test.

For instance, take a company that starts with $1 billion in assets equal to $1 billion in liabilities. Twenty years later, they may have $100 million in liabilities and $200 million in assets.

The problem is if we've started with $30 million or $40 million in real estate or equity, that has accrued and grown, and by the end of the test, 75% of our portfolio may be in stock and real estate. How realistic is that? Sometimes it's just not noticed because actuaries tend to focus on ending surplus.

While investment and reinvestment assumptions can be critical to a test, they're often tremendously simplified. We see companies that have a variety of invested instruments. It is not uncommon to see companies modeling their reinvestment as one typical investment, such as a five-year, noncallable A-rated bond. And that's it. Perhaps this is acceptable but it also indicates the model isn't being used to its full potential in terms of evaluating different strategies or in terms of integrating the model for other purposes.

We frequently see a static approach to investment strategy. No matter what scenario is being modeled, we're going to use a set strategy for a given product line.

But we all know that's not the case. If rates do pop down 300 basis points and stay there, our companies are all going to be pressured to find yield. We saw that in a recent *Wall Street Journal* article. The article was about investments leaving Japan in search of higher yields. This money is going into hedge funds and such because they need the yield. Japan has experienced very low interest rates, and they've stayed low. So they're seeking yield, and I think there will be that pressure within the insurance industry of whether we should actually get a pop down or gradual down scenarios.

Reflecting different investment strategies is something to be considered. These "what if" strategies make up some of the real value of modeling. It can open a dialogue with your investment department. It can really get you thinking of how to anticipate interest rate movements and what actions can be taken for protection.

A comment about CMOs. Obviously your existing CMO portfolio is going to be subject to wide swings in prepayment rates given the pattern of the New York seven scenarios.

However in the pop-up and pop-down scenarios, on a reinvestment basis, you may be getting extra spread on CMOs. without the associated prepayment risk, since these scenarios are flat after the initial interest shocks.

If you purchase a CMO in a pop-up or pop-down scenario, it's going to return principal exactly as modeled and as anticipated. So the return associated with volatility is not priced within some of the New York seven scenarios. To a lesser degree, that's also true in the gradual up, gradual down and up-and-down scenarios.

You may get some extra boost from CMOs in the New York seven scenarios, especially when compared to stochastic scenarios.

One other investment assumption that sometimes is not given the attention that it merits is the level of anticipated cash. This should bear some resemblance to the way you want to manage your business.

A comment on disinvestment assumptions. Typically for cash-flow testing done for statutory purposes, business is in run-off, although we know that's not realistic. We know we're going to write new business, and we also hope that our surplus will give us a positive return. Therefore, the amount of net cash outflows in a cash-flow test is higher than what's realistic.

Nevertheless, it's something that we, as actuaries, are required to model as accurately as we can. This increases the importance of disinvestment strategies. The two basic strategies used are borrowing and sales.

The borrowing rate can be very significant. You should investigate what your company can borrow at and what limits there are to borrowing. In terms of sales, typical modeling choices are selling by category, for instance, first we sell our treasuries, then we sell our corporate publics, and then we sell our mortgage-backed securities and so on down the line.

Sometimes sales priority is set by maximizing capital gains, which is not necessarily a realistic assumption. For tax purposes, losses are typically offset with gains.

That should be considered in your modeling choices. Also the spreads become a vital consideration when you're selling assets in determining an accurate market value at the time of sale.

Unintentional leverage is what happens occasionally in a cash-flow test where there is an unlimited borrowing capacity. When a negative cash flow occurs, you borrow. This can result in an overstated balance sheet. In one extreme case, one of our clients's ending liabilities included two-thirds borrowing and one-third insurance liabilities.

On two-thirds of their assets, they either were earning a positive or negative spread depending upon the scenario and borrowing rate.

It's something that can happen when you have unlimited borrowing. It should be just something to keep your eye out for.