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ASSET PREPAYMENT ASSUMPTIONS

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This session will address asset prepayments from several perspectives. Presentations will cover emerging prepayment experience in the mortgage-backed security arena, special modeling considerations when addressing prepayments, and the initial experience and impact of the NAIC flow uncertainty index (FLUX).

MR. STEPHEN D. REDDY: Asset prepayment assumptions and asset prepayments themselves are a very important part of modeling assets and projecting future cash flows. It's important to understand both what drives prepayments and also the total effect of prepayments on an organization. We will cover asset prepayments from a couple different angles. One will be a discussion of the NAIC FLUX model, which is a regulatory screening tool for measuring cash flow uncertainty and variability. Second will be a discussion of what drives prepayments, particularly mortgage collateral, and modeling considerations relating to those prepayment assumptions.

Our first speaker will be Randy Boushek, a vice president and portfolio manager at Lutheran Brotherhood, which is a fraternal benefit society headquartered in Minneapolis, with approximately $15 billion under management. His responsibilities include overseeing all trading, research and portfolio management within the life company bond portfolio, serving as Investment Division liaison on asset/liability management issues, directing quantitative investment research, and overseeing derivative activities across all fixed income portfolios. He's a member of the NAIC's technical resource groups on collateralized mortgage obligation (CMO) accounting and CMO cash flow volatility that developed the FLUX model. He's a frequent speaker at both actuarial and investment conferences.

Second, we have Steve Abrahams, who's a vice president at Morgan Stanley & Company. Steve is a member of the mortgage research group in the fixed income division and spends a great deal of time studying mortgage prepayments in the residential sector. I think he has some interesting things to say about what's been happening in prepayments the last couple years and what Morgan Stanley is doing in its modeling efforts with respect to prepayments.

Third, we have Catherine Ehrlich, who's a senior vice president at Capital Management Sciences (CMS), which provides fixed income software systems and consulting services to the investment management community. As a manager in the New York office, Catherine is responsible for marketing and client support on the East Coast. Prior to joining CMS, she was an assistant vice president with Metropolitan Life Insurance Company, where she

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had various assignments including cash-flow testing, pricing, and customer support for institutional pension products. She earned her bachelor of arts degree at Colgate University and is a Fellow of the Society of Actuaries and a Chartered Financial Analyst.

I'm Steve Reddy, also with Morgan Stanley. I work in the portfolio strategies group in the Fixed Income Division in New York, doing asset/liability consulting, primarily for life companies. I've had the pleasure of working with Steve. We're part of the same group, but he's much more of an expert in the mortgage prepayment arena.

Randy will lead off and talk about the FLUX system, and then we'll get into some of the other issues involving mortgage prepayments and modeling considerations relating to that.

MR. RANDALL L. BOUSHEK: My assignment on the panel is to discuss the NAIC's FLUX model and to tie that discussion to the general topic of prepayment assumptions. As Steve mentioned, I am a member of the technical resource group that developed the FLUX model under the auspices and at the direction of the NAIC's invested asset working group (IAWG).

My outline for this presentation consists of six points. First, I would like to discuss in general what the FLUX model is and, perhaps, more importantly, what it is not. Second, I want to provide a brief history of the model's development and discuss some of the considerations that led it to take its current form. Third, and most germane to this session, I want to focus on the scenario specification and prepayment assumptions that are necessarily a part of the FLUX model. Fourth, and with a promise to avoid all formulas, I want to discuss the functional mechanics of the model. Fifth, I'd like to review with you a distribution of actual FLUX scores for 1994. Finally, I'd like to comment briefly on one or two open issues.

Just what is FLUX? The FLUX model is a regulatory screening tool. It was developed specifically for insurance regulators for the sole purpose of enabling them to narrow the multitude of cash-flow testing reports that they receive to a more manageable few that may require closer scrutiny because of potential CMO cash-flow volatility. The FLUX model is specifically not a rating mechanism, nor a tool for establishing reserving requirements or pass/fail tests. It is also not a portfolio management tool. To clear up a bit of confusion, it should also be emphasized that FLUX is a calculation model, not a prepayment model. It does use and set the specification for a set of prepayment assumptions provided by the Public Securities Association (PSA), but it is neither a prepayment model nor a valuation model of any kind.

The technical resource group which developed the model was comprised of representatives from Wall Street, the insurance industry, and investment software vendors who provided much of the horsepower for testing various designs and aspects of the model. Our general charge from the IAWG was to develop a methodology for assessing the relative cash flow volatility of individual CMO tranches, with three or four specific constraints. Two key words here are *relative* and *individual*. The FLUX model provides a relative measure of volatility exposure—there is no absolute interpretation to any FLUX score. Further, the FLUX model only attempts to quantify the potential for cash flow volatility without assessing whether that volatility would be good or bad for the holder. More contentiously, the model is specifically designed to evaluate bonds on a tranche-by-tranche (as opposed to aggregate-portfolio) basis, at the direction of the IAWG.

There were three other specific guidelines provided by the IAWG. First, the model was to have an "open architecture," meaning that all formulas were to be publicly available and reproducible by any interested party, and all assumptions were to be under control of the regulators. No "black box" approaches were acceptable. Second, the model was to produce a single score for each CMO tranche across all companies, that is, a score that is independent of book value. Certainly, if I own a bond at a price of 80, and you own the same bond at a price of 120, we have very different statutory risk exposures. Nonetheless, given its specific objective, the model was expressly developed to be independent of holding price. Finally, the model had to be as simple as possible.

As to the development process itself, we initially considered three different models submitted by members of the technical resource group. The FLUX model in its original form was developed and submitted by Andrew Davidson. It underwent several refinements over the course of more than a year before it was submitted in final form to the IAWG. Beyond the design of the model itself, several other issues had to be addressed: How many scenarios, and which ones? How do we combine results from various scenarios? What prepayment assumptions do we use? How do we accommodate floating rate instruments? I'll address scenarios and prepayment assumptions in a moment. The question of combination is actually quite interesting. The FLUX model produces a single numerical value, or score, for each CMO tranche for each scenario. Given a vector of scores corresponding to a set of scenarios for a given tranche, one might make an argument (and more than one did) for either the maximum or mean as the best representative score for the bond. In the end, after considerable deliberation, we settled on root mean square as the most acceptable compromise.

The specification of scenarios and prepayment assumptions is designed to be a dynamic process, under the control of insurance regulators. Striking a balance between simplicity and a representative range of outcomes is particularly difficult here. Based in part on spanning set research by Dr. Thomas Ho, an initial set of five nonlevel interest rate scenarios, plus a base case level rate scenario, was established for the test year 1993. These five scenarios included two increasing rate paths, two decreasing rate paths, and one interest rate whipsaw. With the benefit of further research, a second whipsaw scenario was added for 1994, and the oscillation period of the earlier whipsaw was compressed. The addition, deletion, or alteration of scenarios in the future is entirely at the discretion of regulators.

Once the scenarios have been established and a freeze date is set to determine the initial level of interest rates, dealers are surveyed for their prepayment projections as of the freeze date for a three-dimensional array (agency, program, and coupon) of pass-through collateral for the specified scenarios. All such projections are provided as a vector of monthly prepayment assumptions for each scenario for each collateral cell in the matrix. Once this information has been received, a median speed is calculated for each month in each vector. The resulting matrix of vectors of monthly median speeds then becomes the "official" set of prepayment assumptions for the FLUX model. At any point in time, any broker, vendor, or insurer can calculate "current" FLUX scores using their own proprietary prepayment assumptions; however, the NAIC's "annual" FLUX scores are based solely on the official set of prepayment assumptions, which are publicly available to any interested party.

While the FLUX model utilizes an "official" set of prepayment assumptions, there is technically no "official" FLUX score for any bond. Given the prepayment vectors determined above, and the discount rate and volatility assumptions which I'll discuss in a moment, any broker, vendor, or insurer with an accurate CMO structuring model should be able to produce the same cash flows and FLUX scores for any CMO tranche. Annual scores are submitted to the NAIC electronically by broker dealers and distributed to regulators via the state data network. For simplicity, the bulk of the scores are submitted by Merrill Lynch via its Passport system, with scores for bonds not modeled in Passport submitted by other brokers. Life companies are not responsible for either calculating or reporting FLUX scores.

Regulators can electronically match a company's Schedule D CMO holdings to the master list of FLUX scores on the state data network for their own analysis. Since this is the limited purpose that the FLUX model was designed for, FLUX scores are not published in the insurer's financial statements.

Beyond prepayments, the FLUX model requires two other input assumptions: discount rate and volatility. These assumptions are also set annually by the NAIC. The discount rate is, as one might expect, an interest rate used to discount cash flows in the calculation model. However, the volatility assumption is a specific variable in a few of the FLUX model calculations and not the more typical controlling input into a stochastic interest rate generator or options model. The technical resource group did develop a formulaic approach for determining these assumptions, but as promised earlier I will not get into any specifics here. Suffice it to say that on the basis of this approach the discount rate for 1993 and 1994 was set at 6% and 7.50%, respectively, while the volatility rate was set at 1.75% for 1993 and 2% for 1994.

The FLUX score for any given bond for any given scenario is the sum of two components—a present value measure and a timing measure. The present value measure reflects the magnitude of negative percentage change in present value in each scenario relative to the base case. The timing measure represents the sum of period-by-period differences in scaled cumulative present value of cash flows in each scenario relative to the base case. The present value measure is designed to capture the risk of adverse prepayments on the valuation of bonds priced at a significant premium or discount to par, for example, interest only (IOs) and principal only (POs). The timing measure is designed to capture the risk of adverse prepayments on the reinvestment of cash flows, particularly for companion/support and "jump" tranches. Two key words in these definitions are *negative* and *absolute*, and they underscore a key point about the FLUX model. Namely, that it assesses only the potential volatility of cash flows without regard to direction (shortening or extending) and with no offset for beneficial impact. This also helps explain why the sum of the parts, that is, the weighted average FLUX score for each tranche in a CMO or in the simplest case for an IO and a PO, almost always exceeds the whole, or the FLUX score, for the underlying collateral.

Table 1 shows the distribution of annual FLUX scores for 1994 for the CMO universe as defined by Bloomberg, excluding those bonds for which no FLUX score was submitted. The information presented here includes FLUX scores for approximately 33,000 tranches. The first line shows the distribution of FLUX scores by number of tranches, while the second line is the distribution by dollar value. On a dollar-weighted basis, over 50% of the tranches in the universe had a FLUX score below three at year-end 1994, while almost 75% were below five. In general, 1994 scores are lower than 1993 scores, owing to changes in the starting level of interest rates, projected prepayment assumptions, and the discount rate and volatility assumptions. For the sake of comparison, I have also included the FLUX score for a current coupon Government National Mortgage Association (GNMA) pass-through, which is actually higher than the score for more than half of the dollar-weighted CMO universe. It is interesting to note that the same GNMA pass-through had a FLUX score in excess of six for 1993.

TABLE 1
DISTRIBUTION OF 1994 FLUX SCORES

	0-1	1-3	3-5	5-10	10-20	>20	Average
CMO Universe	37%	22%	12%	11%	7%	11%	6.6
CMO Universe ($-weighted)	18%	35%	21%	14%	6%	6%	5.3
Life Co Holdings ($-weighted)	?	?	?	?	?	?	?
FLUX Score for 30-year GNMA 8% Pass-Through: 3.6							

Source: Bloomberg LP 5/04/95 (universe includes 33,000 tranches)

It is important to remember that "high" FLUX scores are not necessarily bad. High scores indicate the potential for cash-flow volatility. This is not the same as indicating a high level of risk. A concentration of high scores may conceal offsetting risks within the portfolio, or ignore offsetting risks or liability exposures outside of the portfolio. High FLUX scores are simply a cue to regulators that a closer look at actuarial cash-flow testing results may be warranted.

I'd like to comment on one or two other items before closing my remarks. First, I mentioned earlier that "current" FLUX scores can be computed at any time by any broker, vendor or insurer. Beyond the obvious difference in prepayment assumptions, these scores will vary from "annual" FLUX scores for two other reasons (even if the annual prepayment vectors are used). For one thing, the starting point for interest rate scenarios will in all likelihood be different, and for another, some principal may have already paid down since the freeze date for the annual scores. As a caveat, current scores are not necessarily indicative at any point in time of subsequent annual scores.

Second, I also mentioned earlier that FLUX was specifically designed as a bond-by-bond tool. While it is theoretically possible to calculate a portfolio FLUX score by aggregating all projected cash flows before calculating the timing and present value measures, the usefulness of such a number is debatable. Beyond the desire of regulators to be able to independently assess the potential cash-flow volatility of individual investments, the implicit cross correlations between prepayments of different collateral types may incorrectly obviate or amplify the potential cash-flow volatility of the portfolio, and, in particular, may obscure any potential risk unique to statutory book value accounting. At the same time, because of the absolute nature of the calculations, the weighted average FLUX score for a portfolio is also of limited value since it fails to take into account any risk offsets within the portfolio. FLUX scores are most useful for assessing the distribution and concentration of potential cash-flow volatility in a portfolio.

MR. STEVEN W. ABRAHAMS: I was asked to give you an insider's view of what it takes to wrestle with mortgage prepayment risk. I thought what might be most useful would be to go through a truncated version of a process we finished at Morgan Stanley probably two to three months ago. The process involved rethinking our view of mortgage prepayment risk, and coming up with what we think is a new and improved tool for understanding how your bonds are likely to prepay, what their durations are, what their convexities are, and things of that sort.

Usually when I've been involved in modeling processes in the past, rather than jumping immediately to numbers and formulas, my feeling was the best place to start was to look at the data and see, frankly, if I could develop some kind of intuition for the problem that I was up against. The way that we decided to frame it at Morgan Stanley was that we wanted to be able to explain and forecast mortgage-backed securities (MBS) prepayments first over time. As as I began looking at graphs of this sort, I noticed that things definitely change over time. For example, in Chart 1 we have a Federal National Mortgage Association (FNMA) bond, 8% collateral that was originated in 1987. From 1988 to 1993, it simply bounced around paying under 10% constant prepayment rate (CPR), showing something that appears to be a seasonal cycle. All of the sudden from 1993 to 1994 it jumped for the exits. At its peak it was paying over 60 CPR. That's roughly the amount of principal that was paid down in a piece of collateral if it continued prepaying at that rate over a year. It's an annualized figure.

So, we considered things like this and realized we had to explain it over time. We also had to explain prepayments across different coupons. In Chart 2 we compared 30-year FNMA mortgages (FN30) with the highest interest rates, starting with 9.5% on the top line to those at the bottom with 8%. They were all the same issue, year 1987 collateral, and you can see that from 1988 and going into 1992, you could have owned any one of these coupons and essentially faced the same kind of prepayment risk, but in 1992 things began to diverge. Our model had to be able to wrestle with that problem as well.

We were also asked to be able to explain differences in prepayment risk across issue years. Chart 3 is an example of what that profile might look like, using the same mortgage borrower rate of roughly 8.5%, 8% passthrough, but originated at different points in time from 1987 to 1993. You can see that the prepayment patterns simply aren't a lockstep image of one another. There seem to be differences depending upon issue year. You can see that the second oldest issue year, beginning at about 1990, originally starts prepaying much more slowly than the more senior collateral. But in 1992, for some reason, it catches up and crosses over, and that turns out to be just as volatile as the bond that had been originated two to three years before. Why is that?

We also had to be able to explain prepayments across agencies. In Chart 4, we looked at two pieces of collateral with the same borrower rate, one coming from FNMA (FN30), one coming from GNMA (GN30) with completely different risk profiles, not only when they were bouncing around at low rates in the late 1980s, but also during 1993-94.

CHART 1
PREPAYMENTS OVER TIME

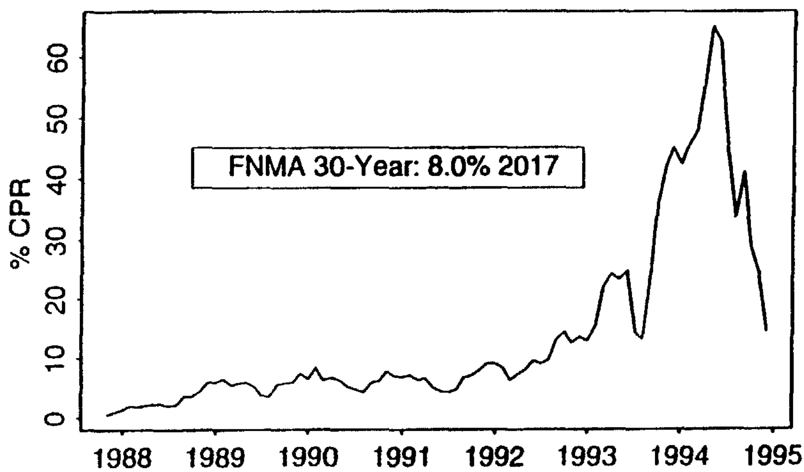


CHART 2
PREPAYMENTS ACROSS COUPONS

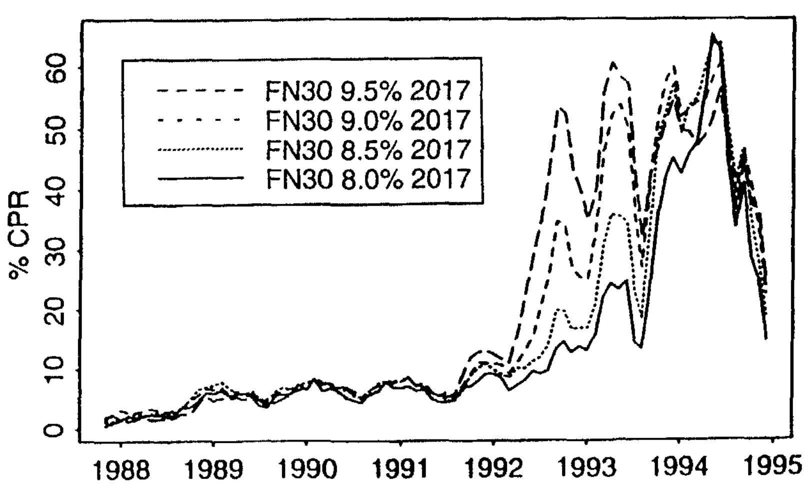


CHART 3
PREPAYMENTS ACROSS ISSUE YEARS

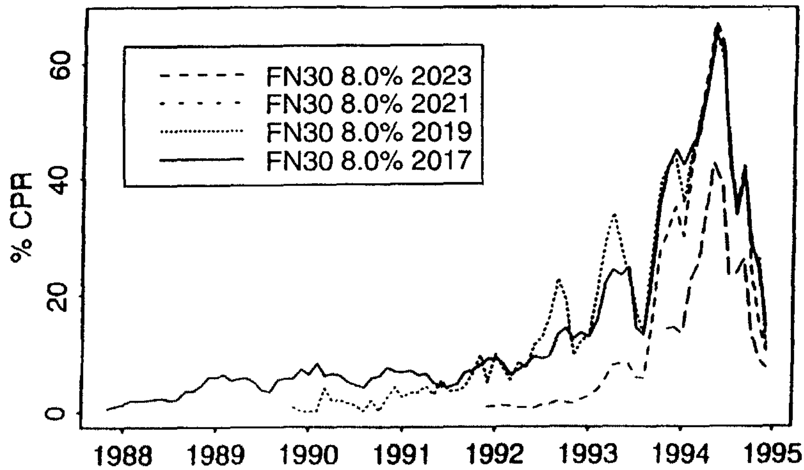
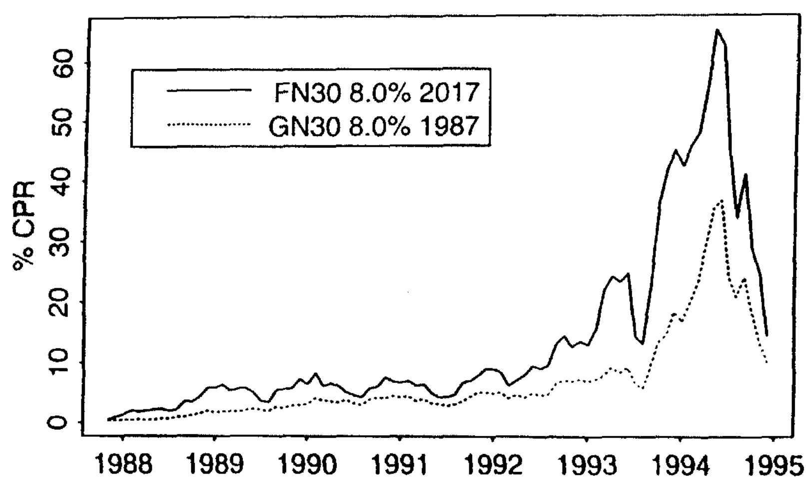


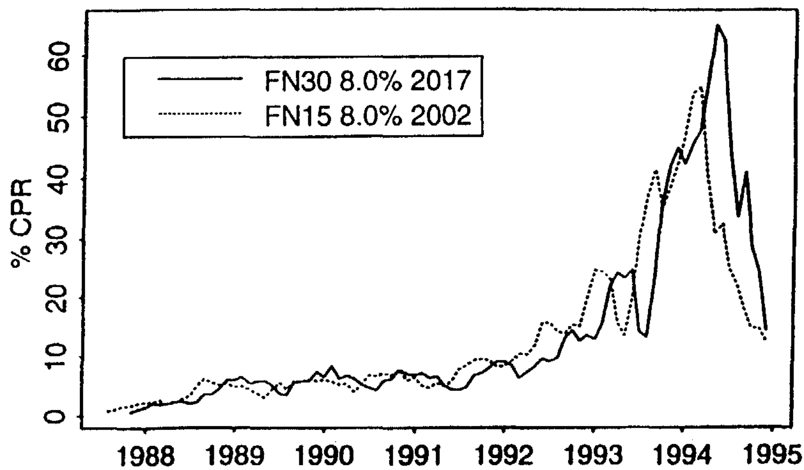
CHART 4
PREPAYMENTS ACROSS AGENCIES



There are different bonds, different prepayment risks. Again, there are lots of stories running around about why that might be the case, but there are clear differences here. We needed some framework, some set of measures, to be able to explain this difference.

And last, there's differential prepayment risk across loan term. Chart 5 shows prepayment histories on 15-year collateral, the dotted line, and on 30-year collateral, the solid black line. You see some similarity in the prepayment patterns, but they are not the same. There are other cases where not only are they not similar, but they're not really comparable at all.

CHART 5
PREPAYMENTS ACROSS LOAN TERMS



This is what we were up against as we rethought our modeling process. Frankly, it's what any prepayment model is up against, and I think as asset managers it's what good portfolio managers are up against, looking at different types of risk and deciding where they're going to place their bet next. In many cases, prepayment risk just seems like this. It's a large series of numbers on a table, and it's not clear exactly why one particular bond is high, one particular bond is low, and we need to somehow simplify the situation. Well, the simplest way to simplify a prepayment problem is to try to reduce it to a model, and a model definitely is a process of simplification. What you aim for is something that gives you a simple and intuitive explanation of what may be going on in mortgage-backs, but without making it so complex that it's unwieldy either to explain or to implement.

What Morgan Stanley decided to do in the process of rethinking was to take prepayment risk and to split it into four buckets. One part we'll call turnover, which is primarily trade-ups and relocations; a second piece we call curtailment, which is the partial prepayment of mortgage collateral ahead of schedule assumability (that's a risk only in Federal Housing Administration (FHA) mortgages, but it's a significant risk when they're securitized into the GNMAs that back your bonds). Finally, refinancings which, given rate movements, are often the dominant risk in prepayments.

Let me just contrast this against approaches that you may be more familiar with. I think until a few years ago most of us in this room would have been comfortable looking at prepayment risk and primarily talking about it in terms of a few general phenomenon. There was the risk of refinancing which you primarily measured through interest rate reincentives, let's say. There was the vague notion of burnout. Some bonds, even given refinancing opportunities, just didn't seem to prepay quickly. There was a component of prepayments related to age, and then there was some evidence of a seasonal cycle in some of the prepayment histories as well.

In 1992–93 when there were large prepayment jumps in the histories we looked at, the market, frankly, was caught short. I think that we began to realize that forecasting prepayments really isn't a static problem. It's not a set of dynamics that stays put over time. Borrowers change. Mortgage bankers and other lenders change. Tax laws change. Regulations change. We've got a nonstationary problem here, if you need to describe it to a statistician, and that means you have to take a much more subtle and flexible approach to the problem, so that you can use your prepayment models and attempt to get some sense of the exposure in your bonds to the different assumptions that these models are making.

Our first cut was to try to split the problem into the pieces I mentioned. When we started rethinking these problems and looked first to housing turnover, in some sense it was the typical cast of suspects when it came to determining the primary driver. Again, housing turnover we would consider relocations. This includes a small component of default, although that tends to be extremely small, and in-agency securities really is indistinguishable from prepayments from other sources. Collateral age was the primary driver. That kind of proxies the average tenure of borrowers in their properties. Interest rate disincentive was a factor that we wanted to consider. I think that it's often over estimated in terms of its importance, but it does turn out that if there's a borrower who has a substantially below market rate, he or she may hesitate slightly longer than other borrowers to move if the occasion arises. That often involves giving up low financing to take on a higher market rate. It turns out that, at least in our estimation, it's a pretty small barrier. Often, people are willing to move because they can get a new job or they've got a more attractive house that they want to buy, and having a marginally lower interest rate than the market offers now doesn't tend to be a barrier.

We also wanted to build in some secondary components to this turnover model. Our feeling is, and I think quantitatively we can show, that homeowner equity plays a role. That, in some sense, describes the borrower's ability to trade up. The housing market strength plays a role. That determines the seller's ability to find a buyer. And, I should also mention seasonality again. People like to move during the summer when it's warm and their kids are out of school, and they typically stay put during the winter.

We also found, and I think this was one of our more interesting findings, that it's worthwhile paying attention to the risk of curtailment. Curtailments also increase with age, along with turnover driven prepayments, and, second, assumability risk decreases as homes appreciate in price. Let me talk a little bit about the curtailment issue first. If you look at prepayments on bonds, for instance, and take a cross-section by age, what you tend to find is that initially prepayments are very low. They tend to go up some kind of seasoning ramp at least qualitatively the way that the PSA prepayment curve would describe, and then for a while they do flatten out, and that's the part of prepayment behavior that we catch in a seasoning curve. Importantly, at least we found with conventional loans in their last five to ten years, prepayments tend to accelerate. The same discount bond that might be prepaying at ten CPR, if it's only a few years old, may be prepaying at 15 CPR if it's within the last five to ten years of its term. When we originally looked at this it was a little bit surprising because there really wasn't much discussion of this curtailment risk. It turns out, though, that there's some good research that came out of the National Association of Home Builders that uses census data and comes to the same conclusion as well. You can find many borrowers who have been in their homes for 20–25 years and have no mortgage debt, and the way that they got there was by paying their loan off in full. That becomes an increasingly popular choice among homeowners as they're coming close to the end of their indebtedness horizon and decide that they just want to be done with the process.

The second interesting thing we found—another component of risk that we ended up modeling was assumability. Now, that's really a risk just with GNMA-backed MBS because those, in turn, are, at least these days, 70% FHA collateral. I'm sure, as you all know, FHA loans can be assumed, and it's a very simple process. With some older loans it's just a matter of signing your note over to the new buyer. With some newer loans the only other hurdle you have to jump is to get a credit check. Turns out to be really a very minimally difficult process. I think that a lot of investors, consequently, have worried that GNMA collateral would tend to prepay quite slowly, particularly if interest rates rose, left many low coupon GNMAs behind, and invited prospective new borrowers—new buyers of those GNMA properties to assume the loans. What we found is that it's very important to pay attention to estimates of home price appreciation in FHA properties. It turns out that if you're looking at FHA properties, let's say, that have 15% or 20% appreciation, which has not been unusual in the last five years in some parts of the country, it becomes increasingly difficult for a new buyer to come in, make a large downpayment, and take the FHA loan. So, frequently in cohorts of loans with good home price appreciation, you get prepayment speeds that look very much like conventional bonds. That's an important part of the story behind why, let's say, some recent new issue GNMA discounts have been prepaying quite well, and that's something that our model, luckily, turned out to capture as well.

Probably the biggest risk in prepayments, particularly short term, is refinancings. I think refinancings have been the subject of a lot of scrutiny, particularly in 1992–93 when I think we on Wall Street spent a lot of time explaining why we were wrong, rather than why we were right. With the benefit partly of hindsight and, hopefully, with the benefit of learning our lessons, I think we've become much more sensitized to the factors that drive prepayments. It does turn out again that if you have to just pick a few factors to focus on, it's the usual group of suspects. Interest rate incentives to refinance still are the dominant reason why borrowers prepay, for all the good reasons you could imagine. It just makes economic sense.

In our model, we also measure burnout, which, at least conceptually, we consider largely a credit or loan to value (LTV)-related phenomenon. The borrower goes back to the mortgage bank, wants to get another loan, and it turns out that his/her property has either depreciated in price or he has had a terrible payment history on either his mortgage or some other loan in the last 12 months. As a result, they either have to wait or they just decide it's too much of a hassle. You can see interesting differences, incidentally, across different agencies in terms of magnitude of burnout. For example, FHA offers its borrowers a streamlined refinancing program that involves neither a credit check of the borrower nor an LTV check. As a result, they don't face a lot of the same credit barriers that conventional borrowers do and, at least to our method of estimating relationships, show significantly much less burnout as well.

We sometimes refer to our housing turnover model as our discount bond prepayment model. When it comes to premium bonds, collateral age also plays an important part, but probably a different direction than you would expect. What we found is that, based on pure age alone, the tendency to refinance goes down over time, sometimes dramatically. There are two inferences, at least, that I've made off of that relationship. One is that over time bonds amortize. There's less principal out there, obviously, and the value of the borrower's refinancing option goes down. Second, I would put my money on this one with greater confidence, as borrowers have spent three, four, five, or ten years paying off a loan. They're very hesitant to go out and extend their debt horizon another three, four, five, or ten years. I think one thing that we saw in 1993 which gives credence to this is the fact that when interest rates fell to 25-year lows, 30-year borrowers, probably the plurality, jumped for 15-year loans, not necessarily electing to reduce their payment, per se, but clearly electing to reduce their debt horizon. So, if you recognize that bonds as they age in and of themselves show a lower tendency to refinance, suddenly you realize that there's possibly more value in seasoned collateral, for instance, than you might have recognized before.

The shape of the curve can also be important; essentially when the curve is steep and borrowers can get cheap adjustable rate mortgages or balloon mortgages, and so on. They tend to refinance faster than if they had a flat curve. There were a series of secondary effects that we noticed driving refinancings. Seasonality, or the time of year, makes some minor difference in refinancings. They tend to fall immediately after the new year. There's an interest rate trend effect. Prepayments are different in a falling rate environment than they are in a rising rate environment. Again, homeowner equity makes a difference when you walk into the bank and they look at your LTV, and housing market strength makes a difference as well. I think that's generally a proxy for a robust economy, consequently, the ability of people to execute these refinancings with little difficulty.

After we had looked at the data, we tried to rethink the problem. I will spare you some of the mathematical relationships we had to describe and some of the statistical methods we used to estimate them, but I can show you some of the results we obtained at the end of the process.

A couple of things are shown in Chart 6. Let me just point out exactly what they are. In the top graph, the solid black line shows what actual prepayments were on some 8.5% collateral. The dotted line reflects the in-sample prepayment fit of the new model, shows you a little history. The dashed line is an old prepayment model that we had at Morgan Stanley. You can see where the dashed line fell down in the waves of 1992–93. We just missed the peaks. We've gone back, learned more, and captured the historic dynamic better. Again, one of the things we wanted to do was catch things over time, and, although it's not split up there, there's a turnover model that's operating from about 1987. In 1992, the turnover model continues to operate in this particular fit, and then the refinancing component turns on as well.

The bottom graph shows that the amount of error you get when you fit prepayment data is relatively minor. Unless, however, you're talking about very leveraged bonds, let's say, two to four CPR when we go into the refinancing waves and the errors swing out, plus or minus six CPR. I think it's important to get a sense of what is possible when it comes to prepayment modeling. If people are looking for estimates that are absolutely right to the last CPR, then that's something that is probably beyond the reach of most models I'm familiar with. This is probably a reasonable set of expectations of error.

CHART 6
FNMA 30-YEAR 8.5% 2017

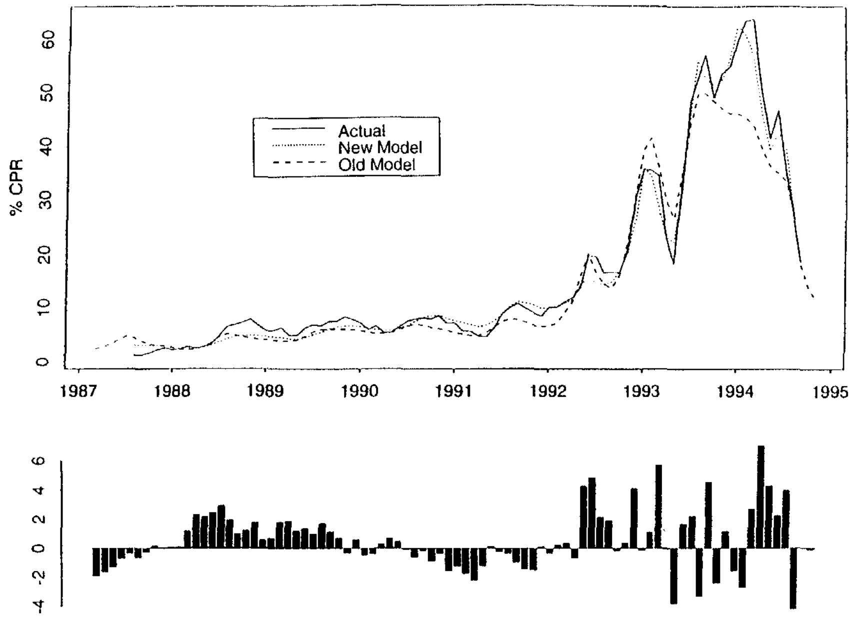


Chart 7 is another example of old versus new. Again, this is a different issue year, same pass-through rate of 8.5%. The errors here, let's say, swing 5–10 for one period or two and then back, but they're pretty much clustered around zero.

Chart 8 shows another coupon. It's a 9%, again old collateral. You can see that the dashed line showing the old model misses some of the prepay volatility of 1992–93, but the new generation catches it. Finally, for a newer issue year, 1990 collateral, again the new model, shown in Chart 9, represents an improvement over what we had before.

What I took away from this whole process was that prepayment modeling is part art and part science. You really have to start with what you think is a good framework for what's going to drive borrowers to prepay, whether it's mechanistic, or whether it's based in a view of financial. You want to get data that's as widespread as possible from a variety of different prepayment environments so that you can look at a whole set of circumstances and see the relationships between the independent variables and the outputs.

Still, more than anything else, I think it's important to recognize that the prepayment model that I have may not be the right prepayment model for a year-and-a-half to two years from now. So, one thing that we've also done is create some software that allows us to change some of the assumptions in our prepayment model either in scenario analysis or for dropping into option-adjusted spread (OAS) analysis. I think you're going to see that it's increasingly important not only to look at interest risk but also to look at prepayment model risk in valuation of securities. Some securities are going to be very sensitive to one set of assumptions and other securities to yet other assumptions.

CHART 7
FNMA 30-YEAR 8.5% 2020

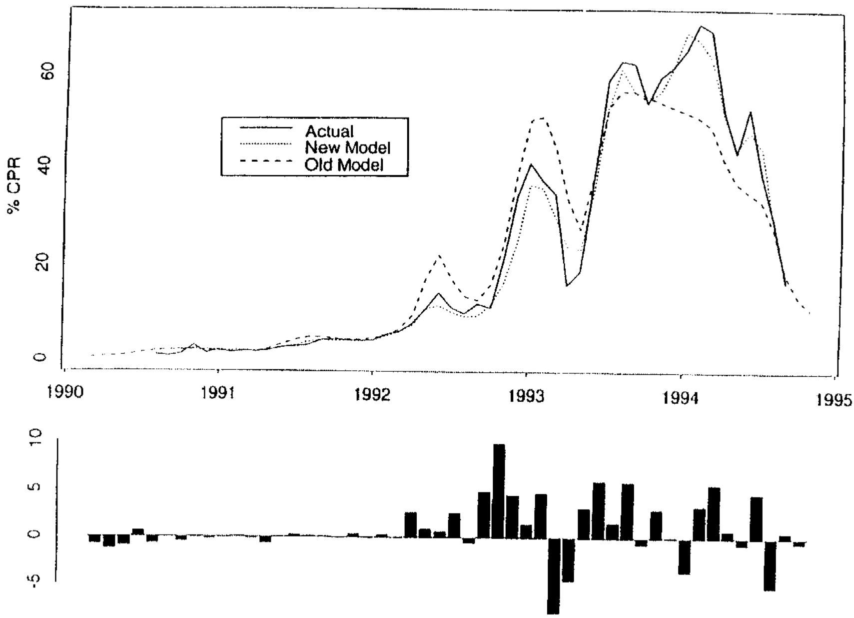


CHART 8
FNMA 30-YEAR 9.0% 2017

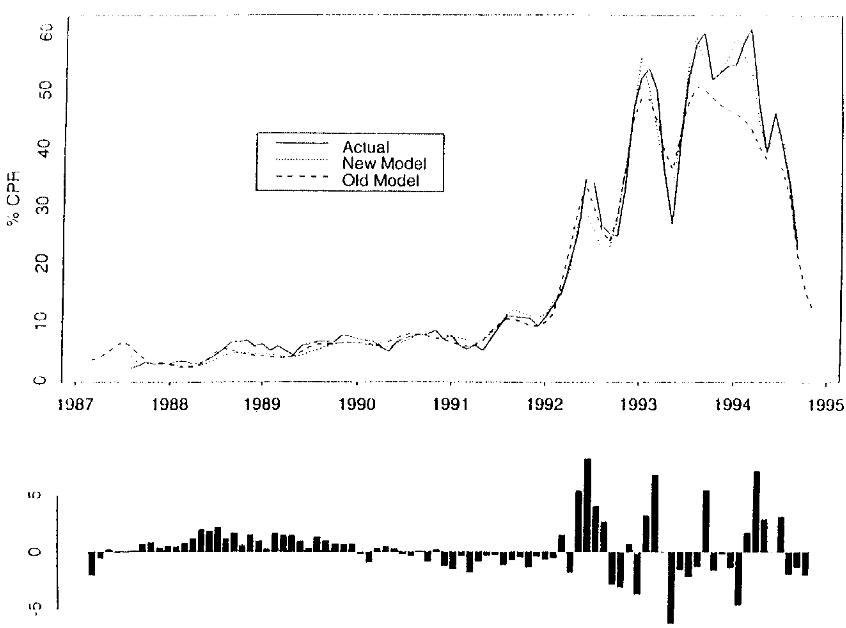
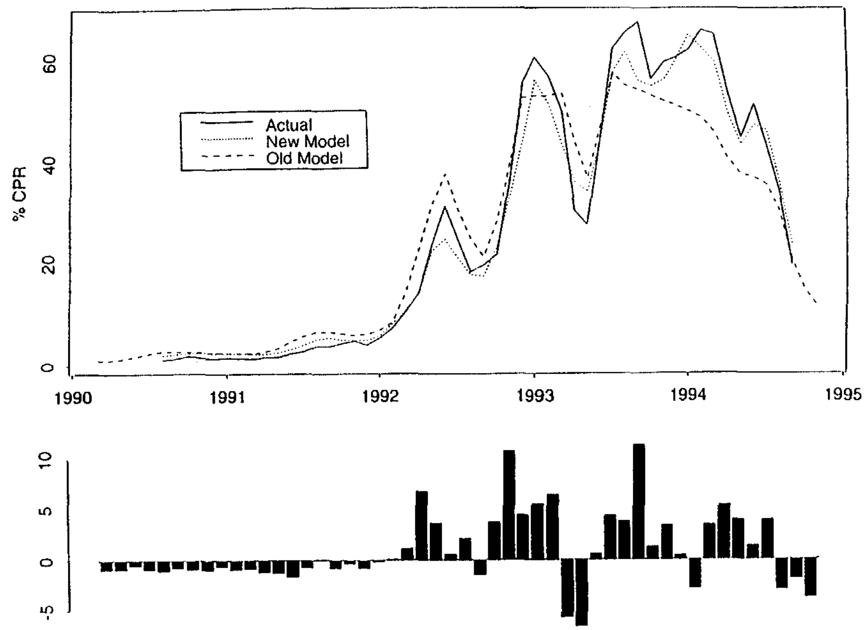


CHART 9
FNMA 30-YEAR 9.0% 2020



We're trying to create tools for our investor base to let them look at this risk, and I think going forward the rest of the street will be doing that as well, something that everybody will probably benefit from.

MS. CATHERINE E. EHRLICH: I work with CMS. For those of you who aren't familiar with us, we provide fixed income analytics to portfolio managers. We analyze all fixed-income-security types: fixed rate, floating rate, prepayable, or callable. We analyze them on a consistent platform.

I will talk about some of the modeling considerations that you have to worry about when you're dealing with assets that prepay. I will give an overview. I will not talk too much or too specifically about mortgage-backed securities, but, rather, I will talk about asset modeling in general.

First, I will briefly discuss interest rate generation models and volatility. I don't want to spend too much time on this because this is a very involved subject. I also will give you a little taste of what the CMS prepayment model looks like, look at our corporate option model, and then finish up with some sensitivity measures.

Any discussion of interest rates begins with the risk and return relationship. The two components that we see in return are the market price return and your income return, and there's different components of risk—credit risk, liquidity risk, model risk, and market risk. What we will deal with here is the model risk and the market risk.

There are many different sources of uncertainty we encounter when attempting to project revenue in the fixed income markets. We have interest rate volatility, model selection and false data estimation. There's not too much you can do about false data estimation. You certainly try your best to not have that problem. Interest rate volatility really depends on the assumptions you pick and the model you pick, and the model selection involves how you actually model securities. The interest rate model that we use at CMS is a Heath-Jarrow-Morton approach, which is an arbitrage-free model. This means that we believe there is a single price for a security on which the whole market agrees. The model also uses a term structure of volatility which is specified by a long-term volatility measure, a short-term volatility measure and mean reversion.

The volatility of interest rates refers to the level of deviation one may expect to see over a given period of time, which is usually one year. The correlation refers to the statistical interaction between two financial quantities such as the six-month London Interbank Offered Rate (LIBOR) and the ten-year constant maturity treasury (CMT), or the six-month Treasury and the ten-year Treasury. We use volatility as an input to the term structure, and it requires three inputs—a long volatility which is expressed as a percent of the current long yield, a short volatility which is expressed as a percent of the current short yield, and the mean reversion which is expressed as a percent of annual decay. Specifying any two of those measures allows you to solve for the third. Mean reversion can be thought of as a dampening effect, so that interest rates behave in a manner that most observers would consider reasonable. This prevents rates from having an upward bias and forces them to revert to average levels. It is, therefore, the amount of time it takes an initial rate shock to dissipate. If mean reversion is kept at zero, long rates are just as volatile as short rates, and there is a tendency for the yield curve to steepen over time. There's nothing necessarily wrong with that. It's just not what most practitioners find reasonable.

Actually, for zero mean reversion and a starting yield curve that is positively sloped, the percentage of volatility for the short end will still be higher than the long end. This is because the starting interest rate at the short end is lower than at the long end. So, as a percentage, you need a higher number to get equal volatility.

Models also employ different valuation techniques. There is Monte Carlo simulation for securities that are path dependent, like mortgage-backed securities. Path dependence implies that the value of the security depends on what happened in the past.

There are also partial differential equation solvers which are for securities that are not path dependent like callable bonds. Past interest rate behavior has no bearing on the current valuation of the security.

Now I will describe the CMS fixed rate prepayment model. As I was saying before, mortgage backed securities are path dependent. As we just heard from the last speaker, homeowners have a variety of influences on their decisions to prepay. CMS uses a five-factor model: refinancing incentive, seasoning, collateral, seasonality, and burnout. With our model, the refinancing incentive is the most important part. We not only look at the difference between the coupon and current long-term rates, but also short-term rates because of the influence of the ARM market. More people are believing they can predict rates and decide where they want to be on the curve.

Seasoning is the second most important factor. Refinancings tend to be low in the first years of homeownership. Dramatic cost savings are required to overcome the inertia that sets in after a mortgage closing. When a mortgage is moderately seasoned, there is a much higher rate of prepayment, due to job relocations, divorce and other demographic factors. If a homeowner has kept his mortgage long enough for it to become fully seasoned, the probability of job changes or relocation are much lower.

Collateral type is also very important. Each collateral type has its own prepayment function, since it will not change over the life of the mortgage. We find that seasonality is not terribly important for the long-term type valuations most of our clients do. We also have found that burnout is becoming less important. We then fit our data using a poisson regression process to come up with our model. By being in client support, we can tell right away if our model gets out of step with the marketplace, because the phones start ringing.

The corporate bond prepayment model has been designed using differential equation problem solvers developed by the defense industry. For corporate bonds we don't really need to model prepayment behavior because corporate treasurers act in a rational manner and exercise the call when it makes sense to do it. With a European call option with a single-option date, you can use a nice analytical approach like Black-Scholes and actually value the call option. With American-type options where there's a period of time that the bond can be called, we need to use some different numerical procedures.

Bonds have the wonderful quality of having a known value at maturity. We can then construct a grid using changes in interest rates as the x-axis and time as the y-axis. We then value the bond at every possible interest rate and every possible moment in time from maturity back to the current valuation date. We could then draw a sloped line through the grid. To one side of the line, it would make sense to exercise the call, and on the other side it doesn't. Determining the location of the boundary is a moving boundary problem and physicists have a variety of techniques to solve this type of problem.

We use a Crank-Nicholson scheme for corporate options. Theoretically, at each point on the grid we need to solve an equation to value the bond. That is a tremendous number of calculations, so we need a scheme to decide which are the important places to solve this equation. Crank-Nicholson allows us to take big steps in time and not lose a lot in accuracy. Once we get close to the current date, we use a different methodology, a fully implicit methodology, to solve the problem where we have smaller steps in time. At each interest rate level and for each time step, the bond price is compared to the call or the put strike price, and we decide if it will be called or put, and we come up with what this boundary is, and we can value the security based on that.

This is a little bit different than a binomial lattice or a Black-Sholes methodology. However, we have found that it gives us much improved accuracy for long duration options, like structured notes.

Now I will discuss some of the uncertainty measures we have been developing.
All fixed income securities will show price fluctuations due to systematic changes in interest rates. Modified Macaulay duration was developed to measure that risk. Certain fixed-income-security types also have uncertain cash flows. If that uncertainty is in some

way a function of interest rates, we need to use effective duration or option-adjusted duration to measure the interest rate price sensitivity.

As an example, we will look at mortgage-backed securities. As noted before, Monte Carlo analytics is used for these securities to account for the prepayment risk. The dynamic nature of the prepayment model ensures that the different rate paths generated by the interest rate model trigger different prepayment rates. So, as the market rate changes and as the security ages, the prepayments will change.

The first step in calculating effective duration is to calculate the OAS using a current price. The OAS is the spread that equates the price with the average present values from all of the different Monte Carlo paths. We then shift the curve up and down 100 basis points and calculate new paths and new path average present values by holding the OAS constant. The percentage change in price, using central differences, is the effective duration of the security.

We can extrapolate this methodology to measuring the uncertainty inherent in the prepayment model. Since mortgage prepayments are not formula based, but are estimated based on the model we have discussed, we need to measure the sensitivity of price of the security to the prepayment assumption. This leads us into the definition of prepayment duration or prepayment uncertainty. I calculate the price of a security if I increase the constant prepayment rate by 1% and if I lower it by 1%, keeping my starting yield curve constant. The difference in these two numbers divided by the starting price is my prepayment duration. Of course these prices are calculated by scaling my dynamic model up and down, not by using a static assumption.

The next thing on this list is the zero volatility spread, and this is spread over the spot curve that equates the price to present value of cash flows derived from 0% volatility. If we then look at that spread and compare it to what the OAS is, the difference in those two numbers is really the time value of the option in basis points.

Another thing we've been looking at is a cash-flow uncertainty number, which is important for insurance companies who are dependent on the timing of cash flows. This is defined as the change in average life or the change in modified duration, given a change in interest rates or in volatility.

The final thing that we're looking at is the volatility uncertainty measure which some people call vega. This is the price sensitivity of the security to the change in volatility assumption.

MR. REDDY: Now I'd like to open the discussion for questions. I'd like to start off with one or two for Randy regarding FLUX. I'm just curious as to whether or not there's any evidence at this point as to how exactly regulators are using the FLUX scores that have been generated so far, and are life companies actually managing their portfolios any differently because of FLUX. Are they working around it or taking it into account?

MR. BOUSHEK: At this point there is a considerable spectrum of use, or nonuse, of FLUX by regulators. Some have not accessed the state data network at all, while others have used FLUX scores as a basis for asking companies for additional information about their portfolios. I suspect that as time passes and more regulators become familiar with the tool, its usage will become more widespread, though there will undoubtedly always be considerable variation in application.

With respect to the impact on portfolio management, I have not seen any material impact on the liquidity or valuation of individual securities attributable to FLUX. While I am interested in knowing how my portfolio will look to regulators, I have yet to consider a FLUX score in any of my portfolio management decisions. The very limited range and scope of the model—a screening tool for further analysis, applicable only to insurers—should ensure that it has at most a very limited impact on the market and on individual investors versus, say, the Federal Financial Institutions Examination Council (FFIEC) test for banks.

MR. REDDY: Another thing on FLUX—what was the reason that the concept of a portfolio FLUX score was not pursued as opposed to individual bond FLUX scores? Wouldn't it make more sense to look at portfolio FLUX because that would recognize the benefit of hedging or diversification that bonds might have in combination with each other?

MR. BOUSHEK: That's a very good question. With respect to assessing prepayment risk, it certainly makes more sense to evaluate the exposures of the entire portfolio. However, remember that the objective here is to evaluate potential cash-flow variability, which is not necessarily the same thing. The primary goal is to provide regulators with a way to prioritize cash-flow testing analysis, not to assign reserving requirements or constrain investment activity. It is also important to keep in mind that risk differs in a market-value versus book-value accounting environment. While in an economic sense certain risks may offset, the timing of income and gain/loss recognition may vary significantly in statutory accounting, posing an acute risk to surplus. From a regulator's perspective, I think there may also be a concern over what I'll call "dismemberment," that is, that a portfolio built from volatile pieces which in aggregate form a less volatile whole may be too easily reconfigured into a much more volatile whole with only modest trading of the pieces.

MR. NEIL T. STRAUSS: I was wondering why you think the 1993 scores showed more volatility than 1994?

MR. BOUSHEK: I see three explanations—the change in the discount rate assumption, the change in the volatility rate assumption, and, most importantly, the change in the initial level of interest rates, which works its way into the prepayment assumptions. At year-end 1993 there were a great number of securities priced at a premium to par and positioned on the "cusp" of the prepayment curve. By contrast, the rise in interest rates in 1994 resulted in a considerable improvement in the general convexity of the mortgage market as prepayment options were pushed farther and farther out of the money. While the addition of a second whipsaw scenario and the compressing of the earlier whipsaw generally subjected cash flows to a greater stress test in 1994 than in 1993, the increasing rate scenarios had a much reduced impact on cash flows as already slow prepayment speeds had much less room to slow down further from the base case than they did in 1993.

MR. STRAUSS: Also, are the FLUX scores, per se, confidential? Are the only ones who can access them the NAIC regulators, or are the companies precluded from disclosing them?

MR. BOUSHEK: No. FLUX scores are public information. The formulas and assumptions are available to anyone interested, and the scores for any given bond may be found through any number of sources.

MR. STRAUSS: But in terms of the distribution that each company would have, or the average score, is that available in any public source or document?

MR. BOUSHEK: No. Companies may choose to make their particular distribution of scores publicly available, but there is no requirement that they do so, and no such requirement is contemplated.

MR. REDDY: Randy, just one other question. I assume FLUX only applies to mortgage-backed securities and not other securities such as callable corporate bonds. Was there any discussion or thought about including some of those securities? I realize there are some different issues involved, but it seems that if the regulators are trying to get a handle on prepayment or cash flow uncertainty, that's certainly another area that potentially could be addressed.

MR. BOUSHEK: That's certainly a fair question. Catherine alluded to this also. There are other instruments besides mortgage-backed securities that have an interest rate sensitivity or cash-flow volatility element to them. The FLUX measure was developed specifically in response to regulatory concerns and requests on CMOs, and by extension, pass-through securities. Theoretically, it could be applied to any kind of optional instrument, but as a practical matter its application right now is limited to mortgage-backed securities.

MR. REDDY: Steve, I'll hit you with a question here. There's some fascinating things in terms of what you have found that really drives prepayments, and that some of the contributing factors are things that have either evolved or have been recently discovered as experience has emerged, but you mentioned that perhaps in about a year-and-a-half down the road, we'll find experience doesn't match what the model might predict. Do you expect that kind of divergence, or shouldn't the models be better going forward than they have been because you are taking into account more factors which, as of today, constitute what you think are really all the relevant factors?

MR. ABRAHAMS: If the impression I made at the end was that the model that we have today won't be good tomorrow, that was definitely not the intended message. I think we have much better models. I think we have a much better understanding of what our prepayment, at least our mortgage-backed prepayment, exposure is, but I think we're also more sensitive to the risks going forward. I think you will find more things, for instance, measures of the sort that Catherine was talking about where you've got a prepayment duration measure. There's some other firms out there that are offering other estimates of bond sensitivity to prepayment assumptions.

I know that what we and others are intending to do is do what, frankly, we had to do by choice in 1992–93, and that is stay on top of our models, constantly look at how well they are actually predicting the kind of prepayments that we're seeing on a month-to-month basis, stay in touch with sources of information that might lead us to believe that the world is changing. I'm regularly in touch with mortgage bankers to find out what kind of new products they're introducing. I try to read the newspapers that the bankers look at so that I can get a sense of what the next trick might be in that area. I think that it's just important to stay on top of that because models should change as environments change. Otherwise you wouldn't be able to adapt your model to new circumstances as they unfold. But for the time being, I think we're in a prepayment environment that is relatively close to where we have been at different points in the past, and, as a result, there's a lot of great history for projecting what's coming around the corner.

MR. REDDY: I know that there are various actuarial models that address prepayments that have evolved over time. However, these models don't go into the detail that Steve and Cathy were describing. But certainly they need to move more in that direction for cash-flow testing and to really get a handle on how prepayments can affect economic surplus or statutory surplus. Certainly it behooves all of us to at least reexamine our current models to make sure that the parameters being used, whether it be two parameters or four or five, are consistent with recent experience. I would encourage anyone to talk to the panel to get more information on recent experience and talk through some of those issues.