1993 VALUATION ACTUARY
SYMPOSIUM PROCEEDINGS

SESSION 5

General Asset Issues

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GENERAL ASSET ISSUES

MR. THOMAS W. REESE: Asset/liability managers must make key decisions that have a critical effect on company profitability. They must decide on appropriate strategies for investments, interest crediting, and product design and pricing.

These critical decisions are made in the presence of great uncertainty. Our financial markets are unpredictable. Only hindsight can identify the best strategy under each set of past conditions.

But this unpredictability does not mean that asset/liability management (ALM) decisions are only guesses. While unpredictable, financial markets still exhibit elements of pattern and shape. Thus asset/liability modeling is based on the assumption that appropriate decisions can be based on the evaluation of a reasonable range of possible future outcomes.

My topic is to discuss the generation of economic scenarios for the evaluation of those possible future outcomes.

Types of Asset Models

Before we generate economic scenarios, however, we need to know how they will be used. The characteristics needed for the scenarios will be driven by the purpose for the asset model. I will characterize three types of asset models:

- Pricing models,
- Predictive models, and
- Simulation models.

While there is some overlap among the areas of use for these three types of asset models, they are each used for different purposes and require economic scenarios with different characteristics.

Asset pricing models calculate the current market value of assets. The market value is the expected present value of the cash flows that result from many possible future economic paths. Most asset pricing models construct interest scenarios using a connected binomial lattice approach. This allows fast calculations to discount present values resulting from a range of possible future outcomes. Asset pricing models require interest scenarios that are arbitrage-free. The subject of arbitrage-free scenarios is well researched for binomial lattices.

Asset pricing models have these characteristics because of their purpose, which is to identify securities that are relatively undervalued or overvalued by the market.

Predictive asset models, on the other hand, seek to predict future movements in the financial markets. They also work from the current date, seeking to allow investment managers to take advantage of better knowledge about likely future events. Predictive asset models typically use extensive regression analysis involving many variables to determine indicated trends. Obviously, these models are complicated.

Predictive models are used to make short-term tactical decisions to take advantage of the knowledge provided by the model.

Simulation models are the third type of asset model. They evaluate a range of possible future results. The time horizon for analysis is long, such as ten or 20 years. Simulation models are typically based on projections of a few key variables that must be consistent with each other. The intention is to project realistic scenarios of future financial conditions to show the effects on company assets and liabilities.

With such simulation of future events, the asset/liability manager can make long-term strategic decisions. The knowledge needed for such decisions is the risk and reward trade-offs that alternative strategies are expected to present.

My thesis is that ALM models, including cash-flow-testing models used by valuation actuaries, are simulation models. They require different types of economic scenarios than would be used for asset pricing or predictive models.

Simulation Model Scenarios

The following is a discussion of the generation of economic scenarios for ALM simulation testing.

The first step in generating interest scenarios is to determine the key parameters to be projected. Typical interest scenario generation models project two key statistics:

- A short-term interest rate, such as the 90-day Treasury rate, and
- A long-term interest rate, such as the ten-year Treasury rate.

Interest scenarios are usually defined in terms of Treasury rates, since they provide a risk-free, noncallable basis on which to build assumptions for other categories of assets.

With these two points on the yield curve known for each future period for each scenario, the next step is to generate the rest of the yield curve. One common approach is to use a fixed formula, by which I mean that a particular pair of short-term and long-term rates will always produce the same yield curve. The fixed formula could involve line segments or a smooth curve, and could be based on either Treasury spot rates or yields to maturity.

Another approach is to add another stochastic element to the scenario generation by calculating a third point of the yield curve, such as the five-year Treasury rate, stochastically based on the values already set for the short-term and long-term rates. Then a yield curve can be developed from this three-point model, resulting in many more different yield curve shapes than the two-point model.

Adjustments for Realistic Scenarios

Generating random interest scenarios is easy; generating realistic scenario sets is more difficult. Projected scenario sets must be analyzed to determine if they appear to present reasonable ranges of possible future financial conditions.

To analyze scenario sets, the following characteristics of the generated scenarios should be considered:

- Volatility of rate changes, separately for short-term and long-term rates,
- Correlation in the movements of the short-term and long-term rates,
- The distribution of rates, watching out that rates are not clustering around boundary conditions you have set while still producing what appears to be a reasonable mean,
- Adjustments in the scenario set to reproduce the shape of the starting yield curve, and
- The effect of mean reversion tendencies.

Mean reversion adjustments assume that interest rates will tend to move toward "normal" values in the long term. That is, interest rates can get up to 20%, but then the probability of them going higher should be considerably less than the probability of moving back lower. The "pull" of mean reversion becomes stronger the farther away rates are from expected ranges.

Our models can assume mean reversion effects separately for:

- Short-term interest rates,
- Long-term interest rates,
- The steepness of the yield curve, and
- Yield curve inversions.

An example of a mean reversion formula is an exponential multiplying factor. For this type of formula, the initial calculated rate is multiplied by:

$$\left[\frac{\textit{Target rate}}{\textit{Initial calculated rate}}\right]^{(\textit{Reversion Factor})}$$

Linear mean reversion formulas are used as well as this exponential example.

Scenario generator input parameters must be calibrated by evaluating the resulting scenario sets. Areas to investigate are:

- Rate volatility by projection year,
- Inversion frequency and length,
- The drift of mean rates, where a logarithmic mean should be used for geometric models and an arithmetic mean should be used for linear models,
- The distribution of rates, and
- The distribution of yield curve steepness, measured as the long-term rate minus the short-term rate.

In setting mean reversion assumptions, it is critical to evaluate the effect of these adjustments on the overall volatility of rates. That is, you might have to assume higher volatility in order to achieve the average volatility you want to project after the volatility dampening effect of mean reversion adjustments.

Arbitrage-Free Adjustments

A further adjustment to the interest rate scenarios has, I think, been confusing to users of ALM models. This is the question: Should the interest rate scenarios be made arbitrage-free?

Arbitrage-free interest scenarios assure that one portfolio of assets cannot be traded for another portfolio with guaranteed improved asset performance. The average present value of any set of cash flows through the scenario set equals the present value using today's spot rates.

Arbitrage-free characteristics are required for asset pricing models. Scenarios must be made arbitrage-free for any pricing model use of asset/liability modeling. These are uses where present value results are the end result, such as for calculating option-adjusted prices, durations, and convexities.

But should simulation model interest scenarios be made arbitrage-free? With current arbitrage-free technology, I believe the answer is "no."

Current arbitrage-free scenario technologies produce undesirable effects for simulation modeling. You can see these effects by examining your interest scenario set before and after it has been made arbitrage-free. In an environment with an upward-sloping yield curve, arbitrage-free scenarios produce two main unrealistic effects on the future yield curves:

- They inflate future interest rates, and
- They tend to flatten the yield curve.

This criticism of arbitrage-free scenarios sets applies to current arbitrage-free technology. More research is needed to find ways to produce arbitrage-free scenarios that are also realistic for simulation models. If these problems are resolved, then simulation scenarios should be made arbitrage-free as well.

Probability-Weighted Scenarios

Of course, one of the problems of simulation models is the enormous number of calculations and resulting long run times required for testing many multiple economic scenarios. Research is being conducted for sampling and selecting subsets of interest rate paths from a larger set of possible interest rate scenarios.

Techniques are still primitive for simulation scenarios, but effective methods have been developed for connected binomial lattice scenarios. The linear path space (LPS) method has been described by Dr. Thomas S.Y. Ho of Global Advanced Technologies.

The problem of a great number of interest rate scenarios is represented by the "immense path space" of a connected binomial lattice (Chart 1). If monthly time intervals are used, a 30-year projection would involve a totally unmanageable 2^{360} different paths to test!

The LPS technology collects similar scenarios by passing through "gates" that divide the possible interest rate outcomes at certain points (Chart 2). For example, consider the immense path space outcomes at the end of year one. If we divide the outcomes into the top, middle, and bottom thirds, scenarios are grouped into only three sets: those with rates going up, forward, or down.

This division into gates is repeated with a second set of gates at year three. Now there are five gates so that each status at year one can move up, forward, or down. If the 30-year immense path space is examined through seven sets of gates, the total number of scenarios is reduced to 3^7, or 2,187 scenarios.

A procedure is used to determine the center node for each gate. Then branches are constructed between the center point for each gate, following the shortest path through that section of the binomial lattice. LPS scenarios are a series of these branches. This process progresses forward through the lattice; it is not a backward substitution redevelopment of the lattice.

Now the number of scenarios that needs to be tested can be further reduced by assigning each LPS scenario a probability. This probability is based on the number of the immense path space scenarios that pass through each combination of gates. This gives a probability weighting for each LPS scenario. When scenarios are processed in descending order of probability, it is seen that extreme scenarios do not affect results. Their outcomes may be extreme, but their probability becomes vanishingly small.

Key Rate Durations

A common way to characterize assets and liabilities is to calculate their "duration," or the expected multiple of their change in price for a given change in interest rates (Chart 3). Option-adjusted durations are calculated by shifting the yield curve by some interest differential to determine the resulting price change. These are parallel yield curve shifts.

CHART 1

Immense Path Space

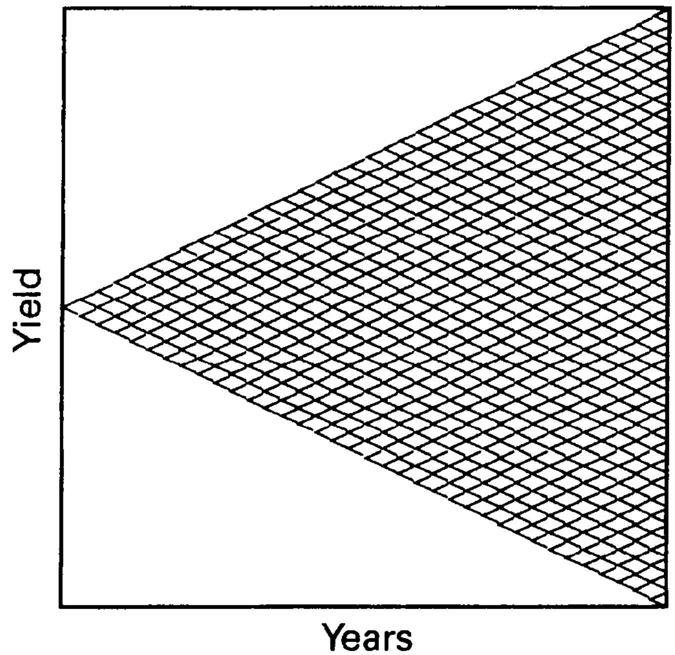


CHART 2

Linear Path Space

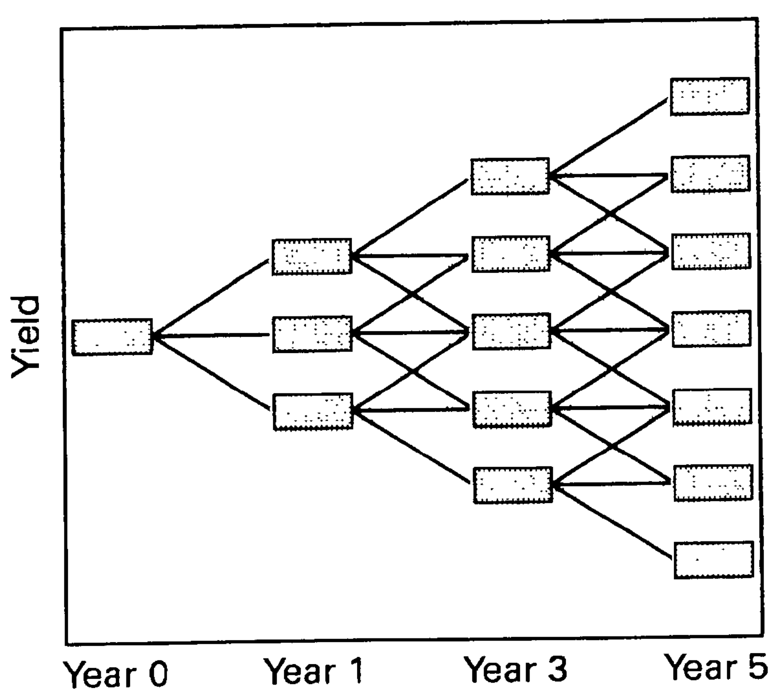
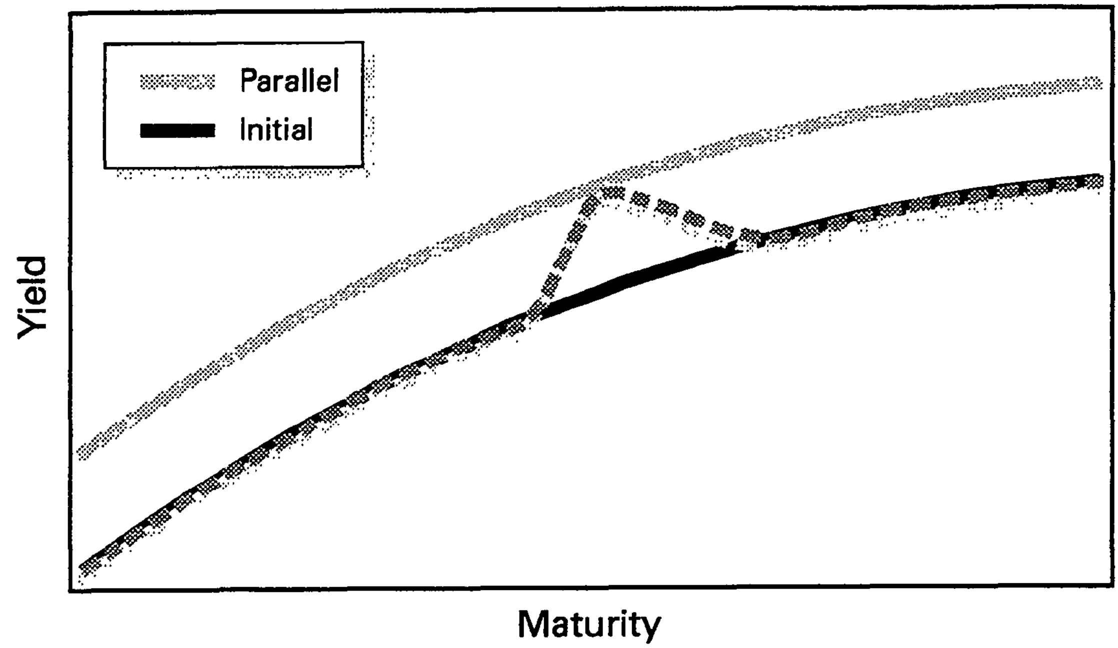


CHART 3

Key Rate Durations



But various assets and liabilities react differently to changes in different parts of the yield curve. What happens if the yield curve changes slope rather than undergoes a parallel shift?

This effect can be analyzed by calculating key rate durations. The effect of a change in part of the yield curve is examined by shifting rates in only that section. The changes around each key rate are determined so that all the key rate changes together equal the normal parallel yield curve shift. In this way, the sum of the key rate durations equals the duration calculated traditionally.

Chart 4 illustrates how key rate durations show the effect of changes in different areas of the yield curve. An 8% coupon callable bond is more sensitive to changes in longer maturity interest rates, and thus has higher key rate durations, than a 9% coupon callable bond. This is because the higher coupon rate bond is more likely to be called than the lower coupon bond.

Calculating Future Asset Values

One of the most difficult practical problems in ALM simulation testing is the calculation of asset market values at future dates along each scenario path, which is sometimes called "horizon pricing." (See Chart 5.) If typical asset pricing methods are used, this evaluation will require the generation of a new set of interest rate scenarios from this point. The computational problems are obvious when each simulation scenario must expand into another scenario set at each point when assets must be priced.

With today's computer technology, multiple interest scenario methods for calculating asset prices at a future date are generally not practical. The approach is theoretically correct, but there isn't enough time to calculate enough horizon pricing scenarios to obtain accurate results. When the number of scenarios is cut back to allow reasonable run times, the accuracy of results is unreliable.

Because of these practical problems, we are pursuing other techniques. Calculation algorithms are used to calculate option prices that do not require the projection of multiple scenarios at the future asset pricing date. For projections that do not require individual asset projections, a portfolio index approach can represent the underlying duration and convexity characteristics of various asset classes.

Whatever method is used, the idea is to get the best approximate asset values for a reasonable amount of work. Really accurate asset values at future dates are not obtainable with reasonable run times.

The method used must produce market yield rate changes consistent with economic scenario changes. This can be accomplished by separating the market yield rate into three components:

- Treasury equivalent yield, based on the weighted average life (WAL) for the asset at each market value calculation date,
- Option-adjusted spread for credit quality, prepayment uncertainty, and liquidity, based on the category of assets and the WAL, and
- Option spread, the increased yield attributable to asset options, such as calls or puts.

CHART 4

Key Rate Durations
9% versus 8% 30-Year Callable Corporate Bonds

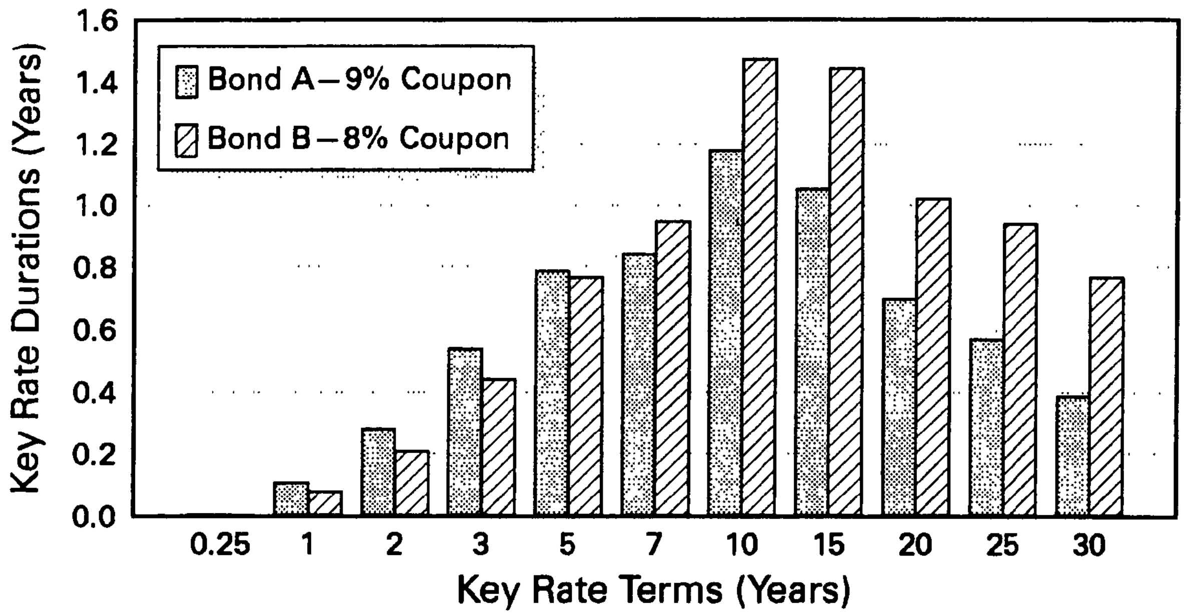
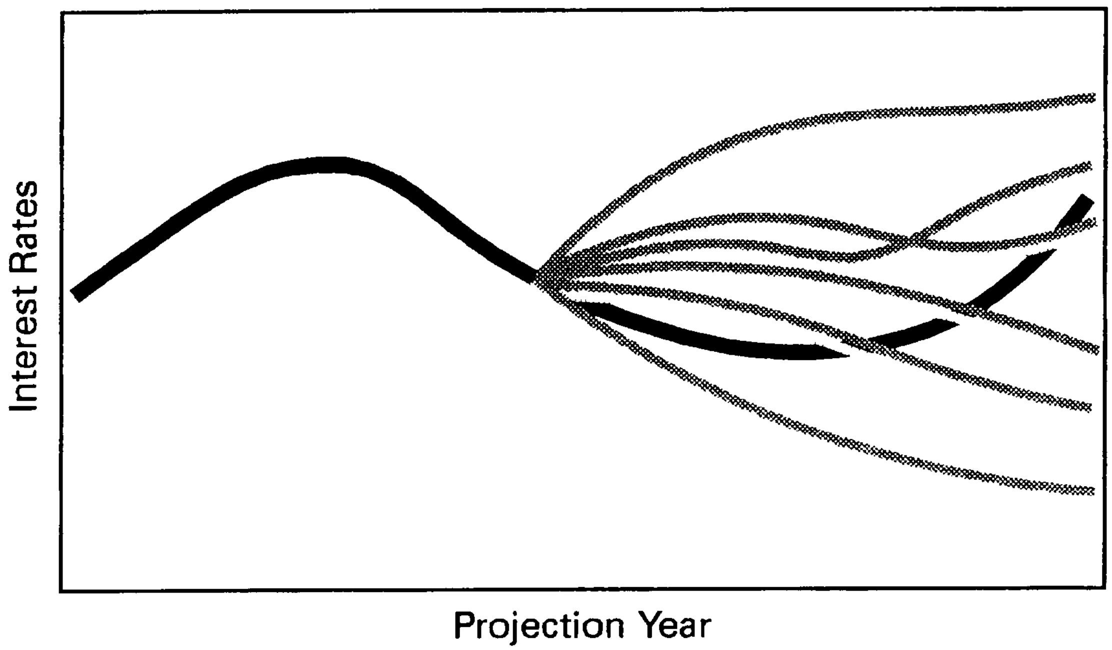


CHART 5

"Future Date" Asset Market Values



Other Scenario Components

I have been using the term "economic" scenarios rather than "interest" scenarios because the ALM simulation requires more than just interest rates to be projected. Consistent projections must also be made to determine changes in inflation, stock values and dividends, real estate values and income, and asset default rates.

How Many Scenarios?

A common question about simulation economic scenarios is: How many scenarios should be tested? The answer to that question depends on the purpose of the projections. To evaluate expected results with a certain degree of accuracy would require a larger number of scenarios.

But we don't always need to know exact expected values -- we just want to avoid making the wrong decisions about strategy alternatives. For evaluation of various strategies, sets of 30 or 40 scenarios are effective in identifying the best-performing strategies. Decisions supported by a small number of scenarios, however, should be subjected to sensitivity testing against another set of scenarios.

Further, the number of scenarios required increases if the purpose of the projections is to evaluate the "tails" of the range of results rather than the expected mean results. Evaluation of the likelihood of insolvency, at the far end of the range of results, should generally use at least 100 or 200 scenarios. The number of scenarios required increases dramatically the further down the tail you are investigating.

Recently Declining Rates

The recent decline in interest rates has been a dramatic event. The ten-year Treasury rate (nominal semiannual) was 8.08% in December 1990, 6.77% in December 1992, and around 5.25% just recently. How extreme is this drop?

We evaluated the probability of this occurrence assuming 12% and 16% annual lognormal volatility rates. To be fair, the probabilities are doubled, to count both the tails for lower and higher interest changes of this extreme since either could have occurred.

Assuming 12% volatility, the change from 1990 to now falls in the tails representing only 3% of the lognormal distribution. The change from 1992 to now is even more extreme, representing only less than 2% of the distribution.

If 16% volatility is assumed, the "1990 to now" probability increases to 10%. However you look at it, we are experiencing interesting times!

GENERAL ASSET ISSUES
ASSET ALLOCATION FOR CASH-FLOW TESTING

MR. JOHN C. SWEENEY: Tom Reese from Tillinghast made the point that we are now in unusual times. It's truly an interesting question whether or not we are. However, it depends on your perspective. If you have eight or ten years of experience in the business, maybe it does seem a little unusual. If you have 25 or 30, you may have lived through some of these economic events before, and maybe it's not so unusual. It does, however, create a problem when you're doing asset and liability management as well as cash-flow testing. And I'll try to address some of these issues as we go along in our discussion.

Let me make a couple of generalizations first. I recognize that all generalizations are false including this one. So let's consider my biases or assumptions. My first working assumption is, actuaries know an awful lot about how to model liabilities, single premium deferred annuities (SPDAs), universal life (ULs), asset valuation reserves (AVRs), interest maintenance reserves (IMRs), and you're not bad on yield curves either. My second bias or assumption is, actuaries know a lot less about modeling assets, bonds, mortgage-backed securities (MBSs), and planned amortization class (PAC) interest only (IO).

Concomitantly, I don't think anybody on Wall Street knows how to price MBSs either. Demonstrably that's what's happened in the last couple of years with interest rates declining and your large mortgage-backed portfolios changing value as well as yield, not to mention duration and negative convexity.

My third bias or assumption is that actuaries know even less about modeling investment strategies and asset allocation in particular. I know I'm going to eliminate some of you. Some actuaries are investment types, but I'm making a generalization. For example, the two major models that I'm familiar with, that do asset/liability and cash-flow testing, have been built by actuaries. Both require that the modeler bring an investment strategy that's developed outside of the system, to the system. The system, the asset and liability system or modeling process will not allow you to solve an optional strategy. It will allow you to input strategies, but it doesn't develop it through optimization. What I would like to address is the issue of how one comes to an optimal asset strategy in the context of asset and liability cash-flow testing.

I think in order for it to be optimal it has to be done in sync with the liability structure. Frankly, most systems we use do not mesh some large ALM system. Most companies with both a life company and a property/casualty company joined at the holding company level require two distinctly different systems for both asset modeling and liability modeling. In the case of the property/casualty company, it can be an integrated process where liabilities and assets are modeled simultaneously in one system. In the case of the life company, we have to solve for the strategy in sync with but outside of the actual liability model. So we're only halfway integrated on the life side.

The final point that I want to make before I continue is that you really have to be realistic about the assumptions in the modeling process that you use as to how things will actually evolve. An actuary was talking about the long-term values of the asset, and how they should be modeled more precisely. Well, if we know how to forecast them precisely, I don't think we'd have to be here together worrying about these sorts of issues.

We must use approximations no matter how you look at it, because you can never get very precise about the future. One of the issues involved here is reinvestment strategies for cash-flow testing. I wonder how many of you anticipated what is happening to interest rates (the dramatic decline) in your models? Have your interest rates reverted to the current level? Are current yields an indication of what you expected to be happening in the future? We must bring some perspective to the modeling process that makes sense in the context of how, for instance, we price MBSs. Are they running off your portfolio at correct speeds? MBSs are modeled by actuaries and by Wall Street analysts, but nobody got it right. In fact, if you've got a mortgage-backed portfolio, you're actually sitting on a cash portfolio for the most part.

I'll make the distinction also, most collateralized mortgage obligations (CMOs) are not in as bad shape as the MBS/pass through securities are. The CMOs have actually performed, in some cases, as they were supposed to, it depends on how it was structured.

Let me point out that I am not going to talk about stochastic differential equations in detail although our models use them in arbitrage-free scenario generation. We're going to allude to mean reversion a little bit. Linear processes ALM modeling and cash-flow testing and LPS will be discussed as well. Really, what I'm going to try and do is bring a little more reality to how we actually do our ALM modeling and cash-flow testing. I hope we will generate some questions about the rightness or wrongness of the whole process.

Let me make a point ahead of time because I know, when you're dealing with your asset and liability models, you do get caught up in the details of asset modeling. We use a portfolio index approach. We do not model every single individual bond in a portfolio. In a way, I guess you would say, we do model a single bond class. We use it as an index. When I speak about these processes I'm not talking about a particular CMO or a particular corporation bond. I'm talking about a class or an index to describe its behavior.

Chart 6 shows the process that we go through to model our assets and liabilities. The investment process that we're trying to get into here really begins with corporate and product line policies. And we break both our life and our property/casualty product lines down into approximately six product lines apiece.

We quantify the liability management process by modeling cash flows and then execute the proper security selection. We execute by buying or selling the proper security to match the liability portfolio. Chart 7 shows the asset and liability management process. As you can see, we have everything flowing together. This is an overview, if you will, of the practice that we have in ALM. This is how we do our ALM. Several of the areas I'll cover will be the capital markets and economic considerations. Now, however, I'm going to talk a little bit about how

CHART 6

The investment process begins with corporate and product line policy, is quantified at the asset-liability management level, and then executed when the proper security for the portfolio is found . . .

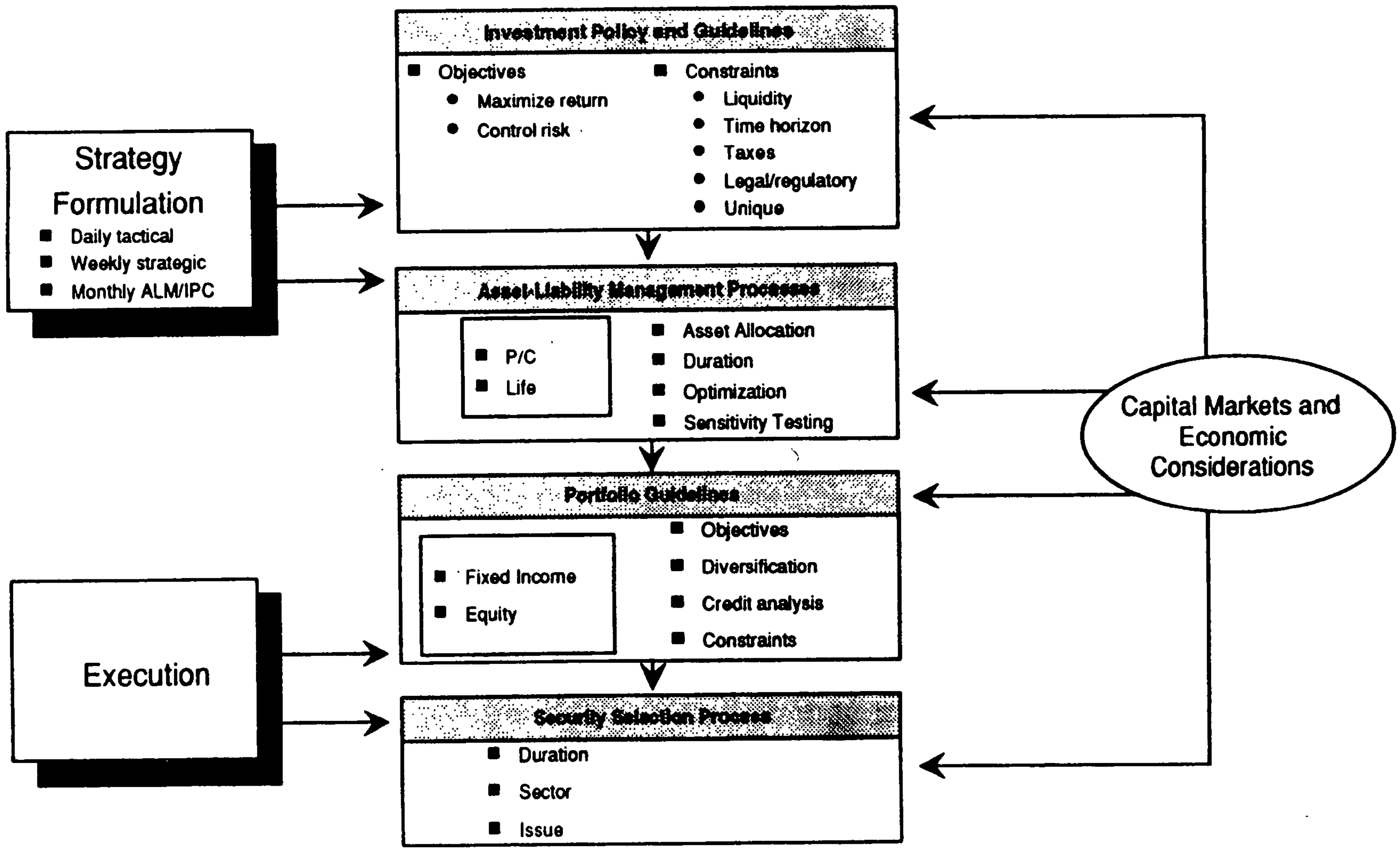


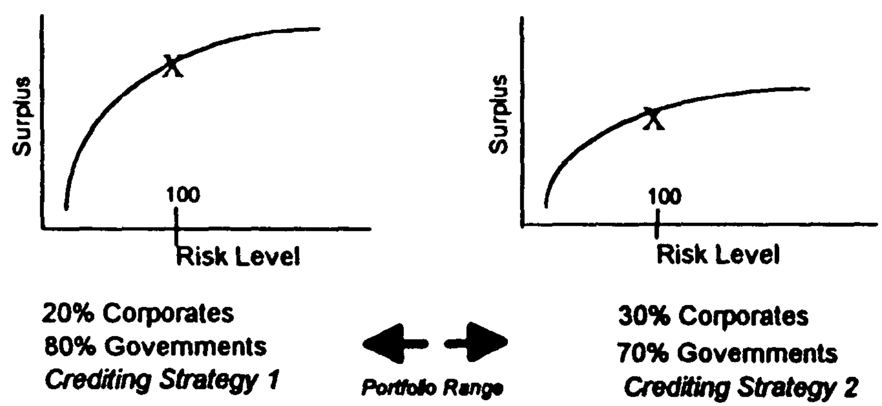
CHART 7

Asset/Liability Management Process

Sensitivity Testing

- Key Asset/Liability Factors
  - Capital Market Assumptions
  - Business Mix
  - Credited Rate vs. Competitor Rate
  - Lapse Rate

- Re-run stochastic optimization to develop portfolio range with same risk level
  - Example:



we put this piece together and developed our portfolio guidelines that are shown at the bottom of the chart.

The process that we use, and you're probably familiar with it, is called the "efficient frontier" approach to surplus management. We use a mark-to-market approach with our asset and liability efficient frontier analysis. And I'll show you how that works. This is the process that we go through. The economic evaluation combines the asset and liability cash flows into an optimization segment of the model. It's a nonlinear optimization model that effectively produces an efficient frontier, or series of asset allocations for a given set of risks we're trying to analyze. It's all driven by the liability cash flows. However, we optimize liability cash flows to asset cash flows.

After the assets and liabilities are modeled, we do sensitivity testing, which in that particular part of the process is where we do our cash-flow testing. Since we use these portfolio indices as our liability proxy, it will look like an asset portfolio but is in effect an index for performance of the liabilities. That is, when we matched up and optimized to the liability cash flow, we combined an asset portfolio with it. That portfolio effectively will respond similarly to the way a liability cash flow will respond as interest rates move up and down. That is how we basically measure our performance.

This is a summarization of the five-part process we follow:

1. Evaluate Balance Sheet
    - Assets
    - Liabilities
    - Capital
2. Evaluate Capital Markets
    - Economic Forecasting
        - Interest Rates
        - Inflation

3. Stochastic Optimizations
   - Range of Portfolios
     - Maximum Return
     - Minimum Risk
     - Corporate Strategy Constraints
4. Sensitivity Testing
   - Change Key Factors and Revise Optimization
     - Credited Rates
     - Lapse Rates
     - Business Mix
     - Capital Market Factors
5. Performance Measurement
   - Target Optimal Allocation
   - Liability Benchmark

Let me just again make the point on the evaluation of the capital markets. It's important that you get this down because the beginning assumptions are important to the modeling process. Is this really very relevant? How important are the mean reversion factors? What are the assumptions that you have in your economic model that drives all the scenarios?

If you're going to use X% for your mean revision number, you have to have some feel for what's right or what you assume to be the case. You're never without a set of assumptions that drive the whole process. You're never really going to know what the values truly are. So the precision of this whole process is a gross approximation. If you're right on in your mean reversion factors, that's fine. But it will take an awful long time for the process to mean revert back to that level. So you'll never know for sure that you hit it.

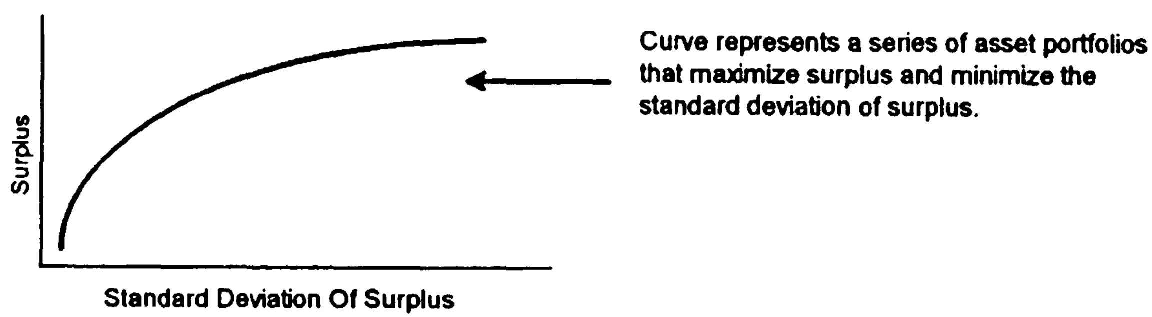
I'm going to pass over just how we do the stochastic optimization (Chart 8). Tom Reese has just told you how we do stochastic scenario testing. We use a process very similar to what Tom uses. His system, in fact, is part of ours. We do use the Tillinghast Actuarial Software. We

CHART 8

Asset/Liability Management Processes

Stochastic Optimization

- **State-of-the-art non-linear stochastic optimization model**
- **Define constraints: asset, asset classes, income, duration, AVR, RBC, etc.**
- **Explicitly considers Asset/Liability cash flows**
- **Dynamic model links behavior of asset and liability cash flows under changing economic environments to produce an optimal portfolio mix given each level of risk.**



have another set of models that do the evaluation of the capital markets. And that's something slightly different but also in the domain of Tillinghast.

We really are driven by market value of current assets. Now I recognize that statutory accounting still applies here. Certainly, you have to consider much in the way of statutory accounting. Since we use Tillinghast Actuarial Software the liability model itself will produce the kinds of GAAP and statutory analysis that you need. We must define our assets in terms of market values. We know of no other way to do that than to use a stochastic capital markets simulation model. This is outside the standard liability model system. But it is relevant. We must feed the data into our liability model.

We also, obviously, do the new asset cash flows. This is the portfolio index approach that I spoke about earlier. The assets or security portfolios are presented as an index of a corporate bond, or MBS, or of a high-yield security, etc.

On the liability side this is really the domain of the actuaries. We can't really do this process both on the property/casualty or the life side without them. This is particularly true on the life side. Some ALM models can do the property/casualty side without actuarial support. But on the life side it's really a team effort on the part of the asset/liability committee for the life company. We need to work with the actuaries to model through the liabilities. So that we get the reserves down. The IMR and AVR and any duration calculations that have to be done. We need all this, in fact, and in our modeling process it must come from the actuaries since an asset analyst can't set renewal assumptions, lapse rate assumptions, etc.

Everyone works together to set the credited rates and review the competitor rates. The actuaries are not always in sync in our belief, but we do manage to work together on this effort.

Finally, a point on the balance sheet side of the asset/liability process is the capital allocation model that we've developed that allocates capital across product lines. It determines the amount of capital that we need per product line. We've worked the risk-based capital assumptions into it as well. We need all this modeling to show profitability by product line, not just because of cash-flow-testing assumptions.

How we evaluate our capital markets is one of the most interesting aspects of our ALM process. We have a capital markets model. It is the state-of-the-art, I believe, in quantitative ALM modeling. This is not an advertisement for our model, it is what we truly believe is the proper modeling approach to capital markets simulation.

We do quantitative economic forecasting. We also do use Vector Auto Regression Models, Neural Nets, and an Econometric Model of about 160 equations. All of these are used to determine the mean reversion factors. We use these outside sources to analyze the historical data. We do our analysis and then use these model outputs to determine what our mean reversion factors are for our capital market simulations.

If you're just going to do guesstimates, you're probably not going to get as good an answer as we do. We put a lot of effort into trying to figure out where the economy is headed and what reversion factors ought to be used. But again, you must know economic history of econometric model to do your forecasting. If I knew how to do this really well, and how to utilize this really well, then I wouldn't be up here now! I'd be on a beach somewhere.

In modeling the yield curve with inflation, we use a Brennan Schwartz two-factor model. It is arbitrage-free. I also agree with Tom Reese, I don't think you need it for the type of work that we do, that is, simulations. We model asset classes against Treasury bonds. They are grouped together so that you see other possible asset allocation. Unfortunately, I'm not going to illustrate one here. This is not because I'm hiding it, I just never thought to bring it along. A typical asset allocation would be 10% say Treasury bonds, 50% corporate bonds, 30% mortgage backs, and 10% in other assets. It is not a CMO or mortgage or a 9% coupon of 2003 or something along that line. It's an index, a grouping of bonds as an asset class.

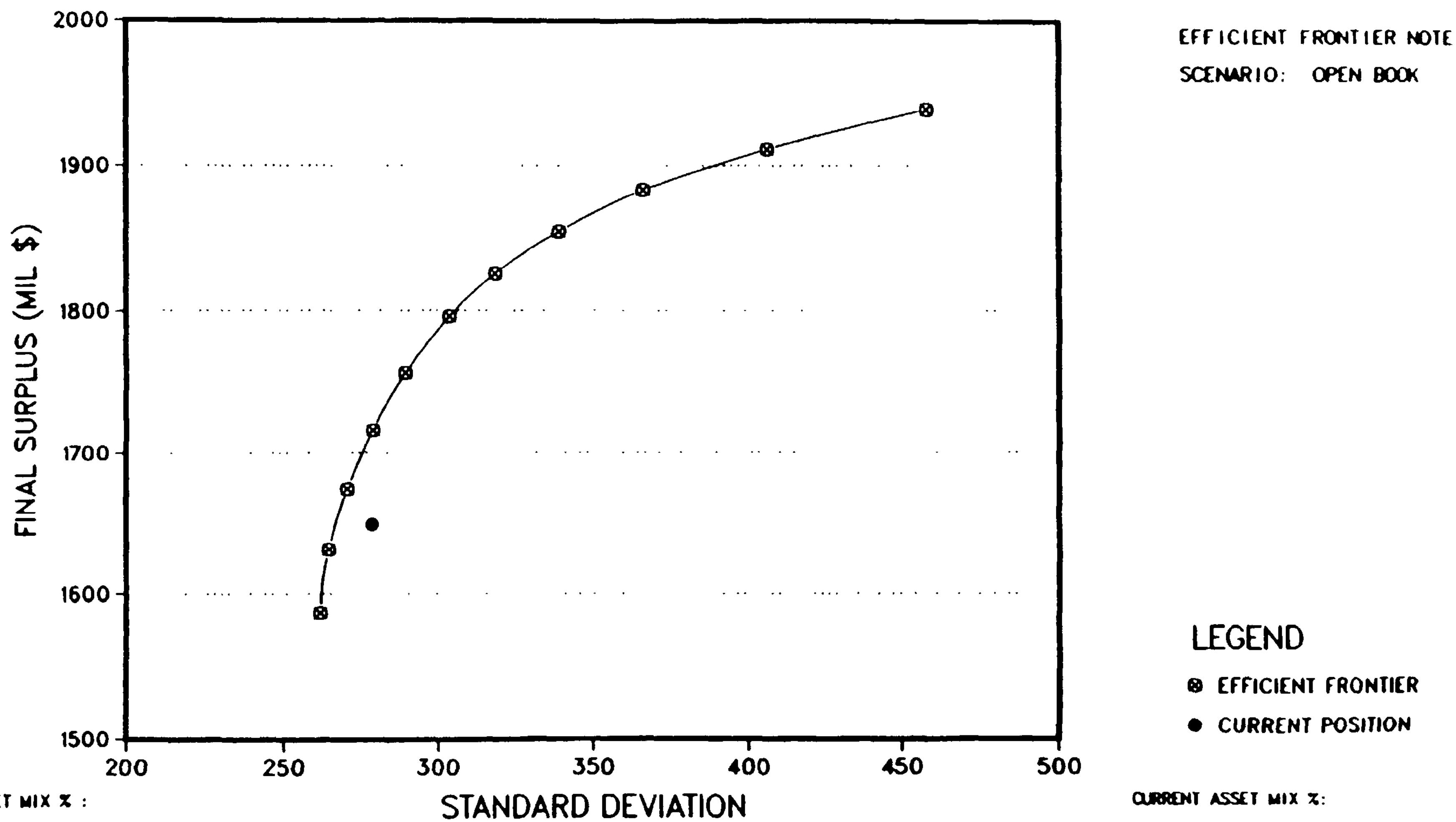
Obviously the time horizon is important when you're doing these sorts of things because a T-bill is not necessarily the risk-free rate in a ten-year horizon. Risk-free rate, is generally conceived as the T-bill rate. Well, in our studies the T-bill rate in a five-year horizon is not risk free. You've got to get your time horizon nailed down and the associated risk-free rates that correspond to that time horizon. This is very important, because if you're not sure what the risk-free rate is, you can really bias your calculations and simulation outputs.

Again, it takes more time to get into that, but remember that T-bills are not risk free in a five- or ten-year horizon or a 20-year horizon for that matter. Regarding the economy, we have the state-of-the-art economic simulation model. We run approximately 300 stochastic scenarios. These scenarios help us define the range of economic possibilities and asset class behavior under uncertain conditions. The output of this particular model is a probabilistically driven assessment of all the capital markets. We produce outputs on a total return basis as well as on an income basis. We segregate the two pieces of the total return and can build a model based on capital gains, yield, or total returns.

As I indicated earlier, we use nonlinear optimization in order to our efficient frontier (Chart 9). You must use some sort of nonlinearity here since the efficient frontier is not a line. The process we use is not, how should we say, proprietary. But I don't know of anyone who's actually using this particular approach. The efficient frontier that we've developed as you can see is really a variation of the original Markowitz process. The only difference here is Harry Markowitz didn't use a liability variable and we do. Since we have the liability cash flows, when we solve for the optimization, you can see that the reward measured as the amount of surplus generated. Incidentally you do not have to use surplus. In fact, depending on what it is that we're interested in, we will use risk and reward factors other than just surplus. In some cases it can be anything from expenses to premiums. I don't really want to define for you what your risk and reward should be. But the emphasis here was on surplus in this particular illustration. We were trying to maximize the amount of surplus available to the company for leverage purposes.

CHART 9

Final Surplus Efficient Frontier
Five-Year Time Horizon



ASSET MIX % :

												CURRENT ASSET MIX %:
LARGE CAP	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0
RE : REIT	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.0
CASH EQUIV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
INT TREAS	53.5	40.8	23.9	4.3	4.0	4.0	3.5	0.6	0.0	0.0	0.0	4.0
LONG TREAS	3.3	0.7	0.0	0.0	0.0	0.0	0.5	3.4	7.7	21.0	33.0	0.0
CORP 1-5	0.0	6.5	13.1	22.4	15.4	10.2	13.4	15.0	15.0	10.8	0.0	15.0
CORP 5-10	0.0	0.0	6.6	13.3	19.7	23.4	14.1	6.8	0.0	0.0	0.0	23.0
CORP 10+	0.7	11.0	16.1	20.3	23.3	26.6	35.9	43.2	50.0	50.0	50.0	5.0
OTHER	30.5	29.0	28.2	27.8	25.5	23.8	20.6	19.0	15.3	6.2	5.0	40.0

The curve represents a series of asset portfolios that we'll maximize at any given standard deviation of the surplus. In the Markowitz approach it would have been total return and standard deviation of return.

The dynamic model links the behavior of the assets and liability cash flows under changing economic environments. It produces what we consider to be an optimal portfolio mix for each level of risk. Now these are not actual outputs, but rather the types of results produced by our ALM system.

If you look over to the right, you can tell that the efficient frontier has more risk and return than portfolios at the far left. That is to say, risk and reward change as you move the portfolio out the curve. Incidentally these are only illustrative portfolios, they're not anything that we would really use. The point is that, when you change the components of your investment strategy, you're going to change your efficient frontier position. It all depends on the amounts and the types of asset classes that you use.

We look at capital market assumptions, the business mix in the liabilities, the credited rate versus the competitor rate, and the lapse ratio. They are basically the key elements in our sensitivity tests. And from that comes our cash-flow testing.

I have a final point on performance measurement. We have a series of asset classes, that would represent corporate bonds, MBSs, equities, etc. Consequently, we have a way of accounting for our performance that relates the performance to that of the liabilities. It's important that we do this simply because, as the liabilities change, certain things happen within the investment group. And you're probably all aware of it. Certainly you have to respond to changes in the market, not only to the interest rates but also to other needs of the company. By using these indices we find it is a better way to convey our performance with the investment portfolio to our senior management than the usual comparison to a seemingly random index, which does not reflect our liabilities at all. Consequently, if there's a slowdown in cash flows in the liabilities, or the nature of the liability changes, the nature of our asset portfolio will change as well. We don't have to explain some of these changes because they are directly tied to the same base, over liability cash flows.

The target portfolio serves as a proxy for the liability structure. So, again, if interest rates move around, we certainly have an idea of where the liabilities are. We use a proxy portfolio to evaluate our actual performance against that liability benchmark. So, it's the product lines that are used as our performance measurement criteria. It's not just an asset class, or an asset allocation by itself without relationship to the liability cash flows and the types of the liabilities we're putting on the books.

There have been a lot of discussions and papers written about these sorts of processes. I don't know how far other companies have taken this whole process. I know this is not a unique concept. Incidentally Goldman, Sachs and Solomon Brothers have both pushed doing something like this. Maybe not quite the way we've done it. And we don't use derivative securities in any way. But it still does give us a pretty good reflection of the liabilities and how they move with interest rates.

Let me make one final point. This is an operative system: this is the way we actually do our analysis and cash-flow testing. Our process is integrated into the liability structure of the life company.

GENERAL ASSET ISSUES

MR. KIN ON TAM: My talk will be an overview of an intercompany credit-risk study on private placements and commercial mortgages. There is a detailed report on the study to date. Display copies of the report and order forms are available during the symposium. The report has been presented over a full-day seminar. In the time I have, I can only give you a few highlights.

Reasons for Studying Credit Risk

First, why should we study credit risk at all? Perhaps the answer can be given by a few rhetorical questions. How else would we know what default losses or risk-adjusted returns to expect? How else would we know the risk-reward relationship between different asset classes and different quality ratings? How else would we come up with factors for asset valuation reserves or risk-based capital?

But, to me, one reason would suffice. If a study can improve to any significant degree the way we underwrite credit risk, we don't need another reason.

Basic Facts About the Credit-Risk Study

The Credit-Risk Study has two sponsors: the Society of Actuaries and the ACLI. It brings together two professional groups: actuaries and investment people. It covers two asset classes: private placements and commercial mortgages. This is because no one has done for these asset classes what Hickman, Altman, and others have done for public bonds. It compiles two types of statistics: incidence and severity. As such, it is more like a morbidity study than a mortality study.

The study has a prospective side and a retrospective side. Prospectively, we try to collect year-by-year data on an ongoing basis. Retrospectively, we got underway by collecting historical data from 1986 through 1989. The results from this four-year period figure significantly in our report.

Defining Credit-Risk Event and Credit Loss

The study establishes a definition for a credit-risk event, a methodology for quantifying credit loss, and a number of breakdowns by which to tabulate the results.

First, how does the study define a credit-risk event? Basically, it is any credit-related deviation from the contractual cash flow. Under this broad definition, we include an out-and-out default on interest or principal, a bankruptcy on the part of the borrower, a restructure of contract terms (typically at below market rates), and the sale of an asset in distress.

Next, how does the study calculate the credit loss emanating from any of these events? It does so by comparing two discounted cash flows: the discounted cash flow as originally contracted and the discounted cash flow as revised (or salvaged) after the credit-risk event. Both cash flows are discounted to the date of the credit-risk event at market rates.

Four Loss Statistics

We will illustrate four loss statistics in a hypothetical example (Table 1). Company XYZ in one year has an exposure of 200 assets with 200 million of total par value. In the course of the year, a single asset with a par value of 1.5 million experiences a credit-risk event.

TABLE 1

	Number	Amount
Exposure	200	200M
CRE	1	1.5M
Incidence	.005	.0075
PVOCF @ CRE		1.8M
PVRCF @ CRE		1.2M
Loss of Severity		33%
Economic Loss	.33*1.5M =	.5M
Loss Rate	.5M/200M =	.0025

Accordingly, the incidence rate is .005 by number and .0075 by amount. The incidence rate by amount is higher than the incidence rate by number because the credit-risk event in question is above average in size.

As of the date of the credit-risk event, let's say the present value of the original (contractual) cash flow is 1.8 million while the present value of the revised cash flow is 1.2 million. These numbers are exaggerated for the purpose of illustration. The recovery ratio is thus 67%, and the loss severity is 33%.

Since both present values are based on market rates, the loss is a market-value loss. But the exposure is not valued at market. So we need to convert the loss to the same basis as the exposure.

We do so by multiplying the par amount at risk by the loss severity before the dividing by the total exposure. The resulting loss per unit of exposure is called the loss rate, or the basis point (b.p.) loss. Note that the loss rate of 25 b.p. is equal to the incidence rate by amount (75 b.p.) times the loss severity (33%). This is not a coincidence but a mathematical relationship.

Private-Placement Results in Historical Context

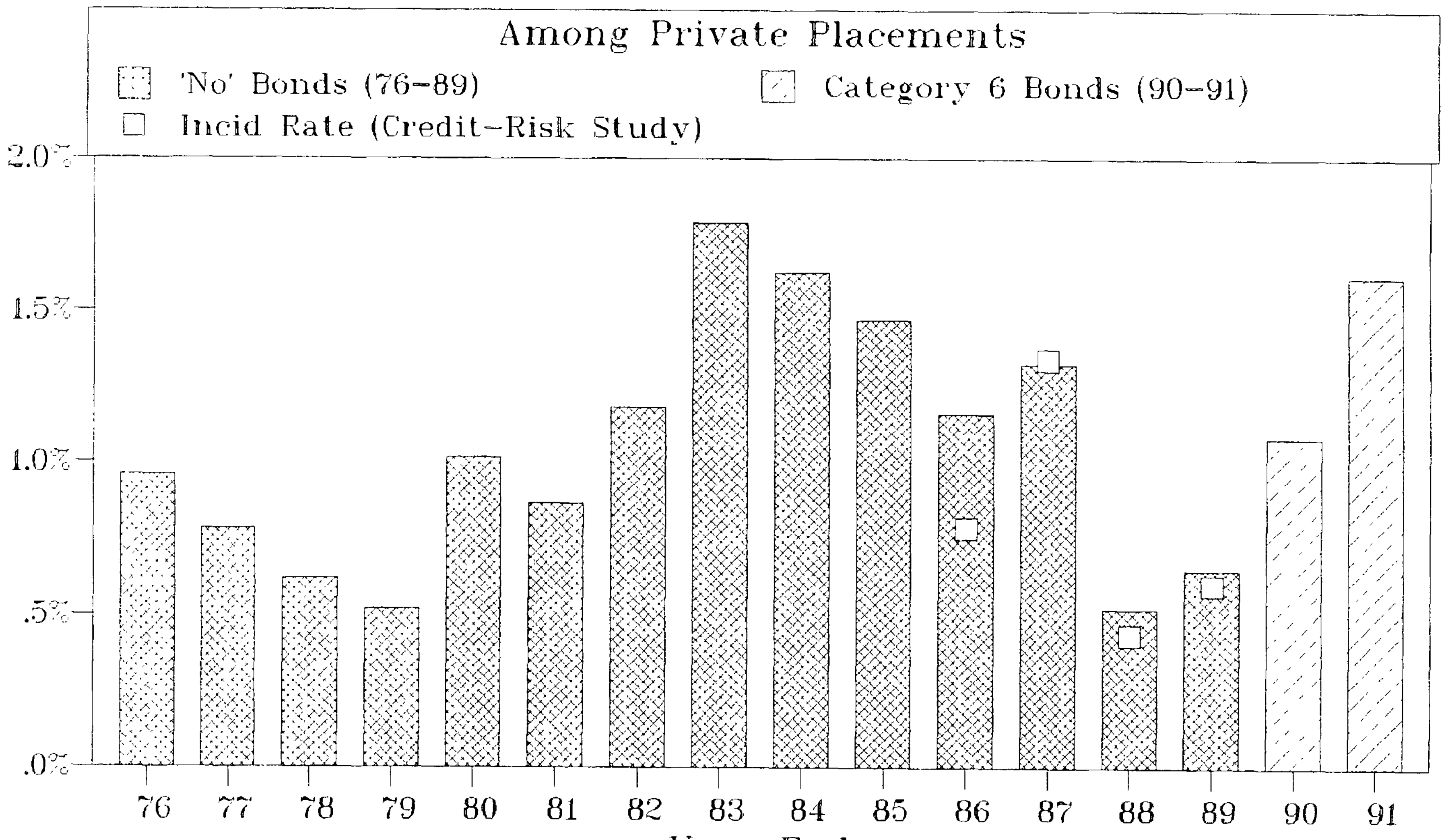
With the methodology out of the way, we are going to look at some actual results, first for private placements and then for commercial mortgages. In either case, we need to put the study in historical context. After all, four years is a very short time. We need to know if the study period is representative of a long-term average. Just as important, we need to know if the study is representative of today's conditions.

Chart 10 shows the percentage of private placements in or near default as tracked by the ACLI from 1976 through 1991. This bar graph is a history of the NAIC "No" bonds through 1989 and the Category 6 bonds thereafter. What can we say about the four years from 1986 through

CHART 10

Percent of NAIC "No" Bonds in 1976-89 and Category 6 Bonds (in or near default) in 1990-91

ACLI Data on US Insurance Company General Account Coverage of 60+% in 1976-89 and 98% in 1990-91



This chart is only illustrative; an incidence rate is an inception rate, which is not directly comparable to the % in a particular status at a point in time.

1989? In terms of private placements in or near default, they seem to be two above-average years and two below-average years. Taken together, the four-year period does not seem all that unusual.

The four "bullets" (square markers) on the chart represent the incidence rates by experience year from our own credit-risk study. They seem very much in line with the bar graph (the percentage of private placements in or near default).

Intercompany Private-Placement Results

Here is a graphic summary of the intercompany results on private placements. The set of four related bar graphs (Chart 11) gives these loss statistics respectively:

1. the incidence rate by number
2. the incidence rate by amount
3. the loss severity
4. the loss per unit exposure

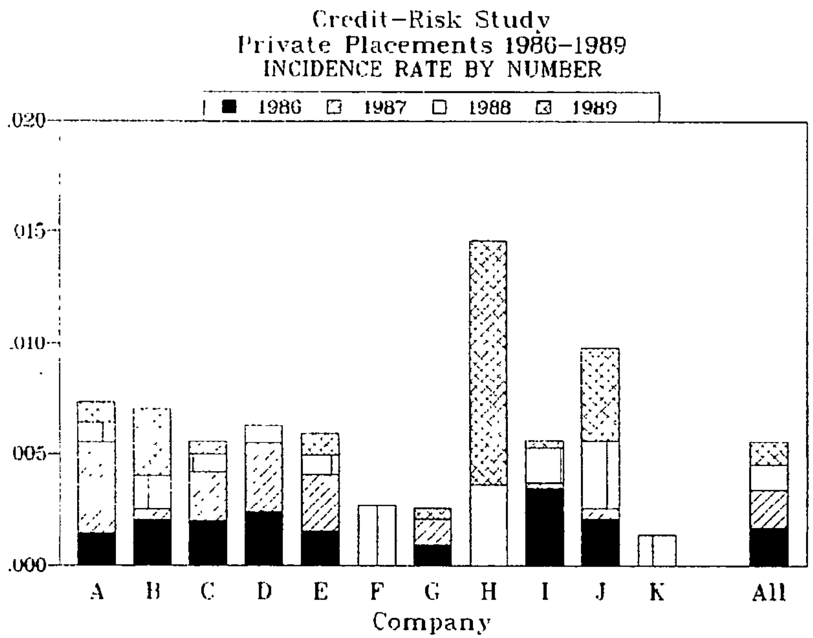
The full length of each bar represents a four-year average. Each bar is partitioned four ways to indicate each year's contribution to the four-year average.

There are 11 companies in the private-placement study. In the interest of confidentiality, they are simply known as companies A through K. It may help to know that the companies are more or less comparable to each other in quality distribution.

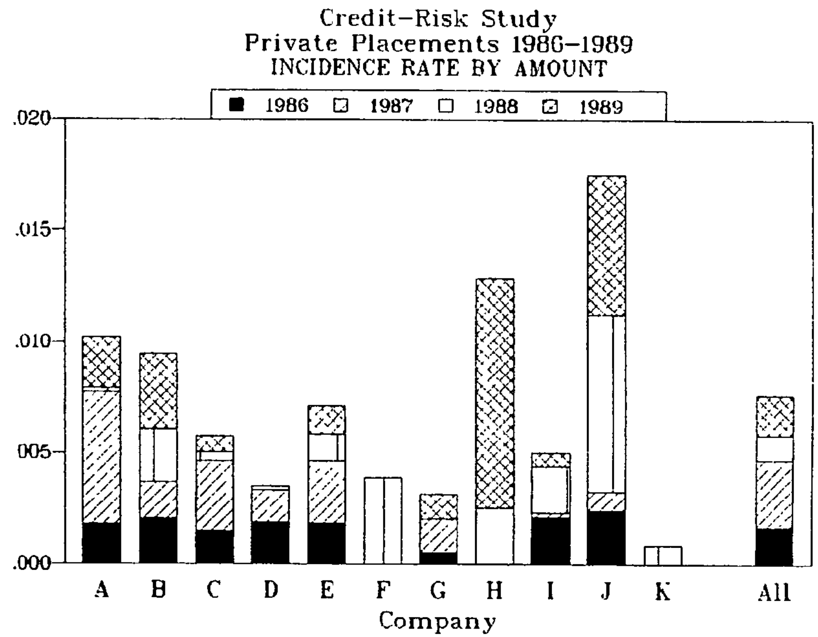
First, let's consider the graph on the incidence rate by number. You can see at once the variation from company to company and the variation from year to year. Isolated in the far right is the incidence rate for all contributing companies combined. It stands at 56 b.p.

The next graph gives the incidence rate by amount by company. The intercompany average of 76 b.p. is higher than the intercompany average for the incidence rate by number.

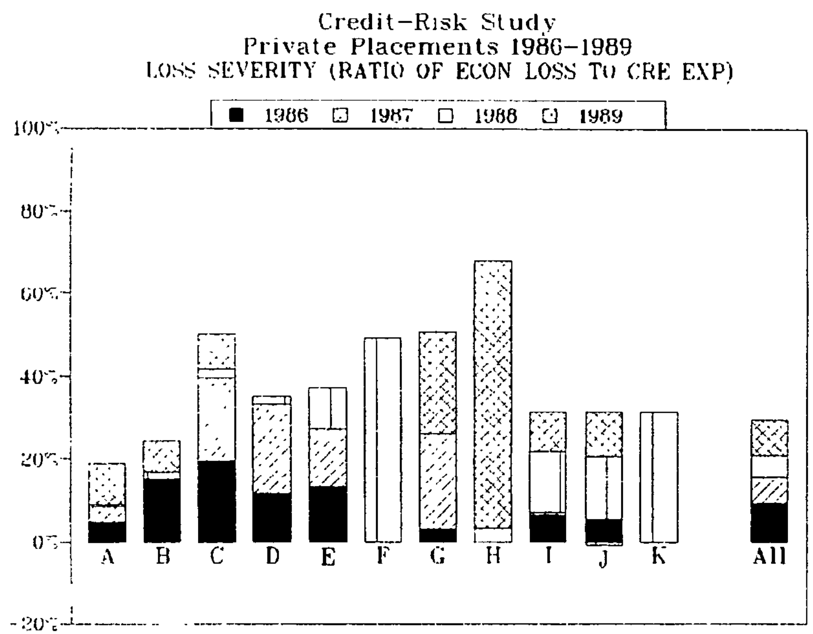
CHART 11



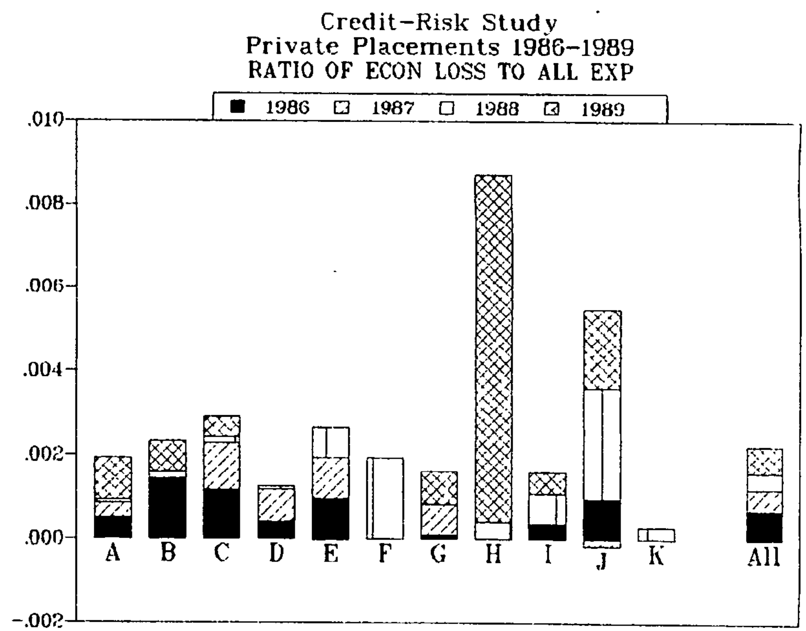
Credit-Risk Study
Private Placements 1986-1989
INCIDENCE RATE BY NUMBER
1986 1987 1988 1989
.020
.015
.010
.005
.000
A B C D E F G H I J K All
Company



Credit-Risk Study
Private Placements 1986-1989
INCIDENCE RATE BY AMOUNT
1986 1987 1988 1989
.020
.015
.010
.005
.000
A B C D E F G H I J K All
Company



Credit-Risk Study
Private Placements 1986-1989
LOSS SEVERITY (RATIO OF ECON LOSS TO CRE EXP)
1986 1987 1988 1989
100%
80%
60%
40%
20%
0%
-20%
A B C D E F G H I J K All



Credit-Risk Study
Private Placements 1986-1989
RATIO OF ECON LOSS TO ALL EXP
1986 1987 1988 1989
.010
.008
.006
.004
.002
.000
-.002
A B C D E F G H I J K All

Next comes the loss severity by company. The intercompany average of 29% is lower than expected from the public-bond experience. Time does not allow us to discuss the many plausible explanations. But one company is above 60% while another is below 20%.

The last of the four intercompany statistics is the multiplicative product of the last two. This is the loss per unit of total exposure. The intercompany average is 22 b.p. Company H stands out because it has both a high incidence rate and a high loss severity.

These intercompany graphs may raise a question in the context of the valuation actuary's opinion. Should each company base its default assumptions on its own experience? The answer may well be, "Yes, but not entirely." Let me explain.

First of all, there is enough variation in the results from company to company to suggest what is true of one company may not be true of another. This argues in favor of each company standing on its own experience.

On the other hand, there is something we can say about the intercompany average on each graph that we cannot readily say about each company on its own? In each case, the intercompany average is more evenly partitioned by year. Thus, you can achieve greater statistical credibility by pooling intercompany data than by restricting to any one company.

Private-Placement Results by Characteristic

Here are the characteristics by which the private-placement results have been analyzed:

- The most recent quality rating
- The earliest quality rating
- The NAIC rating
- The original coupon rate
- The type of credit-risk event
- The funding year (or the issue year)
- The number of years since funding (for the seasoning effect).

The analysis of the results by characteristic is perhaps the most important part of the study. The full report goes into all of these characteristics.

Commercial-Mortgage Results in Historical Context

In the case of commercial mortgages, it is even more important to put the study in historical context. To this end, we resort to yet another ACLI time series.

It is a tribute to the ACLI that it has been tracking the percentage of delinquent mortgages since 1965 (Chart 12). Note that the percentage of mortgages in a status is a prevalence rate rather than incidence rate. The latter has to do with the inception of an event rather than the continuation of a status.

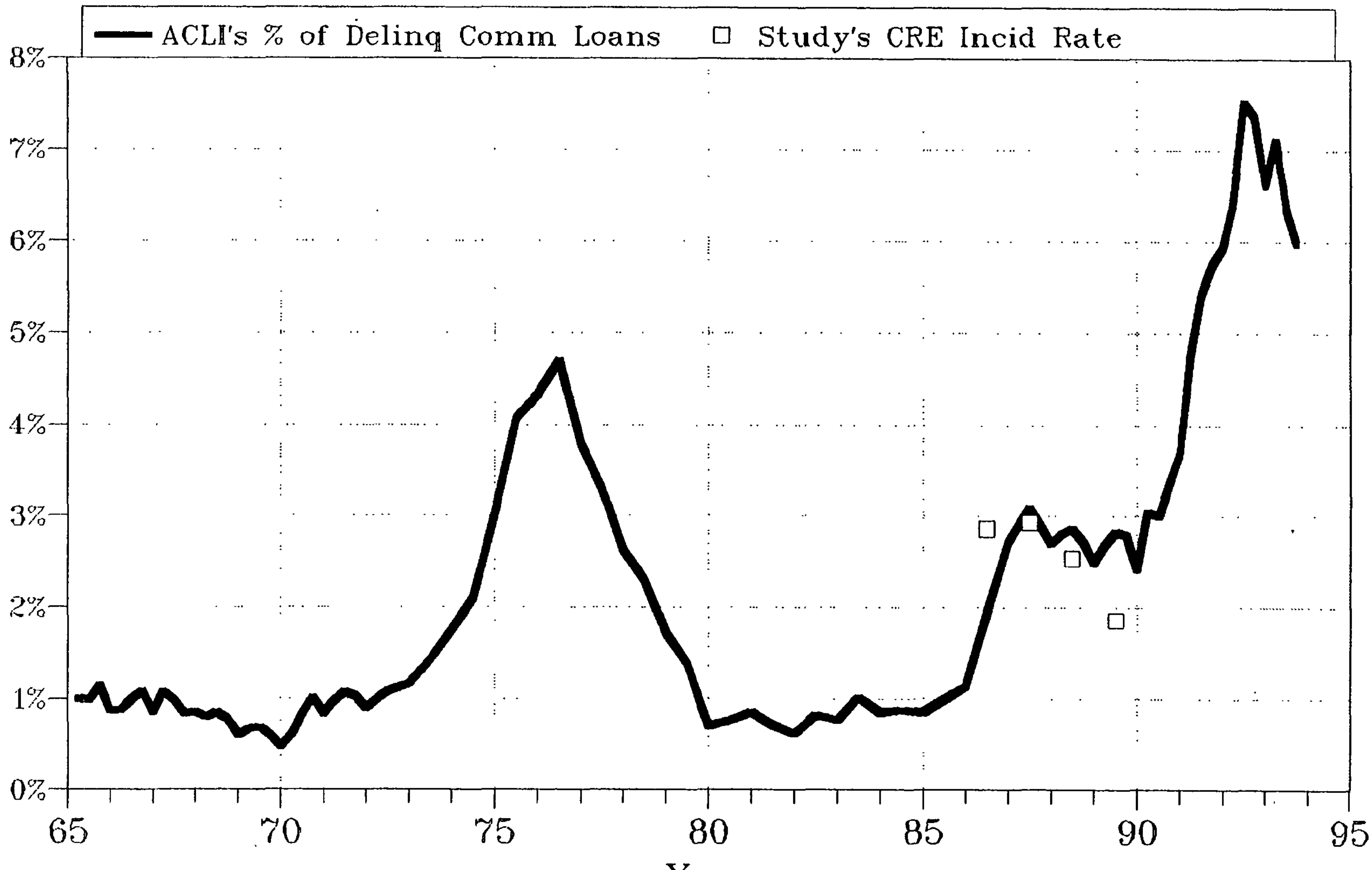
Let us first comment on the flat parts of the graph. During the best of times, from 1965 to 1973 and from 1980 to 1986, the delinquency rate of 1% is remarkably low and remarkably stable.

In between is the period from 1973 to 1980. During this seven-year period, the delinquency rate shot up to five times the baseline level. In all likelihood, a five-to-one ratio is anything but incidental. What can we say about the spikes in the late 1980s and the 1990s? Beginning in 1986, the curve rose sharply, reflecting the real-estate downturn in the oil-patch in the Southwest. By the 1990s, the rest of the country followed in the footsteps of the Southwest, giving rise to an unprecedented level of mortgage delinquency.

What can we say about the four-year period covered by the Credit-Risk Study so far? The period 1986-89 is decidedly worse than the good old days but still better than today. We would do well to keep this perspective in mind in using the results of the study for any short-range or long-range projection. It is for this reason that we dwell on the historical context so much.

CHART 12

1986-89 Credit Risk Study on Commercial Mortgages in the Context of the 1965-93 ACLI Survey



Note that an incidence rate is not directly comparable to a prevalence rate, the % in a status at a point in time.

Intercompany Commercial-Mortgage Results

Here is a graphic summary of the results on commercial mortgages. The four intercompany graphs (Chart 13) give the incidence rate by number, the incidence rate by amount, the loss severity, and the average loss per unit exposure, respectively.

Thirteen companies contributed data to the 1986-89 study on commercial mortgages. Compared to private placements during the same period, commercial mortgages showed a much higher incidence rate. This is true by number (1.88% versus 56 b.p.) and by amount (2.45% versus 76 b.p.). Once again, the variation by year is erratic by company but more stable for all companies combined.

Next, consider the loss severity by company. The overall loss severity of 25% is surprisingly low. Nevertheless, four companies are in the 40-50% range. One reason for tracking the incidence and the severity separately is that you can use one statistic and replace the other. You may wish to do so if, for whatever reason, you find one statistic to be more credible (or more applicable to you) than the other.

The final statistic, the loss rate, is the product of the last two. The intercompany average for commercial mortgages is 61 b.p., as opposed to 22 b.p. for private placements.

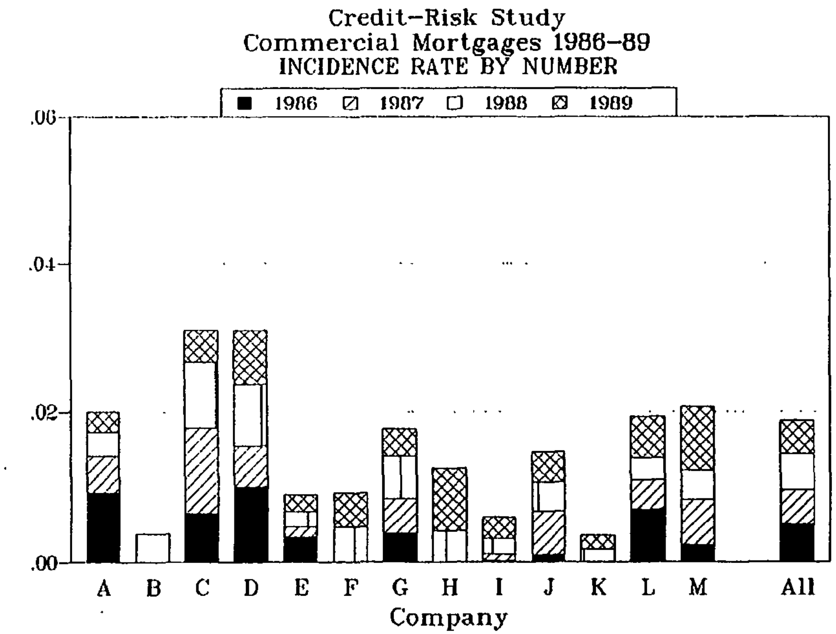
It is important to look at all four of these statistics. A high incidence rate can be offset by a low loss severity and vice versa. But you can also have a high incidence rate coupled with a high loss severity. Such seems to be the case with Company J.

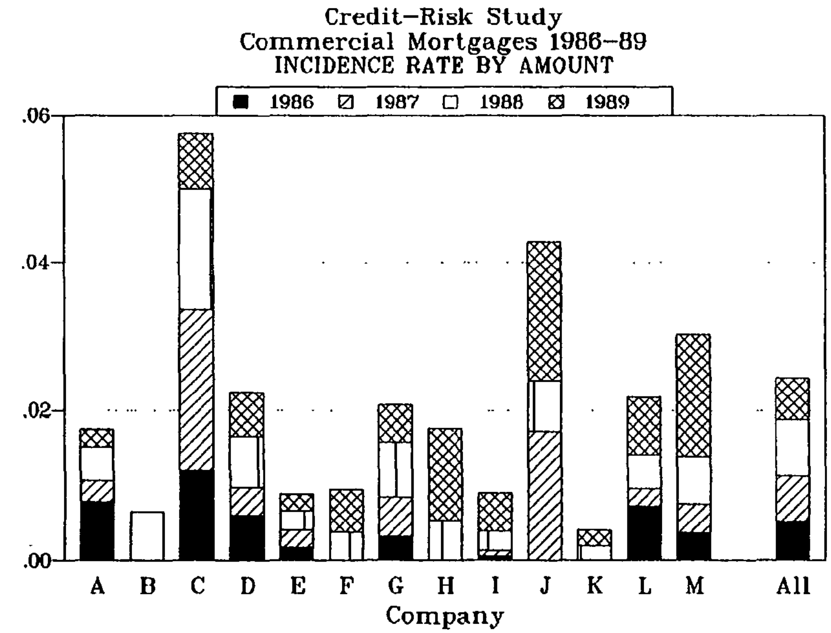
Commercial-Mortgage Results by Characteristic

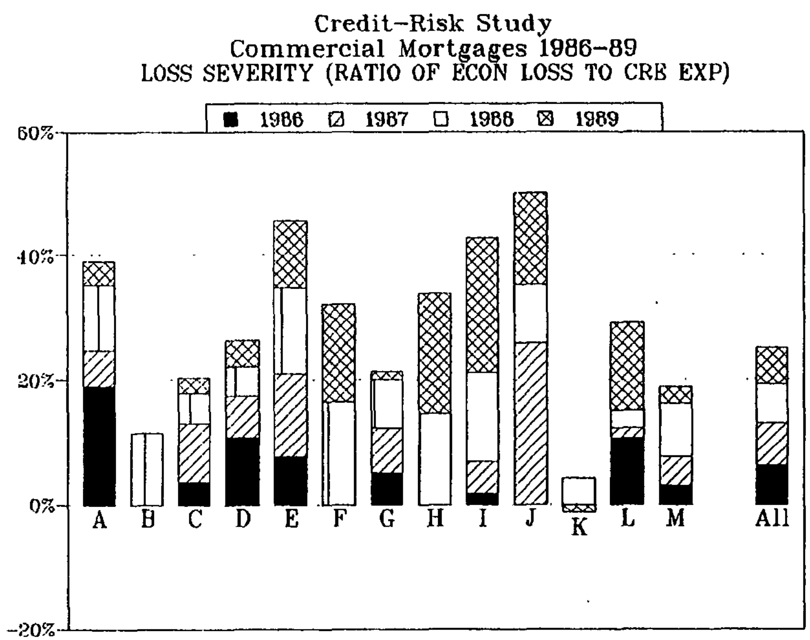
Here are some characteristics by which the commercial-mortgage results have been analyzed. They are:

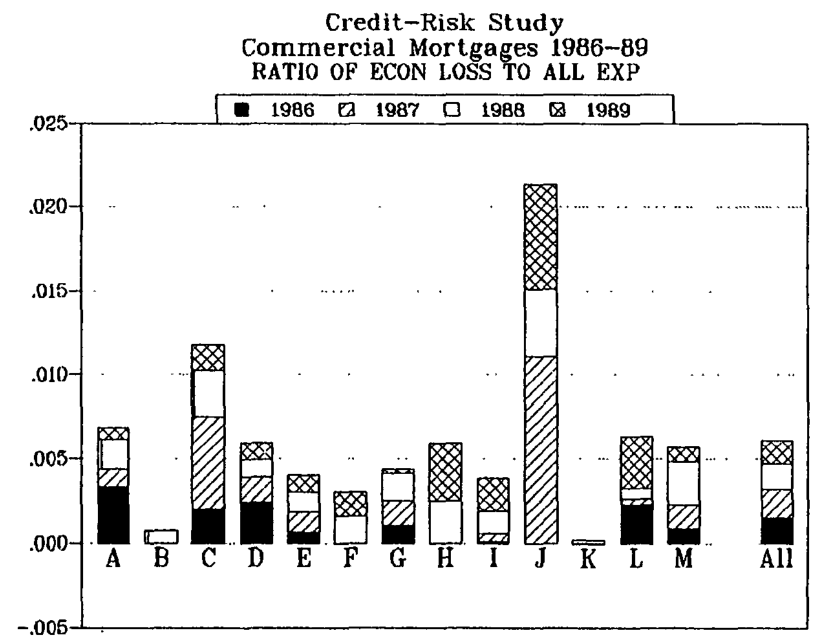
- The coupon rate
- The loan-to-value ratio
- The property type

CHART 13


Credit–Risk Study
Commercial Mortgages 1986–89
INCIDENCE RATE BY NUMBER
1986 1987 1988 1989
.06
.04
.02
.00
A B C D E F G H I J K L M All
Company


Credit–Risk Study
Commercial Mortgages 1986–89
INCIDENCE RATE BY AMOUNT
1986 1987 1988 1989
.06
.04
.02
.00
A B C D E F G H I J K L M All
Company


Credit–Risk Study
Commercial Mortgages 1986–89
LOSS SEVERITY (RATIO OF ECON LOSS TO CRE EXP)
1986 1987 1988 1989
60%
40%
20%
0%
-20%
A B C D E F G H I J K L M All


Credit–Risk Study
Commercial Mortgages 1986–89
RATIO OF ECON LOSS TO ALL EXP
1986 1987 1988 1989
.025
.020
.015
.010
.005
.000
-.005
A B C D E F G H I J K L M All

- The ACLI region
- The funding year (or the issue year)
- The number of years since issue (for the seasoning effect)
- The cross-tabulation between funding year and experience year

The full report covers all but the last two characteristics, which require further analysis.

My presentation was going to end right here. But I cannot resist going back to the ACLI survey to illustrate the significance of two of these factors, geographical region and property.

ACLI "Underperforming" Rates by Region and by Property Type

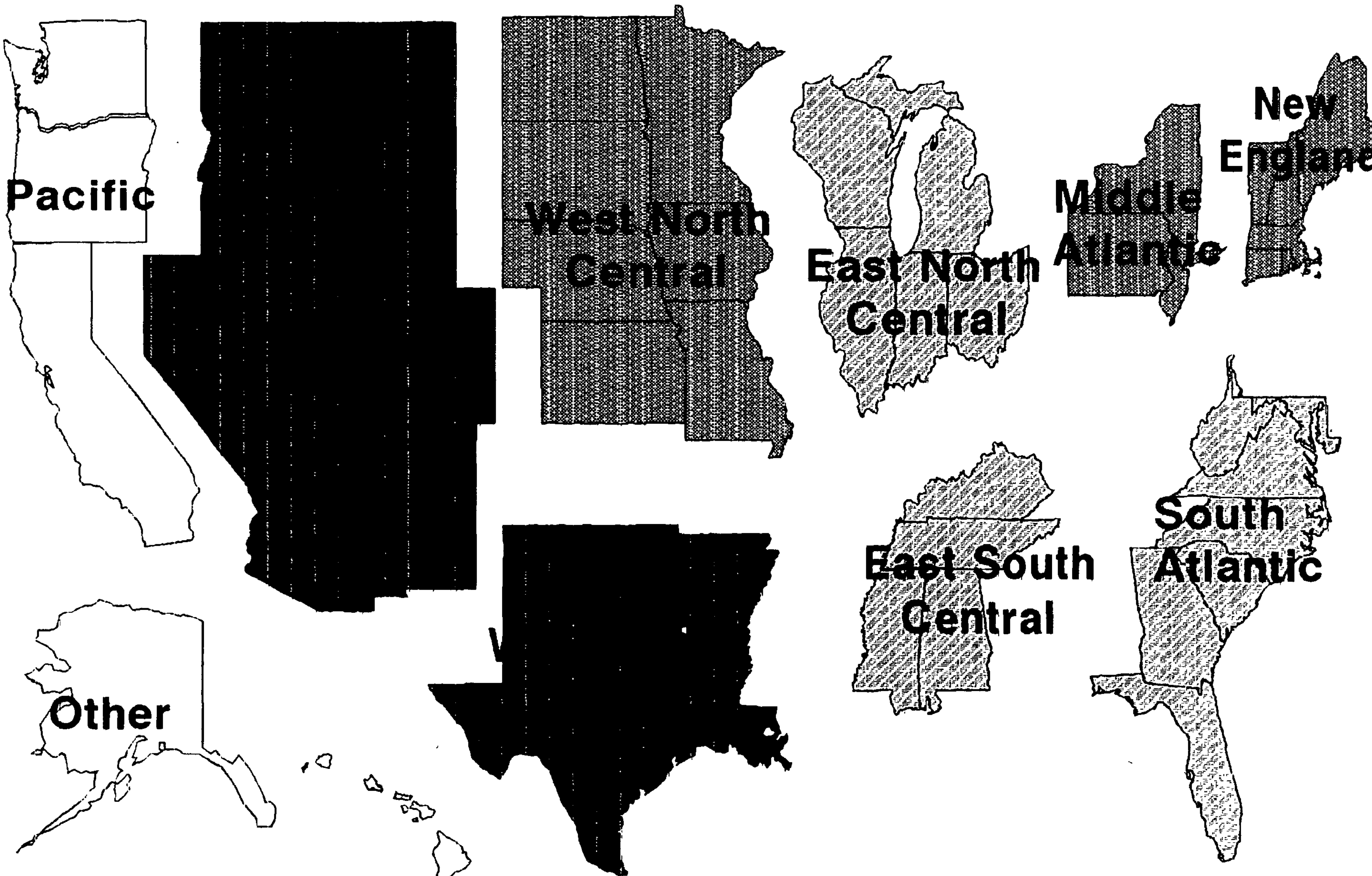
In 1988, the ACLI generalized its mortgage survey to track the experience geographically by subdividing the country into ten regions (Chart 14). These regions can roughly be grouped by their relative advancement in the commercial real-estate downturn over the last five years:

Relative Advancement In R.E. Downturn	Color Code	ACLI Region
Most Advanced	Dark Grey	Mountain West South Central
Next Advanced	Grey	West North Central Middle Atlantic New England
Less Advanced	Light Grey	East North Central East South Central South Atlantic
Least Advanced	White	Pacific Other (Alaska & Hawaii)

In 1988, the ACLI started to track a second category of underperforming mortgages, namely, loans restructured at below-market rates. Combining delinquent and restructured loans, the next

CHART 14

ACLI Geographic Regions For Delinquency Reports



two charts track the most recent five years' experience for all ten regions. This is done in two groups of five regions (Charts 15 & 16).

Five years ago, West South Central was already underperforming at the 20% level. It has not improved since. In the meantime, West North Central has approached the 20% level. In so doing, it has surpassed Mountain, one of only two regions above the 10% mark five years ago. East North Central has gone up slowly enough to stay under 10%. The relatively small "other" region is rather erratic.

Now for the history of the other five regions. Five years ago, none of them had an underperforming rate above 5%. Today, all of them are above 10%. Leading the pack are New England and Middle Atlantic. Both are approaching the 20% mark. South Atlantic and East North Central are neck-and-neck at about 13%. Pacific, for the longest time the most resilient region, is catching up fast at almost 12%.

Is 20% the ultimate underperforming level? If it were so, some regions would still have further to go. But even if it were so by region, it is not so by property type. Chart 17 shows the underperforming percentage by property type. At present, hotels and motels are 32% underperforming, followed by offices at almost 19% and apartments at 13%, followed by industrial at 10% and retail at 9%.

If I dwell on these graphs, it is because some striking trends in the ACLI survey deserve to be better known. They underscore the importance of geographical region and property type. Finally, they provide an excellent backdrop to the Credit-Risk Study.

CHART 15

ACLI Percentage of Delinquent and Restructured Commercial Mortgages September 1988 - June 1993 By Region (1)

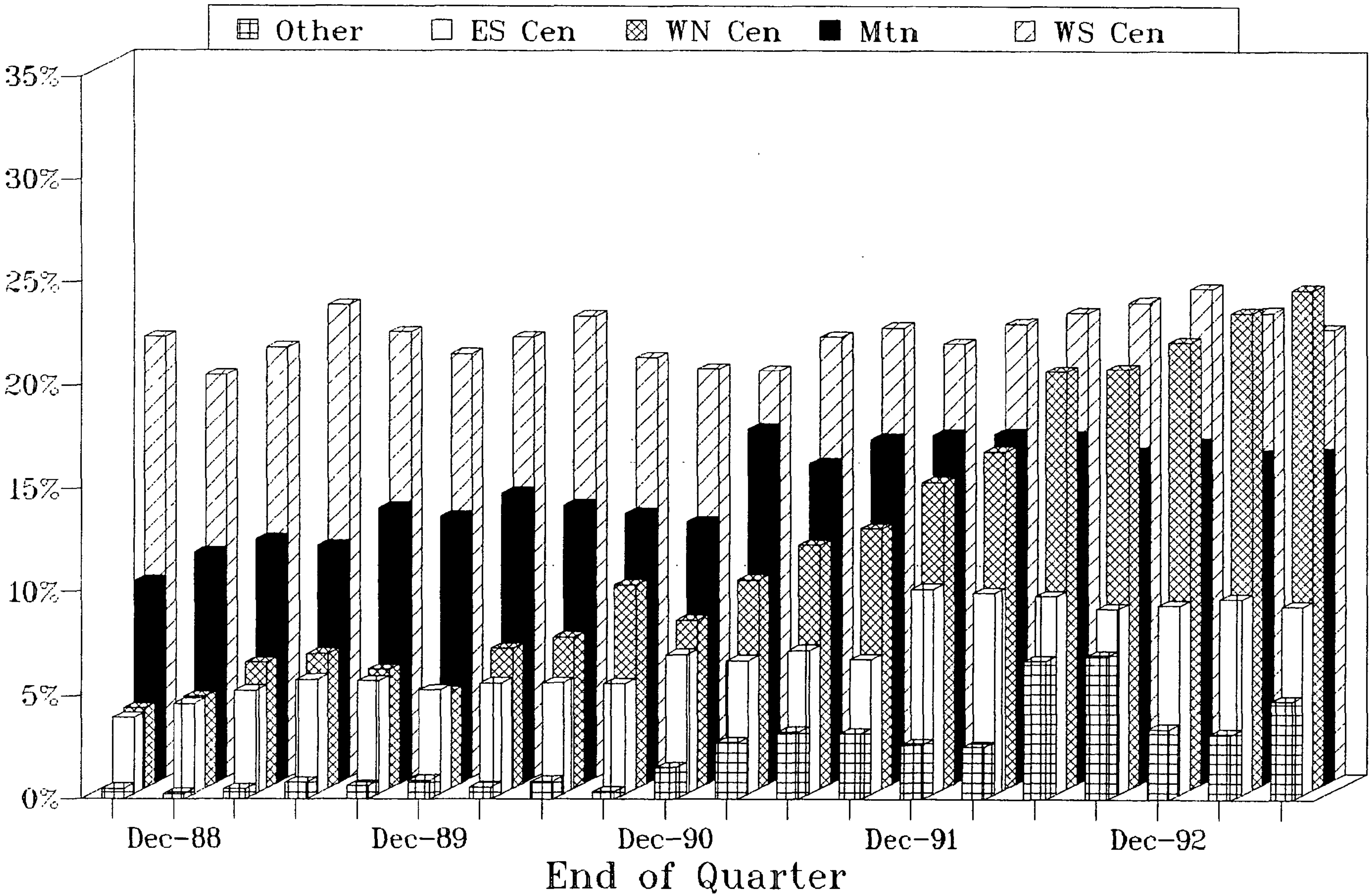


CHART 16

ACLI Percentage of Delinquent and Restructured Commercial Mortgages September 1988 - June 1993 By Region (2)

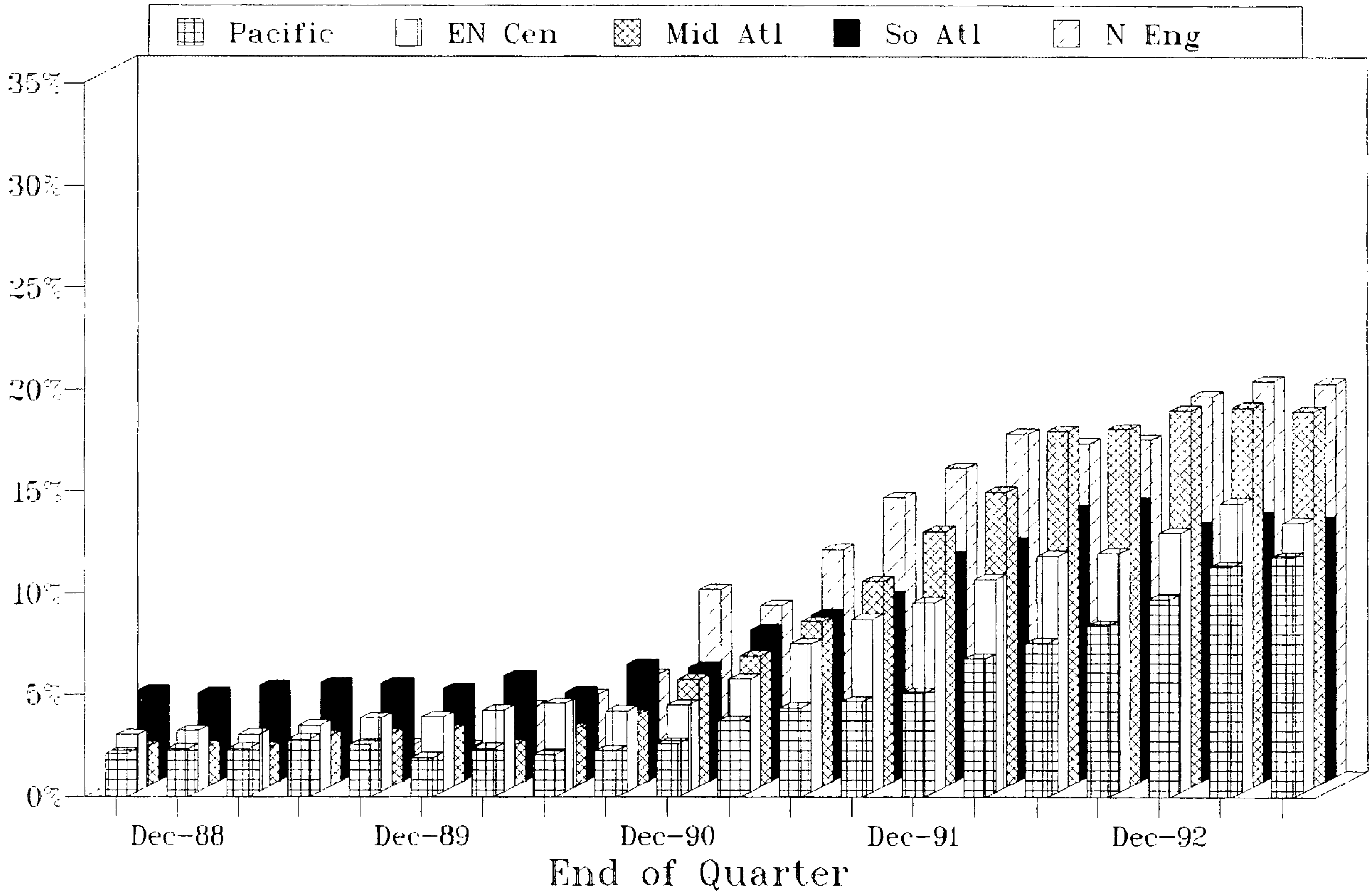


CHART 17

ACLI Percentage of Delinquent and Restructured Commercial Mortgages September 1988 - June 1993 By Property Type