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SYMPOSIUM PROCEEDINGS

SESSION 14

Asset Modeling Issues

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MR. LOUIS M. PIROG: I believe that there is a relationship between the mortgage and real estate market and some infomercials. I suspect that we might have realized that the real estate market was in trouble when we stopped seeing "How to Make a Fortune in Real Estate" on television.

I'm going to talk about some of the experience my company, Aetna, has had in modeling commercial mortgages and real estate. I'd like to start with a view of how modeling these securities has changed and some of the factors driving that change. I'm also going to talk about how we have approached modeling these securities, and finish with some observations on what we have learned.

Prior to 1990 (I'm using 1990 as a "crude" delimiter for when problems began in this market), there hadn't been any significant losses on these securities. I'm not even sure that we saw any losses other than those due to timing. We were confident that one could "diversify away" any material risk by owning a portfolio that was diverse in location and property type.

The real focus was on bond defaults: this was where there had been large losses.

For cash-flow testing, commercial mortgages were usually modeled like bonds or sinking funds: they had a fixed repayment pattern that varied little with interest rate levels. The default cost was some small basis point deduction off the coupon rate.

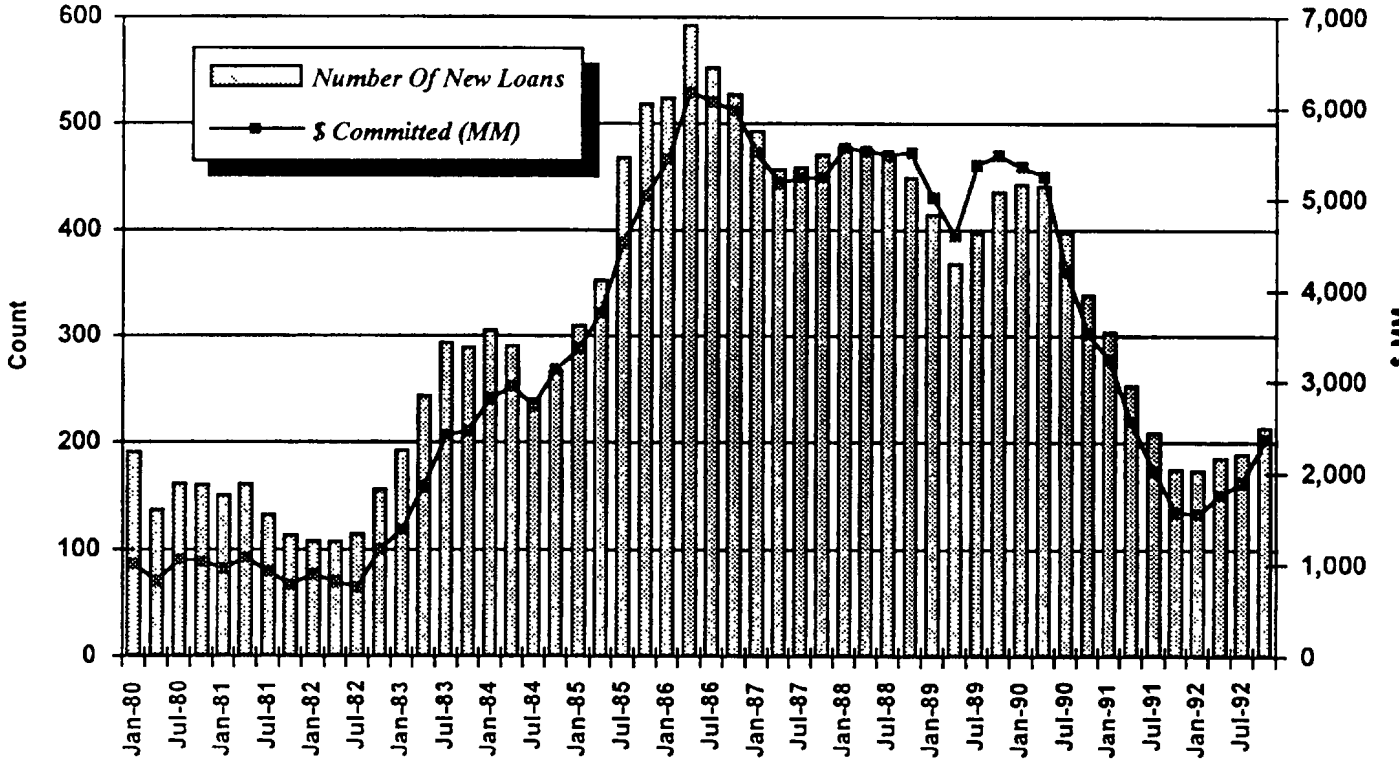
For real estate, similarly favorable assumptions were used. Real estate was modeled as an asset whose value increased over time. In a down scenario, maybe the growth slowed or there was no growth. The income stream from the property was favorable, usually growing at some portion of the inflation rate. After some period of time, the asset could be sold, for cash, with little difficulty in finding a buyer.

Life was good.

Chart 1 shows the quarterly level of new mortgage activity in the life insurance industry over the last 13 years by number of loans and dollars committed. The first thing to notice is the growth in activity from 1983 through 1986: from about $1 billion of commitments to over $6 billion. The level then seems to stabilize at about $5.5 billion until 1990. After 1990, the level declines rapidly to about $2 billion.

CHART 1

New Mortgage Volume



Another thing to notice is that the average size of a commitment is growing. You can see that the dollar line edges up on the bars that represent the number of new loans.

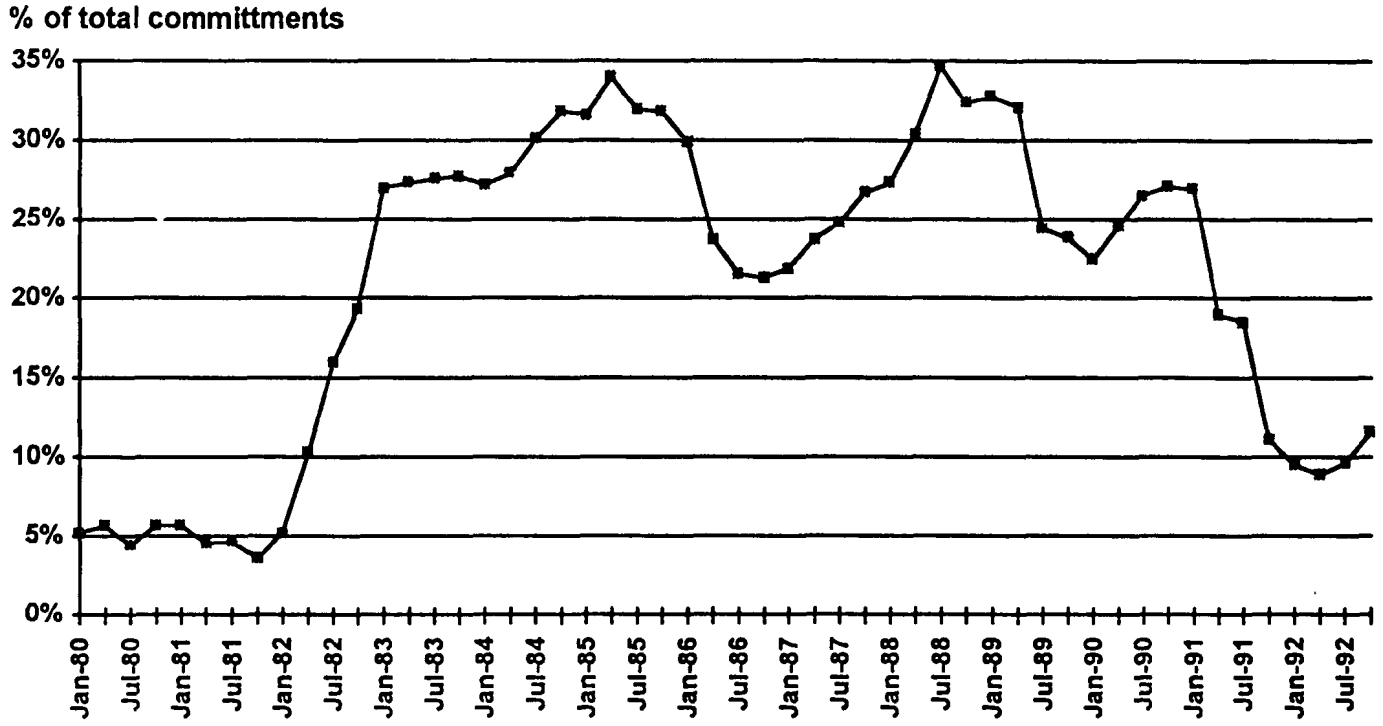
Life insurance companies were investing more heavily in commercial mortgages in the 1980s. "Heavily" here is a relative term: while dollar amounts of investments increased (more than doubling from 1980 through 1990: $82 to $215 billion), mortgages as a percentage of total portfolio stayed relatively constant (16-17%). There were simply more dollars to invest, many from GIC sales.

Subsequent to 1990, economic conditions essentially "put the brakes on" new commitment activity, with fewer dollars to invest and concerns about mortgage performance.

Chart 2 shows what percentage of new commitments were nonamortizing or "bullet" mortgages. In essence, bullet mortgages look a lot like bonds. The growth in the use of bullet mortgages is largely due to insurers using them to fund GICs.

CHART 2

Bullet Mortgages



The mortgages that were written were also customized for asset/liability matching purposes, which meant that these mortgages were heterogeneous in structure, and consequently more illiquid. But that was fine, as they were being used to fill in the "holes" in GIC portfolios.

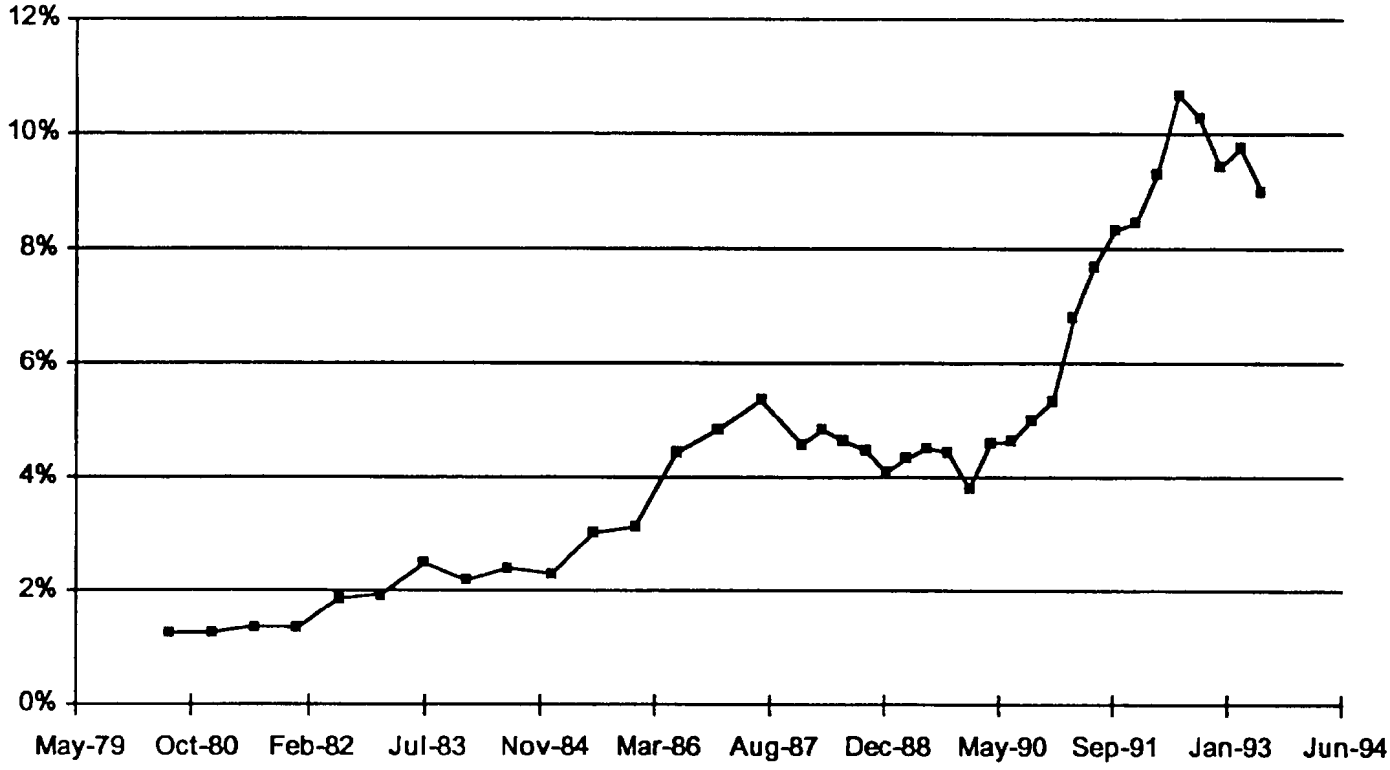
GICs and insurance liabilities were getting shorter in the 1980s, so the mortgage maturities were getting shorter. The average maturity dropped from the 15- to 20-year range prior to 1980 to something in the 7- to 8-year range. This shortening meant that new loans would mature at the same time as older loans, and would be competing for available funds.

Again, beginning in 1990, there was a significant reduction in the relative level of bullet loans, dropping back almost to traditional levels.

Chart 3 shows the percentage of life insurance mortgages that are "bad." *Bad* is defined as delinquencies, in process of foreclosure and foreclosed real estate. From a relatively placid 1% in 1980, the rate climbs to about 4-5% in 1986. It then stays at that level through 1990. In 1990, the rate begins to climb significantly into the double-digit range. Unfortunately, we haven't yet seen a return to historic levels.

CHART 3

"Bad" Mortgages

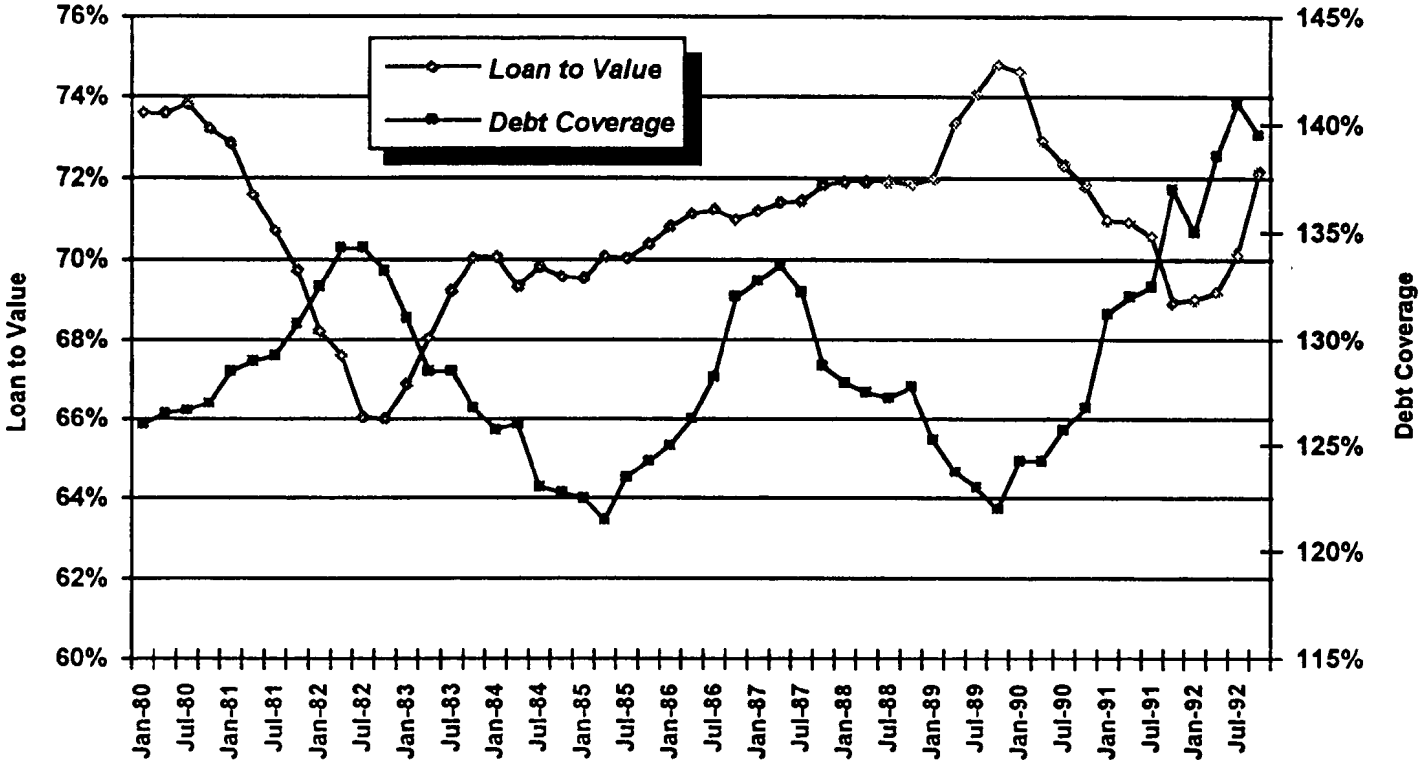


What this implies to me is that the "quality" of mortgages has deteriorated. Part of this deterioration may be due to the volume of shorter, bullet mortgages, maturing at the same time as older mortgages. This competition for funds is further aggravated by the withdrawal of banks from the mortgage market in the late 1980s.

Chart 4 shows the loan-to-value (LTV) ratio and debt-service-coverage (DSC) ratio for new commercial mortgages over the last 13 years. Notice that the LTV varies from about 65% to 75% between 1980 and 1990, while the DSC varies from 122% to 135%. That doesn't seem to be a lot of variation. In fact, that's in line with "threshold" values for LTV and DSC of 75% and 125%, respectively.

CHART 4

Underwriting Statistics



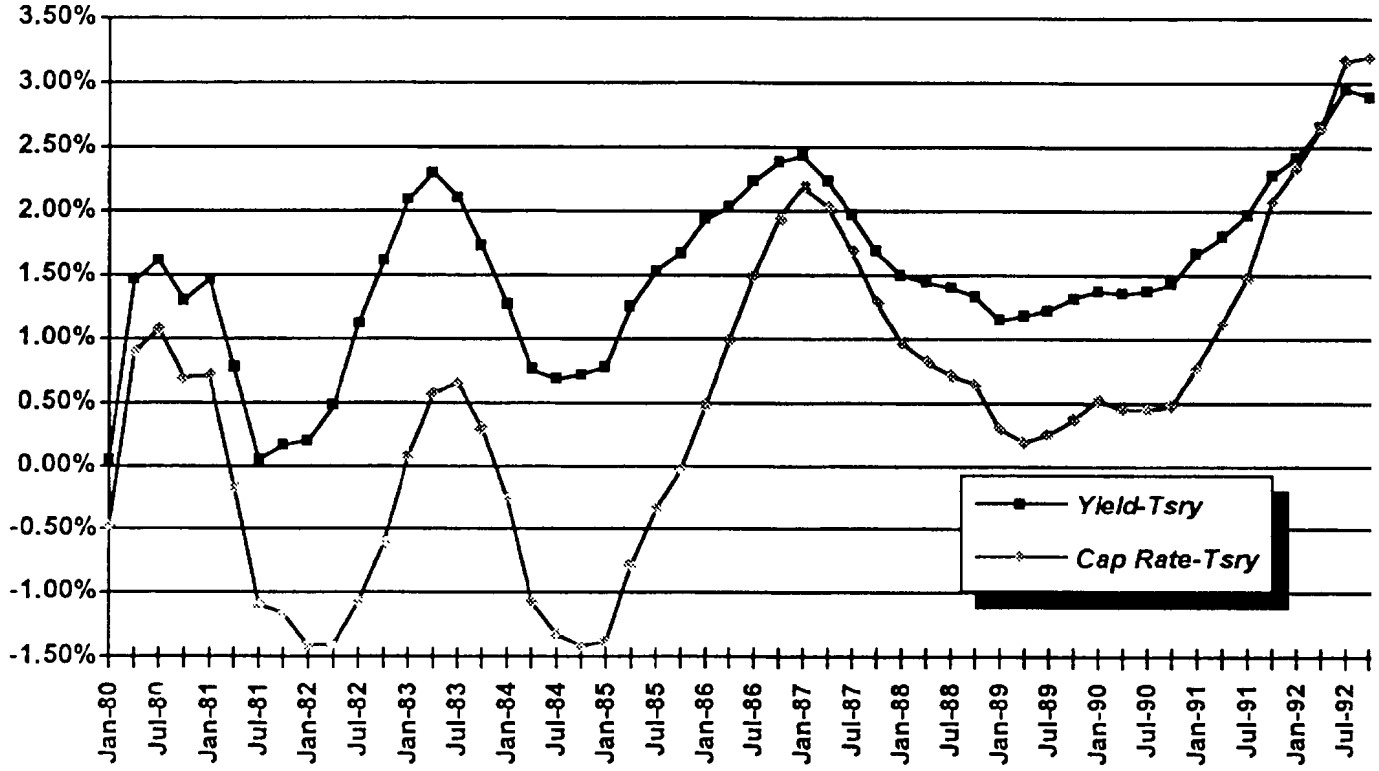
My suspicion is that the underwriting supporting these ratios was aggressive. Optimistic assumptions were made about vacancy and lease rates, leading to attractive property cash flows, which were significantly different from actual property cash flows.

Looking at these ratios from 1990 forward, LTV continues to stay in a 65-75% band, while DSC grows to 140+%. I think this implies that greater focus and stricter criteria are being placed on the ability to meet current loan payments. I'm also inclined to believe that underwriting has become "tighter."

Chart 5 shows the spread between yield on new commercial mortgages and Treasuries, and the spread between the capitalization rate for new commercial mortgages and Treasuries from 1980 forward. What's interesting is the relationship between the two spreads. In the early 1980s, yields are about 50-100 basis points above cap rates. In 1982, that spread widens to 150-200 basis points, then subsequently narrows to 25 basis points in 1987. I view that difference as an indication of how much factors other than current yield are driving the price of mortgages and real estate. Lower cap rates would imply a greater focus on appreciation, while higher cap rates imply more focus on current yield.

CHART 5

Interest Rate Scenarios



It's interesting to note that in the last few data points, spreads are reaching their highest level (300+ basis points) and cap rates are at or above mortgage yields, meaning that appreciation is being given significantly less weight than current income.

Given the last 10-15 years of experience, what is the current situation for modeling commercial mortgages and real estate? We've seen mortgages turn from being the "hot" investment to being the "not" investment. There has been a fundamental shift in the economy: a recessionary period with very low interest rates and available capital to invest in mortgages has dried up. We've been made painfully aware that the value of a commercial mortgage, and consequently the value of the underlying real estate is not a function of the value of the physical structure: it is a function of the tenants and the economy as consumer demand fuels the need for the goods and services of the tenants.

When we model commercial mortgages today, we need to recognize not only the high levels of defaults, but also the effect that these defaults have on the cash flows that the company receives: that is, the C-3 impact as well as the C-1 impact. To do this analysis, we have to look at the underlying collateral that supports the mortgage.

That means we have to analyze the underlying real estate "in depth" and often at a "property specific" level. We need to know more about the property and the environment that the property is in. We are in an economy today where the east and west coasts are clearly in worse shape than the rest of the country. Some of the important information includes type of property (office, retail, etc.), location of property, and makeup of tenants (including terms of leases).

We also need to become comfortable with the "tools of the trade." We have to learn to understand and use the terminology, such as:

Net operating income (NOI) = Gross income - Operating expenses
Property cash flow = NOI - Capitalized costs
Debt service coverage (DSC) = Ratio of cash flow to mortgage service

Loan to value (LTV) = Ratio of book value of loan to market value of property
Gross lease = Rent (includes real estate taxes, insurance, maintenance)
Net lease = Tenant has direct responsibility for real estate taxes, insurance, operating costs.

I like to draw analogies, so I'm going to compare collateralized mortgage obligations (CMOs) to commercial mortgages (CMs).

The values of both CMOs and CMs are driven by the complexity of the underlying collateral. In the case of CMOs, the underlying collateral is usually mortgage pass-throughs, while it's real estate for CMs. The complexity of this collateral makes the security difficult to understand and to model.

Both CMOs and CMs have uncertain future cash flows. For CMOs, the uncertainty is due to prepayment activity of the underlying mortgages (which is largely influenced by interest rate movements, with a small portion due to defaults).

For CMs, payment uncertainty is driven by economic conditions, such as employment and the demand for goods and services.

We are currently seeing unprecedented levels of volatility with both CMOs and CMs.

Interest rates are at a very low level. Many people have refinanced their home mortgages in the last year or so. I think we are also seeing a new aggressiveness in mortgage companies and banks as they actively solicit customers to refinance.

Similarly, we are seeing CMs in default at historically high levels as an earlier graph indicated.

Small changes in assumptions can produce significant changes in results. With CMOs, this sensitivity can result from planned amortization class (PAC) bands being broken or write-downs of interest only (IO) tranches.

For CMs, a modest decline in the income stream for a property or the belief that expiring leases may not be easily renewed could move the borrower to default.

You make several startling discoveries when you decide to model commercial mortgages and real estate in detail. The first is the blank stares you get from your investment area people when you ask them how specific interest rate scenarios will impact the cash flow from various properties. You have to build an economic scenario around the interest rate scenario. The investment people will ask for projections of gross domestic product (GDP) growth, employment growth, housing starts, and inflation. With that information, they can provide assumptions about rent growth, expenses, vacancy levels, and capitalization rates. Once you've developed an economic scenario, it's also important that it gets reviewed for reasonableness. For instance, if you assume that vacancy rates remain high for extended periods, what does that imply for the total economy? Is the scenario too extreme?

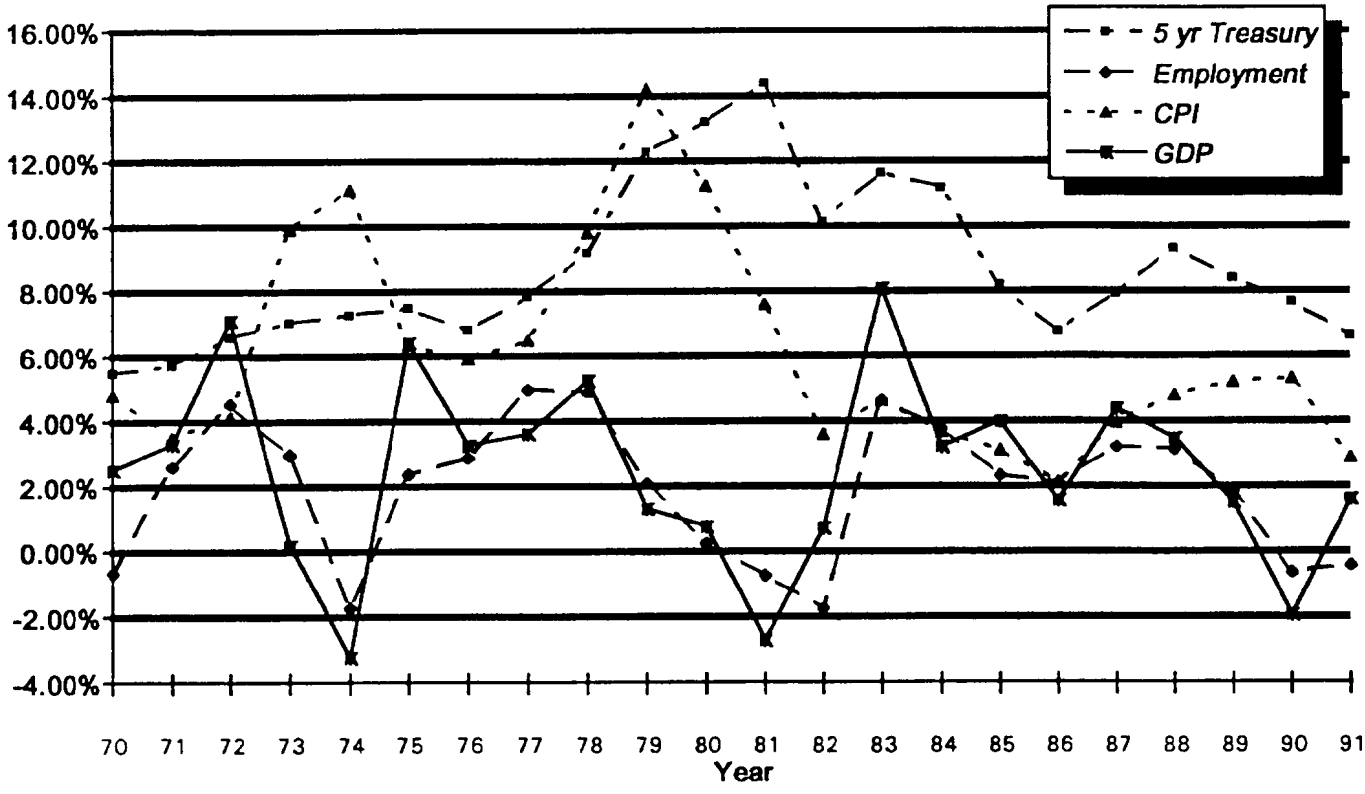
Where do you find data on general market conditions? Data are scarce. The ACLI has data on incidence. There are informational reports provided by several companies. The Society of Industrial and Office Realtors provides survey data on market rents and vacancy by metropolitan areas. The Society of Actuaries Credit Study is developing some loss severity data. As future years of experience expand the database, more useful information will become available.

As there is no standardized method of rating properties, you will have to rely on your company's investment people and the network of appraisers that they use to develop profiles of the properties owned. Because you are dealing indirectly with the underlying property, you will often have to rely on individuals outside of the company for information.

Chart 6 shows a plot of several economic indicators: the five-year Treasury rate, the percentage change in employment, the percentage change in CPI, and the percentage change in the GDP from 1970. There aren't any strong correlations here. The best is between employment and CPI, which has a 60% R-squared. The remaining correlations are well below 20%.

CHART 6

Economic Indicators



Another consideration in modeling is how mortgages and real estate are accounted for and the purpose of the modeling.

On the statutory side, what, if any reserves are held for default losses, either in the AVR as in voluntary reserves? How are writedowns accounted for; when do the writedowns occur; and when are they recognized in earnings?

Testing performed for statutory purposes is often an asset adequacy analysis, which will necessitate the projection of both asset and liability cash flows. This implies that future earnings will be available as an offset to losses. This type of testing will be the responsibility of the actuary. Consequently, even though you may rely on investment officers and/or economists to develop assumptions, you still need to satisfy yourself that the assumptions are reasonable in an

overall sense. If your scenario has vacancy dropping to zero and rents growing 10% a year, you should probably be suspicious.

On the GAAP side, you will need to recognize how your company establishes reserves for impaired assets, as well as the mechanics of write-downs, which will probably differ in some manner from statutory treatment.

The GAAP analysis will not be an asset adequacy analysis. Rather, it will be an analysis to determine an appropriate level of impairment reserves by first identifying those mortgages with a high probability of default and then estimating the loss. This analysis will not directly involve the liabilities. It will not be an actuarial opinion. It will be the responsibility of the investment department to develop assumptions for this type of analysis.

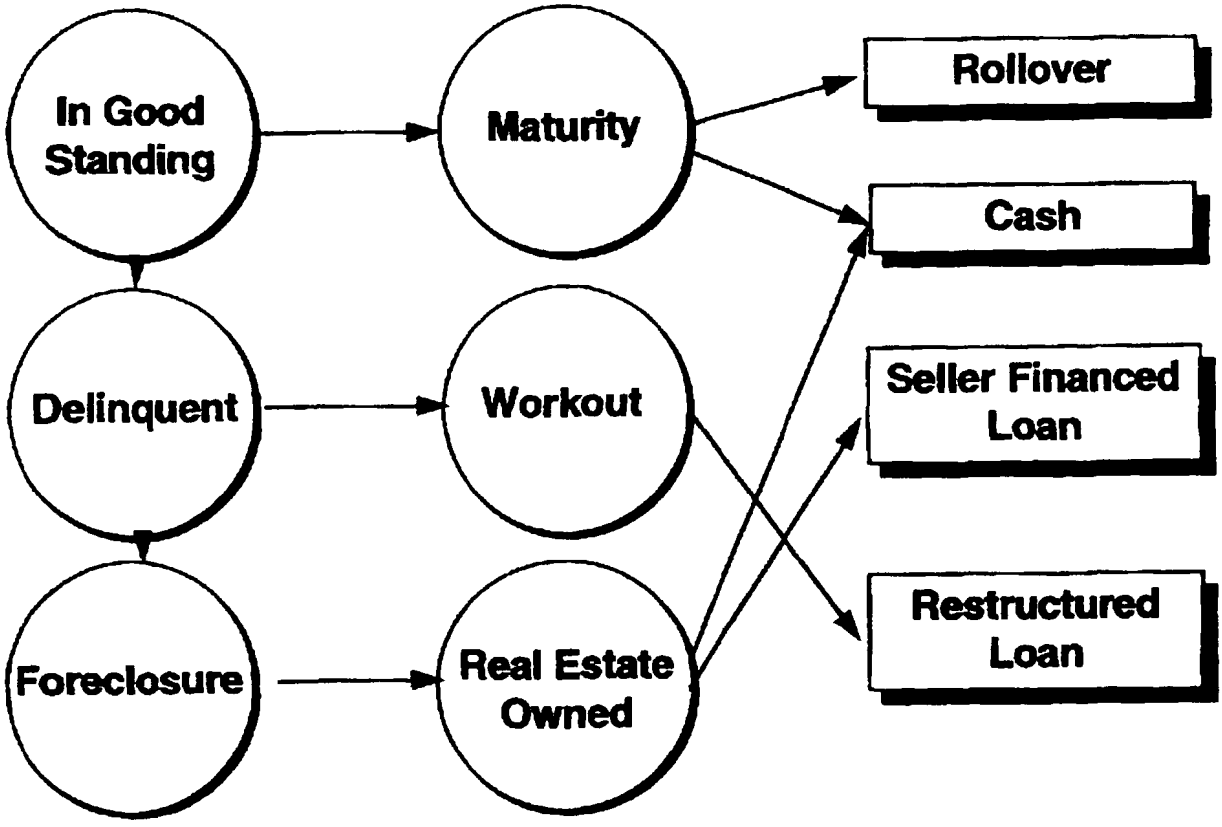
I want to describe what we have been using to model commercial mortgages and real estate. The model is basically a Markov chain with five states: in good standing, in default, workout, in process of foreclosure, and foreclosed real estate.

The transition probabilities (i.e., the probabilities of moving from state to state) are dependent on the DSC and LTV of the property. As these ratios change over time, the probability matrix changes to make transition to certain states more likely and transition to other states less likely.

Chart 7 is a schematic of how the model works. For example, a mortgage enters at the "in good standing" state. Based on the transition probabilities (which are influenced by DSC and LTV, which are in turn influenced by the fundamentals of the underlying property), the property may either remain in good standing or move to "delinquency." If the mortgage remains in good standing until maturity, some portion is paid in cash and the rest is rolled over into a new loan.

CHART 7

Transition States



What often triggers the move to delinquency is a low DSC on the property: not enough income is generated to support the mortgage. If the mortgage moves to delinquency, it can then transition to either "workout" or "in process of foreclosure." Whether the mortgage goes to workout or in process of foreclosure will usually depend on LTV: is there sufficient value in the property to incent the owner to negotiate, or will the owner just walk away from the building?

If the mortgage moves to workout, new loan terms are negotiated, and the mortgage reappears as a restructured loan.

If the mortgage moves to "foreclosure," it becomes "real estate owned," and is subsequently sold. On sale, some portion is received in cash, and the rest becomes a seller financed loan.

Some additional assumptions/inputs for the underlying property are:

- Property income. Where does it come from? Some possible sources are rent, recoveries, sales-related income (often in retail properties), and parking fees.
- Property expenses. These are basic operating expenses as well as tenant improvements and commissions.
- Lease expirations. These include timing and level of lease expirations, with recognition of their associated lease rates.
- "Global" environment. *Global* can be defined as broadly as the area of the country or as narrowly as the block in which the building is located. Information needed is current vacancy levels, lease rates, and the amount of available space.
- Loss on sale/timing of sale. When a property is sold, how much money, if any, is lost? How long is a property held before it is sold?

I'd like to make a few observations on the results that we have seen using the above model.

The final state of a mortgage can be very different from the starting state. Mortgages that default can become restructured loans or they can be foreclosed and end up as money purchase loans. It is often difficult to anticipate what will happen to a mortgage being modeled.

As a consequence of uncertainty of the final disposition of the mortgage, modeled cash flows look very different from the contractual cash flows. Much of the difference is caused by restructuring the mortgage or writing a new mortgage instead of receiving cash.

With differences in cash flows, there can be significant differences in present values.

I'd like to end with some observations and advice on what we've learned.

New models and new skills are definitely required to model and understand commercial mortgages and real estate. The same type of learning process that took place in the 1980s with

respect to asset/liability matching is occurring now with mortgages and real estate. Actuaries and investment people need to communicate and reach a common understanding of these assets.

As I mentioned earlier, the modeling results are very sensitive to assumptions and minor changes in those assumptions. This sensitivity makes developing appropriate scenarios all the more difficult.

There is a great deal of subjectivity in developing modeling methods and assumptions. Reasonable professionals can arrive at different answers. With increased regulatory scrutiny of life insurance companies, there is the potential for "second guessing" or "20/20 hindsight" by examiners, made all the more likely given the dramatic changes in the market over the last few years.

If you have a significant investment in commercial mortgages and real estate, you need to spend the time and money to better understand the investment.

Finally, I mentioned at the beginning how at one point, television stations stopped running advertisements for "How to Make Money in Real Estate." Well, I've started to see those programs again, so maybe the outlook for commercial mortgages and real estate is improving.

ASSET MODELING ISSUES
ASSET MODELING ISSUES -- COLLATERALIZED MORTGAGE OBLIGATIONS

MR. JAMES G. STOLTZFUS: I was asked to share with you the experiences I've had with CMOs. My experience has primarily been with annual cash-flow testing, asset/liability matching studies, and actuarial valuations including actuarial appraisals.

I would like to spend some of my portion discussing some of the issues that occur when modeling CMOs. However, it seems appropriate to spend time discussing some of the basics to CMOs. I will try to keep the discussion on basics in general terms.

Basic CMOs -- CMOs represented nearly $45 billion of U.S. life insurance company assets as of December 31,1990. For many companies, CMOs make up more than 20% of their invested assets. This type of investment continues to grow both in dollar amount and as a percentage of total life company assets. Due to the current returns on these investments, some companies are investing up to 40% of their portfolios in CMOs.

CMOs are a series of bonds, which are collateralized by a pool of mortgages or a pool of pass-through securities. CMOs split the cash flows from the underlying collateral, both principal and interest, into nonhomogeneous pieces, also known as tranches, with varying priorities. There is not a standard design for a CMO nor is there a standard number of tranches.

The underlying pool of collateral consists of mortgages that generally have like characteristics, that is, the same or similar interest rate and years to maturity. An agency or investor purchases the mortgages and then sells off pieces of the block to other investors. The agencies that collateralize these mortgages are a government agency such as the Government National Mortgage Association (GNMA), or private corporations with borrowing rights at the U.S. Treasury such as the Federal Home Loan Mortgage Corporation (FHLMC) or Federal National Mortgage Association (FNMA). There are also many private corporations that collateralize mortgages. Some examples are Capstead, Prudential, Bear Stearns, and on and on. These corporations guarantee timely payment of principal and interest on the securities they issue.

Some of the advantages of CMOs to investors are the ability to purchase a cash-flow structure more appropriate to the investors' needs, which differs from traditional pass-through securities. Investors can choose tranches that compress the return of principal into a more compact time frame, allowing a better match of assets to liabilities. Also the investor will generally receive a yield higher than Treasury bonds, bills, or notes. Also the credit risk is generally minimized due to the large underlying pool.

Probably the biggest disadvantage of CMOs is the unpredictability of cash flows, primarily due to prepayments, which I will explain more about later.

There are some generalities that can be made. First, usually only a few tranches will receive principal payments at any given time. Second, most tranches, with the exception of principal only and accrual tranches, receive interest payments tied to the tranche coupon rate and the outstanding balance on the tranche. Third, in all cases, the sum of the principal and interest paid to all the tranches cannot exceed the principal and interest received on the underlying collateral. Last, no two CMOs are identical.

Some of the other key terms I will use are defined below. Most of the terms are fairly common in CMO literature. There are, however, one or two that I will use that are more descriptive.

As I mentioned earlier, tranches are the individual bonds created from the pool of mortgages or the CMO. Tranches can be defined as sequential or prioritized. In sequential CMO tranches, principal cash flows from the underlying collateral are used to pay down one tranche at a time. For prioritized tranches, scheduled cash flows are paid to higher priority tranches such as PACS and excess cash flows are used to pay down lower priority tranches.

The acronym PSA refers to the standard prepayment model established by the Public Securities Association. This model is .2% in the first month grading uniformly to 6% in the 30th and later months.

A collar refers to the scheduled protection range for a tranche over which scheduled payments can be made. Prepayment speeds will vary over the course of the investment. However, if prepayments fall within the "collar," the tranche will receive its scheduled payments. This is because there is enough support or lower priority tranches that will pick up the excess payments. If prepayments exceed the collar range, the future payments will probably be modified because tranches with a lower priority will have run out.

A window refers to the period of time during which the tranche is scheduled to receive its cash flows.

Types of Tranches -- In the initial development of CMOs, tranche types tended to be simple and common. Today, these terms greatly oversimplify tranche definitions. The following list of tranches is not meant to be an all-inclusive list. However, I have tried to discuss the types that have been prevalent in most of the work that I have done.

Sequentials are the simplest form of tranche. A CMO consisting entirely of sequential tranches will pay down the principal to each tranche in an established order. For example, assume we have a CMO with three sequential tranches labeled A, B, and C. All of the tranches will receive a coupon payment based on the amount of the outstanding principal at the time of payment. After each tranche has received its coupon payment, the remaining collateral cash flow is used to pay down the principal on tranche A. After all of A's principal is returned, the collateral cash flow is used to pay down tranche B. This is continued until the last tranche is paid down.

The accrual class, or Z, tranche receives no interest or coupon payments. Rather it accrues at the stated coupon rate, similar in concept to a zero coupon bond. This tranche will continue to accrue until a defined event triggers payment of the principal and accrued interest. For a sequential Z tranche, the event is usually the pay down of all the other tranches. This may not be true for all sequentials out there today. PAC Zs fit into a higher priority of payments while support Zs are similar to support tranches.

PAC tranches are designed to lessen the risk associated with prepayments in both up and down interest environments. This tranche is set up with scheduled cash flows. As long as prepayments remain in a defined range, the collar, this tranche will receive its scheduled payments. This is due to the structure of the CMO, which provides support tranches that receive excess principal in the case of higher prepayments or cut back on their payments in the case of low prepayments. It is important to note that PACs do not guarantee their payment schedule. They are designed to work in a constant prepayment environment. We all know that in the real world, prepayments will vary and therefore will have a wide range of impacts on the behavior of PAC tranches.

These tranches are generally very high priority tranches. That is, they will receive their scheduled payment before some other lower priority tranche will get its payment. Many of the newer CMOs contain multiple PAC levels. The highest priority PACs receive payments first, followed by lower priority PACs and then other support tranches. Any modeling that is performed must be careful to account for this.

A target amortization class (TAC) tranche is a one-sided PAC. Protection is provided in the case of high prepayments. If prepayments slow down, there is no protection against extended payments. The opposite is true for a reverse TAC; there is protection against extended payments, but no protection for high prepayments. As with PAC tranches, TACs may also be afforded varying priority levels.

Support tranches are around to support other tranches, which have a scheduled payment. These tranches tend to be fairly low priority. That is in the case of excess prepayments, these tranches will receive principal first after scheduled payments have been made. In the case of slower prepayments, they will receive principal last and after scheduled payments have been made. These tranches are generally more volatile and are priced for higher yields.

IOs are speculative. As the name implies cash flows consist only of a portion of the interest payments from some identifiable portion of principal. Large deviations in prepayment rates can

result in negative yields or yields that are quite different than those quoted. These bonds are best the longer the underlying balance is outstanding. For example, if interest rates go up, the underlying collateral schedule lengthens due to slower prepayments, and the investor will receive more interest. Over the past year or so, I am sure most of us have read about the dissatisfaction with this type of tranche by some investors due to the falling interest rates and therefore, the quicker payback of the underlying principal on this type of tranche.

Principal only tranches (POs), as the name implies, return only the principal on some identifiable portion of collateral. Opposite of the IO tranches, this tranche provides higher yields the sooner your principal is paid back, that is, if interest rates fall and prepayments speed up. Although there is less principal risk, there tends to be more reinvestment risk resulting from receiving your principal in a down interest environment. Investors in POs will always get at least their principal back, but the actual timing of payments determines their yield. Generally these tranches are sold at deep discounts allowing the bullish investor to play with the discount tradeoff.

A floating rate tranche (floater) is a variable rate tranche where the coupon is tied to a formula based on some index. Generally, if a floater exists, there will be an inverse floater whose coupon behaves in the opposite direction to that of the floater.

Coupon rates for most tranches are less than the interest rate on the underlying collateral. The residual tranche holder receives the excess of collateral coupons over the coupons paid to the other tranches. Despite this simple definition, CMOs can have residual tranches with many of the characteristics of any of the other tranches discussed already. These tranches, in my experience, are not commonly held by insurance companies because of their tax implications.

Other types of tranches, which I will not go into great detail on, are:

- Liquidity tranches, which set up primarily for banks with a window of less than five years.

- Accretion directed tranches, which pay principal from specified accretions of accrual bonds and may also receive payments from collateral paydowns. The priority level on this type of tranche may in some cases be higher than PACs.
- Jump tranches, which tend to have a low principal payment priority. However, if some strike level is pierced, the tranche changes priority. For example, if a 10-year Treasury level is less than 8%, the tranche may become a PAC-type of tranche with scheduled payments. The tranche is called "sticky" if it continues to maintain the higher priority level even if the strike level is no longer pierced. A "nonsticky" tranche will convert back to the original priority level when the strike level is no longer pierced.

Again, I only gave a brief description of some of the types of tranches that insurance companies invest in. There are many other types of tranches and new types being created each month. It is important to the modeling of cash flows to understand the characteristics of each tranche that the company holds as well as other tranches contained in the CMO invested in.

Risks -- CMOs are one of the more challenging asset types to understand and to derive cash flows for. Generally, two asset risks are analyzed when performing an asset/liability study. These are the credit risk or C-1 risk and the asset/liability matching risk or C-3 risk.

Since most CMOs are government agency backed, the C-1 risk is not a concern. However, when the CMO is a nonagency issue, a default in the underlying pool falls back on the institution that created the pool. It is important to understand the impact on the CMO and its tranches in the case where a default occurs. Some organizations use credit enhancement to reduce the risks here. Some forms of credit enhancement are:

1. A letter of credit from a third party.
2. Insurance from a third party.
3. A subordinated or residual tranche to absorb losses. The issuer may retain possession of the tranche with the lower payment priority.

Also, credit risk may be significant on IOs. If actual prepayments exceed the pricing prepayment speed for the CMO, the underlying principle on this tranche may dissipate before the investor has recovered the initial outlay, therefore incurring a capital loss. It may be argued that this situation also generates C-3 risk.

Examining the C-3 risk requires two steps. The first is to project the cash flows from the underlying collateral, which include prepayments specific to the economic scenario. The second is to determine how these cash flows are allocated to the individual tranches.

The most important factor affecting the cash flow is the level of prepayments and their impact on individual tranches. As is common, I will generally refer to prepayments as some multiple of PSA.

Prepayments are impacted by a wide range of factors, not all of which are economic. We have generated formulas, some simple and some very complex, which give a good estimate of prepayment experience on some pools of mortgages. However, to my knowledge there is no formula that reproduces the prepayment experience on every CMO out there. This may be due to some of the following factors:

- Sale of the home -- Except in the case where the mortgage is assumable and this is exercised, the sale of a home will result in a prepayment of the mortgage. This also relies some on seasonality as more homes are sold in the spring and summer.
- Interest rate levels and economic conditions -- Generally a good estimator of prepayments is the relationship of current mortgage rates to the interest rate on the underlying collateral. As interest rates decrease, there is a higher propensity to refinance at a lower rate. If interest rates increase, people tend to hold onto their mortgage. The level of rate may also have an impact on prepayments. For example, if your current mortgage rate is 10% and the rates drop by 2%, there is a better chance that you will refinance than when your current mortgage is 6% and rates drop by 2%. Other factors that may prevent prepayments are the cost of refinancing or lack of knowledge about refinancing.

- Defaults -- For agency-backed CMOs, defaults should be considered prepayments because the sponsoring agency pays off the balance in the event of a default. For nonagency-backed CMOs, defaults should not be considered as a prepayment unless the sponsor has some type of credit enhancement tool.
- Casualty of the home -- In the event the home is destroyed, a homeowner's policy may pay off the mortgage.
- Accelerated payments -- If refinancing is not a viable option for the homeowners, they may make additional principal payments.
- Seasoning -- Prepayment levels tend to increase with the age of the mortgage and then level off or decrease. The general belief is that if a prepayment has not been made after a certain time period, the mortgage will not be prepaid.

Other factors include:

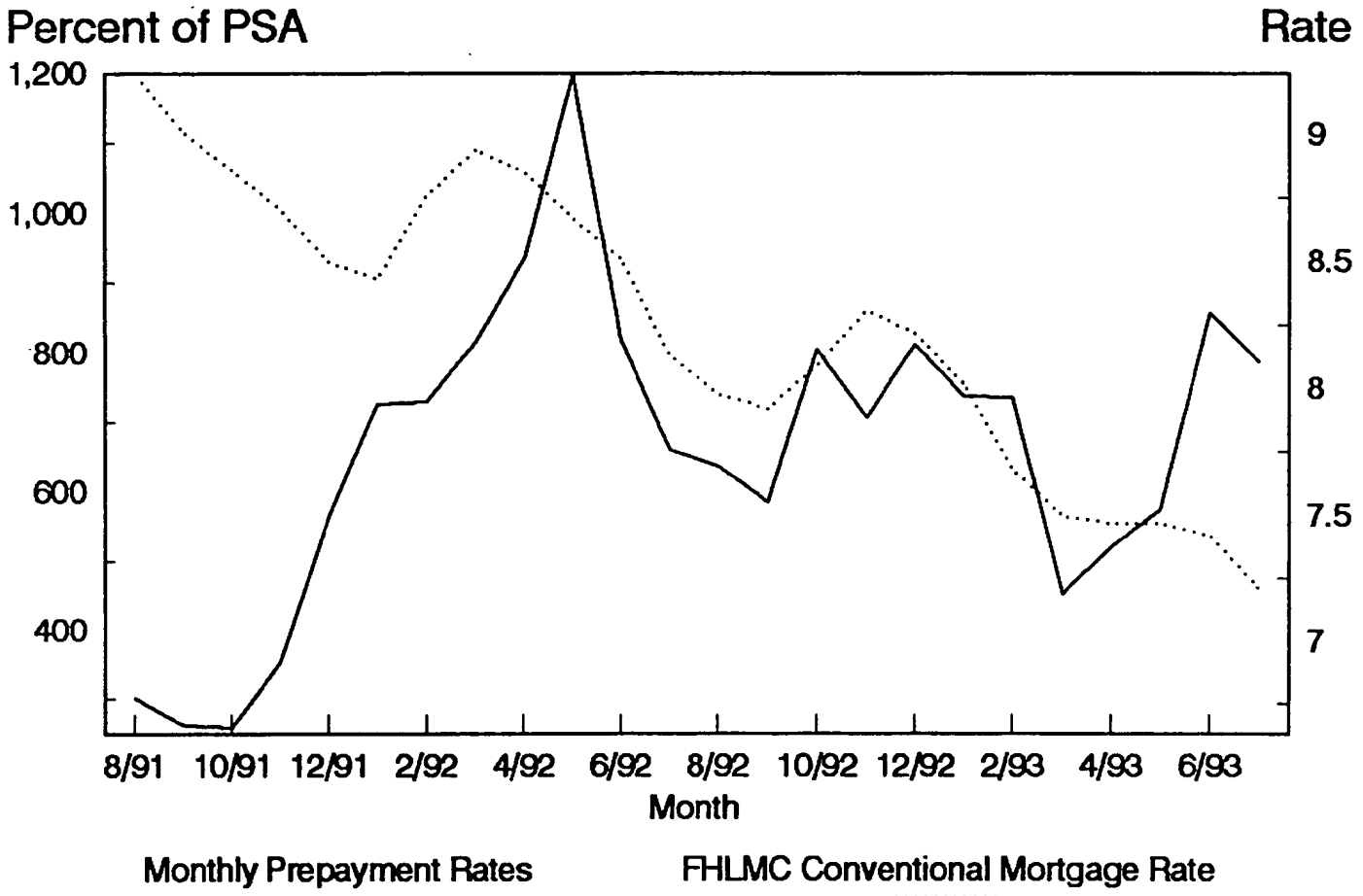
1. The type of mortgage. Is it variable, balloon, or other?
2. The agency or organization sponsoring the mortgages. GNMA pools will experience lower prepayments on average than other pools because many of the mortgagees lack the resources or financial knowledge to refinance.
3. Geographic variations. Some areas of the country experience less mobility and refinancing than others.

As before this list is not meant to be all inclusive. But it should give you an idea of the considerations involved in modeling prepayments.

To give you an idea of the impact of changes in interest rates on the prepayment rates, I have prepared Chart 8. This chart shows monthly prepayment rates as a percentage of PSA over the last two years for a specific CMO issued in 1989 with a gross weighted average interest rate of 10.6%. This CMO is FHLMC 78. For comparison, the chart also shows the FHLMC average conventional mortgage rate for first-time, fixed-rate mortgages. These rates were obtained from the Federal Reserve Statistical Release published weekly during this period.

CHART 8

Historical Prepayment Rates on FHLMC 78



As you can see from Chart 8, there is a delayed inverse relationship on this CMO when comparing the historical prepayment rates to some interest index.

Next, I have a series of four charts showing the impact on the cash flows of a sequential CMO due to a change in prepayment rates.

Chart 9 shows the principle cash flows at the pricing speed of 175% PSA.

Chart 10 shows the principle cash flows at a prepayment speed of 400% PSA. You will note that the underlying collateral in Chart 9 runs out in 2009 at 175%, while in Chart 10 the underlying collateral runs out in 2004 at 400%. This is quite a drastic change to your cash flows if this asset is supposed to match some liability stream.

Chart 11 shows the total cash flows (principle and interest) at 175% for each tranche.

Chart 12 shows the total cash flows now at 400% PSA for each tranche.

Many companies today can access sophisticated investment systems that provide cash flows based on a given future scenario. In these cases, it is important to get some comfort with the prepayment formula used in these systems. For those individuals not having access to an investment system, or running more scenarios than the investment system can generate, some type of prepayment formula is a must.

Data Needs -- Usually you will need the following information in order to project the cash flows:

1. Prospectus. This document explains the priority of each tranche and the overall structure of the CMO at issue. A prospectus contains all of the conditions on each tranche and generally shows the expected cash flows at pricing speeds. For those companies that actively trade CMOs, this may not be available.

CHART 9

Sequential CMO with Z Tranche
Sample Principal Cash Flows -- 175% PSA

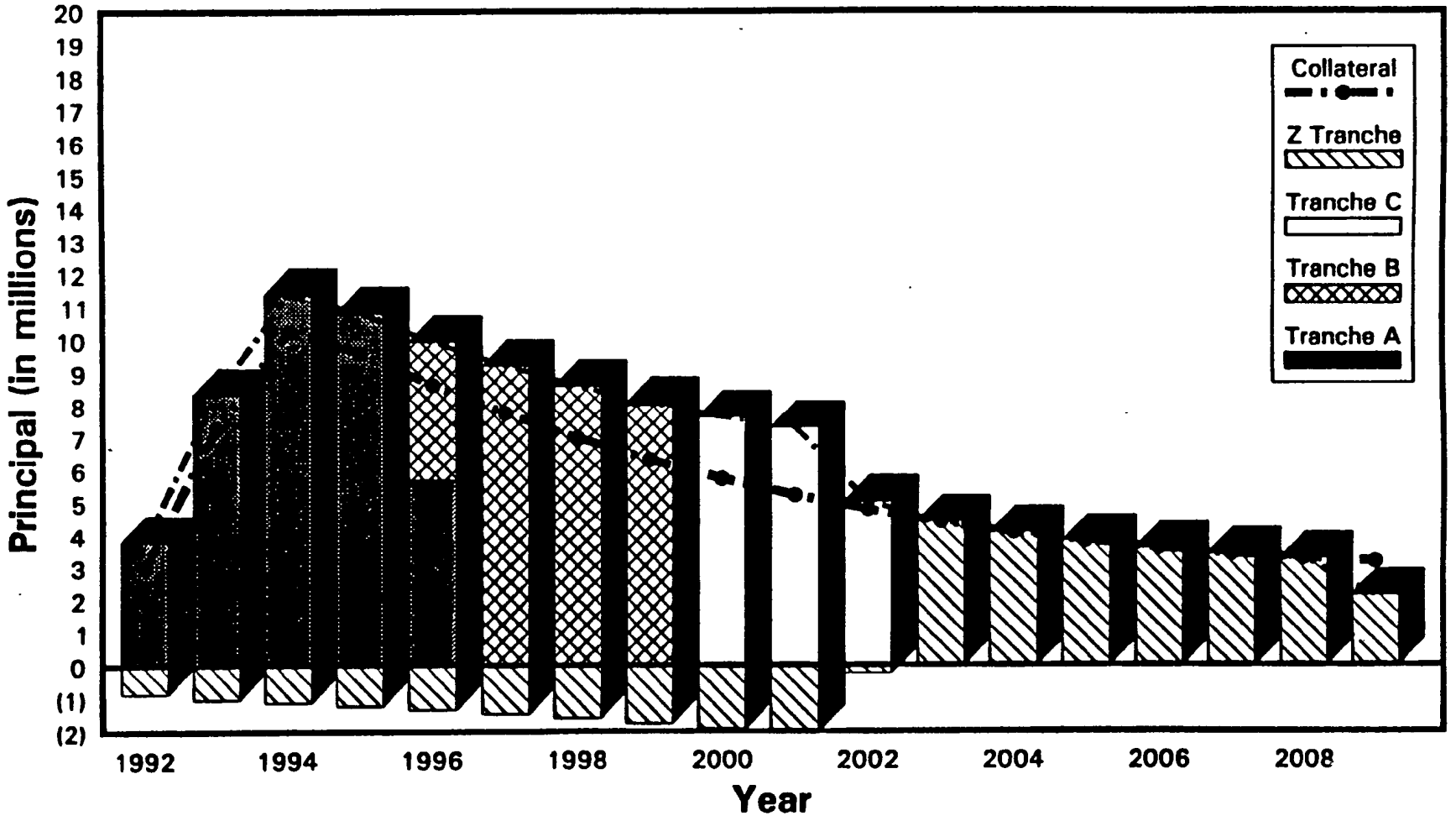


CHART 10

Sequential CMO with Z Tranche
Sample Principal Cash Flows -- 400% PSA

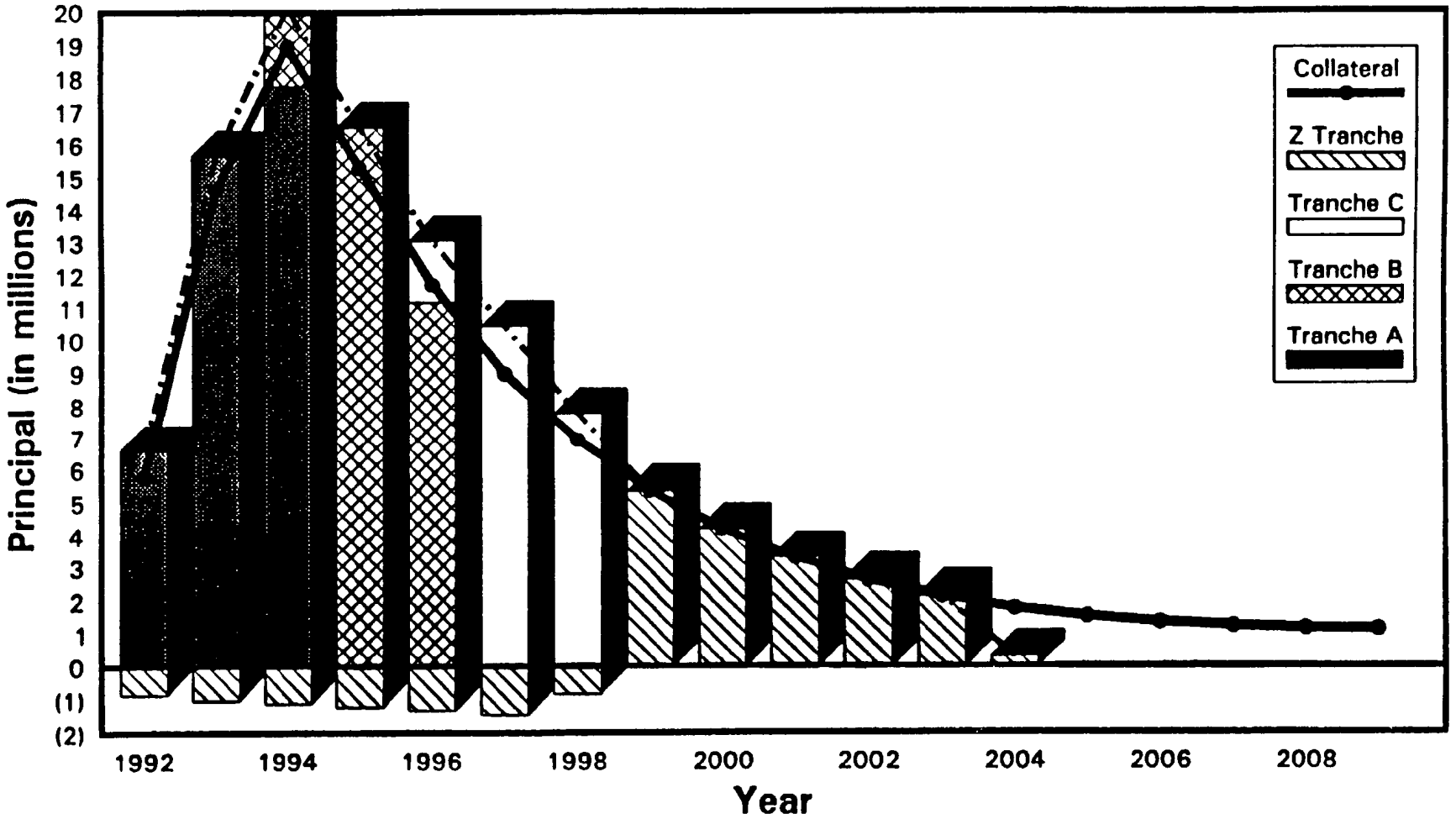


CHART 11

Sequential CMO with Z Tranche
Sample Total Cash Flows -- 175% PSA

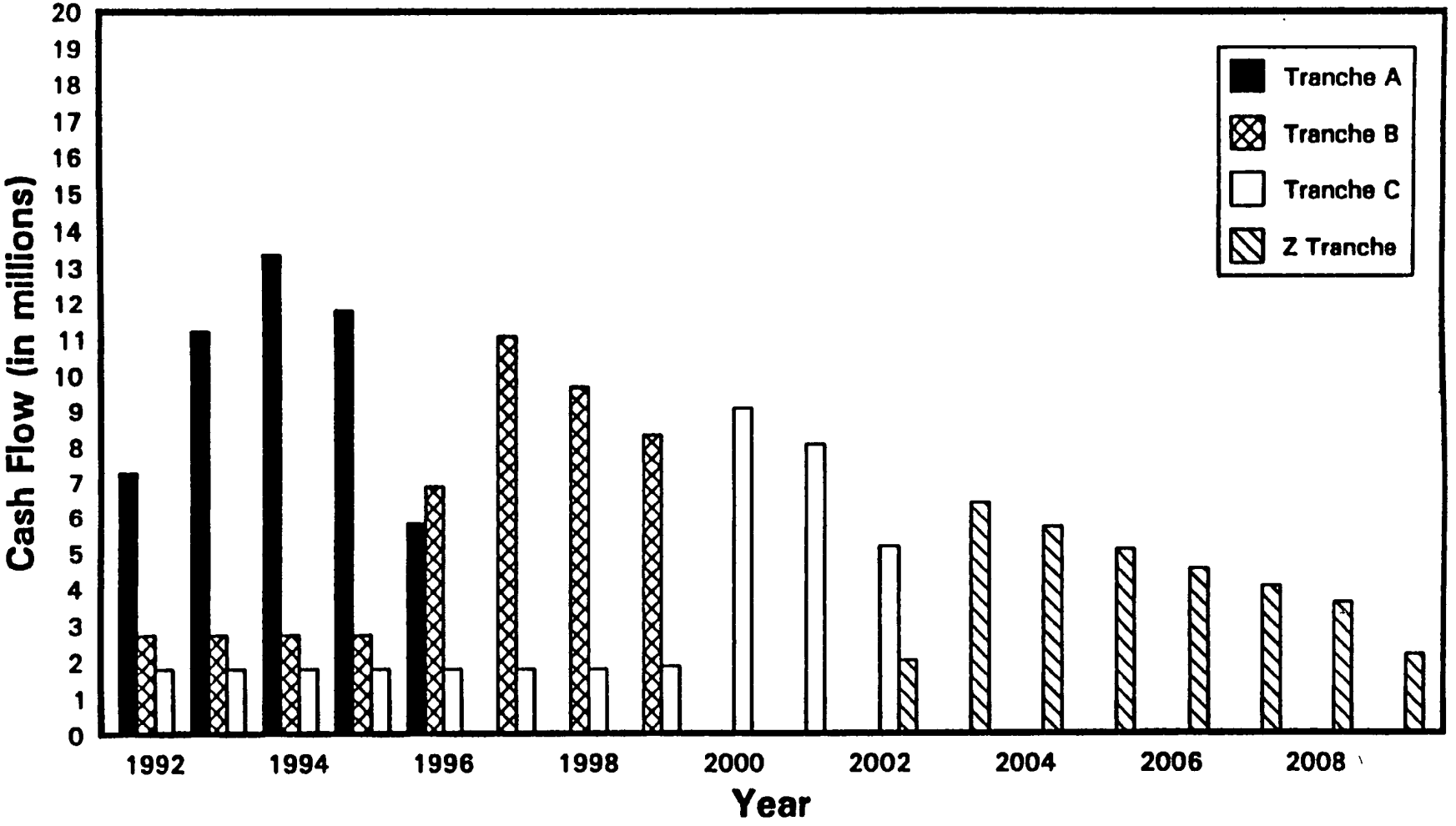
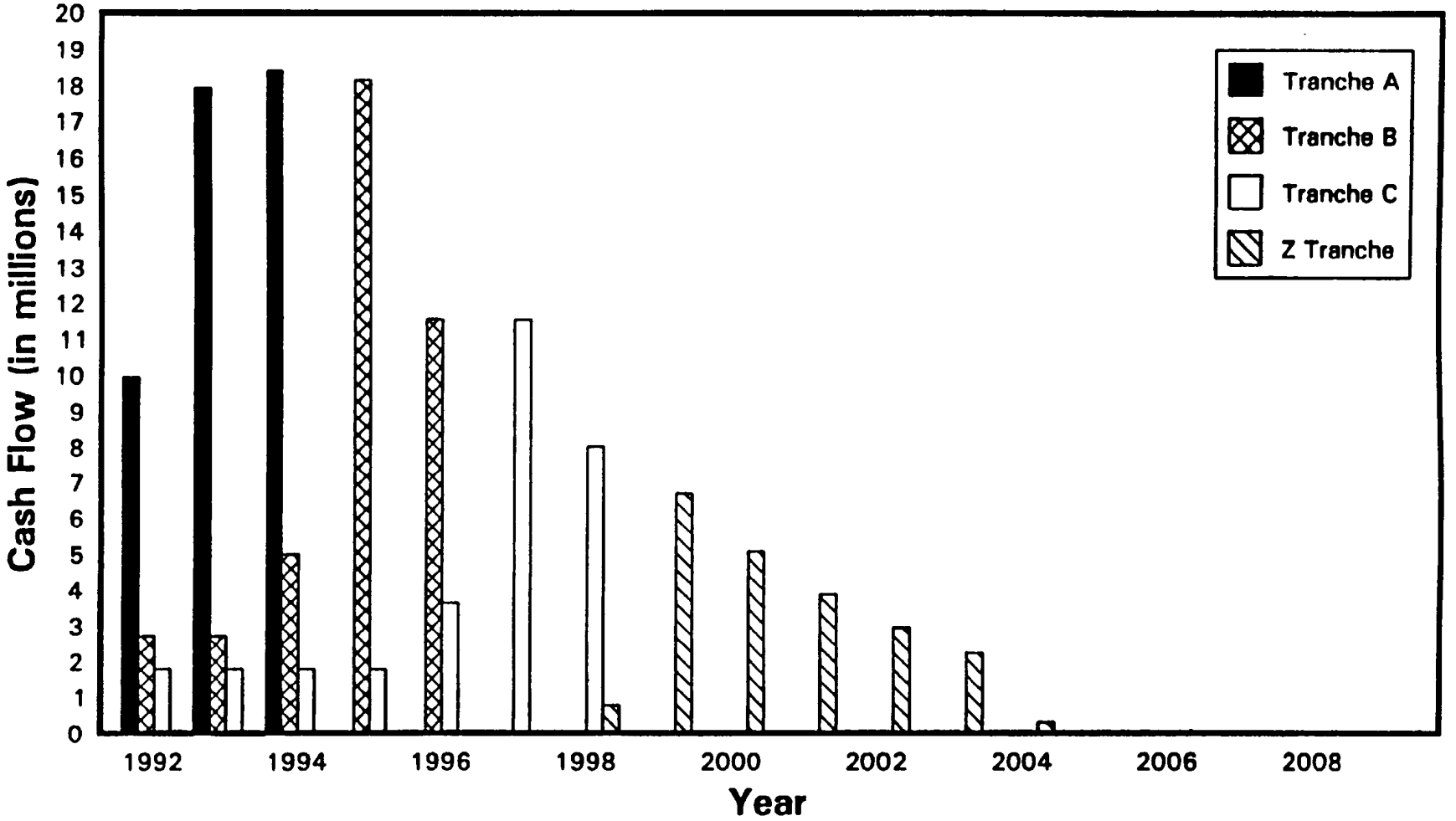


CHART 12

Sequential CMO with Z Tranche
Sample Total Cash Flows -- 400% PSA



2. Current collateral balance
3. Original collateral balance
4. Tranche structure and balance of each tranche
5. Tranche coupon or interest rates
6. Book value of the tranche owned
7. Market value of the tranche owned
8. Yield rate at purchase
9. Prepayment provisions - collars
10. Collateral interest rate and maturity date
11. Sample cash flows at varying prepayment speeds

The last item is needed if you are generating the cash flows yourself. This gives you the ability to test your prepayment formula and tranche allocations for reasonableness.

Modeling CMOs -- If you came to this session to hear about a simple method or a magic formula for modeling CMOs, I will not be able to help you. Unfortunately, I cannot tell you that modeling CMOs is a systematic function. I cannot even tell you that anyone I know has it down to a science. Generally, no two CMOs are identical. Each reacts differently to the environment based on the characteristics of the underlying collateral and the tranche structure.

The "right way" to model CMOs will depend on the individual circumstances of your portfolio. You need to determine what is material and what is not. Detailed seriatim projections are nice but may require more time and expense than is budgeted for in the project. Modeling "modeled CMOs" can save a lot of time and expense but loses some of the accuracy of a seriatim projection.

Many of you have access to an investment system to obtain projected cash flows for each scenario you are going to test. The advantage of this is accuracy if you trust the underlying prepayment formula built into the projection system. However, if you are performing a large number of set interest scenarios, the cost and time of input and the computer space available may

be limiting factors. Also, this leads to less flexibility for further testing as additional cash flows will be needed for additional scenarios. For random scenarios, inputting cash flows may lead to inconsistencies between the interest rate assumption and prepayment rates if the system randomly generates interest scenarios and you are plugging in cash flows. Also, the actuary gets no feel for the dynamics of the investment portfolio and most likely cannot assist in the management of the portfolio. You do not get a feel for why tranches are or are not behaving as expected.

Modeling CMOs is the next step. Even if you are doing a seriatim valuation, you will probably need to model within each CMO.

The key steps to modeling a CMO are:

- Calculate the principal pay down on the underlying collateral.
- Allocate interest earnings on the tranche owned.
- Allocate principal repayment to individual tranches.

For the calculation of the principal pay down, you can use general mortgage principles. That is, the starting balance for the period accumulated with interest and the periodic principal and interest payment deducted at the end of the period. You then also reduce the ending balance for additional principal prepayments. We assume that the interest rate is level for the entire period (either monthly, quarterly, or annually).

The next step is to allocate any interest earnings on the tranche owned and on any accrual or Z tranches contained in the CMO. This is simply the beginning periodic balance of the tranche times the coupon rate for the tranche. If the CMO contains accrual tranches, it is important to allocate interest to these. Remember that the accrual tranches accumulate until all tranches with a higher payment priority are paid down. The interest that is "earned" by these tranches may be used as principal to pay down the other tranche balances.

The last step in modeling a CMO is the allocation of principal and principal repayments to each of the individual tranches. I make one simplifying assumption when I am modeling. Any scheduled payments to prioritized tranches are assumed to be level throughout the payment window. This does introduce a small but immaterial difference into the calculations when compared to actual schedules shown in the prospectus. Generally, scheduled payments are skewed to the beginning of the window and decrease slowly throughout the remainder of the window.

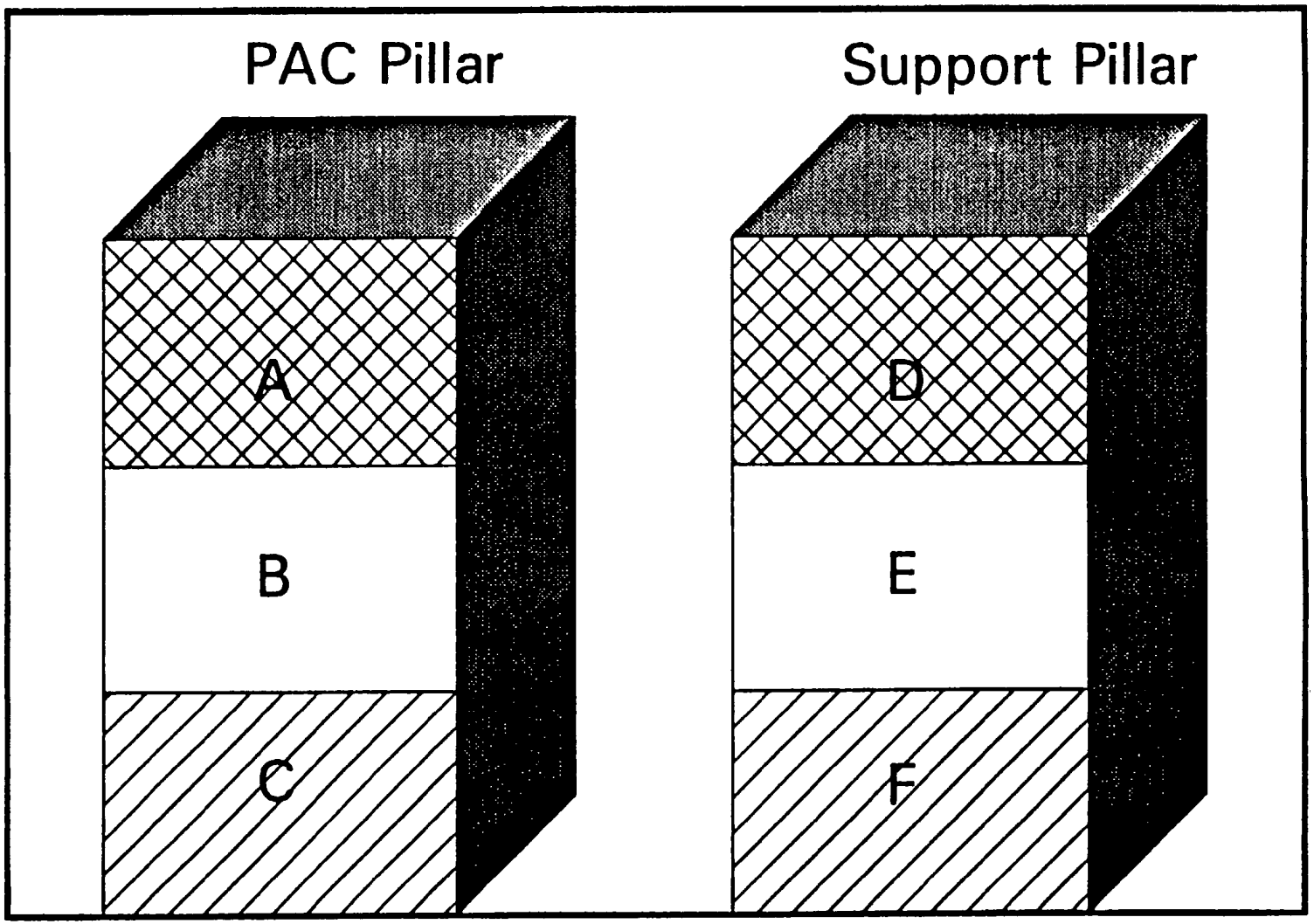
One other note is that if prepayments slow down for a period of time and scheduled payments are not met, when the speed picks back up, the tranches that missed their payments receive all catch-up payments first. This will have some impact when testing some "up" interest scenarios.

One helpful way I have found to allocate principal to tranches is to use a concept that I call pillars. Each pillar is a level of priority. Each tranche is placed into a pillar based on the priority of its cash flows. Cash flows allocated to each pillar are paid sequentially.

As shown on Chart 13, consider a simple CMO that has two levels of priority: it contains three PAC tranches and three support tranches. The first pillar or level of priority contains the PAC tranches and is a higher priority than the second pillar containing the support tranches. All scheduled payments in this example will be allocated to the first pillar and all excess payments will be allocated to the second pillar. Each pillar may pay down simultaneously depending on excess principal received over the scheduled payments. If a higher amount of prepayments comes in, the second pillar will run down faster eventually leaving no support for the first pillar. If a lower amount of prepayments or principal comes in, the first pillar will continue to receive up to its scheduled payments. If less than the scheduled payment comes in, the first pillar will receive all of the principal and pick up enough principal to get it back on schedule when payments pick up again. In recent years, we have been seeing that, due to the decreases in interest rates, the support pillars have been dramatically reduced due to the high level of prepayments. If all of the support tranches are repaid and only the PAC tranches remain, the CMO will essentially become a sequential CMO.

CHART 13

PAC CMO Structure



Another example is a sequential CMO that will have only one level of priority or pillar since a specific tranche cannot receive principal payments until the earlier tranches are paid down.

Most of the current CMOs will have five or more pillars (levels of priority). There may be multiple PAC pillars, a support pillar, TAC pillars, residual pillars, and others. The levels of priority have been increasing over the last few years as the designers of these instruments have been structuring tranches for more and more investment purposes.

We can now discuss an example of modeling a CMO. This CMO, which is FHLMC 1239, has multiple priority levels. In this case, more than one of the tranches is paying down concurrently. The underlying model input for this CMO is shown in Table 1.

This particular CMO contains approximately 20 tranches. There are two levels of PAC tranches, which I have labeled P11 and P22, and support and residual tranches. On this CMO, as of the valuation date, the residual tranches had disappeared. The company in this example owns a piece of the third tranche shown (a high-priority PAC tranche). In the essence of saving time, I would like to point out three things and we will move on.

First, I have grouped some tranches together. The purpose of this was to save computer processing time and space. Keeping track of and checking 10 tranches is much easier than 20 tranches. Second, three of the modeled tranches have already started paying down. Last, the tranches with the highest protection are the P11 tranches. As excess payments come in, they will first go to the support tranches in the order shown. Then after the support is paid down, excess payments will go to the P22 tranches in the order shown. After all lower priority levels are paid down, the excess payments will be allocated to the P11 tranches in the order shown.

Table 2 shows other important information used in the modeling. The CMO had an original weighted average maturity of 29.6 years. As of the valuation date, the weighted average maturity stood at 28.2 years. The original interest rate on the collateral is 8%. This along with

TABLE 1

Modeling CMOs
FHLMC 1239 Model Input
(amounts in thousands)

	Pillar	Tranche within Pillar	Original Collateral	Current Balance
P11	1	1	39,604	32,408
P11	1	2	226,932	226,932
P11	1	3	30,682	30,682
P11	1	4	35,053	35,053
P22	2	1	22,694	21,094
P22	2	2	9,618	9,618
P22	2	3	9,836	9,836
P22	2	4	12,197	12,197
Support	3	1	38,000	31,829
Support	3	2	74,384	74,384

the 29.6 years is used to calculate the scheduled payment on the underlying collateral. The coupon rate on the tranche owned is 7.5%. There are no accrual (or Z) tranches on this CMO.

TABLE 2

Modeling CMOs
FHLMC 1239 Model Input
(amounts in thousands)

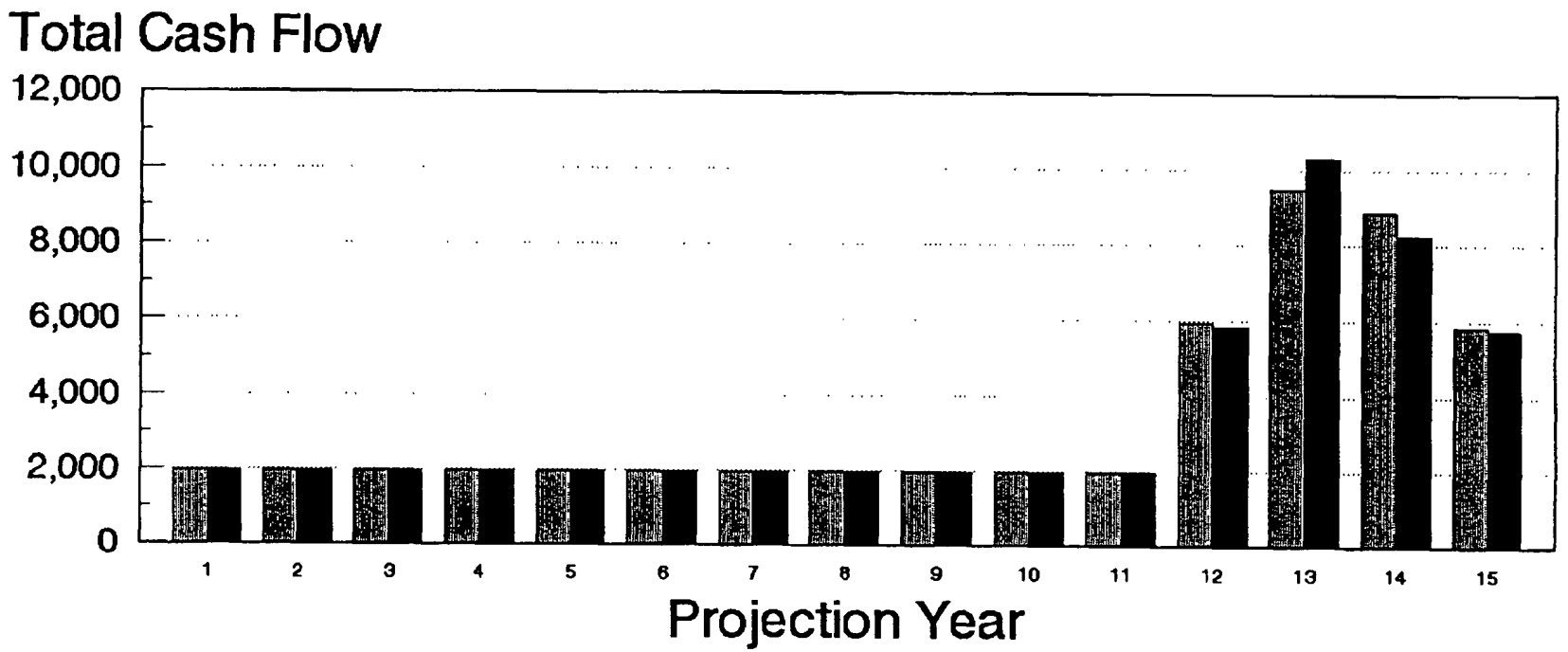
Original Weighted Average Maturity (WAM)	29.6 years
Current WAM	28.2 years
Original Weighted Average Coupon (WAC)	8.0 %
Coupon Rate	7.5 %
Coupon on Z Tranche	0.0 %

Chart 14 shows a comparison of the projected cash flows to actual pricing cash flows. The total annual projected cash flows came out reasonably close to the pricing cash flows at the sample prepayment rate of level 180% of PSA. This CMO was relatively easier than most because there were only three levels of priority. Many of the recently designed CMOs have more than one tranche receiving payments at any one time. This makes developing a model tougher if you are not tied into an investment system. Obviously, the more priority levels contained in the CMO, the more difficult the modeling and thus a higher level of checking should be involved.

Modeling Modeled CMOs -- Now that you know one way to model individual CMOs, the next step is how to handle the entire portfolio. Again if you are tied to an investment system, no modeling will be required. This is also true if you are inputting cash flows in for each CMO from a system.

CHART 14

Modeling CMOs
FHLMC 1239 Model
Comparison of Actual to Projected Cash Flows



Cash flows include principal and interest.
Based on Pricing PSA Speed of 180% PSA
All Amounts shown in thousands.

There are a variety of methods on how to handle the entire portfolio. They are probably as numerous as the number of people at this session. Some of the techniques include:

1. Make-your-own CMO. This method was common in the past. Until a few years ago, a lot of CMOs were sequential. This method is more difficult on CMOs that have multiple levels of priority. The difficulty arises in that tranches for different CMOs react differently depending on the pricing aspects and structure of the CMO.

   In one example of making your own CMO, the expected periodic principal cash flows for all of the sequential CMOs in a portfolio are combined to get a stream of total expected principal cash flows. Then each year's principal payment could be the outstanding balance of a tranche. The coupon rate for each tranche would be the weighted average coupon for all of the remaining tranches at that time. You would then project the collateral and allocate the principal to a given tranche. This method can work well with sequentials. But as I hinted earlier, I would be extremely careful using this method on CMOs with multiple levels of priority. You also must be careful here to have a reasonable prepayment formula.
2. Seriatim valuation. This method is as accurate as the accuracy of the models on each of the individual CMOs. Basically you perform the procedure that I discussed earlier on each CMO. The drawbacks of this are the time involved. It is time-consuming to model and check cash flows. This is especially true if the CMO portfolio is large, i.e., 100 or more CMOs. For the company that only has a few CMOs, this technique may be ideal.
3. Modeling based on expected assumptions. This method is as general as it sounds. Some valuations were performed by modeling a portion of the portfolio and then grouping the remaining CMOs by expected cash flows, by coupon and weighted average life of the tranche, types of tranches, CMOs with similar tranche structures, and so on.

Some of the key constraints may be materiality of the CMO portfolio, the expected time frame of the project, and the capabilities of your projection system.

Market Values -- The last item I would like to discuss is market values. The true meaning of a market value is the value of the item on the open market. If the company does not actively

trade CMOs, the simplest assumption is that market value equals book value. You assume that they are illiquid and are held to maturity.

For those companies that trade CMOs, you really need to build in a market value calculation into your projection in order to properly reflect capital gains and losses on the portfolio. The key is to obtain market values from a reliable source. Once you have this, an initial market yield can be calculated from the market value and the expected future cash flows. Whether the expected cash flows are calculated at current prepayment speeds or pricing speeds varies by projection system.

There are a few approaches to calculating market values. One common approach is to calculate the spread between the current market yield (as of the valuation date) and the Treasury curve. Future market yields will then be equal to the Treasury rate for the current weighted average maturity of the tranche plus the initial spread. Future market values are the discounted cash flows at those future market yields. This method assumes that the risk characteristics of the tranche are stable throughout the projection period. However, due to prepayments, all tranches, even PACs, can become more volatile as the underlying support for the CMO erodes.

Sources of Information -- There are a few published articles, which provide information on CMOs. Two sources are the 1990 Valuation Actuary Symposium *Proceedings* and the 1991 Valuation Actuary Symposium *Proceedings*. For the 1991 symposium, refer to sessions 3 and 8. In addition, other less detailed information can be obtained. One source is the new Academy practice note. Another is the *Handbook of Fixed Income Securities*, chapter 29, which is currently part of the syllabus for the Fellowship exams.

Conclusion -- CMOs are probably the most difficult asset in your portfolio to deal with. You will need to deal with prepayments, market values, the level of precision desired versus your project time frame, the information available, the personality of each CMO, and possibly, many other issues.