# Notes on
# MORTGAGE BACKED SECURITIES[1]

**Mortgage** A *mortgage loan* is a loan secured by a piece of real estate. When a mortgage loan is first made, it is said to be *originated* by the lending institution, which is typically a bank, a thrift institution or a mortgage banking firm. The loan itself is a financial contract obligating the borrower to make a specified set of (typically monthly) payments to the lender. The *mortgage* is the security agreement that gives the lender (the mortgagee) the right to seize by foreclosure the property securing the loan if the borrower (the mortgagor) fails to make contracted payments.[2]

Once originated, a mortgage loan can be held as an investment by the originator, sold to another investor for cash, or pooled together with other mortgages and used to collateralize other securities.

**Mortgage loan types** Mortgage loans were designed originally as *fixed-rate, level-pay* loans. These loans have the following properties:

1. the term of the loan is fixed, (30 years is traditional, but 15 year loans have become more popular lately);
2. the contract interest rate, or *coupon*, on the loan is fixed for the life of the loan;

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[1] These notes were prepared by Prof. Paul A. Spindt for classroom use.

[2] Notice that the terms "mortgage" and "mortgage loan" are not, strictly speaking, interchangeable: A mortgage is evidence of a security agreement, whereas a mortgage loan is a financial contract specifying an exchange of cash flows and is evidenced by a note.

3. the monthly payments are constant throughout the life of the loan;
4. the payments fully amortize the loan.[3]

Other mortgage loan types include:

1. *Graduated-payment mortgage* loans (GPMs) have a fixed term (typically 30 years) and a fixed coupon, but have payments that increase over a period of time. For example, the GNMA's GP program GPM has payments that increase annually at 2.5%, 5%, or 7.5% for 5 years and then level off for the remaining life of the loan. During the early years of a GPM, the balance owed commonly increases through *negative amortization* because initial payments are insufficient to pay all the interest due. The unpaid interest accrues as additional principal. Regular amortization begins once payments graduate to the point of covering all the monthly interest due.

   GPMs are not originated as actively today as they were during the early 1980s.

2. *Growing equity mortgage* loans (GEMs) have a fixed coupon and payments that increase throughout the life of the mortgage. Initial payments are set to the fully amortizing level given a term of 30 years. Increasing the payments accelerates the principal repay-

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[3] Level payments fully amortize a loan when they are structured so as to pay off all interest and principal. Each payment is allocated first to pay the interest accrued since the last payment and and then to reduce the principal balance. Early in the repayment schedule, payments are allocated mostly to interest and later they are allocated mostly to principal reduction.

ment with the result that the loan is paid off much sooner than the original maturity.

3. *Adjustable rate mortgage* loans (ARMs) have a fixed term (typically 30 years) and a coupon that is reset periodically according to an index interest rate. One popular ARM, for example, has a coupon that is adjusted annually to be equal to a set spread over the 1-year constant maturity Treasury note rate. Other ARM index rates are also popular such as the 5-year constant maturity Treasury note rate, the 6-month T-bill rate, and thrift cost-of-funds indexes.

   Most ARMs cap the size of the coupon increase at 2% per year with a lifetime cap of 6%. Caps are options to borrow money at below-market rates granted by the originator to the borrower. When coupon decreases are also capped, the coupon is *collared.*[4]

   The variation in the ARM's coupon causes its payments to vary. Once the coupon is reset, payments are scheduled to fully amortize the balance of the principal over the remaining life of the loan assuming the interest rate remains constant. There is no negative amortization in ARMs.

4. *Balloon mortgage* loans require periodic renegotiation of the mortgage terms. For example, a loan may be written as a fixed-rate level-pay loan amortized over 15 years due in 5. The terms of the loan are then renegotiated after 5 years.

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[4] A collar consists of a cap and a floor. The cap is a call option granted to the borrower, and the floor is a put option granted to the lender.

**Mortgage loan payments** The payments on a fixed-rate level-pay loan constitute an annuity whose present value (when discounted at the loan's coupon rate) is equal to the principal amount of the loan. A formula giving the monthly payments, $X$, on a $T$-year fixed-rate level-pay mortgage loan with an original principal of $P_0$ and a coupon rate of $100i\%$is:[5]

$$X = P_0 \left( \frac{\frac{i}{12}}{1 - \left(1 + \frac{i}{12}\right)^{-12T}} \right).$$

For example, the monthly payment on a \$187,000 loan written at 10% for 15 years is \$2009.51.

In a fixed-rate level-pay mortgage loan, each payment consists of:

1. *interest* equal to $\frac{100i}{12}\%$ of the principal balance outstanding at the time the payment is due, and
2. *scheduled principal repayment* equal to the excess of the payment amount over the interest portion.

A schedule specifying the principal balance before each payment, the payment, the interest portion of the payment, the scheduled principal repayment, and the principal balance outstanding after the payment is

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[5] Some people find this formula easier to apply than the one given in the text:

$$X = P_0 \left( \frac{\frac{i}{12}\left(1 + \frac{i}{12}\right)^{12T}}{\left(1 + \frac{i}{12}\right)^{12T} - 1} \right)$$

Financial calculators, such as the HP-17B, and spreadsheet programs, such as Microsoft's Excel, have built-in functions to solve for annuity payments.

called an *amortization schedule.* An amortization schedule for a 15-year fixed-rate level-pay mortgage loan is presented in Exhibit 1.

**Remaining principal balance** The *remaining principal balance* can be determined by constructing an amortization schedule. Alternatively, the following formula can be used to determine the principal balance $P_s$ remaining after $s$ payments on a fixed-rate level-pay loan with an original balance of $P_0$, an original term of $T$ years and a coupon of $100i\%$:

$$P_s = P_0 \left( \frac{1 - \left(1 + \frac{i}{12}\right)^{-(12T-s)}}{1 - \left(1 + \frac{i}{12}\right)^{-12T}} \right).$$

The concept underlying this formula is that the principal balance remaining on a fixed-rate level-pay loan is always equal to the present value of the remaining stream of loan payments discounted at the contract rate of interest.

**Servicing fees** Mortgage loans are serviced by a servicing agent who may be the originator of the loan, the investor who owns the loan, or a third-party who has bought the right to service the loan. The servicing agent collects the monthly payments from the borrower and forwards the proceeds to the owners of the loan. In addition, the servicer administers an escrow account for payment of property taxes and insurance, keeps records, and reminds the borrower when payments are overdue. For performing these tasks, the servicing agent is paid a *servicing fee.* The fee, which is typically 50 basis points (at an annual rate), is netted from the interest portion of the mortgage payment.

Exhibit 2 is an example an amortization schedule with a servicing fee. For the loan in the exhibit, the present value of the service fee cash flow is $5,322.95 at a 10% rate of discount.

**Prepayments** are payments made by borrowers in excess of their scheduled loan payments. Some prepayments are entire, as for example when a home is sold.[6] But partial prepayments can also be made. Mortgage loans amortize more quickly than originally scheduled when mortgagors add partial prepayments to their regular payments.[7]

Most prepayments are optional and subject only to the discretion of the borrower. When market rates on new mortgages fall below the contract rate on a seasoned mortgage, the borrower has incentive to refinance at the lower rate. For example, in the mortgage loan described in exhibits 1 and 2, the balance remaining on the loan after 12 payments is $181,330.69. If by the time the 12th payment is made, the mortgage rate (for a 14-year loan) falls to 8%, the present value of the claim against the borrower for the remaining stream of 168 monthly payments of $2,009.51 will be $202,710.90. The borrower can buy back the claim at par for only $181,330.69 or $21,380.21 less than its present discounted value. The borrower could raise the cash to repurchase the original claim by signing a new 14-year loan for a principal amount of $181,330.69. Payments on the new loan would be $1,797.56 or $211.95

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[6] Conventional mortgage loan agreements contain a *due-on-sale* provision that requires prepayment of the loan when the property securing the loan is sold. The federal *Depository Institutions Act of 1982* preempted state laws prohibiting enforcement of due-on-sale provisions. Government insured loans normally do not contain due-on-sale provisions.

[7] This is the basic idea behind GEMs.

less per month than the original payments.

Prepayments affect the cash flow from a mortgage loan. Mortgage loan cash flows are uncertain because prepayments are not known in advance. Prepayment risk is one of the primary risks associated mortgage loans. Because prepayments are more likely when interest rates fall and less likely when rates rise, prepayment risk is positively correlated with interest rate risk.

**Pass-throughs** A *mortgage pass-through security* is created when a collection of mortgage loans is pooled into a trust and shares of the pool are sold to investors. Pools may be formed by large originators or by intermediary firms who purchase mortgages from originators. The servicing agent for the pool collects monthly payments from the mortgagors in the pool, pays out certain pool-related costs such as insurance, retains a service fee, and passes through the rest of the cash flow to the investors.

Pass-throughs are created by three quasi-government agencies and various private intermediaries. Pass-throughs created by the agencies are called *agency pass-throughs* and all involve some form of guarantee.

1. *Government National Mortgage Association:* GNMA ("Ginnie Mae") is a government-owned corporation. Its pass-throughs guarantee timely payment of interest and principal and are backed by the full faith and credit of the US government. Ginnie Mae pass-throughs, called *mortgage-backed securities* (MBSs), are only issued against pools of government-insured mortgage loans; GNMA

pools contain no conventional loans.[8]

2. *Federal National Mortgage Association:* FNMA ("Fannie Mae") is a private-sector stockholder-owned corporation spun off by the US government in 1968. It is regulated by the US Department of Housing and Urban Development (HUD). Like Ginnie Mae, Fannie Mae issues MBSs, but unlike GNMA MBSs, FNMA pass-throughs are not obligations of the US government. Nevertheless, FNMA guarantees the timely payment of interest and principal to MBS investors.
3. *Federal Home Loan Mortgage Corporation:* FHLMC ("Freddie Mac") is a federally-chartered stockholder-owned corporation. It is authorized to purchase conventional mortgages as well as FHA and VA sponsored mortgages. Freddie Mac pass-throughs are called *participation certificates* (PCs). Standard Freddie Mac PCs are guaranteed as to the timely payment of principal. Freddie Mac has a new "Gold PC" program under which the timely payment of interest is also guaranteed.

None of these agencies originate mortgage loans. They acquire their collateral either by purchasing loans for cash or by swapping their pass through securities for loans from originators.

Private-label pass-throughs are issued by large originators, such as Bank of America and NationsBank, and by private conduits, such as

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[8] Insuring agencies are Federal Housing Administration (FHA), Veterans Administration (VA), and Farmers Home Administration (FmHA).

Citimae (a Citicorp subsidiary) and Residential Funding Corporation (a GMAC subsidiary). Private conduits purchase and securitize both conforming and nonconforming mortgages.[9]

**Prepayment models** The cash flow characteristics of pass-throughs derive from the cash flow characteristics of the underlying mortgages. Uncertainty about pass-through cash flow follows from the unpredictability of mortgage prepayments.

To evaluate the price or yield of a pass-through, some estimate of the security's cash flow is needed. Because a pass-through's cash flow is equal to scheduled payments (less servicing and insurance fees) plus prepayments, an estimate of prepayments is required. There are several conventional "models" for estimating prepayments:

1. *Constant prepayment rate (CPR):* The CPR model assumes that a constant percentage of the outstanding principal balance prepays each month. The CPR is an annual rate. The monthly rate that when compounded produces the CPR is called a *single monthly mortality* rate (SMM). That is,

   $$\mathrm{SMM} = 1 - (1 - \mathrm{CPR})^{\frac{1}{12}}$$

   An SMM of $z\%$ means that $z\%$ of the remaining principal after scheduled principal payments have been made will prepay during the month. For example, a CPR of 6% (.06) translates to an SMM

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[9] Nonconforming mortgage loans do not necessarily have higher risk than conforming loans. Many "jumbos," (loans in excess of $187,000) for example, are to high income borrowers and have ample value-to-loan ratios.

of .5143% (.005143). If you owned a pass-through on which the outstanding balance at the beginning of a month was \$181,824.99 and scheduled principal payments were \$494.30, then an SMM of .5143% would imply prepayments of $.005143(\$181,824.99 - \$494.30) = \$932.58$.

2. *Public Securities Association (PSA):* The PSA model specifies that the CPR is .2% during the first month of a mortgage pool's life, and that it increases by .2% each month thereafter until the $30^{\text{th}}$ month when levels off at 6% for the remainder of the life of the pool. Faster or slower prepayment speeds can be expressed as scalings of PSA. For example, a "200% PSA" assumption implies a CPR of $2\left(\frac{.2s}{30}\right)$ for months $s = 1, \ldots, 30$ and 12% thereafter.

3. *FHA experience* Annually, HUD publishes survivorship data for FHA-insured mortgages. These data can be used to extrapolate prepayment rates. Prepayment patterns can be discerned for different types of pools. The FHA experience for a given pool type can then be scaled to generate a prepayment assumption.

None of these "models" is designed to capture the variation in prepayments generated by borrower responses to interest rate changes.

**Scheduled payments** In projecting pass-through cash flow, prepayments are assumed to be whole loans. This assumption implies that scheduled monthly payments will change from month to month as loans prepay and evaporate from the pool. To calculate the scheduled monthly payment $X_s$ for any month $s$, use the following formula:

$$X_s = P_{s-1}\left(\frac{\frac{i}{12}}{1-\left(1+\frac{i}{12}\right)^{-(12T-s+1)}}\right)$$

where $P_{s-1}$ is the pool's principal balance at the end of month $s-1$ after that month's scheduled payments and assumed prepayments are logged, $100i\%$ is the contract rate on the mortgages in the pool, and $T$ is the original maturity of the pool loans.

Exhibit 3 shows the estimated cash flow of a 15-year original maturity pass-through with a 10% contract rate, a .5% servicing fee, and 100% PSA prepayments.

**Yield** The interest rate that makes the present value of a pass-through's cash flow equal to its price is the security's *cash flow yield.* The cash flow yield is a monthly interest rate simply annualized. Pass-through yields, however, are normally quoted on a bond-equivalent basis. To convert a cash-flow yield $r$ to a bond-equivalent yield $y$ you need to compound the monthly rate $\frac{r}{12}$ to a semiannual rate and then double it:

$$y = 2\left(\left(1+\frac{r}{12}\right)^6 - 1\right).$$

For example, if the cash flow yield on a pass-through is 9.5%, then the security's yield would be quoted as 9.69% bond-equivalent. Conversely, if a pass-through is quoted at 10% bond-equivalent, then its cash flow yield is 9.8%.

**Price** A pass-through's price is the present discounted value of the estimated cash flow. For example, the price of the pass-through in exhibit 3 is \$182,567.01 at a required cash flow yield of 10% and \$187,000 (par) at a required cash flow yield of 9.5%. MBS prices are quoted like bond prices as percentages of par with remainders expressed as $32^{\mathrm{nds}}$, so in this example, the prices would be quoted as 97:20 and 100 respectively. Remember that market convention calls for quoting yields in bond-equivalent terms. Before discounting an estimated cash flow, the yield must be converted to cash flow (monthly) basis.

**Duration** Recall that *duration* is the weighted average of the maturities of the cash flows generated by a security in which the weights are fractions of total present value returned. The (Macaulay) duration of a pass-through can be calculated from the formula

$$D = \frac{1}{12P}\left(\sum_{i=1}^{n} \frac{t_i C_i}{(1+\frac{y}{12})^i}\right)$$

where $n$ is the number of months of remaining in the term of the mortgage pool, $y$ is the pass-through's cash flow yield, $C_i$ is the pass-through's cash flow (including interest, scheduled principal and prepayments) in the $i^{\text{th}}$ month, and $P$ is the bond's price. Modified duration is equal to Macaulay duration divided by the periodic interest factor $1 + (y/12)$. Modified duration measures the price sensitivity of the pass-through. The percentage change in the pass-through's price precipitated by a given change in yield is approximately equal to (minus) the change in yield times modified duration:

$$\%\text{ change in price} \approx -D^{*}\text{change in yield,}$$

where $D^*$ is modified duration. The approximation is best for small changes in yield.

The duration of a pass-through depends on the bond's cash flow yield and its prepayment pattern. Holding prepayments constant, duration decreases (increases) as interest rates increase (decrease). Holding yield constant, duration decreases (increases) as prepayments increase (decrease).

**Prepayment risk** Like any bond, the price of a pass-through moves inversely with interest rates. But interest rate changes also have an effect on prepayments which in turn affect cash flow and price. As rates rise, prepayments slow possibly extending the duration of a pass-through and heightening its sensitivity to interest rates. The risk that a price decline will be augmented by the effect of interest rates on prepayments is called *extension* risk. When rates fall, prepayments speed up thus shortening duration and decreasing the sensitivity of price to yield movements. The risk that price increases will be attenuated by the effect of interest rates on prepayments is called *compression* risk. See exhibit 4.

**Multiclass pass-throughs** Pass-throughs derive their cash flows from the underlying mortgages in the pool. Pass-through cash flows can also be securitized by selling securities that claim different pieces of the cash flow. Two common types of multiclass structures whose cash flows derive from MBSs are Stripped MBSs, which distribute coupon interest and principal unequally, and CMOs (collateralized mortgage obligations), which distribute principal more predictably (to some classes) over a range of prepayment speeds.

**REMICs** Pass-throughs are typically structured as grantor trusts to insure that the entity issuing the pass-through is not taxable. Prior to 1986, the IRS had ruled that any entity issuing multi-class pass-throughs was a taxable entity regardless of whether or not they were structured as a grantor trust. Real estate mortgage investment conduits (REMICs) were created by TEFRA in 1986 to allow issuers to issue multiclass pass-throughs without being treated as a taxable entity. The law now allows issuers to treat the sale of multiclass pass-throughs as a sale of assets rather than as debt used to finance the acquisition of the underlying collateral.

REMICs can be structured as corporations, partnerships or trusts. One typical structure consists of a pair of trusts. The underlying collateral (a pool of mortgages or MBSs) is owned by one trust, called the lower tier REMIC. There are “regular” (debt) and “residual” (equity) interests in this trust. The residual interests are sold to investors, and all the regular interests become the assets of the second trust, which in turn sells various claims against these assets. (See *CMO Residuals*, below).

**Stripped MBSs** Instead of *pro rata* distribution of interest and principal to shareholders, *strips* provide unequal distributions. Strips create *synthetic-coupon* pass-throughs. For example, a high-coupon strip and a low-coupon strip can be created from underlying collateral by distributing principal payments evenly to the two classes and paying say 25% of the interest to one class and 75% of the interest to the other. In this example, if the underlying pool has a 10% coupon, then the low-coupon class will have a synthetic coupon of 5% and the high-coupon class will have a synthetic coupon of 15%.

**IOs and POs** The extreme case of stripped MBSs is exemplified by *interest-only (IO)* and *principal-only (PO)* class securities. The par value of a PO is the original principal of the underlying collateral, but the PO is sold at a deep discount. For example, the par value of the 15-year PO whose projected cash flow is depicted in exhibit 5 is $187,000, but it would be sold for $101,165 if priced to yield 9.5% at origination. Once purchased, the yield realized on a PO depends on prepayment speed – increases in prepayments generate increases in yield. An increase in the prepayment speed from 100% PSA to 200% PSA would raise the yield on the PO bought for $101,165 from 9.5% to about 13.5%. Falling interest rates benefit PO prices for two reasons:

1. lower interest rates mean that future payments are discounted less heavily thus raising the value of the cash flow; and
2. as rates decline below the coupon on the underlying collateral, prepayments speed up thus increasing current payments to PO holders.

When rates rise, both effects operate in the opposite direction to reduce PO prices. The overall result is that prepayments cause PO price movements to extend in both up markets and down markets. Exhibit 6a depicts the PO price/yield relationship for various prepayment speeds.

While PO prices increase when prepayments accelerate, IO prices decrease. The IO class derives its cash flow from interest on the outstanding balance of the underlying collateral. Prepayments reduce the outstanding principal causing interest payments to decline. The effect of prepayment speed on IO prices is substantial: Priced to yield 9.5%, the IO depicted in exhibits 5 and 6b would cost $85,834 at 100% PSA and $72,979 at 200% PSA.

IO prices to move very differently with interest rates than do PO prices. An increase in interest rates, for example, depresses IO values because the cash flows are discounted at a higher discount rate. The impact is limited, however, owing to the front-loaded nature of IO cash flows. The increase in rates also tends to slow prepayments enhancing the cash flow to the IO. IO prices will rise if the impact of slowed prepayments is sufficient to offset the effect of higher discount rates. Similarly, IO prices may fall when rates fall is the (negative) effect of accelerated prepayments caused by the decline in mortgage rates is sufficient to overcome the (positive) effect of a lower discount rate. In practice, IO prices do tend to move in the same direction as interest rates except when market rates move substantially above the contract rate on the underlying collateral. (See exhibit 6c.)

Both IO and PO prices are more sensitive to interest rates than pass-through prices are.

**CMOs** *Collateralized mortgage obligations, or CMOs,* are multiclass securities created by repackaging the cash flows from whole mortgages or pass-throughs to distribute prepayment risk differentially among several bond classes. CMOs are analogous to dual-purpose closed-end mutual funds. Ordinary closed-end mutual funds issue shares and use the proceeds to purchase a pool of assets such as equities, bonds or bank loans. Dual-purpose funds issue two types of shares, income and capital, that entitle their owners to different claims on the aggregate cash flow from the fund's assets. Owners of the income shares receive all the interest or dividend cash flow as well as scheduled principal payments (in the case of loans) or a fixed amount of principal when the fund is liquidated (in the case of equities). The capital shares are residual claims. Similarly, CMOs are tailored to create different claims against the cash flows of the underlying pool of mortgages (or mortgage-backed securities).

CMOs were introduced by Freddie Mac in 1984.

**CMO residuals** A *CMO residual* is a claim on any cash flow left over after all other bond classes have been paid. Residuals have no face value; they are like an equity layer in the CMO structure.

Residual cash flow arises for several reasons:

1. CMOs are commonly overcollateralized to enhance their credit ratings. For example, a \$100 million CMO issue may be collateralized by \$107 million of mortgages or mortgage-backed securities.

The \$7 million in extra collateral is a credit enhancement because it provides a cushion for the cash flows to CMO holders against defaults in the underlying collateral. Absent defaults, the extra collateral generates residual cash flow.

2. The bonds embedded in a CMO structure normally don't pay a coupon as high as that on the underlying collateral. Moreover, classes with shorter planned maturities carry lower coupon rates than classes of longer planned maturities. These interest rate differentials generate residual cash flow.
3. Cash flow from the underlying collateral received by the CMO issuer can be invested for a short while before it must be paid out to CMO bond holders. In many CMOs, the collateral pays monthly and the CMO bonds pay quarterly. The temporary reinvestment of funds before they must be paid out generates residual cash flow.

CMO residuals are normally structured so that their value moves in the *same* direction as interest rates. For example, when rates rise, prepayments tend to slow thus slowing the payoff of the lower coupon classes in the CMO structure. This extends the cash flow to the residual caused by interest rate differentials. Moreover, the reinvestment rate on temporary funds increases when rates rise and this increases residual cash flow.

**Sequential-pay CMOs** The first CMOs had a simple *sequential-pay* structure. In a sequential-pay CMO, bond classes (or tranches) are retired in order. For example, a simple sequential-pay CMO might have four classes: an A tranche, a B tranche, an accrual class or "Z-bond", and a residual. Classes A and B would have stated principal amounts, coupons, and maturities. The A tranche would receive all the principal payments (including prepayments) along with its coupon interest until the tranche is retired.[10] While the A tranche is outstanding, the B tranche would receive coupon interest payments only. Once the A tranche is fully retired, all principal payments from the underlying collateral would go to the B tranche until it is retired.

Z bonds also have a stated coupon and an initial principal amount.[11] But Z bonds receive no payments until earlier classes have been fully retired. Instead, the interest that would be paid to the Z class is actually paid to earlier classes (speeding the retirement of the senior classes) and simultaneously accrued to the principal of the Z bond. Once the senior tranches have been retired, all principal payments from the underlying collateral are directed to the Z bond to retire its initial principal and accrued interest. While it is being retired, the Z bond also receives current coupon interest.

The cash flow patterns associated with a sequential-pay CMO are exemplified in exhibits 7a, b and c.

**Simultaneous-pay CMOs** Cash flows to the various bond classes in a CMO depend on the structure of the CMO and the rate at which the underlying collateral prepays. Although prepayment (or call) risk is

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[10] The stated maturity of the A tranche would be the maximum length of time required to retire the tranche assume prepayments were zero.

[11] Their stated maturity is equal to the maturity of the underlying collateral.

mitigated in the senior classes of sequential-pay CMOs, there is still uncertainty as to the actual maturity of these bonds. To reduce prepayment risk, CMO designers introduced a variation on the sequential-pay structure called the Planned Amortization Class (PAC) tranche. A PAC bond has a stated face value, a stated interest rate, and a planned amortization schedule. The planned amortization period may begin immediately when the CMO is issued or at some future date. During the planned amortization period, principal payments to the PAC take priority over principal payments to other classes. At the same time, principal payments in excess of those needed to achieve the PAC's planned amortization are distributed to a "support" (or "companion") tranche thereby protecting the PAC against call risk.

PACs are not entirely immune from prepayment risk because principal payments from the underlying collateral may be too fast or too slow during some period to satisfy a planned amortization schedule. For example, if prepayments are too fast early in the life of a PAC, then principal payments later will be insufficient to satisfy the amortization schedule. Similarly, if prepayments are too slow early in the life of a PAC, then principal payments may be too small to meet the PAC amortization requirements.

The range of prepayments over which principal payments from the underlying collateral are adequate to satisfy PAC requirements is called the PAC's *collar*. As long as prepayments remain within the collar, the

PAC is protected from call risk.[12] Depending on the size of the PAC tranche (relative to the amount of the underlying collateral) and the size of the PAC collar, call risk can be virtually removed from some PAC bonds. The risk is not eliminated; it is simply shifted onto, and concentrated in, the companion classes.

Exhibits 8a, b and c show how principal payments from the underlying collateral are distributed to a PAC and companion class as prepayment rates change.

*TAC (Targeted Amortization Class) bonds* are similar to PAC bonds in that they specify an amortization schedule and are designed to limit call risk. However, the call protection provided by TAC bonds is asymmetric: they provide protection against contraction risk, but not extension risk. TACs are designed and priced for a given prepayment speed assumption. If prepayments exceed this rate, the excess principal is paid to companion classes. If prepayments are slower than assumed, however, principal payments to TAC bonds will fall short of targeted amortization and the bond will extend.[13] Generally, TAC bonds (and reverse TAC bonds) are created from PAC companion classes.

**Floaters and inverse-floaters** The underlying collateral in most CMO structures is fixed rate. In an effort to appeal to investors (such as financial institutions) who wish to avoid the interest rate risk associated

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[12] A planned amortization schedule may still be met if prepayments wander briefly outside a PAC's collar.

[13] *Reverse TAC bonds* have been created to appeal to investors who are willing to accept contraction, but not extension, risk.

with any fixed rate investment, CMO issuers innovated floating rate tranches into CMO structures. *Floaters* are bond classes in a CMO structure having a coupon rate that varies directly with some index rate, most commonly, 1-month LIBOR. The coupon on a floater is normally capped to provide some assurance that the cash flow from the underlying collateral will be adequate to cover the interest payment.[14]

Caps, even low ones, are not generally sufficient by themselves to assure investors that the interest payments on a floater can always be made.[15] To provide additional assurance (and to allow higher caps), floaters are often structured with deep discount coupon support tranches. Low coupon tranches provide a cash reservoir that is paid to the CMO residual when floater rates are low, and can be shifted to the floater if floater coupons rise.

An *inverse (or reverse) floater* is used in some structures as a floater companion class. The coupon on an inverse floater is reset coincidentally with the coupon on a floater, but varies inversely with the index rate. The formula for a reverse floater coupon is

$$C = \bar{B} - (l \times \mathrm{LIBOR}),$$

where $l$ is the coupon leverage parameter (equal to the ratio of the floater's principal to the inverse floater's principal) and $\bar{B}$ is chosen such that the weighted average of the floater rate and the inverse floater

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[14] There may also be "step caps" which are limits on how much the coupon can change, month to month.

[15] A cap at coupon on the underlying collateral would be sufficient, but then why have a floater?

rate is equal to some constant rate less than or equal to the coupon on the underlying collateral. For example, consider a floater with an original principal amount of \$15.4 million paying 1-month LIBOR + 75bp. Suppose the underlying collateral consists of 9% coupon MBSs. An inverse floater class with a principal amount of \$7.7 million could carry a coupon of $25.5\% - 2\mathrm{LIBOR}$.

From an investors standpoint, buying an inverse floater is like a leveraged position in a fixed rate investment financed at LIBOR.[16] In fact, it is equivalent to buying a fixed rate bond carrying a coupon of $\bar{B}/(l+1)$ on a margin (equity proportion) of $1/(l+1)$.

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[16] It is a very bullish investment. Not only is it borrowing short and lending long, it is also leveraged.