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FIXED INCOME

RESEARCH

NOVEMBER 3, 2004

Mortgage Securities

UNITED STATES

Guide to Mortgage-Backed Securities

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Acknowledgments

This is the third edition of the *Guide to Mortgage-Backed Securities*, originally published in 1995. For this updated version, sections on MBS trade mechanics, mortgage securities lending, and a number of useful appendices have been added. We thank Ana DiStefano for her careful and patient preparation of this paper and Peg Pisani for her fine editing of all three editions. We also thank Darrell Wheeler, Ivan Gjaja, and Gaurav Bansal for their helpful comments. Last, but certainly not least, we thank Ben Hebert for his extensive help in updating this paper.

I. Introduction

The mortgage-backed securities (MBSs) market has experienced phenomenal growth over the past 25 years. The total outstanding volume of MBSs has increased from about $100 billion in 1980 to more than $4.2 trillion, and as Figure 1 shows, MBSs form a major component of the US bond market.

Figure 1. Size of Various Sectors of the US Debt Market in 2004[a] (Dollars in Trillions)

Single-Family (1–4) Mortgage Debt	$7.6
Mortgage-Backed Securities	4.2
Asset-Backed Securities	1.8
US Treasuries	3.8
Corporate Bonds	4.6
Agency Debt	2.7

[a] As of the end of second quarter 2004.
Sources: *Inside MBS & ABS*, Bond Market Association.

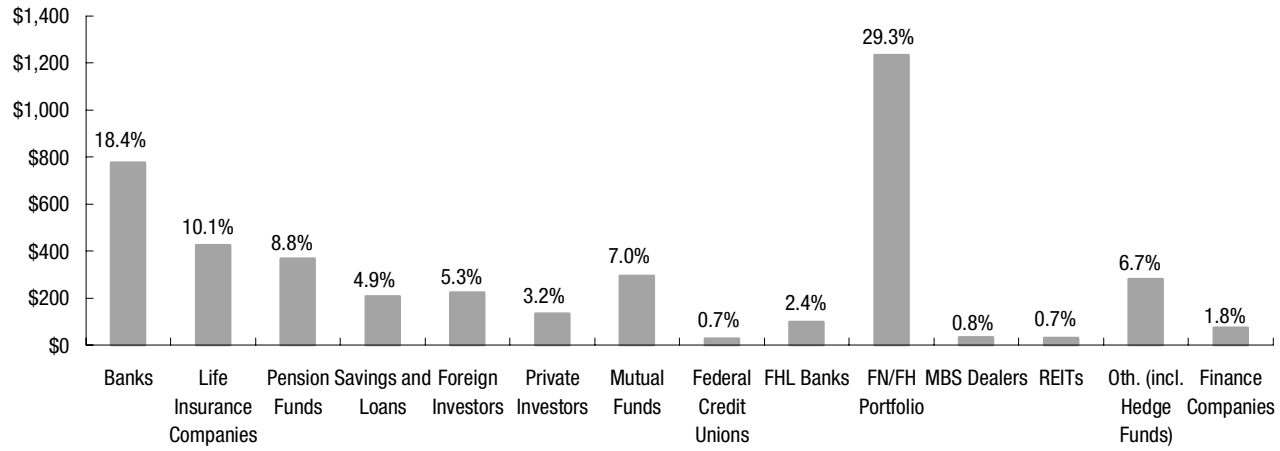
What accounts for the explosive growth of the MBS market? Increased securitization of mortgages and ready acceptance of MBSs by fixed-income investors are both key reasons. Mortgage originators became much more disposed to sell loans into the secondary market after the high-interest-rate environment of the late 1970s and early 1980s, when the disadvantages of holding fixed-rate long-term loans in their portfolios became apparent. The growing market share of originations by mortgage bankers, who have little interest in holding onto mortgage loans, also has contributed to the increasing securitization of mortgages. In addition, many institutions have increasingly come to view securitization as a means of turning illiquid assets into liquid securities and, hence, a tool for efficient balance sheet management.

The federal government has played an equally important role. Three agencies, **Ginnie Mae** (the Government National Mortgage Association), **Fannie Mae** (the Federal National Mortgage Association), and **Freddie Mac** (the Federal Home Loan Mortgage Corporation) are major players in the secondary mortgage market in issuing and guaranteeing MBSs.[1] These federal housing finance agencies were created to facilitate the flow of mortgage capital and, hence, to ensure that lenders have adequate funds to make new mortgage loans. The three agencies are generally credited with significantly reducing the cost of mortgage borrowing for American homebuyers, as well making mortgages more widely available.

On the demand side, MBSs have come to represent a significant portion of fixed-income holdings for many types of investors over the past decade. Figure 2 shows a breakdown of holdings of MBSs by investor type.

[1] Although all three entities are commonly referred to as agencies, only Ginnie Mae is now a true agency. Fannie Mae, which the government established in 1938, and Freddie Mac, which Congress created in 1970, are now private entities, although both have strong ties to the government. The market convention is to refer to all three as agencies (although *government-sponsored enterprises* (GSEs) is becoming a more common term for Fannie Mae, Freddie Mac, and other such entities), and we follow this convention.

Figure 2. Mortgage-Backed Securities — Holdings by Investor Type, as of Year-End 2003 (Dollars in Billions)



Note: Numbers shown at the top of the bars are holdings as a percentage of total outstanding MBSs.
Source: *Inside MBS & ABS*.

Why Mortgage Securities?

As Figure 2 indicates, MBSs are now core investments for most institutional investors, for a number of reasons:

- **Higher returns**. MBSs typically yield 100bp or more over Treasuries and offer higher yields than comparable-quality corporate bonds. Although some of this higher yield compensates for their complexity and embedded prepayment options, MBSs still have outperformed comparable Treasuries and corporate bonds over time.
- **Credit quality**. Ginnie Mae MBSs are backed by the full faith and credit of the US government and, hence, like Treasuries, are considered to carry no credit risk. Fannie Mae and Freddie Mac MBSs do not have US government guarantees, but because of Fannie Mae's and Freddie Mac's close ties to the government, their MBSs are perceived to have minimal credit risk. MBSs from other (private) issuers typically carry triple-A or double-A ratings from one or more of the credit rating agencies.
- **Choice of investment profiles**. The MBS sector provides a wider range of investment characteristics than most other parts of the fixed-income market. For example, MBSs are available with negative, short, or very long durations. Prepayment sensitivities can range from low to very high. Coupons can be fixed (from 0% to more than 1,000%) or floating (directly or inversely with a range of indices).
- **Liquidity**. The amount of outstanding MBSs, trading volume (second only to US Treasuries), and involvement of major dealers provide an active, liquid market for the majority of MBSs.
- **Development of analytic tools**. Since the mid-1980s, many major dealers (and some buy-side firms) have devoted considerable resources to developing analytic models for evaluating MBSs. These efforts have led to a better understanding of mortgage cash flows and greater comfort with the characteristics of mortgage securities.

Outline of Paper

MBSs are more complex and challenging than traditional noncallable bonds, or even standard callable corporates. Much of this complexity arises from mortgagors' option to prepay their loans at any time. Thus, the cash flows from an MBS depend on the rate at which the underlying loans are prepaid. Prepayment rates, in turn, depend on various factors, such as mortgage rates, economic conditions, and mortgage characteristics. Thus, determining the risk/reward profile of a particular MBS is more difficult and involves more analysis and effort than for traditional bonds.

The purpose of this paper is twofold: first, to provide an introduction to MBSs and methods of MBS analysis for fixed-income investors new to MBSs, and second, to act as a reference for those already familiar with MBSs. The paper is organized as follows:

- Section II reviews key features of agency mortgage pass-through securities, the most basic and most prevalent type of MBSs, and discusses the mechanics of MBS cash flows.
- Section III discusses the basics of MBS analysis, such as prepayment estimation and modeling, and nominal spreads.
- Section IV describes option-adjusted spread methodology, which has become the standard way of evaluating MBSs.
- Section V explains repurchase transactions and dollar rolls, a common MBS investment strategy.
- Section VI gives an overview of structured MBSs, such as collateralized mortgage obligations (CMOs) and interest-only MBSs.
- Section VII provides an introduction to the various types of nonagency MBSs.

This paper also includes seven appendices, which contain additional information on the topics discussed in the previous sections:

- Appendix A contains a list of resources for MBS investors.
- Appendix B provides a glossary of common terminology.
- Appendix C lists standard definitions for CMOs.
- Appendix D extends the discussion of settlements dates.
- Appendix E offers an introduction to MBS mathematics.
- Appendix F discusses the back-office clearance and settlement processes.
- Appendix G introduces risk-based capital standards and their applications to MBSs.

II. Agency Pass-Through Securities

The basic mortgage-backed security structure is the pass-through. As the name implies, a pass-through passes through the monthly principal and interest payments (less a servicing fee) from a pool of mortgage loans to holders of the security. Thus, investors in the pass-through are, in effect, buying shares of the cash flows from the underlying loans. Structured MBSs, such as collateralized mortgage obligations (CMOs) and interest-only and principal-only STRIPs (IOs and POs), carve up mortgage cash flows in a variety of ways to create securities with given prepayment and maturity profiles. We discuss pass-throughs in this section, and we describe structured mortgage securities (agency and nonagency) later in this paper.

Development of the Pass-Through Market

The pass-through is the most common structure for mortgage-backed securities. A pass-through issuer acquires mortgages either by originating them or by purchasing them in the whole-loan market. Many mortgages with similar characteristics are collected into a pool, and undivided ownership interests in the pool are sold as pass-through certificates. The undivided interest entitles the owner of the security to a pro rata share of all interest payments and all scheduled or prepaid principal payments.

The growth of the pass-through market stems in large part from the active role of the US housing finance agencies in the primary and secondary mortgage markets. Ginnie Mae, Freddie Mac, and Fannie Mae account for nearly all of the issuance and outstanding principal amount of mortgage pass-throughs.

The programs of the three major federal housing agencies reflect the historical development of US housing policy. Fannie Mae was created in 1938 as a wholly owned government corporation. Its charter mandated that it purchase **Federal Housing Administration** (FHA)-insured (and, since 1948, **Veterans Administration** (VA)-guaranteed) mortgages for its portfolio.[2] Congress intended to ensure that mortgage lenders would continue to be able to make residential mortgage loans, even in periods of disintermediation (when withdrawals by depositors are high) or when delinquencies and defaults are high. Fannie Mae's purchase activities encouraged the standardization of repayment contracts and credit underwriting procedures for mortgages.

In 1968, the government restructured its role in the housing finance market. Fannie Mae was privatized, although it retained its mandate to buy FHA/VA loans for its own portfolio. Ginnie Mae was spun off as a separate agency that would undertake some of Fannie Mae's previous activities. In particular, Ginnie Mae assumed the financing of home loans not ordinarily underwritten in the established mortgage market, such as loans to low-income families.

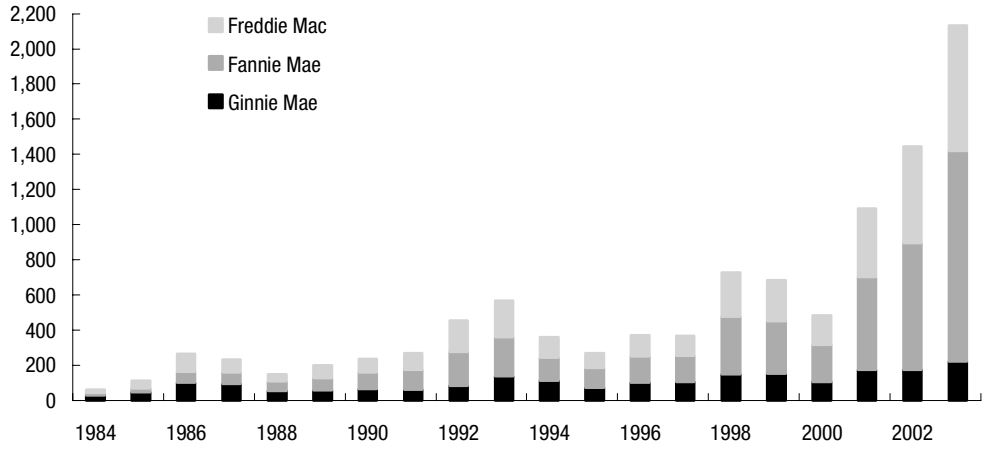
[2] The FHA and the VA are US government entities that provide mortgage insurance intended to serve low- and moderate-income homebuyers and military veterans, respectively.

Ginnie Mae's most important activity has been its mortgage pass-through program, which was instituted in 1970. Under this program, Ginnie Mae guarantees the payments of principal and interest on pools of FHA-insured or VA-guaranteed mortgage loans.

The enhanced availability of credit to homeowners who qualify for FHA and VA loans led to calls for similar treatment for non-government-insured (or conventional) mortgages. In 1970, Congress established Freddie Mac to develop an active secondary market for conventional loans, and in 1972, Fannie Mae began to purchase conventional mortgages. Thus, by 1972, lenders could sell their newly originated conventional mortgages to either Fannie Mae or Freddie Mac.

Freddie Mac issued a small volume of pass-throughs in the 1970s, while Fannie Mae began its MBS program in late 1981. As Figure 3 indicates, issuance volume from all three agencies increased as rates rallied in the mid-1980s, and it hit new peaks in the refinancing waves of 1993, 1998, and (most dramatically) in 2003.

Figure 3. Agency Pass-Through Securities Issuance, 1984–2003 (Dollars in Billions)



Source: Bond Market Association.

Terminology

In Figure 4 we provide a description of a fairly typical mortgage pass-through, or pool. The lower half of Figure 4 gives key current pool characteristics. This information is updated each month by the agencies (traditionally called "pool factor tapes") for their pools (for nonagency MBSs, issuers provide updated data for their deals each month).[3]

[3] The WA credit score and LTV ratio are the weighted-average original credit scores and LTV ratios for the loans remaining in the pool.

Figure 4. Fannie Mae Pool 486183

Issue Date	3/01/99	Delay	55 Days
Collateral	30-Year Fixed-Rate Loans	Original Balance	$25,000,304
Net Coupon	6.0%		
Current Balance	$3,174,029	Current Loan Size	$93,354
Factor	0.12695961	WA Credit Score	715
WAC	6.583%	WA LTV Ratio	81
WAM	23-00 Yrs.	Pct. Investor Loans	2%
WALA	5-07 Yrs.	Pct. Refinance Loans	49%

WA Weighted-average. WAC Weighted-average coupon. WALA Weighted-average loan age. WAM Weighted-average maturity.
Note: Current balances, factor, WAM, and WALA as of September 1, 2004.
Sources: Fannie Mae, The Yield Book®, and Citigroup.

Figure 4 shows some of the terminology and information used to analyze MBSs:

- **Net coupon and WAC**. The net coupon of 6% is the rate at which interest is paid to investors,[4] while the weighted-average coupon (WAC) is 6.583% on the pool of mortgages backing the pass-through. The difference between the WAC and the net coupon is called the servicing spread. Pass-throughs issued by Fannie Mae and Freddie Mac (as well as **Ginnie Mae II**[5] program securities) allow for variations in the note rates on the underlying loans (as is the case for the pool in Figure 4). In this case, the WAC could change over time (as loans are prepaid), and, hence, the latest updated WAC is shown. For Ginnie Mae pools that have been issued under the so-called **Ginnie Mae I** program, the underlying mortgage loans all have the same note rate with a servicing spread of 50bp.
- **WAM and WALA**. The weighted-average maturity (WAM) is the average (weighted by loan balance) of the remaining terms on the underlying loans, while the WALA is the weighted-average loan age. The sum of the WAM and WALA in Figure 4 is (23-00+5-07), or 28-07. If the underlying loans had original terms of 30 years, why is this figure not 30 years exactly? There are two reasons: (1) some of the loans may have had original terms of less than 30 years (for example, 25 years) because a pass-through backed by "30-year loans" in fact may have mortgages with any original term of greater than 15 years (although the majority of loans will typically have 30-year original terms); and (2) some mortgagors are in the habit of sending in extra monthly payments, above and beyond the scheduled monthly payment, to build up equity in their properties at a faster rate. These extra payments, often referred to as curtailments or as partial prepayments (as opposed to a full prepayment of the whole mortgage), shorten the remaining term until the mortgage is paid off, because the monthly payment remains unchanged (for fixed-rate loans) while the balance to be amortized decreases. The WAM reflects the extent of this shortening.
- **Delay**. Cash flows are passed through to investors with a delay to allow servicers time to process mortgage payments. For the Fannie Mae pool shown in Figure 4, the stated delay is 55 days, which means that the principal and interest for September, say, is paid on October 25,[6] rather than on October 1. Thus, the

[4] This is the annualized rate. Mortgage cash flows are monthly, so each month investors receive interest at a rate of (6/12)%; in other words, 0.005 times the balance outstanding at the beginning of the month.

[5] The Ginnie Mae II program allows for multiple-issuer pools (i.e., loans from a number of different issuers are pooled, whereas Ginnie Mae I pools contain loans from a single issuer), as well as for different note rates on the underlying pools. The Ginnie Mae II program has become well established over the years, with recent issuance exceeding that of Ginnie Mae I.

[6] 25 is obtained by subtracting a month (30 days) from the stated delay of 55 days.

actual delay is 24 days. Ginnie Mae I pools and FHLMC Golds have a stated delay of 45 days,[7] while Ginnie Mae II pools have a stated delay of 50 days.[8] Of course, these delays are factored into calculations of returns to investors.

- **Pool factor**. The Fannie Mae pool in Figure 4 had a factor of 0.12695961 as of September 1, 2004. The factor is the proportion of the original principal balance outstanding as of the stated factor date. The factor declines over time because of scheduled principal payments (amortization) and prepayments. In this case, amortization alone would have reduced the factor by less than 10% in the five and a half years since the pool was issued; thus, this pool clearly has experienced heavy prepayments. As we discuss in the next section, a comparison of the actual factor with the factor under amortization alone is used to estimate prepayment rates on mortgage pools.
- **Loan size**. The current average loan size of $93,354 is obtained by dividing the current pool balance by the number of loans that remain outstanding. (Alternatively, a "weighted-average" loan size could be computed.[9]) With the "conforming" loan limit (see "Types of Agency Pass-Through Collateral") at $333,700 in 2004,[10] a wide range of loan sizes is possible. Loans from high housing cost areas like California and the Northeast tend to be larger than average, while 15-year loans, which are often taken out by borrowers who desire to pay off their mortgages quickly, tend to be smaller than average. Because the savings in dollars that a borrower can achieve by refinancing is to some degree proportional to the size of the loan, loan size data are important for prepayment analysis.[11]
- **Additional disclosure data**. In June 2003, the agencies began to release additional data including loan-to-value (LTV), credit score, occupancy type, loan purpose, and property type. Some of these are shown in Figure 4. These additional disclosures have brought agency pool data closer to the generally more detailed level of information available for nonagency MBS, giving the market a better sense of the profile of borrowers collateralizing agency pools and increasing the transparency of the agency MBS market.

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[7] Almost all Freddie Mac pass-throughs are issued now under its Gold program, which was started in 1990. Freddie Mac pass-throughs issued prior to the introduction of the Gold program have a delay of 75 days and, hence, are often labeled 75-day *participation* certificates (PCs).

[8] There is an alternative convention in which the stated delays are one day shorter than those given here (for example, the Fannie Mae stated delay would be 54 days using the alternative convention, which is used on Yield Book and Bloomberg). To avoid confusion, investors should just keep track of payment dates. For example, for Fannie Mae pools, the payment date is the twenty-fifth of the month regardless of how the stated delay is quoted.

[9] Normally, a weighted average would be obtained by weighting each loan by its balance. Because loan-level data are not available for agency pools, the state geographic distribution can be used as weights. However, for Freddie Mac pools, a weighted-average original loan size is available (since July 2004).

[10] This limit applies to loans securitized by Freddie Mac and Fannie Mae. Ginnie Mae normally has lower limits determined by FHA and VA.

[11] Weighted-average loan sizes are likely more relevant for prepayment analysis.

Types of Agency Pass-Through Collateral

In general, the agencies segregate loans into pools by the following categories:

- Type of property (single-family or multifamily);
- Payment schedule (level, adjustable, other);
- Original maturity; and
- Loan coupon rate.

Single-family loans, defined as loans on one- to four-family homes, provide the collateral for the great majority of agency pass-throughs. A brief description of agency multifamily programs is given later in this section. Here we review single-family collateral types.

Government and Conventional Loans

Loans insured by two US government entities, the FHA and the VA, collateralize Ginnie Mae pools. Other loans are referred to as conventional loans. Conventional loans back almost all Fannie Mae and Freddie Mac pools, although both agencies have issued pools backed by FHA/VA programs.

Because of restrictions on loan size and lower down payment requirements, FHA and VA borrowers tend to be less affluent than conventional borrowers, characteristics that in the past have led to slower Ginnie Mae prepayment rates. However, because income levels and housing costs vary from region to region, certain regions have greater concentrations of FHA/VA loans. Hence, prepayment differentials between Ginnie Mae and Fannie Mae/Freddie Mac speeds can partly reflect regional housing market differences. Strong home price appreciation and deteriorating FHA/VA borrower credit profiles may be behind Ginnie Mae prepayment speeds that have been surprisingly fast recently.

Conforming and Nonconforming Loans

Conventional loans may be segregated further into conforming and nonconforming loans. Conforming loans are those that are eligible for securitization by Fannie Mae and Freddie Mac. For these loans, the original loan balance must be less than the specified Fannie Mae/Freddie Mac limit (currently $333,700 but changed each year based on housing inflation), and the loans must meet Fannie Mae/Freddie Mac underwriting guidelines (in terms of required documentation, borrower debt-to-income ratios, LTV ratios, etc.).

Nonconforming loans form the collateral for private-label MBSs. In most cases, these loans are nonconforming because they exceed the Fannie Mae/Freddie Mac loan size limit (“jumbo” loans). However, the sizes of a significant number of loans in private-label deals are below this limit, but are nonconforming because they do not meet Fannie Mae and Freddie Mac underwriting standards. An overview of nonagency MBSs is given in Section VII.

Payment Schedules and Loan Terms

Within each of these “administrative” categories, loans are further classified by payment type and term.

Fixed-Rate Loans

These loans remain the basic collateral for pass-throughs. As the name implies, they are fully amortizing loans with fixed coupons and, hence, fixed monthly payments. The most popular loan term is 30 years, although 15-year loans appeal to those who want to build equity faster in their homes and who can afford higher monthly payments. Smaller amounts of pass-throughs are backed by 20-year and ten-year loans, which, like 15-year loans, are often issued as refinancing vehicles.

Adjustable-Rate Mortgages (ARMs)

ARMs became popular during the high-interest-rate period of the early 1980s. Since then, they have continued to account for a significant fraction of total mortgage originations. During periods of high fixed mortgage rates, as much as 60% of originations have been ARMs, but even when fixed rates are low, ARMs typically constitute at least 15% of originations. An explanation for their popularity is the low initial coupon (or teaser rate), which attracts borrowers (such as first-time homebuyers) who want to minimize their starting monthly payments. After the teaser rate period is over, the coupon resets off a specified index, such as the one-year Treasury rate, subject to periodic caps (the maximum amount that the coupon can change at each reset date) and life caps (the upper limit on the ARM coupon). Securitization rates for ARMs are typically less than for fixed-rate loans, because some originators hold them in their portfolios.

An increasingly common type of mortgage is the **hybrid ARM**. As the name implies, a hybrid has features of both fixed-rate loans and ARMs: it has a fixed coupon for a specified number of years (typically three, five, seven, or ten), after which the coupon, as with a standard ARM, resets periodically off a specified index. In recent years, hybrids have constituted the great majority of ARM issuance.[12]

Balloon Loans

Fannie Mae and Freddie Mac securitize these loans. The loans amortize according to a 30-year schedule, with a balloon payment due at the end of five or seven years. Balloon MBSs were first issued in late 1990 and were quite popular in the refinancing waves of 1992 and 1993, but they have declined in popularity since then, partly because of the growing popularity of hybrid ARMs.

There are various other payment types, such as **graduated payment mortgages** (**GPM**s), which typically have lower initial monthly payments and higher subsequent ones relative to a standard fixed-rate loan. The idea behind these mortgages is to make it easier for first-time buyers to purchase a home. Such types are a fairly minor segment of the market nowadays.

[12] For more details on hybrid ARMs, see *The New Citigroup Hybrid ARM Prepayment Model*, Citigroup, September 21, 2004.

Figure 5. Agency Pass-Through Programs — Characteristics

	Ginnie Mae	Fannie Mae	Freddie Mac
Types of Mortgage	FHA/VA	Conventional (Some FHA/VA)	Conventional (Some FHA/VA)
Guarantee	Timely payment of interest and principal	Timely payment of interest and principal	Timely payment of interest and principal
Guarantor	US Government	Fannie Mae	Freddie Mac
Amount (In Billions)			
• Issued to Date	$2,267	$5,065	$3,906
• Currently Outstanding	$457	$1,879	$1,190
Main Collateral Types and Amounts Outstanding (in Billions)[a]	30 Year Fixed-Rate Ginnie I: $243 Ginnie II: $105 15-Year Fixed-Rate Ginnie I: $24 Ginnie II: $1 ARMs: $38 Multifamily: $29	30-Year Fixed-Rate: $1,157 15-Year Fixed-Rate: $441 Balloons: $13 ARMs: $193 Multifamily: $75	30-Year Fixed-Rate: $669 15-Year Fixed-Rate: $356 Balloons: $35 ARMs: $81 Multifamily: $16
Servicing Spread	Ginnie Mae I: 50bp Ginnie Mae II: 25bp–75bp[b]	Typically 40bp–80bp[c]	Typically 40bp–80bp[d]
Delays (Days)			
• Stated	45 (Ginnie II: 50)	55	45
• Actual	14 (Ginnie II: 19)	24	14

[a] Data for Ginnie Mae breakdown does not add to total due to different sources of data, Freddie Mac breakdown is as of December 2003. [b] 50bp-150 bp for Ginnie Mae II pools issued prior to July 2003. [c] According to Fannie Mae MBS prospectuses, in most instances, the interest rates of the underlying fixed-rate loans in a single pool are grouped so that the rates are within a 200bp range. [d] According to Freddie Mac prospectuses, the servicing spread can be up to 250bp. ARMs Adjustable-rate mortgages. FHA Federal Housing Administration. VA Veterans Administration.

Notes: For Freddie Mac, the delay shown is for Gold PCs; older PCs issued before the Gold program have a 75-day delay. Data are as of June 2004 unless otherwise indicated. Issuance is cumulative since 1980.

Sources: Ginnie Mae, Freddie Mac, Fannie Mae, Bond Market Association, and Citigroup.

Types of Pass-Through Trading

Most agency pass-through trading is on a **to-be-announced** (**TBA**) basis. In a TBA trade, the buyer and seller decide on general trade parameters, such as agency, coupon, settlement date, par amount, and price, but the buyer typically does not know which pools actually will be delivered until two days before settlement. The seller is obligated to provide pool information by 3 p.m. two days prior to settlement (the "48-Hour Rule"). The pools delivered are at the discretion of the seller, but must satisfy BMA[13] good delivery guidelines, which specify the allowable variance in the current face amount of the pools from the nominal agreed-upon amount,[14] the maximum number of pools per $1 million of face value, and so on.

By making what are really unique and often small pools interchangeable, the TBA market facilitates liquidity in pass-through trading. Almost all newly issued pools trade as TBAs. Most price quotes shown for pass-throughs, and valuation analyses such as those discussed in the next section, are for TBA coupons. Such pricing and analyses assume WACs and WAMs based on an estimate of what is most likely to be delivered at the time.

Pass-Through Vintages

Investors also can specify a particular loan origination year (or vintage, sometimes also referred to as a specific WAM) when buying a block of pass-throughs. For example, whereas a TBA trade might be for $100 million of 30-year Freddie Mac

[13] The Bond Market Association (BMA), a trade group representing bond dealers, formerly known as the Public Securities Association (PSA).

[14] Because the face amount of the pools can be any arbitrary amount (for example, $3,174,029 in the example in Figure 4), it might be difficult to obtain pools whose outstanding amounts sum *exactly* to the agreed upon trade amount. Hence, some variance is allowed in the amount delivered. At one time, this variance was 2% from the agreed upon amount, it then changed to 1%, and it is currently plus or minus 0.01%.

6.5s, a vintage trade might specify $100 million of 1998 30-year Freddie Mac 6.5s. The investor would then receive Freddie 6.5% pools collateralized by loans originated in 1998. Because the 1998 Freddie 6.5s may have favorable prepayment characteristics relative to new production (for example, more burnout or more seasoning), they would typically sell at a premium to TBAs.[15]

Specified Pools

A large and active market also exists in specified pools, in which buyers know exactly which pools they are buying and, hence, relevant characteristics such as WAC, WAM, age, prepayment history, and so on. With this extra degree of certainty, specified pools typically trade at a premium to comparable TBA coupons.

Story Bonds

While trading in specified pools often involves seasoned bonds, it can also involve new pools with specific prepayment characteristics. Some examples include:

- **Prepay penalty pools**, which are backed by loans that carry a penalty (typically about six months of interest) if the loan is refinanced within the first three or five years.
- **Low WAC pools**, which are pools with WACs lower than the typical TBA average. For example, conventional TBA 5.5s currently are assumed to have a WAC of 5.92%, so 5.5% pools with a WAC of, say, 5.75% trade at a premium to TBA 5.5s.
- **Low loan balance pools**, which are backed by "smaller than average" loans. Because refinancing costs are a higher hurdle for such loans and because smaller loan balances can imply less affluent borrowers, then other things being equal, such loans may prepay more slowly than average.

Combined Pools

Freddie Mac Giant PCs and Fannie Mae MegaPools, introduced in mid-1988, and Ginnie Mae Platinum pools, introduced in late 1994, are mortgage pass-throughs that the agencies create by combining already outstanding pass-throughs. Such pools benefit investors who own small pass-through pools or seasoned pools that have paid down. These investors can swap their holdings for a pro rata share of a new Giant PC, MegaPool or Platinum pool. Similarly, these programs help lenders design more marketable securities. Lenders can take recently securitized smaller pools that are still held in portfolio and aggregate them into a bigger pool.

From the investor's perspective, large pools provide the following advantages in addition to greater liquidity:

- **Greater diversification**. When the combined pool is backed by pass-throughs from many investors, the geographic distribution of the underlying mortgages is typically greater. This diversification reduces the risk of random prepayment and default variations. Thus, the prepayment rates of combined pools would follow average mortgage sector prepayment rates more closely than will most standard pools.

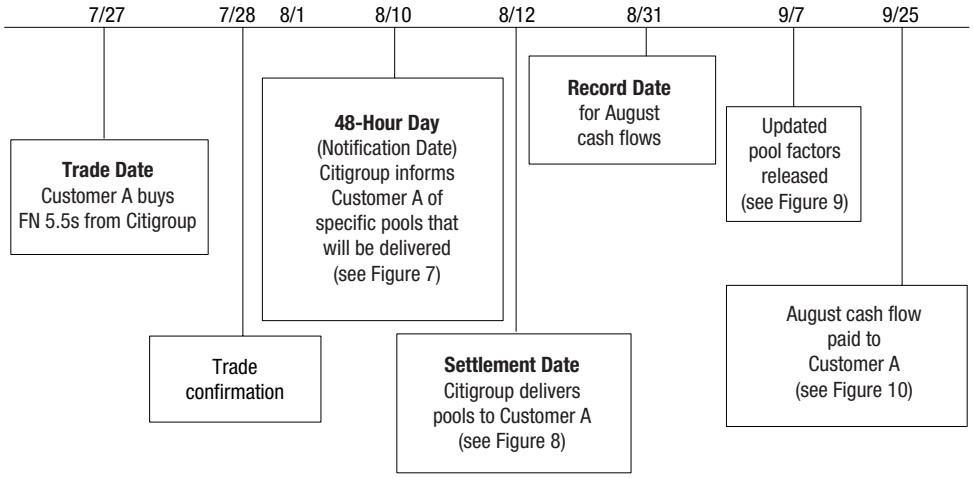
[15] For readers with access to Citigroup's Yield Book system or to Citigroup FI Direct, report MB712 gives market and theoretical prices for TBAs and specified origination year pass-throughs.

- **Lower administration costs.** Investors can track the monthly payments and balances of a few large pools more efficiently than they can for a greater number of small pools.
- **Lower reverse repurchase rates.** Investors can achieve lower financing rates when entering into reverse repurchase agreements by pledging bigger pools. Securities dealers and banks often pass on the administrative cost savings of larger pools to the customer.

An Agency Pass-Through Trade

As mentioned, most agency pass-through trading occurs on a TBA basis. TBA trading is the norm in the agency pass-through market for several reasons. It greatly improves market liquidity, allowing trades of large size to take place (most MBS pools are relatively small, typically less than $10 million). It also helps mortgage lenders to hedge interest rate exposure after a borrower locks in a rate.[16] As an example, we follow a TBA trade for $2 million face value of Fannie Mae 30-year 5.5% pass-throughs. Figure 6 shows a time line of the steps in the process.

Figure 6. TBA Fannie Mae 30-Year 5.5% Trade



Source: Citigroup.

Trade and Confirmation Dates

On Tuesday, July 27, 2004, a portfolio manager at Customer A tells his salesperson at Citigroup that he wishes to purchase $2 million face value of 30-year 5.5s.[17] The salesperson checks with the desk and quotes a price of 99-17 for standard August settlement. The customer accepts, and a **trade confirmation** is sent out within one day of the trade date. (In fact, the trade confirmation is normally sent out immediately.)

[16] Between the lock-in date and the loan closing date, the lender has interest rate exposure on a future loan that the lender is committed to making but that has not yet been finalized.

[17] Although TBA trades are typically larger than $2 million, we have used a small amount for simplicity.

48-Hour Day and Good Delivery Requirements

TBA trades normally settle according to a monthly schedule set by the Bond Market Association, a trade group of fixed-income dealers (formerly called the Public Securities Association, or PSA). For Fannie Mae 5.5s, the August 2004 settlement date was Thursday, August 12, 2004 (see Appendix D). The buyer has to be notified as to which pools will be delivered before 3 p.m., two business days prior to the settlement date, or Tuesday, August 10, in this case. This is the **48-hour rule**; hence, the **notification date** is often called the **48-hour day**.

The pools have to satisfy requirements for **good delivery** established by the Bond Market Association. These requirements have changed over time, but at present, for each $1 million **lot** (trades are usually transacted in terms of $1 million units, called lots), the following constraints apply:

- A maximum of three pools per lot is allowed;[18] and
- **Variance** refers to the difference between the face amount of the pools delivered and the agreed-upon face amount. Some variance is allowed in recognition of the fact that the face amount of a pool, which is the sum of the current balances of the underlying mortgage loans, is unlikely to be a nice round number, such as $1 million. The allowable variance is 0.01% per lot (that is, for a $1 million lot, the sum of the par amounts of the pools in each lot should be within 0.01% of $1 million, or between $999,900 and $1,000,100).

On Tuesday, August 10, Citigroup notifies Customer A which pools will be delivered, sending the information shown in Figure 7.

Figure 7. 48-Hour Day — Notification of Pools to Be Delivered for $2 Million Fannie Mae 5.5% TBA Trade

Lot 1. Fannie Mae Pool #111		
Issue Date	June 1, 2004	
Original Face	$1,020,000	
Current Factor	0.98044118	
Current Face	= Original Face * Current Pool Factor = $1,020,000 * 0.98044118 = $1,000,050	
Lot 2. Fannie Mae Pools #222 and #333		
	Pool #222	**Pool #333**
Issue Date	August 1, 2004	August 1, 2004
Original Face	$499,910	$500,000
Current Factor	1.0000000	1.0000000
Current Face	$499,910	$500,000

The listed pools were created for this example. Assume factors and face amounts as of August 1, 2004.
Source: Citigroup.

Settlement Calculations

Figure 8 shows financial details of the settlement, which takes place on Thursday, August 12, 2004. Account A pays Citigroup an amount equal to the current face amount times the agreed-upon price of 99-17, plus accrued interest from the beginning of the month. Accrued interest is computed on a 30/360 basis.

[18] Slightly more liberal good delivery requirements are allowed for very old pools. See the Bond Market Association's *Uniform Practices* manual for complete details, or contact your Citigroup salesperson.

Figure 8. $2 Million 5.5% 30-Year Trade: Settlement

Current Face Amount	= $1,000,050 + $499,910 + $500,000 = $1,999,960
Accrued Interest	= Current Face Amount * Coupon Rate * (Settlement Day of Month – 1)/360 = $1,999,960 * 5.5% * (12 – 1)/360 = $3,361.04
Total Amount Due	= Current Face Amount * (Price / 100) + Accrued Interest = $1,999,960 * (99.53125 / 100) + $3,361.04 = $1,993,946.23

Source: Citigroup.

Clearing Trades

The clearing process refers to the mechanism by which trades are settled, i.e., how money is exchanged and changes in ownership of the securities are recorded. Almost all trades are now settled electronically, or via the **book entry** method**. Physical delivery**, in which certificates of ownership are delivered, is now rarely used. In Appendix F we provide a detailed description of the clearing and settlement process from more of a back-office perspective.

Record Date

The owner of an agency pool on the last day of a month (the **record date**) is entitled to the cash flows for that month. For August 2004, the record date is August 31, 2004. Account A is recorded as the owner of the three pools shown in Figure 7 and, hence, receives the August cash flow, consisting of interest and principal for the month. The August payment is actually made in September. Payments for most Ginnie Mae and Freddie Mac MBSs are made on the fifteenth of each month, and for Fannie Mae MBSs, on the twenty-fifth of each month (see the definition of delay in the glossary in Appendix B and the discussion that follows Figure 4).

Pool Factor Updates and Principal and Interest Calculations

Interest due to investors for the month of August is based on the principal balance at the beginning of August and is determined on a 30/360 basis. The principal payment is calculated by comparing the pool factors on August 1 and September 1. All three agencies release updated factors for their pools near the beginning of each month according to a set schedule, shown in Figure 9.

Figure 9. Agency Pool Factor Monthly Release Schedule

	Factors Released on	Factors Incorporate Prepays
Freddie Mac	Evening of Fourth Business Day of Month	Up to End of Previous Month
Fannie Mae	Evening of Fourth Business Day of Month	Up to End of Previous Month
Ginnie Mae	Morning of Fifth Business Day of Month	Up to End of Previous Month

Source: Citigroup.

In our example, Fannie Mae releases an updated pool factor in the evening of the fourth business day of September (September 7, 2004). This is termed the **September 1 factor**, although it reflects prepayments received during August. This factor is used to calculate payments due to the investor for the month of August and to be paid on September 25. Figure 10 shows details of the calculations. Updated pool factors are posted on MBS analytic systems such as Citigroup's Yield Book®.

Figure 10. $2 Million 30-Year Trade: Interest and Principal Payments for August (Paid on 25 Sep)	
Principal Paydown	= Original Face Amount * (Previous Pool Factor – New Pool Factor)
Interest Payment	= Face Amount as of Aug 1 * Coupon Rate / 12
Pool A	Sep 1 Factor = 0.97941177, Aug 1 Factor = 0.98044118
Principal Paydown	= $1,020,000 * (0.98044118 – 0.97941177) = $1,050.00
Interest Payment	= $1,000,050 * 5.5% / 12 = $4,583.56
Pool B	Sep 1 Factor = 0.99500000, Aug 1 Factor = 1.0000000
Principal Paydown	= $499,910 * (1.00000000 - 0.99500000) = $2,499.55
Interest Payment	= $499,910 * 5.5% / 12 = $2,291.25
Pool C	Sep 1 Factor = 0.99500000, Aug 1 Factor = 1.0000000
Principal Paydown	= $500,000 * (1.00000000 – 0.99500000) = $2,500.00
Interest Payment	= $500,000 * 5.5% / 12 = $2,291.67
Total Payment Received by Investor on 25 Sep 04	= $1,050.00 + $2,499.55 + $2,500.00 + $4,583.56 + $2,291.25 + $2,291.67 = $15,216.03

Source: Citigroup.

TBA Trade "Fail"

In a TBA transaction, the seller does have the costly option to be late (or "fail") in delivering securities to the buyer. For example, if collateral is needed for new CMO deals, this additional demand could cause a temporary shortage of the coupon being used to back the new deals. However, in the case of a "fail," the buyer benefits by not having to pay the seller until the securities are delivered. The price of the securities, including accrued interest that is to be paid, does not change. Therefore, the buyer receives both of the following:

- Interest on the money that was to be paid for the security; and
- Interest (as well as principal if a record date is passed) on the security that will eventually be delivered.

To summarize, although the security has not been delivered, the buyer does "own" the security in the sense that cash flows that would have gone to the buyer (if a "fail" had not occurred) still must be passed to the buyer by the seller. And the buyer receives the "extra" interest earned on the funds that were to be paid to the seller (compensation for the inconvenience of the "fail").

Multifamily Pass-Through Programs

Although small in comparison to the single-family MBS sector, pass-throughs backed by multifamily mortgages comprise a sizable market, as shown in Figure 5. Fannie Mae and Freddie Mac have securitized multifamily loans (defined as mortgages on five or more family homes) for many years, and their programs have gone through various revisions over the years. Investors should note some common features of multifamily MBSs:

- Many multifamily loans have prepayment penalties, giving the investor a degree of call protection. The penalty is often in the form of yield maintenance; thus, the amount of the penalty depends on the decline in interest rates since issuance. The objective is to fully compensate the investor for the prepayment. New multifamily issuance from Fannie referred to as DUS may even have a Fannie

promise to replace any loan in the pool that repays owing to a default or prepayment.[19]

- Many multifamily loans have balloon payments due, with the balloon date typically occurring between five and 15 years.

Project loans is a term that refers to FHA-insured mortgage loans made on a variety of property types such as multifamily housing, nursing homes, and hospitals. The loans are either securitized as Ginnie Mae pass-throughs or sold as FHA PCs. Project loans typically have prepayment penalties. In addition, some project loans are putable; in other words, the investor has the option of selling the bond to the issuer for a specified price at specified times.

Multifamily pass-throughs and project loans are special cases of MBSs backed by **commercial real estate** loans. Commercial mortgage-backed securities (CMBSs) combine the features of standard MBSs with those of callable corporate bonds and are discussed further in Section VII.

[19] *A Guide to Fannie Mae DUS MBSs*, Darrell Wheeler, Citigroup, January 3, 2001.

III. Basics of Mortgage Security Analysis

In this section we discuss the basics of MBS analysis, starting with prepayments. Standard bond valuation measures, such as yield spread, are also described. Although the dependence of mortgage cash flows on interest rates (through prepayments) makes traditional bond analysis of limited use for MBSs, such analysis is still a useful starting point.

Measuring Prepayments

Prepayments are calculated by comparing actual principal received with scheduled principal; the difference is the prepaid principal. The convention is to state prepayment rates in terms of the outstanding principal balance (as opposed to, for example, the initial balance). Observed prepayment rates can be stated in one of several different units.

Single Monthly Mortality (SMM)

This refers to the prepayment rate for a month and forms the basis for all prepayment calculations. The SMM is the fraction of the beginning-month balance that prepays during the month. By convention, the scheduled principal is subtracted from the balance before calculating the prepayment rate. (The SMM is defined mathematically in equation E1 in Appendix E). For example, if the principal balance at the beginning of a month is $100, scheduled principal is $0.5, and total principal received is $1, then prepaid principal equals $0.5, and the SMM is $0.5 divided by ($100 – $0.5), or 0.5 / 99.5, which is 0.5025%.

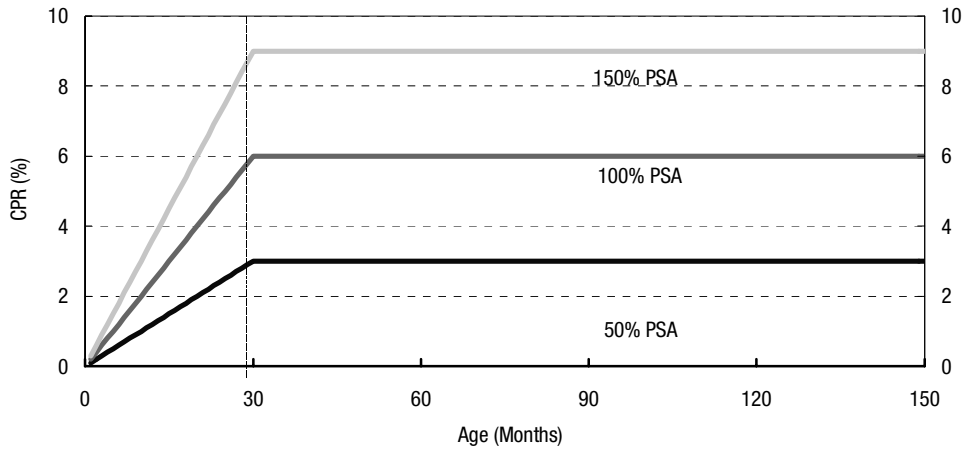
Constant Prepayment Rate (CPR)

The CPR is the annualized version of the SMM; that is, it is the cumulative prepayment rate over 12 months given the same SMM each month. It is given by equation E2 in Appendix E. For a small SMM (less than a few percent), the CPR is approximately 12 times the SMM.

Public Securities Association (PSA) Convention

The PSA benchmark curve was introduced in the mid-1980s to account for the seasoning (or aging) pattern typically observed with MBSs. New loans tend to have low prepayment rates, which gradually increase until the loans are seasoned. The PSA measurement convention adjusts the CPR for age, as shown in Figure 11. The base PSA curve, or 100% PSA, assumes the prepayment rate starts at 0% CPR at age 0 and increases by 0.2% CPR month until month 30, after which the speed is a constant 6% CPR. A rate of 50% PSA means that the CPR in any month is half that implied by 100% PSA. A rate of 200% PSA means that the CPR in any month is twice that implied by 100% PSA, and so on. Formulae for converting from CPR to PSA, and vice versa, are given by equations E3 and E4 in Appendix E.

Figure 11. The PSA Prepayment Convention



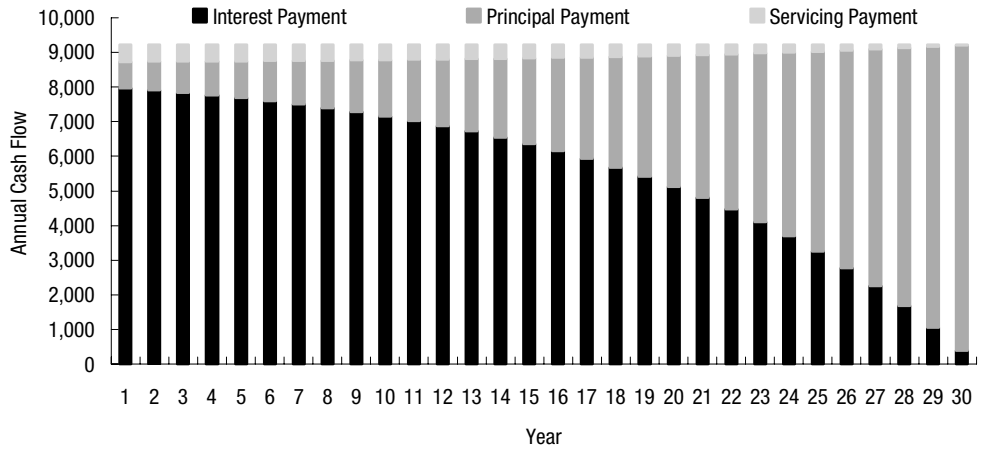
Source: Citigroup.

Prepayment speeds are rarely stated in terms of SMM. Instead, the speed is stated typically in its annualized form, CPR. The PSA is less used (an exception is the pricing speed assumptions for CMO deals), because actual mortgage seasoning patterns often do not follow the PSA pattern.

The Effect of Prepayments on MBS Cash Flows

Figure 12 shows the cash flows from a hypothetical pass-through pool in the (unlikely) case of zero prepayments, that is, all the underlying loans survive the full 30-year original term.

Figure 12. Pass-Through Cash Flows with No Prepayments



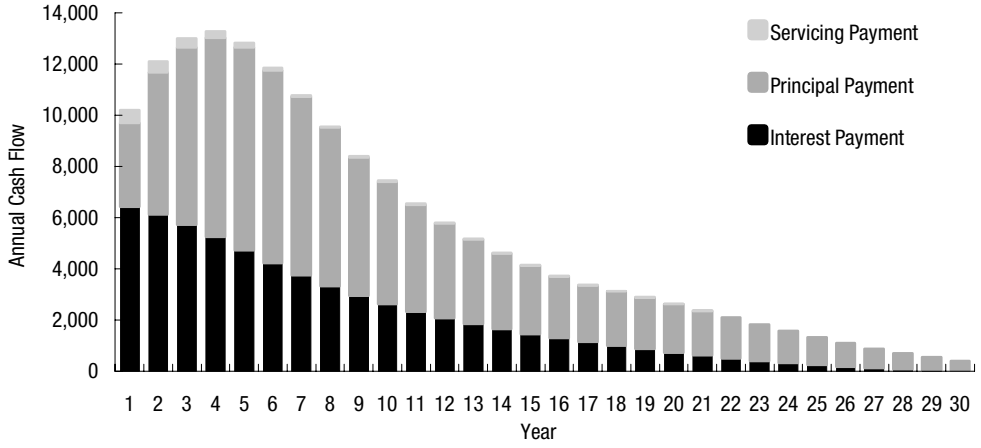
Source: Citigroup.

Although the total monthly payment from the underlying loans is constant, the payment to the pass-through holders is the total payment minus the servicing spread. For example, if the mortgagors pay a 6% coupon on average, while the Fannie Mae investors receive a 5.5% coupon, then the servicing spread is 50bp. Hence, the

servicing amount is proportional to the remaining principal balance and declines as the remaining balance declines.

In practice, of course, all MBSs experience some prepayments. Figure 13 shows the pass-through cash flows if prepayments occur at a constant rate of 100% PSA. While actual speeds will vary from month to month, Figure 13 does provide a good representation of the likely cash flow pattern from an MBS, with principal payments and total cash flows peaking and then declining over time, as the principal balance declines.

Figure 13. Pass-Through Cash Flows at a Constant Prepayment Rate of 100% PSA



Source: Citigroup.

A Brief Primer on Prepayment Analysis and Modeling

Prepayment projections are fundamental in valuing MBSs. Here we briefly describe the main factors that influence prepayment rates.

Prepayments occur for several reasons, the most important of which are **home sales** and **refinancings**. Minor causes include **defaults**, which typically average less than 0.5% CPR, and **curtailments** or **partial prepayments**, referring to mortgagors' paying more than the scheduled payment each month to obtain a faster equity buildup. Like defaults, curtailments are typically low (less than 0.5% CPR), although some evidence exists that they are higher for very seasoned loans. When the loans are very seasoned and the remaining balance is small, some mortgagors may pay off their mortgage in full. (Full payoffs can also occur because of the destruction of the home from natural disasters such as hurricanes and earthquakes.)

Home Turnover

When a home is sold in the United States, the attached mortgage is typically paid off.[20] Hence, prepayment rates on discount mortgages depend on the turnover rate of existing homes. This rate has recently been running at around 8% per year, although the historical average is closer to 6%. Thus, 6%–8% CPR can be considered an

[20] The main exceptions are FHA and VA loans (the collateral for Ginnie Maes), which are assumable by the buyer of the house. However, except for new deep discount loans, few such mortgages are assumed, because of the expense of obtaining a second mortgage on top of the existing one.

average overall baseline prepayment rate for discount mortgages. However, the prepayment rate for discounts depends on several factors:

- Housing turnover rates depend on mortgage rates and the general state of the economy. In addition, US home sales exhibit a pronounced seasonal pattern, with summer sales almost double those in the winter.
- Newer discount MBSs tend to have lower speeds than seasoned ones, because people typically do not change homes again soon after moving. The length of this **seasoning period** depends on various factors, such as the difference between the current loan rate and prevailing rates, housing inflation and resulting equity buildup in the house, and loan type. FHA/VA loans are assumable, a characteristic that reduces the speeds on newer deep-discount Ginnie Maes and, in effect, lengthens the seasoning period.
- Because speeds on newer discounts tend to be much lower than on seasoned ones, speeds on seasoned discounts tend to be higher than the 6%–8% average.
- Conventional (Freddie Mac/Fannie Mae) loans historically have had somewhat higher turnover rates than FHA/VA (Ginnie Mae) loans, although more recently the difference appears to have reversed.
- If a particular MBS has a concentration of loans in a particular geographic area (for example, predominantly in California), speeds can vary from the average.
- As indicated earlier, defaults and curtailments can add 1% CPR or so to the prepayment rate.

Refinancings

Prepayments on premium coupons consist of refinancings as well as housing turnover. Typically, refinancing rates start to accelerate when mortgage rates drop about 50bp below the WAC on the loans, and to level out when the loans are well in the money, as further increases in refinancing incentive lead to little marginal increase in refinancing activity. Investors should note some other points regarding refinancing:

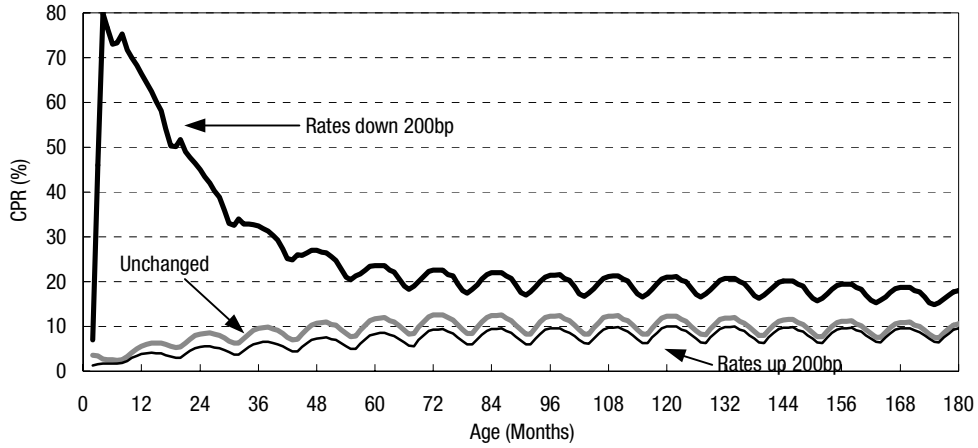
- Speeds on premium coupons exposed to refinancing opportunities for the first time can exceed 70% CPR. However, pools typically do not experience such high speeds for a sustained period of time. As the mortgagors who are the most capable or anxious to refinance exit the pool, speeds typically slow down, a process known as **burnout**.
- However, further drops in mortgage rates may temporarily cancel the effects of burnout, as we saw in 1992, 1993, 1998, and 2003. In fact, low levels of mortgage rates seem to cause a **media effect**, with publicity about low rates and proactive mortgage lenders spurring an extra degree of refinancing activity, even in burnt-out MBSs.
- The seasoning period for premium coupons with ample refinancing incentive is very short. In 2003, for example, MBSs seasoned less than a year prepaid at more than 60% CPR.
- Loan and borrower characteristics, such as the LTV or the borrower's credit score can affect the ability to refinance. In particular, the loan balance can play an important part as the costs of refinancing will be a larger hurdle for smaller balance loans, which, as a result, tend to have slower speeds.

How Do We Project Speeds?

As this brief discussion indicates, projecting speeds is not a trivial task. Prepayment rates depend on a host of variables, such as interest rates and other economic factors, on borrower characteristics such as credit and demographics, and on mortgage characteristics such as coupon, loan age, type, previous exposure to refinancing opportunities, and so on. Recent actual speeds on a pool or a deal give some guidance, but may be misleading if interest rates have recently changed significantly.

Econometric prepayment models are now the usual means to estimate likely speeds in a given interest rate environment. The Citigroup Prepayment Model is one such model. It uses a number of variables, such as past and current interest rates, housing inflation, mortgage characteristics, and so on, to obtain prepayment projections.[21] Figure 14 shows projections from Citigroup's model for new **current-coupon**[22] conventional pass-throughs for several projected interest rate levels.

Figure 14. Projected Monthly Prepayment Rates for a Conventional Current Coupon Pass-Through



Source: Citigroup.

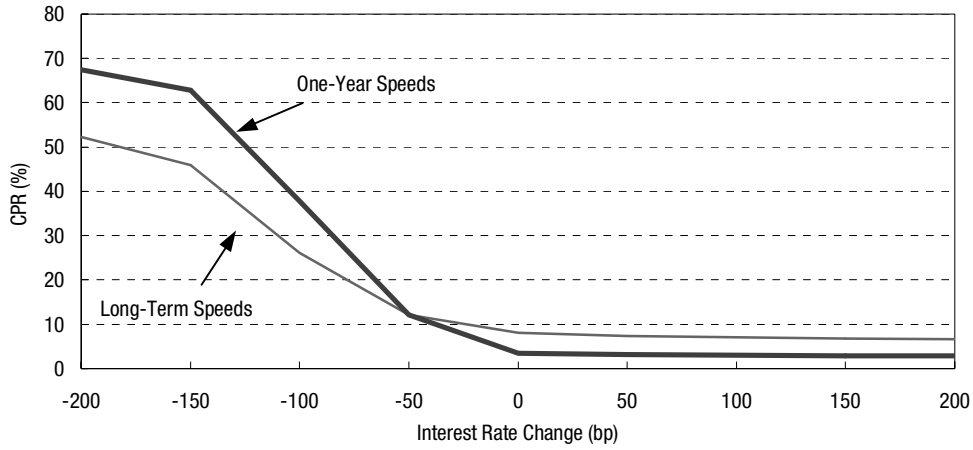
- At current rates, projected speeds are due mostly to housing turnover and increase for several years as the loans season.
- If rates drop by 200bp, speeds rise very sharply, peaking at close to 80% CPR, and then gradually decline over time because of burnout, as the most capable or able refinancers exit the pool.
- If rates rise by 200bp, speeds drop, as refinancings vanish and housing markets slow because of lower levels of affordability. The seasoning period of the pass-through lengthens, because the mortgagors, now holding a discount loan, have a disincentive to move. However, over time, speeds are projected to increase gradually, as housing markets adjust to higher rate levels and the pass-through becomes fully seasoned.

[21] For a detailed description of prepayment behavior and of the Citigroup Prepayment Model, see our paper *Anatomy of Prepayments,* most recently updated in March 2004.

[22] The current coupon refers to a pass-through priced at or close to par. For example, if 30-year mortgage rates are around 6%, then the typical WAC for newly issued pass-throughs will be around 6%. Assuming a servicing spread of about 50bp, this implies that 5.5% pass-throughs will be the current coupon.

For practical purposes, the vector of monthly projections from the model is converted into a summary number, which is a weighted average of the monthly numbers, with more weight given to earlier speeds to reflect the higher earlier balances.[23] Figure 15 shows one-year and long-term (life of security) projected CPRs for the current-coupon pass-through for the three interest scenarios in Figure 14 and some additional scenarios.

Figure 15. Projected One-Year and Long-Term CPRs for a Current-Coupon Pass-Through



CPR Constant prepayment rate.
Source: Citigroup.

The average speeds in Figure 15 reflect the same seasoning patterns that were shown in Figure 14. In the base case and in higher interest rate scenarios, projected speeds are lower in the short term (the next year) than in the long term. This reflects the increase in speeds over time due to turnover seasoning illustrated in the base and +200bp scenarios in Figure 14.

If interest rates decline by 100bp or more, the loans become highly refinanceable, and this leads speeds to spike sharply. However, because rates are assumed to stabilize after the initial drop, burnout causes refinancing activity to decline over time, and thus, short-term speeds are faster than long-term ones.

Figure 15 also illustrates the distinctive "S-curve" that characterizes prepayment rates as a function of the economic incentive to refinance (i.e., the amount the coupon is "in the money"). The S-curve is reversed in Figure 15 because the refinancing incentive increases as rates decline. For discounts (corresponding to unchanged or higher rates in Figure 15), speeds depend mostly on housing turnover, which (over longer periods of time) is relatively insensitive to interest rates; hence, the S-curve is relatively flat for unchanged and higher rates. If interest rates decline, however, and the coupon becomes a premium, speeds accelerate sharply. As rates keep falling, the S-curve starts to flatten again, as the coupon is now well in the money and further increases in the refinancing incentive lead to only marginal increases in refinancing activity.

[23] The convention used by Citigroup is to calculate the single speed (either CPR or PSA) that gives the same weighted average life for the pass-through as the vector of monthly projections. This is termed the **WAL-equivalent** speed.

Yield, Average Life, and Nominal Spreads

Given a prepayment projection, we can calculate an MBS's cash flows using standard formulae (see Appendix E). From the cash flows and a price, standard bond mathematics gives us the yield.

For US fixed-income securities, the Treasury market is often used as a benchmark, and bond yields are typically quoted as a spread to a comparable Treasury.[24] For MBSs, which return principal not in one lump sum (or "bullet payment") but in uncertain monthly increments, the definition of a "comparable" Treasury is not transparent. The convention in the market is to compare MBSs to Treasuries with a maturity close to the weighted-average life (**WAL**) of the MBS. The WAL is defined as the average time that a dollar of principal is outstanding. It is calculated by multiplying the proportion of principal received at time t by t, and then summing over t (see equation E6 in Appendix E). Figure 16 shows traditional bond analysis applied to TBA Fannie Mae 5.5% pass-throughs.

Figure 16. Traditional Analysis of TBA Fannie Mae 5.5s

Price: 99-05, Assumed WAM: 29-08 Years, WALA: 2 Months	
Projected Long-Term Speed	9.1% CPR
Yield @ Projected Speed	5.64%
WAL @ Projected Speed	8.2 Years
Yield of WAL (8.2-Year) Treasury	4.40%
Spread over WAL Treasury	124bp

WAL Weighted-average life. WALA Weighted-average loan age. WAM Weighted-average maturity.
Source: Citigroup.

It can be seen that both the yield and the WAL (and, hence, the comparable Treasury) depend on the projected prepayment rate, which in turn depend on interest rate levels. Therefore, it is advisable to examine such measures over a range of interest rate scenarios. Figure 17 shows projected speeds, yields, and WALs for the Fannie Mae 5.5% for parallel yield curve shifts of 100bp up and down, as well as the base case.

Figure 17. Scenario Analysis for a Fannie Mae 5.5% Pass-Through (WAC: 5.92%, WAM: 29-08 Years, Price: 99-05)

	Interest Rate Moves (bp)		
	-100bp	0bp	100bp
Projected LT CPR	29%	9.1%	6.4%
WAL	2.9Years	8.2Years	10.2Years
Yield	5.77%	5.64%	5.63%
WAL Treasury Yield	2.23%	4.4%	5.65%
Spread/WAL Treasury	354bp	124bp	-2bp

	1-Year	2-Year	3-Year	5-Year	10-Year	30-Year
Initial Yield Curve	2.23%	2.86%	3.27%	3.96%	4.64%	5.41%

LT Long-term.
Source: Citigroup.

[24] In recent years, swaps have been increasingly used as a benchmark for MBSs. For linguistic simplicity, we use Treasuries as the benchmark in our discussion of MBS valuation, but obviously the points made hold regardless of the benchmark that is chosen.

The results in Figure 17 illustrate the usefulness and the shortcomings of static analysis when applied to MBSs. The analysis is useful for getting a sense of the shortening and extension of the MBS as rates change. For example, if rates drop 100bp, the Fannie Mae 5.5% becomes a premium, prepayments surge, and the WAL shortens from 8.2 years to 2.9 years. Conversely, if rates increase 100bp, speeds slow slightly, and the WAL extends to 10.2 years. Note the asymmetry of the response, with a much bigger change in WAL if rates drop than if rates increase. This illustrates the fact that the Fannie Mae 5.5%, because it is close to par and not subject to any significant refinancings at current rate levels, is at the lower end of the prepayment S-curve shown in Figure 15. Thus, if rates drop 100bp, the projected speed quickly climbs up the cusp of the S-curve. However, in the other direction, there is only a mild decline in speeds along the flat part of the S-curve. This indication of the WAL sensitivity with respect to prepayments can be especially useful for structured mortgage securities such as CMOs (described in Section VI), because it may not be obvious otherwise for complex structures.

However, scenario analysis has serious shortcomings for valuation analysis. In Figure 17, the yield of the MBS increases slightly as rates drop 100bp, because the security is priced slightly below par. However, because its WAL has shortened and the WAL Treasury has also dropped 100bp, the spread over the WAL Treasury has increased, to 354bp. This apparently strong performance versus Treasuries is misleading, of course as the high prepayments on the MBS have to be reinvested at lower prevailing rates.

We describe a sounder methodology to estimate the impact of interest rate and prepayment variations in the next section.

IV. Option-Adjusted Analysis of Mortgage Securities

> ". . .The race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favor to men of skill; but time and chance happeneth to them all."
>
> Ecclesiastes 9:11

Traditional bond analysis has serious limitations when applied to MBSs (or indeed any other type of callable bond). Among these limitations are:

- The **yield spread**, the standard measure of incremental return over a benchmark Treasury, compares an MBS to a single, somewhat arbitrarily chosen point on the yield curve. Because an MBS returns principal over a period of time, rather than in one lump sum, it would be preferable to compare it to an appropriate portfolio of Treasuries or swaps.[25]
- MBS cash flows vary with interest rates, typically in a manner adverse to the MBS holder. The cost of such prepayment variation needs to be incorporated in any measure of the MBS's return relative to Treasuries or swaps.

In the mid-1980s, Salomon Brothers pioneered the development of option-adjusted analysis for MBSs. This approach has since become widely used to analyze MBSs and other callable bonds. Here we give a brief description of the methodology and its application to MBSs.

The Z-Spread

Developing a more accurate static measure of incremental return over Treasuries — improving on the yield spread — is straightforward. Let us return to the Fannie Mae 5.5% example illustrated in Figures 16 and 17. In the base case, given the projected speed, the yield of the Fannie Mae 5.5% is 5.64%, its WAL is 8.2 years, the interpolated 8.2-year Treasury yield is 4.40%, and hence, the Fannie Mae 5.5's spread to its WAL Treasury is 124bp.

This analysis can be interpreted as assuming that the Fannie Mae 5.5% returns all of its principal after 8.2 years (that is, it is a 8.2-year bullet security), and thus, the appropriate discount rate is the 8.2-year Treasury plus a spread (in this case, 124bp). Rather than making this assumption, we can discount each cash flow from the Fannie Mae 5.5% by an appropriate Treasury rate plus a spread. For example, the cash flow in month 64 can be discounted by the 64-month Treasury zero rate plus a spread. Instead of zero rates, we could use forward rates. If $f_1, f_2, \ldots$, are the one-month forward rates (based on the current yield curve) for months 1, 2, ... , then for a given spread s the discount rate for month n is

$$DIS(n,s) = 1 / [(1 + f_1 + s)(1 + f_2 + s) \ldots (1 + f_n + s)] \quad (1)$$

[25] As indicated in the previous section, for illustrative simplicity, we assume Treasuries as the benchmark.

Hence, if CF(1), CF(2), ... are the projected cash flows from the Fannie Mae 5.5%, then their present value is

$$PV(s) = CF(1) * DIS(1,s) + CF(2) * DIS(2,s) + ... \quad (2)$$

The value of s that makes the present value PV(s) equal to the market price is the solution of

$$Price = PV(s) \quad (3)$$

and is defined as the Z-spread.[26] In concept, it is similar to the standard spread over Treasuries, but it is clearly a more accurate measure of incremental return over Treasuries for securities that return principal not in one lump sum but over many periods. Rather than calculating the incremental return over a single Treasury, the Z-spread gives it relative to a portfolio of Treasuries chosen according to the timing of the MBS's cash flows.

For a flattish yield curve, the Z-spread and the spread/WAL tend to be very close to each other. In general, the relationship between the Z-spread and the spread/WAL depend on the shape of the yield curve and the dispersion of the MBS's cash flows.

Option-Adjusted Spread

The yield curve spread, while an improvement over the standard yield spread, is still a static measure; that is, it assumes that interest rates and cash flows remain unchanged. Of course, such an assumption is at variance with reality. Interest rates and prepayment speeds will vary over time in an uncertain manner.

In general, the MBS investor suffers a cost as a result of this variation. We can think of this cost as the value of the embedded option in the MBS resulting from the mortgagors' ability to prepay their loans at any time. However, it is a complicated effect, with several factors at work, and standard option pricing theory can be of limited use.

- The strongest factor is typically **reinvestment risk**. Prepayment speeds tend to increase when interest rates decline, so that the investor has to reinvest an increased amount of prepaid principal at lower prevailing rates. Conversely, if interest rates increase, prepayments will decline, reducing the cash flow that the investor can reinvest at prevailing higher rates.
- Changes in prepayments change the time until each dollar of principal is returned. Thus, for example, for MBSs priced at a deep discount, if there is a decline in interest rates and a corresponding pickup in speeds, the benefit of an earlier return of principal at par may mitigate or even outweigh reinvestment risk. One example is POs, which typically benefit from interest rate and prepayment volatility.
- The impact of typical prepayment patterns is often quite different from that implied by option valuation theory. For example, if speeds on a high-premium security have reached an upper plateau, volatility can be a benefit, because speeds cannot increase much further but can decline significantly. Very high-coupon IOs are an example. In addition, no matter how out of the money

[26] Other names for the Z-spread include *yield curve margin*, *yield curve spread*, and *zero-volatility OAS*.

mortgage loans are, there will always be some prepayments, because of home sales.

How do we incorporate interest rate (and hence, prepayment) volatility in the valuation of MBSs? For a given path of interest rates and a given spread s, the projected value of the MBS is given by equation 2. Financial theory tells us that the value of a stream of contingent cash flows is (under certain conditions) the expected present value of the cash flow stream. Hence, with PV(s) defined as in equation 2,

$$\begin{aligned} \textit{Value of MBS} &= \textit{Average value of PV(s) over all possible interest rate paths} \\ &= \textit{AVGPV(s)} \end{aligned} \quad (4)$$

The option-adjusted spread (**OAS**) is defined as the value of s in equation 4 that makes the value of the MBS equal to its market price; that is, it is the solution of

$$\textit{Price} = \textit{AVGPV(s)} \quad (5)$$

Thus, conceptually, the OAS is a straightforward extension of the traditional yield spread over Treasuries. We start by replacing a single Treasury discount rate by a series of forward rates to determine the Z-spread and then factor in the effect of volatility by calculating this spread over the spectrum of possible future interest rates. However, the actual calculation of the OAS involves some complicated steps, as we discuss next.

Interest Rate Volatility and Calculation of OAS

To calculate the expected value over future interest rate paths, a **term structure model** is needed to describe the evolution of interest rates over time.[27] Such a model must be consistent with today's yield curve (this typically means that the set of benchmark securities, e.g., Treasuries, must be fairly priced under the model — they must have zero OASs), and it should generate interest rate paths that are internally consistent (that do not lead to arbitrage opportunities) as well as consistent with historical interest rate behavior.

A **one-factor** model has just one random factor that shocks the yield curve each period; hence, such a model assumes that different interest rates are perfectly correlated. A **two-factor** term structure model, such as the Citigroup model, avoids this unrealistic assumption and is preferable, leading to more realistic simulated interest rate paths. In addition, Citigroup's model includes another desirable characteristic of term structure models, namely **mean reversion**. This property prevents simulated rate paths from going to levels, such as more than 100%, that seem unlikely for a stable country such as the United States.

Volatility

An important element in the term structure model is the specification of volatilities. A good model should use different volatilities for different maturity rates. For example, three-month Treasury yields tend to be more volatile than ten-year Treasury yields, and the interest rate paths generated by the term structure model

[27] More precisely, the model describes the evolution of the term structure of interest rates, hence the name given to such models.

should reflect this. A term structure model that has different volatilities for different maturity interest rates is said to incorporate a **term structure of volatility**.

Two different sources of volatility inputs are: (1) empirical volatilities calculated from historical interest rates; and (2) the options markets. In the first case, the parameters within the term structure model are adjusted so that simulated interest rate paths display specified volatilities. The second method uses implied volatilities from the options markets. In this case the model parameters are chosen so that the model reprices a chosen set of option instruments. As discussed elsewhere, both methods provide useful insight into MBS value.

Calculation of OAS

Simulation is used to evaluate the expected value in equation 5. The steps are as follows:

1. Using computer-generated pseudo-random numbers and the term structure model, hundreds of hypothetical interest rate paths are simulated, including short-term rates for discounting and longer-term rates that are important for prepayment analysis.
2. On each interest rate path the prepayment model is used to project prepayment rates and, hence, the MBS's cash flows.
3. For each path, the present value of the cash flows is calculated using equation 2, with the discount rates being the short-term forward rates along that path plus a specified spreads. The average of these present values gives us an estimate for the AVGPV(s) term in equation 4.

To find the OAS corresponding to a given market price, we start with an initial estimate for the OAS and use iteration to solve equation 5. That is, we start with an initial spread s, calculate AVGPV(s) and keep adjusting s until AVGPV(s) equals the market price (within a given tolerance). Conversely, we can use equation 5 to find the theoretical price corresponding to a given OAS.

Option Costs and Interpretation of OAS

In Figure 18, which shows a portion of a daily Citigroup report, we illustrate a typical example of OAS analysis.

Figure 18. OASs to the Swap Curve for Fannie Mae Pass-Throughs

Coupon (%)	WAM	Price	Proj. LT CPR (%)	Yield (%)	WAL (Yrs.)	Spread WAL (bp)	Z-Spread (bp)	OAS (bp)	Option Cost
4.5	29-06	92-28	6.80	5.59	9.6	44	28	10	18
5.0	29-08	95-31	7.3	5.63	9.4	50	34	6	28
5.5	29-08	98-30	9.1	5.68	8.2	71	43	2	41
6.0	29-04	101-19	15.9	5.58	5.3	112	57	0	57
6.5	28-02	103-23	19.8	5.36	4.3	115	72	9	63
7.0	27-08	105-09	24.1	5.12	3.5	117	86	18	68
7.5	26-11	106-27	28.0	4.75	3.0	99	87	17	70

CPR Constant prepayment rate. LT Long term. OAS Option-adjusted spread. WAL Weighted-average life.
Note: Prices are as of the close on June 29, 2004, using market vols.
Source: Citigroup.

The option cost is the difference between the zero volatility OAS (the Z-spread) and the OAS. It is a measure of the cost to the investor of volatility in interest rates and, hence, in prepayments. Thus, for the Fannie Mae 4.5%, the Z-spread is 28bp, the OAS is 10bp, and, hence, the option cost is 18bp. The Fannie Mae 4.5% is a discount. Thus, it has some degree of call protection (the option is out of the money), and the option cost is lower than for higher coupons. For the Fannie Mae 6.5%, in comparison, the option cost is much higher, at 63bp as the Fannie Mae 6.5% is a premium and on the "cuspy" part of the prepayment curve. Therefore, small interest rate changes can lead to sharp prepayment speed changes.

As the coupon increases, the option cost eventually starts to decline, even though, theoretically, the coupons are becoming deeper and deeper in the money. This illustrates the complex and multidimensional nature of prepayment behavior. The critical element is not the amount that the coupon is in the money, but the sensitivity of speeds to interest rate changes (or the slope of the prepayment curve). Recall that prepayment speeds, as a function of the coupon, resemble an "S" curve — they tend to be flat for discount coupons, increase sharply as the coupon becomes a premium and then level out at very high premiums. Therefore, speeds on high premiums, like those on discounts, tend to be less affected by small interest rate changes than speeds on cuspy coupons.

What Does the OAS Represent and How Should It Be Used?

OAS analysis has become an essential tool for MBS investors. Its widespread acceptance indicates that most investors are well aware of the optionality inherent in MBSs. However, while OASs are a critical component in analyzing MBSs, investors should be aware of their limitations and of the many assumptions that go into an OAS calculation.

The OAS has been derived here as an extension of the standard spread over Treasuries, to account for the dispersion and uncertainty associated with the return of principal from MBSs. Can it be realized as a return over Treasuries? Theoretically, with dynamic hedging, the answer is yes, *provided that all the assumptions in the model (for term structure movements, prepayments, volatility, etc.) hold true*.

From a practical point of view, it is perhaps best to think of the OAS playing the same role for MBSs (and other callable bonds) as the standard spread does for noncallable bullet bonds; that is, it acts as a useful measure of relative value, allowing an assessment of a MBS's value relative both to other MBSs and to its own past levels. In fact, various studies have shown that, applied consistently over time, OASs can be good indicators of cheap or rich MBSs. However, while the OAS can act an initial filter in identifying seemingly rich or cheap securities, it is a single, summary number, and investors should supplement it with other analyses such as holding-period returns to obtain a more complete risk/reward profile of a security.

Assumptions in OAS Models

Although widely used, market participants maintain some skepticism about OASs. Much of this skepticism derives from the often wide differences in OASs produced for the same securities by different models. However, given the steps involved in the OAS calculation, it would be surprising if such disparities did *not* occur. The two main steps are:

1 Generating a set of interest rate paths; and

2 Projecting prepayment rates along each path.

The first step involves using a term structure model and making a set of volatility assumptions. No consensus exists as to the correct term structure or volatility model, and thus, it is natural that models differ. Similarly, it goes without saying that prepayment projections, which involve assumptions about future demographic trends, mortgagor behavior, housing markets, and economic conditions, will differ from model to model.

Given that it is inevitable that different models will produce different numbers, investors should become comfortable with one or two well-formulated and consistent models — in particular, understanding key assumptions — and use these models.

Effective Duration

Standard duration measures, such as Macaulay or modified, can be misleading for MBSs, because of the dependence of MBS cash flows on interest rates. OAS methods provide a more useful measure, generally known as effective duration.

The standard formula to calculate effective duration is given by equation E9 in Appendix E. Effective duration is defined as the percentage price change for a 100bp parallel change in yields, assuming the OAS remains unchanged. The calculation is illustrated in Figure 19 for a Fannie Mae 6.5%.

Figure 19. Calculation of Effective Duration for a Fannie Mae 6.5% Pass-Through

1	Current price = 103–23	→	OAS = 9bp
2	Interest rates move up 50bp in parallel: OAS = 9bp	→	Price = 101.6
3	Interest rates move down 50bp in parallel: OAS = 9bp	→	Price = 105.2
4	Effective Duration = Pct. price change per 100bp change in yields = 100 x (105.2 – 101.6)/103.7 ≅ 3.5		

OAS Option-adjusted spread.
Note: Based on closing prices and market vols as of June 29, 2004.
Source: Citigroup.

As interest rates change, the usual impact of changing discount rates on fixed-income securities tends to be modified in the case of mortgage securities by changes in prepayments. This effect is most pronounced for cuspy premiums. As interest rates decline, the positive effect of lower discount rates is partly balanced by the negative effect of higher prepayment speeds, resulting in a smaller price increase. Conversely, if rates rise, declines in speeds can lengthen the average life of the MBS, accentuating the discount-rate-related price decline. The net effect typically is that the effective duration is lower than the modified duration for prepayment-sensitive securities. IOs represent an extreme case in which the effect of prepayment changes

overwhelm the discount rate effect, leading to negative durations. However, deep discounts and seasoned high premiums may have similar effective and modified durations, because speeds on these coupons change little for a small change in interest rates.

Effective Durations and Market Price Moves

Market price moves for MBSs often differ from those predicted by effective durations, even for good OAS models. This should not be surprising, given the assumptions used in calculating effective durations. Major assumptions include:

- Constant OAS;
- Parallel yield curve shifts;
- No change in other relevant factors, such as mortgage rate to Treasury spreads and volatilities; and
- Symmetric price changes.

These assumptions rarely hold in practice, leading to deviations between effective and empirical durations.[28] Furthermore, interest rates changes can lead to substantial shifts in a particular MBS's effective duration. For example, the effective duration of a conventional 6.5% is projected to drop from about 3.5 to about 1 if interest rates decline by 100bp (other things being equal). However, over a longer period of time, as deviations from assumptions average out, effective durations from a good OAS model should track empirical durations.

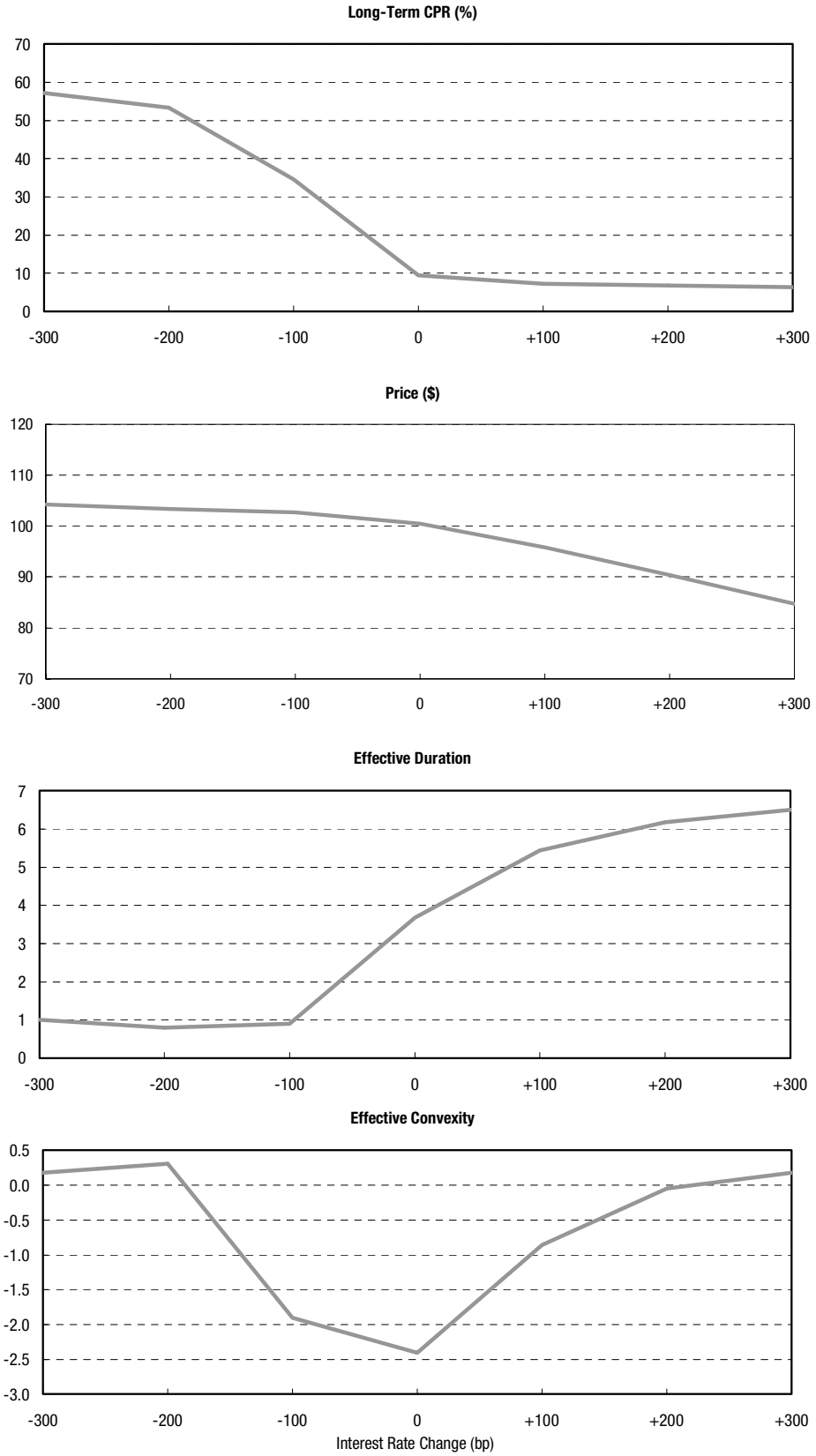
Convexity

As with duration, OAS methodology leads to more meaningful convexity estimates for MBSs than traditional measures. The formula used to calculate convexity for MBSs is given by equation E10 in Appendix E. As with the effective duration calculation, price changes are calculated assuming parallel yield curve shifts and a constant OAS, with the convexity calculated by comparing the relative price change in up-rate moves with that in down-rate moves.

Noncallable bonds have positive convexity; that is, the percentage price increase if interest rates decline is greater than the percentage price decline if rates increase by the same (small) amount. In other words, if the price is plotted against various interest rates, the curve will be convex. For MBSs, convexity is often negative, because rising prepayment rates dampen the price increase in declining rate scenarios. Figure 20 plots projected prices, effective durations, and convexities for a conventional current-coupon MBS at various interest rate levels.

[28] Empirical durations refer to those calculated from market price changes. For a more detailed discussion of mortgage durations, see *Mortgage Durations and Price Moves*, Citigroup, March 2001.

Figure 20. Current-Coupon MBS — Projected Speeds, Prices, Durations, and Convexities for Various Interest Rate Changes



Parallel shift in basis points. CPR Constant prepayment rate.
Source: Citigroup.

As interest rates drop, the current-coupon MBS becomes a premium, and prepayments accelerate, leading to a slowdown in price appreciation, which is reflected as a decline in duration. This decline in turn is reflected in the negative convexity of the bond. As rates keep dropping and projected speeds on the MBS level off, the duration and the convexity start to increase. In fact, for a 200bp drop, the convexity becomes positive; the MBS is a high premium, speeds have leveled off, and it assumes some of the characteristics of a short fixed-cash-flow bond.

If interest rates increase, prepayments on the MBS slow down and become less sensitive to rate changes. As a result, the duration and convexity both increase, with the convexity again eventually becoming positive.

What Does Negative Convexity Mean for Investors?

Convexity is a method to estimate the impact of prepayment variation on the likely price appreciation of an MBS. For an MBS, negative convexity dampens the price appreciation if interest rates fall. Thus, even though the MBS may have significantly higher returns than a comparable Treasury under unchanged rates, it may underperform the Treasury if rates drop.

However, subject to the assumptions in the model, the OAS incorporates the impact of prepayment volatility and, hence, of negative convexity. Does this mean that two bonds with the same OAS should be treated the same, even if one has much more negative convexity than the other? To some extent, yes, because presumably the MBS with the greater negative convexity had a higher nominal yield to arrive at the same OAS. However, to the extent that reality deviates from the assumptions in the OAS model and given that it is difficult to dynamically hedge the MBS so as to fully realize the OAS, higher negative convexity does imply a greater degree of uncertainty about the OAS. This observation reinforces the point made earlier: that investors should supplement OAS with scenario and holding period analysis to obtain a more complete risk/reward profile for the MBS, as well as stress-testing the results by changing some of the assumptions (e.g., refinancing sensitivity) in the model.

V. Mortgage Securities Lending

Securities lending markets, which in essence involve the temporary exchange of cash for securities, are huge and extremely active. The mortgage securities lending market, in particular, is very active because of the high credit quality and liquidity of most MBSs. In this section we explain the mechanics of the transactions that take place in this important market.

Although there is a fair amount of variation in the transactions that are characterized as securities lending activity, mortgage securities lending essentially occurs through two channels: **repurchase transactions** and **dollar rolls**. We provide more precise definitions of these activities later, but in the broadest terms, repurchase transactions are securities transactions in which one party agrees to sell securities to another in return for cash, with a simultaneous agreement to repurchase the same securities at a specific price at a later date. At the termination of the transaction, the securities are resold at the predetermined price plus a previously determined interest rate. A dollar roll is analogous to a repurchase transaction except that the party borrowing the securities does not have to return the same securities, but can instead return "substantially similar" ones.

Why would two parties participate in such transactions? There is no single answer to this question because there are a number of participants in securities lending markets and their motivations may vary. The key point is that because the lending activity is secured by collateral, the borrowing rate is typically lower than the interbank short-term uncollateralized lending rate. So, for example, a hedge fund that wishes to increase its leverage may loan its securities for cash to finance its positions cheaply. An institutional investor, such as a pension fund, may lend out securities from its portfolio to boost income or to defray custodial fees. A broker-dealer may borrow and lend securities as part of its market-making activities. Such activities might include borrowing securities to cover a short position or simultaneously borrowing and lending securities to earn a higher rate on the securities loaned versus the securities borrowed.

Securities lending activities are a vital part of today's capital markets and provide an important source of liquidity and flexibility to all market participants. The factors that fueled the growth of these activities in the past — an increase in the amount of outstanding securities, the development of custodial and securities lending departments, and the active short-term cash management strategies employed by investors — should continue to provide a strong impetus in the future.

Repurchase Transactions

A **repurchase agreement** (**repo**) is an agreement between a **seller** and a **buyer**, in which the seller sells securities to the buyer with a simultaneous agreement to repurchase the securities at an agreed-upon price (**repurchase price**) at a future point in time (**repurchase date**).[29] The seller is charged interest (at the **repo rate**) for the

[29] The **seller** is also referred to as the **borrower** (of funds), and the **buyer** is also referred to as the **lender** (of funds).

use of funds and, typically, pays these interest costs at the maturity of the repo. The buyer of the securities is said to have entered into a **reverse repurchase** (**reverse repo**) agreement.

Because the repo is a form of secured lending, it may provide a relatively inexpensive source of funding compared with other short-term money-market instruments of similar duration. In general, the following factors primarily determine the repo rate: (1) the credit quality of the underlying collateral; (2) the maturity of the repo; and (3) the liquidity of the collateral. In addition, to provide a buffer against a loss in the market value of the security, the lender of funds usually requires a **margin** amount. In practice, the margin amount is established by lending out a sum of money less than the market value of the underlying collateral. The difference between the market value of the collateral and the dollar proceeds lent out is called a **haircut**.

Mechanics

Collateral

A variety of collateral types are allowed in a repo, including agency pass-throughs (Ginnie Mae, Fannie Mae, Freddie Mac), agency REMICs, double-A and triple-A nonagency CMOs, double-A pass-throughs, and whole loans. The seller receives the *identical* collateral back at the maturity of the repo.

Haircut

The haircut deducted in a repo is used to set up a margin account that the buyer (the lender of funds) will use as a hedge against a decline in the market value of the securities. Haircuts range from 1% to 10%, but can be as high as 25%–50% if the securities are perceived to have high price volatility or low liquidity. The haircut can also depend on the fiscal strength of the borrower (the seller of securities). The securities are typically **marked to market** on a daily basis. A decline in the market value of the securities can result in a **margin call**, whereas an increase will result in a payment to the borrower of funds. Margin calls must be settled promptly; **T+0** is typical.

Term

The length of a repo can extend from one day (**overnight repo**) to more than one day (**term repo**) or be **open**. An **open repo** is equivalent to a series of overnight repos on the same security, with the repo agreement effectively being renewed each day at a new rate. Term repos cover specified periods rarely extending beyond three months, with 30 days the most common term.

Title

The party entering into the repo (the borrower of funds) loses title to the security over the repo period. However, all payments of principal (scheduled or unscheduled) and interest are forwarded to the original owner. The transfer of title allows the buyer (the lender of funds) to now "repo out" the securities (sell the securities and, thus, borrow money) if it so desires. This activity of combining repos and reverse repos is commonly known as a "repo book."

Repo Calculations

Repo calculations are straightforward. The **repo principal** (the funds provided to the borrower) is simply the market value of the collateral obtained by the lender, reduced

by the haircut. The interest cost of the loan (**repo interest**) is obtained by applying the repo rate to the repo principal. Figure 21 provides a sample calculation.

Figure 21. Sample Repo Calculation

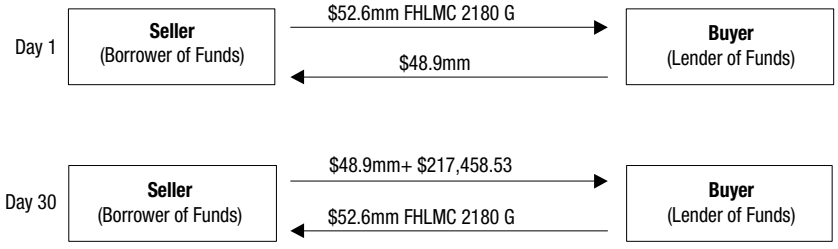
Repo $52.6 Million Freddie Mac CMO 2180 Class G for 30 Days at 5.34% With a 5% Haircut	
Repo Principal	= Par Amount * Factor * ((Bid Price + Accrued) / 100) * (1 – Haircut) = $52,555,848 * 1.000 * ((97-22 + 0-06) / 100) * (1 – 0.05) = $48,867,084.42
Repo Interest	= Repo Principal * Repo Rate * Repo Term in Days / 360 = $48,867,084.42 * 5.34 / 100 * 30 / 360 = $217,458.53

Source: Citigroup.

We note two points about the calculation in Figure 21. First, the bid price of the security is for cash settle (T+0). Second, the cash flow characteristics of the repoed bond are *not* relevant to the transaction because the buyer (the lender of funds) does not retain any coupon or principal payments, but passes them on to the seller (the borrower of funds). Of course, the second observation is not strictly true in the sense that the repo rate and the haircut charged are influenced, to some extent, by how volatile the cash flows of the MBS are, because this volatility, in turn, will affect how the market value of the security fluctuates.

Figure 22 illustrates the flows of cash and securities in a representative repurchase transaction.

Figure 22. The Repo Transaction



Source: Citigroup.

As discussed, repos constitute a form of secured lending, and as a result, repo rates are typically lower than other short-term (unsecured) borrowing rates. For example, the one-month mortgage repo rate might be roughly 10bp lower than one-month LIBOR. In this case, a mortgage investor could have earned an incremental return of approximately 10bp per year by funding his mortgage securities through repos versus simply holding them (assuming interim cash flows are invested in one-month LIBOR). More recently, with rates close to all-time lows, spreads have become compressed, making it difficult to profit from this strategy.

Risks

Credit Risk

Credit risk refers to the possibility that one of the parties to a repo transaction may default, which in turn may result in the loss of the full value of the securities borrowed or funds loaned. For example, if the borrower of funds defaults, the lender

can liquidate the collateral but may still not be able to recoup the full amount of the repo principal. To hedge against this particular risk, the lender charges the haircut. In addition, both parties usually evaluate the credit quality of their counterparties before entering into a repo transaction. Whatever the hedge employed, it should be kept in mind that hedge ratios often break down in extreme market conditions.

Liquidity Risk

A market disruption, such as a squeeze, may result in the lender's being unable to deliver the securities back to the borrower at settlement. This qualifies as a failed transaction, rather than a default, because the lender will typically be able to settle the transaction at a later date.

Market Risk

The repo position may suffer because of an adverse move in the market prices of assets or interest rates. For example, a borrower locked into a fixed-term repo financing arrangement is subject to interest rate risk, which is the risk that an initially attractive borrowing rate may become very costly if short-term interest rates fall substantially over the course of the repo.

Settlement Risk

Both parties to a repo may risk the loss of the full value of the securities or funds if the exchange of securities for funds is not completed in both legs of a repo transaction. For example, such a situation may occur if it is possible to complete delivery of funds without simultaneously receiving delivery of collateral. To avoid these situations, settlement of a repo transaction usually takes place on a delivery-versus-payment (DVP) basis, where delivery of securities takes place if and only if payment of cash occurs at the same time.

Dollar Rolls

Dollar rolls are another way to obtain financing via the mortgage market. Repurchase agreements do not involve the transfer of a security's cash flows; principal and interest continue to be sent to the original owner. In contrast, in a dollar roll transaction, the original owner gives up principal and interest to the temporary holder of the securities (assuming record dates are passed during the period of the roll). In addition, the returned security does not have to be exactly the same as the original security, but instead should be "substantially similar" to qualify as a financing transaction (rather than a sale and purchase). "Substantially similar" has been defined in the American Institute of Certified Public Accountants *Statement of Position 90-3* as meaning that the original and returned security should be of the same agency/program, original maturity, and coupon (for example, 30-year Freddie Mac Gold 5s) and both should satisfy good delivery requirements. The dollar roll can be thought of as two simultaneous transactions, one buy and one sell order, for the same TBA security for different settlements.

For an investor with a long position in pass-throughs for forward settlement who wants to avoid actually taking delivery of bonds (and subsequently receiving principal and interest payments), rolling the position forward each month can be attractive from a financing as well as operations perspective. By continually rolling the position forward, he stays invested in mortgages, but never reaches settlement for

receiving bonds and often obtains an attractive financing rate on the funds obtained during each roll period. Figure 23 compares the main features of repos and dollar rolls.

Figure 23. Repo (Repurchase Agreement) Versus Dollar Roll

	Repo	Dollar Roll
Security Type	Any	Pass-through
Financing Rate	Usually related to general collateral	Often lower than repo rate (at times, substantially lower)
Principal and Interest	Goes to original owner	Goes to holder on each record date
Used for Short Covering	No	Yes
Haircut	Yes	No
Identical Securities Returned	Yes	No
Prepayment Risk	No	Yes

Source: Citigroup.

A Sample Dollar Roll Computation

Suppose a Citigroup pass-through trader "buys $2 million of the July/August roll" for Freddie Mac Gold 5s down 10/32nds ("the drop") from an investor. If the price for Bond Market Association July settlement is 95-29, then the trader is simultaneously buying $2 million Gold 5s for July settlement (July 15, 2004) at a price of 95-29 and selling $2 million for August settlement (August 12, 2004) at a price of 95-19 (= 95-29 - 0-10). This transaction gives the trader a long position from July 15 to August 12, which could be used to collateralize a CMO deal settling at the end of July, for example. (The trader would subsequently need to go long to cover his short position for August settlement.) Figure 24 shows the mechanics of the roll for the trader and investor. Figure 24 shows the net proceeds for the trader and investor (for the cases of rolling and not rolling).

Figure 24. Dollar Roll Example Per $100 Face (Period for Dollar Roll is 28 Days: 15 Jul–12 Aug)

Date	Transaction	Trader	Investor
Jul 15	Trader buys from investor	Pays 95-29 + accrued interest = 96.101 for bonds	Receives 95-29 + accrued interest = 96.101 for bonds and invests 96.101 in money market near Fed funds rate at 1.09%.
	Investment	96.101 (in securities)	96.101 (in cash).
Aug 12	Investor buys back from trader	Receives 95-19 + accrued interest = 95.747 for bonds. Also pays for 0.3% of 100 for Aug to make up for expected paydown (price is 95-19 + accrued interest = 95.747, transaction done simultaneous to dollar roll).[a]	Pays 95-19 + accrued interest = 95.747 for bonds (reestablishing original long position). Receives proceeds of 96.101 * (1 + 0.0109 * 28/360) = 96.182 on money market investment.
Aug 16		Receives payment corresponding to July payment period, principal paydown 0.3% and one month of interest. (These cash flows are present valued back to Aug 12 to obtain net proceeds in Figure 25.)	

[a] Because of principal paydowns, the trader will not have the same amount of bonds to give back to the investor and so must purchase additional bonds to make up for these paydowns. In practice, this is not a concern.
Source: Citigroup.

Figure 25. Dollar Roll Example: Net Proceeds Per $100 Face

Date	Scenario	Trader	Investor
Aug 12	If investor does roll	(1 – 0.003) * 95.747 + (0.3 + 5.0 / 12) / (1 + 0.0109 * 4 / 360) = 96.176, which implies (96.176 / 96.101 - 1) * 360 / 28 = 1.01% financing rate (annualized)	96.182 – 95.747 = 0.435
	If investor does not roll		-0.003 * 95.747 + (0.3 + 5.0 / 12) / (1 + 0.0109 * 4 / 360) = 0.429

Source: Citigroup.

The investor can roll his position (as shown on the right side of Figure 24), or the investor can choose not to roll his bonds. In this latter case, the investor receives the principal paydown and coupon interest and pays for 0.3% of bonds to make up for the principal paydown (this 0.3% purchase just serves to make it easier to compare the two cases of rolling and not rolling bonds). As shown in Figure 25, the proceeds from not rolling (0.429) are almost the same as those in the case of choosing to roll the bonds (0.435). Put another way, the implied financing rate of 1.01% (calculated in Figure 25 under the "Trader" column) is very close to the 1.09% investment rate available. There is no significant advantage to rolling the Gold 5s in this example (the roll for these bonds is said to be "trading at or near carry"). Note that prepayment risk, which enters through the principal paydown, was not considered.[30]

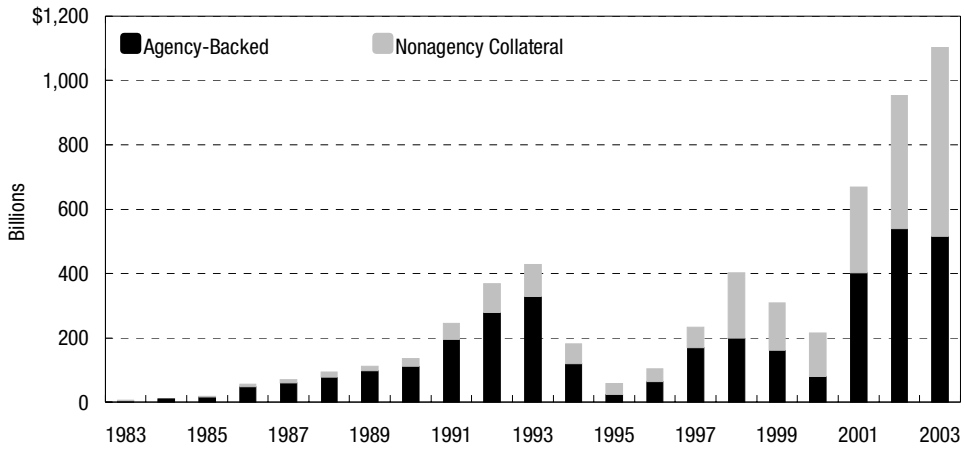
[30] It was assumed that the principal paydown could be forecast perfectly accurately in the example. In practice, there is always some uncertainty about what the paydown will turn out to be. For a more comprehensive look at dollar rolls, see *Dollar Rolls – In Practice and Theory*, Citigroup, July 1, 2004.

VI. Structured Mortgage Securities

Despite the dramatic growth of the mortgage pass-through market, the cash flow characteristics of pass-throughs did not meet all of the needs of some institutional investors. To broaden the range of potential investors, structured mortgage-backed instruments with a variety of maturity and prepayment profiles have been created out of basic mortgage cash flows.

A landmark in the development of the MBS market occurred in June 1983, when Freddie Mac issued the first CMO. Since then, the CMO market has grown rapidly, and as of year-end 2003, more than $5.7 trillion of CMOs had been brought to market by the agencies, investment banks, mortgage bankers, thrifts, home builders, insurance companies, and commercial banks (see Figure 26). In recent years, the majority of CMOs backed by agency collateral have been issued under the Fannie Mae and Freddie Mac name.[31]

Figure 26. Collateralized Mortgage Obligations — Issuance, 1983–2003 (Dollars in Billions)



Source: *Inside MBS & ABS*.

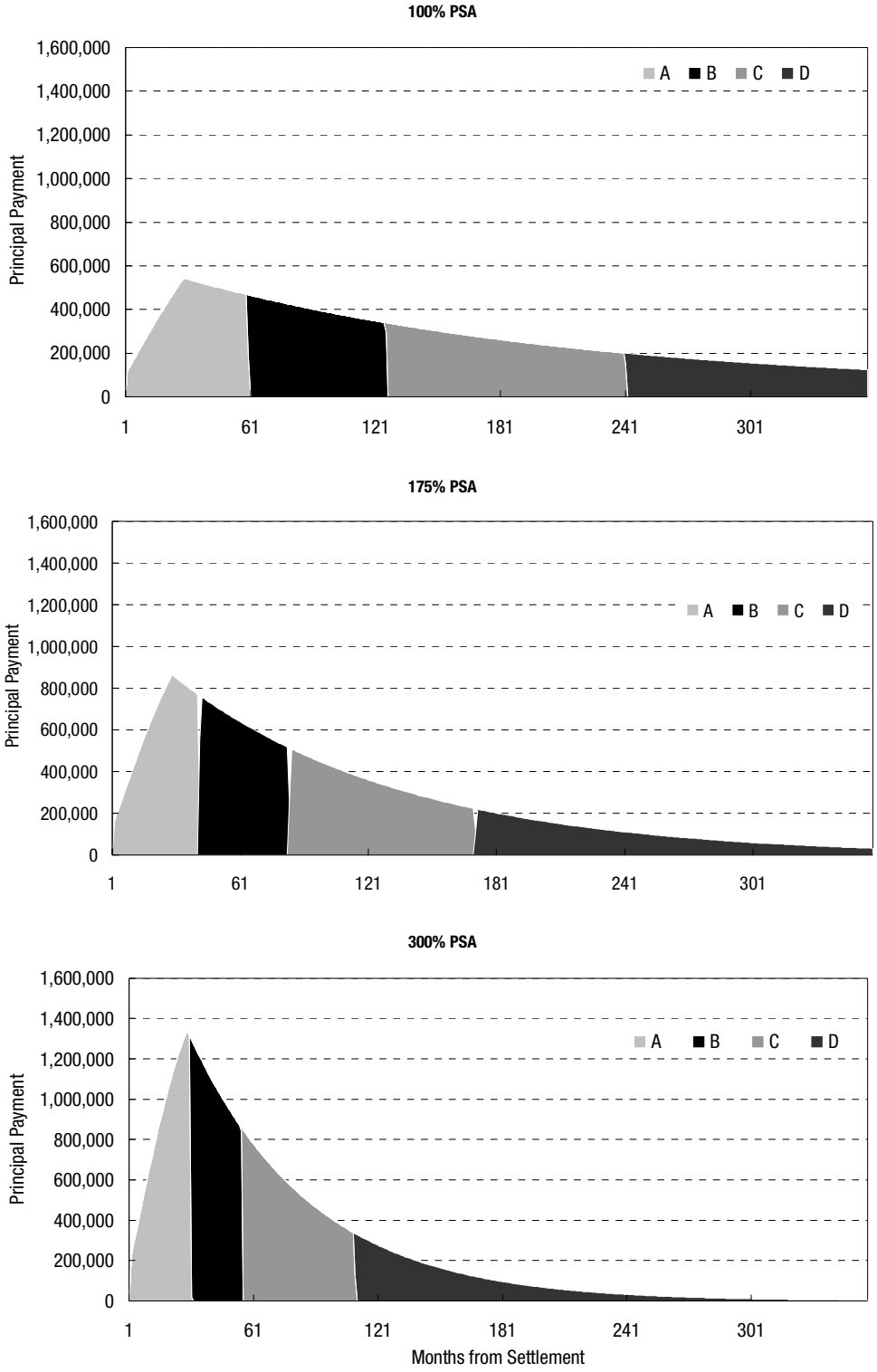
Development of the CMO Market

CMOs comprise a number of classes of bonds issued against specified mortgage collateral. The collateral can be agency pass-through pools, whole loans (typically nonconforming loans), or classes from other CMO deals (termed Re-REMICs). Early CMO structures, which typically had three or four classes, illustrate well the basic CMO principle. Figure 27 shows a hypothetical CMO with four classes labeled A, B, C, and D. These classes, or tranches, are retired sequentially. All principal payments are directed first to the bonds with the shortest maturity, the class A bonds. When the A bonds are retired, the principal payments are directed to the bonds with the next shortest maturity, the class B bonds. The process continues until all of the bond classes have been paid off. The allocation of cash flows from a pool of mortgages

[31] The term real estate mortgage investment conduit (REMIC) is often used synonymously with CMOs. The Tax Reform Act of 1986 allowed CMOs to be issued in the form of REMICs, which have certain tax and accounting advantages for the issuer. Most CMOs are issued now as REMICs.

among the classes of this type of CMO is illustrated in Figure 27 at several different prepayment rates.

Figure 27. Four-Tranche Sequential-Pay CMO — Projected Principal Payments at 100%, 175%, and 300% PSAs



Source: Citigroup.

The CMO structure shown in Figure 27 creates short-, intermediate-, and long-term MBSs from the underlying collateral, giving investors a choice of maturities. Class A remains a relatively short-term security even if prepayment speeds slow down, while the later classes obtain a degree of call protection because the earlier classes act as a buffer against prepayments.

In addition to the desire for more choice in maturity characteristics, several other factors played a role in the expansion of the CMO market:

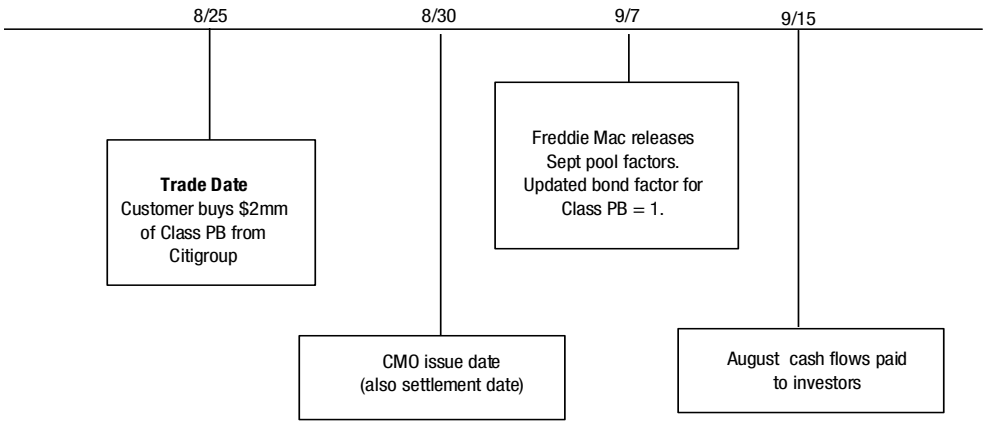
- The size of typical CMO deals means that monthly speeds are less erratic than for a typical pass-through pool. CMO deals are typically collateralized by several hundred pools, which leads to geographical diversification in the underlying loans as well as a reduction in the degree of "noise" in monthly prepayments;
- Agency CMOs offer the same high credit quality as corresponding agency pass-throughs; and
- CMO classes often offer attractive yields relative to other comparable credit quality fixed-income instruments.

Another major factor in the expansion of the CMO market was the development of numerous CMO bond types, catering to different investor needs — in essence, customizing mortgage cash flows.

A CMO Trade

On July 23, 2004, Citigroup prices Freddie Mac 2844, a collateralized mortgage obligation (CMO) deal backed by Freddie Mac 5% pass-throughs.[32] The CMO issue date (the day on which the CMO settles) is August 30, 2004. Among the bonds in this deal is Class PB, a six-year PAC bond with a coupon of 5%. On August 25, 2004, a customer agrees to buy $2 million face value of Class PB at a price of 102-00. Figure 28 shows a timeline of the trade.

Figure 28. New-Issue CMO Bond — Freddie Mac 2844, Class PB: Purchase and Settlement



Source: Citigroup.

[32] More precisely, group 1 of this deal is backed by 5s. CMO deals often consist of a number of "groups," each of which, in practice, acts as a separate deal.

Settlement Date

Newly issued CMOs normally settle when the deal settles (issue date). (In secondary trading of CMO classes, the settlement is T+3, or three business days after the trade date.) The **accrual date** for agency CMOs — that is, the date from which interest starts to accrue on the bonds — is, as with agency pass-throughs, usually the first of each month, or August 1, 2004, in this case.

Settlement Calculations

Because this is a new issue, the current **bond factor** is 1.0, so the current face is equal to the original face of $2 million. Because the accrual date is August 1, 2004, the accrued interest is:

Accrued interest = Current face * coupon rate * (day of month - 1) / 360
= $2,000,000 * 5% * (30 - 1) / 360 = $8,055.56

Hence, the total amount due from the investor is:

Total amount due = Current face * (price / 100) + accrued interest
= $2,000,000 * (102 / 100) + $8,055.56
= $2,048,055.56

Record Date

The record date is the last business day of the month, or August 31, 2004, in this case.[33] The customer is noted as the owner of $2 million of Class PB and, hence, entitled to August interest and principal payments, which are paid with a delay in September.

Updated Pool and Bond Factors and Investor Cash Flow Calculations

As shown in Figure 9, Freddie Mac releases updated pool factors on the evening of the fourth business day of the month. The CMO deal trustee uses these pool factors, which reflect principal payments on the underlying loans during the previous month, to calculate principal payments due to the various classes in the CMO, according to the principal allocation rules specified in the deal prospectus and, hence, to calculate updated (or current) bond factors for each class. In this case, all of the August principal payments were allocated to other classes in the deal, so the updated bond factor for Class PB remains at 1.00 (signifying that none of the principal backing this class has yet paid down). In other words, Class PB is not yet in its principal payment window.

Calculation of August Cash Flow for Class PB

Payment dates for agency CMOs usually correspond to the payment dates for the underlying pass-throughs. For Freddie Mac, the payment date is the fifteenth of the month. The interest paid is:

Interest payment = Face amount (as of August 1, 2004) * coupon rate / 12
= $2,000,000 * 5% / 12 = $8,333.33

[33] The payment goes to the holder of the security as of the close of business on this date.

Because the updated bond factor for Class PB is 1.00, it receives no principal (principal payments on the collateral are directed to other bonds in the deal, as specified in the prospectus).

CMO Bond Types

The classes in the hypothetical CMO deal shown in Figure 27 are usually labeled sequential bonds, for the obvious reason that principal is allocated sequentially to the classes. A glossary of standard agency definitions of the many different bond types developed over the years is given in Appendix C. Here, we provide a brief description of the main types.

Accrual or Z-Bonds

The Z-bond was the first departure from standard sequential bonds. As the name implies, Z-bonds receive no interest until their principal payment window starts. Instead, the interest due is accrued and added to the Z-bond's principal balance, which, as a result, increases until earlier classes are retired, and collateral cash flows are directed toward making interest and principal payments to the Z-bond. The Z-bond was typically the last bond in a CMO deal, although in recent years many deals placed Z-bonds earlier in the structure.

A Z-bond has a beneficial effect on the cash flow stability of earlier bonds, because the interest that should have been paid to the Z-bond is used to pay down the other bonds. For example, if prepayment speeds slow, the growing balance on the Z-bond and the increasing amount of Z-bond interest available for paying down the other bonds can partially balance the effect of slower collateral principal payments.

PACs, TACs, and Companions

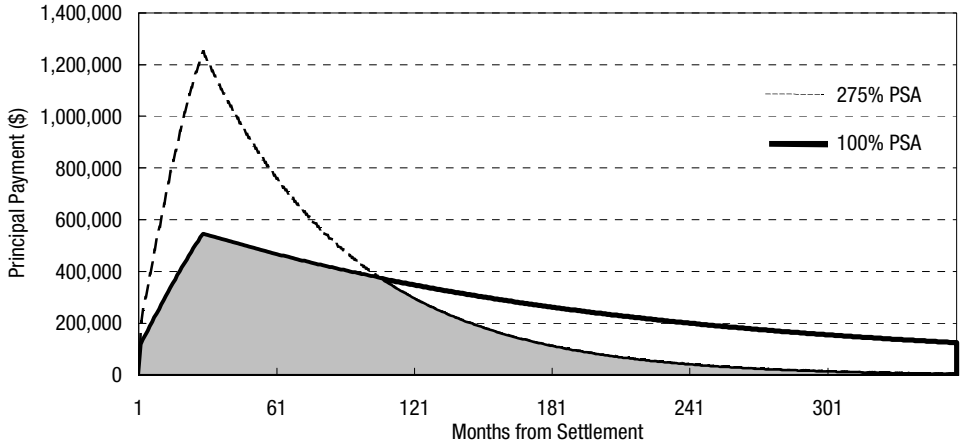
Planned amortization class (PAC) bonds are perhaps the most important innovation in the CMO market to date. First issued in 1986, PAC bonds and their various offshoots have dominated CMO issuance since early 1989. Because of their central role in the CMO market, we discuss PACs in somewhat more detail here than other CMO bond types.

PACs expand on the basic rationale behind CMO bonds. Whereas the early CMO bonds used sequential segmentation of principal to offer investors a better defined maturity profile than pass-throughs, PAC bonds go further and essentially remove maturity uncertainty provided prepayments stay within a given range. A PAC bond is characterized by a specified principal payment schedule (much like a sinking fund on a corporate bond). In allocating principal paydowns from the collateral to the CMO bonds, priority is given to meeting the PAC principal schedule; thus, other bonds in the deal, termed **support** or **companion** bonds, for obvious reasons, absorb prepayment variations as much as possible. As might be expected, companion bonds typically have a high degree of WAL sensitivity to prepayment changes and tend to be priced at higher yields as compensation.

A PAC bond's degree of prepayment protection is typically characterized by **a PAC band**, such as 100% to 275% PSA. The PAC's principal payment schedule is derived by taking the minimum of the collateral principal payments at two constant

speeds (in this example 100% PSA and 275% PSA), as shown Figure 29. These two speeds constitute the PAC band.

Figure 29. Creating a PAC Redemption Schedule With a Protected Range of 100%–275% PSA



Source: Citigroup.

The shaded area in Figure 29 represents the maximum available principal paydown schedule for the specified PAC band. The PAC's payment schedule will be met as long as the collateral prepays at a constant prepayment rate that is within the stated PAC band. The schedule may not be met if speeds vary over time, even if, on average, they stay within the PAC band.

Offshoots of PAC bonds include **Targeted Amortization Class** (**TAC**) bonds, **reverse TACs**, **PAC Is**, **PAC IIs**, and so on. TAC bonds are in essence one-sided PACs; they provide a degree of call protection if prepayment speeds increase from pricing assumptions. Reverse TACs, as the name implies, provide protection against a slowdown in speeds. PAC Is, PAC IIs, and so on are PAC bonds with progressively narrower PAC bands than standard PAC bonds.

A more detailed analysis of PAC structures is provided elsewhere.[34] Some general rules of thumb should be kept in mind:

- PAC bonds typically have more call risk than extension risk. The lower PAC band — typically 80%–100% PSA for conventional collateral and lower for Ginnie Maes — is unlikely to be broken to any appreciable degree, because normal housing turnover implies that average speeds are unlikely to fall below the lower PAC band for any length of time. However, if interest rates drop, speeds may well exceed the upper band (typically 250%–400% PSA), especially for coupons exposed to refinancing opportunities for the first time.
- As prepayments vary from the pricing speed and support bonds are paid down at rates different from initial pricing assumptions, the effective PAC bands will change, a phenomenon known as PAC band drift. This drift is typically small and gradual, with the lower and the upper bands rising. However, the effect does emphasize that it is essential to evaluate PAC (and other CMO) bonds using a

[34] See *An Introduction to CMO Cashflow Structures*, Citigroup, April 2001.

vector of monthly projections rather than a single (or scalar) projected CPR or PSA.

➤ In most cases, short-term PACs (WALs less than two to three years) have low prepayment uncertainty. Even if prepayment speeds pick up significantly, the companion classes will still be there to absorb the extra principal payments.

It is difficult to make general statements about PACs (or other CMO bonds). Much depends on the collateral and its prepayment profile as interest rates change. Also important is the structure of the CMO — for example, the amount of support classes remaining in the deal. Although CMO bonds are typically priced at a spread over a benchmark Treasury, OAS analysis is critical in evaluating the effect of changing interest rates and prepayments on a particular CMO structure.[35]

Floating-Rate Bonds

Floating CMO bonds were first issued in September 1986. The coupons typically reset monthly at a stated spread over an index (LIBOR being the most common) subject to a cap on the coupon. Floating-rate CMOs appeal to many European and Japanese investors, as well as US commercial banks and thrifts.

The cap on floating CMO bonds is typically higher than the coupon on the fixed-rate collateral, because a low cap would diminish the floater's appeal to investors. In structuring such bonds, it is necessary to ensure that the coupon income from the collateral is sufficient to make the coupon payments on the floaters for any combination of the index and prepayment rate.

The usual solution is to pair the floater with an **inverse floater**, which pays down simultaneously with the floater. As suggested by the name, the coupon on the inverse floater moves inversely with the index, such that the combination of the floater and the inverse floater is a fixed-rate bond with a coupon equal to or less than the collateral coupon. This constraint still allows a fair degree of flexibility in the structuring of the bonds. For example, if we issue $80 million of the floater and $20 million of the inverse, it is not difficult to see that for every basis point increase in the index (and, hence, in the floater coupon), the coupon on the inverse has to decline by a factor of 80/20, or four. This number is termed the **multiplier** or **leverage** of the inverse floater coupon. Alternatively, we could issue $66.67 million of the floater and $33.33 million of the inverse floater, in which case the inverse floater would have a multiplier of two.[36] Floaters can be structured, in terms of principal paydown types, as sequential-pay bonds, PACs, TACs, companions, and so on.

Conceptually, CMO floaters are straightforward extensions of standard floating-rate bonds, with prepayment variability adding a new dimension. OAS methodology provides a means of estimating the net combined effect of the cap and of prepayment variations. Typically, CMO floaters offer cap- and prepayment-adjusted returns superior to those of similar credit quality standard floaters.

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[35] Also useful is a technique called **distribution analysis,** which involves examining WALs and other bond characteristics over the hundreds of paths used to calculate OASs, for example, examining the WAL stability of a PAC bond over varied and realistic interest rate paths. A description of distributional analysis is given in "Anatomy of PAC Bonds," Michael Bykhovsky and Lakhbir Hayre, *Journal of Fixed Income*, June 1992. Citigroup's Yield Book allows distributional analysis for CMOs.

[36] Obviously, the coupons have to be modified for caps and the inverse floater coupon has a floor.

Inverse floaters are an unusual type of instrument. Properly used, they provide a unique means of reducing the interest rate exposure of a fixed-income portfolio, and they have the potential to provide very high returns. However, inverse floaters are exposed to a variety of interest rate and prepayment risks and are recommended only for investors possessing the background and analytic tools to understand these risks.

Stripped Mortgage-Backed Securities

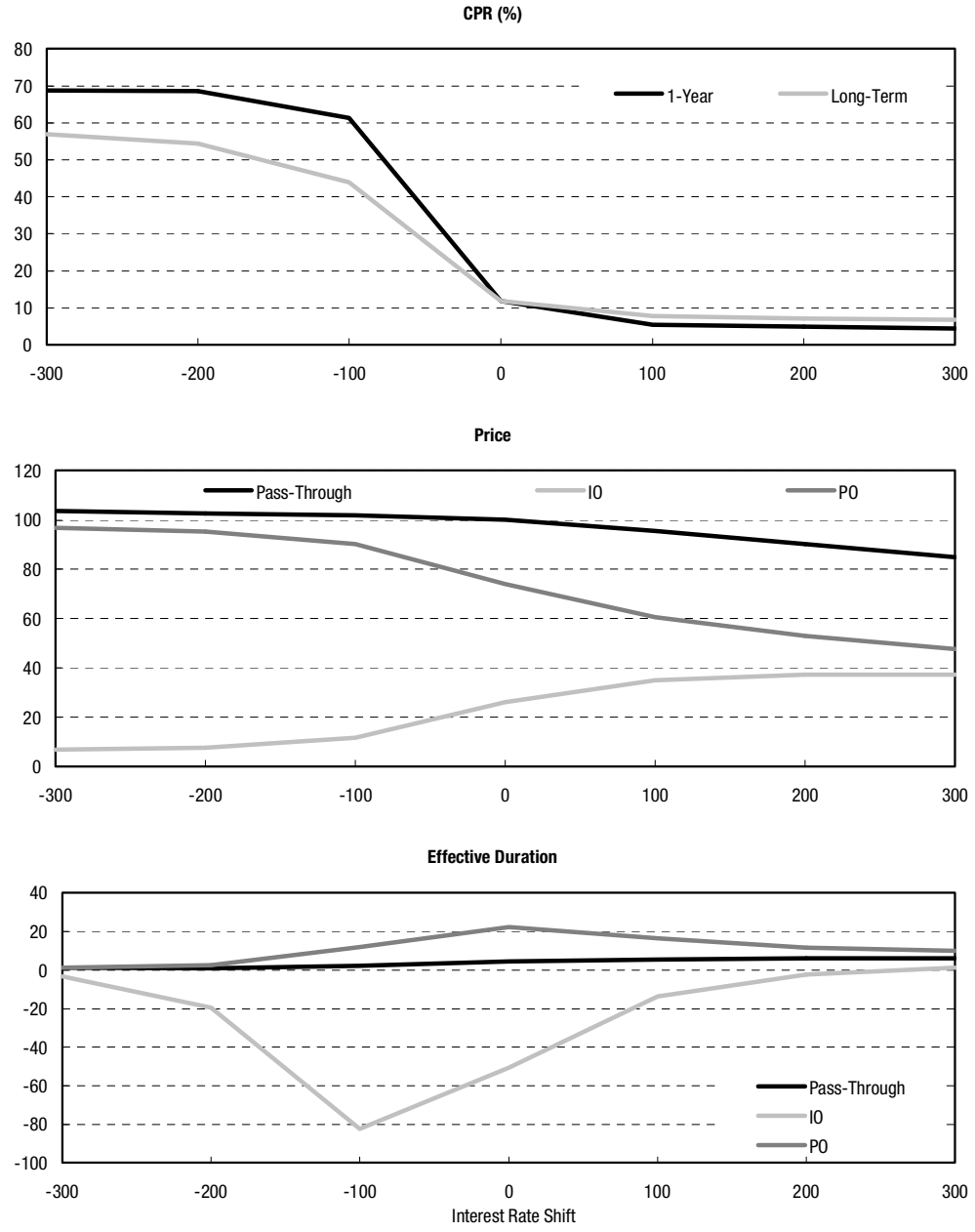
First issued in 1986, mortgage STRIPs are created by dividing the cash flows from a pool of mortgages or mortgage securities and allocating specified percentages of interest and principal to each new STRIP. For example, a Fannie Mae 6% pass-through can be stripped to produce two securities, one with a 4.5% coupon and the other with a 7.5% coupon, simply by directing more of the interest from the underlying collateral to the higher coupon and less of the interest to the lower coupon. If the ratio of interest to principal is varied, STRIPs with a wide range of coupons and performance characteristics can be created.

The predominant types of mortgage STRIPs (constituting almost all the issuance in recent years), and the most elementary, are IO and PO STRIPs. IO STRIPs receive all of the interest payments from the underlying collateral and none of the principal. PO STRIPs receive all of the principal and none of the interest.

IOs and POs are much more sensitive to prepayment rate changes than the underlying collateral. Faster prepayments reduce the principal balance of the underlying collateral more rapidly, leading to smaller interest payments in future periods and hurting the IO, but returning principal at par at a faster rate, helping the PO. Conversely, slower prepayments help IOs but hurt POs.

Figure 30 shows projected speeds, prices, and effective durations under changing interest rates for hypothetical IOs and POs and for the underlying current coupon pass-through collateral. The graph illustrates the complex combined effects of changing discount and prepayment rates on IOs and POs.

Figure 30. Hypothetical Current-Coupon IOs and POs — Projected Speeds, Prices, and Durations in Various Interest Rate Scenarios



Source: Citigroup.

- As interest rates decline, speeds on the collateral begin to accelerate. For the PO, higher speeds combined with lower discount rates boost the price, leading to a high positive duration and giving the PO positive convexity. For the IO, the price actually falls as interest rates decline, as higher speeds overwhelm the effect of lower discount rates. Thus, the IO displays negative duration.
- As interest rates continue to drop and prepayments begin to level off, the rate of price appreciation for the PO begins to slow, while for the IO the price begins to level off. Fairly stable speeds mean that the discount rate effect becomes relatively more important. Thus, the duration of the PO starts to decline, while that of the IO begins to increase.

- Increasing interest rates lead to slower prepayments, which hurt the PO and help the IO. The IO price increases as slower prepayments outweigh higher discount rates. Again, however, as interest rates keep increasing and speeds level off at the lower end of the prepayment S curve, the effect of lower discount rates begins to dominate, and the IO price levels off and eventually declines as rates continue to increase, thus displaying positive duration.[37]

The IO and PO market acts as a barometer of market perceptions and expectations of prepayment speeds, and the unusual duration characteristics of these instruments make them among the most versatile and useful vehicles in the fixed-income markets. Investors can use IOs and POs to hedge prepayment or interest rate risk or combine them with other securities to create synthetic instruments or portfolios with desired investment or duration profiles. They also can be used simply to take a position on prepayments. However, their extreme sensitivity to prepayments implies a high degree of risk, and investors in these instruments should have a correspondingly deep understanding of prepayment and OAS analysis.

[37] The analysis in Figure 30 was done at a time when interest rates were at historically low levels, with the ten-year Treasury yield at 5%. As a result, the declining rate scenarios in Figure 30 (with a drop of 200bp corresponding to a ten-year rate of 3%) take interest rates to levels not seen in recent decades and may correspond to a severe recession. In this case, the projected prepayment speeds for these scenarios may be too fast.

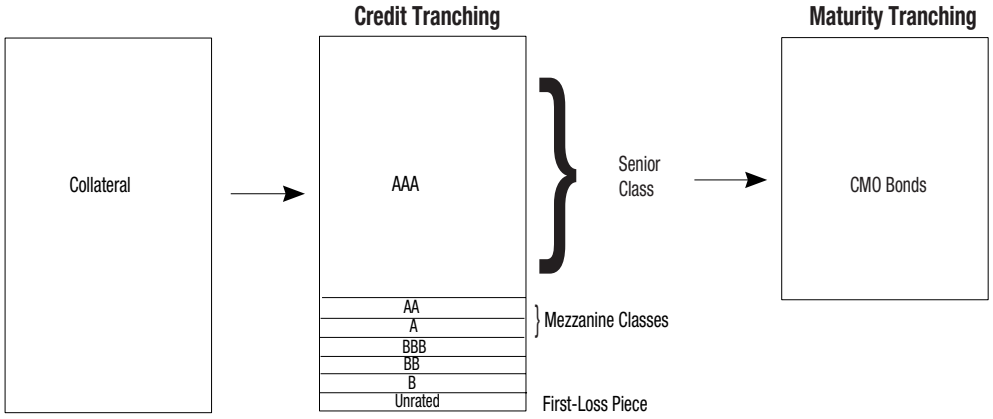
VII. The Nonagency Market

In this section we give an overview of nonagency (or nonconforming) mortgage securities, including commercial MBSs (CMBSs). This is a large and diverse sector, covering the complete spectrum of borrower demographics and credit characteristics, as well as loan sizes and types.

Cash Flow Structure of Nonagency Mortgage Securities

Despite the many different types of collateral backing nonagency deals, the cash flow structures of these deals tend to be fairly similar. With agency MBSs, agency guarantees assure investors that they will receive timely payment of interest and principal, regardless of the delinquency or default rates on the underlying loans. Because nonagency MBSs have no such guarantees, some other form of protection (or credit enhancement) is needed to shield investors from borrower delinquencies. Most deals now have internal credit enhancement through a senior/subordinated structure.[38] In its most basic form, there is a senior class and a subordinated (or junior) class. The latter class absorbs principal shortfalls from liquidation (hence, it is sometimes called a first-loss piece). Rating agency requirements determine the amount of the subordinated class, but typically, for the senior class to be rated triple A, 2%–20% of the deal, depending on the collateral, tends to be in the junior classes. The triple-A class is then typically structured as a CMO, with PACs, sequential bonds, etc. The junior class itself is often tranched, but along credit lines, from double A or single A (sometimes called mezzanine classes) down to an unrated piece. As the ratings imply, any principal losses are absorbed in reverse order (i.e., the unrated class is the first-loss piece and so on). Figure 31 shows a typical structure for a nonagency MBS deal.

Figure 31. Typical Structure for a Nonagency Deal



Source: Citigroup.

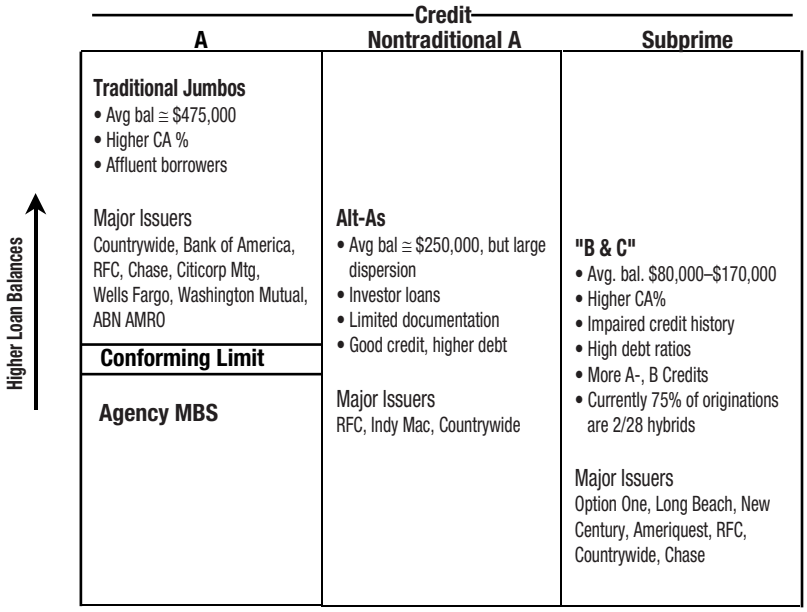
[38] External credit enhancement, infrequently used in recent years, means obtaining insurance of some sort from an external source to cover shortfalls and losses resulting from delinquencies and defaults.

Nonagency MBSs, particularly those with lower ratings, tend to trade at much wider spreads than comparable corporate bonds. In fact, one could argue that the law of large numbers implies less uncertainty about credit losses for a large, geographically diversified group of mortgage loans than for a single corporation, in which the investor has greater exposure to event risk. This implies that, for example, a triple-B rated bond from a deal backed by such a group of loans should trade tighter, not wider than a triple-B rated corporate bond.

Types of Nonconforming Residential Mortgages

Figure 32 gives a rough schematic representation of some of the main sectors of the nonconforming market.[39] Also shown in the figure are some major issuers in the various sectors.

Figure 32. The Spectrum of Residential Mortgage Loans



RFC Residential Funding Corporation
Source: Citigroup.

Traditional Jumbo Loans

Deals backed by jumbo loans (generally termed whole loan (WL) deals) constitute the largest sector of the nonagency market. As might be expected, such loans are characterized by the following:

- Affluent, financially sophisticated borrowers;
- Large loan sizes, with a current average of around $475,000, compared with an average of about $180,000 for agency loans;

[39] We say *rough* because the nuances of the distribution of borrower credits is difficult to represent in a simple table. For example, many loans in Ginnie Mae pools could be considered to be below A credit, based on LTVs, debt-to-income ratios, and so on; however, a US government guarantee makes this a nonissue for investors. Also note that some manufactured housing borrowers may be rated single A, based on criteria such as credit history and debt ratios.

- A heavy California (and to a lesser extent, Northeast) concentration, with most deals having 30%–50% of the loans from California; and
- Generally high credits and LTV ratios below 80%.

These factors imply:

- Very efficient refinancers and, hence, fast speeds in an interest rate rally;
- Strong geographical effects — for example, speeds on WL deals were generally slower than on comparable agency pools from 1994 to 1997 because of the California housing recession at that time; and
- Generally low default rates, although, again, geographical effects can outweigh demographic factors for a period.

The prepayment characteristics of jumbo loans means a greater degree of negative convexity for WL MBSs relative to comparable agency MBSs. However, many firms (including Citigroup) have developed prepayment models for jumbos that take into account these characteristics, so that valuation measures such as OAS reflect these specific prepayment characteristics. OASs on WL CMO bonds have recently been 10bp–20bp wider than those on comparable agency CMOs.

Alternative-A Loans

Alternative-A (Alt-A) loans tend to be of moderately high credit quality. Although the average loan balance is not much higher than for agency loans, loan sizes vary widely with significant percentages — typically 30%–40% — above the agency conforming limit. The loans that are below agency loan size limits may be nonconforming — that is, not eligible for agency pools — for a variety of reasons, the main ones being that the loans are on investor properties, are underwritten using limited or alternative documentation (for example, the borrower may be self-employed and not have a history of regular income), or are cash-out (or equity take-out) loans with a new LTV that exceeds agency guidelines for such loans. In some cases, the loans may qualify for agency pools, but the borrower may obtain a better rate through a nonagency program. On average, recent alt-A loans have been originated at about 40bp–50bp above standard conforming loans.

The nature of alt-A loans leads to distinctive prepayment patterns:

- Baseline speeds tend to be high, because of ongoing “curing”; that is, borrowers’ situations improve so that they are able to refinance at a lower rate. This implies an ongoing stream of refinancings even if mortgage rates do not change. Dispersion in WACs tends to accentuate this phenomenon.
- The high proportion of refinancings in total alt-A speeds leads to a short seasoning period relative to agency collateral.
- However, sensitivity to interest rate moves tends to be lower relative to jumbo borrowers, because most alt-A borrowers face extra hurdles in refinancing their loans.

These patterns imply a flatter prepayment curve for alt-As relative to conforming or jumbo loans, giving them attractive convexity characteristics.

Agencies now purchase alt-A loans, as both Fannie Mae and Freddie Mac have relaxed certain underwriting guidelines in an effort to increase market share. This has

led to lower alt-A rates. The spread between agency and alt-A rates has decreased from about 90bp in 2000 to 40bp–50bp currently.

In fact, agency involvement could actually improve the favorable convexity characteristics of new alt-A deals, as the agencies skim off the "cream" of the alt-A borrower pool leaving in the alt-A pools those borrowers who face the greatest hurdles in obtaining a loan.

The Subprime Sector: B&C and Home Equity Loans

The term B&C is used as a synonym for subprime loans. These are loans made to borrowers with imperfect credit histories and higher debt-to-income ratios than those allowed by the agencies. Based on the degree of these deficiencies, the loans are classified as being of A (or A-), B, C, or D credit quality, although an A rating does not imply that the loan is of the same quality as agency loans. Subprime loans tend to be originated at several hundred basis points above conforming agency (prime quality) loans. However, there is no industry standard for classifying loans by credit quality, and hence, the loan rate on, for example, C loans may vary from issuer to issuer. Our studies indicate that, typically, subprime lenders originate A- loans at 100bp–200bp above agency conforming rates, while note rates on B loans tend to be about 100bp higher, and those on C and D loans are each about 150bp higher than the preceding category.

About 75% of B&C loans originated currently are 2/28 hybrids. The coupon on 2/28 hybrids is fixed for two years. It resets every six months thereafter, indexed to six-month LIBOR. Most B&C loans have prepayment penalties.

The term home equity loan (HEL) is often used by market participants interchangeably with B&C loans. The term is justified because the majority of B&C loans are cash-out refinancings. More accurately, HELs also include second liens and high-LTV loans.

Citigroup has developed issuer-specific HEL prepayment models based on extensive data analysis. The main characteristics of HEL speeds, relative to agency collateral, are:

- **High base case speeds**, typically averaging 25%-35% CPR. This is mainly due to credit curing; that is, borrowers' improving their rating, and, hence, being reclassified from, say, a C to a B loan. As indicated, such a reclassification can lower the coupon rate by more than 100bp, providing ample refinancing incentive even if interest rates do not decline.
- **Cash-out refinancings** occur even without a drop in coupon, as borrowers take equity out of their homes to consolidate other debt.
- **A short seasoning ramp**, because of the high proportion of refinancings in total speeds.
- **Lower sensitivity to interest rates**, which is a result of the small loan balances and the extra refinancing hurdles faced by subprime borrowers.
- **Higher levels of defaults**, as might be expected given the nature of the loans. Our studies indicate that annual default rates peak at about 3% on average, or more than six times typical rates on conventional agency loans.
- **Prepayment penalties**, which help to slow speeds.

These attributes lead to attractive convexity characteristics for MBSs backed by subprime loans. In addition, subordinate pieces off subprime collateral provide a challenging but potentially rewarding opportunity for investors.

Summary of Prepayment Characteristics

For reference purposes, Figure 33 gives a simplified guide to the effect of various loan characteristics on prepayments and defaults, based on the previous discussion.

Figure 33. Major Factors Influencing Prepayments and Defaults

		Refinancings		
Factor	Turnover	Rate-Driven	Other[a]	Defaults
Collateral and Borrower Related				
Larger Loan Sizes	—	↑	↑	—
Higher Credit Score, Lower Debt	↑	—	↓	↓
More Second Liens	—	↓	↑	—
Higher LTV	↓	↓	↓	↑
Macroeconomics				
Lower Rates	↑	↑	—	↓
Healthier Economy	↑	↑	↑	↓
Higher Home Prices	↑	↑	↑	↓

[a] Refinancings on lower credits that are insensitive to rate moves, driven by debt consolidation and credit improvement.
Source: Citigroup.

Commercial Mortgage-Backed Securities[40]

The term commercial mortgages is used to denote loans on multifamily housing,[41] as well as loans on a variety of nonresidential property types, such as office, retail, hotel/motel, and various others (such as industrial and nursing home). Issuance of securities backed by commercial mortgages reached about $88 billion in 2003 with issuance of $96.5 billion projected for 2004, compared with roughly $45 billion in 1997 and only $17 billion in 1993. The size of CMBS deals has increased, to a fixed-rate average of about $1.2 billion and a floating-rate average of $940 million in 2004, reflecting a trend toward deals backed by many loans from several issuers and investor interest in secondary market liquidity.[42]

Most commercial loans have payments based on an amortization schedule of 25–30 years, but have a balloon payment due, usually after ten years. Prepayment risk is low compared with that for other mortgage sectors. Commercial mortgage loans typically have severe restrictions on prepayments, such as a complete prohibition (or lock-out), a yield maintenance provision (which means that if the loan is prepaid, the borrower has to compensate the lender for the loss of an above-market coupon), or defeasance.[43] Such penalties, combined with the considerable expense and time involved in refinancing a commercial loan, means that CMBS are unlikely to be

[40] For a full discussion of CMBSs, investors should review *A Guide to Commercial Mortgage- Backed Securities*, Darrell Wheeler, Citigroup, June 9, 2001.

[41] Loans on one- to four-family properties are included in the agency definition of single-family mortgages.

[42] The term *fusion deal* is used to refer to transactions containing some large loans. The industry convention is to define a fusion deal as one in which an individual loan is more than 10% of the collateral or loans of greater than $50 million constitute more than 15% of the deal.

[43] A defeasance provision allows the borrower to obtain a release of the mortgaged property by pledging US Treasury securities whose cash flows equal or exceed that of the mortgage loan.

exposed to a sudden spike in refinancings, at least during the prepayment penalty period.[44]

CMBSs constitute a hybrid type sector in the mortgage market, combining features of MBSs and corporate bonds. A key difference between residential and commercial mortgage loans is that the latter are nonrecourse; that is, if the borrower defaults, the lender cannot seize any other assets of the borrower. In other words, the income-producing capabilities and value of the underlying asset is key to CMBS analysis. Hence, evaluation of the credit risk in CMBSs depends on specific property characteristics, such as the ability to make mortgage payments (a commonly used measure is the debt service coverage ratio (DSCR), which is the net operating income divided by debt payments) and the ability to refinance the loan at the balloon date (hence, rating agencies attach significant importance to initial LTV). In addition, general relevant business trends, such as apartment or office vacancy rates, have to be analyzed.[45]

For senior CMBS classes, the likelihood of losses from defaults is negligible, even under extreme scenarios, because of the stringent subordination amounts required by the rating agencies. Typically, there is 14%–16% (more recently 15%–20%) of credit support for triple-A CMBS classes, compared with 10% or less for triple-A bonds from nonagency deals backed by prime quality, single-family loans. In fact, capital market developments currently seem to be driving spreads on senior CMBS classes. An example is provided by the events in the fall of 1998, when CMBS spreads widened with other spread product despite good commercial real estate fundamentals. Since then, CMBS spreads have tightened sharply as the fixed-income markets have stabilized. However, as has been the case historically, the sector still offers substantially higher spreads relative to comparable-quality corporate bonds, even though one could argue that CMBSs backed by a diversified pool of loans present less credit uncertainty and event risk than a similarly rated corporate bond.[46]

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[44] In fact, for CMBSs the term **refinancing risk** typically refers to the possibility that the borrower will not be able to refinance the loan at the balloon date.

[45] For a full discussion of default modeling, investors should see *CMBS Default Parameters — Enhanced to Reflect Watchlist Criteria,* Darrell Wheeler, Jeffrey S. Berenbaum, and Gilbert Chua, Citigroup, November 17, 2003.

[46] This point is illustrated by the fact that investors prefer CMBS deals backed by a large number of small loans to those backed by a few large loans.

Appendix A. Resources for MBS and ABS Investors

In this appendix, we compile some key sources of information on mortgage securities for investors. In particular, Fannie Mae, Freddie Mac, and Ginnie Mae have a number of knowledgeable professionals available to answer questions about their own securities. For ease of reference, we have listed some of the resources that they offer in this regard. In addition, commercial vendors, such as Bloomberg®, serve as sources of information on agency and nonagency securities.

Fannie Mae

- **Fannie Mae on Bloomberg®.** *MBSenger*® is an electronic newsletter published by Fannie Mae and available on Bloomberg®. It can be accessed by typing *MBSN <GO>*. The newsletter reports on economic, housing, and mortgage market news, among other areas of interest to investors.
- **Helpline.** This service provides answers to nonroutine questions about Fannie Mae securities (8:30 a.m. to 5:30 p.m., Eastern time, every business day). Call (800) BEST-MBS.
- **Deal Factory®.** Deal Factory® is Fannie Mae's automated system for evaluating mortgage loan packages. Lenders can submit loan files for rapid, loan-level risk analysis, credit evaluation, and pricing, and then receive a timely, competitive bid for their product. Upon request, lenders can also benefit from Deal Factory's referral to third-party purchasers of loans not eligible for purchase by Fannie Mae. For more information, contact the Deal Factory® Hotline at (888) 326-6432 or look at the Fannie Mae website.
- **PoolTalk®.** Investors in Fannie Mae MBSs have 24-hour access to pool information (CUSIPs, pool factors, WACs, WAMs, etc.) through PoolTalk®, an easy-to-use tool available online. For more information, contact the Fannie Mae Helpline or look at the Fannie Mae website.
- **Pool Data Direct®.** An investor can download an array of monthly trading and analysis information from Pool Data Direct®. For more information, contact the Fannie Mae Helpline or look at the Fannie Mae website.
- **Web Site (http://www.fanniemae.com).** This Web site contains useful information about Fannie Mae and its mortgage and debt securities programs.

Freddie Mac

- **Freddie Mac on Bloomberg®.** Freddie Mac Almanac on Bloomberg® (type *FMAC <GO>*) contains housing news and a variety of other financial and product information.
- **Investor Inquiry**. This service provides answers to questions about Freddie Mac securities and disclosure (9:00 a.m. to 5:00 p.m., Eastern time, every business day). Call (800) 336-3672, or e-mail Investor_Inquiry@freddiemac.com.
- **Debt Marketing.** For detailed information on Reference Bills, Notes, and Bonds, Callable debt, Freddie Notes and other debt securities, please contact (571) 328-3700.

- **Web Site (http://www.freddiemac.com).** Freddie Mac has special sections of its Web site devoted to mortgage securities and debt securities. The mortgage securities site contains, among other things, product information, offering circulars, new-issue announcements, and all single-class and multiclass disclosure for Freddie Mac PCs and REMICs. Freddie Mac's debt Web area also contains product literature and announcements, offering circulars, and disclosure information. The *Economic and Housing Research* (http://www.freddiemac.com/news/finance) section of the Web site contains a number of very useful economic data series for mortgage market participants. In particular, the site contains a weekly survey of mortgage rates (PMMS), a home price index, an economic housing forecast, and a housing refinance survey. Freddie Mac's Web site is accessible 24 hours a day, seven days a week, with no password or access restrictions.

Ginnie Mae

- **General Information.** General information regarding Ginnie Mae securities can be obtained by calling Ginnie Mae's Office of Capital Markets. This service also provides information on pool factors and REMIC factors. Call (202) 401-8970 (8:30 a.m. to 5:00 p.m., Eastern time, every business day).
- **Ginnie Mae on Bloomberg®.** Investors can access information about Ginnie Mae Platinum® securities, Multiple Issuer Pools, REMICs, and Callable Trusts on Bloomberg® by typing *GNMA <GO>*. The information provided on Platinum® pools is particularly comprehensive and includes an overview of the program, a fee schedule, and a list of all Platinum pools issued.
- **Web Site (http://www.ginniemae.gov).** The *Ginnie Mae Guides* are among the most useful resources available on the Web site. The *Guides* provide an in-depth description of the Ginnie Mae I and Ginnie Mae II programs. Changes to Ginnie Mae programs (and, therefore, to the *Guides*) are usually announced by *All Participants Memoranda*, which can also be found on the Web site.

The Bond Market Association

The Bond Market Association (BMA)[47] represents securities firms and banks that underwrite, trade, and sell debt securities (including mortgage- and asset-backed securities) domestically and internationally. The association speaks for the bond industry and advocates its positions. The association also keeps members informed of relevant legislative, regulatory, and market-practice developments.

- **Publications.** The association publishes books, brochures, manuals, and other educational materials. Investors who are new to the ABS and MBS markets will find the following publications especially useful: (1) *Uniform Practices for the Clearance and Settlement of Mortgage-Backed Securities and Other Related Securities*; (2) *An Investor's Guide to Asset-Backed Securities (ABS)*; (3) *An Investor's Guide to Collateralized Mortgage Obligations (CMOs)*; (4) *An Investor's Guide to Mortgage-Backed Securities*; (5) *Standard Formulas for the Analysis of Mortgage-Backed Securities and Other Related Securities*. To order these publications, look at the organization's Web site.

[47] Originally called the Public Securities Association (PSA).

- **Web Site (http://www.bondmarkets.com).** The BMA Web site is a gold mine of useful information on regulatory, legislative, and market-practice developments relevant to all US fixed-income sectors. However, some parts of the Web site are only accessible to BMA members. Other useful items include a list of MBS settlement and notification dates, and helpful publications for new investors in mortgage- and asset-backed securities.

Commercial Vendors

Several commercial vendors serve as a source of data and news on mortgage securities. Perhaps the best known is Bloomberg®. Others include Telerate and Reuters.

Appendix B. Glossary of Common Terms

ABS

In addition to being an acronym for **asset-backed security**, this term is used to denote **asset-backed speed**, a prepayment measurement convention used to price ABS deals backed by car loans. As opposed to SMM and CPR, which measure prepayments in terms of the current remaining balance, ABS measures prepayments as a percentage of the *original* balance; thus, 1.5% ABS means that 1.5% of the original balance prepays each month.

Amortization

The repayment of principal over the term of a loan, rather than in one lump sum at maturity. For a fixed-rate mortgage loan, the (constant) monthly payment is calculated so that the loan is fully paid off over the loan term.

Adjustable Rate Mortgage (ARM)

The coupon on an ARM resets at a specified frequency (usually once a year), at a specified spread over an index (such as the one-year Treasury or LIBOR rate), subject to periodic caps (usually 100bp or 200bp) and a lifetime cap (usually 500bp or 600bp above the coupon at origination). In recent years, most ARMs have been hybrids, in which the coupon is initially fixed for a specified number of years (typically three, five, seven, or ten), then resets annually.

Average Life

See **WAL**.

Bond Market Association (BMA)

A trade association of fixed-income securities dealers, formerly known as the Public Securities Association (PSA). The BMA establishes rules for fixed-income settlement procedures (such as good delivery requirements), deals with issues that affect the bond markets, and publishes brochures on fixed-income securities (see Appendix A for some examples).

Book-Entry Securities

Book entry securities are also known as wireable securities. US Treasury and agency securities (including Fannie Mae and Freddie Mac MBSs) are book-entry securities that are transferred from one entity to another through Fedwire.

Bounce

This operational term refers to sending securities back to where they were originated on the trade date for one of the following reasons: (1) cash was not received; (2) the dollar amount was not the same as expected; (3) the seller switched the securities; or (4) there is discrepancy in trade information.

Buy-In

The process of repurchasing a security previously bought from a customer or broker-dealer who failed to deliver the security to the purchaser within 60 calendar days of the settlement date. Any losses incurred in closing the original transaction are passed along to the original seller who failed to deliver. (Also see **Fail**.)

Callout Date

The callout date is also referred to as **48-hour day**. In a TBA trade, information about the actual pools that will be delivered from the seller to the buyer is only provided two days before the actual settlement date (by 3:00 p.m.).

Carry

The spread between the yield on a MBS and the rate at which money is borrowed to finance the MBS equals the cost to "carry" the security. When the financing rate is greater than the yield, the security has **negative carry**. When the financing rate is less than the yield, the security has **positive carry**.

Clearing Agent

An organization that provides various services for customers and customers' accounts, such as holding inventory positions, receiving and delivering securities, and disbursing funds.

Collateralized Mortgage Obligation (CMO)

A common term for a structured mortgage security and used interchangeably with **REMIC**. See Appendix C for definitions of common CMO bond types, such as PACs (planned amortization classes).

Conforming Loans

Mortgage loans that satisfy (or conform to) agency underwriting criteria, in terms of maximum loan balance, loan-to-value (LTV) ratio, debt-to-income requirements, and so on.

Conventional Loans

Mortgage loans that are *not* insured by the US government (i.e., by the FHA or VA). Conventional loans can be **conforming** or **nonconforming**.

Constant Prepayment Rate (CPR)

An annualized prepayment rate assuming monthly compounding. It is the fraction of the current principal balance, after accounting for scheduled amortization, that would be prepaid over the next 12 months for a given constant monthly prepayment rate (see also **SMM**).

Current Face

The current principal balance on a security. It is equal to the original balance times either the current pool factor (for pass-throughs) or bond factor (for structured MBSs).

CUSIP

A unique nine-digit identification number for each publicly traded security. CUSIP also stands for the Committee on Uniform Securities Identification Procedures, which assigns the numbers.

Custodian

In the clearing process, an organization that holds securities under its own name or under its control on behalf of its customers. In addition to custody, custodians also offer their clients cash management and securities lending services. For example, custodians can help their institutional clients earn incremental income on their portfolios by lending securities from this portfolio to broker-dealers who wish to borrow them.

Delay

The principal and interest payments due on an MBS are passed through to investors with a delay to allow servicers time to process mortgage payments. For example, the stated delay on a Ginnie Mae pool is 45 days. Thus, the principal and interest for September is paid on October 15, rather than October 1. (See the earlier discussion, which follows Figure 4, for more details.)

Dollar Roll

In a dollar roll transaction, a pass-through investor agrees to sell securities in the current month and buy back the same amount of substantially similar securities in a forward month at a second, lower price. The second price is specified as a difference, or **drop**, from the first price. The investor forgoes principal and interest payments over the term of the roll and is compensated by the interest earned on the cash proceeds of the initial sale and by the lower repurchase price at the future date. The transaction is favorable to the investor when the drop is large enough to reduce the implied financing rate below short-term reinvestment rates. (See Section V for more details.)

Factor

The fraction of the original balance that is still outstanding. For example, a factor of 0.65 means that the current balance is 65% of the original; that is, scheduled principal payments (amortization) and prepayments have led to 35% of the original balance being paid down. For bonds in structured MBSs and ABSs, the term **bond factor** denotes the remaining principal balance of the bond as a fraction of the original. Collateral and bond factors are updated each month and used to determine principal payments to investors. The three agencies update pool factors near the beginning of each month.

Fail

A failure to deliver securities versus payment on the settlement date. The originator of the delivery is held liable.

Fannie Mae (the former Federal National Mortgage Association, or FNMA)

A private corporation originally created by the US government to facilitate the flow of mortgage capital by purchasing and creating a secondary market in such loans. It

still has close ties with the US government and is usually referred to as an **agency** or a **government-sponsored enterprise** (**GSE**). (See its Web site **http://www.fanniemae.com** for more details.)

Fedwire

Connects the Federal Reserve offices, depository institutions, the US Treasury, and other government agencies. Fedwire is typically used to transfer large dollar payments and book-entry securities electronically from one institution to another on behalf of investors.

Freddie Mac (the former Federal Home Loan Mortgage Corporation, or FHLMC)

A private corporation originally created by the US government to facilitate the flow of mortgage capital by purchasing and creating a secondary market in such loans. It still has close ties with the US government and is usually referred to as an agency or a **GSE**. (See its web site **http://www.freddiemac.com** for more details.)

Ginnie Mae (formerly known as the Government National Mortgage Association, or GNMA)

An agency of the US government that securitizes mortgages insured by the US government agencies, the **Federal Housing Administration**, the **Veterans Administration**, and the **Rural Housing Service**. Ginnie Mae MBSs carry the full faith and credit of the US government and, hence, have the same credit quality as US Treasuries. (See its Web site **http://www.ginniemae.com** for more details.)

Haircut

A percentage of the price of a security used to establish a margin account. This margin account is used to provide the cash lender with a hedge against a decline in the market value of the security. Haircuts are commonly used in repurchase (repo) transactions.

IO

An **interest-only** structured MBS, which is entitled to interest payments only from the collateral cash flows (see also **PO**).

Netting

When two parties enter into offsetting trades (a pair-off), there is no need to receive/deliver securities. Instead, only the net gain/loss needs to be accounted for. Netting takes this one step further by performing a similar function with many participants simultaneously. For example, if A sells a security to B and B already has a sell position to C for the same amount of the same security, then B has no resulting net position and does not need to receive/deliver any securities for these transactions.

Pair-Off

See Netting.

Par Amount

The principal balance of an MBS at issuance. Used synonymously with **face amount**.

Percent PSA

A prepayment measurement convention. 100% PSA means that the prepayment rate increases linearly from 0% CPR at loan age 0 to 6% CPR at loan age 30 months, and then remains at 6% CPR, while 150% PSA means that the CPR is 1.5 times the CPR at a 100% PSA, and so on. (See Appendix E for more details). CMO deals are usually priced at a percentage of PSA.

PO

A **principal-only** structured MBS that is entitled to principal payments only from the collateral cash flows (see also **IO**).

Pool

A collection of individual mortgages that are grouped together by primary lenders (banks, thrifts, mortgage bankers) to constitute the collateral for an MBS.

Prime Broker

Prime brokers facilitate the clearance and settlement of securities trades. Prime brokerage involves three parties**:**

- The customer, typically a substantial retail or institutional investor,
- The executing broker, which executes the trade for the customer,
- The prime broker, which settles, clears, and finances the customer trades executed by one or more executing brokers.

Prime brokerage allows the customer to utilize the services of several executing brokers, while maintaining one account (with the prime broker) and receiving one consolidated account statement.

Public Securities Association (PSA)

See **Bond Market Association**.

Record Date

The date used to note ownership of a security, to determine the distribution of the next payment. For agency MBSs, it is the last day of the month; on this date, the owner receives the principal and interest payment for the month (usually paid the next month). For other MBSs and ABSs, the prospectus specifies the record date.

Real Estate Mortgage Investment Conduit (REMIC)

A tax vehicle used to issue structured MBSs, but now the term is used synonymously with **CMO** to denote such securities.

Repurchase Transaction (Repo)

Repurchase transactions are securities lending transactions in which one party agrees to sell securities to another party against the transfer of funds, with a simultaneous agreement to repurchase the same securities at a specific price at a later date. (See Section V for more details.)

Single Monthly Mortality (SMM)

The percentage of remaining principal that, after accounting for scheduled amortization, pays down in a month. The annualized value of the SMM is the **CPR**. (See Appendix E for a mathematical definition.)

Weighted-Average Coupon (WAC)

The average coupon on the loans in a pool, weighted by the loan balances. The difference between the WAC and the pass-through coupon paid to investors is termed the **servicing spread**.

Weighted-Average Life (WAL)

A measure of the investment life of a fixed-income security that returns principal over a period of time, rather than in one lump sum at maturity. It is the average time until a dollar of principal is returned. (See Appendix E for a mathematical definition.)

Weighted-Average Loan Age (WALA)

The average age of the loans in a pool, weighted by the loan balances.

Appendix C. Standard Agency Definitions of CMO Bond Types

Agency Acronym	Definition
Principal Types	
AD	Accretion Directed (or Stated Maturity). Classes that are designed to receive principal payments from accretion on specified accrual classes. These classes may also receive principal payments from principal paid on the underlying collateral.
CPT	Component. Classes consisting of "components." The components of a component class may have different principal and/or interest payment characteristics but together constitute a single class. Each component of a component class may be identified as falling into one or more of the categories in this chart.
NPR	No Payment Residual. Residual classes that are designed to receive no payments of principal.
NSJ	Non-Sticky Jump. Classes whose principal payment priorities change temporarily upon the occurrence of one or more "trigger" events. A non-sticky jump class "jumps" to its new priority on each payment date when the trigger condition is met and reverts to its original priority (does not "stick" to the new priority) on each payment date when the trigger condition is not met.
NTL	Notional. Classes having only a notional principal amount. A notional principal amount is the amount used as a reference to calculate the amount of interest due on an Interest-Only class that is not entitled to any principal.
PAC	Planned Amortization Class. Classes that are designed to receive principal payments using a predetermined schedule derived by assuming that the underlying mortgages will prepay within a range bounded by two constant prepayment rates. A PAC schedule will produce a wide "structuring range" above and below the prepayment assumption for the related series. The PAC classes in any series may include two or more "types." The PAC class or classes within any type have a single structuring range. The different types have different structuring ranges and different principal payment priorities. In cases where there is more than one type, the PAC classes are designated as type I PAC classes, type II PAC classes, and so forth (standard abbreviations: PAC I, PAC II, and so forth).
SCH	Scheduled. Classes that are designed to receive principal payments using a predetermined schedule, but that are not designated as PAC or TAC classes. Classes using both PAC and TAC components are also designated as scheduled classes.
SEQ	Sequential Pay. Classes that receive principal payments in a prescribed sequence, that do not have predetermined schedules, and that under all circumstances receive payments of principal continuously from the first payment date on which they receive principal until they are retired. Sequential pay classes may receive principal payments concurrently with one or more other sequential pay classes. A single class that receives principal payments before or after all other classes in the same series may be identified as a sequential pay class.
SJ	Sticky Jump. Classes whose principal payment priorities change permanently upon the occurrence of one or more "trigger" events. A sticky jump class "jumps" to its new priority on the first payment date when the trigger condition is met and retains ("sticks to") that priority until retired.
STP	Strip. Classes that receive a constant proportion, or "strip," of the principal payments on the underlying collateral.
SUP	Support (or companion). Classes that receive principal payments on any payment date only if scheduled payments have been made on specified PAC, TAC, and/or scheduled classes.
TAC	Targeted Amortization Class. Classes that are designed to receive principal payments using a predetermined schedule derived by assuming that the underlying mortgages will prepay at a single constant prepayment rate. The TAC classes in any series may include two or more types. The different types have different principal payment priorities and/or have schedules that are derived from different assumed prepayment rates. In cases where there is more than one type, the TAC classes are designated as type I TAC classes, Type II TAC classes, and so forth (standard abbreviations TAC I, TAC II, and so forth).
XAC	Index Allocation Class. Classes whose principal payment allocations are based on the value of an index.
Interest Types	
ARB	Ascending Rate. Classes that have predetermined class coupons that change one or more times on dates determined before issuance.
DLY	Delay Class. Floating-rate or inverse floating-rate Class for which there is a delay between the end of the interest accrual periods and related payment dates.
EXE	Excess. Residual classes that receive any principal and interest paid on the underlying collateral in excess of the amount of the prescribed principal and interest to be paid on all classes in the series. Excess classes sometimes have specified principal amounts but no specified class coupon.
FIX	Fixed Rate. Classes whose class coupons are fixed throughout the life of the class.
FLT	Floating Rate. Classes with class coupons that are reset periodically based on an index and that vary directly with changes in the index.
INV	Inverse Floating Rate. Classes with class coupons that are reset periodically based on an index and that vary inversely with changes in the index.
IO	Interest Only. Classes that receive some or all of the interest payments made on the underlying collateral and little or no principal. Interest-only classes have either a nominal or a notional principal amount. A nominal principal amount represents actual principal that will be paid on the class. It is referred to as nominal because it is extremely small compared with other classes. A notional principal amount is the amount used as a reference to calculate the amount of interest due on an interest-only class that is not entitled to any principal.
NPR	No Payment Residual. Residual classes that are designed to receive no payments of interest.
PO	Principal Only. Classes that do not receive any interest.
PZ	Partial Accrual. Classes that accrete a part of their interest, which is added to the outstanding principal balance, and simultaneously receive payments of the remainder as interest.
W	Weighted-Average Coupon. Classes whose class coupons represent a blended interest rate that may change from period to period. WAC classes may consist of components, some of which have different interest rates.
Z	Accrual. Classes that accrete all of their interest, which is added to the outstanding principal balance. This accretion may continue until the class begins to receive principal payments, until some other event has occurred, or until the class is retired.
Other Types	
LIQ	Liquid Asset. Classes intended to qualify as "liquid assets" for certain savings institutions. Liquid asset classes have final payment dates not later than five years from their dates of issuance.
RTL	Retail. Classes designated for sale to retail investors. Retail classes frequently are sold in small "units" or other increments and may receive principal payments in accordance with special priorities and allocation procedures.
TBD	To Be Defined. Bonds that do not fit under any of the current definitions.

Source: Freddie Mac.

Appendix D. Settlement Dates

TBA Agency Pass-Throughs

There are four categories in the Bond Market Association settlement date schedule.

- **Class A**. 30-year conventional
- **Class B**. 15-year
- **Class C**. 30-year Ginnie Mae
- **Class D**. Balloons, ARMs, other

Figure 34 provides examples of some actual settlement dates.

Figure 34. Examples of BMA Settlement Dates

	Oct 04	Nov 04
Class A	14th (Thu)	15th (Mon)
Class B	19th (Tue)	18th (Thu)
Class C	21st (Thu)	22nd (Mon)
Class D	25th (Mon)	23rd (Tue)

Source: Citigroup.

The BMA generally publishes the settlement dates about six months in advance. No formula is used to determine the dates, but general guidelines are that the dates must be after pool factors become available, should not occur too close to the end of the month, and should not fall on a Friday (to help avoid a fail over a weekend).

CMOs/ABSs

CMOs and ABSs traded in the secondary markets use **corporate settlement**. These securities settle three days after the trade date (T+3). Exceptions to this might occur if securities are held through the depositories Cedel or Euroclear. New issues normally settle when the deal settles (issue date).

Interest-Only/Principal-Only Strips (Secondary Trading)

The settlement date convention for strips is a little more complicated. The settlement convention for strips is given by the following three rules:

1. For the first part of the month before the 48-hour day is reached, use TBA settlement date (for current month).
2. On the 48-hour day, when TBA settlement date coincides with skip-day settlement (settlement two days after the trade date [T+2]), convert to skip-day settlement at this point and for most of the rest of the month (see number 3).
3. Very near the end of month, when skip-day settlement falls into the next month, switch to next month's TBA settlement date and continue with number 1.

Figure 35. Examples of IO/PO Settlement Dates (Aug 04)[a]

Trade Date	Settlement Date
August 1–10	August 12 (Thu)
August 11–27	Skip-Day (T+2)
August 28–31	September 15 (Wed)

[a] August 12 and September 15 are BMA TBA settlement dates.
Source: Citigroup.

Appendix E. Mortgage Mathematics

Cash Flows Assuming No Prepayments

First, we define some terminology. For a level pay mortgage, let

WAC = Gross coupon in percent (for example 9%)

G = WAC / 1200 = Monthly coupon (for example 9 / 1200 = 0.0075)

$U = 1 / (1 + G)$ = Monthly discount factor for rate G,

N = Original loan term in months,

n = Age of loan in months,

$R = N - n$ = Remaining loan term in months.

Then, for each dollar of mortgage, in month n,

$$\text{Monthly Payment} = PAY_n = \frac{G}{1 - U^N}$$

$$\text{Remaining Balance (End of Month)} = BAL_n = \frac{1 - U^R}{1 - U^N}$$

$$\text{Principal portion of payment} = PRIN_n = \frac{GU^{R+1}}{1 - U^N}$$

$$\text{Interest portion of payment} = INT_n = \frac{G(1 - U^{R+1})}{1 - U^N}$$

Because this is a level-pay mortgage, the total monthly payment is constant. The subscript n in the formula is for convenience in extending the results in the case of prepayments.

Prepayment Terminology

For a given pool of mortgages, let

B_n = remaining principal balance per dollar of original balance after the nth monthly payment assuming zero prepayments

F_n = pool factor (the actual remaining balance per dollar of original principal)

$Q_n = F_n / B_n$ = fraction of the pool that has *not* yet prepaid

While F_n incorporates both scheduled and unscheduled principal payments, Q_n is "normalized" so that changes in Q_n reflect prepayments only.[48] Thus, for month n,

SMM_n = The fraction of pool outstanding at beginning of month that is prepaid during the month

[48] If we think of the pool as consisting of a very large number of $1 mortgages, then Q_n can be interpreted as the fraction of mortgages that have survived (not prepaid) to month n.

$$= \frac{Q_{n-1} - Q_n}{Q_{n-1}} = 1 - Q_n / Q_{n-1} \quad \text{(E1)}$$

The survival factor Q_n and the monthly prepayment rates SMM_1, SMM_2,... are related through the equation

$$Q_n = (1 - SMM_1)(1 - SMM_2)....(1 - SMM_n)$$

For the period from month k to month *n*, the constant *SMM* that is equivalent to the actual prepayments experienced is given by

$$(1 - SMM)^{n-k} = Q_n / Q_k$$

The CPR corresponding to a given SMM is given by

$$1 - CPR = (1 - SMM)^{12} \quad \text{(E2)}$$

If AGE is the loan age in months, then the PSA and the CPR are related to each other according to the following formulas:

$$PSA = CPR * 100 / 6 * max(1, 30 / AGE) \quad \text{(E3)}$$

$$CPR = PSA * 0.06 * min(1, AGE / 30) \quad \text{(E4)}$$

Mortgage Cash Flows with Prepayments

The survival factor Q_n links MBS cash flows with and without prepayments. With PAY_n, $PRIN_n$, INT_n, and BAL_n defined as above in the case of zero prepayments, let PAY'_n, $PRIN'_n$, INT'_n, and BAL'_n be the corresponding quantities with prepayments, and let PP_n be the principal prepaid in month *n*. It is not difficult to show that, given Q_{n-1}

PAY'_n = *Scheduled monthly payment* = $PAY_n * Q_{n-1}$,

$PRIN'_n$ = *Scheduled principal payment* = $PRIN_n * Q_{n-1}$,

INT'_n = *Scheduled interest payment* = $INT_n * Q_{n-1}$,

PP_n = *Principal prepaid* = $(BAL'_{n-1} - PRIN'_n) * SMM_n$, *and*

BAL'_n = $BAL'_{n-1} - PRIN'_n - PP_n = BAL_n * Q_n$.

The total cash flow to the pass-through holder for month *n* is

$$CF_n = PRIN'_n + PP_n + (C / WAC) * INT'_n$$

where C is the pass-through rate and WAC is the weighted-average coupon on the underlying loans. In other words, the pass-through holder receives all principal payments, but interest at a rate C rather than the loan rate WAC.

Yield

For a given prepayment projection and resulting cash flows CF_1, CF_2, ..., the **mortgage yield** is the discount rate *x* that equates the present value of the cash flows to the price of the MBS. It is the solution of the equation

$$PRICE + ACCRUED = \sum_{t=1}^{M} \frac{CF_t}{(1 + x/1200)^{t+a-1}} \quad \text{(E5)}$$

where ACCRUED is accrued interest, M is the number of remaining cash flows, a is the number of days from settlement to the first cash flow date *divided by* 30, and the yield *x* is stated as an annualized percent.

Yields on MBSs are generally quoted on a bond-equivalent basis (that is, assuming semi-annual compounding) to make them comparable to Treasuries and corporate bonds. The **bond equivalent** yield *y* can be obtained from the mortgage yield *x* using the following relationship

$$(1 + x / 1200)^{12} = (1 + y / 200)^2$$

so that $y = 200[(1 + x/1200)^{6} - 1]$

Weighted-Average Life

The weighted-average life (WAL) is defined as the average time a dollar of principal is outstanding. For a given prepayment rate, it is defined as

$$WAL\,(\text{in years}) = \frac{1}{12} \sum_{t=1}^{M} (t + a - 1)\, p_t \quad \text{(E6)}$$

where a is as defined above, and p_t is the fraction of original principal returned in month t under the projected prepayment rate. (Note that $p_1 + p_2 + ... + p_M = 1$.)

Duration and Convexity

Traditional durations are given by the following formulae:

$$\textbf{Macaulay Duration} = \frac{1}{12 * P} * \sum_{t=1}^{M} \frac{(t + a - 1)CF_t}{(1 + x/1200)^{t+a-1}},$$

$$\textbf{Modified Duration} = \text{Macaulay Duration} / (1 + y / 200), \quad \text{(E7)}$$

where *P* denotes the full price, or the right-hand side of equation E5.

If the security cash flows are fixed, then

$$\text{Modified Duration} = \frac{-100}{P} * \frac{dP}{dy} \quad \text{(E8)}$$

and hence, the modified duration provides a measure of relative price sensitivity with respect to interest rate changes.

For MBSs, cash flows vary with interest rates, so that we cannot use equation E7**.** Instead we approximate the right-hand side of equation E8 directly by **effective duration**, defined as

$$\text{Effective Duration} \approx \frac{-100}{P} * \frac{\Delta P}{\Delta y}$$

$$\approx \frac{100}{P} * \frac{P(-\Delta y) - P(\Delta y)}{2 * \Delta y} \quad \text{(E9)}$$

where P(-Δy) and P(Δy) are the projected prices if the yield curve is shifted in parallel by small amounts -Δy and Δy, respectively. The standard convention is to obtain projected prices by holding OAS constant. However, nothing in the definition of effective duration (E9) stops us from using projected OASs to obtain the prices. We also can consider nonparallel yield curve shifts. For example, *partial durations* with respect to a particular part of the yield curve are obtained by changing only that part of the yield curve.

Convexity is calculated in a similar manner for MBSs:

$$\begin{aligned}\text{Convexity} &= \frac{100}{P} * \frac{d^2 P}{dy^2} \\ &\approx \frac{100}{P} * \frac{\left(\frac{P(-\Delta y) - P}{\Delta y} - \frac{P - P(\Delta y)}{\Delta y} \right)}{\Delta y} \\ &= \frac{100}{P} * \frac{P(\Delta y) + P(-\Delta y) - 2P}{(\Delta y)^2}\end{aligned} \tag{E10}$$

Appendix F. Clearance and Settlement in the Back Office

The MBS and ABS market participants that typically receive the most attention are primary market originators, institutional investors, and broker-dealers such as Citigroup that facilitate the flow of capital between originators and investors by establishing secondary markets. Missing in this picture are the roles played by other securities market service providers such as prime brokers, custodians, and clearing and settlement organizations. The back-office services provided by these entities — portfolio administration, risk management, "netting" trades, among others — considerably ease the administrative and operational complexities involved in securities lending and trading.

Clearance and settlement refer to the mechanics of the exchange of funds and securities resulting from trading activities. Completing a securities transaction involves the interaction of back-office departments, banks, clearing corporations, other depositories, and funds transfer systems. This section provides more of a back-office perspective on how money and securities are transferred between these organizations in consummating a trade. It also provides brief descriptions of some of the major organizations involved in clearing and settling MBS and ABS trades.

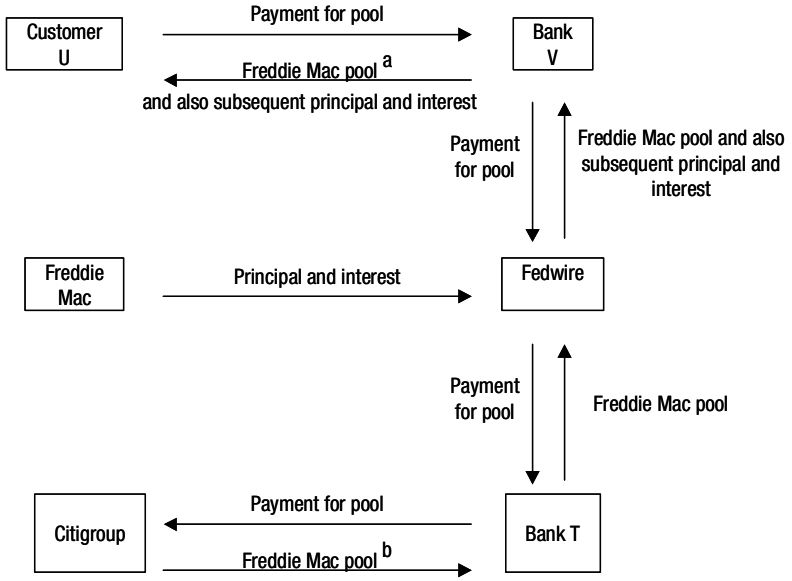
Our discussion is by no means definitive – the continued growth and globalization of securities markets, technological advances, and an increasing focus by investors on "putting their money to work" continue to alter the landscape of back-office services. In particular, modern financial institutions such as Citigroup can assume multiple back-office roles, and offer their institutional clients a number of portfolio administration (clearing, custody, financing, and lending) and portfolio allocation services.

Clearing and Settling a Specified Pool Pass-Through Trade

To directly use a clearing organization such as Fedwire which is operated by the US Federal Reserve (or Fed), membership in that clearing organization is normally required. In the case of Fedwire, banks and other depository institutions that are members of the Federal Reserve System have direct access, but other financial institutions such as broker-dealers do not. So, to trade securities that only clear through certain organizations like Fedwire, a nonmember, such as a broker-dealer, must use an intermediary **clearing agent** (normally a bank).

Suppose Customer U, which uses bank V as its clearing agent, buys a specified Freddie Mac pool from broker-dealer Citigroup, which uses Bank T as its clearing agent. (Freddie Mac, Fannie Mae, and Ginnie Mae pools clear through Fedwire.) Figure 36 shows how the funds/securities are transferred.

Figure 36. Payment for a Security



[a] Bank V holds the Freddie Mac pool on behalf of Customer U, the beneficial owner. [b] Citigroup's clearing agent, Bank T, holds the Freddie Mac pool (prior to the trade) on behalf of Citigroup, the original beneficial owner.
Source: Citigroup.

On the settlement date:

1. Customer U instructs Bank V to (a) receive the pool from Broker-Dealer Citigroup via Citigroup's clearing agent Bank T (the pool is taken from Bank T's Fedwire account), and (b) make the appropriate payment to Bank T.
2. Bank T, acting on instructions from Broker-Dealer Citigroup, transmits a message to Fedwire authorizing delivery of the Freddie Mac pool to Bank V's Fedwire account versus payment of the agreed-upon price.
3. The Federal Reserve executes these instructions by making the appropriate security and cash entries to the Fed accounts of Banks V and T. More specifically, Bank V's account is debited with cash and credited with securities, while the opposite flows are recorded for Bank T.
4. Bank V in turn makes the appropriate entries to Customer U's account, and Bank T does the same for Citigroup.

As far as Freddie Mac and the Federal Reserve are concerned, Bank V is the holder of the security and should receive payments of principal and interest on it. Customer U is the beneficial owner (the true owner) of the pool through its Clearing Bank V. Therefore, principal and interest from the pool is received first by Bank V and is subsequently credited to Customer U's account.

If Bank T and Bank V happen to be the same clearing bank (denoted as Bank TV for clarity), then Fedwire is not directly involved in the trade. Instead, Bank TV clears the trade internally by crediting to Customer U's account securities obtained by debiting Broker-Dealer Citigroup's account. In addition, cash is debited from Customer U's account and credited to Broker-Dealer Citigroup's account. There is no need to change anything in Bank TV's Fed accounts because Bank TV's security/cash position at the Fed is unchanged.

Special Considerations for TBA Pass-Through Trades

The previous subsection describes the settlement process for specified pool pass-through trades. The description also applies to TBA pass-through trades. However, several additional activities often take place between the trade date and the settlement date, particularly in the case of TBA trades. Because trades often settle forward (on one of the Bond Market Association settlement dates), there is a relatively long time between the trade date and settlement date. This means that there is a relatively longer period of time during which a trade should be monitored to guard against one party's not fulfilling its trade obligations.

Assuming both parties in a trade are participants of the Mortgage-Backed Securities Clearing Corporation (MBSCC) and the trade is executed through MBSCC, the trade is marked to market on a daily basis because both parties must meet daily margin requirements, which help to ensure that the trade is completed. MBSCC, to some extent, acts as a huge back office for its participants. It nets the trade activity for each participant involved in a TBA trade category (such as 30-year Freddie Mac Gold 5s for October settlement, for example) and provides a summary net position to each of its member participants. For example, a firm with offsetting long and short positions (possibly with different counterparties) has no net security position and can settle its position by paying or receiving cash depending on the prices at which the offsetting trades were executed.

For participants with net securities positions, MBSCC matches net sellers with net buyers and provides a service, called Electronic Pool Notification, that helps the matched parties exchange pool information in preparation for delivery of securities. When settlement is reached, net positions are paid off and pools must be delivered. This happens as discussed in the previous subsection.

When outstanding trades are marked to market or must satisfy margin requirements, as in cases in which MBSCC is involved, for example, the basic cash flow mechanics presented in Section II become more complicated. For a trade that is marked to market, cash will be paid or received in all likelihood prior to the settlement date. On the settlement date, payment is made **net** of all the prior cash paid or received due to margin requirements. When MBSCC is involved, the final price paid at settlement is further complicated by the netting process (which averages out prices across different trades in determining the price to be paid on the settlement date).

Appendix G. Risk-Based Capital Standards[49]

Institutional investors need to be cognizant of their supervisory agencies' capital standards before investing in MBSs and ABSs. These capital requirements will likely be based on standards for capital adequacy that were initially formalized in the 1988 Basle Accord. The Accord was established by the Basle Committee on Banking Supervision of the Bank for International Settlements. The committee consists of senior representatives of bank supervisory authorities and central banks from the Group of Ten (G10) countries.[50]

The 1988 Accord was primarily concerned with credit risk and instituted a **minimum ratio** of capital to assets for internationally active banks. The Accord takes into account the relative risk of an asset by relating capital requirements for a particular asset to the credit risk of this asset. Assets are assigned to five different risk buckets with weights of 0%, 10%, 20%, 50%, and 100%. Figure 37 shows the four risk categories used in the US risk-based regulatory regime.

Figure 37. Depository Risk-Based Capital Standards[a]

Risk Weight	Financial Instrument Characteristics	Examples
0%	Unconditionally backed by the national government in one of 30 economically developed countries	Cash, US Treasuries, Ginnie Mae pass-throughs
20%	Low default risk, easily liquidated	Freddie Mac, Fannie Mae mortgaged-backed securities; federally insured banking deposits
50%	Low to moderate default risk, well collateralized	Many private-label mortgage-backed securities, single-family mortgages with down payments of 20% or, if less, mortgage insurance.
100%	Ineligible for lower risk-weight categories	Single-family mortgages with down payments of less than 20% and no mortgage insurance, some second mortgages, commercial loans, asset-backed securities

[a] Under Basel II (to take effect at the end of 2006), changes are planned with respect to instruments such as sovereign debt and low-rated tranches of securitizations.
Source: Federal Reserve Board, Office of Thrift Supervision. Adapted from "Risk-Based Ratios: Getting Closer," Edward L. Golding and Carol A. Wambeke, *Secondary Mortgage Markets*, July 1998, pp. 29–31.

Total risk-weighted assets are calculated by assigning balance sheet assets (such as those listed in Figure 37) to specified categories and multiplying the amounts by risk weights used for the category. In general, banks and thrifts are required to maintain a capital to risk-weighted asset ratio of at least 8%. Figure 38 illustrates the capital reserves calculation for Fannie Mae and Ginnie Mae pass-throughs.

[49] The authors gratefully acknowledge the invaluable contributions of Scott Benedict of Cleary, Gottlieb, Steen, & Hamilton, Steve Rehm, and Ethan Heisler of Citigroup Global Markets in putting this Appendix together.

[50] The G10 countries consists of Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States.

Figure 38. Capital Reserves for Fannie Mae and Ginnie Mae Pass-Throughs

Security	Risk Weight	Risk-Weighted Assets	Required Capital Reserves
$100 Fannie Mae Pass-Throughs	20%	20% * $100 = $20	8% * $20 = $1.60
$100 Ginnie Mae Pass-Throughs	0%	0% * $100 = $0	8% * $0 = $0

Source: Citigroup.

Since 1988, the Basle Committee has amended the capital accord several times. In particular, in January 1996, the Accord was supplemented with a "market risk measure" that calculates capital requirements separately for the trading portfolios of banks with large equity, debt, foreign exchange, or commodity operations. In June 1999, the Basle Committee published a consultative paper, *A New Capital Adequacy Framework*, which provides a framework for replacing the 1988 Accord. The new capital framework, commonly known as Basle II, consists of three "pillars," minimum capital requirements, a supervisory review process, and the "effective use of market discipline." The Basle Committee intends for the new framework to be available for implementation at the end of 2006.[51]

Banking supervisors of each of the participating G10 countries — as well as several countries that are not members of the Basle Committee — interpret and apply the Accord standards through their own regulations and directives. In the United States, two years after the Accord and in the aftermath of the thrift crisis, the Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) required thrifts to adopt a risk-based capital ratio that was based on the Basle recommendations. Currently, the Federal Reserve System and other federal banking regulators[52] apply these standards to all US banks, thrifts, and, while not mandated by the Basle Accord, bank holding companies.[53]

Figure 39 summarizes international risk-based capital credit risk weights for securities held in the banking book. Positions held in trading portfolios are not risk-weighted separately, but are included in portfolio-wide market risk capital calculations. This summary also assumes that there has been no transfer with recourse by the investing bank or thrift. We have left a few risk weights in brackets because the text of the written UK, EU, and Japanese capital regulations that we have been able to find are not clear on these items.

[51] "G10 central bank governors and heads of supervision endorse the publication of the revised capital framework," June 26, 2004, http://www.bis.org/press/p040626.htm.

[52] Namely, the Federal Deposit Insurance Corporation (FDIC), the Office of the Comptroller of the Currency (OCC), and the Office of Thrift Supervision (OTS).

[53] In addition to the Basle Accord standards, US institutions are required to maintain non-risk-weighted "leverage ratios" (Tier I capital divided by balance-sheet assets) of at least 3%-4%. Tier I capital refers to the permanent equity capital of a bank, consisting of equity capital and disclosed reserves. Equity capital includes cumulative preferred stock, noncumulative perpetual preferred stock, and other instruments that cannot be redeemed at the option of the holder.

Figure 39. International Risk-Based Capital Weights

Security Type	US Banks	US Thrifts	UK Banks	EU Banks	Japanese Banks	Example of Mortgage Pool or CMO/ABS Trust
Ginnie Mae Pass-Throughs	0[a]	0[a]	0	0	0	Ginnie Mae Pool #482736
CMOs Backed by Ginnie Mae Collateral	20[a]	20[a]	[20][b]	[20]	[20][c]	Fannie Mae CMO 1992-G35
Fannie Mae/Freddie Mac Pass-Throughs	20[a]	20[a]	20	[20]	20	Freddie Mac Pool #181991
Fannie Mae/Freddie Mac CMOs	20[a]	20[a]	20	[20]	20	Freddie Mac CMO 1758
Qualifying Residential Mortgage Loans[d]	50[a]	50[a]	50	50	50	
No agency Miss	50[a]	20 if SMMEA; Otherwise 50[a]	50	50	50[c]	NASCOR 1998-12
Asset-Backed Securities	100	100	100	100	100	Citibank Credit Card 1999-2

[a] Except for IO and PO strips, residuals and subordinated classes, which are assigned a 100% risk weight regardless of issuer or guarantor. However, the OTS is in the process of deciding whether lower risk weights may be appropriate for agency IOs and POs.

[b] The UK Financial Services Authority (FSA) assigns a 10% risk weighting to OECD government securities (and CMOs backed by GNMA or other government collateral) that have (i) a fixed rate and one year or less left to maturity, or (ii) a floating rate (and any remaining maturity).

[c] As of the time of publication, the Japanese Ministry of Finance capital regulations are not clear on these specific securities. Japan's large banks tend to follow US risk-based capital regulations by analogy.

[d] The regulations are not completely precise on this point, but most current residential mortgage loans with LTVs of 80% or less or backed by approved mortgage insurance if their LTVs are higher would fall in this category. Nonqualifying mortgage loans include those with LTVs greater than 80% and no private mortgage insurance. These loans are assigned a risk weight of 100%. FHA-insured or VA-guaranteed loans are exceptions to both of these rules and are assigned risk weights of 20% by US banks and thrifts.

Source: Citigroup.

Disclosure Appendix

ANALYST CERTIFICATION

We, Lakhbir S. Hayre and Robert Young.hereby certify that all of the views expressed in this research report accurately reflect my personal views about any and all of the subject issuer(s) or securities. I also certify that no part of my compensation was, is, or will be directly or indirectly related to the specific recommendation(s) or view(s) in this report.

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