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An Introduction to the Mortgage Market and Mortgage Analysis

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INTRODUCTION

The mortgage-backed securities market has developed rapidly since the late 1970s. Thrift institutions had been the primary sources of mortgage money, but in the late 1970s and early 1980s, investors who had not traditionally invested in mortgages began to play a greater role in housing finance. Recognizing attractive opportunities, these new investors began to include mortgage securities in their fixed income portfolios. The influx of new investors has altered the traditional mortgage business and has forced a closer examination of the issues related to pricing and valuing mortgage securities.

This paper describes the characteristics of mortgage securities and develops an analytic framework for their valuation. It discusses the various methods currently used to price mortgage securities and gives some insights into future trends in valuation analysis. The paper highlights the institutional and market realities of investing in these securities, as these factors are critical for developing an effective understanding of the securities as well as for creating investment or trading strategies.

MORTGAGE CHARACTERISTICS

A mortgage is a loan secured by some form of real property. While there are mortgages secured by such things as airplanes, locomotives, and financial assets, the most common security for a mortgage is real estate. The real property, such as a house, can be claimed by the lender (the mortgagee) if the borrower (the mortgagor) fails to make payments to the lender as required by the loan contract. The overall credit quality of a mortgage, therefore, depends on both the credit of the borrower and the market value of the property securing the loan.

The most active market for mortgages has been for those backed by single-family residences. Residences for one to four families are considered to be "single-family" homes. While the markets for mortgages backed by multifamily developments and commercial properties are expected to grow substantially over the next several years, they are currently only in the early stages of development.

Single-family Mortgages

Until recently, most single-family mortgages had the same basic characteristics: an original term to maturity of 30 years, a fixed contractual interest rate, and a monthly payment amount that remains constant over the entire term of the loan. The monthly payments on such a loan consist of some principal as well as all of the interest due each month. The monthly payments are fixed so that the principal payments made each month will completely repay the loan principal balance by the final maturity. As can be seen in Figure 1, the monthly payment in the early years consists mainly of interest, but as the loan ages, gradually more and more of the payment goes toward paying off the principal balance of the loan.

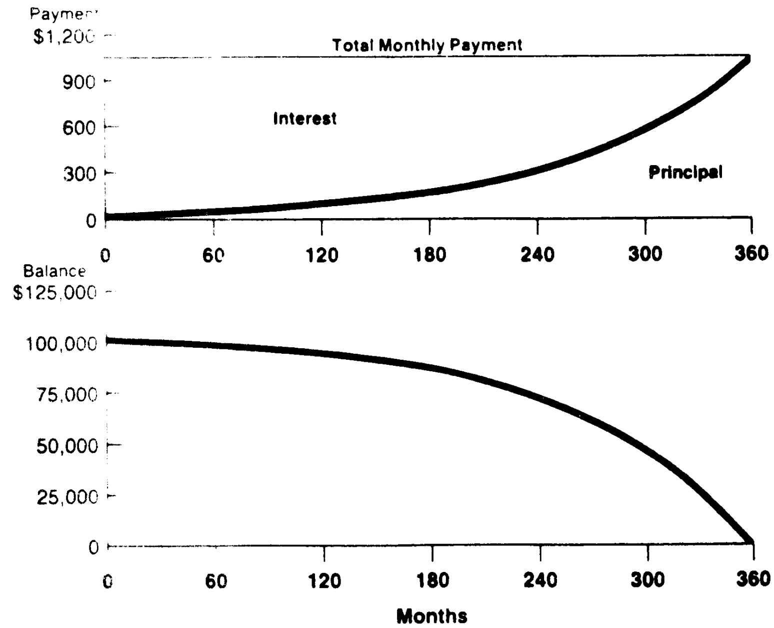
Fixed Rate

The *30-year, fixed-rate, level-pay mortgage* structure was established by the Federal Housing Administration (FHA) in the 1930s and was the dominant type of mortgage for almost 50 years. Borrowers had few choices about the maturities, rate structures, or payment structures on the mortgages they used to finance their homes. While widely accepted, this mortgage structure tended to create problems for borrowers and lenders alike. Borrowers found that they could not qualify for mortgages when interest rates were high. For traditional lenders, long-term mortgages created a mismatch between the maturities of their assets and the maturities of their liabilities. The net interest spreads on their portfolios were, therefore, highly cyclical; when interest rates rose the lenders' costs of financing would rise faster than the yields on their assets, and when rates fell the costs of their liabilities would fall faster than the yields on their assets.

Figure 1

Distribution of Mortgage Cash Flows

12% Mortgage



The problems with the traditional mortgage became particularly acute in the late 1970s and early 1980s when interest rates skyrocketed. Few borrowers were able to qualify for new mortgages and the spreads between the yields on lenders' assets and liabilities began to evaporate. Alternative mortgage structures were developed to allow more borrowers to be able to afford mortgages, even when interest rates are high, and to provide lenders with a better hedge against changes in their costs of funds. Today, prospective borrowers can select from an almost overwhelming array of mortgages with different maturities, interest rate structures, and payment structures.

The *15-year, fixed-rate, level-pay mortgage* appeals to many borrowers who prefer shorter term obligations. The ***graduated payment mortgage*** (GPM) has a fixed-rate, but the monthly payments increase annually by a fixed percentage for the first several years of the mortgage (usually five years) before leveling off and remaining fixed throughout the remaining term of the loan. For the first few years of a GPM's life, therefore, the borrower makes a lower monthly payment than would be made on a traditional mortgage with the same interest rate. Because of the artificially low monthly payments, the amount of interest that is *paid* on the GPM in the early years is not sufficient to cover the amount of interest that is *accrued* on the mortgage; the difference is added to the principal balance of the mortgage. Rather than amortizing the loan's principal balance steadily over the term of the mortgage, therefore, GPMs have *negative amortization* for the first few years of their lives. The *growing equity mortgage* (GEM) is similar to the GPM in that the scheduled monthly payments increase over time. The monthly payment amount on a GEM, however, is always sufficient to cover the interest accrued each month and the increased payment goes toward faster reduction of the loan's principal balance.

Adjustable Rate

The alternative mortgage instrument that has so far had the greatest impact on the mortgage market is the *adjustable rate mortgage* (ARM). The contractual interest rate on an ARM is tied to some published interest rate index and the mortgage rate will change at designated adjustment intervals as the index changes. ARMs currently available in the market differ in many ways. Some of the key features are described below.

Index – Currently, the most popular indices in the United States are the constant maturity 6-month, 1-year, 3-year and 5-year Treasury indices published by the Federal Reserve, as well as the Federal Home Loan Bank of San Francisco (eleventh district) Cost of Funds index (COFI). The cost of funds index is the average book cost of funds of thrift institutions who are members of the eleventh district of the Federal Home Loan Bank System (California, Arizona, and Nevada).

The various indices can perform very differently as interest rates change over time. In general, the shorter the term of the instrument tracked by the index, the more volatile the index will be. The index based on the constant maturity 5-year Treasury, for example, will generally be less volatile than the index based on the constant maturity 1-year Treasury. Since the Cost of Funds index is based on the book cost of funds, it is not entirely sensitive to current market conditions and it tends to lag current interest rates.

Margin –The margin is the amount by which the interest rate on an ARM exceeds the index rate. If the index in a particular month is 9%, for example, and the margin is 225 basis points, the interest rate on the mortgage in that month would be 11.25%.

Rate and Payment Adjustment Periods – The length of the period between rate adjustment dates is usually, but not always, the same as the maturity of the ARM index; ARMs indexed to the 1-year Treasury, for example, usually adjust annually. The rate adjustment period usually, but not always, corresponds to the payment adjustment period. There are ARMs, however, with semi-annual rate adjustments tied to changes in the 6-month Treasury, that have payments that adjust annually.

Rate Caps – Most ARMs have limits as to the amount by which the mortgage interest rate can change at each adjustment date and/or over the life of the loan. These caps alter the extent to which the mortgage rate adjusts to the index. The periodic caps usually limit both increases and decreases in the mortgage rate, while the lifetime cap usually limits only the highest rate the mortgage can reach.

Payment Caps – Some ARMs have limits as to the percent by which a mortgage's monthly payment can increase on any given payment adjustment date from the prior month's payment. Often, but not always, ARMs with payment caps allow for negative amortization to absorb the difference between the amount of interest that is being accrued on the mortgage and the amount of interest that is included in the mortgage payment.

Multifamily Mortgages

Multifamily loans are those secured by properties housing more than four families. These loans are structured in several different ways. Many multifamily mortgages have scheduled maturities of 180 months, but pay principal and interest each month based on a 360-month amortization schedule; the principal remaining at maturity is repaid in full as a balloon payment. Such a loan usually cannot be prepaid during the first few years of the loan's life. The "lock-out" periods on these loans usually last for about 4.5 to 5 years. Not all multifamily mortgages have these features, however. Some fully amortize over their lives and do not have balloon payments at maturity. Others do not have lock-out periods prohibiting prepayments during the early years of the lives of the loans.

Commercial Mortgages

Commercial mortgages are backed by properties such as shopping centers, hotels, office buildings, and industrial complexes. There has been very little standardization in the commercial mortgage market. The market for these mortgages has been relatively undeveloped because of the diversity of mortgage structures, underwriting standards, types and quality of collateral, etc. The recent establishment of rating standards by Standard & Poor's for securities backed by commercial mortgages should help to increase the homogeneity of these mortgages.

THE SECONDARY MARKET FOR MORTGAGES

Long before mortgage-backed securities were created, mortgages were bought and sold by investors as whole loans, or unsecuritized mortgages. In general, most of these transactions took place between lenders in capital deficit areas and lenders in capital surplus areas. Lenders with loan demand exceeding their deposit flow would sell their loans to lenders with deposit flow exceeding their loan demand. Many other large investors, however, were not involved in this market because of the specialized and extensive underwriting and operational capabilities these investments required.

Advantages of Securitized Mortgages

Mortgage-backed securities were created primarily to simplify the trading of mortgage instruments and thereby encourage wider participation in the market by investors who had not traditionally invested in these instruments. Mortgage securities generally provide investors several advantages over unsecuritized mortgages, some of which are described below.

Additional Insurance Protection

The security of an individual mortgage loan involves two factors: the borrower's ability to make payments and the market value of the property that the lender can claim if the borrower defaults on the loan. While the existence of FHA insurance or private mortgage insurance on a loan reduces potential losses, it does not guarantee timely payments each month during delinquency and foreclosure and may not, in certain cases, completely eliminate the risk of loss of principal. The mortgage-backed security structure solves this problem by adding an additional layer of insurance at the security level. The Government National Mortgage Association (GNMA), for instance, guarantees the timely payment of principal and interest each month on its securities, a guarantee that is backed by the full faith and credit of the U.S. Treasury. Regardless of what happens to the individual FHA or VA mortgages underlying a GNMA pool, the investor is assured of timely payments each month and need not be concerned with the credit quality of individual loans or lenders.

Quality Underwriting Standards
The mortgages that can be used to back federal agency mortgage securities must conform to standard underwriting guidelines which provide investors with the assurance that the loans collateralizing their securities are investment quality. Investors need not go through the often tedious process of evaluating the individual loans in a pool, as the loans are all underwritten during the securitization process.

Settlement Process
Settlement procedures on mortgage-backed securities have been standardized through the Public Securities Association (PSA). These procedures specify such things as the types of securities that can be delivered, the range of principal balances that can be delivered, and the standard settlement dates for mortgage-backed securities. Whole loan settlements, on the other hand, are often problematic because of the lack of standard procedures for these transactions.

Payment Process
An investor holding a mortgage-backed security need not collect monthly payments on each individual mortgage loan underlying a pool, but instead receives a single check based on the investor's pro rata share of the entire pool.

Use as Collateral
Mortgage-backed securities can be used as collateral for a number of different types of borrowings. While whole loans can be used as collateral for some types of borrowings, they are not as widely accepted as securitized mortgages nor are the borrowing costs usually as attractive as when securities are used as collateral.

Market Liquidity
The market for mortgage-backed securities is far more liquid than the market for unsecuritized loans. Large blocks of mortgage securities can be traded in a matter of seconds with bid/offer spreads of 1/8th of a point or less. While the market for whole loans is growing, it can still be very difficult to buy or sell these loans as quickly or with the execution available in the securities market.

Pass-through Securities

Pass-through securities are issued against pools of mortgages and the cash flows generated by the mortgages are passed from the servicers of the underlying loans to the holders of the securities on a monthly basis. The investors receive payments comprised of scheduled principal and interest and any unscheduled payments of principal (resulting from prepayments and defaults) that may have occurred. While there have been many pass-through securities issued by private corporations, the most widely held mortgage pass-throughs are those guaranteed by firms that are often thought of as agencies of the U.S. government: the Government National Mortgage Association (GNMA), the Federal National Mortgage Association (FNMA), and the Federal Home Loan Mortgage Corporation (FHLMC).[1] While the basic structures of the GNMA, FNMA, and FHLMC securities are very similar, they differ in many ways that influence how they are valued in the market. Figure 2 highlights some of these differences and the following sections describe the significance of these differences to security valuation.

Guarantee

GNMA, FNMA, and FHLMC all guarantee the principal balances of their securities. GNMA and FNMA, however, guarantee *timely* payment of principal and interest, while FHLMC provides this additional guarantee on a relatively limited portion of its pools. The strength of the guarantee of payment becomes particularly important when the mortgages underlying the securities are experiencing significant defaults. GNMA and FNMA investors would continue to receive interest and principal amortization payments in such an environment, while most FHLMC investors would receive interest only.

Mortgage Collateral

The mortgages underlying the different types of securities differ in many ways that can affect security valuation.

Mortgage Insurance – Securities backed by mortgages that are VA-guaranteed or FHA-insured (all GNMAs and a few FNMAs and FHLMCs) have a different level of credit risk than do securities backed by privately insured (conventional) mortgages. FHA/VA-backed securities also tend to prepay slower than securities backed by conventional mortgages because the mortgages can be assumed and, it is believed, because FHA/VA borrowers tend to be less mobile than borrowers with conventional mortgages.

[1] FNMA and FHLMC are not actually agencies of the U.S. government, but are private corporations that were created by Acts of Congress. Only GNMA has a guarantee of payment backed by the full faith and credit of the U.S. government.

Figure 2

MBS Program Comparison

	GNMA I	GNMA II	FHLMC-Regular	FHLMC-Guarantor	FNMA
Guarantee	Timely payment of principal and interest		Timely payment of interest, ultimate payment of principal	Some pools timely payment of principal and interest, other pools timely payment of interest, ultimate payment of principal	Timely payment of principal and interest
Mortgage Collateral:					
Insurance	FHA/VA		Conventional and FHA/VA		Conventional and FHA/VA
Payment Structure	Fixed rate, GPM, Buydown, ARM		Fixed rate, ARM		Fixed rate, ARM, GEM, GPM
Property Type	Single-family, Multifamily, Mobile Home		Single-family, Multifamily		Single-family, Multifamily
Maximum Original Maturity	15, 30, 40 years		15, 30 years		15, 30, 40 years
Pooling Requirements:					
Mortgage Coupons	50 bp above security rate	Between 50 and 150 bp above security coupon rate	No Requirement	All mortgage rates must be higher than the security coupon rate and must be within 200 bp of each other	Mortgage rates usually are at least 25 or 37.5 bp (depending on type of servicing lender performs) above security coupon and they must be with 200 bp of each other
Mortgage Age	All loans must be originated within one year of each other and within one year of the GNMA commitment date		Conventional Loans: No Limits; FHA/VA Loans: Loans must be at least 12 mos. old for pools issued prior to April 1986; no limits for pools issued after April 1986		Conventional Loans: No Limits; FHA/VA Loans: Loans must be at least 12 mos. old for pools issued prior to April 1986; no limits for pools issued after April 1986
Mortgage Maturities	At least 90% of the pool's original principal balance must be in mortgages with maturities of 20 years or more in the 30-year program		No Requirements		No Requirements
Pool Information					
Mortgage Coupons	50 bp over security rate	No Information	WAC as of issue date for some pools; no information for other pools		WAC as of issue date
Mortgage Age	No Information		No Information		No Information
Mortgage Maturities	Final Maturity		WAM as of issue date for some pools; final maturity for all pools		WAM as of issue date and final maturity for all pools
Payment Delay Penalty	14 days	19 days	44 days		24 days

Mortgage Payment Structure – While the bulk of the mortgage pass-through securities currently outstanding is backed by fixed rate, fixed payment, fully amortizing mortgages, there is a growing population of securities backed by alternative mortgage structures such as GPMs, ARMs, and balloon mortgages.

Original Maturity – The mortgages backing pass-through securities can have different original maturities. Most have original maturities of either 15 or 30 years. The length of the maturity will affect the size of the amortization payments for mortgages of a given age and possibly the rate at which they will prepay.

Payment Delay
The payment delay refers to the length of time between the date borrowers make their monthly payments to lenders and the date investors holding the securities backed by these loans receive the monthly payments. This is an interest-free delay because investors stop earning interest on any principal repaid in a month as of the date the payment is made to the lender. (For calculating security interest payments, the pass-through structure assumes that all principal payments occur on the first of the month). Because of this interest-free period, the longer a security's payment delay, the lower its yield will be relative to other securities with the same coupon and price. Conversely, for two securities with the same coupon and yield, the security with the longer payment delay will have a lower price than the security with the shorter payment delay.

Pooling Requirements
Each security program has different requirements regarding the characteristics of the mortgages that can be pooled together. In general, the more homogeneous the loans, the easier it is to predict how the pool will perform as it ages and as economic conditions change.

Mortgage Rates – Mortgages with different mortgage rates will prepay differently in response to changes in interest rates. The higher the mortgage rate, the more sensitive a loan's prepayment rate will be to changes in interest rates. The greater the diversity of the mortgage rates included in a pool, the more difficult it is to predict the amount and timing of the pool's principal payments.

Mortgage Ages – As mortgages age, they tend to prepay faster as a result of such things as homeowners relocating, trading up or down in house sizes, etc. The more diverse the ages of the loans included in a pool, the more difficult it is to predict how the pool's prepayments will vary as the pool ages.

Mortgage Maturities – For two mortgages with the same coupon rate, the mortgage with the shorter remaining term will have greater monthly amortization payments than the mortgage with the longer remaining term. As will be discussed later, if the mortgages in a pool have very different remaining terms, it is difficult to determine how much of a pool's total monthly principal payment is amortization and how much is prepayment. It is, therefore, difficult to analyze the pool's historical payment experience and to predict how it is likely to behave in the future.

Pool Information Provided

Depending on the requirements of a pass-through program, the characteristics of the loans underlying a pass-through security can be widely disparate. In most cases, however, the information published about a pool does not adequately indicate the extent to which the characteristics of the underlying loans are different. While combining heterogeneous loans in a pool makes it very difficult to predict how the pool is likely to repay, it becomes even more complicated when the information that is provided about the pool does not adequately describe the characteristics of the underlying loans. The amount of information provided for the various pools differs by security program.

Mortgage Coupons – The only security program for which there is perfect certainty as to the mortgage rates underlying a pool is the GNMA I program; all of the mortgages backing a GNMA I pool must have mortgage rates of exactly 50 basis points over the security coupon rate. For all other mortgage pass-through pools, the most detailed information that is available is the weighted average coupon rate (WAC) on the underlying mortgages as of issue date. It is probable, however, that a pool's WAC will change as the pool ages and the loans in the pool amortize and prepay. For several types of pools, no mortgage rate information is provided, except the maximum range of mortgage rates allowed to be pooled together given a security program's pooling requirements.

Mortgage Ages – No pass-through program currently provides detailed information about the ages of the mortgages in a specific pool. The pooling requirements for each program represent the only information that is available.

Mortgage Maturities – The exact distribution of mortgage maturities included in a pool is generally unavailable. Usually, the most information that is provided is the weighted average maturity (WAM) on the underlying mortgages as of issue date. As with a pool's WAC, it is highly probable that a pool's WAM will change as the pool ages and the loans in the pool amortize and prepay. For many pools, the only maturity information that is available is the final maturity of the pool, which is the maturity date of the loan with the longest maturity in the pool. Clearly, this statistic provides very little information about the distribution of the maturities in a pool and, therefore, how the loans are likely to perform in the future.

While pass-through securities pay investors their pro rata share of the principal and interest payments made on the mortgages backing a security through the maturity of the security, Collateralized Mortgage Obligations (CMOs) allocate the cash flows generated by the underlying mortgages to several different classes of investors. Most of the existing issues have four classes of bonds, or "tranches." The principal payments produced from the underlying mortgages are paid to the different tranches in sequence.

In the traditional CMO structure, investors in the first class of a CMO receive all of the principal payments on the underlying mortgages until the first class is completely repaid. Investors in each successive class receive no principal until each of the earlier classes is completely repaid. Investors in each class, except any accrual classes, receive only interest payments while investors in the earlier classes are receiving principal. In the majority of CMO issues, the last tranche is an accrual class ("Z-bond") which receives no cash payments at all until the earlier tranches are fully retired. Instead, the face amount of the Z-bond accretes at its stated coupon rate. When the other tranches have been retired, the Z-bond investors begin to receive both coupon payments (on the then higher principal balance) and principal payments received from the remaining collateral.

As with pass-through securities, the timing of the principal payments

[2] For a detailed discussion of CMOs, see Roll, Richard, "Collateralized Mortgage Obligations: Characteristics, History, Analysis," Goldman Sachs Mortgage Securities Research, April 1986.

on CMOs is sensitive to the prepayments on the mortgages backing the securities. Unlike pass-through securities, CMOs are usually considered to be debt on the books of the issuers. CMOs generally do not make payments to investors on a monthly basis, but pay quarterly or semi-annually.

Stripped Mortgage-Backed Securities[3]

Stripped mortgage-backed securities (SMBSs) are securities formed by segregating the principal and interest payments on a pool of mortgages. Unlike CMOs, which divide mortgage principal payments among different classes of bonds with varying maturities, SMBSs divide the mortgage principal and interest payments unequally among different classes of securities, each of which has a maturity equal to the maturity of the underlying pool of mortgages. There are two types of SMBSs currently outstanding: those backed by relatively low coupon mortgage pools whose market prices are below par and others backed by mortgage pools with relatively high coupons such that the current market values of the underlying mortgages are above par.

In an SMBS backed by discount coupon mortgages, the mortgage pool is used to construct both a very low coupon, deep discount security and a high coupon, premium security. Each class of the resulting SMBS receives one-half of each dollar of principal paid on the underlying mortgages, but the interest is divided unequally. A $100 million pool with a 9% coupon (9.5% rate on the underlying mortgages), for example, could be stripped into two classes, one $50 million class receiving one-third of the interest and another $50 million class receiving two-thirds of the interest. This would create a $50 million security with a 6% coupon rate and a $50 million security with a 12% coupon rate. The discount SMBS would benefit from the prepayments on mortgages 350 basis points higher than the SMBS coupon rate. The prepayments on the premium SMBS would be considerably lower and less interest-rate sensitive than the prepayments on comparable coupon securities, because the mortgages underlying this security would be 250 basis points lower than the SMBS rate.

SMBSs that have been structured using premium coupon collateral have had two types of classes: one class with claim to most of the mortgage pool's principal balance and to some of the interest generated

[3] For a deta[illegible] stripped mortgage-backed securities, see Roll, Richard, "Stripped Mortgage-Backed Se[illegible] Goldman Sachs Mortgage Securities Research, July 1986.

by the pool, and another class with claim to a very small portion of the pool's principal balance and to some of the pool's interest payments. As an example, a $100 million pool of mortgages with an 11% coupon rate (11.5% rate on the underlying mortgages) could be stripped to form a $99 million class (99% of the total principal) that receives 4.95% of the interest generated by the mortgage pool, and a $1 million class (1% of the total principal) that receives 6.05% of the interest produced by the mortgage pool. The $99 million first class would have a coupon rate of 5% (4.95/.99), while the $1 million second class would have a coupon of 605% (6.05 ÷ .01). The first class is a seemingly ordinary mortgage pass-through security with a 5% coupon. The second class is effectively an "interest-only" security because the amount of principal returned is trivial compared to the coupon payments.

The first class of an SMBS backed by premium collateral is a deep discount security whose value is enhanced by fast prepayments. Since there is such a big difference between the security coupon rate and the rates on the underlying mortgages, this security will normally trade at a higher price than a comparable coupon security with otherwise equivalent features, because the mortgages underlying the SMBS will prepay faster than the mortgages backing generic discount securities.

Since the bulk of the payments received by the second class of an SMBS backed by premium collateral are comprised of interest on the underlying pool of mortgages, this security is highly sensitive to the timing of the prepayments on the pool; the higher the prepayments the less interest this class receives. With most fixed income securities, the price of a security falls when interest rates rise, because the present value of the future cash flows decreases with the higher discount rate. With the "interest-only" SMBSs, however, the price of the security can be expected to increase as interest rates rise (within a certain range of interest rates), because the rising rates cause prepayments to fall, increasing the security's cash flows enough to offset the effects of the higher discount rate. After a certain point, however, further increases in interest rates have a relatively small effect on prepayment rates, so the price of the SMBS begins to fall with further increases in interest rates.

MORTGAGE PRINCIPAL PAYMENTS

One of the biggest risks associated with any type of mortgage-backed security is the uncertainty about the timing of principal payments on the mortgages underlying the security. The actual cash flow an investor receives from a mortgage-backed security depends on the amortization schedules and the termination pattern (resulting from prepayments and defaults) of the many individual mortgages included in the pool.

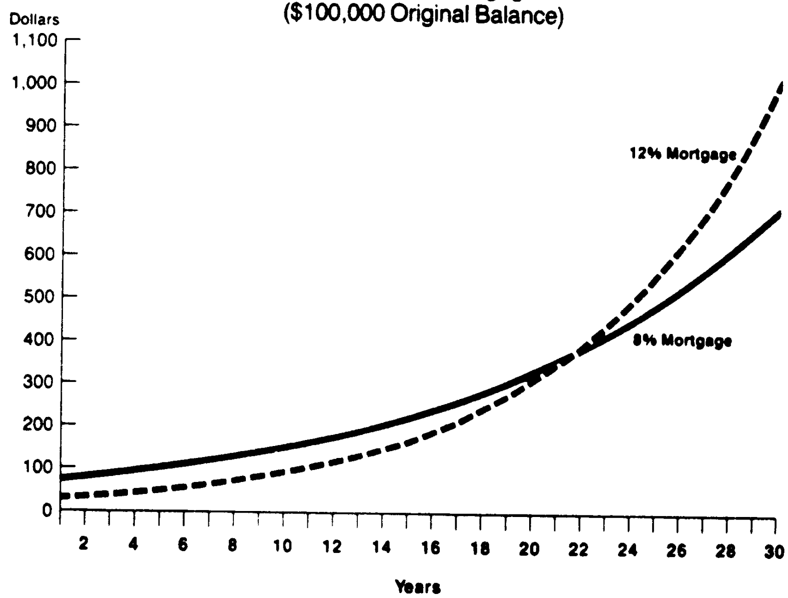
Since mortgage security investors are assured of the ultimate repayment of the principal balance of a pool, the actual pattern of cash flows from the pool will not affect the yield on their investments if the security is purchased at its parity price (i.e., the par value adjusted for the effect of the delay in monthly payments). If the security is purchased at any other price (at a discount or premium), however, the investor's yield will vary significantly depending on the timing of the repayment of the principal balance through principal amortization payments and principal prepayments.

Figure 3 shows the principal amortization payments of an 8% mortgage and a 12% mortgage, both with remaining terms of 30 years. The principal payments on these mortgages increase each month at a rate equal to the mortgage rate divided by 12. For either mortgage, therefore, the older the mortgage, the greater its amortization payments. The principal amortization payments on the 8% mortgage are higher than on the 12% rate mortgage until year 22. Since the monthly principal payments on the 12% mortgage increase at a faster rate than do the principal payments on the 8% mortgage, eventually the amortization payments on the 12% mortgage catch up with and then exceed the payments on the 8% mortgage.

Figure 3

Amortization Principal Payments

8% and 12% Mortgages
($100,000 Original Balance)

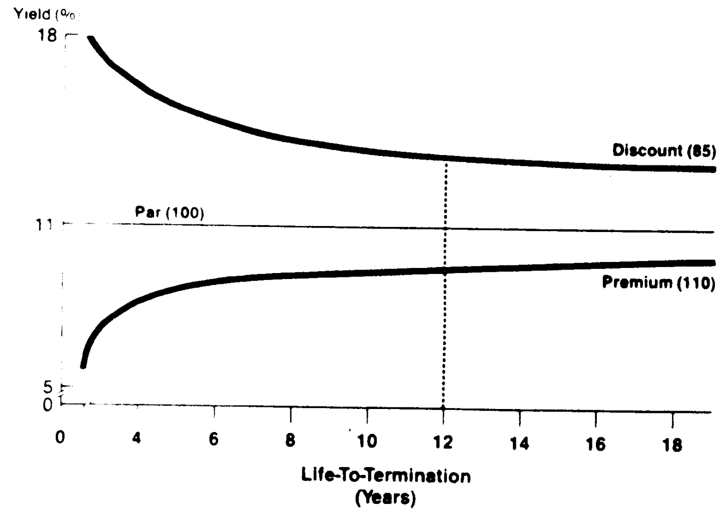


While principal amortization payments on a single mortgage loan are predictable, it is difficult, if not impossible, to predict when a mortgage will prepay and the timing of a mortgage's prepayment can have a significant impact on its yield. As is shown in Figure 4, when a new 11% mortgage is priced at par (100%), its yield will be equal to its coupon rate of 11%, regardless of whether it prepays in the fifth, twelfth, or twentieth year, or even runs to maturity. If, on the other hand, the mortgage is priced at a discount (such as 85%), the yield increases as the time the mortgage is outstanding is reduced. The yield on the mortgage will be higher if the loan prepays in its fourth year, for example, than if it prepays in its twelfth year. This occurs because the value of the discount from par (15%) is recouped over a shorter period of time. The investor may have paid only 85% of the outstanding principal balance of the loan, but the investor will receive 100% of the principal balance when the loan is repaid. The earlier the 15% discount is received, the higher the yield will be. If the mortgage is priced at a premium, on the other hand, its yield *decreases* as the time until the loan is terminated shortens. In this case, the investor pays a premium over par for a relatively valuable stream of monthly coupon payments which, by ending prematurely at the time of prepayment, reduces the return on the premium paid, and thus, the yield on the total investment.

Figure 4

Yield to Termination on a New 11% Mortgage at Various Secondary Market Prices

(Discount, Par, Premium)

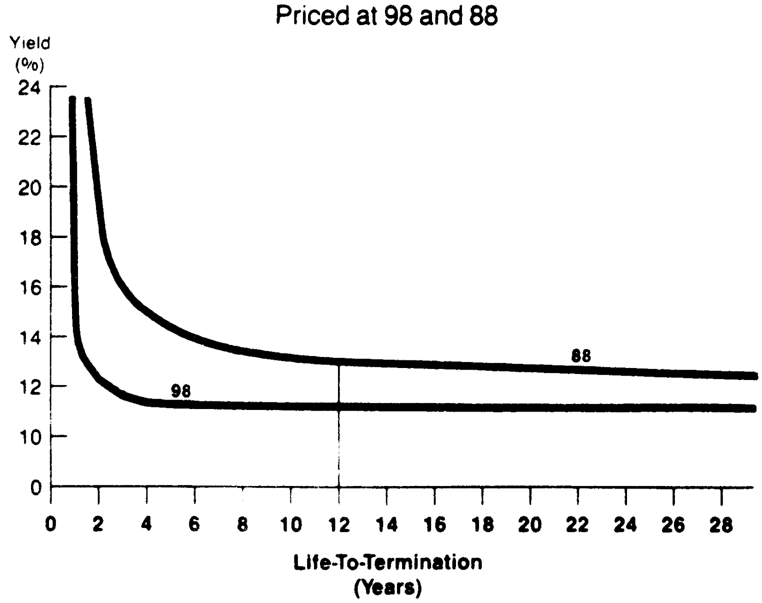


As is shown in Figure 5, the *magnitude* of the discount on a mortgage affects the relationship between the yield and the assumption about when the loan will be repaid. As would be expected, the farther away from par a mortgage is priced, the more sensitive the mortgage's yield will be to the length of time the mortgage is outstanding. The greater the discount, the greater the absolute and percentage increase in yield that will result from an early termination. The yield assuming a 12-year prepayment, for example, on an 11% mortgage is 11.25% when it is priced at 98, and 12.95% when it is priced at 88. When the prepayment is assumed to occur in the fourth year, however, the yield of the mortgage priced at 98 increases by 2.1% to 11.49%, while the yield of the mortgage priced at 88 increases by almost 15% to 14.86%

Figure 5

Yield to Termination on a New GNMA 11%

Priced at 98 and 88



It is important to note that, while the *yield to maturity* on a mortgage priced near par will be insensitive to the timing of principal payments, the *total return* from such an investment probably will be sensitive to principal payments. Prepayments tend to increase as interest rates fall because there is a greater incentive to refinance mortgages with high rates at lower market rates and there is a reduced disincentive to prepay loans with relatively low rates. The increased cash flow on an MBS that results from faster prepayments must then be reinvested at lower market interest rates. The cumulative influence of reinvesting the cash flows at lower rates can, over time, have a major impact on the total return of the investment, regardless of its purchase price. Conversely, when prepayments slow in a rising rate environment, the cash flows that can be reinvested at higher rates are reduced, thus diminishing the total return on the investment.

ESTIMATING PRINCIPAL PAYMENTS ON A POOL OF MORTGAGES

Any valuation of mortgage securities must incorporate a projection of future scheduled and unscheduled principal payments on the underlying mortgage loans. Estimating each of these components of a security's principal payments can be particularly problematic. The following sections describe some of the methods used to project mortgage principal payments and discuss some of the advantages and shortcomings of these methods.

Measuring and Estimating Prepayments

Terminations can be caused by either prepayments or defaults. The net effect to the pass-through investor is virtually identical: the investor receives principal payments over and above those resulting from normal amortization. The following sections will refer to both types of unscheduled principal payments as prepayments.

Life Estimates

The simplest approach to estimating prepayments on a pool of mortgages is to assume that nothing but amortization is received on the pool for some specified period of time after which the remaining balance on the pool prepays in full. For years, the standard prepayment assumption used to quote yields on mortgage-backed securities was a 12-year life assumption. This convention assumes that all of the loans backing a mortgage security are brand new 30-year mortgages whose cash flows consist of interest and scheduled amortization of principal for 12 years and full prepayment of the remaining principal balance at the end of the twelfth year.

There are several problems with this approach to estimating prepayments on mortgage securities. Many of the securities outstanding in the market today are significantly seasoned, so the assumption that they are all new can understate the principal amortization that will be received on these securities. Also, this convention was adopted during a period of relatively stable interest rates when the range of mortgage rates outstanding was narrow. In the current environment, with more volatile interest rates and a wide range of security coupons outstanding, the assumption of full prepayment after 12 years cannot be applied to all mortgage securities. While an individual mortgage generates level payments of interest and scheduled principal until it prepays in full (unless it has partial prepayments), this pattern does not hold true for the pools of mortgages backing mortgage securities, where prepayments can be expected to be distributed over time as different loans in the pool prepay.

FHA Experience

In order to avoid the shortcomings inherent in using life estimates to predict prepayments on mortgage securities, many market participants turned to using the average prepayment experience observed by the Actuarial Division of the Federal Housing

Administration on FHA insured mortgages. "FHA experience" represents the average prepayment and default experience of all FHA-insured single-family, 30-year mortgages over many years. Each FHA series consists of 30 termination balances, one for each year of a 30-year mortgage's life, representing the portion of a pool's original balance that would be outstanding at the end of each year if the pool prepaid according to the average FHA experience. From these balances it is possible to derive prepayment rates showing the average percentage of FHA loans that prepaid in each year of their life relative to the total number of loans of the same age outstanding at the beginning of the period. While the FHA experience series provides a benchmark for viewing the prepayment experience of a group of mortgages as they age, these base rates are often adjusted to reflect expectations for higher or lower prepayments in the future. If it is expected that prepayments on a particular pool will be twice as fast as those implied by the base FHA experience series, for example, one would adjust the FHA series accordingly and refer to the prepayment distribution as "200% FHA."

While using FHA experience as a benchmark to predict prepayments is far superior to using a point life estimate, there are still many problems associated with using FHA experience as a model of prepayments. One problem relates to the way the underlying data are aggregated. Table 1 illustrates the breakdown of the FHA experience series released in 1981. The prepayment rate for the first year of a mortgage's life is derived from the percentage of mortgages originated in the years 1957 through 1981 that prepaid after one year. Thus, a mortgage written at the beginning of 1957 would be examined at the end of 1957 to see whether it prepaid in its first year, one written in 1958 would be examined at the end of 1958, and so on. Since the prepayment rates for each of the succeeding years of a mortgage's life are derived in a similar manner, the number of distinct observation years included in each sample declines from 25 for the first year's prepayment rate (from mortgages originated between 1957 and 1981) to one year of observations for the 25th year's prepayment rate (from mortgages originated in 1957 only). The prepayment rates for the early years of a mortgage's life, therefore, are based on the experience of mortgages originated at the various market rates that existed between 1957 and the early 1980s, while the prepayment rates in the later years represent only the experience of mortgages originated in the late 1950s and early 1960s, when rates were uniformly low, mortgages that were thus less likely to prepay in the high interest rate environment of the late 1970s and early 1980s.

Table 1

Breakdown of FHA Experience
(Figures Released in Spring 1982)

Age in Years	Origination Years	Observation Years	Number of Years Observed	Prepayment Rates
1	1957-1981	1957-1981	25	1.13
2	1957-1980	1958-1981	24	3.77
3	1957-1979	1959-1981	23	5.17
4	1957-1978	1960-1981	22	5.73
5	1957-1977	1961-1981	21	6.21
6	1957-1976	1962-1981	20	6.80
7	1957-1975	1963-1981	19	7.12
8	1957-1974	1964-1981	18	7.23
9	1957-1973	1965-1981	17	7.00
10	1957-1972	1966-1981	16	6.69
11	1957-1971	1967-1981	15	6.59
12	1957-1970	1968-1981	14	6.43
13	1957-1969	1969-1981	13	6.12
14	1957-1968	1970-1981	12	5.86
15	1957-1967	1971-1981	11	5.59
16	1957-1966	1972-1981	10	5.34
17	1957-1965	1973-1981	9	5.10
18	1957-1964	1974-1981	8	4.89
19	1957-1963	1975-1981	7	4.67
20	1957-1962	1976-1981	6	4.40
21	1957-1961	1977-1981	5	4.11
22	1957-1960	1978-1981	4	4.94
23	1957-1959	1979-1981	3	5.78
24	1957-1958	1980-1981	2	6.68
25	1957	1981	1	7.62
26-30	Forecasted Data Points		0	

The FHA has historically updated the series every one or two years by incorporating the most recent experience of both old and newly-originated loans into the series. Beginning with the series released in 1984, however, the series includes only the experience of loans originated since 1970. By removing the experience of the very old FHA loans from the data, the newer FHA series better reflects the more recent prepayment experience and reduces, though does not eliminate, the bias built into the earlier series. Since the newer FHA series includes only the experience of mortgages originated between 1970 and 1983, however, the average prepayment rates calculated for years 14 through 30 of the series were not based on actual experience, but were estimated.

In addition to the bias caused by the aggregation of the FHA data and the confusion related to the periodic updating of the FHA experience series, there also exists a more obvious and fundamental problem associated with the way the data are averaged. While the relationship between the actual coupon rate on a mortgage and current market rates has a significant impact on prepayments, the FHA experience ignores this important relationship. Each series is the average prepayment experience of a group of loans with a wide range of coupon rates prepaying in vastly different interest rate environments. The prepayment rates on 8% mortgages originated in a rising rate environment will be considerably different than the prepayment rates on 17% mortgages originated in a falling rate environment, but the FHA experience does not capture these differences.

Conditional Prepayment Rates (CPRs)

The use of conditional or constant prepayment rates (CPRs) to measure prepayments on mortgage securities has gained popularity over the last several years. A conditional prepayment rate (CPR) is the percentage of principal outstanding at the beginning of a period that prepays during that period. The term "CPR" usually refers to an annualized prepayment rate, while the terms constant monthly prepayment (CMP) and single monthly mortality (SMM) refer to the unannualized monthly prepayment rate.[4] These statistics reflect the actual prepayment experience of mortgage securities and are pure numbers that can be easily interpreted, understood, and monitored on a historical basis.[5]

The greatest disadvantage in using a single CPR for estimating future prepayments on a mortgage security is, not surprisingly, the greatest strength of using the FHA experience: a single prepayment rate applied over the entire remaining term of a security cannot accurately capture the influences of aging on prepayments during the early years of a mortgage's life. At a constant interest rate level, prepayments on a new mortgage pool can be expected to increase during the first several years of its life, before leveling off. While a series of CPRs could be used to reflect better the varying influence of prepayments on mortgages cash flows over the life of a security, estimating the appropriate CPRs is a difficult and often subjective process.

It is reasonably accurate to use a single CPR to estimate prepayments for seasoned pools of mortgages and for pools with coupon rates above the current market level, because mortgage age has much less of a significant influence on prepayments for pools backed by these

[4] CPR = 1-(1-(CMP/100))[12]

[5] For a further discussion of the CPR approach and the methodologies for calculating historical CPRs, see Pinkus, Scott M. and Firestone, Evan B. "Mortgage Securities: Predicting Prepayments." *Mortgage Banker*, December 1983.

types of mortgages. The difference between the mortgage rate on the loans in the pools and the current market mortgage rate is the dominant influence on prepayments. This difference will determine the extent of the incentive to refinance a high rate mortgage for a new mortgage with a lower rate. For older mortgages, this difference will determine the degree of a borrower's disincentive to prepay a relatively low rate mortgage. This disincentive can lead a borrower to postpone a desired move; permit a loan to be assumed (if allowed); or take out a second, or wrap-around, mortgage rather than refinancing an existing loan when greater leverage is desired.

By regularly monitoring the historical prepayment experience of the securities issued under the major pass-through programs, it is possible to observe the effects of changing interest rates on prepayments. It is possible to isolate the differing influences of mortgage aging and changing interest rates by segregating homogeneous securities (such as GNMA 30-year, single-family pass-throughs) by coupon and approximate mortgage age.

The PSA Prepayment Model

The PSA standard prepayment model was developed by the Public Securities Association (PSA), which consists of major dealers in the mortgage-backed securities and Treasury markets. The PSA model was created primarily to provide standardization to the prepayment models used to price new CMO issues. To date, this model has been used almost exclusively for analyzing CMOs and is not widely used to analyze pass-through securities.

The PSA model represents a compromise between the FHA experience and constant prepayment methods of predicting mortgage prepayments. Like FHA experience, the prepayments incorporated in the PSA model vary with the assumed age of the mortgages underlying a security. During the first 30 months of a mortgage's life, PSA prepayments increase linearly; 100% PSA provides for a .2% (per annum) prepayment in the first month which increases by .2% in each succeeding month until it reaches 6% in month 30. After month 30, the PSA model stays at 6% for the remainder of the mortgage's life. After month 30, therefore, using PSA is exactly the same as using a constant CPR.

As with using either FHA experience or a CPR, the PSA model does not explicitly account for the effect of the current level of interest rates relative to the coupon rate on the mortgage. Instead, the recommended procedure is to use a PSA "multiple." A multiple such as 200% PSA, for example, might be appropriate for a mortgage selling at a premium, while a multiple such as 50% PSA might be appropriate for a mortgage selling at a discount.

Econometric Models[6]

It is possible to derive an econometric model to predict mortgage prepayments from the detailed historical prepayment and default experience of any large portfolio of individual mortgage loans or mortgage securities. The key factors that influence mortgage prepayment rates (such as mortgage coupon rates, future market interest rates, and mortgage age) can be explicitly considered as variables in such a model. This avoids having to make arbitrary or subjective adjustments to a prepayment assumption, as is required with the use of life estimates, FHA experience, or with the PSA model.

By determining the statistical relationships between one or several independent variables and the dependent variable to be forecasted, an econometric model acts as a formal proxy for the informal evaluation techniques employed by an experienced decision maker. Econometric modeling offers a systematic and statistically sound method of estimating prepayments, but it requires explicit estimates of the future values of a number of variables which are often themselves difficult to forecast. Many investors are unfamiliar with a number of the variables that could be included in such a model (e.g., regional migration patterns, average home costs, housing starts, etc.). Furthermore, the statistical relationships that proved meaningful during the 1960s, 1970s, or early 1980s may not hold true in the current interest rate environment and can even be misleading for predicting behavior today.

Amortization Principal Payments[7]

In order to calculate accurately the scheduled principal payments for a mortgage security, it is necessary to know the mortgage rate and maturity of each of the mortgages in the pool. Because this information is rarely available, it is necessary to make assumptions about the distribution of the maturities and mortgage rates given the information that is available. As was discussed earlier, the most detailed maturity

[6] For a further discussion of this approach as applied to the Federal Home Loan Mortgage Corporation's mortgage portfolio, see Peters, Helen F., Pinkus, Scott M., Askin, David J., "Figuring the Odds: A Model of Prepayments," *Secondary Mortgage Markets*, May 1984.

[7] See Pinkus, Scott M. and Mara, Susan D. "Measuring the Maturity of a Mortgage Security: When is a WAM Not a WAM?", *Mortgage Banker*, February 1985.

information that is generally available for any mortgage security is the weighted average maturity (WAM) of the mortgages in a pool as of the pool's issue date. This information is provided for all FNMA securities and for FHLMC Guarantor securities issued after June 1983. For all GNMA securities and for all FHLMC securities issued prior to July 1983, however, the only maturity information available is the final maturity date of the mortgage with the longest remaining term as of the pool's issue date.

Table 2 illustrates how estimates of principal amortization payments can vary when the exact distribution of the maturities on the individual mortgages in a pool is not known. In this hypothetical example, a $3 million pool has a final maturity at issue date of 350 months. While the pool's WAM is approximately 283 months, the actual maturities range from 200 to 350 months. If all of the mortgages in the pool are assumed to have the same maturity as the pool's final maturity,

Table 2

Impact of Maturity Distribution on Estimated Principal Payments

Pool Maturity Distribution (12% Mortgages)

Principal Balance	% of Pool's Total Balance	Maturity (Months)	Scheduled Principal Payment	% of Pool's Total Payment
$1,000,000	33.3%	200	$1,583.28	65.1%
1,000,000	33.3	300	532.24	21.9
1,000,000	33.3	350	317.01	13.0
$3,000,000	100.0%	283	$2,432.53	100.0%

Estimated Scheduled Principal Payments

Maturity Assumptions	Scheduled Principal Payment
Final Maturity (350 months)	$ 951.03
Weighted Average Maturity (283 months)	1,909.74
Actual Scheduled Principal	2,432.53

the pool's next scheduled principal payment would be calculated as $951.03. Using the WAM as a single maturity assumption for the pool, the scheduled principal payment would be calculated as $1,909.74. Both of these payment amounts, however, are substantially different from the $2,432.53 total scheduled principal that would actually be paid on the underlying mortgages. The greater the dispersion of the maturities on the loans in a pool, the less useful the published maturity information will be in calculating the pool's scheduled principal payments.

If a pool's scheduled principal payments are misestimated because the actual distribution of maturities on the underlying loans is not known, the amount of prepaid principal calculated for the pool will also be incorrect. (Principal prepayments are calculated as the principal paid in excess of the amount of principal scheduled to have been paid.) To the extent a pool's historical scheduled principal payments are *understated* by using either the pool's WAM or final maturity, the pool's prepayment experience will be *overstated.*

Table 3 illustrates a hypothetical pool's total principal payment for a given month, together with the breakdown of amortization payments and prepaid principal that would be calculated under two different maturity assumptions: the *final maturity* of the pool and the *original weighted average maturity* adjusted for seasoning. The interaction between the maturity assumption and the calculation of prepayments can be clearly seen. The longer the remaining term to maturity is assumed to be, the smaller the portion of total principal payments that is considered to be scheduled principal, and the greater the portion that is assumed to be prepaid principal. When comparing the historical prepayment experience of different pools, therefore, it is critical to consider the maturity assumption that was made when the prepayment rates were calculated. While the prepayment rate calculated for a pool using its WAM is likely to be lower than one calculated for a similar pool for which a WAM is unavailable and a final maturity was used, the total principal payments on the two pools could, in fact, be identical.

Table 3 also shows that when a shorter remaining term is assumed (the adjusted WAM) and a lower prepayment rate is calculated for the pool, the yield produced when that prepayment rate is projected over the same remaining term is actually the higher of the yields shown. Conversely, the lower yield results when the longer remaining term (the final maturity) and a higher prepayment rate are assumed for the future. Clearly, the faster amortization schedule that is implicitly projected when the shorter maturity is assumed more than offsets the impact of the lower prepayment rate in the yield calculation.

Table 3

Impact of Maturity Assumption on Prepayment Estimates and Projected Yields

FNMA 8%

Security Principal Balance:	$1,000,000
Final Maturity:	300 Months
Adjusted WAM:	200 Months

	Final Maturity	Adjusted WAM
Total Principal Payment:	$5,000.00	$5,000.00
Assumed Amortization Principal:	968.94	2,282.88
Estimated Prepaid Principal:	$4,031.06	$2,717.12
Conditional Prepayment Rate (CPR):	4.7%	3.2%
Assumed Price:	77.25	77.25
Projected Yield:*	12.29%	12.77%

* The projected cash flow yields are based on the maturity assumptions shown and the historical CPRs calculated using those maturity assumptions.

Principal Payments: Generic Versus Pool Specific Trades

There are two distinct approaches to handling the uncertainty of principal payments when evaluating mortgage securities, differing largely with the way the mortgage-backed securities are bought or sold. Mortgage securities can be traded on a *generic* basis or on a *pool specific* basis. A generic trade is one in which the specific pools that will be delivered are not identified at the time of the trade, and any pool of the same security type with the agreed upon coupon rate can be delivered at the specified price. Securities can also be traded on a specified pool basis. In these instances, the pools that must be delivered are those that were identified at the time of the transaction.

When evaluating a generic transaction, future principal payments on the securities are usually estimated based on either the average characteristics of all securities similar to those being examined or based on a reasonable worst case scenario of the characteristics of the securities that could be delivered against the trade. When evaluating a generic trade involving FNMA 8% securities priced at a discount, for example, an investor could assume that the securities that will be delivered will have the same average age and average historical prepayment experience as the averages for the population of FNMA 8% securities, or the investor could assume that only newly originated securities will be delivered with longer than average remaining terms and slower than average prepayment rates.

For a specified pool transaction, the parties involved have the advantage of knowing the actual characteristics of the individual pools being traded as well as the historical principal paydown experience of each pool. While this information can be useful when evaluating a potential transaction, its value is often overestimated. The historical prepayment experience of a particular pool is only relevant to the extent it provides insight into how the pool will prepay in the future. Many market participants jump to the conclusion that a "fast-pay" pool, one that has historically prepaid at a faster rate than the average for similar pools, will continue to prepay at a faster than average rate. The historical prepayment data on a pool must be carefully evaluated to determine how *consistently* the pool prepaid faster or slower than the average for similar securities, and over what time period. If a pool has a fast 12-month average prepayment rate, for example, but a monthly prepayment history showing little or no prepayments in most months with only a few months with large prepayments, it cannot be assumed that the pool will have faster than average prepayments in the future. It is possible, on the other hand, that a pool will consistently prepay faster than average as a result of the specific characteristics of the mortgages in the pool (the location of the loans, the maturities of the loans, the mortgage rates, etc.).

Table 4 shows the actual prepayment experience of two specific GNMA 8% pools, as well as the average experience of all GNMA 8% pools. Pool 10747 had prepayments that were consistently faster than the generic averages, indicating that the pool may be somewhat more valuable than a generic pool. Pool 10749, on the other hand, had only one prepayment over the nine months shown and, in fact, had not had another prepayment since 1979. The fact that the 6- and 12-month average prepayment rates on pool 10749 were faster than the average for all GNMA 8% pools is really irrelevant when one considers the pool's monthly prepayment experience.

Table 4

Generic Versus Pool Specific Prepayment Data

	All GNMA 8% Pools "Generic Data"	GNMA 8%-Pool 10747 "Consistently Fast"	GNMA 8%-Pool 10749 "Sporadic Prepayments"
Mar 1985	2.3% CPR	5.0% CPR	0% CPR
Feb 1985	2.4	11.0	0
Jan 1985	2.3	5.6	0
Dec 1984	2.3	0	0
Nov 1984	2.3	8.2	47.4
Oct 1984	2.0	11.5	0
Sep 1984	2.6	3.8	0
Aug 1984	3.0	0	0
Jul 1984	3.7	15.0	0
Summary Statistics:			
3-mo avg	2.3% CPR	7.2% CPR	0% CPR
6-mo avg	2.3	7.0	10.2
12-mo avg	2.8	5.2	5.3
Avg to date	3.4	7.5	7.5

VALUING MORTGAGE SECURITIES

Determining when a security has value relative to other securities is a subjective process that in many ways depends on what a portfolio manager is trying to accomplish. Many investors use estimated yields as a basis for valuing different securities. If the yield on a particular mortgage-backed security, using an estimated prepayment rate, is greater than the estimated yield on another security, the first security is often thought to be more valuable. Other differences between the securities, such as their relative price volatilities, prepayment risk, liquidity, or credit quality, however, can more than offset any yield advantage when viewed within a risk-return framework. The following sections discuss some of the factors that should be considered when evaluating the relative value of mortgage securities.

Forward Prices[8]

Unlike most other types of securities, mortgage-backed securities can be bought and sold for delivery several months later than the date of the transaction. The forward delivery market is necessary because of the nature of the mortgage origination process. The pricing of forward transactions should reflect the cost of financing the securities between two settlement dates, given the return from holding the securities during this period. Often, however, the pricing does not appear to reflect this "cost of carry." In such situations, the market demand for a certain type of security for delivery in a particular month may have driven up the price for that security relative to the price for the same security for delivery in a later month. It is important to recognize when these conditions exist in order to take advantage of any arbitrage opportunities that may be created.

[8]See Mara, Susan D., "Pricing Mortgage-backed Securities in the Forward Market," *Mortgage Banking*, November 1985

In general, the forward delivery market for mortgage-backed securities exists primarily to facilitate the origination of mortgage loans and their packaging as securities for sale in the secondary market. Mortgage lenders often commit to originate and sell loans at specified rates several months before the loans are actually closed. To hedge themselves against interest rates rising between the time they set a rate and the time they sell the loans, mortgage originators will often commit to securitize and sell the loans for delivery on a future date, thus locking in the current sale price of the loans.

Market forces tend to ensure that the difference between the price of a security for delivery in one month and its price for delivery in a later month will provide a return on the security equal to the returns available from investing in other instruments between the two delivery dates. Frequently, however, the demand for a particular security for delivery on a specific date exceeds the supply of that security, driving up the security's price for the first delivery date relative to its price for the later delivery date. When this happens, the difference between the two prices reflects an implied cost of carry that is lower than comparable market rates, creating arbitrage opportunities.

The implied cost of carry associated with a particular price differential can be calculated by considering all of the factors that affect the return from holding the mortgage-backed security between the two delivery dates:

- security coupon income during the period;
- security price level;
- difference between the security prices on the two delivery dates;
- recovery of any price discount or premium through scheduled and unscheduled principal payments;
- number of days between the two delivery dates;
- number of days of accrued interest paid on the security delivered on the first date relative to the number of days of accrued interest paid on the security delivered on the second date;
- reinvestment of security cash flows between the delivery dates;
- and security payment delay penalty.

It is important to be aware of the costs of carry implied by the prices for securities for delivery in different months in order to recognize when securities can be sold for an unusually high price in one month and/or purchased in another month at a cheaper price level.

Relative Price Volatility and Implied Duration[9]

The total return on a mortgage security over a relatively short-term horizon is usually very dependent on changes in the market value of the security over the horizon. Portfolio managers who actively manage their fixed income portfolios attempt to improve their short-term performance by anticipating the direction and, to a lesser extent, the magnitude of future price movements. If they believe rates will rise, these investors will try to reduce the average price volatilities of their portfolios, as measured by the durations on their securities. If they expect that rates will fall, they will try to increase the volatilities of their holdings by lengthening the average durations of their portfolios.

Using the traditional cash flow duration measure for estimating the price volatility of a mortgage security, however, can be seriously misleading. Since the traditional measure is based on a security's future cash flows, it is necessary to estimate future prepayments on a mortgage security in order to calculate its duration. Prepayments on a mortgage security, however, are themselves extremely sensitive to changes in interest rates. Even if it was possible to predict accurately what the future prepayments of a mortgage security would be if interest rates remain stable at their current levels, these estimates would be of limited value since interest rates are unlikely to remain stable over the life of the security. While duration has become a standard measure of interest rate sensitivity for most fixed income portfolio managers, it is necessary to alter the approach and broaden the concept to account properly for the interest-sensitive nature of the cash flows on a mortgage security.

The historical price relationships of mortgage securities offer some clues about how these securities are likely to perform in different interest rate environments. Figure 6 shows the price relationship between the GNMA 8 and GNMA 13 over the period of January 1, 1984 through January 1, 1986. The price relationship between these securities was not linear over that period, but can be better represented by a slightly curved line. The degree of curvature in the line representing their price relationship increases significantly after the price of the GNMA 13 reaches par and becomes a premium. This indicates that the price volatility relationship between the GNMA 8 and GNMA 13 coupons changes at different price levels,

[9] For a detailed discussion of the price volatility and duration characteristics of mortgage securities, see Pinkus, Scott M. and Chandoha, Marie A., "The Relative Price Volatility of Mortgage Securities." *The Journal of Portfolio Management*, Summer 1986.

and these changes become more rapid as the price of the GNMA 13 rises above par. The GNMA 13 becomes less and less volatile relative to the GNMA 8 as it trades at higher price levels, particularly in the premium area.

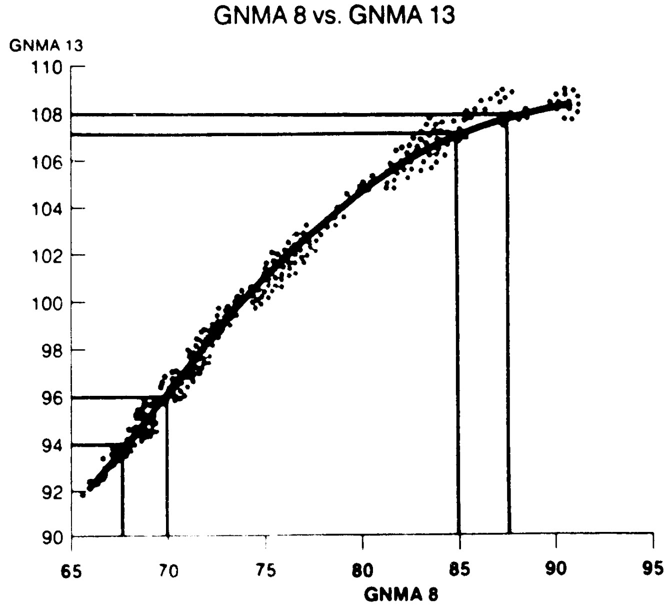
As was discussed before, the current level of interest rates will determine the extent of a borrower's incentive to prepay an existing high-rate mortgage and refinance the balance with a new, lower-rate loan. For older, low-rate mortgages, the current level of interest rates will determine the extent of a mortgagor's disincentive to pay off a relatively desirable loan. Current coupon securities, those priced just below par, are generally backed by mortgages recently originated at current market rates. Securities with coupons higher than the current coupon rate, therefore, are more likely to be prepaid than the current coupon, while securities with coupons below the current coupon are less likely to be prepaid.

The prepayment risk associated with current or higher coupon mortgage securities is in many ways analogous to that of a callable bond or any security with an implicit call option that is at or in the money. The risk that a mortgage security will prepay increases rapidly as the difference between the security's coupon and the current

Figure 6

Historical Price Relationship*

GNMA 8 vs. GNMA 13



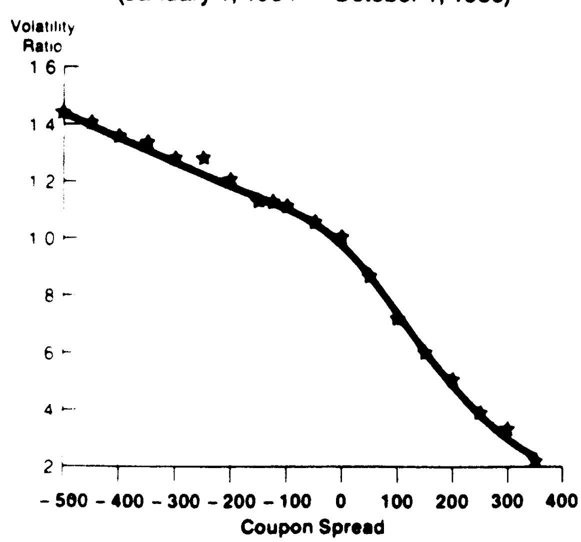
*Using daily prices from January 1, 1984 to January 1, 1986 coupon increases, as the option to call the bonds at par becomes more in the money. The price volatility of a mortgage security, therefore, will reflect the market's changing assessment of this risk.

Regression analysis can be used to measure the impact of this prepayment risk on the price volatility of securities with coupon rates above or below the current coupon. Figure 7 shows the results of regressing the percentage price changes of GNMA securities with different coupon spreads versus the current coupon against the percentage price changes of the current coupon GNMA. As is clear from this graph, GNMAs with coupons that are below the current coupon have prices that are more volatile than the prices of the current and higher GNMA coupons (i.e., high relative price volatility ratios). Also, the relative price volatility curve shown in the exhibit is relatively flat for the discount coupons, but falls sharply for coupons at the current coupon level and higher. As interest rates fall and the difference between a security's coupon and the current coupon becomes greater, the prepayment risk associated with the security increases substantially as the implicit call option becomes in the money. The deeper in the money the call option becomes, the less volatile is its price with respect to the current coupon GNMA.

Figure 7

GNMA Relative Price Volatility Curve

Volatilities Estimated Relative to Current Coupon GNMA
(January 1, 1984 — October 1, 1986)



Regression Estimates ("b")

While the graph in Figure 7 reflects the price volatilities of different GNMA coupons relative to the price volatility of the current coupon GNMA, it is also useful to be able to compare the price volatilities of mortgage-backed securities relative to other types of fixed income securities. Since duration is the measure of interest rate sensitivity most commonly used for fixed income securities, it is appropriate to develop a measure for mortgage securities that can be directly related to duration. It is possible to calculate an "implied duration" for mortgage securities by estimating the price volatility of a given GNMA (such as the current coupon) relative to another fixed income instrument for which the standard duration measure is meaningful, such as the 10-year Treasury. Given the duration of the 10-year Treasury and the observed historical price volatility of the Treasury relative to the GNMA, it is possible to calculate what the duration of the GNMA would have to be to produce the observed relative price volatility, given the following relationship:

$$\text{Relative Price Volatility of the 10-year Treasury to the Current Coupon GNMA} = \frac{\text{Duration of 10-year Treasury}}{\text{Implied Duration of Current Coupon GNMA}}$$

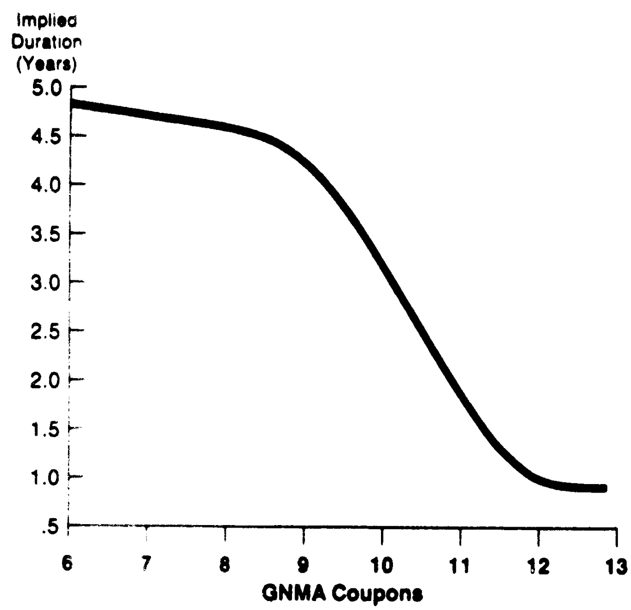
Once the implied duration of the current coupon GNMA has been calculated, the implied durations of GNMAs with higher or lower coupons can be determined from the relative price volatility curve shown in Figure 7. The volatility estimates on this curve are indexed to the benchmark GNMA, the current coupon, which was assigned a value of one. By assigning the benchmark GNMA a value equal to its implied duration and rescaling the curve accordingly, it is possible to create an implied duration curve for GNMAs with coupons above or below the current coupon. Figure 8 illustrates the GNMA implied duration curve estimated over the time period of April 1986 through October 1986.

Implied durations are based on actual market data and, therefore, the market's implicit valuation of the prepayment option on these securities. Portfolio managers can use implied durations to compare the true interest rate sensitivities of mortgage securities to those of other fixed income securities and to manage more effectively the interest rate exposure of any portfolio that includes mortgage securities.

Figure 8

GNMA Implied Duration/Coupon Curve*

(April 1, 1986 — October 1, 1986)



* Closing Prices as of October 17, 1986.

Options Pricing Theory

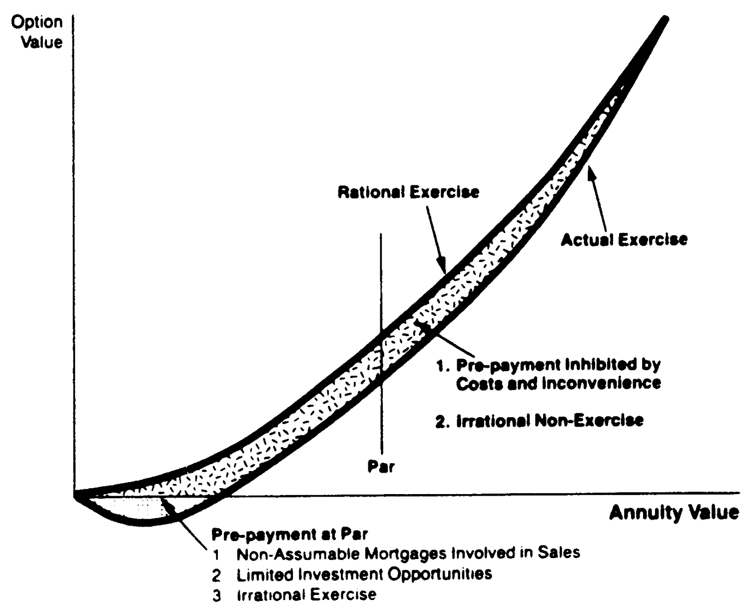
A mortgage is really a hybrid security consisting of a long position in an annuity (the mortgage's scheduled principal and interest payments) and a short position in a call option on the annuity (the borrower's option to prepay the mortgage at any time). The risks and returns from holding the mortgage can be partitioned and allocated to the two parts. The option entitles the borrower to retire some or all of the annuity at any point in time. It is a "call" option because prepayment is tantamount to purchasing the annuity from the investor (who is effectively short the call) for a predetermined exercise price of approximately par.

The annuity portion of a mortgage is subject to the same risks as a portfolio of Treasuries, the only uncertainty being due to changes in the level and shape of the yield curve. The option portion of the mortgage presents a more complex pricing problem. An option's market value depends on the market value of the underlying cash asset, a relationship that is non-linear.

Figure 9 shows two curves relating option value to portfolio value. The upper curve depicts the option value if mortgage borrowers could be expected to exercise "rationally." This curve is bounded below at zero. It rises with the value of the mortgage's annuity portion. At high values of the annuity, the option value moves one for one with the annuity value. In this range, the option is said to be "in the money" because the market value of the annuity exceeds the exercise price. At low values of the annuity, the option is out of the money. Its exercise at this point would actually bring a net loss since the value of the asset received would be less than the exercise price.

Figure 9

Actual and Rational Prepayment Options



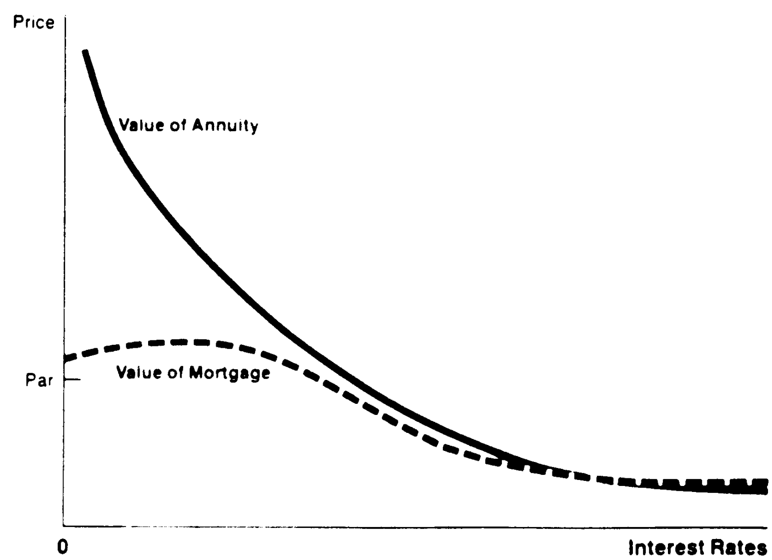
The lower curve depicts what actually happens in the mortgage market. Borrowers do not always prepay "rationally." For various reasons, they may prepay when the option is out of the money, when the current level of mortgage rates is higher than the rates on their mortgages. Similarly, they may not prepay when it is clearly advantageous to do so, when current rates on new mortgages are well below the rate on the old mortgage. Such behavior implies that the market value of the prepayment option is consistently below the value of a "rational" option price. Since the mortgage investor has sold the option to the borrower, the combined value of the mortgage annuity and the option is higher than it would be if prepayments were always made on rational economic grounds.

The total value of the mortgage consists of the annuity portion less the option portion. This is shown in Figure 10. The upper curve in this figure depicts the response of the annuity portion to interest rates.

The lower curve gives the total value of the mortgage, annuity less option, at different interest rate levels. The mortgage value departs significantly from the annuity curve as rates decline. This is the region of "negative convexity" which is due to the prepayment option moving more deeply into the money. There is actually an upper bound on the mortgage value as rates decline. It is reached when the option's value begins to move one for one with the value of the annuity.

Figure 10

Annuity Value and Mortgage Value



The difference between the annuity and mortgage curves in Figure 10 is related to the variability over time of the yield on current coupon mortgages, which is, in turn, related to the general variability of interest rate levels (i.e., interest rate volatility). Higher volatility induces a larger difference between mortgage value and annuity value at low levels of interest rates. This is due to the fact that an option's value is positively related to the volatility of the underlying asset. Since the value of the prepayment call option is deducted from the annuity's value when calculating the mortgage's value, the mortgage will be worth less when interest rates are volatile relative to, say, otherwise equivalent Treasuries. An increase in the variability of interest rates, therefore, will cause mortgage yields to widen with respect to Treasuries, even in the absence of a change in the level of interest rates or in expected prepayment rates.

Considering the performance characteristics of mortgage securities within an options pricing framework offers valuable insight into some of the more subtle factors that influence their performance, such as interest rate volatility and the slope of the yield curve. While the prepayment option in a mortgage security is in many ways analogous to a pure call option, the irrationality in the exercise of the prepayment option makes it far more difficult to value. Fundamental to any valuation of the prepayment option, therefore, is an estimate of the sensitivity of prepayments to changes in interest rates.

Total Return Analysis

A yield to maturity assumes that a security will be held to maturity and all of the security's cash flows will be reinvested at the security's internal rate of return. Because of these assumptions, this measure has limited value for investors who intend to sell the security before maturity and for those who wish to see the effects of changes in interest rates on the value of their holdings. Total return analysis measures all of the factors that can affect the value of an investor's position as of the end of a specified holding period:

- coupon income;
- recovery of any purchase discount or premium;
- reinvestment income earned on any principal and interest payments received during the holding period;
- and any price appreciation or depreciation on the security balance remaining at the end of the horizon.

Yields to maturity often provide misleading information about the relative values of different mortgage securities. Total returns calculated using reasonable assumptions usually produce better insights into the risk/return profiles of the securities. As an example, on July 29, 1986, the GNMA 11 had the highest yield to maturity (using projected CPRs) of any other GNMA (see Table 5), and on this basis the GNMA 11 appeared very attractive. On a total return basis, however, the GNMA 11 did not appear nearly as attractive[10].

Table 5

GNMA Projected Yields
(As of 7/29/86)

Coupon	Price	Rem. Term	Projected* CPR	Projected Yield (CBE)
7.5	92-28	245	6.0	8.95
8	94-12	245	6.0	9.17
8.5	95-19	259	6.0	9.43
9	97-01	294	5.0	9.63
9.5	99-20	291	5.5	9.69
10	102-26	332	4.0	9.70
10.5	105-22	348	4.0	9.77
11	106-01	330	10.0	9.83
11.5	106-05	325	25.0	9.17
12	106-22	336	30.0	9.01
12.5	106-26	324	37.0	8.74
13	107-12	322	40.0	8.58
13.5	107-29	321	40.0	8.76
14	108-08	310	45.0	8.37

* Projected CPR assuming a stable interest rate scenario over the remaining term of the security

Because the prepayment rate on the GNMA 11 was expected to increase by more if interest rates fell than it would decrease if interest rates rose, the GNMA 11 would underperform other GNMA securities if rates did anything but remain stable. Table 6 shows 1-year total returns on GNMA 8, 9, 11, 11.5, and 12 coupons under three interest rate scenarios: stable rates, rates rising by 100 basis points, and rates falling by 100 basis points. The prepayment rates on the securities were assumed to start at the beginning prepayment rate and to change linearly over the holding period to the terminal prepayment rate shown for each scenario. The securities were assumed to be sold at the end

[10]See Hunter Susan Mara, "The Risk of Owning GNMA 11s in the Current Market," Goldman Sachs Mortgage Securities Research, August 1986.

of the holding period at their beginning yields to maturity, or that yield plus or minus 100 basis points, depending on the interest rate scenario. The securities' cash flows were assumed to be reinvested at 6.5% under all scenarios.

Table 6

Total Returns

				CPR			1-Year Total Returns(CBE)*		
Coupon	Price	Rem Term	Beg CPR	-100	0	+100	-100	0	+100
8	94-12	245	6.0	6.5	6.0	5.5	13.61	9.00	4.46
9	97-01	294	5.0	5.5	5.0	4.5	14.61	9.44	4.37
11	106-01	330	10.0	30.0	10.0	6.0	8.10	9.56	6.22
11.5	106-05	325	25.0	37.0	25.0	7.0	8.35	8.80	10.60
12	106-22	336	30.0	40.0	30.0	10.0	8.26	8.61	11.49

* Using a 6.5 reinvestment rate under all scenarios

In order to evaluate the risk/reward tradeoffs of owning the securities under different interest rate scenarios, it is helpful to calculate expected averages of the total returns, weighting the return of each security in a given scenario by the probability of that scenario's occurrence. Table 7 shows several of these weighted returns, with probabilities somewhat arbitrarily assigned to each interest rate scenario to reflect different biases or expectations about future market conditions. The stable scenario assumes that there is a 50% chance of rates remaining stable, a 25% chance of rates rising, and a 25% chance of rates falling. The bullish scenario assumes that there is a 50% chance of rates falling, a 25% chance of rates remaining stable, and a 25% chance of rates rising. The bearish scenario assumes that there is a 50% chance of rates rising, a 25% chance of rates remaining stable, and a 25% chance of rates falling. The neutral scenario assumes that there is an equally likely chance of rates rising, falling, or remaining stable.

Under each of these weighted scenarios, the GNMA 11 does worse than all of the other securities shown. While the GNMA 11 outperforms the other securities if there is a 100% chance of rates remaining stable, as long as there is any significant chance of rates either rising or falling, the 11 underperforms the other securities; the risk of poor performance if rates change overwhelms the slight advantage the 11 has if rates remain stable. The yields to maturity on these securities did not capture the sensitivity of their returns to changes in interest rates. Total return analysis provides a better indication of how the securities are likely to perform in different interest rate environments.

Table 7

Weighted Total Returns (CBE)

Coupon	Neutral	Stable	Bullish	Bearish
8	9.02	9.02	10.17	7.88
9	9.47	9.47	10.76	8.20
11	7.96	8.36	8.00	7.53
11.5	9.25	9.14	9.03	9.59
12	9.45	9.24	9.16	9.96

Neutral = 33% -100; 33% 0; 33% +100
Stable = 25% -100; 50% 0; 25% +100
Bullish = 50% -100; 25% 0; 25% +100
Bearish = 25% -100; 50% 0; 50% +100

CONCLUSION

In recent years, the mortgage securities market has become increasingly complex in terms of the types of mortgages created, the structures of the securities issued, and the methods of analysis used to assess the value of these instruments. To be successful in this market environment, it is essential that an investor have a good grasp of the structural characteristics of the securities as well as their underlying mortgage collateral. It is important to recognize how the various features can affect the valuation of these instruments, particularly since market participants are increasingly basing their evaluations on the specific characteristics of an individual mortgage pool. In addition, one must be familiar with the different forms of analysis available in order to understand how the market is likely to evaluate these securities and to assess how they might perform under different market conditions.

The mortgage market will probably continue to grow more complex over the next several years as market participants develop new products, structures, and analytical techniques to take advantage of the immense profit opportunities in this market. These opportunities will undoubtedly continue to produce an environment conducive to both innovation and change.