Mortgage Securities

July 3, 1997 Kyle Nagel 212-902-1730

Volatility and the Mortgage Market: A Primer

As interest rates have held their range in recent months, relative value in the mortgage market has been influenced to a large extent by the decline in volatility. Since the beginning of the year, long-dated (3x7) swaption volatilities have declined by over two percentage points, while short-dated volatilities on 10-year Treasuries have declined by slightly more than three percentage points. Here we discuss several measures of volatility, the roles they each play in the mortgage market, and some of the issues surrounding their use. In particular, we discuss:

- why mortgage investors should care about volatility,
- how volatility is used by some of the largest participants in the mortgage market,
- the relevance of actual and implied volatilities,
- the directionality of volatility, and
- what implied volatilities exist in the interest rate derivatives markets.

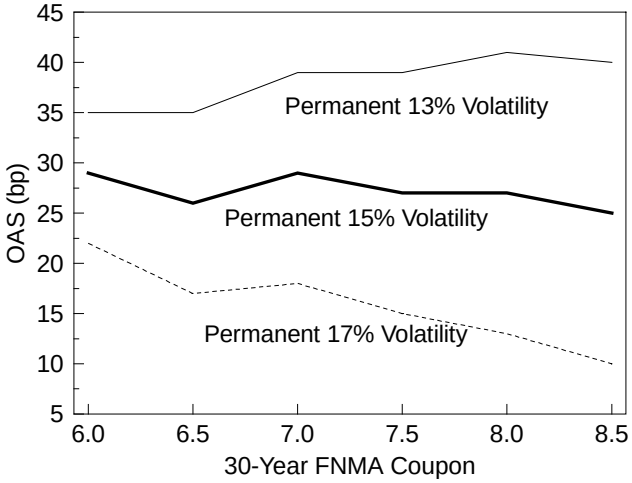
Why Should Investors Care About Volatility?

Purchasing a mortgage-backed security is almost always equivalent to purchasing a noncallable bond and selling an embedded, interest-rate-linked prepayment option. Since the valuation of this option is a function of volatility as well as prepayment assumptions, MBS valuation must also be a function of volatility.

Volatility affects current coupon and slight premium mortgages more than discounts and high premiums. That is, the $102-priced coupons, right below the cusp of refinancing, typically have the highest vegas, or sensitivities to volatility. In the graph at right, we show the effect of changing volatility assumptions on the OASs of FNMA 30-year mortgages at current market prices. Clearly, increasing the volatility assumption lowers OAS of all coupons and reduces the OAS for premiums and current coupons more than for discounts. A permanent one percentage point decline in long-dated volatility raises spreads on current coupon 30-years and GNMA ARMs by roughly 5-6 bp; the effect on 15-years is roughly half that of 30-years.

Owing to the effects of volatility on mortgage valuation, whenever we look at relative value in the mortgage market, we explicitly incorporate volatility in the analysis. Such volatility adjustments can be important when comparing vintages with TBAs, 15-years against 30-years, and large coupon swaps (for example, 6s into 8s).

Volatility Significantly Affects Mortgage OAS



Mortgage-Volatility Market Linkages

The link between the mortgage market and the volatility markets is significant, at least in part because of the activities of the agencies, servicers, and some large hedge funds. These entities purchase mortgages (thus implicitly selling options) and hedge the resulting exposure in the derivatives markets. This explicit link creates a strong bond

between the mortgage market and the volatility markets.

For instance, some hedge funds purchase mortgages and buy back the short option positions by purchasing swaps and swaptions, attempting to exploit inefficiencies between the mortgage and swaptions markets. Moreover, when it is attractive to sell volatility in the ARM market (by purchasing ARMs) and simultaneously buy volatility in the cap or swaption markets, activity in GNMA ARM Trusts picks up. In this case, arbitrageurs are taking advantage of the relative pricing of volatility in the ARM and caps markets by bundling together GNMA ARMs and stripping their caps. In addition, mortgage servicers often purchase out-of-the-money floors to hedge the erosion of their servicing cash flows when interest rates rally.

Some of the largest and most influential participants connecting the mortgage and capital markets are the mortgage agencies. The agencies link option valuation in the mortgage market with option valuation by buying mortgages for their retained portfolios and hedging the short option positions by selling callable debentures. The agencies also incorporate a number of financing techniques — such as swaps, swaptions, and caps — when funding their mortgage purchases.

All of these forces are increasingly linking mortgages with the markets for volatility and, consequently, are significantly influencing relative value in the mortgage market. When the embedded options in mortgage securities are priced inconsistently relative to other options, then hedge funds, the agencies, and other investors are quick to take advantage of the mispricing — resulting in mortgage prices that are linked reasonably closely with the options markets.

Actual and Implied Volatility

Broadly speaking, there are two ways to measure volatility: actual (realized) volatility and implied volatility. Both measures of volatility can affect MBS performance.

Actual volatility is the variability of yields (or prices) experienced over a specified period; it is usually calculated as the annualized standard deviation of daily percentage changes in yield. For example, actual volatility may be measured over a 30-, 90-, or 360-day period as the standard deviation of percentage yield changes over the selected time frame.

However, extreme market levels are more likely to affect option exercise than are day-to-day market changes. For this reason, the Garman-Klass formula is commonly accepted as an appropriate measure of volatility. The Garman-Klass formula measures volatility using the opening and closing yields and the intraperiod high and low 10-year yields. Using the last year's high and low yields, Garman-Klass volatility is estimated to be roughly 9%, compared with 11–12% under the standard variability measure. These actual volatilities contrast with current implied volatilities in the 13% range for three-month options on the 10-year Treasury.

While actual volatility is a measure of past yield movements around a historical average, implied volatility can be viewed as an estimate of future volatility as implied by an option price. Using an option pricing model and an interest rate model, we find implied volatility as the value that sets the theoretical price of the option equal to its current market price. (Clearly, implied volatility is a function of the option pricing model used, and insofar as the model assumptions differ from reality, implied volatility may also differ.)

Implied volatility can be estimated for either American options (exercisable at any point until expiration) or European options (exercisable only at the expiration date). Furthermore, these options can have strikes that are either in, at, or out of the money.

Implied volatility can be short- or long-*dated*, corresponding to the time until expiration of the option or contract. For example, implied volatilities of three-month options on the 10-year Treasury are short-dated, whereas implied volatilities of 10-year caps on three-month LIBOR are long-dated.

Additionally, volatility can be measured for long- or short-*maturity* instruments. Three-month options on the 10-year Treasury are long-maturity volatilities, whereas 10-year caps on three-month LIBOR are short-maturity volatilities.

Implied volatilities can be calculated on a forward basis, as well as on a spot basis. The resulting forward volatility is the market expectation of implied volatility over a period starting at some point in the future, rather than the near-term volatility expectation. For example, assume that three-month options on the 10-year Treasury have an implied volatility of 14% and six-month options have an implied volatility of 12%. What does this imply for the expected three-month volatility three months in the future? The calculation is as follows:

$$[(0.12^2 \times 6/12 - 0.14^2 \times 3/12) \times 12/3]^{.5} = 9.6\%.$$

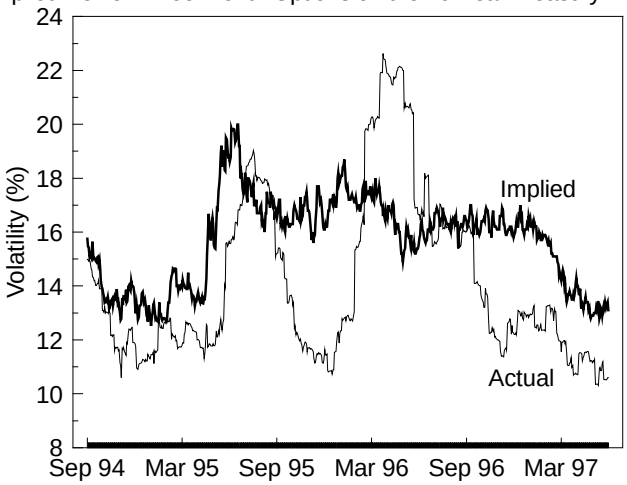
The computation indicates that the three-month expectation of volatility three months from now is 9.6%, while the spot three-month volatility expectation is 14%. Thus, in the same way that we speak of the term structure of implied forward interest rates, we can also describe the term structure of implied forward volatilities.

Actual volatility is important because it affects the return on an MBS. If interest rates fluctuate over a particular holding period, thus affecting prepayments, then the holding period return on the mortgage is affected. Actual volatility also affects the performance of a delta-hedged portfolio. Delta-hedging involves rebalancing the portfolio, and volatility increases the need and cost to rebalance periodically. Actual volatility matters more than implied volatility to most total-return investors, as well as to most banks, because their use of options is often limited.

Even if options are not being used to hedge the portfolio, implied volatility is important. Since the mortgage and volatility markets are increasingly linked by hedge funds and the agencies, which *do* use options as part of their mortgage investment strategies, movements in implied volatility are likely to result in changes in the spread that these large investors demand for holding mortgages. Thus, implied volatility will often matter indirectly, even for mortgage investors who do not explicitly use option strategies themselves.

Actual and Implied Volatility Are Seldom Equal

Actual Three-Month Vol. on the 10-Year Treasury Versus Implied Vol. of Three-Month Options on the 10-Year Treasury



Actual and implied volatilities need not be equal — in fact, they seldom are. The graph above illustrates three-month actual volatility on the 10-year Treasury, as well as the implied volatility of three-month options on the 10-year Treasury. Clearly, actual and implied volatilities differ substantially most of the time (much like actual and implied forward interest rates). Interestingly, today's low implied volatility environment is probably a reflection of the current low actual volatility. However, note that the spread between actual and implied volatility was even larger in mid-1996, with implied volatilities in the options markets often "looking past" temporary episodes of abnormal actual volatility.

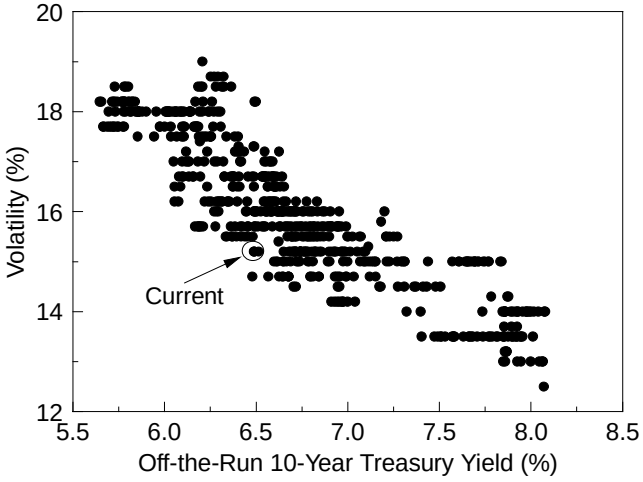
The Directionality of Volatility

Implied volatility is low today because actual volatility is low and because it is influenced by the level of interest rates. That is, volatility has empirically been directional over the last three years; prior to the last three years, and for significant sub-periods of those three years, directionality was notably nonexistent. The graph below illustrates that, as interest rates decline, volatility has tended to increase. (The same is also

true for implied volatilities of options whose strikes correspond to lower rate levels.)

Volatility Has Exhibited Market Directionality

3x7 Swaption Volatility — 9/94 to Present



Several explanations have been proposed for this empirical directionality of volatility. First, the directionality of volatility may be the result of investors, dealers, and servicers increasing purchases of implied volatility (options) to hedge short options positions when interest rates fall, or the result of their increasing actual volatility by making large, frequent adjustments to their Treasury hedges. Second, directionality may exist because the Federal Reserve has tended to move in discrete rate steps. If monetary policy is implemented in 25 bp increments, then an easing or tightening at a 5% yield level induces more volatility than an identical policy move at a 9% yield. Third, directionality may result from increased volatility as interest rates reach new lows and uncertainty increases regarding MBS prepayment rates and mortgage hedges.

Interestingly, basis point volatility, which is simply the market interest rate multiplied by percentage volatility, is only slightly positively related to market rates. Thus, the directionality of volatility is actually a function of the option pricing and term structure models used. Nonetheless, directionality clearly exists and should be incorporated when analyzing relative value in the mortgage market.

The directionality of volatility gives rise to a significant complication when analyzing mortgage spreads. This complication arises because structural, nondiversifiable prepayment risk is also correlated with market interest rate levels. The practical consequence of these correlations is that, when mortgages widen in a rally, it becomes difficult to determine which portion of the widening results from rising volatility and which portion from prepayment risk. Thus, while volatility is important in the mortgage market, closely correlated variables such as prepayment risk can be equally important in explaining changes in spreads.

Interest Rate Derivatives and Mortgages

There are numerous fixed income options that can be used as benchmarks for implied volatility in the mortgage market. Here we discuss three: Treasury options, caps and floors, and swaptions. (Various measures of actual volatility can also be helpful at times.)

Treasury options give investors the right to buy or sell specific Treasury securities or futures at a given strike price for a specified period. The Treasury options market is among the most liquid, and it has the longest trading history (15 years) for empirical analysis. However, Treasury option volatilities are short-dated, while the volatility that affects mortgage cash flow is typically long-dated. Short-dated volatilities can themselves be volatile, and changes in short-dated volatilities can easily be reversed, so usually only a fraction of their movement results in a lasting impact on mortgage valuation. Moreover, when a Treasury option position is used to hedge a mortgage, the short-dated option loses time value more quickly than the embedded mortgage option. That is, the time decay of the short-dated option is more dramatic than the time decay of the longer-dated embedded mortgage option, resulting in short-dated options being somewhat inappropriate for hedging mortgages. That said, the superior liquidity of Treasury options has made them quite popular among active total return investors seeking to manage their convexity exposure over one- to 12-month holding periods.

Caps are structured as a series of calls on interest rates, and floors are structured as a series of puts. Caps and floors provide their holders with cash flows based on a notional amount of principal if interest rates rise above or fall below the strike rate. The majority of caps and floors are struck on LIBOR or constant-maturity Treasury (CMT) rates. Ten-year CMT instruments are well suited for use in fixed rate mortgage analysis, as the borrower's prepayment incentive is closely tied to intermediate Treasury rates. LIBOR-based instruments are well suited for analyzing floaters, inverse floaters, or any other security whose coupon contains explicit caps and floors on a short-maturity index rate; for CMT ARMs, CMT-based instruments are appropriate. Caps and floors are generally less liquid than Treasury options, although liquidity is still fair. However, caps and floors are typically much longer-dated and can be as long as 20–30 years in maturity. Out-of-the-money floors often serve as good long-term hedges for mortgage positions, protecting against underperformance in refi-inducing rallies.

Swaptions are options to enter into swaps to pay or receive a fixed or floating rate of interest for a specified period. Swaptions are typically quoted as, for example, three-into-seven-year or 3x7, indicating that the holder possesses a three-year option to enter into a seven-year swap. These 3x7 swaptions resemble 10NC3 agency debentures. Since the agencies use the debenture market as one source of funding for mortgage purchases, it seems reasonable to expect the relative pricing between the two markets to be strongly linked. Note, however, that the agencies can incorporate a number of financing options, including issuing bullet debt and selling Treasury call options, as well as trades across the entire volatility spectrum. Moreover, the agencies' dominance of the swaptions market, where bid-offered spreads on implied volatilities are fairly wide, may result in swaption price signals that are distorted by technical factors. The swaptions market is relatively young and is less liquid than the markets for Treasury options, caps, and floors.

Of the various implied volatilities, the long-dated cap, floor, and swaption volatilities best resemble the options implicitly sold when mortgages are purchased. They also have reasonable liquidity and are more stable than short-dated Treasury volatilities. On a theoretical basis, either long-dated cap or swaption volatilities would be appropriate for valuing mortgage securities. On an empirical basis, however, the noise level and high correlations among *all* implied volatilities — and their correlations with actual volatilities, interest rate levels, and mortgage prepayment risk — mean that the answers are not at all clear-cut. We have historically used three- or six-month options on the 10-year Treasury in constructing our relative value measures, because those options are so liquid, have a long trading history, and can easily be used to hedge positions over short horizons.

What Does All This Mean?

We can draw several conclusions from the foregoing analysis. First, mortgage investors clearly need to make allowances for interest rate volatility (along with prepayment uncertainty and financing costs) in analyzing mortgage securities and their embedded options. Second, actual volatility matters for most mortgage investors, although several types of implied volatility can also play useful roles. Third, as is usually the case in the mortgage market, no single approach is best in all situations; they all have their advantages, drawbacks, and complications.

Several developments in the last few years have underlined the importance of volatility to the mortgage market. First, the agencies have become much more active in the volatility markets, and they have effectively exploited volatility differences across various markets in funding their mortgage purchases. Second, in 1995, a change in the hedge accounting rules for mortgage servicers dramatically increased their use of interest rate derivatives, and floors in particular, to hedge their cash flows. Third, many hedge funds have adopted a long-term focus in the mortgage market and are willing to maintain sizable trades to exploit volatility differences across markets. All of these forces are increasingly highlighting the importance of interest rate volatility in the mortgage market.