# Mortgage Security Hedging and the Yield Curve

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THE steepening of the yield curve in response to tighter monetary policy this past spring puzzled many market analysts and economists. Most of the explanations of this phenomenon have focused on macroeconomic issues such as market expectations of higher inflation or higher future interest rates. This article offers an additional, markets-based explanation that examines hedging activity—particularly the hedging of mortgage-backed securities—and its effect on the short-run dynamics of the yield curve.

When interest rates rise, both the duration and the expected maturity of a mortgage-backed security (MBS) increase. If market participants seek to counteract the increased price risk in MBSs by taking short positions in similar duration Treasury securities, the increase in MBS duration should cause participants to move their short Treasury positions out the yield curve, effectively increasing the "supply" of long duration Treasuries.

Thus the hedging of mortgage securities in the Treasury market may—in the short run—magnify any increases in long-term rates that accompany policy tightening. To the extent that such hedging activity has become a standard feature of the marketplace in the last few years, it may have permanently altered the short-run dynamics of the yield curve and thus changed the transmission of monetary policy.

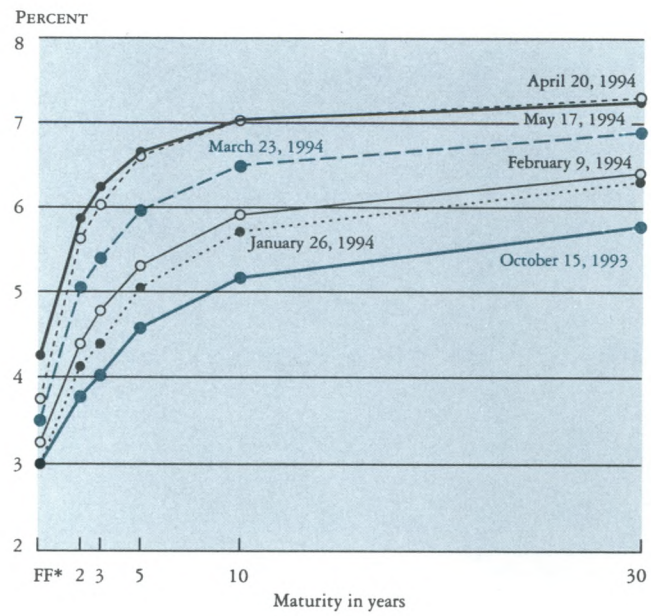
## Recent Movements in the Treasury Yield Curve

Chart 1 highlights several significant movements in the yield curve since the fall of 1993. First, long rates began to rise in October 1993, well before monetary policy tightened. Second, despite little or no observable inflation pressure, the Treasury yield curve did not flatten after policy was tightened: the 125 basis point increase in the federal funds rate from February through May of 1994 was accompanied by a 133 basis point increase in the ten-year Treasury rate. Third, after the change in policy direction in February, the yield curve became more hump-shaped: the two-year Treasury yield rose 175 basis points, but the thirty-year yield increased only 96 basis points.

Although the steepening after February was extreme by historical standards, Cohen and Wenninger (1994) have

*Chart 1*

Treasury Yield Curves




Source: Bloomberg L.P.

*FF is federal funds rate.

noted that since the mid-1980s, the short-run responsiveness of long rates to changes in the federal funds rate has increased sharply. A 100 basis point increase in the funds rate caused (on average) only a 15 basis point increase in the ten-year yield in the early 1980s, but a 40 basis point or more increase in the ten-year yield more recently (Chart 2).[1] In other words, when monetary policy is tightened, the yield curve now flattens less. Indeed, in the latest episode, it did not flatten at all.

Interestingly, the change in yield curve dynamics coincided with large-scale structural changes in financial markets, in particular the development of new financial instruments and the widespread securitization of home mortgages.[2] In 1983, less than 20 percent of the stock of residential mortgage debt was securitized; by 1993, nearly 50 percent was securitized. Increased securitization has led to increased use of mark-to-market accounting of mortgage debt, making owners of mortgage assets more sensitive to short-run rate movements.[3] To the extent that mortgage securitization caused quicker adjustments of mortgage portfolios to changing market conditions and thus brought closer links between mortgage and Treasury markets, it may have contributed to the change in yield curve dynamics.

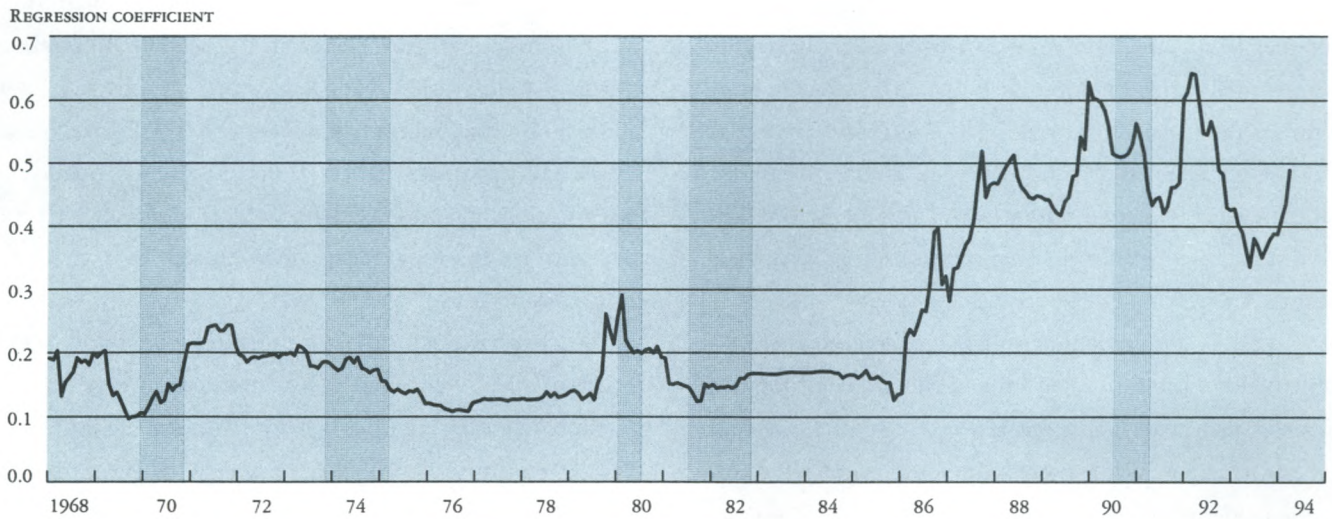
## How MBS Hedging Using Treasuries Could Steepen the Yield Curve

When long-term interest rates rise (because of policy tightening or other factors such as higher expected inflation), households, in aggregate, refinance and prepay their mortgages more slowly. For a typical mortgage pool, slower prepayments mean that the future mortgage principal will be repaid more slowly, thus extending the expected maturity of the MBS and increasing its duration. This is extension risk: slower prepayments increase the sensitivity of MBS prices to rising yields (see the box below).

Dealers in MBSs and collateralized mortgage obligations (CMOs) hold inventories of these securities, which they attempt to hedge against such extension risk. One common hedging strategy used by dealers is to offset long MBS positions by taking short positions in combinations of Treasuries that approximate the mortgage security's duration.[4] Thus as rates rise and prepayments fall, dealers must increase the duration of their Treasury hedges to roughly match the increasing duration of their MBS portfolios. For example, a dealer hedging its MBS portfolio with short positions in two- to five-year Treasuries might change to a combination of five-

*Chart 2*

**Sensitivity of Ten-Year Treasury Yields to Changes in the Federal Funds Rate**




Source: Cohen and Wenninger 1994.

Note: Chart plots coefficients from five-year rolling regressions of monthly changes in ten-year Treasury yields on monthly changes in the federal funds rate, that is, $\beta$ from $\Delta 10yr = \alpha + \beta \Delta FF$. Shaded areas indicate periods designated recessions by the National Bureau of Economic Research.

to seven-year Treasuries; a short position in five- to seven-year Treasuries might be changed to a short position in seven- to ten-year securities. (Thirty-year bonds are not generally used to hedge MBSs.)

As durations rise and market participants attempt to change their hedges simultaneously, the increase in short positions of long maturity Treasuries should cause their yields to rise by more than the yields of shorter maturity bonds, and the yield curve should steepen. The higher long-term yields could, in turn, reduce refinancing and prepayment rates even further, again increasing MBS duration (and its price sensitivity) and causing additional changes in Treasury hedges. Thus MBS hedging could cause positive feedback or a "multiplier" effect that would further steepen the yield curve.[5]

Just as dealers may use Treasury securities to hedge their MBS positions, portfolio managers who hold mortgage securities often use the government securities market to adjust their portfolios in an attempt to maintain a target duration. From a market dynamics standpoint, such portfolio rebalancing is analogous to dealer hedging of mortgage inventories: as interest rates rise and mortgage securities extend, the portfolio's duration increases. Longer duration in turn prompts managers to sell longer maturity Treasuries to

## Mortgage Security Structure: Call and Extension Risk

Fixed rate mortgages give homeowners the option to prepay part or all of the mortgage loan, at any time and for any reason, before the final maturity date. The prepayment option can dramatically affect the price sensitivity of the mortgage security because the timing and amount of prepayments change the actual life of the security.

Although the underlying mortgage loans often have thirty-year terms, an MBS is never viewed as a thirty-year instrument. Mortgage market participants constantly forecast future prepayments to predict the security's expected life. If fast prepayments (usually due to a decline in interest rates) cause the maturity (or duration) of an MBS or CMO to shorten substantially relative to expectations, that security is subject to "call risk."

Call risk is analogous to the risk to an owner of a callable bond: as interest rates fall and the price of the bond rises, the issuer (here a household) can exercise its option and call the bond at par. While there is no loss of principal in this case, the owner of the security must reinvest the proceeds at lower market interest rates.

If, on the other hand, slow mortgage prepayments (due to rising interest rates) cause the duration of an MBS to lengthen, then the MBS is subject to "extension risk." Slower prepayments mean mortgage principal is repaid later, thus extending the expected maturity of the MBS. Longer maturity also means that the security's price becomes more sensitive to rising yields. As the mortgage extends with the rising rates and slower prepayments, its price falls more than it would have had the prepayment speed remained constant (see Chart 3).

Both mortgage pass-throughs and collateralized mortgage obligations (CMOs) are subject to call and extension risk. By construction, however, some CMO tranches are substantially more sensitive to such risks than the underlying pass-through, and other tranches are less sensitive. This split may have increased aggregate hedging related to mortgage securitization.

In a nutshell, call risk forces investors to reinvest in falling rate environments, and extension risk exposes investors to escalating price risk in rising rate environments. Hedging activity is probably greater with extension risk because rising price risk and outright losses require a quicker adjustment of hedge positions than does the opportunity cost of lower reinvestment returns.

regain their portfolio's target duration. If many portfolio managers attempt such duration adjustments simultaneously, the excess supply of longer maturity Treasuries will steepen the yield curve.

## Mortgage Prepayments and the Shift in Monetary Policy

Although long rates began rising in late 1993, MBS dealers were slow to lower their forecasts of MBS prepayment rates (see table below). After the change in policy direction in February, however, estimates of expected future prepayment rates dropped sharply, presumably because the policy change signaled that further declines in interest rates were unlikely. In fact, in 1992 and 1993, mortgage prepayment rates had been much higher than most dealers had anticipated, and so the policy shift may have caused a particularly large drop in assumed prepayment speeds.

Chart 3 illustrates how critical prepayment expectations are for mortgage security prices and durations. In the chart, we consider the relationships among price, yield, and prepayment speed for an 8 percent coupon thirty-year conventional MBS currently yielding 9½ percent at a prepayment speed of 15 percent (point A). As interest rates change, different assumptions about prepayment response to the change in yield determine both the price and the duration of an MBS. For example, a 50 basis point increase in yield that does not affect the speed of mortgage prepayments would lead to a move from point A to point B and a price decline of 1.92 percent. More realistically, the increase in rates could slow prepayments from 15 percent to 10 percent per year—a move from point A to point C—and cause a larger 3.75 percent price decline. Alternatively, a fundamental change in the direction of future rates could produce a large drop in prepayments to, say, 5 percent per year—a move from point A to point D—and a large drop in the MBS price.[6]

With slower prepayments, the duration of the MBS is longer as well. In Chart 3, the duration of the MBS depends on the *slope* of the line connecting point A to one of the three other points—whichever reflects the expected prepayment speed. The effect of prepayment assumptions on duration is sizable, even for relatively small interest rate changes. A 50 basis point increase in rates with no change in prepayments (point B) will give this MBS a duration of 3.28, or approximately that of a four-year Treasury. If the same 50 basis point increase in rates is accompanied by a drop in prepayment speed from 15 percent to 5 percent (point D), duration increases to 5.36, roughly that of a seven-year Treasury.

The table above shows that actual declines in prepayment speeds and increases in effective duration during early 1994 were indeed quite large—of the same order of

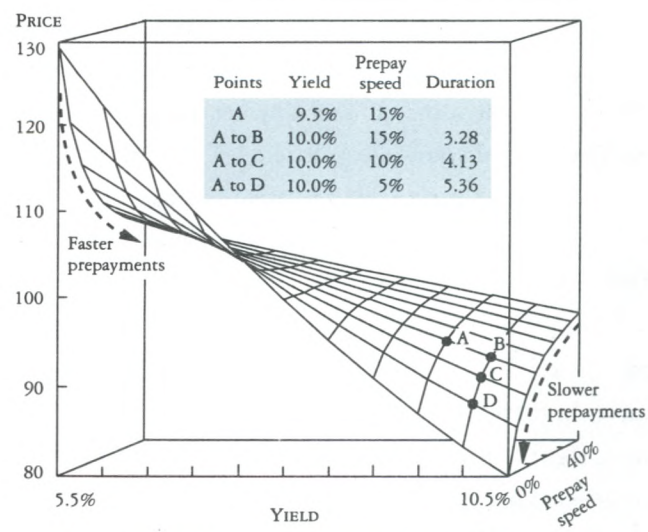
**Dealer Prepayment Forecasts and Effective Durations**
FNMA 7.5 Percent Coupon Thirty-Year Conventional MBS

| Date | "Effective" Duration (Years) | Prepayment Forecast (Percent) | Ten-Year Yield (Percent) | Fed Funds Rate (Percent) |
|---|---|---|---|---|
| October 15, 1993 | 3.40 | 21.8 | 5.17 | 3.00 |
| January 26, 1994 | 3.49 | 20.8 | 5.71 | 3.00 |
| February 9, 1994 | 3.52 | 20.8 | 5.91 | 3.25 |
| March 23, 1994 | 4.81 | 11.9 | 6.49 | 3.50 |
| April 20, 1994 | 5.27 | 9.5 | 7.03 | 3.75 |
| May 17, 1994 | 5.41 | 9.0 | 7.04 | 4.25 |

Source: Bloomberg L.P.
Notes: Prepayment forecasts are dealer medians quoted in PSA and converted to conditional prepayment rates in percent. Effective durations are calculated with dealer median prepayment forecasts using Bloomberg analytics. Dealers include First Boston Corporation, DLJ, UBS Securities, Paine Webber, Bear Stearns, Smith Barney, Prudential Securities, Merrill Lynch, Lehman Brothers, and Salomon Brothers.

*Chart 3*

**Price-Yield-Prepayment Surface for a Typical Mortgage-backed Security**




Note: Example is 8 percent coupon thirty-year conventional mortgage-backed security.

magnitude as those in Chart 3. Duration (for a FNMA 7½ percent coupon MBS) was basically unchanged from October to February, remaining at about 3½ years, and then rose sharply after the policy change in February to nearly 5½ years by mid-May. Hedging this particular MBS would call for a short position in four-year Treasuries in February but a short position in seven- to eight-year Treasuries by May. However, because most hedging is done with new-issue Treasuries, in practice such an MBS would be hedged with three- to five-year Treasuries in February and five- to ten-year Treasuries by May. (Issuance of seven-year Treasury debt was discontinued after April 1993, making it a less likely hedging vehicle.)

While this example of a particular MBS illustrates the duration and hedging issues, in practice, market participants hedge entire portfolios of MBSs and CMOs, not individual mortgage securities. Unfortunately, we have no information on the composition of these portfolios, so it is impossible to say exactly how durations and hedges of MBS portfolios may have actually changed in late 1993 and early 1994.[7] Thus we turn to more indirect evidence to try to identify links between the mortgage and Treasury markets.

## Empirical Evidence

Some market participants have estimated that from October 1993 to April 1994, aggregate dynamic hedging of mortgage extension risk by dealers, portfolios managers, and other investors resulted in Treasury market sales of more than $300 billion in ten-year Treasury equivalents. Although this figure is impossible to verify, we can provide some circumstantial evidence that mortgage security hedging using Treasuries had a significant, although probably not dominant, effect on the Treasury yield movements in late 1993 and early 1994.

Because mortgages are usually hedged with Treasuries up to ten years in maturity, but not with thirty-year Treasuries, the flattening of the Treasury curve between ten and thirty years seen in Chart 1 provides some evidence supporting a link between MBS hedging and the Treasury yield curve. In particular, the spread between the ten- and thirty-year securities fell from nearly 60 basis points in early February 1994 to less than 20 basis points by early May, a flattening that is very hard to explain by expectations of higher inflation or higher short-term rates over the next year or two. Such a flattening of the long end of the yield curve would result, however, if relatively more ten-year securities were being sold to hedge mortgage securities.

In contrast, mortgage security hedging does not explain the bulge in the Treasury curve from two to five years over the same period. Indeed, MBS hedging should have put downward pressure on two-year Treasury yields in particular. It seems likely that widely cited macroeconomic factors such as expectations of higher inflation and higher future interest rates dominated movements at the short end of the yield curve.

Although the yield curve evidence is ambiguous, daily price correlations between MBSs and Treasuries show consistently stronger relationships between MBSs and longer maturity Treasuries in early 1994. A minimum condition for mortgage hedging to have affected the yield curve is that MBSs should have behaved more like ten-year securities and less like shorter term securities from October to May. In fact, price correlations between different maturity Treasuries and the 7½ percent FNMA in Chart 4 show just such a pattern. When long rates began to rise in October and November, the correlations between prices of two-year Treasuries and mortgage securities fell, while the correlations between the MBS and five-year Treasuries rose slightly.

After the policy tightening in February, correlations between the MBS and two-year Treasuries dropped again, and correlations between the MBS and the five-year Treasury dipped slightly. In contrast, the ten-year Treasury/MBS correlations were stable or rising in February and March. Further, the timing of the changes in price correlations corresponded quite closely to that of the increases in MBS duration in the table on page 95. In late 1993, this MBS behaved like a five-year rather than a two-year Treasury. By March and April 1994, its duration increased enough that the MBS price behaved more like that of a ten-year than a five-year Treasury.

While the price correlations are consistent with a relationship between MBS hedging and Treasury prices, they cannot tell us if such activity was actually occurring. One obvious question is whether MBS activity was really large enough to affect Treasury prices. Chart 5 suggests that it was. New five- to ten-year Treasury supplies (lower right), which are most likely to be used for hedging purposes, were about

$45 billion a quarter during 1993, while dealer inventories of MBSs, both pass-throughs and CMOs, were $50 billion or more in late 1993 and early 1994.[8]

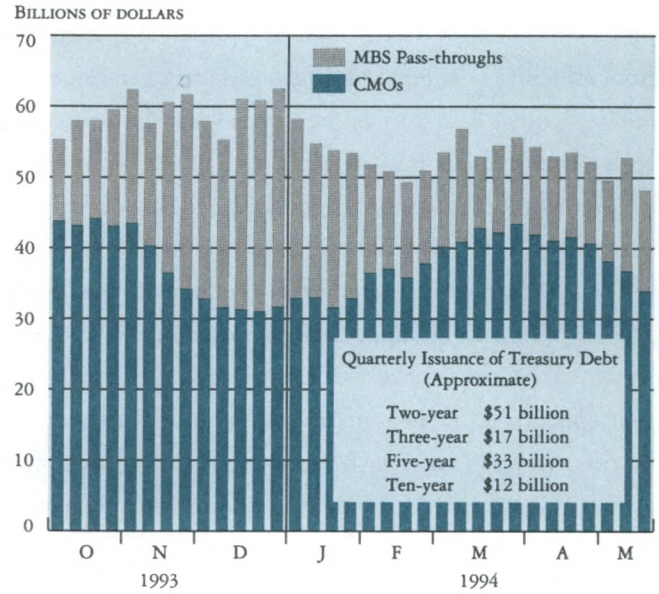
Comparing the outstanding amounts of Treasury and mortgage securities at year-end 1993 provides further evidence that the mortgage market was large enough to affect the Treasury market. In fact, private holdings of Treasury marketable debt maturing in two to ten years were *smaller* ($964 billion) than outstanding securitized agency mortgage debt ($1,350 billion).

Perhaps the most direct information on the demand for Treasury securities for hedging purposes comes from the repurchase agreement market for Treasury collateral—the "repo" market. The holder of Treasury collateral pays the repo rate to the party seeking to borrow the collateral (often for delivery against short sales in the cash market). A short seller usually borrows a specific Treasury issue to meet its cash market delivery obligations.

The repo rate for general collateral (that is, any maturity Treasury) is similar to other overnight interest rates. However, imbalances between supply and demand for specific Treasury issues are reflected in issue-specific repo rates.[9] For example, low repo rates reflect excess demand in the collateral market for a particular Treasury issue because the holder of the collateral pays the repo rate.

*Chart 5*

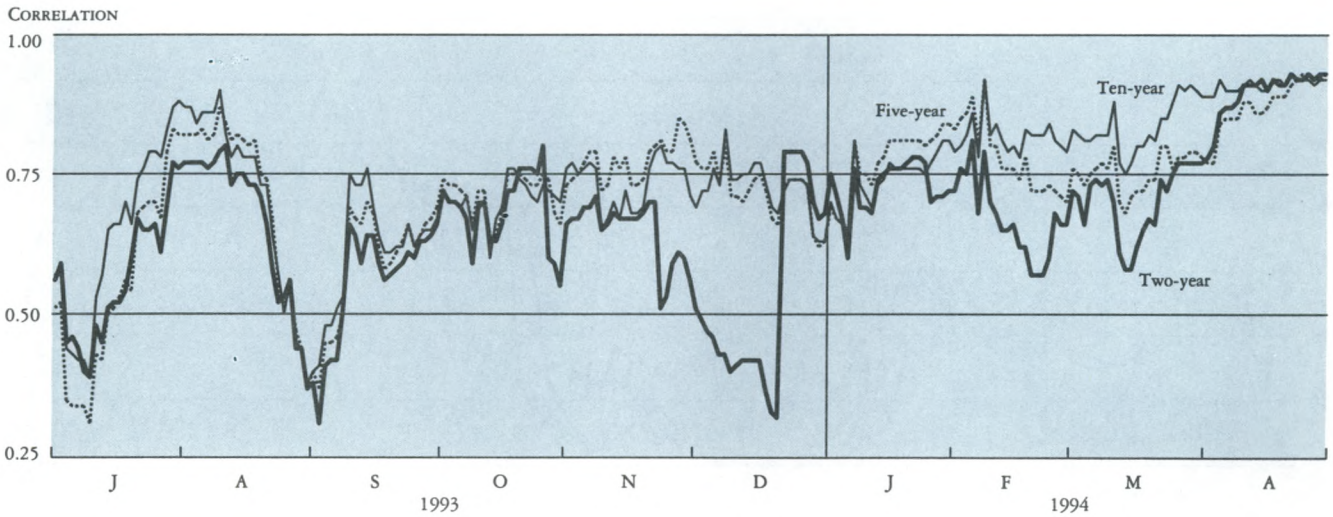
**Dealer Positions in Mortgage-backed Securities and Collateralized Mortgage Obligations**




Source: DRI/McGraw-Hill.

*Chart 4*

**Price Correlations: Mortgage-backed Securities and Treasuries**
FNMA 7.5 Percent Coupon with Two-, Five-, and Ten-Year Treasury Securities




Source: DRI/McGraw-Hill.

Note: Chart plots twenty-day lagged rolling price correlations.

Repo rates for particular maturities are commonly presented as spreads relative to the rate for general collateral. A high repo spread (that is, low repo rate) can be interpreted as the financing premium that a short seller must pay in order to borrow a particular maturity Treasury security overnight.

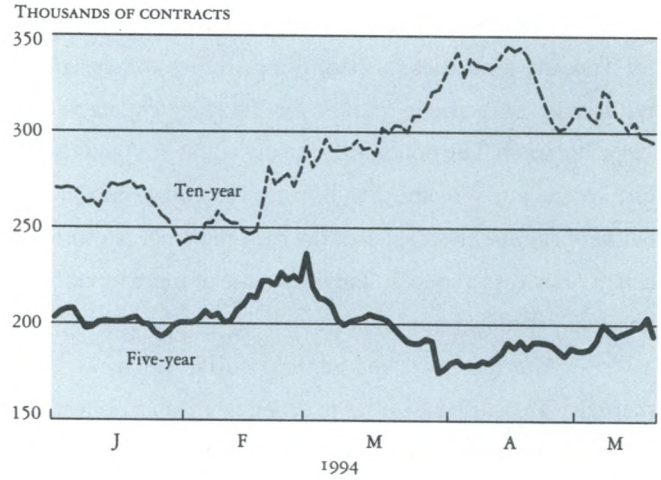
Repo spreads for the most recently issued or "on-the-run" Treasuries are shown in Chart 6.[10] Spreads for the first four months of 1994 are consistent with high demand for progressively longer dated Treasuries, presumably stemming from efforts to counteract mortgage security extension risk. Spreads widen first for five- and seven-year maturities and then for the ten-year maturities.[11]

Further evidence of increased hedging activity can be seen in Chart 7, which shows open interest in the five- and ten-year Treasury futures market from the beginning of 1994.[12] These data support the repo data: open interest increased first for the five-year contract and then for the ten-year contract as rates continued to rise.[13] Moreover, the increase in open interest for the ten-year contract corresponded closely to the high and sustained financing premium in the ten-year repo market through April.

In contrast, open interest for thirty-year bond futures shows a mild upward trend during the period (Chart 8) but no clear pattern that can be related to MBS hedging. Furthermore, it is difficult to extract information about hedging activity from movements in the open interest for the thirty-year bond contract because daily trading volume is particularly high relative to open interest.[14] The high

*Chart 7*

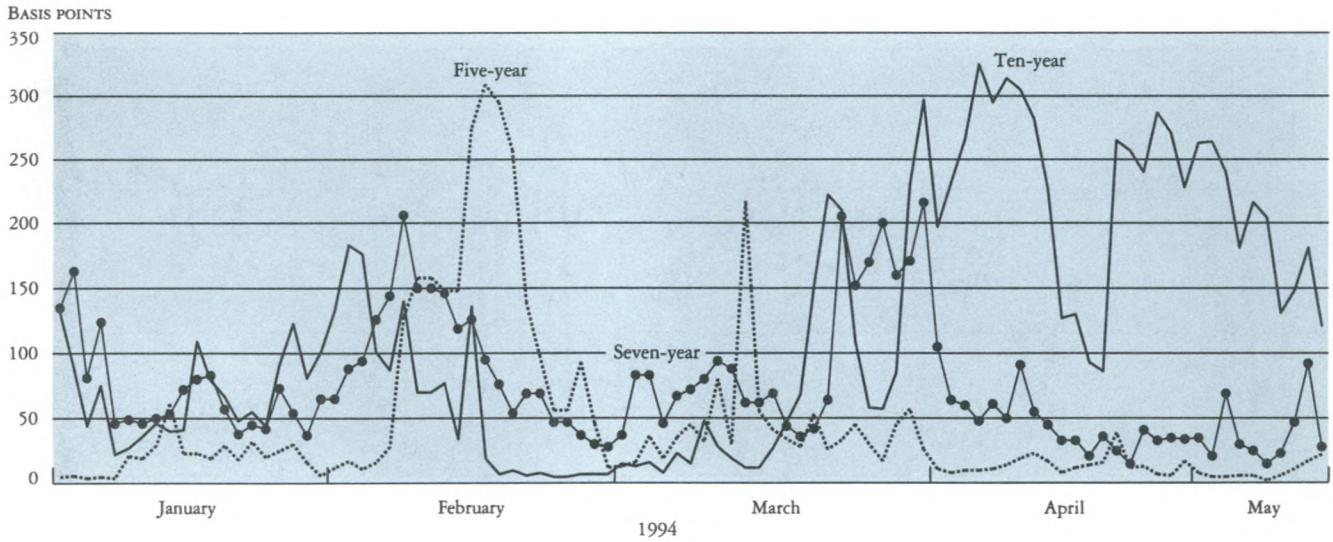
U.S. Treasury Five- and Ten-Year Note Futures
Open Interest




Sources: Chicago Board of Trade; DRI/McGraw-Hill.
Notes: Each contract has a $100,000 face value.

*Chart 6*

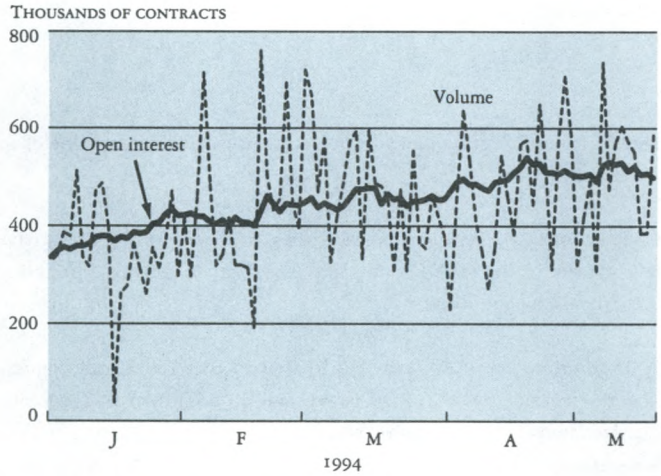
Selected Treasury "Repo" Spreads




Source: Federal Reserve Bank of New York.
Note: Chart shows the general repurchase agreement rate minus the rate on each specific maturity.

*Chart 8*

**U.S. Treasury Thirty-Year Bond Futures**
Volume and Open Interest




Sources: Chicago Board of Trade; DRI/McGraw-Hill.

Notes: Each contract has a $100,000 face value.

volume reflects a high level of intraday trading and hedging, which is unlikely to be related to the MBS market.

## Summary

The circumstantial evidence presented above, as well as widespread reports from market participants, suggests that shifts in mortgage security hedges and realignments of portfolios in response to longer MBS durations had a significant effect on the Treasury yield curve, particularly after the change in monetary policy direction in February 1994. Although MBS hedging certainly cannot explain all the shifts in the yield curve in early 1994, some macroeconomic evidence does support the relationship: the flattening of the ten- to thirty-year spread in early 1994 and the increased (short-run) sensitivity of long rates to changes in short rates. In addition, estimates of mortgage prepayments and durations, evidence on MBS and Treasury prices and volumes, and information from the repo and futures markets all suggest that the hedging of mortgage security extension risk was widespread and had a significant impact on the short-run movements of the Treasury market, particularly the ten-year market.

Although there is no evidence that hedging activity has affected the long-run relationship between long-term and short-term interest rates, this latest episode is further evidence that the short-run dynamics of the yield curve have changed over the last decade. As a result, the transmission of monetary policy from short-term interest rates to the real economy via long-term interest rates has probably changed as well.

1. In addition to using the simple regression evidence presented in Chart 2, Cohen and Wenninger (1994) estimate more complicated time series models of the term structure to show an increase in the short-run sensitivity of long rates to short rates.

2. The mid-1980s change in yield curve dynamics may also have been a delayed reaction to the 1979 change in Federal Reserve policy regime toward a stronger anti-inflation stance.

3. Mortgage securitization may have contributed to the greater sensitivity of long-term interest rates to short-term interest rates by moving residential housing finance away from financial intermediaries and directly into financial markets. Before mortgage securitization, a rise in short-term rates hurt the cash flows of financial intermediaries who held mortgages. But because mortgages were not marked to market, intermediaries were probably slow to adjust their asset portfolios to reflect the decline in mortgage values. This slow portfolio adjustment meant that any feed-through to long-term interest rates tended to be indirect and slow. With the advent of mortgage securitization, however, the majority of mortgages are no longer held on bank balance sheets but in MBSs, which are marked-to-market daily and, in many cases, dynamically hedged. Further, portfolios containing mortgages are adjusted more quickly, and as a result, the adjustment of long rates to short rates is probably quicker as well.

4. Dealers who attempt to hedge MBSs using offsetting Treasury positions are, by definition, using imperfect hedges. Because of the implicit path-dependent optionality and negative convexity of MBSs, hedges must be adjusted dynamically as market conditions change. See the box on page 94.

5. This process is probably somewhat symmetric. When interest rates fall, durations and maturities of MBSs shorten and MBSs are subject to call, or refinancing, risk (see the box on page 94). To hedge such call risk, market participants could sell shorter duration Treasuries and buy longer

*Note 5 continued*
duration bonds, putting more downward pressure on long-term yields in the short run.

6. The slowing in prepayments exacerbates the effect that rising rates have on the price of the MBS because the repayment of mortgage principal occurs over a longer period.

7. In addition, some CMO tranches, by construction, contain substantially more extension risk than MBS pass-throughs and involve more complicated relationships between yield changes, prepayments, and duration than is suggested by Chart 3. For such securities, Chart 3 and the table on page 95 may underestimate changes in durations and thus changes in hedges.

8. We focus on dealer inventories of mortgage securities because they are the most likely to be dynamically hedged.

9. When the repo rate for a specific Treasury issue diverges from the repo rate for general collateral, it is said to be "on special" or "special."

10. On-the-run Treasuries provide the best liquidity for hedgers.

11. Because the last seven-year Treasury was issued in April 1993, the "seven-year Treasury" in Chart 6 is actually a six-year security during this period.

12. Open interest is the net number of outstanding futures contracts.

13. Increases in open interest suggest that market participants have established more permanent positions, and thus these increases may be interpreted as evidence of greater hedging activity within the futures market.

14. For the five- and ten-year futures, daily volume is one-third to one-half of open interest.

*Cohen, Gerald D., and John Wenninger.* 1994. "The Relationship between the Federal Funds Rate and Economic Activity." Federal Reserve Bank of New York Research Paper no. 9406.