Constant-Duration Mortgage Index

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Agency mortgage-backed securities (MBS) typically offer higher yields than Treasuries. Unlike corporate bond spreads, which reflect default risk, MBS spreads primarily compensate buyers for prepayment risk. The prepayment option that investors are short to individual borrowers causes MBS to display negative convexity and consequently duration drift. This duration drift often complicates the management of this important asset class in fixed-income portfolios.

The unstable duration of MBS makes it difficult to compare performance of this asset class on a duration-adjusted basis to other sectors of the fixed-income market. For example, a return comparison of the Lehman Brothers MBS and Government/Corporate indexes is complicated by the difference in their duration and especially by the instability of this difference. There is a need for a simple and transparent methodology of hedging an MBS index to a "constant-duration" target.

The cash flow uncertainty of the MBS is undesirable for most investors, particularly those who manage assets against a stable duration target or a fixed liability stream. As a result, some investors have chosen to exclude MBS from their portfolios. Others have developed various techniques for incorporating MBS into their investment strategies despite these drawbacks.

The negative convexity may be hedged away using volatility-sensitive instruments, such as interest rate options and other derivatives. Structured mortgage products may be used to gain exposure to the mortgage sector while limiting the negative convexity and prepayment risk associated with pass-throughs. Alternatively, portfolios of pass-throughs can be maintained at a desired duration by the use of dynamic hedging techniques.

While such strategies are well known, their use essentially creates a new asset class with risk/return characteristics different from those of unhedged MBS. This poses problems for active portfolio managers whose performance and tracking error are measured against standard industry benchmarks, such as the Lehman Brothers Aggregate or Government/Corporate indexes. Such benchmarks measure performance on an unhedged basis, and do not reflect the hedging costs that are inherent in such portfolio strategies.

In this article, we consider "duration-stabilized" MBS investments as a distinct synthetic asset class. We propose a framework for developing performance benchmarks for this asset class, and explore its performance versus Treasuries. On the whole, we find that such duration-stabilized MBS investments retain much of the total return advantage of "pure" mortgages, with acceptable tracking error relative to a representative Treasury target.

We show, for instance, that an investment in the Lehman MBS index hedged monthly with a fully financed two-year Treasury note to match the duration of the Treasury

index outperformed the index by 19 basis points per year over the past five years. The annual standard deviation of the outperformance is 118 bp per year.

To find out the degree of the strategy's dependence on the choice of the hedging instrument, we investigate hedging with other on-the-run securities. Hedging with the ten-year note results in outperformance of 50 bp per year over the Treasury index, with a tracking error of 110 bp per year. This difference reflects the benefits of the special financing enjoyed by the ten-year on-the-run Treasury.

We also investigate an alternative hedging instrument, financed in a different way — rolling current-coupon MBS. This all-MBS strategy outperforms the Treasury index by 19 bp per year despite the extreme MBS spread widening of 1998, performing in line with other spread products.

These results may increase the appeal of MBS to asset-liability managers with fixed duration targets, such as insurance companies. They might also convince rating agencies not to penalize insurance companies for large holdings of MBS, provided they are managed in this fashion. The entire hedged portfolio should exhibit less rate sensitivity in the stress tests performed by rating agencies.

I. BASIC STRATEGY FOR DYNAMIC REBALANCING

Let us assume an investor has designated certain funds for investment in MBS with a specified target duration. 100% of the funds are put in a core position in MBS agency pass-through securities represented by the Lehman Brothers MBS index. The duration of the portfolio is then adjusted by an overlay of a highly liquid hedging instrument. As the duration of the core MBS investment changes over time, the portfolio duration is maintained at the target level by adjusting the size of the overlay, leaving the core position intact. We use the term "hedging" liberally to refer to these rebalancing adjustments in the overlay position.

This is how such a strategy would be implemented. Consider a constant-duration target of four years maintained by monthly rebalancing using the on-the-run ten-year Treasury note as the hedging instrument. At the close of business on December 31, 1997, for example, the MBS index had a duration of 2.40, and the on-the-run ten-year a duration of 7.08.

For each $100 invested, the duration target of four years corresponds to a target dollar-duration of $400. The investment in the MBS index, with a dollar-duration of $240, is $160 short of the target. To achieve the target dollar-duration requires purchasing $160/7.08 = $22.60 of the on-the-run ten-year note. This amount is assumed to be borrowed via a repo transaction, so that it adds to the dollar-duration of the position but not to its market value. Purchase of $22.60 of the hedging instrument for each $100 invested corresponds to a hedge ratio of 0.226.

One month later, on January 31, 1998, we compute the strategy return as the total return of the MBS index for that month plus the total return of the Treasury note (net of financing) times the hedge ratio. In January of 1998 the MBS index return was 0.99%, while the on-the-run ten-year Treasury returned 2.05%. The cost of financing using the ten-year special repo rate (compounded daily over the month of January) was 0.33%. Thus, the strategy return is 0.99% + 0.226(2.05% – 0.33%) = 1.38%.

II. TARGET FOR PERFORMANCE COMPARISON

The duration to which a portfolio is constrained plays a major role in determining its performance, and a fair benchmark for such a portfolio must have the same duration target. We can then analyze the historical risk and return of the mortgage-based strategy versus a Treasury benchmark, having constructed both to have the same duration.

The disadvantage of using constructed constant-duration Treasury benchmarks to measure the strategy performance is that there is no purely objective way to define a constant-duration reference investment. For example, we could just as well define our four-year Treasury investment based on a single bond, a single point on a fitted yield curve, or a blend of two on-the-run securities. In each case the weighted average return would be different, potentially significantly.

To avoid introducing this benchmark creation ambiguity, we use the Lehman Brothers Treasury index as both the duration target and the reference for measuring performance. Instead of a constant-duration target such as four years, the strategy duration is hedged to match that of the Treasury index. In practice, this duration is quite stable. The performance of this variant of the strategy should thus be indicative of performance versus a "pure" constant-duration benchmark. This approach makes possible a fair comparison of historical performance against an objective, widely accepted Treasury benchmark.

III. ANALYSIS OF HISTORICAL SIMULATION RESULTS

The dynamic strategy is backtested over a period of sixty months, from January 1994 through December 1998. The historical simulation is performed for three main hedging variants of the strategy: with the current-coupon MBS bought for forward settlement; with each of the benchmark Treasury securities; and with two-, five-, and ten-year Treasury futures contracts. In all cases, the Lehman Brothers Treasury index serves as the performance benchmark and the target duration.

For each choice of hedging instrument, the simulation is performed using several different rebalancing frequencies (controlled by a tolerance for duration drift). Each run is repeated twice, with a zero-transaction cost assumption and with an assumed bid-ask spread of 1/32.

Hedging Vehicle

Highly liquid on-the-run Treasuries and Treasury futures contracts are the ideal hedging instruments. We repeat our historical simulation of the strategy against the same duration target using on-the-run Treasuries of four different maturities and three futures contracts. There are noticeable differences in performance, depending on the maturity of the selected instrument.

A strategy that uses Treasuries for hedging is no longer a pure investment in mortgages. As we compare historical performance against the Treasury index, it is unclear how much of our strategy's return is attributable to the core mortgage investment, and how much to the success of the overlay position in Treasuries. To explore this issue, we develop and simulate performance of an all-MBS version of the strategy as well.

Conventional current-coupon thirty-year mortgages normally are the most liquid sector of the pass-through market. These securities trade on a generic (TBA) basis for forward settlement in such volume that the transaction costs are only slightly more than those for on-the-run Treasuries. We have therefore investigated the case of a mortgage investment duration-hedged with the current-coupon conventional TBA (represented by Fannie Mae thirty-year TBA generics).[1]

Due to the settlement conventions in the MBS market, the financing of the hedging instrument is implicit rather than explicit. Returning to the January 1998 example, we would establish the hedge at the end of December by purchasing the current-coupon mortgage for February settlement. At the end of January, we would liquidate this position by a corresponding sale for February settlement, never taking delivery of any actual mortgage pools. A new position (possibly in a different coupon) would be purchased for March settlement to establish the hedge for February.

The appendix describes the precise rules of defining the current-coupon pass-through.

Performance Results Vary Over Time

Exhibit 1 presents a summary of the historical simulation results for five choices of hedging instruments. Exhibit 2 illustrates the distribution of monthly outperformance for two of them, the ten-year on-the-run Treasury and the current-coupon MBS. We consider the annualized average outperformance of the strategy relative to the Lehman Brothers Treasury index, as well as the tracking error (the annualized standard deviation of this outperformance).

Over the time period studied, the strategy results depend strongly on the choice of hedging instrument. Performance is the best for the ten-year on-the-run note and is considerably higher than that achieved with the two-year Treasury hedge. Transaction costs are responsible for this difference to some extent, as larger face values of shorter-duration bonds need to be bought and sold to achieve the same effect on portfolio duration. All the Treasury hedges except the two-year perform better than the current-coupon MBS hedge, which also has the highest tracking error.

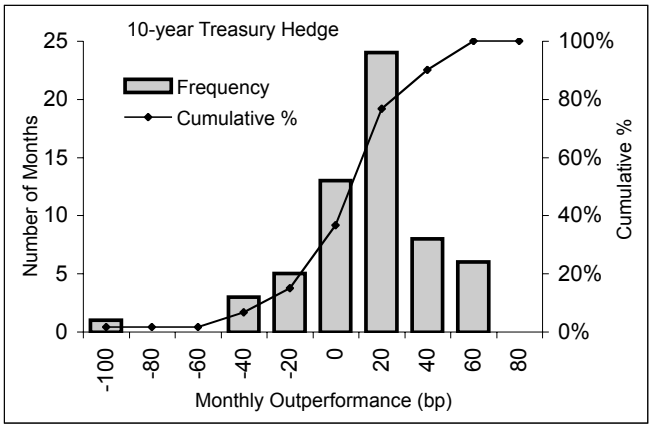
These results do not necessarily demonstrate a

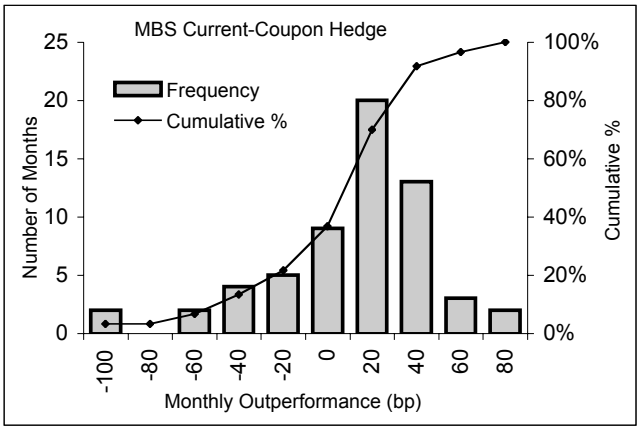
EXHIBIT 1
Relative Performance and Tracking Errors versus Treasury Index (with transaction costs)

Hedge Security	Full Period (5 years) 12/31/93-12/31/98 (% per year)		Subperiod (4 years) 12/31/93-12/31/97 (% per year)	
	Outperf.	Tracking Error	Outperf.	Tracking Error
2-Yr. Tsy.	0.19	1.18	0.41	1.17
5-Yr. Tsy.	0.41	1.14	0.47	1.14
10-Yr. Tsy.	0.50	1.10	0.54	1.09
30-Yr. Tsy.	0.37	1.07	0.67	1.00
Current-Coupon MBS	0.19	1.37	0.58	1.28

EXHIBIT 2

Distribution of Monthly Outperformance versus Treasury Index (with transaction costs), 1994-1998



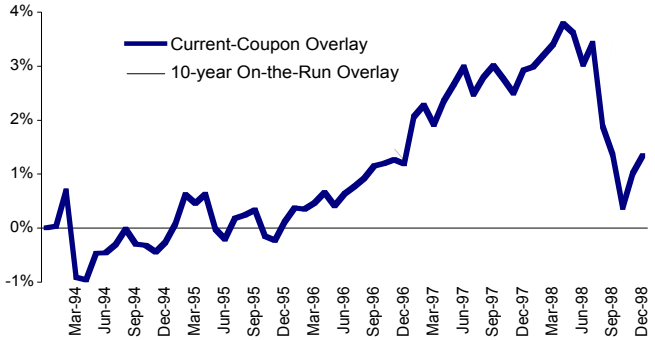


clear advantage of one hedging instrument over another. Rather, performance depends quite strongly on the time period. Over a shorter period that excludes 1998, the current-coupon MBS hedge performs better than all Treasury hedges except the thirty-year.

To further illustrate this point, Exhibit 3 shows the evolution of the cumulative outperformance over the Treasury index achieved by the strategy using two different hedging instruments, the ten-year on-the-run note and the current-coupon MBS. We can see the effect of different time periods on the strategy performance versus Treasuries and on the relative performance of the two different hedging instruments.

EXHIBIT 3

Comparison of Hedge Instruments: Cumulative Advantage over Treasuries December 31, 1993-December 31, 1998



For instance, up to the fall of 1998, the performance of the current-coupon MBS hedge is better than that of the ten-year Treasury hedge. It is the events of the second half of 1998 that are responsible for the difference in the overall performance of these two hedging instruments.

Since the performance characteristics of the strategy can change radically depending on the market environment, it is not appropriate to conclude that any one version of the strategy will be the best one to use. Rather, we analyze various factors that affect performance. With a better understanding of why certain strategies outperform others in a given environment, practitioners can implement their views more effectively.

Financing, Positive Carry, and Hedge Ratios

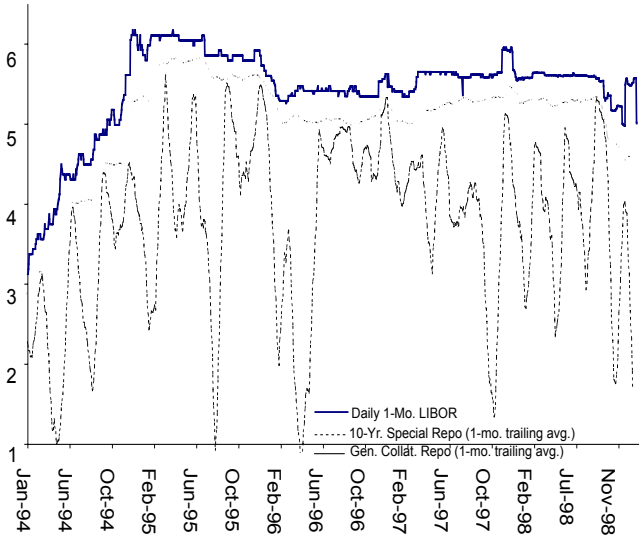
The overlay position, beyond its role in achieving the desired portfolio duration, contributes to the long-term performance of the strategy. When we finance the purchase of a bond, we pay interest on the borrowed money at short-term rates, and earn the coupon income of the security. When the longer-term coupon rate is higher than the financing cost, a long financed position earns a steady interest rate differential, or "positive carry."

Exhibit 4 illustrates the levels and variability of the ten-year special overnight repo rate over the study period, plotting its one-month trailing average versus one-month LIBOR and general collateral repo rates.

To understand the contribution of special financing of the on-the-run securities to performance of the

EXHIBIT 4

Ten-Year Special and General Collateral Repo Rates versus One-Month LIBOR
January 31, 1994-December 31, 1998



Treasury-hedged strategy, we repeat the historical simulation using two-, five-, and ten-year Treasury futures contracts. Exhibit 5 shows the noticeable advantage of the five-year and ten-year on-the-run hedges over their respective futures-based hedges. Besides the special financing of these securities, another factor contributing to this advantage is the "flight to quality" of the second half of 1998 that made on-the-run Treasuries especially "rich." Exhibit 5 shows that their advantage over futures hedges is considerably smaller over a subperiod that does not include 1998.

To explicitly quantify the effect of special financing, we look at the relative performance of the on-the-run Treasuries, financed at their respective special repo rates, versus their respective duration-hedged futures contracts. The annualized results, presented in Exhibit 6, are consistent with relative performance of the corresponding hedges in our dynamic strategy.

Financing terms play the same role whether hedging is effected with bonds or mortgages, although the mechanics of the transaction are different in each case. For bonds, we explicitly account for the spot bond purchase and its financing as two separate transactions.

For mortgages, the market convention is that all trades in a given mortgage settle on one specific date each month. Purchasers can specify whether they would like

EXHIBIT 5

Effect of Special Financing on Performance of Treasury Hedges (with transaction costs)

Hedge Security	OTR with Special Financing (% per year) Outperf.	Tracking Error	Futures Contracts (% per year) Outperf.	Tracking Error
Full Period (12/31/93-12/31/98)				
2-Yr.	0.19	1.18	0.20	1.14
5-Yr.	0.41	1.14	0.24	1.12
10-Yr.	0.50	1.10	0.37	1.09
Subperiod (12/31/93-12/31/97)				
2-Yr.	0.41	1.17	0.46	1.16
5-Yr.	0.47	1.14	0.42	1.13
10-Yr.	0.54	1.09	0.48	1.11

to settle in the coming month or the subsequent one; the agreed-upon forward price will depend on the settlement date. The difference in forward prices between the first available settlement month and the next one, known as the "drop," accounts for the difference between the mortgage coupon rate and the cost of financing.[2]

Exhibit 7 shows the average magnitude of the price drop for the current-coupon MBS over the study period. For both mortgages and bonds, the financed purchase has earned a positive carry over the last five years.

Thus, a long financed position in the hedge instrument in and of itself is expected to earn money, while a short position will incur a cost. The magnitude of the return enhancement due to the positive carry effect is proportional to the market value of the financed position.

The MBS index has been shorter than our selected duration target (the Treasury index) for the entire course

EXHIBIT 6

Performance of On-the-Run Treasuries versus Futures — December 31, 1993-December 31, 1998

Instrument	Avg. Dur. Ratio (OTR/Futures)	Annualized Return Difference (%) Mean	Std. Dev.
2-Yr.	0.99	0.02	0.17
5-Yr.	1.07	0.14	0.44
10-Yr.	1.25	0.28	0.95

EXHIBIT 7
Price Drop of Current-Coupon FNMA, 1994-1998

Year	Average Drop (32nds)
1994	10.3
1995	5.2
1996	5.5
1997	5.6
1998	2.8

of the study (see Exhibit 8). Neutralizing this duration difference requires a long hedge position in the selected security. The size of the position needed to achieve a given adjustment of portfolio duration depends on the duration of the hedging instrument. The shorter its duration, the larger the overlay position necessary to match the target dollar-duration, and the greater the influence of its return on overall performance.

Position Rebalancing: Triggers, Frequency, Costs

A major issue for any dynamic strategy is the timing and frequency of rebalancing. The rebalancing decision is especially important for a negatively convex core position. This is illustrated in Exhibit 9, which plots the durations of the Lehman Brothers Treasury and MBS indexes against the ten-year Treasury yield over a period of five years. As the MBS index has a large negative convexity (averaging –1.18 over the study period), its duration reacts strongly to changes in yield. When Treasury yields rally, the duration shortens considerably.

The Treasury index, by contrast, has a small positive convexity. Its duration over the same period remained relatively stable, experiencing a slight rise with any drop in yields. Negative convexity hurts an unhedged mortgage investor whenever yields move consistently in the same direction. As yields drop in a sustained rally, MBS durations shorten. This in turn reduces MBS returns relative to a constant-duration benchmark. In a sustained market downturn, the opposite effect occurs — rising yields cause duration to lengthen, increasing the magnitude of the negative price returns.

The goal of dynamic rebalancing is to mitigate this negative effect of duration drift in market trends. By continually monitoring and adjusting the position duration, we ensure that the position is neither underexposed in a rally nor overexposed in a market downturn.

If the duration drift were the only concern, the position should be rebalanced as frequently as possible, in response to every market move. Yet frequent rebalancing

EXHIBIT 8
Duration Difference between Lehman Brothers Treasury and MBS Indexes
December 31, 1993-December 31, 1998

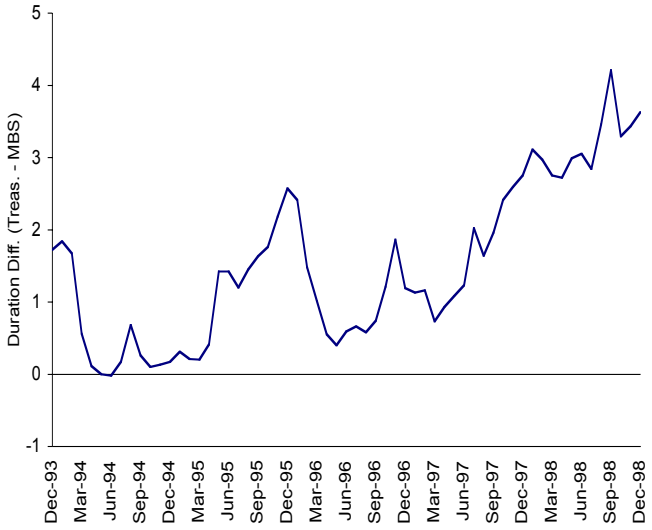
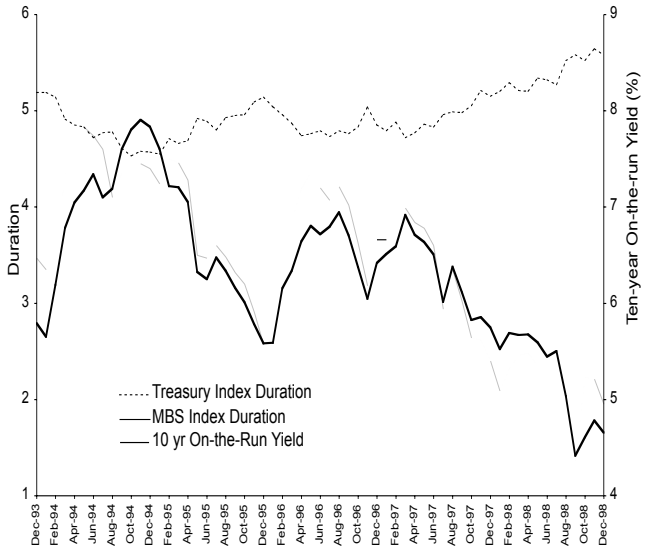


EXHIBIT 9
Relationship Between Yield Levels and MBS Duration



has negative consequences as well. The most obvious of these is transaction costs.

If yields move back and forth between two levels, an investor would be better off holding the position constant rather than paying to buy and sell additional amounts of the hedging security. To make matters worse, the timing of the buy and sell transactions would in this case cause additional losses.

As interest rates drop, the duration of the underlying core mortgage position is also reduced, while the target duration remains the same or increases. This necessitates adding duration by boosting the overlay position, which means buying bonds immediately after rates have fallen, and bond prices have increased. When rates rise again, the mortgage duration increases, and the overlay size must be reduced by selling part of it precisely when prices have just gone down. This buy-high sell-low phenomenon creates a significant drag on performance, known as "whipsaw loss."

Rebalancing Triggers. In our implementation of the strategy, duration mismatch is monitored daily. At the outset, a decision is made on the maximum permissible size of the duration mismatch. Crossing the duration mismatch threshold triggers a position rebalancing.

This threshold controls the frequency of rebalancing, and is thus one of the most important parameters of the strategy. We explore a wide range of duration mismatch tolerances, from the case of monthly rebalancing to a very tight duration tracking with a threshold of just 0.05 years, which in volatile months leads to rebalancings on almost a daily basis.

There are two other events that may trigger transactions in our strategy. First, with our decision to finance purchases in the forward market, we need to roll the position forward each month. Second, depending on which rule we use to define the current-coupon security (see the appendix), a change in market levels might trigger a trade up or down in coupon. Here, as with the duration drift trigger, there is a trade-off between the desire to stay with the current-coupon and the desire to avoid unnecessarily frequent transactions.

The current-coupon selection is always reviewed at the end of each month. Even if the same coupon retains its "current" status, at month-end the whole overlay position is rolled over for one more month. When the current-coupon changes midmonth (if such switches are allowed), the overlay is rolled over again at a full cost of replacing the whole position. Thus, switching the current-coupon is always expensive in terms of transaction costs.

It is usually advantageous to keep the selected coupon unchanged for the entire month. The performance summaries we present reflect results obtained without midmonth current-coupon switches.

Details of Daily Rebalancing. Whenever a decision to rebalance is made for any reason, the size of the trade is determined by a hedge ratio β that ensures matching the dollar-duration of the hedged position to that of the target:

$$D_{TRS}(1 + r_{TRS}) = D_{MBS}(1 + r_{MBS}) + \beta \times P_{CC} \times D_{CC}$$

where D_{TRS}, D_{MBS}, and D_{CC} are the durations of the Treasury and MBS indexes and the current-coupon; r_{TRS} and r_{MBS} are the month-to-date total returns of the Treasury and MBS indexes; P_{CC} is the price of the current coupon; and β is the hedge ratio.

The return terms reflect the fact that equal investments in the two indexes as of the beginning of a month may have different market values later in the month. This difference in market value (and hence dollar-duration) affects the hedge amount required to maintain the duration neutrality of the two sides.

Exhibit 10 is a detailed illustration of the strategy's daily implementation. It provides examples of transactions driven by all three types of events: the roll to a new settlement date each month-end, midmonth current-coupon switches, and duration-driven rebalancing. It shows how P&L amounts are calculated based on market movement and transaction costs.

We choose October 1998 to analyze daily transactions as it was an extremely volatile month in terms of both Treasury yields and mortgage durations. The volatility of the daily changes in the ten-year on-the-run Treasury yield was almost twice the average over the full study period (9 bp versus 4.8 bp). The duration of the MBS index was also extremely unstable, going from a low of 1.17 on October 5 to a high of 2.92 on October 9, and changing by as much as 0.88 in a single day, October 8. The choice of a relatively tight duration threshold (0.2) and midmonth current-coupon switches makes it a very eventful month in terms of adjusting the overlay position.

It also exemplifies the negative effect of frequent rebalancing on strategy performance in volatile periods. In October 1998 the strategy would have underperformed the Treasury index in any case. But avoiding midmonth rebalancing and keeping the same coupon through the entire month would have significantly reduced the underperformance, from –120 bp to –68 bp.

EXHIBIT 10

Analysis of Daily Transactions With Midmonth Current-Coupon Switching
Notional Amount = $100,000; Duration Mismatch Threshold = 0.2

	Prerebalancing Position													P&L = (Price E – Price B)		Amount – Cost		
	Duration			Hedge	$Dur	Hedge	Sell			Buy				Price		Amt	Trans	Daily
Date	MBS	Treas	CC	Ratio	Diff	Chg	Bond	Price	Amt	Bond	Price	Amt	Action	Begin	End	Begin	Cost	P&L
09/30/98	1.37	5.58	4.36	0.840	0.56	0.129	Oct 6s	99.75	12,913	Nov 6s	99.69	12,913	roll					
10/01/98	1.32	5.61	4.31	0.969	0.14	0.000								99.69	99.97	96,867		272
10/02/98	1.26	5.62	4.20	0.969	0.33	0.079					100.06	7,889	rebal	99.97	100.06	96,867	1	90
10/05/98	1.17	5.66	4.01	1.048	0.35	0.086					100.28	8,600	rebal	100.06	100.28	104,756	1	228
10/06/98	1.40	5.64	4.27	1.134	–0.53	–0.125		99.88	12,514				rebal	100.28	99.88	113,355	2	–462
10/07/98	1.79	5.59	4.74	1.008	–0.91	–0.193		99.25	19,331				rebal	99.88	99.25	100,842	3	–633
10/08/98	2.67	5.51	5.53	0.815	–1.57	–0.291		97.75	29,076				rebal	99.25	97.75	81,511	5	–1,227
10/09/98	2.92	5.44	4.79	0.524	–0.03	–0.007	Nov 6s	97.31	52,434	Nov 6.5s	99.69	51,730	switch	97.75	97.31	52,434	16	–246
10/13/98	2.79	5.44	4.68	0.517	0.18	0.000								99.69	99.97	51,730		145
10/14/98	2.30	5.48	5.27	0.517	0.47	0.090	Nov 6.5s	100.78	51,730	Nov 6s	98.69	60,710	switch	99.97	100.78	51,730	18	403
10/15/98	2.34	5.47	5.28	0.607	–0.06	0.000								98.69	98.59	60,710		–57
10/16/98	2.20	5.50	5.26	0.607	0.14	0.000								98.59	99.19	60,710		360
10/19/98	2.34	5.48	5.38	0.607	–0.08	0.000								99.19	98.88	60,710		–190
10/20/98	2.53	5.45	4.78	0.607	0.05	0.000								98.88	98.53	60,710		–209
10/21/98	2.57	5.45	4.81	0.607	–0.01	0.000								98.53	98.44	60,710		–57
10/22/98	2.59	5.42	4.83	0.607	–0.07	0.000								98.44	98.41	60,710		–19
10/23/98	2.67	5.41	4.92	0.607	–0.23	–0.048		98.28	4,817				rebal	98.41	98.28	60,710	1	–77
10/26/98	2.53	5.44	4.83	0.559	0.23	0.049					98.22	4,921	rebal	98.28	98.22	55,894	1	–36
10/27/98	2.27	5.45	4.59	0.608	0.43	0.094					98.66	9,435	rebal	98.22	98.66	60,815	1	265
10/28/98	2.16	5.44	4.51	0.702	0.15	0.000								98.66	98.84	70,249		132
10/29/98	2.02	5.45	4.37	0.702	0.40	0.091					99.09	9,131	rebal	98.84	99.09	70,249	1	174
10/30/98	2.12	5.43	4.42	0.794	–0.15	–0.039	Nov 6s	98.81	79,381	Dec 6s	98.75	75,449	roll	99.09	98.81	79,381	24	–247
11/02/98				0.754													75	–1,391

MBS Index Return:	–0.13%
Current-Coupon Position Return (P&L/Notional):	–1.39%
Overall Strategy Return:	–1.52%
Treasury Index Return:	–0.32%
Outperformance for the Month:	–1.20%

Let us follow the implementation of the strategy on a day-by-day basis. At the end of September, we establish the initial overlay position of $96,867 in the Fannie Mae 6% purchased for November settlement. This corresponds to a hedge ratio of 0.969 relative to the notional amount of $100,000.

By the close of the second business day in October the position's dollar-duration has become sufficiently less than the target to require rebalancing. The new duration-equalizing hedge ratio is now 1.048, so that an additional $7,889 (shown as 0.079 change in the hedge ratio) of the current-coupon needs to be bought. The overall P&L for this day is made up of the gain on the beginning overlay amount of $96,867 reduced by the transaction costs incurred in adjusting the hedge ratio by 0.079.

On October 9 the 6% coupon loses its "current" status, and has to be replaced with the 6.5%. This means selling the whole overlay position ($52,434) and buying almost as much (when we transact because of the coupon switch, we rebalance as well) in the new current-coupon.

As Exhibit 10 shows, the transaction costs on that day are several times higher than when only incremental changes are made to the overlay. After just two days this change has to be reversed, again leading to heavy transaction costs. All midmonth transactions are done for November settlement.

Finally, on the last business day in October, we roll over the whole overlay position by selling the full amount in the 6% coupon for November settlement and buying a new amount in the same coupon, dictated by the recomputed hedge ratio, for December settlement. Although the depth of the roll market makes the transaction relatively efficient, it incurs transaction costs on the entire position, making the monthly roll costly compared to rebalancing trades.

Summing up all daily P&L amounts gives the monthly P&L of –$1,391. Dividing that by the notional amount produces the overlay position's return for the month of –1.39%. The MBS index returned –0.13%, so the overall strategy return, which is the sum of the two, is –1.52%. This is a 120 bp underperformance of the Treasury index, which in October 1998 returned –0.32%.

Why did the strategy perform so poorly in this month? Analysis reveals this to be a rather extreme example of whipsaw loss. As seen in the first graph in Exhibit 11, this was an exceptionally volatile month, with the ten-year yield climbing from 4.15% to 4.78% and ending the month at 4.61%. Mortgage duration, similarly, rose from 1.17 to 2.92, and finished the month at 2.12. The volatility of the daily changes in the ten-year on-the-run Treasury yield was almost twice the average over the entire study period (8.95 bp versus 4.81 bp).

The second graph in Exhibit 11 makes it clear why rebalancing with a duration-drift trigger led to severe underperformance in this month. To adjust for changes in MBS index duration, the hedge ratio was decreased rapidly as rates climbed during the first half of the month. The graph shows that these reductions of the hedge ratio,

EXHIBIT 11

Timing of Midmonth Rebalancings Affects Performance — October 1998

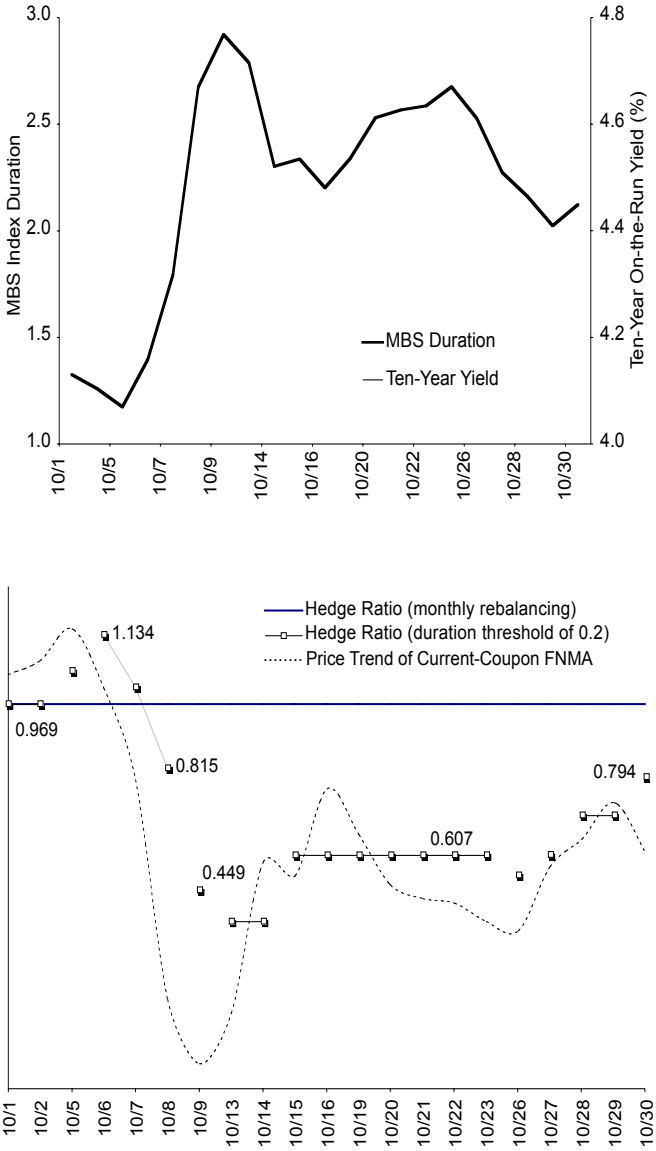


EXHIBIT 12

Performance Summary, December 31, 1993-December 31, 1998 (% per year)

	Duration Mismatch Threshold							
	0.1		0.2		0.5		Monthly	
	Outperf.	Tr. Error	Outperf.	Tr. Error	Outperf.	Tr. Error	Outperf.	Tr. Error
With Transaction Costs								
2-year Treasury	0.09	1.14	0.06	1.10	0.24	1.16	0.19	1.18
5-year Treasury	0.36	1.11	0.30	1.11	0.46	1.11	0.41	1.14
10-year Treasury	0.45	1.08	0.40	1.09	0.53	1.11	0.50	1.10
30-year Treasury	0.28	0.99	0.25	0.99	0.38	1.02	0.37	1.07
Current-Coupon	–0.02	1.31	0.01	1.33	0.10	1.36	0.19	1.37
Without Transaction Costs								
2-year Treasury	0.41	1.15	0.36	1.13	0.50	1.16	0.42	1.18
5-year Treasury	0.48	1.12	0.42	1.11	0.55	1.12	0.49	1.14
10-year Treasury	0.49	1.08	0.43	1.09	0.56	1.11	0.53	1.10
30-year Treasury	0.30	0.98	0.26	0.99	0.39	1.02	0.38	1.07
Current-Coupon MBS	0.17	1.30	0.19	1.32	0.25	1.35	0.32	1.36

which correspond to selling the hedge security, occur precisely when prices are at their lowest levels for the month. The hedge is repurchased later in the month, after prices have recovered significantly.

Clearly, the strategy of keeping the hedge ratio constant for the month would have performed significantly better in this particular month.

Performance as a Function of Rebalancing Frequency. Exhibit 12 shows how performance of the strategy is affected by the rebalancing frequency. The last column represents the limiting case in which no mid-month rebalancing occurs. As we proceed to the left, smaller values for the duration threshold correspond to more frequent intramonth rebalancing.

In general, regardless of which hedging instrument is used, the tracking error tends to decrease with more frequent rebalancing. This is to be expected — the more closely the hedged duration is matched, the lower the risk of large return differences.

The effect on mean outperformance versus the Treasury benchmark is less clear. In general, a small number of rebalancings per month tends to offer an improvement in performance over monthly rebalancing. But as rebalancing becomes more frequent, the performance starts to deteriorate again. For this particular time period the optimal (performance-maximizing) setting for the duration threshold seems to be in the vicinity of 0.4 or 0.5 years.

In the simulations using current-coupon MBS as the hedging instrument, we do not see this peak at all. Rather, over the time period studied, the strategy performs better with monthly rebalancing than it does with any duration trigger.

Exhibit 13 shows the average number of mid-month rebalancings that corresponds to various duration thresholds. As the threshold is tightened, the rebalancing frequency increases exponentially, leading to a larger transaction costs penalty. The optimal thresholds observed in hedging with on-the-run Treasuries require, on average, less than one extra rebalancing per month.

Exhibit 13 also shows that the same duration thresholds require more frequent rebalancing when hedging with the current-coupon, whose duration moves in the same direction as that of the core position.

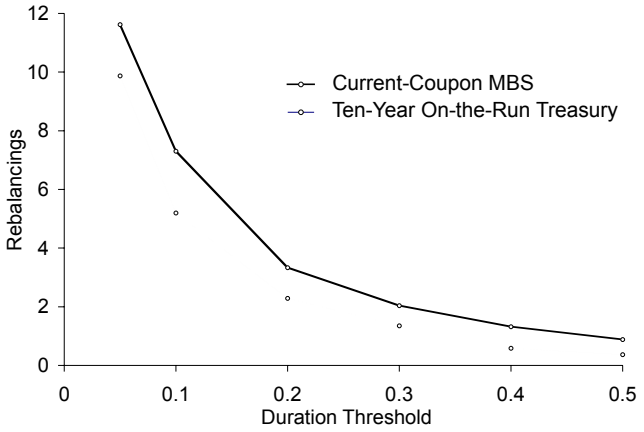
Performance in Different Yield Environments

Categories of Yield Curve Changes. Frequent rebalancing improves performance by avoiding duration drift in trending months, but hurts performance at other times due to transaction costs and whipsaw loss. Whipsaw loss is more pronounced when rates are volatile than when yields are stable, so we examine how performance of the strategy depends on the prevailing yield environment.

We define three types of yield environment: stable, volatile, and trending, based on the overall change in yields over the whole month and the volatility of daily yield changes. By decomposing the results in this fashion, we can better understand how the strategy performance

EXHIBIT 13

Average Number of Midmonth Rebalancings for Different Duration Thresholds



is affected by the choice of hedging instrument and the frequency of rebalancing.

Exhibit 14 illustrates the definitions that we use to classify each month into one of these three categories. We use the ten-year on-the-run Treasury as a yield barometer. Over the five-year period that this study covers, the average magnitude of the monthly change in the ten-year yield is 22 bp, while the average intramonth volatility, as measured by the standard deviation of daily yield changes during the month, is 4.8 bp.

We categorize a month as trending if the overall yield change for the month exceeds 25 bp in either direction. Months without a trend are characterized as either volatile or stable, based on whether the intramonth yield volatility is greater or less than 5 bp.

Strategy Performance. The graphs in Exhibit 15 show the annualized performance of the strategy as a function of rebalancing frequency in each of the three types of yield environment, hedging both with current-coupon MBS and the ten-year Treasury. Results are presented including the effect of transaction costs (heavier line) and without them.

As expected, this breakdown demonstrates that the hedged mortgage strategy provides solid outperformance over Treasuries in stable months, but underperforms in market trends. Both of these effects are most apparent when the duration of the hedged mortgage portfolio is rebalanced only at the beginning of each month. As the frequency of rebalancing increases, these effects are reduced.

In stable months, when rebalancing is largely unnecessary, performance is hurt by a combination of whipsaw loss and increased transaction costs. In trending months, by contrast, more frequent rebalancing consistently improves performance.

In the months we have classified as volatile, yields move up and down frequently, but ultimately settle not far from where they started the month. This provides an unstable environment in which the timing of a particular rebalancing can have a large effect on performance. In such months, as in stable months, frequent rebalancing hurts performance.

Comparing results in stable and volatile months with and without transaction costs, we see that the main source of performance degradation for frequent rebalances is the whipsaw loss. Reducing the duration threshold to 0.5, 0.4, or 0.3 years leads to a steep decline in performance even when transaction costs are ignored. The additional performance degradation due to transaction costs is illustrated in each case by the increasing divergence of the two lines as rebalancing becomes more frequent.

These results could lead to the conclusion that lowering the duration drift threshold further should only continue to hurt performance. Yet the graphs for

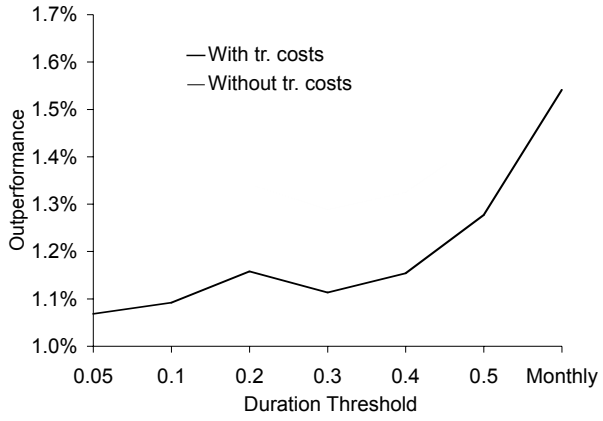
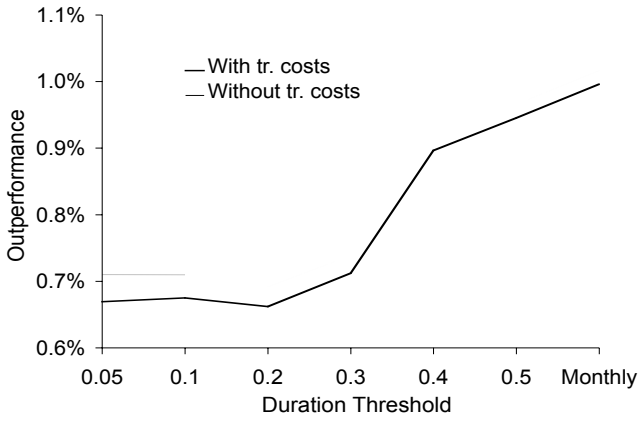
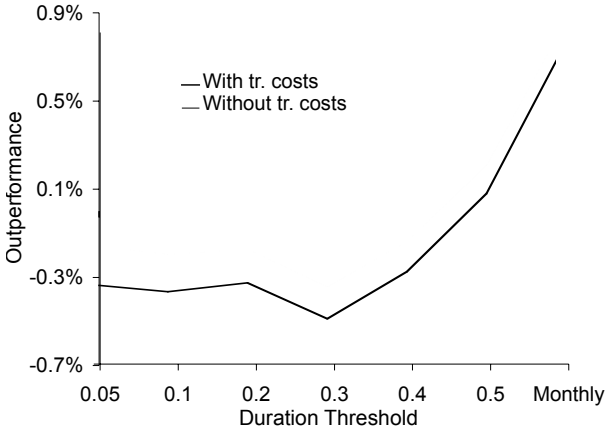
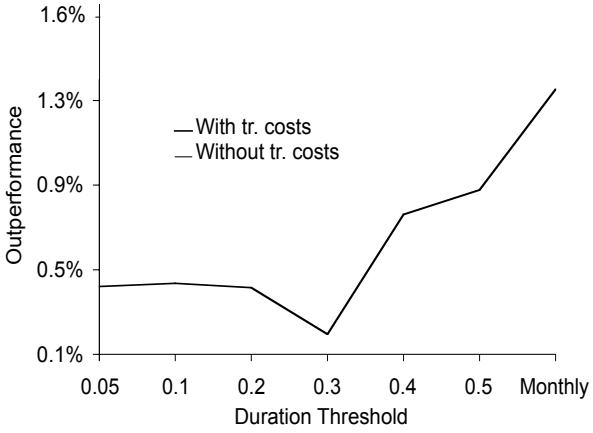
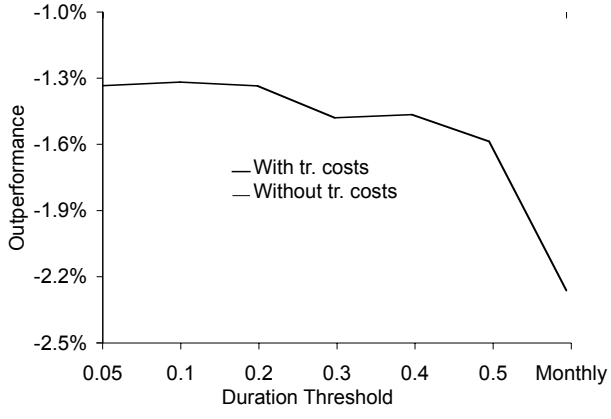
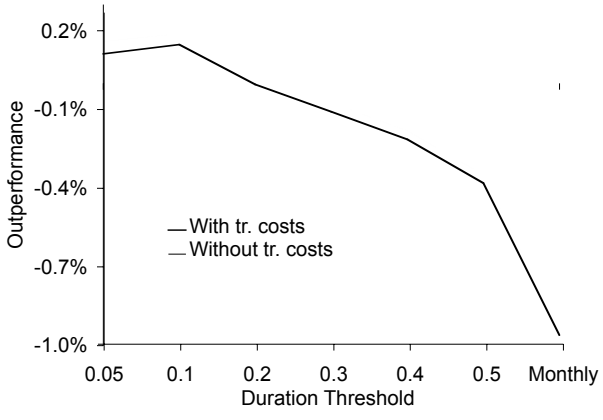
EXHIBIT 14

Yield Environment Categories

		Criteria		Stat. Avg. (1994-1998)	
Definition	Months	Yield Change (bp/mo.)	Std. Dev. (bp/day)	Yield Change (bp/mo.)	Std. Dev. (bp/day)
Stable	26	< 25	< 5	12.1	3.8
Volatile	16	< 25	> 5	15.0	6.2
Trending	18	> 25	—	42.5	5.0
Total	60			22.0	4.8

EXHIBIT 15

Sensitivity of Performance to Rebalancing Threshold under Different Yield Curve Environments
December 31, 1993-December 31, 1998

Current-Coupon Hedge (% per year)	Ten-Year Treasury Hedge (% per year)
Panel A. Stable Months	
	
Panel B. Volatile Months	
	
Panel C. Trending Months	
	

volatile months in Exhibit 15 show that performance can sometimes be improved by more frequent rebalancing. Specifically, as the threshold is reduced from 0.3 to 0.2, the decline in performance reverses. This is due to the presence of "mini-trends" in intramonth yield changes. Even in months that are not classified as trending according to the net yield change over the month, yields may keep moving in the same direction for several days in a row. During these periods, yields essentially are trending, and as the mortgage duration drifts with yields, it is beneficial to rebalance. A timely rebalancing within such a mini-trend can have a noticeably positive effect on performance.

Exhibit 16 presents an example of a volatile month (March 1996) when changing the duration threshold from 0.3 to 0.2 leads to two additional midmonth rebalancings. The rebalancing on March 7 occurred in the middle of a steep four-day yield increase and reduced underperformance for the month from –16 bp to –5 bp.

All these observations are true for either of the hedging instruments shown, the current-coupon MBS and the ten-year Treasury, but it is instructive to compare the two sets of results. Almost all the effects we have noted are magnified for the MBS hedge as opposed to the Treasury hedge. In the monthly rebalancing case, including transaction costs, the mortgage hedge strategy earns more in stable months (1.5% versus 1.0%), but fares much more poorly in trending months (–2.3% versus –1.0%). As rebalancing becomes more frequent, several additional differences emerge.

With the duration threshold set at 0.05, the underperformance of the mortgage hedge improves only to –1.3%, while the Treasury hedge is able to produce an outperformance of 0.1%. Thus, with frequent rebalancing, the Treasury hedge produces outperformance in all three yield environments, while the mortgage hedge with frequent rebalancing underperforms the benchmark in both volatile and trending months in this period.

Exhibit 15 also explains why the strategy performance peaks at a threshold of 0.4 or 0.5 with the Treasury hedge, while no such effect is apparent when hedging with MBS. The improvement of the Treasury-hedged strategy performance in trending months begins as the duration threshold is first reduced, but the most significant decreases in the stable and volatile months do not happen until the threshold is reduced to 0.3 and below. With the mortgage-hedged strategy, however, the performance reduction in stable and volatile months occurs concurrently with the improvement in trending months. There is thus no rebalancing frequency that can provide the desirable effects of more frequent hedging without the negative side effects.

An explanation for many of the performance differences seen here is that hedging the duration of a mortgage position via a fully financed purchase of additional mortgages amplifies the strategy's risk exposures. Regardless of hedging instrument, the strategy inherently is long mortgage spread and short volatility relative to equivalent-duration Treasuries. Hedging with more mortgages increases the exposure to mortgage spreads and makes the position's convexity even more negative. While the additional spread exposure may provide added income in stable months, it makes the strategy more vulnerable to a collapse in spreads.

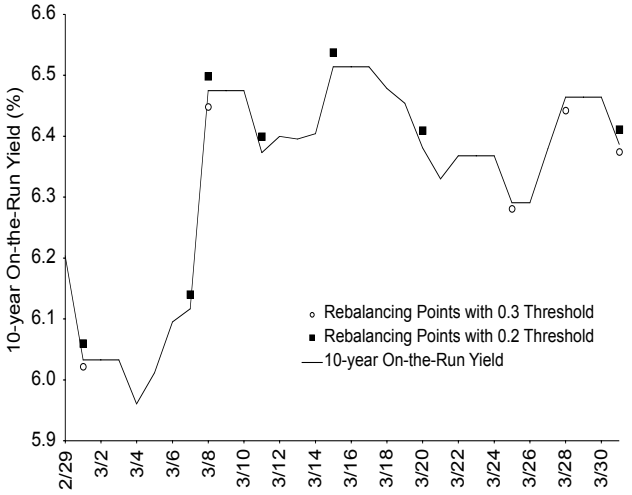
Further, by adding negative convexity, the hedge itself compounds the performance problems in trending months that it is meant to counteract. Similarly, the volatility exposure of the hedge itself can lead to additional losses in particularly volatile months.

The Treasury hedge, which is positively convex, does not suffer from these problems. It actually serves as a counterbalance to the negative convexity of the core mortgage position.

A full summary of the historical simulation results for the mortgage-hedged strategy is presented in Exhibit 17. The strategy performance is extremely sensitive to the prevailing yield environment over the investment period.

EXHIBIT 16

Breaking Mini-Trends in a Volatile Month
March 1996



While the annualized outperformance with monthly rebalancing during stable months is 1.54% after transaction costs, during trending months the same strategy underperforms the Lehman Brothers Treasury index by 2.26%.

Thus, the overall performance during any period will be determined primarily by the relative occurrence of trending and stable yield conditions. The results also show that performance depends strongly on the rebalancing frequency, and that over the study period frequent rebalancing is, ultimately, a negative factor.

Comparison with Other Spread Products

Another way to evaluate the dynamic hedging strategy is to compare its results to other measures of asset class performance versus Treasuries. Lehman Brothers publishes excess returns (or "duration-cell returns") for various spread sector indexes, which are calculated by comparing the return of each component security to those of duration-matched Treasuries.[3]

Exhibit 18 shows the historical mean and standard deviation of excess returns for the Lehman Brothers MBS and Corporate indexes over the ten-year period from 1989 through 1998. The mortgage-hedged strategy, simulated over the second half of this period, assuming monthly rebalancing and no transaction costs, produces an annualized mean outperformance of 32 bp with standard deviation of 136 bp (Exhibit 17). This performance is in line with and somewhat better than the long-term historical averages for the overall mortgage and corporate markets presented in Exhibit 18.

Impact of MBS Spreads

Perhaps the most important factor influencing performance of this mortgage strategy is the level of and changes in mortgage spreads. Because the core portfolio is fully invested in the MBS index, it should earn the option-adjusted spread (OAS) of mortgages over Treasuries on a steady basis. In any spread tightening, the strategy should handily outperform duration-matched Treasuries.

Exhibit 19 plots the average OAS of the MBS index during the 1993-1998 period. MBS spreads were generally tightening or stable for most of this period. This favorable spread environment leads to a steady upward climb in the cumulative performance of the strategy. The dramatic widening of spreads in the second half of 1998 had a devastating effect on the mortgage-hedged version of our strategy, wiping out several years' worth of cumulative outperformance. The double exposure to spreads, both in the core position and in the hedge, made the strategy particularly vulnerable to this spread event.

The Treasury-hedged strategy, by contrast, held its ground in 1998. While the core mortgage position suffered from the spread widening, the gains achieved by the hedge position in Treasuries helped buffer this loss. The difference in the performance of the two hedge

EXHIBIT 17

Role of Rebalancing Frequency in Different Yield Environments — Current-Coupon Hedge, % per Year
December 31, 1993-December 31, 1998

	Duration Mismatch Threshold							
	0.1		0.2		0.5		Monthly	
	Outperf.	Tracking Error	Outperf.	Tracking Error	Outperf.	Tracking Error	Outperf.	Tracking Error
With Transaction Costs								
Stable (26/60)	1.09	0.91	1.16	0.92	1.28	0.92	1.54	0.92
Volatile (16/60)	–0.37	1.23	–0.33	1.26	0.08	1.27	0.77	0.96
Trend (18/60)	–1.32	1.76	–1.34	1.77	–1.59	1.84	–2.26	1.91
Total (60)	–0.02	1.31	0.01	1.33	0.10	1.36	0.19	1.37
Without Transaction Costs								
Stable (26/60)	1.29	0.91	1.34	0.91	1.44	0.91	1.69	0.92
Volatile (16/60)	–0.20	1.21	–0.17	1.24	0.21	1.24	0.87	0.95
Trend (18/60)	–1.12	1.75	–1.15	1.76	–1.42	1.83	–2.13	1.91
Total (60)	0.17	1.30	0.19	1.32	0.25	1.35	0.32	1.36

EXHIBIT 18

Historical Excess Returns in Corporate and MBS Markets, 1989-1998

	Annualized Excess Return (bp)	Annualized Std. Dev. (bp)
Lehman MBS Index	20	134
Lehman Corp Index		
Aaa	18	96
Aa	20	115
A	26	149
Baa	27	213
Total	23	151

securities over the entire study period stems from this turbulent period.

When hedging with current-coupon MBS to match the target duration, our strategy assumes unintended additional spread duration. Exhibit 20 illustrates the increased spread exposure of the mortgage-hedged strategy during 1997 and 1998. Bridging the widening duration gap between the Treasury and MBS indexes requires larger amounts of the current-coupon overlay. This leads to a disproportionate increase in the spread duration of the total position, as evidenced by the top line in Exhibit 20. The widening of mortgage spreads at the same time causes the inferior performance of the strategy during this period.

To control spread duration, we implement a hybrid strategy that prevents sharp increases in spread exposure by imposing a limit on the overall spread duration, equal to the duration of the Treasury index (target duration). The position in the current-coupon is increased as needed until this limit is reached. If at that time the strategy's curve duration is still less than the target, the remaining duration adjustment is achieved with ten-year Treasury futures contracts.

The proportions of the overlay in the current-coupon (β_{CC}) and in the futures contracts (β_{Fut}) are determined according to the equations:

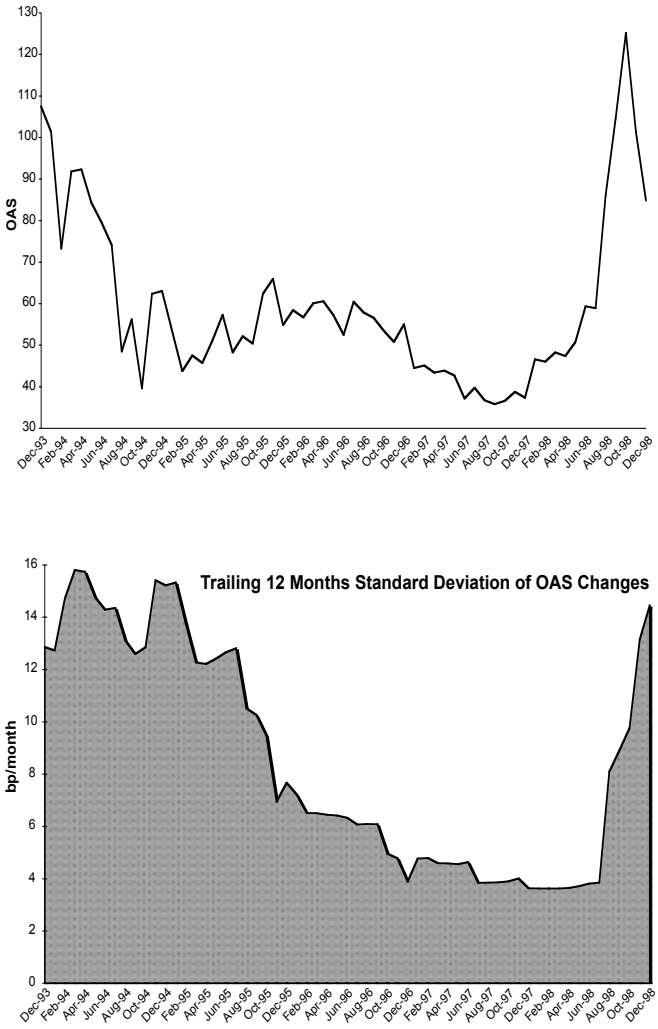
$$D_{S,MBS} + \beta_{CC} D_{S,CC} = D_{TRS}$$

$$D_{MBS} + \beta_{CC} D_{CC} + \beta_{Fut} D_{Fut} = D_{TRS}$$

where D_{TRS}, D_{MBS}, D_{CC}, and D_{Fut} are the durations of the Treasury and MBS indexes, the current-coupon and the ten-year futures contracts; $D_{S,MBS}$ and $D_{S,CC}$ are the spread durations of the MBS index and the current-coupon.

EXHIBIT 19

MBS Index Option-Adjusted Spread (OAS) December 31, 1993-December 31, 1998



When compared to the current-coupon hedging over the last two-year period, marked both by widening mortgage spreads and shortening durations, this approach increases the annualized outperformance by 14 bp (from –5 bp to +9 bp), while reducing the tracking error from 1.47% to 1.25%. Over the entire study period (1994-1998), the improvement in annualized outperformance is 4 bp (from 19 bp to 23 bp), and the tracking error is reduced from 1.37% to 1.27%.

Duration Target

The target duration also plays an important role in determining the performance of a dynamic strategy.

EXHIBIT 20

Hedging Treasury Index Duration with Current-Coupon MBS Boosts Spread Exposure of the Overall Position

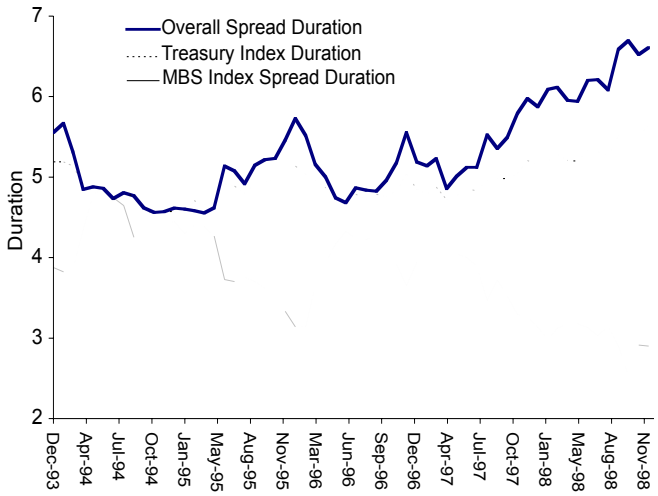


EXHIBIT 21

Effect of a Shorter Duration Target Monthly Rebalancing, with Transaction Costs December 31, 1993-December 31, 1998

Hedge Security	All Treasuries (% per year) Outperf.	Tracking Error	Interm. Treasuries (% per year) Outperf.	Tracking Error
2-Yr. Treasury	0.19	1.18	0.31	1.12
5-Yr. Treasury	0.41	1.14	0.43	1.03
10-Yr. Treasury	0.50	1.10	0.34	1.05
30-Yr. Treasury	0.37	1.07	0.38	1.15
Current-Coupon MBS	0.19	1.37	0.14	1.09

Hedging the core investment with the same instrument but to a different duration target can produce very different results. The crucial factor is the difference between the duration of the core investment and that of the target.

Ideally, the performance of the investment should be driven by the performance of the selected MBS asset class, with the hedge providing the desired exposure to yield curve shifts. The greater the duration difference to be hedged, the greater the magnitude of the hedge, and the more the performance of the strategy will be influenced by the hedge security. The direction of the duration difference is critical as well, as it determines the sign of the overlay position. A duration target longer than the index requires adding duration via a long overlay position.

As we note in our discussion of hedging instruments, it has been generally advantageous to be long the financed hedge position. Thus, a longer target duration requires a higher hedge ratio and might be expected to give the strategy a higher overall return if the carry is positive, and greater return volatility (more dependence on the performance of the specific hedge security). Both these effects are seen in Exhibit 21, which compares the strategy performance achieved versus the Treasury index with that achieved versus the Lehman Brothers Intermediate Treasury index.

Historically, the Lehman Brothers Treasury index has been longer than the MBS index.[4] This means that the overlay position is long most of the time. In the recent period, the duration gap between the two has been particularly wide. When the target is the Intermediate Treasury index, the overlay frequently has to be shorted. The benefit of owning an overlay position with positive carry is reversed, leading to poorer performance.

This reduction in performance is especially pronounced for the ten-year Treasury hedge which enjoyed beneficial financing over the study period. While performance of the ten-year hedge is the best against the Treasury index (when the overlay position is large), it is weaker compared to other hedges against the Intermediate Treasury index, when the overlay position is small or even negative (short). For the current-coupon hedge, the mean annual outperformance declines from 0.19% to 0.14%. Tracking errors, though, are lower in almost all cases.

IV. CONCLUSION

We have given a numeric justification to a few perhaps self-evident points about investing in MBS. The most undesirable property of this asset class — its negative convexity — can be (and for asset-liability managers, must be) mitigated partially by dynamic rebalancing to a stable duration target. One simple way to achieve this is to use an overlay.

We show that even when the transaction costs of overlay rebalancing are included, such a strategy retains most of the spread advantage over Treasuries offered by MBS. We find the volatility of such a strategy to be in line with that of other spread products. The performance and

risk of this duration-stabilized MBS investment are highly dependent on a number of parameters:

- *Choice of the overlay instrument.* Over the period of the study, the fully financed ten-year on-the-run Treasury performs better than other Treasury hedges and current-coupon MBS bought for forward settlement.
- *Duration target.* The farther away this target is from the duration of the MBS index, the greater the influence of the overlay instrument on performance, and the higher the volatility.
- *Frequency of rebalancing.* Rebalancing too frequently hurts performance during volatile months with no significant trend. In such months, the strategy buys more of the overlay at high prices and sells it at depressed prices. When the market does shift into a trending phase, the dynamic readjustment of duration plays the crucial role of compensating for negative convexity. A failure to rebalance quickly hurts performance at such times. The optimal rebalancing frequency is the one that achieves the best trade-off between these two conflicting influences.

Our results indicate that there is no single best set of strategy parameters. The course the market follows during a particular time period will determine both the overall success of a strategy and the relative performance of different hedging instruments and rebalancing frequencies.

A tightening of mortgage spreads will not only mean good performance for all variants of this strategy, but is also likely to make mortgages the best hedging security over the period. Large changes in interest rates will cause this synthetic asset class to perform poorly overall, and will favor frequent rebalancing. Long periods of stability imply the opposite — the strategy performs well, and frequent rebalancing is detrimental.

Our conclusion, therefore, makes no recommendation of a particular optimal parameter set.

The strategy investigated in this study can be used to construct fair performance benchmarks for the synthetic asset class of duration-targeted mortgages. MBS investors who bear the cost of dynamic duration hedging in their portfolios can design a custom benchmark by choosing the target duration and the hedging security most closely aligned with their needs. For example, instead of the single-security hedge that we consider, they may use a blend of two or more securities or futures contracts to reduce exposure to non-parallel shifts in the yield curve.

Even the core MBS investment can be modified to focus on a particular subset of the MBS index. This customized version of the strategy could then be used as the performance benchmark for the hedged portfolios. The portfolio manager may seek to outperform the benchmark either by selecting a core MBS portfolio that will outperform the MBS index at the core of the benchmark, or by using a superior hedging strategy.

Thus, a manager may change the choice of hedging vehicle or rebalancing frequency from month to month to reflect views on market direction, yield curve twists, or volatility.

Alternatively, the strategy could be viewed as a possible style for MBS investing. Regardless of how a particular portfolio is benchmarked, the historical simulation results presented here give some indication of how different variations in hedging strategy are likely to affect performance in different market environments.

APPENDIX

Definition of the Current-Coupon MBS

We define the current-coupon as "the security nearest to par from below." This definition can be translated into a trading policy according to several different rules. In the strict interpretation of this definition, the strategy will trade the entire overlay position any time the price of the mortgage currently held as the hedging instrument rises above 100, or any time the market declines sufficiently for the next-higher coupon to start trading under 100 as well.

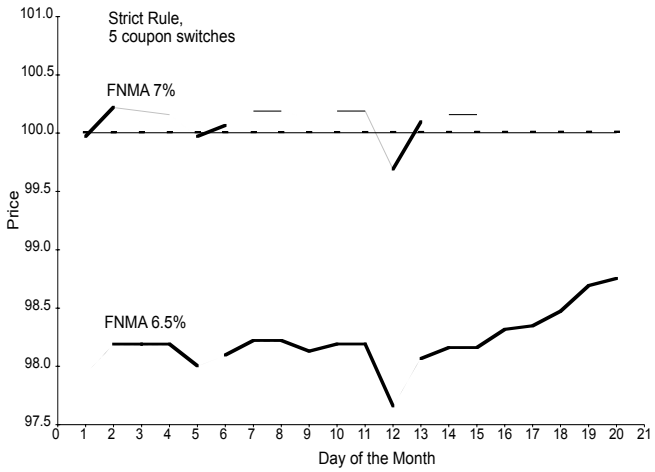
When the price of such a security hovers near par, it may frequently cross the line, losing and regaining its current-coupon status several times during a month. A realistic strategy concerned with transaction costs should not turn over the entire overlay position each time the par-priced line is crossed. To avoid excessive transaction costs, we develop a relaxed rule in which the price of the current-coupon security is allowed to reach 100.5 before relinquishing its status (and requiring a trade) to the one closest to par from below.

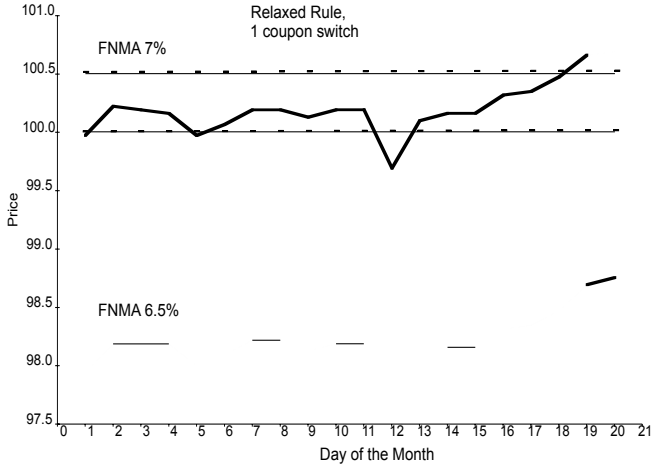
Exhibit A illustrates these two rules, using the daily price histories of the Fannie Mae 7% (upper line) and the Fannie Mae 6.5% (lower line) during December 1995. In each half of the figure, the security used for hedging each day is indicated by a heavy solid line. Under both definitions of current-coupon, we begin the month with 7% and end it with 6.5%. The relaxed rule requires only a single trade toward the very end of the month, while the strict rule would have traded back and forth several times as the price of the 7% flirted with par. We see that in certain periods the relaxed rule can dramatically reduce the overlay turnover.

A third possibility is to disallow any midmonth coupon

EXHIBIT A

Current-Coupon Selection Rules, December 1995





switches, and let the current-coupon security be the one that meets the definition at the beginning of the month. Performance and tracking errors presented in this article are obtained without midmonth coupon switching.

ENDNOTES

The authors thank Kenneth B. Dunn for motivating this research. While the conclusions presented in this report reflect the authors' opinions, the study benefited significantly from many discussions with Mr. Dunn.

[1]For a description of mortgage generics, see Dynkin et al. [1999].

[2]The relationship between the price drop and the financing cost for mortgages is complicated by the prepayment option. Given the price drop between two settlement months and an estimated prepayment speed for the coming payment, one can calculate an implied financing cost. For current- coupon mortgages, the implied financing rate is often lower than general collateral repo rates. This is similar to the special financing rates often available for on-the-run Treasuries. For a detailed discussion of implied MBS financing cost, see Carlson and Tierney [1995].

[3]For the methodology of computing excess return, see "Attribution of Portfolio Performance Relative to an Index" [1998].

[4]Over the study period (1994-1998) the average month-end duration was 4.96 for the Treasury index, 3.05 for the Intermediate Treasury index, and 3.44 for the MBS index.

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