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Gaining Exposure to Mortgage Benchmarks — A Guide for Global Investors

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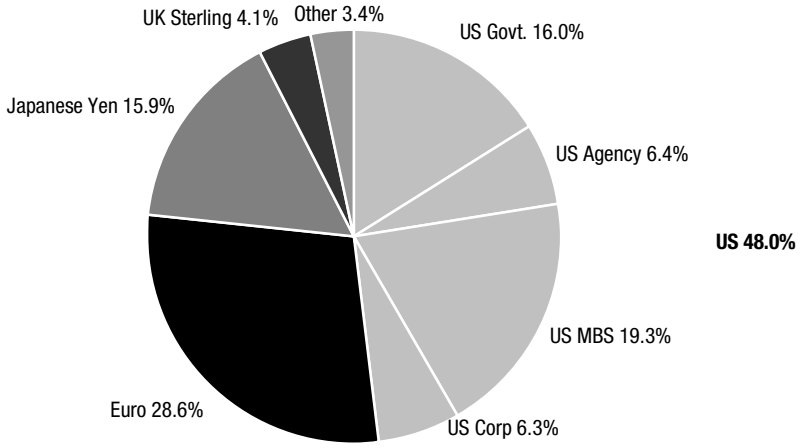
Introduction

Traditionally, the international bond portfolios of many investors outside the United States have been benchmarked to indices composed primarily of government securities. Recently, there has been a movement toward using benchmarks that contain more credit products, such as corporate bonds or mortgage-backed securities (MBSs). Reasons for the switch from government bond indices include the following: The diminishing size of the US Treasury market, and the resulting reduced exposure to the US bond market; an increasing exposure to Japan, which is a concern because of the low yields on Japanese government bonds; and competitive pressures forcing portfolio managers to search for incremental returns.

Given the immense size of the US MBS market — roughly $3 trillion as of early 2001 — world bond indices generally have a significant component in MBSs. For example, Figure 1 shows the composition of the Salomon Smith Barney World Broad Investment Grade (BIG) Index.

Figure 1. Composition of the Salomon Smith Barney World BIG Index by Market Value, 1 Mar 01



Source: Salomon Smith Barney.

Mortgage securities comprise about 20% of the Salomon Smith Barney World BIG Index.

The MBS sector represents almost 20% of SSB's World BIG Index and, as one would expect, the percentages in other comprehensive world investment-grade indices are similar. Thus, benchmarking to an investment-grade world bond index requires a significant exposure to MBSs.

However, MBSs are relatively complex securities, and proper active management of an MBS portfolio requires specialized expertise and analytic tools.[1] To a large extent, this complexity arises from prepayment risk. The mortgages backing MBSs are generally fully prepayable at any time, and prepayment rates depend on a host of economic, mortgage-market, and demographic factors. Hence, access to a sound

[1] An introduction to MBSs is given in *Guide to Mortgage Securities*, Lakhbir Hayre, May 1999, Salomon Smith Barney.

prepayment model is essential for analyzing MBSs.[2] Another difficulty arises from back-office issues; MBSs usually have monthly cashflows, which contain both interest and principal. The back offices of many non-US institutions do not have the systems to handle the settlement or management of mortgage securities.

In this paper, we address several topics that are pertinent for money managers who are now benchmarked to indices that contain significant amounts of MBSs. In the next section of this report, we describe methods of gaining exposure to MBSs without actually buying them. We first discuss using high-grade, nonmortgage products — Treasuries, corporate bonds, and agency debentures — to track the mortgage component of the index. Our conclusion is that there generally is significant tracking error in using nonmortgage products. Furthermore, MBSs have historically outperformed Treasuries and agency debentures, so an investor may be giving up significant yield by using these substitutes in place of MBSs. A better alternative is to use mortgage index swaps, which provide the investor with the return on a mortgage index in return for paying a floating rate (typically close to LIBOR). We give a brief description of such swaps.

In the third section of this report, we discuss tracking a mortgage index using a portfolio of a small number of highly liquid MBSs. Several such portfolios are constructed, and tracking results are described for each. Our conclusion is that it is possible to track the mortgage index with a fairly small number (less than a dozen) of liquid MBSs. In addition, we show that constructing these tracking portfolios can be a simple process that requires only a modest knowledge of the mortgage market. We also describe common active strategies for outperforming the mortgage index.

In the final section, we discuss how to deal with back-office issues. Although the lack of back-office capabilities should not be an impediment to taking delivery of MBSs given the availability of third-party vendors who provide back-office services, we also describe the “dollar roll market,” which, in essence, allows investors to buy MBSs without actually taking delivery. The mechanics and economics of the dollar roll market are examined, and a mathematical description of dollar rolls is provided in an appendix.

[2] A description of prepayment modeling may be found in *Anatomy of Prepayments: The Salomon Smith Barney Prepayment Model*, Lakhbir Hayre and Robert Young, April 2000, Salomon Smith Barney.

Methods of Gaining Exposure to MBSs Without Buying MBSs

A major concern of investors who are new to the mortgage market is the complexity of the product and the concomitant difficulty of issue selection. In particular, given their lack of familiarity with MBS prepayment and valuation models, new investors often lack confidence in their ability to select issues that will accurately track (and hopefully outperform) the overall mortgage market. In addition, new investors might be restricted from taking delivery of MBSs because of back-office constraints.

In this section, we discuss two approaches to tracking the mortgage market without buying MBSs. First, we look at substituting other fixed-income products for MBSs. Second, we examine the use of mortgage-index swaps. Each of these approaches has strengths and weaknesses. However, both suffer from what we believe to be a major drawback — investors are denied the opportunity to increase their mortgage expertise through direct experience in the MBS market. We will pursue this argument further, making the case that the long-term interests of new MBS investors might be better served through the acquisition of portfolios of TBA (to be announced) pass-throughs.

Tracking the Mortgage Index Using Treasuries, Corporates, or Agency Debt

Perhaps the simplest approach to addressing the difficulties associated with managing a mortgage portfolio is to completely avoid MBSs, by substituting other fixed-income products for the MBS portion of the benchmark. Unfortunately, as we demonstrate in this section, tracking errors under this approach historically have been substantial. In addition to producing sizeable tracking errors, comparable Treasuries and agencies have lagged the performance of the MBS sector during the past decade.

MBSs have outperformed comparable Treasuries and agencies in the past.

In Figure 2, we show the tracking errors that would have resulted from substituting portfolios from each of the following sectors for MBSs since January 1990: Treasuries, all corporates, AAA/AA corporates only, A corporates only, BBB corporates only, and agency debt. The tracking portfolios were duration matched and rebalanced monthly.[3]

[3] All of the data in this report for Treasuries, agencies, corporates, and mortgages came from the SSB BIG (Broad Investment Grade) Index. We define the tracking error between two portfolios as the standard deviation of the differences in their monthly returns, which we express in basis points per month. In the current example, substitute-sector portfolios, which were duration matched to the mortgage index, were constructed each month through the following two-step procedure: (1) Divide the substitute sector of interest into four maturity subsectors: 1–3 years, 3–7 years, 7–10 years, and >10 years. (2) Weight the two subsectors with durations that surround that of the mortgage index, so that the duration of the mortgage index is matched (assign zero weights to the remaining two sectors). For example, suppose that the duration of the mortgage index at the beginning of a particular month is 3.50, and the durations of the 1–3, 3–7, 7–10, and >10 subsectors of the agency sector are 1.58, 3.04, 5.72, and 11.20, respectively. In this case, the duration-matched agency portfolio would be constructed by applying weights of 0.00, 0.83, 0.17, and 0.00 to the 1–3, 3–7, 7–10, and >10 agency subsectors, respectively. In addition to matching duration, we could have partial-duration matched the substitute-sector portfolios to the mortgage index. We did not because we do not have partial durations for our indices prior to January 1995 and, for reasons of consistency and comparability, we wanted to use the same methodology throughout the entire period analyzed (January 1990 to December 2000). However, we do not believe that constraining the substitute-sector portfolios to be partial-duration matched would have significantly altered our results. We came to this conclusion based on comparisons of the results of the two methodologies in subperiods in which we did have the requisite partial durations. These comparisons generally showed only minor differences. For example, between January 1998 and December 2000, we found that a partial-duration-matching constraint increased the tracking errors of Treasuries and AAA/AA corporates by about 2bp per month, and decreased that of agencies by about 1bp per

Figure 2. Tracking Errors of Selected Nonmortgage Sectors Versus the SSB Mortgage Index

	Tracking Error		
Sector	Jan 90–Dec 97	Jan 98–Dec 00	Jan 90–Dec 00
Treasuries	31.3 bp/month	36.1 bp/month	32.6 bp/month
Agencies	30.0	23.7	28.3
Corporates — All	33.7	28.8	32.3
Corporates — AAA/AA	30.8	23.3	28.8
Corporates — A	34.6	24.8	32.0
Corporates — BBB	43.6	46.5	44.4

Source: Salomon Smith Barney.

The current OAS advantages of MBSs suggest that they should continue to outperform Treasuries and agencies.

Not surprisingly, Treasuries show the largest tracking error of the overall sectors, 32.6bp per month over the entire period. In addition, the results for the period beginning January 1998 suggest that the tracking error of this strategy has recently increased to 36.1bp/month. This also is not surprising, because this period corresponds to an era of shrinking Treasury supply and, at the same time, more volatile yield spreads between the Treasury sector and other fixed-income sectors. In addition to substantial tracking error, on average duration-matched Treasuries lagged the performance of the MBS sector by 3.1bp per month between January 1990 and December 2000. Furthermore, given the historically wide OAS advantage of mortgages over Treasuries today (about 100bp), we would expect this deficit to be, on average, even larger in the future (100bp per 12 months, which provides an expected deficit of 8.3bp per month).

Somewhat more surprising is that the results in Figure 2 indicate that duration-matched portfolios drawn from the overall corporate market would have not tracked the mortgage market any better than would have their Treasury counterparts since January 1990. However, examining the results for the various credit subsectors of the overall corporate sector suggests why — the spread volatility of the lower-rated corporate sectors added considerable noise. This can be inferred from the relative magnitudes of the tracking errors of the various credit subsectors of the overall corporate sector. However, even the highest-grade corporates (AAA/AA) have historically displayed significant tracking errors (e.g., 28.8bp per month since January 1990 and 23.3bp per month since January 1998). In terms of performance, mortgages and the highest-grade corporates have provided comparable results over the past decade on average (MBS returns lagged those of duration-matched AAA/AA corporates by 0.1bp per month between January 1990 and December 2000). Given the comparable OASs of the two sectors today, we would expect this relationship to be maintained in the future.

month, relative to those shown for the same period in Figure 2. Why did an explicit partial-duration-matching constraint make so little difference? Likely for two reasons: First, the simple, duration-matching approach outlined in this footnote does a reasonable job of partial-duration matching the substitute-sector portfolios to the index. The second reason is because tracking errors caused by mortgage-specific factors (e.g., prepayment exposure) overwhelmed the effects of any residual yield-curve exposure.

Substituting nonmortgage products for MBSs has historically resulted in large tracking errors.

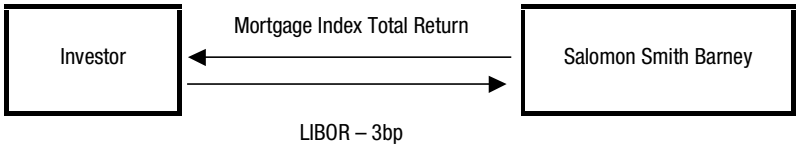
Interestingly, duration-matched portfolios of agency debt have not historically produced tracking errors versus MBSs that have been any better than those provided by the highest-quality corporates. For example, Figure 2 shows a tracking error since January 1990 of 28.3bp per month for agencies versus 28.8bp per month for AAA/AA corporates. Furthermore, the corresponding tracking errors since January 1998 are 23.7bp per month and 23.3bp per month, which suggests that there has not been any recent improvement in the tracking performance of agencies relative to that of high-grade corporates.[4] One might have expected agency debt to provide less tracking error, because all of the MBSs in the SSB Mortgage Index were agency issues. What this result suggests is that the tracking error between MBSs and both agency debt and AAA/AA corporates was not credit related but prepayment related. Furthermore, on average duration-matched agencies lagged the returns of the MBS sector by 1.2bp per month between January 1990 and December 2000. In addition, the current OAS advantage of the MBS sector (about 20bp) suggests that mortgages should continue to modestly outperform agency debt on average in the future.

We conclude that to reduce tracking errors to a level below those that we have shown for agency debt and high-quality corporates versus mortgages, one must consider products with performances tied directly to those of MBSs. Possibilities include mortgage index swaps and the TBA sector of the MBS market.

Mortgage Index Swaps

A mortgage index swap allows investors who want to gain exposure to the mortgage market to do so without buying MBSs. As illustrated in Figure 3, the investor pays a dealer (such as Salomon Smith Barney) a rate tied to LIBOR (recently, about LIBOR minus 3bp), and receives in return the total return of a specified mortgage index (such as the SSB Mortgage Index). Although less common, an investor can also do the reverse trade if he wants to short the index; that is, the investor pays the return from the index to Salomon Smith Barney and receives LIBOR less a spread (recently LIBOR minus 30bp, as shown in Figure 4).

Figure 3. Total Rate of Return Swap — Buying the Mortgage Index

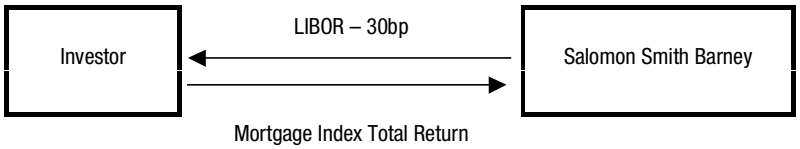


Note: Spreads to LIBOR shown are for illustrative purposes only.

Source: Salomon Smith Barney.

[4] Most recently, the tracking performance of agencies (versus mortgages) has improved relative to that of high-grade corporates. For example, in the year 2000, the tracking performance of agencies improved to 21.1bp per month, while that of AAA/AA corporates deteriorated to 27.8bp per month. Admittedly, this is a very short historical period from which to extrapolate likely future performance.

Figure 4. Total Rate of Return Swap — Selling the Mortgage Index



Note: Spreads to LIBOR shown are for illustrative purposes only.
Source: Salomon Smith Barney.

Figure 5 shows recent representative terms for a mortgage index swap.

Figure 5. Typical Terms of a Mortgage Index Swap[a]

Notional Amount	$50 million to $500 million
Maturity	One year
Payment/reset frequency	Monthly
Settlement	Sixth business day of the following month
Investor Long Mortgage Index	
Receives	Total rate of return of the Mortgage Index
Pays	One-month LIBOR – 3bp
Investor Short Mortgage Index	
Receives	One-month LIBOR – 30bp
Pays	Total rate of return of the Mortgage Index
Cost of unwinding	At midmarket level

[a] These terms are for illustrative purposes only and are subject to change because of different market conditions.
Source: Salomon Smith Barney.

Advantages of Mortgage Index Swaps

There are several advantages to entering into a mortgage index swap relative to buying a portfolio of mortgage-related securities, which include the following:

There are no tracking errors or back-office issues with a mortgage index swap . . .

- There is no basis risk or tracking error versus the index, since the investor is receiving the exact return on the index.
- There are no pool-specific risks, such as idiosyncratic prepayment risk.
- The investor does not have to worry about settlement or other back-office issues, since there is no delivery of actual MBSs.

Disadvantages of Mortgage Index Swaps

Among the disadvantages relative to buying MBSs outright are the following:

- An index swap exposes the investor to counterparty risk, namely the risk that the dealer for some reason does not make payments on the swap. This risk is nonexistent or at least very remote if one buys agency MBSs, since they are guaranteed by the government or quasi-government entities.

. . .but liquidity is not as good as in the regular MBS market.

- Investors forego the potential to outperform the index through active index strategies, such as underweighting or overweighting MBSs, security selection within the mortgage market, and so on.
- Liquidity and size are obviously not as good as in the regular MBS market, which sees huge trading volume every day.

- The investor does not develop the experience and expertise that would come with actually trading MBSs.

Funding Strategies for Mortgage Index Swaps

An investor wishing to surpass the returns of the Mortgage Index could use a strategy of buying a one-year Mortgage Index swap and investing in credit card floaters. Credit card floaters are currently paying LIBOR plus 5bp for AAA-rated, LIBOR plus 25bp for A-rated, and LIBOR plus 75bp for BBB-rated bonds for maturities between one and two years. The investor will be paying LIBOR minus 3bp for the index swap. Thus, the combination of the Mortgage Index swap and the credit card floater will return the Mortgage Index plus 8bp, 28bp, or 78bp depending on the rating of the floater.

Of course, no return comes without risk, but it is relatively low with this strategy. There are credit and spread-duration risks, which should be less of a concern if the investor buys and holds the paper to maturity.[5] These risks may be realized should the investor decide to unwind the position before the end of the year. Additionally, it is unlikely that the maturity of the floater will exactly match that of the index swap (for example, a "one-year" floater may actually have a maturity of 1.2 years, or 0.9 years, etc.). However, these risks should diminish as the maturity of the floater nears. Another consideration is the size of the trade. If it exceeds certain limits, currently about $100 million, the investor might have to buy bonds backed by different deals or with a longer time to maturity.

In Summary

Mortgage index swaps do not allow money managers to develop the hands-on experience critical to long-term success in managing an MBS portfolio.

Mortgage index swaps allow investors to obtain exposure to MBSs without actually having to buy them directly, and can hence be a good transition vehicle while the portfolio manager gets familiar with the MBS market. However, if MBSs are expected to continue to be part of an investor's benchmark in the future, our view is that mortgage index swaps are not a good *long-term* solution. As indicated above, the money manager misses the chance of developing the hands-on experience critical for long-term success in managing an MBS portfolio, and there may be size, liquidity, and credit issues.

[5] By credit risks, we mean spreads widening because of credit concerns rather than actual principal losses (the chances of such losses are fairly remote for a short-term investment-grade credit card security).

Tracking the Mortgage Index Using TBA Pass-Throughs

In this section, we show that the relative homogeneity of the mortgage market has historically allowed the construction of liquid, TBA pass-through portfolios that have tracked the performance of the mortgage index quite well. We further demonstrate that these tracking portfolios could have been selected using simple rules restricted to a small number of issues.

We argue that the advantages of this approach over substituting agency debt or high-grade corporates for mortgages in a portfolio are twofold. First, our analysis suggests that the resulting tracking errors should be substantially smaller. Second, by investing in the mortgage market, investors will likely move up the MBS learning curve faster — and the knowledge gained in this process can be later exploited in active strategies.

TBAs, Vintages, Specified Pools, and the Mortgage Index

Most agency pass-through trading occurs on a TBA basis.

Most agency pass-through trading occurs on a TBA basis. TBA trading is popular because it greatly improves liquidity, allowing trades of large size to take place with narrow bid/ask spreads (bid/ask spreads of $1/32 or less are typical for the most actively traded issues). In a TBA trade, the buyer and seller agree on general trade parameters, such as par amount, issuer, type, coupon, and price (e.g., $100 million of Fannie Mae 30-year 6.5% pass-throughs at a price of $99-16). However, the buyer does not know the specific pools that will be delivered until two business days before settlement date (48-hour day), when the seller must provide the information. TBA trades normally settle in accord with a monthly schedule set by the Bond Market Association (BMA), a trade group of fixed-income dealers. Unless otherwise specified, the pools delivered must satisfy the "good delivery" requirements set by the BMA for each $1 million lot: no more than three pools per lot and maximum variance of 0.01% per lot.[6]

The TBA market is a relatively simple way to gain exposure to the mortgage market because it obviates the need to make decisions regarding "seasoning." Seasoning refers to the age of the mortgage loans underlying a pool. Older loans are referred to as being "more seasoned" than newer loans. Seasoning matters primarily because it affects the prepayment characteristics of the underlying mortgages. Generally, the prepayment characteristics of seasoned pools are deemed to be advantageous relative to those of newer pools and, therefore, seasoned pools usually trade at price premiums over new pools.[7] Consequently, when an investor buys TBA pass-throughs, he will typically be delivered the newest production pools available.

[6] Slightly more liberal "good delivery" requirements are allowed for very old pools. See the Bond Market Association's *Uniform Practices* manual for details. For an introduction to MBS operational issues (settlement, clearance, etc.), and more information about the TBA market, see *The Mechanics of Investing in Mortgage- and Asset-Backed Securities*, Salomon Smith Barney, November 1999.

[7] Seasoned pools generally prepay faster as discounts and slower as premiums than do new pools. This is advantageous to the investor. In high interest-rate environments, when the MBS's market price is below par, faster prepayments, which return principal at

Alternatively, an investor can place stipulations on his TBA trades, or trade specified pools. One of the most popular TBA stipulations is "vintage," which refers to the year in which the loans underlying a mortgage pool were originated. For example, an investor, who believes that the favorable prepayment characteristics of 1996 origination Freddie Mac Gold 8s (relative to new production) were not fully reflected in their price spread over TBAs,[8] might want to stipulate 1996 origination bonds for his TBA purchases of that issue. In this case, although the investor would still not know the specific pools that he would be delivered when he enters into the trade, he would know that any pools that were delivered must contain loans that were originated in 1996. In contrast, an investor who traded specified pools would, as the term suggests, know exactly which pools were to be delivered.

The advantage of putting stipulations on TBA trades (or trading specified pools) is that a knowledgeable investor can attempt to exploit his knowledge by purchasing issues that he believes are cheap, and selling issues that he believes are expensive. The disadvantages include increased complexity (one must consider the attributes of specific vintages or pools) and reduced liquidity (maximum trade sizes will generally be smaller, and the bid/ask spreads wider, than in standard TBA trades).

The TBA market provides advantages in terms of size, liquidity, and simplicity over the alternatives.

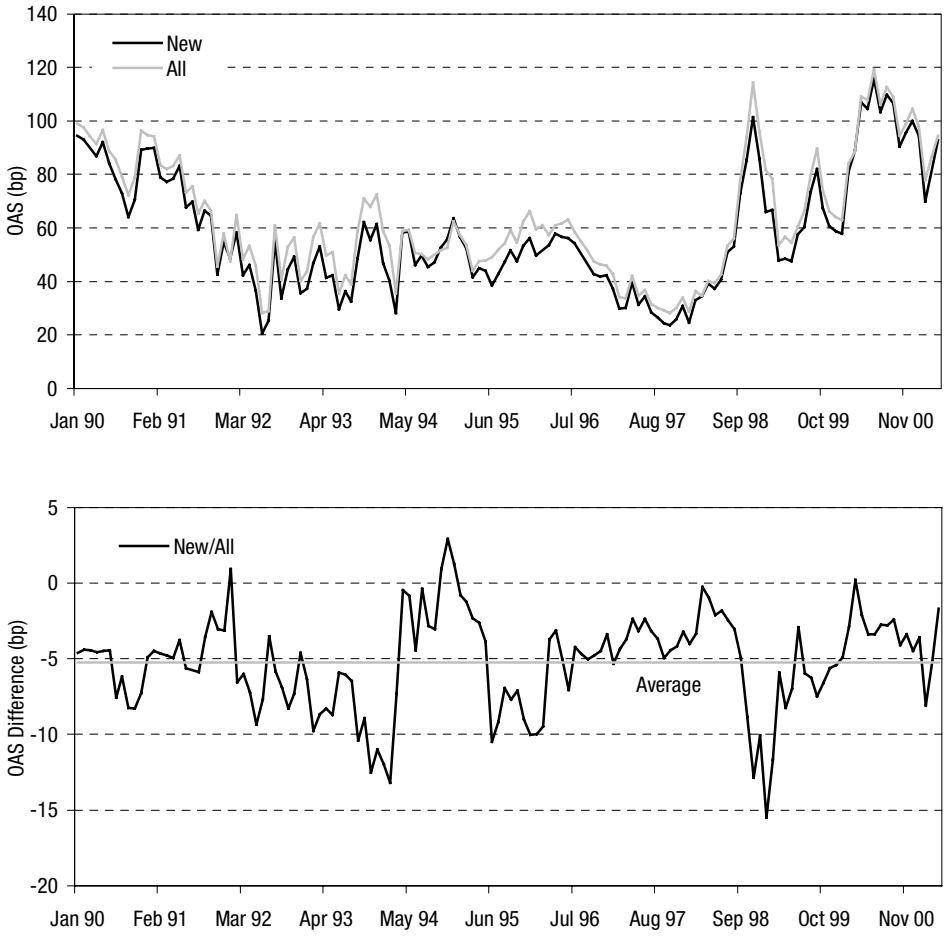
Consequently, investing in MBSs through standard TBA trades can provide advantages in terms of size, liquidity, and simplicity over the alternatives. But what does an investor sacrifice to obtain these advantages? We see two areas of potential concern: value and tracking error. With respect to value, Figure 6 shows that the OAS of the new sector[9] of the SSB Mortgage Index on average has been about 5bp less than that of the overall index since January 1990. This suggests that mortgage portfolios constructed from new-origination MBSs (the type of pools most likely to be delivered in TBA transactions) might be expected, over time, to return about 0.05% less per year than the overall mortgage market.

par, boost the yield of the pool. Conversely, in low interest-rate environments, when the MBS's market price is above par, slower prepayments are beneficial, allowing the above-market coupon to be earned for a longer period of time.

[8] The prices of vintages are usually quoted as price spreads over the comparable TBA issues. For example, the price of 1996 Freddie Mac Gold 8s might be quoted as $24/32 over the price of TBA Freddie Mac Gold 8s.

[9] "New" MBSs are currently defined as those with weighted-average loan ages of less than 18 months and 12 months, for mortgages with original terms to maturity of 30 years and 15 years, respectively. Prior to July 1996, "new" MBSs were defined as those with weighted-average loan ages less than 30 months. For more information, see *Total Rate-of-Return Indexes*, Salomon Smith Barney, July 3, 1996.

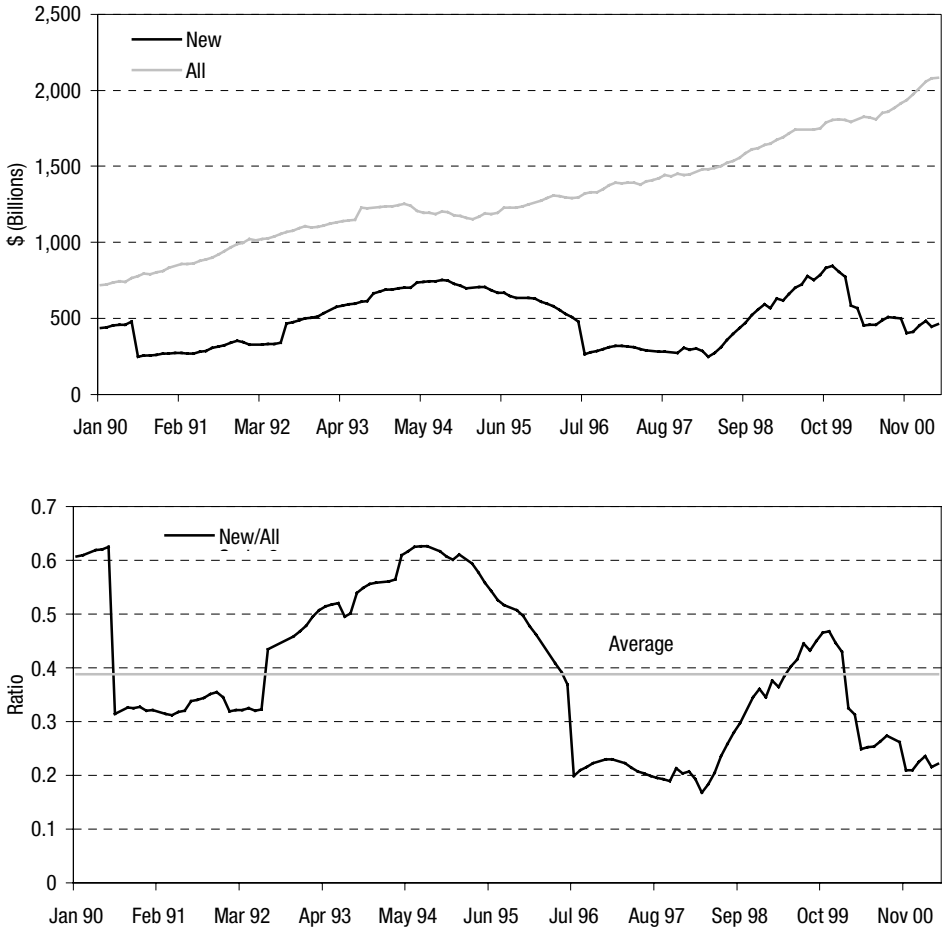
Figure 6. OAS — New Versus All Sectors of the SSB Mortgage Index, Jan 90–Apr 01



Source: Salomon Smith Barney.

With respect to tracking error, Figure 7 shows that the new sector of the mortgage index has only represented about 40% of the market value of the overall index, on average, since January 1990. Consequently, it is possible that portfolios constructed from new origination MBSs would have exhibited significant tracking errors versus the index. However, in the next two sections, we demonstrate that, in fact, portfolios of new-origination MBSs that would have tracked the overall mortgage market quite well could have been selected using simple rules restricted to a small number of issues.

Figure 7. Outstanding Market Values — New Versus All Sectors of the SSB Mortgage Index, Jan 90–Apr 01



Source: Salomon Smith Barney.

Constructing a Tracking Portfolio

To construct a mortgage portfolio that will have a low tracking error versus the mortgage index, one needs to understand the composition of the mortgage market and the historical return relationships between the various mortgage sectors. In this section we examine these aspects of the mortgage market and discuss their relevance for constructing mortgage portfolios that historically have tracked the mortgage index well.

Fortunately (from the perspective of constructing tracking portfolios), the agency mortgage market is relatively homogeneous; in the SSB Mortgage Index there are only three issuers (Fannie Mae, Freddie Mac, and Ginnie Mae) and, currently, only two mortgage types (30-year and 15-year).[10] Furthermore, the credit and prepayment

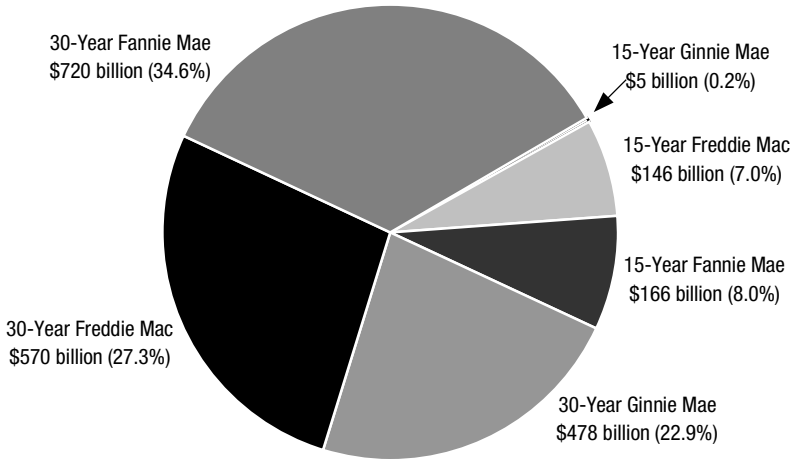
[10] "Thirty-year" and "15-year" refer to the original maturities of the underlying, self-amortizing mortgage loans. In the past, other mortgage types, such as balloon MBSs, were large enough to attain representation in the SSB index. However, 30-year and 15-year MBSs have always represented the vast majority of the index. For current SSB index inclusion criteria, see *Salomon Smith Barney US Broad Investment-Grade (BIG) Bond Index: April 2001 Changes*, Salomon Smith Barney, January 22, 2001.

attributes of the MBSs of two of the issuers, Fannie Mae and Freddie Mac, are deemed to be so similar by the market that participants often refer to MBSs from both of these issuers generically as "conventional" MBSs.[11] In contrast, Ginnie Maes are generally believed to offer superior credit and somewhat different prepayment characteristics relative to those of their conventional counterparts.[12]

The agency mortgage market is relatively homogeneous, which simplifies tracking portfolio construction.

In Figure 8, we show the current breakdown of the SSB Mortgage Index by issuer and mortgage type. The largest sector consists of 30-year Fannie Mae MBSs, which represent almost 35% of the total ($2.084 trillion) market value of the index. This sector is closely followed in size by the 30-year Freddie Mac sector (27%) and the 30-year Ginnie Mae sector (23%). Together, 30-year Fannie Maes, Freddie Macs, and Ginnie Maes comprise nearly 85% of the index. The balance of the index is nearly evenly split between 15-year Fannie Maes and 15-year Freddie Macs (the size of the 15-year Ginnie Mae sector is negligible).

Figure 8. Composition of the SSB Mortgage Index by Issuer and Mortgage Type — Market Values, Apr 01



Source: Salomon Smith Barney.

[11] Strictly speaking, the term "conventional" refers to the type of loan that underlies both Fannie Mae and Freddie Mac MBSs. Conventional loans are mortgages that are not insured by either the Federal Housing Administration (FHA) or the Veterans Administration (VA), two US government entities.

[12] Either the FHA or the VA insures the loans underlying Ginnie Mae MBSs. The prepayment characteristics of these loans differ from those of their conventional counterparts because, among other differences, the loan balances are generally smaller and the borrowers less affluent. In addition, Ginnie Mae MBSs are backed by the "full faith and credit" of the US government. In contrast, conventional MBSs are guaranteed by either Fannie Mae or Freddie Mac, which are private corporations. See *Guide to Mortgage-Backed Securities*, Salomon Smith Barney, March 1999, for additional information.

In Figure 9, we show the historical tracking errors of each of these sectors relative to each of the other sectors since January 1990. We define the tracking error between two sectors as the standard deviation of the differences in their monthly returns.[13] The numbers that read diagonally in the figure represent the tracking error between each sector and itself (zero, of course). Of greater interest are the between-sector results. In particular, 30-year Fannie Maes and 30-year Freddie Macs have, historically, displayed the lowest tracking error (3.3bp per month), closely followed by their 15-year counterparts (4.2bp per month). This accords nicely with the conventional wisdom (no pun intended) that Fannie Maes and Freddie Macs are largely interchangeable. In contrast, the tracking errors between either of the 30-year conventional sectors and 30-year Ginnie Maes (both 17.2bp per month), or between any of the 30-year and 15-year sectors (18.3bp per month to 24.0bp per month), are considerably larger. These results suggest that if an investor desired to limit the number of issues in his portfolio, he could have substituted Freddie Macs for Fannie Maes of the same type (or vice versa) without increasing the tracking error of his portfolio significantly.

From a tracking perspective, Fannie Maes and Freddie Macs have been largely interchangeable.

Figure 9. Tracking Error Between Sectors — by Issuer and Type — of the SSB Mortgage Index (bp/Month), Jan 90–Dec 00

	Sector					
	30-Year			15-Year		
Sector	Fannie Mae	Freddie Mac	Ginnie Mae	Fannie Mae	Freddie Mac	Ginnie Mae
30-Yr Fannie Mae	0.0	3.3	17.2	18.3	19.1	22.2
30-Yr Freddie Mac		0.0	17.2	18.8	19.5	22.2
30-Yr Ginnie Mae			0.0	22.9	24.0	22.3
15-Yr Fannie Mae				0.0	4.2	14.8
15-Yr Freddie Mac					0.0	15.0
15-Yr Ginnie Mae						0.0

Source: Salomon Smith Barney.

Currently, more than 95% of the SSB Mortgage Index resides in five coupons.

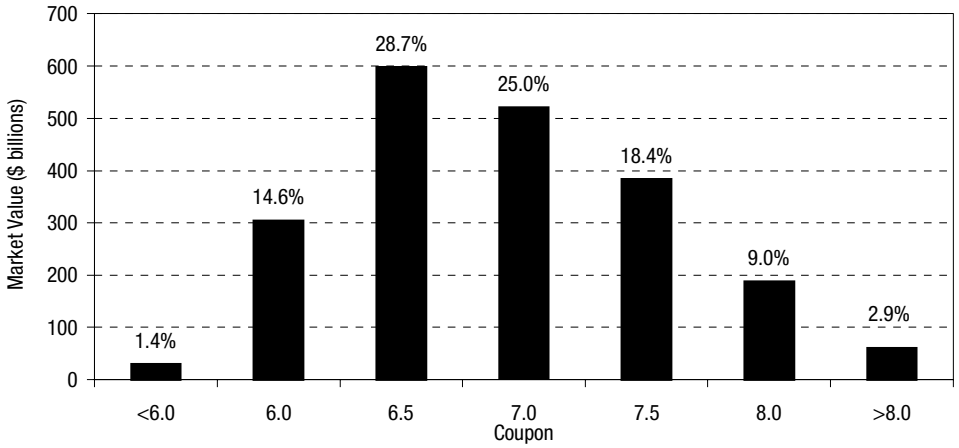
So far, we have looked at the mortgage market categorized by issuer and mortgage type. Of course, each of these sectors is made up of pools with a variety of coupons. In Figure 10, we show the distribution of the SSB Mortgage Index by coupon. Coupon is the primary determinant of a mortgage's prepayment characteristics and hence its duration and convexity. However, even after accounting for duration and convexity differences, substantial tracking errors between coupons remain because of coupon-specific prepayment risk. For example, after adjusting for duration and convexity differences, the tracking error between the premium and discount sectors of the mortgage index was 22.7bp per month between January 1995 and December 2000.[14] This result suggests that, from a tracking perspective, coupon is an important attribute to align between an MBS portfolio and the MBS index. Fortunately (again from the perspective of constructing tracking portfolios), historically, the number of

[13] The durations of the sectors have differed modestly, but adjusting for duration differences had no significant impact on the results.

[14] The premium sector (MBSs with prices greater than $100) is comprised of MBSs with coupons above the current coupon; conversely, the discount sector (MBSs with prices less than $100) is comprised of MBSs with coupons below the current coupon. Because premium MBSs are subject to refinancing, they generally have shorter durations and more negative convexities than their discount counterparts. In addition, premiums are generally subject to greater refinancing-related prepayment uncertainty.

coupons outstanding has been modest. For example, more than 95% of the market value of the SSB Mortgage Index currently resides in five coupons between 6.0% and 8.0%, inclusive.[15]

Figure 10. Composition of the SSB Mortgage Index by Coupon, Apr 01



Source: Salomon Smith Barney.

TBA issues have historically tracked the overall MBS market well.

The final dimension that we need to investigate is seasoning.[16] As discussed, seasoned MBSs are generally deemed to be more valuable than their newly originated (TBA) counterparts and, consequently, usually trade at price spreads over their corresponding TBA issues. However, these price spreads have historically been relatively stable. This suggests that, although new-origination MBSs typically comprise only a minority of the market value of the index, new issues might serve as reasonable proxies for the entire mortgage market. The data in Figure 11, which show the tracking errors of new MBSs versus the overall cohort for selected sectors since January 1995, support this conjecture. For example, the new sector of 30-year conventional 7s had a tracking error of only 3.7bp per month versus all 30-year conventional 7s. Furthermore, while the other sectors shown had larger tracking errors, none exceeded 8.6bp per month.

[15] Why are so few coupons currently outstanding? First, almost all MBSs are issued with coupons in 0.5% increments, which limits the number of coupons issued. Second, as interest rates (more or less) secularly declined during the past two decades, most of the higher-coupon MBSs, which were largely issued in the 1980s and early 1990s, almost completely prepaid.

[16] A comprehensive breakdown of the current composition of the SSB Mortgage Index (by issuer, type, coupon, and seasoning sector) is provided in Appendix A.

Figure 11. Tracking Error Between Selected New and All Sectors of the SSB Mortgage Index, Jan 95–Dec 00

Sector	Tracking Error
30-Yr Conventional 6.0 — New Versus All	4.9 bp/month
30-Yr Conventional 7.0 — New Versus All	3.7
30-Yr Conventional 8.0 — New Versus All	5.5
30-Yr Ginnie Mae 6.5 — New Versus All	6.2
30-Yr Ginnie Mae 7.5 — New Versus All	4.3
30-Yr Ginnie Mae 8.5 — New Versus All	8.0
15-Yr Conventional 6.0 — New Versus All	6.3
15-Yr Conventional 7.0 — New Versus All	8.6
15-Yr Conventional 8.0 — New Versus All	7.3

Source: Salomon Smith Barney.

These observations suggest that it should be possible to construct reasonable index-tracking portfolios through purchases of TBA pass-throughs restricted to a modest number of coupons in each of the following sectors: 30-year conventionals, 30-year Ginnie Maes, and 15-year conventionals. Because of its negligible size, the 15-year Ginnie Mae sector can be safely ignored. And, within the 30-year and 15-year conventional sectors, the close correspondence of the monthly returns of Freddie Macs and Fannie Maes suggests that we need only choose MBSs from one of these issuers. These observations also suggest that, to minimize tracking errors, the important attributes to align (on a market-value-weighted basis) between a mortgage portfolio and the mortgage index are issuer (Ginnie Mae and conventional), mortgage type (30-year and 15-year), and MBS coupon.

TBA Tracking Portfolios — Historical Results

To test these conclusions we constructed portfolios of MBSs selected from the following sectors of the SSB Mortgage Index: new 30-year Fannie Maes, new 30-year Ginnie Maes, and new 15-year Fannie Maes.[17] The "new" sectors were selected because we believe that they were good proxies for the MBSs that would have been delivered in TBA transactions. We defined issues by issuer, type, and coupon. For example, three candidate issues for the portfolios were new 30-year Fannie Mae 8s, new 30-year Ginnie Mae 8s, and new 15-year Fannie Mae 8s. Their corresponding issues in the benchmark were all 30-year conventional (Fannie Mae and Freddie Mac) 8s, all 30-year Ginnie Mae 8s, and all 15-year conventional (Fannie Mae and Freddie Mac) 8s.

[17] Substituting Freddie Macs for Fannie Maes would not have materially affected our results. Alternatively, we could have followed a strategy of "interlacing" the coupons of these two issuers — without having increased the total number of issues held in the tracking portfolios. For example, in 30-year conventionals, we could have taken our exposure in 6.0s in Freddie Macs, in 6.5s in Fannie Maes, in 7.0s in Freddie Macs, in 7.5s in Fannie Maes, etc. We did not do this for reasons of analytical simplicity and, in any case, it would not have materially affected our results. However, investors who are concerned about aligning their portfolios' exposures to Freddie Mac and Fannie Mae with those of the mortgage index could follow such a strategy.

To minimize tracking error, the most important attributes to align between a mortgage portfolio and the mortgage index have been issuer, type, and coupon.

The specific issues in the portfolios were selected with the objective of minimizing the differences between the market-value weights of the new issues in portfolios relative to those of their corresponding overall issues in the index.[18] Given the way that we have defined the issues in the portfolios and the index, this objective was consistent with our observation that, from a tracking perspective, the most important attributes to align between a mortgage portfolio and the mortgage index have been issuer, type, and coupon. More formally, we minimized the sum of the squared differences between the new issue weights in the portfolios and the corresponding overall issue weights in the index. For example, suppose the weight of new Fannie Mae 6.5s in the portfolio was 0.15 (out of a total portfolio weight of 1.0) and the weight of all conventional 6.5s in the index was 0.19. In this case, the contribution to the objective function provided by this issue would be (0.15-0.19)^2=0.0016. These contributions were calculated for each issue, summed, and minimized. The portfolios were rebalanced monthly.[19]

The results of applying this objective function without constraints since January 1990 are shown in Figure 12. The figure shows the average, standard deviation, minimum, and maximum values of the *differences* between the tracking portfolios and the index for the following parameters: monthly total return, effective duration, and effective convexity. The figure also shows these statistics for the number of issues held in the tracking portfolios and the value of the objective function. On average, the tracking portfolios outperformed the index by 0.4bp per month, with a tracking error of 11.1bp per month. In their best and worst months, the returns of the tracking portfolios deviated from those of the index by 28.9bp and -44.0bp, respectively. On average, the portfolios had longer effective durations (0.38) and lower effective convexities (-0.21). The number of issues held in the tracking portfolios ranged between nine and 23, with an average of 15.4. Finally, the average value of the objective function (0.004) indicates that the weights of the issues in the portfolios and the index were, typically, closely matched.[20]

Figure 12. Tracking Portfolio Results — No Constraints, Jan 90–Dec 00

	Difference (Portfolio – Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	0.4 bp/month	0.38	-0.21	15.4	0.004
Standard Deviation	11.1	0.23	0.15	3.8	0.008
Minimum	-44.0	-0.86	-0.74	9.0	0.000
Maximum	28.9	0.72	0.11	23.0	0.068

Source: Salomon Smith Barney.

[18] For liquidity reasons, we eliminated from consideration for inclusion in the portfolios any new issues with less than $1 billion outstanding.

[19] We make no claim that, from the perspective of minimizing tracking error, this is the optimal formulation of the problem. However, it is simple, intuitive, easy to apply in practice, and as we will show, it has produced good results historically.

[20] Given that the optimization was unconstrained, why was the optimal value of the objective function not exactly zero in all periods? Because we eliminated from consideration for inclusion in the portfolios all new issues with less than $1 billion outstanding (done for liquidity reasons), and this often prevented an exact match of the market-value weights of the portfolios' issues and their corresponding index issues.

A tracking error of 11.1bp per month is substantially better than those discussed for tracking portfolios constructed from Treasuries, corporates, or agencies. However, it is substantially worse than the tracking errors that we showed for new-origination MBSs versus their overall cohorts in Figure 11, which ranged between 3.7bp/month and 8.6bp/month. How is this possible? A resolution to this paradox, and a way to improve our results, are suggested by the significant deviations in duration and convexity between the portfolios and the index, shown in Figure 12. Newly originated MBSs are typically longer and more negatively convex than their seasoned counterparts. By building tracking portfolios of new-origination MBSs, with the objective of matching their market value weights to those of the corresponding (more seasoned) MBSs in the index, we have systematically mismatched both the duration and convexity of the tracking portfolios relative to the benchmark. This observation suggests that constraining the portfolios to be duration and convexity matched relative to the index might improve their tracking accuracy.

Matching duration has also been important.

In Figures 13 and 14, we test this conjecture by showing the effects of matching duration, and duration and convexity, respectively.[21] Matching duration reduces the tracking error substantially, to 5.7bp per month. Interestingly, matching both duration and convexity did not show quite as much improvement (6.6bp per month). An explanation for this result is suggested by a comparison of the average objective function values under the two approaches. Matching duration increased the average value of the objective function to 0.019 (from 0.004 in the unconstrained case), while matching both duration and convexity increased the average value to 0.074. These results suggest that the benefit of matching duration more than offset the cost of poorer alignment between the portfolios and the index of issue market-value weights. In contrast, the cost of the significantly larger issue mismatches, which arose from simultaneously matching convexity, were not completely offset by the benefits of aligning convexity with the benchmark. Consequently, we conclude that to minimize tracking error it is desirable to match duration but not convexity.

Figure 13. Tracking Portfolio Results — Duration Matched, Jan 90–Dec 00

	Difference (Portfolio – Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	-0.2 bp/month	0.00	-0.33	13.6	0.019
Standard Deviation	5.7	0.00	0.17	4.1	0.023
Minimum	-16.6	0.00	-1.37	5.0	0.000
Maximum	13.2	0.00	0.02	23.0	0.199

Source: Salomon Smith Barney.

[21] We reran the optimization with the same objective function, but with the addition of constraints to match these parameters exactly in every period.

Figure 14. Tracking Portfolio Results — Duration and Convexity Matched, Jan 90–Dec 00

	Difference (Portfolio – Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	-0.3 bp/month	0.00	0.00	12.3	0.074
Standard Deviation	6.6	0.00	0.00	5.2	0.106
Minimum	-24.7	0.00	0.00	2.0	0.001
Maximum	20.3	0.00	0.00	23.0	0.592

Source: Salomon Smith Barney.

Focusing on the duration-matched case shown in Figure 13, we see that the number of issues held in the tracking portfolios ranged from five to 23, with an average value of 13.6. What if an investor desires, perhaps for reasons of simplicity, to hold a smaller number of issues in his portfolio than these numbers imply? How much additional tracking error will this likely entail? We address these questions in Figures 15, 16, and 17, where we show the effects of limiting the maximum number of issues held in any period to 15, ten, and six, respectively.

Figure 15. Tracking Portfolio Results — Duration-Matched, 15-Issue Limit, Jan 90–Dec 00

	Difference (Portfolio — Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	-0.3 bp/month	0.00	-0.36	12.3	0.021
Standard Deviation	5.9	0.00	0.18	2.5	0.022
Minimum	-19.6	0.00	-1.37	5.0	0.002
Maximum	13.2	0.00	0.02	15.0	0.199

Source: Salomon Smith Barney.

Figure 16. Tracking Portfolio Results — Duration-Matched, Ten-Issue Limit, Jan 90–Dec 00

	Difference (Portfolio — Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	-0.6 bp/month	0.00	-0.41	9.3	0.044
Standard Deviation	7.3	0.00	0.29	0.9	0.027
Minimum	-26.0	0.00	-1.40	5.0	0.010
Maximum	13.4	0.00	0.25	10.0	0.199

Source: Salomon Smith Barney.

Figure 17. Tracking Portfolio Results — Duration-Matched, Six-Issue Limit, Jan 90–Dec 00

	Difference (Portfolio —Index)				
	One-Month Total Return	Effective Duration	Effective Convexity	Number of Issues Held	Objective Function Value
Average	0.1 bp/month	0.00	-0.57	5.5	0.142
Standard Deviation	9.7	0.00	0.60	0.8	0.096
Minimum	-43.8	0.00	-4.61	2.0	0.025
Maximum	52.4	0.00	0.22	6.0	0.592

Source: Salomon Smith Barney.

The mortgage market can be tracked with reasonable accuracy with as few as six issues.

Limiting the number of issues held to 15 increased the tracking error insignificantly (from 5.7bp per month to 5.9bp per month). A ten-issue limit increased tracking error modestly, to 7.3bp per month. Interestingly, even limiting the maximum number of issues held in any period to six only increased the tracking error to 9.7bp per month.[22] This result might be surprising to investors who are not familiar with the mortgage market. How can six bonds accurately track a market that has an outstanding value of more than $2 trillion? The answer to this question lies in the homogeneity of the agency mortgage market: three issuers (two of which have been largely interchangeable from a tracking perspective), two primary mortgage types, and a handful of coupons.

We conclude that tracking portfolio construction can be a simple process that basically involves holding a relatively small number of the largest outstanding issues.

Based on our historical analysis, we conclude that it should be possible to construct reasonable index-tracking portfolios through purchases of TBA pass-throughs restricted to a modest number of coupons in each of the following sectors: 30-year conventionals, 30-year Ginnie Maes, and 15-year conventionals. The important attributes to align with the index are a portfolio's effective duration and its issue market-value weights — where "issue" is defined by the following three MBS attributes: issuer (Ginnie Mae and conventional); type (30-year and 15-year); and coupon. A concomitant conclusion is that the construction of these tracking portfolios does not have to involve rocket science. We have demonstrated that tracking portfolio construction can be a simple process that basically involves holding a relatively small number of the largest outstanding issues.

Pools, Pools, and More Pools

We need to elaborate on our conclusion that the SSB Mortgage Index can be accurately tracked with only six issues, because it could be misleading to investors who are not familiar with the mortgage market. We have defined "issue" by MBS issuer, type, and coupon. For example, under our analysis, all Fannie Mae 30-year 6.5% pools are treated as one issue. However, if an investor were to take delivery of $100 million Fannie Mae 30-year 6.5s, he could be delivered as many as 300 individual pools. (Remember that "good delivery" is defined as three pools per $1 million lot with no greater than 0.01% variance.) Consequently, a large portfolio containing six issues (as per our definition of issue) could potentially be comprised of thousands of individual pools. From a portfolio manager's perspective this should not be a problem because, analytically, he can continue to think of all of his Fannie Mae 30-year 6.5% pools as a single issue.

However, from a back-office perspective, this could be of greater concern. Consequently, before taking delivery of MBSs, an investor should insure that his back office is capable of processing the number of pools likely to be delivered. What if an investor's back office is not capable of processing a significant number of

[22] In fact, the tracking errors of the six-issue portfolios have recently been even lower. For example, between January 1998 and December 2000, the tracking error was only 6.1bp per month, which was within 1bp per month of the tracking error of the non-issue-limited portfolios. Why the recent improvement? Likely because the successive refinancing waves of the 1990s have concentrated outstanding MBSs in fewer coupons.

pools? In this case, an investor could still invest in MBSs by stipulating minimum pool sizes on his TBA purchases, thus limiting the number of pools delivered. The downside to this approach is that pool-size stipulations have a cost. For example, the cost of a $100 million pool-size stipulation for current-coupon MBSs could range from $1/64 to $1/32 for 30-year conventionals and from $1/32 to $3/32 for 30-year Ginnie Maes.[23]

What if an investor's back office cannot handle MBSs at all, perhaps because of an inability to process amortizing bonds? All is still not necessarily lost. There is a well-developed forward market in MBSs, which allows investors to gain exposure to the mortgage market without taking actual delivery. However, there are many important issues regarding this approach, which we discuss in detail in the section entitled "Dollar Rolls — Mortgage Exposure Without Taking Delivery."

Potential Risks and Rewards of More Active Management

Issuer, type, coupon, and vintage are four mortgage attributes that many active managers choose to mismatch versus their benchmarks.

Most investors, after gaining familiarity with the mortgage market, will likely choose to more actively manage their mortgage investments than the index-tracking approach outlined in this report allows. What strategies do active MBS portfolio managers typically employ, and what are the magnitudes of the risks of these strategies? Not surprisingly, three of the mortgage attributes that many active managers choose to mismatch versus their benchmarks are exactly those that we determined were most important in an index-tracking strategy: issuer, type, and coupon. In addition, many active managers take positions relative to the index with respect to vintage. The tracking errors that we discussed for each of these mortgage attributes are representative of the magnitudes of the risks of these strategies. The rewards of such strategies will, of course, be dependent on a manager's ability to time changes in the relative prices of these attributes.

Other strategies popular with active managers are financing-related, which we discuss in detail in the next section of this report. Finally, as a portfolio manager's mortgage sophistication continues to grow, he will often become involved in structured mortgage products — CMOs, IOs, and POs.[24] One reason that structured MBSs are popular with many portfolio managers is that they allow one to take more focused risk positions (e.g., curve, volatility, or prepayment exposures) with respect to a benchmark than are possible using pass-throughs alone. [25]

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[23] The cost of pool-size stipulations is largely driven by what Fannie Mae, Freddie Mac, and Ginnie Mae charge for consolidating a large number of small pools into a single, large pool. Investors will generally not recover this fee (in the form of a higher market price) when they sell a large pool. Consequently, pool-size stipulations effectively increase bid/ask spreads. One other clarification regarding Ginnie Maes is necessary. Ginnie Mae pools are issued under two different programs: the single-originator Ginnie Mae I program and the multi-originator Ginnie Mae II program. Under the Ginnie Mae II program, the loans from many mortgage originators are consolidated into a single pool. Therefore, at issue, Ginnie II pools are generally much larger than their Ginnie I counterparts. Consequently, pool-size stipulations in Ginnie IIs are typically free. The Ginnie Mae pool-size-stipulation costs quoted in this report are for Ginnie Is. Investors who desire large pools should consider Ginnie Mae IIs for their Ginnie Mae purchases.

[24] For an introduction to structured MBSs, see *An Introduction to CMO Cashflow Structures*, Salomon Smith Barney, April 23, 2001.

[25] See *Beyond Duration: Risk Dimensions of Mortgage Securities*, Salomon Smith Barney, July 1992.

Dollar Rolls — Mortgage Exposure Without Taking Delivery

Many investors new to MBSs have concerns about back-office issues. MBSs have monthly cashflows, which typically contain both interest and principal, and the back-office systems of some investors who are new to MBSs may be designed to handle only bonds that pay interest annually or semiannually. However, we think that back-office issues should not be a major concern. There are commercial vendors who will provide settlement and clearance services for portfolio managers. In addition, many dealers have *prime broker* units, which provide back-office and other administrative services for clients.[26] It should also be noted that the growth in non-US mortgage- and asset-backed securities markets, especially in Europe and Japan, implies that non-US investors will eventually have to revamp their back-office systems to handle securitized products. In the meantime, however, *dollar rolls* provide a mechanism for investors to have long positions in MBSs without actually taking delivery.

Dollar rolls remove back-office problems, and provide a means of taking advantage of attractive financing rates.

The term "dollar roll" is used to denote a transaction in which the holder of a mortgage pass-through agrees to sell the security in one month and simultaneously agrees to buy a "substantially similar" security in a later month (usually for a lower price).[27] It is a very large market, with monthly volume typically being in the hundreds of billions of dollars. There are various reasons why dollar rolls are done. For investors, it is often a technique to achieve favorable short-term funding and to enhance returns. For dealers, the typical counterparty on the other side, dollar rolls provide a means to cover short positions. Finally, and most relevant in our context, it provides a way (through dollar rolling each month) for investors to maintain a long position in MBSs without actually taking delivery (and thus avoiding back-office problems). In this section, we provide a concise description of a dollar roll, and discuss how they can be used to maintain a long position in mortgage pass-through securities.

Anatomy of a Dollar Roll

Suppose an investor owns $1 million of Fannie Mae 6.5s, and decides to roll the securities from April to May. Key terms that are part of the transaction include:

- **Settlement Dates.** These are set in advance by the Bond Market Association (BMA), an industry trade group. Assume that the two settlement dates are April 13 and May 11.[28]

[26] Please contact your sales coverage for more information about SSB's Fixed Income Prime Broker service. See also Appendix B of our November 1999 publication, *The Mechanics of Investing in Mortgage- and Asset-Backed Securities.*

[27] See the November 1999 Salomon publication *The Mechanics of Investing in Mortgage- and Asset-Backed Securities* (hereafter, referred to as *Mechanics*) for a general discussion of dollar rolls and comparison to repurchase agreements (repos). The term substantially similar means the same agency, program, and coupon (for example, 30-year Fannie Mae 7s).

[28] See Appendix D of *Mechanics* for a discussion of BMA settlement dates.

➤ **Drop.** This is the difference between the April price, at which the investor sells the Fannie Mae 6.5s, and the May price, at which the investor agrees to buy back similar Fannie Mae 6.5s.

Suppose that on the trade date (say, April 4), TBA 30-year Fannie Mae 6.5s for April 13 settlement are priced at $99-15 and the forward price for May 11 settlement is $99-10 The drop is hence 5 ticks or 5/32nds. The investor has thus agreed to sell $1 million of Fannie Mae 6.5s on April 13 for $99-15 (or $994,687 for $1 million par) and buy back $1 million par of Fannie Mae 6.5s on May 11 for $99-10 (or $993,125 for $1 million par) — plus accrued interest in both cases.

Economics of a Dollar Roll

What does the investor get, in purely economic terms, from doing the dollar roll? The investor gives up the right to the cashflows to be paid in May (on May 25 for Fannie Maes), since these cashflows are paid to the holder of record at the end of April. In return, the investor receives the reinvestment income from the sales proceeds between the two settlement dates, plus the drop. Figure 18 compares the economics of rolling and not rolling the Fannie Mae 6.5s.

Figure 18. The Economics of a Dollar Roll

Initial position: Hold $1 Million TBA 30-yr FNMA 6.5s		
Reinvestment rate		5.00%
Projected April prepayment speed, CPR		2.0%
Age, months		2
Face Balance		1,000,000
Front month price (price for 4/13/01settlement)		99 15/32
Drop		5/32
First settlement date		April 13, 2001
Second settlement date		May 11, 2001
Date	**Roll FNMA 6.5s**	
4/13/01	Receive $1 million x (99-15) + accrued interest = $994,687 + $2,167 = Reinvest proceeds @ 5%	$996,854
5/11/01	Reinvested cash with interest = $996,854 x (1 + 5% x (28 days) / 360) =	$1,000,731
	Buy back $1 million TBA 30-yr FNMA 6.5s @ (99-10/32) with accrued interest of $1,806	($994,931)
	Net Cash Flow	$5,800
	Total value of cash and repurchased FNMA 6.5s	**$1,000,731**
	Do Not Roll (Hold $1 Million FNMA 6.5s)	
4/13/01	Value of $1 million FNMA 6.5s @ (99-15) + accrued interest =	$996,854
5/11/01	PV of coupon & principal to be paid on 5/25	$7,913
	Remaining principal after April paydown = $1,000,000 - $2,511 =	$997,489
	Total value of the portfolio = $997,489 x (99-10) + accrued interest + PV (5/25 payment) =	**$1,000,345**
5/25/01	Coupon	$5,417
	Scheduled principal payment	$831
	Prepayments at 2% CPR	$1,681
	Total payment to MBS holder	$7,928
	Roll advantage	**$386**
	Breakeven drop	**4/32**
	Breakeven reinvestment rate	**4.50%**

Source: Salomon Smith Barney.

In comparing the two alternatives of rolling or not rolling, some assumptions have to be made:

- **Prepayment Rate.** This is needed to determine the principal paydown and the remaining balance after one month. We project a prepayment speed of 2% CPR for the month.
- **Reinvestment Rate.** This is the rate at which, if the roll is done, the proceeds from selling the Fannie Mae 7s on April 13 are reinvested. We assume a reinvestment rate of one-month LIBOR, or 5%. This rate is also used to discount the cashflows from the Fannie Mae 7s (received on May 25) back to May 12, the second settlement date.

For a given reinvestment rate (and, to be precise, a given prepayment rate), the drop that makes one indifferent between rolling and not rolling is called the *breakeven drop*. Conversely, for a given drop (and assumed prepayment rate), we can calculate the *breakeven reinvestment rate.* Appendix B provides a formula for calculating breakeven drops and reinvestment rates; it essentially means solving for the value of the drop or the reinvestment rate that equates the future values of the investor's holdings from rolling and not rolling. In the example we use, for a reinvestment rate of 5%, the breakeven drop is 4 ticks, while for a drop of 5 ticks, the breakeven rate is 4.5%. In general, drops tend to be a little higher than breakeven values, to induce investors to roll their bonds. (Dealers often *need* to own the bonds at month-end, whereas investors do not have the same imperative to roll their MBSs.)

Maintaining a Long Position in MBSs Using Dollar Rolls

As indicated earlier, the dollar roll market can be used by investors who do not want to take actual delivery (for example, because of back-office limitations) to maintain a long position in MBSs. In principal, the steps are straightforward:

- Establish a long position in MBSs by buying TBAs for forward settlement;
- Before the settlement date, roll out the bonds;
- The following month, roll out the bonds again immediately after buying them back;
- Repeat each month going forward.

This position should yield a return slightly better than holding the MBSs outright, to the extent that drops are usually slightly higher than their breakeven values. If we forget this incremental extra return, then rolling the bonds gives returns equivalent to having a long position in the MBS. Perhaps more important in this context is the fact that the investor never takes delivery of the bonds and so does not have to worry about whether the back office can handle settlement and delivery.

However, there are certain complications and issues that should be considered:

- The MBSs and dollar amounts that are rolled each month would have to be rebalanced each month, reflecting changes in whatever tracking portfolio is used.

- There is no guarantee that the roll market for a specific coupon will be advantageous to the investor every month.
- The economics of a roll are dependent, among other things, on an assumed prepayment rate for the security and on an assumed reinvestment rate; the investor needs to make sure he is comfortable with these assumptions and hence with the economics of the roll.
- There is a remote chance that the dealer may experience a "fail," and be unable to deliver the securities back to the investor. However, there are onerous penalties for failing, so this may actually be beneficial for the investor. (The possibility of a fail exists with other types of transactions as well.)
- The investor cannot utilize certain active strategies to beat the index, such as buying seasoned MBSs instead of TBA MBSs.

Our recommendation would be to use dollar rolls selectively, initially as a temporary measure until back-office issues are dealt with and, subsequently, as a tool to enhance returns when rolls are very advantageous for the investor.

Appendix A — Composition of the SSB Mortgage Index

Figure 19. Composition of the SSB Mortgage Index by Issuer, Type, Coupon, and Seasoning Sector — Market-Value Weights, Apr 01

	30-Year Fannie Mae					15-Yr Fannie Mae					
Coupon	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**Total**
<6.0					0.0			0.8	<0.1	0.8	**0.8**
6.0	0.1	3.9	0.3		4.3	<0.1		1.9	0.7	2.6	**6.9**
6.5	0.5	8.1	1.8		10.3	0.1	0.4	0.7	1.1	2.3	**12.6**
7.0	1.9	5.1	2.1		9.1	0.3	0.2	<0.1	0.8	1.4	**10.5**
7.5	3.2	2.4	1.2		6.8	0.3	<0.1		0.4	0.7	**7.6**
8.0	1.7	0.6	0.7		3.0	<0.1			<0.1	0.2	**3.2**
8.5	0.4	<0.1	0.3	<0.1	0.8					0.0	**0.8**
9.0	<0.1		0.1	<0.1	0.2					0.0	**0.2**
Total	**7.8**	**20.2**	**6.5**	**0.1**	**34.6**	**0.8**	**0.6**	**3.5**	**3.1**	**8.0**	**42.6**

	30-Year Freddie Mac					15-Yr Freddie Mac					
Coupon	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**Total**
<6.0					0.0			0.5	<0.1	0.6	**0.5**
6.0	<0.1	3.5	0.2		3.9	<0.1		1.7	0.6	2.3	**6.2**
6.5	0.3	6.7	1.6		8.7	0.1	0.4	0.7	1.0	2.1	**10.9**
7.0	1.4	3.9	1.7		7.0	0.2	0.2	0.2	0.8	1.3	**8.4**
7.5	2.2	1.8	1.0		5.0	0.2	<0.1		0.3	0.6	**5.6**
8.0	1.2	0.6	0.5		2.2					0.0	**2.2**
8.5	0.3	<0.1	0.2		0.5					0.0	**0.5**
9.0					0.0					0.0	**0.0**
Total	**5.5**	**16.6**	**5.2**	**0.0**	**27.3**	**0.5**	**0.6**	**3.1**	**2.8**	**7.0**	**34.3**

	30-Year Ginnie Mae					15-Yr Ginnie Mae					
Coupon	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**New**	**Moderate**	**Seasoned**	**Super**	**Total**	**Total**
<6.0					0.0					0.0	**0.0**
6.0		1.4	0.1		1.5					0.0	**1.5**
6.5	<0.1	4.1	0.9		5.1		<0.1	<0.1	0.1	0.2	**5.2**
7.0	0.6	3.6	2.0		6.2					0.0	**6.2**
7.5	1.5	2.5	1.2	<0.1	5.2					0.0	**5.2**
8.0	1.6	1.2	0.7	0.2	3.7					0.0	**3.7**
8.5	0.4	0.1	0.2	<0.1	0.8					0.0	**0.8**
9.0	<0.1		<0.1	0.3	0.5					0.0	**0.5**
Total	**4.2**	**12.9**	**5.1**	**0.6**	**22.9**	**0.0**	**<0.1**	**<0.1**	**0.1**	**0.2**	**23.1**
Total	**17.5**	**49.7**	**16.8**	**0.7**	**84.7**	**1.3**	**1.3**	**6.6**	**6.0**	**15.3**	**100.0**

Source: Salomon Smith Barney.

Figure 20. SSB Mortgage Index Seasoning Category Definitions, Apr 01

Seasoning Category	30-Year MBSs	15-Year MBSs
New	Loan Age < 1.5 Years	Loan Age < 1 Year
Moderately Seasoned	1.5 Years ≤ Loan Age < 5 Years	1 Year ≤ Loan Age < 2 Years
Seasoned	5 Years ≤ Loan Age < 10 Years	2 Years ≤ Loan Age < 3 Years
Super Seasoned	Loan Age ≥ 10 Years	Loan Age ≥ 3 Years

Source: Salomon Smith Barney.

Appendix B — Dollar Roll Calculations

Definitions of Terms

Note: Roll period is assumed to be one month

BAL_0 = Original balance at beginning of roll period.

AI_0 = Accrued interest for sale at beginning of roll period.

P_0 = MBS price for settlement at beginning of roll period.

BAL_1 = Balance at end of roll period.

AI_1 = Accrued interest for repurchase at end of roll period (i.e., next month's settlement).

P_1 = MBS price for settlement at end of roll period = P_0 – DROP

r = Reinvestment/funding rate

CF = Interest and principal cash flow associated with the month in which the roll is initiated.

N = Number of days from list settlement date at beginning of roll period to second settlement date at end of roll period.

N_1 = Number of days from second settlement date to date on which cash flow (CF) is paid.

In dollar terms, the gain to the investor for doing the roll compared to not doing the roll, i.e., the value of the roll (V), can be expressed as:

$$\text{Value of Roll} = \begin{bmatrix}\text{Future value of}\\ \text{roll proceeds at}\\ \text{end of roll period}\end{bmatrix} - \begin{bmatrix}\text{Buy - and - hold}\\ \text{MBS value}\\ \text{at end of roll}\\ \text{period}\end{bmatrix} + \begin{bmatrix}\text{Value at end of roll}\\ \text{period of MBS}\\ \text{cash flow earned}\\ \text{during roll period}\end{bmatrix}$$

Or, in mathematical terms:

$$V = BAL_0 * (P_0 + AI_0) * \left(1 + \frac{N * r}{360}\right) - \left[BAL_1 * (P_1 + AI_1) + \frac{CF}{\left(1 + \frac{N_1 * r}{360}\right)}\right]$$

Note that the first term is the terminal value of the portfolio if the dollar roll is done, while the term inside the brackets is the corresponding value should the investor hold the security (using the forward price in both cases).

For a given drop, the value of r that leads to a zero gain (i.e., V=0) is the implied (or breakeven) financing rate. Similarly, for a given r, the value of the drop that leads to a zero gain is the breakeven drop.

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