MBS Index Returns: A Detailed Look

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Lehman Brothers produces and publishes a family of rules-based indexes that cover a broad universe of fixed-income securities. Producing any index involves four basic steps. First, the set of securities that will compose the index at any given time is identified according to a fixed set of rules. All securities in the index are then priced using an appropriate combination of trader quotes and matrix pricing techniques. Returns of all securities in the index are computed using beginning and end-of-period prices as well as interim cash flows. Finally, the index return is calculated as a market-weighted average of individual security returns.

Although the same basic methodology is used in the production of all indexes, the specific trading practices and conventions prevalent in each market need to be reflected in the calculation of index returns. In the case of U.S. mortgage-backed securities (MBS), a number of issues pose challenges at each step in the process.

The decentralized origination of mortgage debt leads to an unmanageably large number of investable securities or "pools." To build an index, groups of similar pools are therefore combined to form a more manageable set of "generic" aggregates. This aggregation, while solving the problems caused by a large number of securities, raises the related issue of how to price this securities universe, since obtaining daily quotes even for every generic (let alone every pool) is not realistic. Computing returns for mortgage-backed securities is also complicated by such unique characteristics of the mortgage market as once-a-month settlement, payment delays, and delayed reporting of pool factors. The task is further complicated by the staggered settlement dates and factor reporting dates throughout the month for different classes of MBS.

To deal with these issues, Lehman Brothers has developed a set of conventions that lead to a well-behaved index, with meaningful index returns and statistics, and facilitates combining MBS securities with government and corporate bonds into aggregate indexes. The conventions and assumptions used in computing MBS index prices and returns are explained in this report. Mathematical calculations are provided in the appendix.

To calculate returns on mortgage portfolios, investors face all these intricacies and more. Various portfolio accounting systems have their own ways of dealing with the special characteristics of MBS securities. These different conventions can make comparing portfolio and index returns difficult. The final section of this report focuses on issues specific to portfolio returns, with the goal of helping investors to understand their portfolios' performance against our MBS index.

I. AGGREGATING POOLS INTO MBS GENERICS

More than half a million mortgage pools exist in the United States, making this universe so big that creating a pool-based index is not feasible. The investment characteristics of fixed-rate mortgage pools are relatively homogeneous along such dimensions as issuer, program, coupon, and loan origination year. In addition, MBS market participants view most mortgage pools belonging to categories defined along these dimensions as fungible. As a result, an index based on such aggregates would adequately represent the mortgage market.

Using aggregates in the index is possible because most mortgage pass-throughs trade on a generic basis. Investors typically place orders to buy and sell "Ginnie Mae thirty-year 7s of 1996" or "Fannie Mae fifteen-year 6s of 1997" without specifying actual pools.

To create generic aggregates, pools are grouped along the three most important dimensions: agency/program (sector), coupon, and origination year. This creates a universe of approximately 3,200 generics, or annual aggregates.[1] These generics are then treated as individual securities for purposes of pricing and computing returns and statistics. The amount outstanding for each generic is set to the sum of the included pools; statistics such as weighted-average maturity (WAM) and weighted-average coupon (WAC) are market-weighted averages of the individual pool data. The Lehman Brothers MBS index is then built from the mortgage generics using the same rules-based criteria as all other Lehman indexes.[2]

Each generic must have a total outstanding balance of at least $100 million and a remaining term of at least twelve months to be included in the MBS index. Certain less-liquid sectors, such as GNMA manufactured housing, buy-down, and graduated payment mortgages, are excluded. Exhibit 1 lists MBS sectors and indicates whether they are currently included in the MBS index.

Within each sector, pools are grouped first by pool coupon in increments of 0.250%. Thus the maximum pool coupon variation within each generic is limited to ±0.125% around the generic's coupon. Each

EXHIBIT 1
Index Participation of MBS Sectors

Sector Code	Cusip Code	Sector Description	In the Index
Gna	GNA	GNMA I Single-Family 30-year	Yes
GNb	GNB	GNMA II Single-Family 30-year	Yes
GNc	GNC	GNMA Buydown 30-year	No
GNd	GND	GNMA I Graduated Payment 30-year	No
GNe	GNE	GNMA II Graduated Payment 30-year	No
GNf	GNF	GNMA I Single-Family "Midget" 15-year	Yes
GNg	GNG	GNMA II Single-Family "Midget" 15-year	No*
GNh	GNH	GNMA Manufactured Home Class B 15-year	No
FHa	FHA	FHLM Cash Single-Family 30-year	Yes
FHb	FHB/FGB (gold)	FHLM Guarantor and Gold Single-Family 30-year	Yes
FHc	FHC/FGC (gold)	FHLM Guarantor and Gold FHA/VA 30-year	No*
FHd	FHD/FGD (gold)	FHLM Guarantor and Gold Single-Family 15-year	Yes
FHe	FHE	FHLM Cash Single-Family 15-year	Yes
FHf	FGF	FHLM 5-year Balloon	Yes
FHg	FGG	FHLM 7-year Balloon	Yes
FNa	FNA	FNMA Conventional Long-Term 30-year	Yes
FNb	FNB	FNMA Government Long-Term 30-year	Yes
FNc	FNC	FNMA Conventional Intermediate 15-year	Yes
FNd	FND	FNMA 7-year Balloon	Yes

*These sectors are not explicitly excluded from index participation, but there are currently no generics in these sectors with outstanding balances above the $100 million index threshold.

coupon group is then segregated by origination year.

A pool is mapped to an origination year based on the weighted-average origination year of the underlying loans, not the year the loans were securitized to create the pool. This approach creates generics that are more homogeneous in prepayment characteristics, which depend on the underlying mortgages. It is especially important for relatively new pools composed of seasoned loans.

The resulting aggregates are then assigned eight-character identifiers called "generic cusips." The naming convention reflects the three dimensions along which pools are aggregated. The first three letters represent sector (see "Cusip Code" column in Exhibit 1). The three digits following represent coupon: The first two show the whole part of the coupon; the third digit shows the number of eighths and may be 0, 2, 4, or 6. Finally, the last two digits of the eight-character cusip show the origination year. Thus, FNC07497 denotes a fifteen-year Fannie Mae with a coupon of 7.5% issued in 1997.

Exhibit 2 shows the current composition of the most liquid generic in each sector of the MBS index. The table highlights the vast differences in liquidity among sectors of the mortgage market. A single generic may be composed of several thousand pools in the most liquid sectors or a handful in the least liquid.

The pools that compose a given generic may also exhibit significant diversity due to demographic, geographic, and other effects. For example, the average pool factor (fraction of original pool balance outstanding) for FNMA 7s of 1993 (FNA07093) is 0.698, but the standard deviation is 0.111, indicating that the factor for a given pool from this group could easily be below 0.6 or above 0.8.

For purposes of computing returns and other analytics, each pool is mapped onto a generic security to which it contributes its outstanding balance. The mapping of a particular pool to a generic may occasionally change over time.

This is because every pool is backed by a large number of individual mortgage loans. While these loans will typically be fairly homogeneous, their origination dates are not necessarily all in the same calendar year. As the underlying loans prepay, each at its own rate, the average origination date for a given pool may migrate from one year to another. Pool mappings are recalculated each month according to the weighted-average loan age (WALA) reported for each pool by the agencies.[3]

For example, an FHLM pool of fifteen-year single-family loans issued in March 1998 with a WALA of five months will be put into a generic with a 1997 origination year. By December 1999, though, uneven prepayments might bring the WALA of this pool to twenty-two, in which case the pool would be mapped into

EXHIBIT 2

Most Liquid Generics in Each Sector of the MBS Index, May 1998

Code	Cusip	Sector Description	Outstanding ($ million)	Number of Pools	Factors	
					Avg.	St. Dev.
FNA	FNA07093	FNMA Conventional Long-Term 30-year	36,315	9369	0.698	0.111
FGB	FGB07097	FHLM Gold Single-Family 30-year	30,595	2586	0.951	0.053
GNA	GNA07093	GNMA I Single-Family 30-year	27,696	6830	0.704	0.095
FNC	FNC06493	FNMA Conventional Intermediate 15-year	16,578	5843	0.568	0.095
FGD	FGD06493	FHLM Gold Single-Family 15-year	14,022	4368	0.558	0.098
GNB	GNB07097	GNMA II Single-Family 30-year	7,055	117	0.984	0.023
GNF	GNF06493	GNMA I Single-Family 15-year	3,031	1786	0.561	0.080
FND	FND07096	FNMA 7-year Balloon	3,024	731	0.734	0.130
FGG	FGG06093	FHLM 7-year Balloon	1,751	688	0.531	0.143
FHB	FHB08487	FHLM Guarantor Single-Family 30-year	1,015	4596	0.119	0.076
FGF	FGF06496	FHLM 5-years Balloon	689	299	0.752	0.123
FHA	FHA09489	FHLM Cash Single-Family 30-year	346	15	0.073	0.012
FNB	FNB08076	FNMA Government Long-Term 30-year	268	29	0.361	0.235
FHD	FHD08087	FHLM Guarantor Single-Family 15-year	222	1867	0.079	0.041
FHE	FHE08486	FHLM Cash Single-Family 15-year	133	19	0.040	0.031

1998 origination. The WAC of a pool might similarly drift over time, but would never cause a change in pool mapping since pools are mapped based on the pass-through (pool) coupon, which is set when the pool is created and never changes.

All three agencies have programs for the secondary aggregation of existing pools: platinum pools (Ginnie Mae), giant pools (Freddie Mac), and mega pools (Fannie Mae). These programs allow holders of multiple pools with small remaining balances to consolidate their holdings. Swapping many small and illiquid pools for one large pool improves liquidity, simplifies back-office operations, and reduces custodial costs. All the underlying pools are already part of generics, so these "pools of pools" do not participate in the creation of aggregates and are not included in the index in order to prevent double counting.

II. PRICING MBS GENERICS

Collecting Quotes and Matrix Pricing

The Lehman Brothers mortgage trading desk selectively quotes prices for to-be-announced (TBA) issues and price spreads over TBA for seasoned issues.[4] Quotes are provided for the most-liquid sectors and origination years within them on a per coupon basis. For non-quoted issues, mapping procedures have been established and are reviewed periodically to reflect the current trading patterns of particular mortgage sectors, coupons, or seasoning categories.

As shown in Exhibit 3, four levels of detail are used in quoting MBS prices. For the most-liquid sectors (GNMA I thirty-year, FNMA thirty- and fifteen-year), the trading desk provides both TBA prices and explicit spread-over-TBA price quotes for certain origination years within the sectors. At the next level (GNMA II thirty-year, FHML Gold thirty- and fifteen-year), only TBA prices are quoted directly; the price spreads of the three most-liquid sectors are used for seasoned issues. Pass-throughs with long payment delays (FHML Cash and Guarantor thirty- and fifteen-year) are priced at a fixed spread below the prices of similar issues in conventional sectors. The illiquid FNMA Government (FHA/VA) thirty-year sector is wholly matrix priced. Finally, all FNMA and FHMLC balloons and GNMA I

EXHIBIT 3
Types of MBS Price Quotations

Code	Sector	TBA	Seasoned
Quoted TBA Prices and Selectively Quoted over-TBA Spreads for Seasoned Issues			
GNA	GNMA I Single-Family 30-year	Quoted	Quoted/mapped spreads
FNA	FNMA Conventional Long-Term 30-year	Quoted	Quoted/mapped spreads
FNC	FNMA Conventional Intermediate 15-year	Quoted	Quoted/mapped spreads
Quoted TBA Prices and Comparable Sectors over-TBA Spreads for Seasoned Issues			
GNB	GNMA II Single-Family 30-year	Quoted	GNA over-TBA spreads
FGB	FHLM Gold Single-Family 30-year	Quoted	FNA over-TBA spreads
FGD	FHLM Gold Single-Family 15-year	Quoted	FNC over-TBA spreads
Freddie Mac Non-Gold			
FHA	FHLM Cash Single-Family 30-year	N/A	FNA price minus 16/32
FHB	FHLM Guarantor Single-Family 30-year	N/A	FNA price minus 16/32
FHD	FHLM Guarantor Single-Family 15-year	N/A	FNC price minus 16/32
FHE	FHLM Cash Single-Family 15-year	N/A	FNC price minus 16/32
Single Price Quoted for TBA and Seasoned Issues			
GNF	GNMA I Single-Family 15-year	Quoted	
FND	FNMA 7-year Balloon	Quoted	
FGF	FHLM 5-year Balloon	Quoted	
FGG	FHLM 7-year Balloon	Quoted	

fifteen-years use the TBA price quotes for all origination years.

The set of origination years for which over-TBA price spreads are provided is chosen separately for each sector and coupon level to best represent the way the market trades. Typically, the years for which spreads are quoted for a particular coupon will correspond to those years in which it experienced significant issuance. Origination years that are not quoted directly in one way or another are normally mapped to the nearest-quoted later year.

Exhibit 4 illustrates how this mapping approach is used to price all 8% FNMA thirty-year conventional single-family pass-throughs from a set of quotes for selected origination years (shown in bold).

Adjusting Quotes to Obtain Index Prices

Once a price quote is obtained for a generic MBS, it must be adjusted for the difference between index and market settlement conventions. A single standard settlement day each month is designated by the Bond Market Association (formerly Public Securities Association, or PSA) for each sector of the MBS market. Quoted prices for MBS generics are always for this standard PSA settlement. The MBS index, however, uses a same-day settlement convention to reflect the current market value of securities held by the index.[5]

The discrepancy between the settlement convention used for quotes and for pricing the index necessitates price adjustments of two types. First, a pure adjustment of forward prices to spot prices reflects the cost of carry. More important, when the index and PSA settlement dates are in different months, the index price includes one more payment of principal and interest.

To illustrate, we calculate the index price for FHLM fifteen-year 7s of 1997 (FGD07097) on April 3, 1998. As shown in Exhibit 5, the April PSA settlement date for this sector was the sixteenth. The quoted price for PSA settlement as of the third was 102.19 (Exhibit 6). With accrued interest of 0.29 as of the sixteenth, the settlement payment based on this quote would be 102.48. The present value of this payment as of the third (discounting by a GNMA repo rate standard for all pass-throughs in the index) is 102.27. The index price for immediate settlement on the third is backed out by subtracting the accrued interest of 0.04 from this present value and equals 102.23. The exact formula is shown in Case I in the appendix.

In this example, calculation of the index price adjusts the PSA settlement quote for the cost of carry until settlement. This is sufficient because a purchase that settles on April 3 will entitle the buyer to the identical set of cash flows as a purchase that settles on April 16, since each monthly cash flow belongs to the owner of record at the end of the month.

The situation at or near the end of the month is different. The trader quote on April 24 is for May PSA settlement. Such a purchase will entitle the buyer to receive cash flows from this security starting in June. A purchase for immediate settlement (or an existing position) would entitle the owner to an additional payment of principal and interest in May, however.

In this case, the index settlement price is backed out to match the sum of the present values of the two quantities following. The first principal and interest cash flow (which would be received in May) is discounted from the payment date back to the present. The position remaining after this paydown is valued by discounting the quoted price and the appropriate accrued interest from the PSA settlement date back to the present.

This calculation is complicated by the May cash

EXHIBIT 4
Thirty-Year Single-Family FNMA 8% as of April 22, 1998

Origination Year	PSA Settlement Price	Spread over TBA (32nds)	Outstanding Market Value ($ million)
1997	**103.500**	**0**	**6,154**
1996	103.500	0	11,544
1995	103.500	0	6,918
1994	**103.531**	**1**	**7,146**
1993	**104.063**	**18**	**2,707**
1992	**104.188**	**22**	**14,703**
1991	104.188	22	4,022
1990	104.188	22	468
1989	104.188	22	207
1988	104.188	22	168
1987	**104.375**	**28**	**708**
1986	104.375	28	399
1977	**104.625**	**36**	**174**
1976	104.625	36	235
1975	104.625	36	160
1974	104.625	36	156

EXHIBIT 5

Fifteen-Year MBS (PSA Class B), April 1998

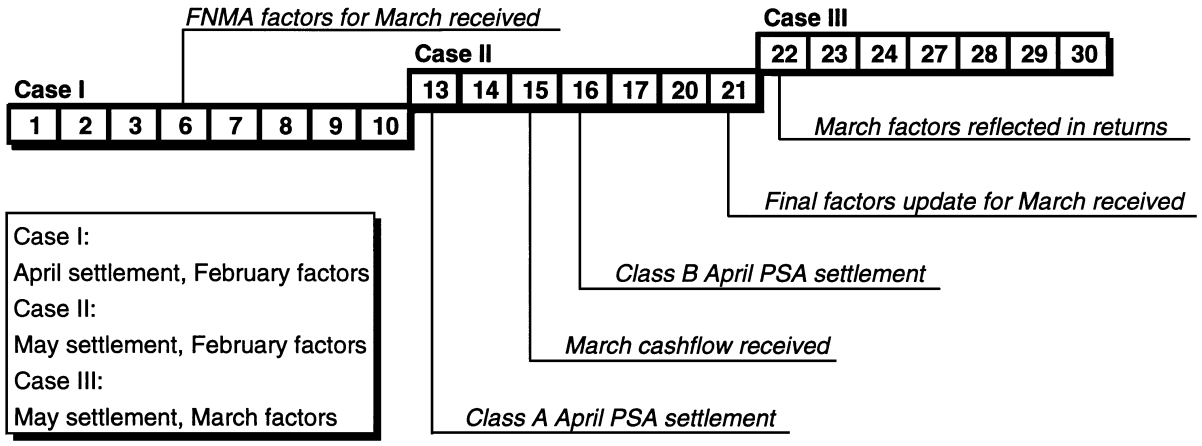


EXHIBIT 6

Fifteen-Year Single-Family FHLM Gold 7s of 1997, April 1998

MBS Index Settlement			PSA Settlement					MTD Returns (%)		
Date	Price	Accrued	Date	Price	PSA	SMM	Price	Coupon	Paydown	Total
03/31/98	101.77	0.58	04/16/98	101.78	1,183	1.976	-0.054	0.558	-0.0368	0.467
04/01/98	101.93	0.00	04/16/98	101.88	1,183	1.976	0.146	-0.001*	-0.0446	0.101
04/02/98	102.05	0.02	04/16/98	102.00	1,183	1.976	0.262	0.018	-0.0442	0.235
04/03/98	102.23	0.04	04/16/98	102.19	1,183	1.976	0.437	0.036	-0.0439	0.430
04/06/98	102.10	0.10	04/16/98	102.06	1,183	1.976	0.309	0.092	-0.0428	0.358
04/07/98	102.03	0.12	04/16/98	102.00	1,183	1.976	0.246	0.111	-0.0424	0.314
04/08/98	101.96	0.14	04/16/98	101.94	1,183	1.976	0.183	0.129	-0.0421	0.271
04/09/98	101.93	0.16	04/16/98	101.91	1,183	1.976	0.150	0.148	-0.0417	0.257
04/13/98	101.73	0.23	05/18/98	101.66	1,183	1.976	-0.042	0.223	-0.0403	0.141
04/14/98	101.82	0.25	05/18/98	101.75	1,183	1.976	0.042	0.241	-0.0399	0.244
04/15/98	101.90	0.27	05/18/98	101.84	1,183	1.976	0.126	0.260	-0.0399	0.346
04/16/98	101.99	0.29	05/18/98	101.94	1,183	1.976	0.210	0.278	-0.0399	0.448
04/17/98	102.02	0.31	05/18/98	101.97	1,183	1.976	0.236	0.297	-0.0399	0.493
04/20/98	101.92	0.37	05/18/98	101.88	1,183	1.976	0.139	0.353	-0.0399	0.452
04/21/98	101.85	0.39	05/18/98	101.81	1,183	1.976	0.078	0.371	-0.0399	0.409
04/22/98	101.85	0.41	05/18/98	101.81	1,104	1.829	0.078	0.390	-0.0374	0.431
04/23/98	101.85	0.43	05/18/98	101.81	1,104	1.829	0.074	0.409	-0.0374	0.446
04/24/98	101.88	0.45	05/18/98	101.84	1,104	1.829	0.100	0.428	-0.0374	0.490
04/27/98	101.62	0.51	05/18/98	101.59	1,104	1.829	-0.142	0.483	-0.0374	0.304
04/28/98	101.62	0.53	05/18/98	101.59	1,104	1.829	-0.146	0.502	-0.0374	0.319
04/29/98	101.65	0.54	05/18/98	101.63	1,104	1.829	-0.120	0.520	-0.0374	0.364
04/30/98	101.99	0.58	05/18/98	102.00	1,104	1.829	0.208	0.558	-0.0374	0.729

*See Case I in the appendix for an explanation of the small negative coupon return on the first day of the month.

flow, which is the subject of this adjustment and is not yet known. Rather than projecting it using a proprietary (and subjective) prepayment model, we use the simple approximation that next month's single monthly mortality (SMM), or percentage of outstanding prepaid, will be equal to the most recently observed one. The formulas are given in Cases II and III in the appendix. In Case II, we project the SMM for the May prepayment based on February, while in Case III we use the March SMM.

While all events that affect the MBS index are essentially monthly in nature, they occur throughout the month. The PSA subdivides the market into five classes of MBS securities, A through E, with a distinct settlement date for each. Similarly, the agencies issue monthly pool factor reports on different days for different types of pass-throughs. There may also be one or more updates following the initial factor release.

To simplify index calculations, our convention is to address each of these monthly events simultaneously for all securities in the index. Thus, all securities in the index switch to their respective next month PSA settlement dates as soon as the earliest class (Class A) switches. As a result, the month of PSA settlement is always the same for all securities in the index.

Similarly, pool factor updates are not applied to the index data base in a piecemeal fashion as they come in. Instead, factors are updated all at once after the last factor update is received. Currently, the last factor update for the previous month is received on the fifteenth business day of each month. Starting on the next business day, the SMM computed from the previous month's factors begins to serve as the estimate for the current month's prepayment.

This convention ensures that all securities progress through the same sequence of calculations in the course of a month, regardless of their individual characteristics. Exhibit 5 helps to clarify this process. For the fifteen-year FNMA shown, the Case I calculation (based on a quote for April settlement) could have been applied until the Class B settlement date of April 16. Starting on the thirteenth of the month (the Class A settlement date), however, the entire index is quoted for May settlement. Similarly, the switch from Case II (based on February factors) to Case III (March factors) is delayed from the sixth, when factors were received for this particular security, until the twenty-second, when all index pool factors are updated.

III. COMPUTING RETURNS

Returns on Individual Generics

Because mortgage pass-throughs are amortizing securities, their realized return always consists of two parts — the return on the portion of the initial investment that is still in securitized form, and the return on the portion paid out as cash. Thus, all return calculations will be affected by the remaining balance and paid-down amount numbers, which in turn depend on the current month prepayment estimate.

Advancement into a month determines which month's prepayment is used as an estimate in computing month-to-date returns. Exhibit 6 traces month-to-date returns for a particular Freddie Mac pass-through. At the beginning of April, the March factors are not yet available for some securities in the index, so the February prepayment (PSA of 1,183 for this particular pass-through) is used as an estimate for all securities in the index. When on the sixteenth business day (April 22, 1998), the factors are updated for the index, March prepayment (PSA of 1,104 for this security) begins to serve as an estimate in calculating month-to-date returns.

These switches in prepayment estimates may lead to discontinuities in the daily sequence of month-to-date returns. If prepayments change little from one month to the next, the effect is negligible. When there is a significant change in prepayments, this discontinuity can become noticeable (particularly in the paydown return). Investors who closely monitor month-to-date returns need to be aware of this potential discontinuity. Note in Exhibit 6 that on April 22 there was a small jump in paydown return.

The coupon return calculation for the MBS index reflects the 30/360 day count convention, and makes monthly coupon flows independent of the actual number of days in a particular month. In the end-of-month return calculation, accrued interest is brought up to the full monthly coupon (thirty days accrual), regardless of the actual number of days in the month. For end-of-month calculations, the MBS index is assumed always to settle on the last day of the month, whether it is a business day or not.

So, if the last business day happens to be the twenty-seventh, the accrued interest on that day will jump from twenty-six days worth up to the full monthly coupon. For an 8% pass-through, for example, the accrued interest will go from $8 \times 26/360$ (+0.578%)

directly to 8 × 30/360 (+0.667%) instead of to 8 × 27/360 (+0.600%).

All Lehman Brothers indexes assume no reinvestment. In calculations of month-to-date coupon and paydown returns for the MBS index, this assumption introduces an asymmetry. When the index settlement date is before the cash flow payment date (1 + agency delay), the value of the future cash flow is discounted. But after the payment date, the cash flow already received is not reinvested forward.

This effect can be seen in Exhibit 6. Up to the cash flow payment date (through April fourteenth), the paydown return increases as the coming payment is discounted over fewer days (see the formulas in the appendix). From that day on, it stays constant (except for the one jump due to the prepayment estimate switch on the twenty-second).

Both interest and principal components of the received cash flow contribute to the paydown return, while coupon return is based on only the surviving portion. Because the beginning or "base" value for all return calculations is the last day of the previous month, on the very first day of the current month the mortgage security "sheds" one cash flow. Thus, the full paydown return for the month is realized on the first day of the month (Exhibit 6).

Exhibit 7 traces the daily sequence of MBS index returns for April 1998. Alongside the month-to-date returns, we show daily returns that highlight the conventions described above.[6] As the table shows, the same return patterns explained for an individual generic are also evident at the index level.

Aggregating the Generics' Returns into the Index Return

Returns on the MBS index are computed as market value weighted-averages of the individual generics' returns. As a result, index returns are determined not only by the price changes but also by the index composition. While this is true for all Lehman Brothers indexes, the effect is more pronounced for the MBS index due

EXHIBIT 7
Daily MBS Index Returns for April 1998

	MTD Returns (%)				Daily Returns (%)			
Date	**Price**	**Coupon**	**Paydown**	**Total**	**Price**	**Coupon**	**Paydown**	**Total**
03/31/98	**-0.094**	**0.581**	**-0.064**	**0.423**				
04/01/98	0.208	-0.002	-0.068	0.138	0.208	-0.002	-0.068	0.138
04/02/98	0.343	0.018	-0.068	0.293	0.135	0.019	0.000	0.154
04/03/98	0.506	0.037	-0.067	0.476	0.163	0.019	0.000	0.183
04/06/98	0.366	0.096	-0.066	0.395	-0.140	0.058	0.001	-0.081
04/07/98	0.348	0.115	-0.066	0.397	-0.018	0.019	0.000	0.002
04/08/98	0.258	0.134	-0.066	0.327	-0.090	0.019	0.000	-0.070
04/09/98	0.251	0.154	-0.065	0.340	-0.007	0.019	0.000	0.013
04/13/98	0.006	0.232	-0.064	0.173	-0.246	0.078	0.001	-0.167
04/14/98	0.121	0.251	-0.064	0.308	0.115	0.019	0.000	0.135
04/15/98	0.205	0.270	-0.063	0.412	0.084	0.019	0.000	0.103
04/16/98	0.262	0.290	-0.063	0.489	0.058	0.019	0.000	0.077
04/17/98	0.257	0.309	-0.063	0.504	-0.005	0.019	0.000	0.015
04/20/98	0.138	0.367	-0.063	0.443	-0.119	0.058	0.000	-0.060
04/21/98	0.050	0.387	-0.062	0.374	-0.089	0.019	0.000	-0.069
04/22/98	0.045	0.404	-0.078	0.371	-0.005	0.017	-0.016	-0.003
04/23/98	0.041	0.423	-0.078	0.386	-0.004	0.019	0.000	0.016
04/24/98	0.058	0.443	-0.078	0.423	0.017	0.019	0.000	0.037
04/27/98	-0.243	0.500	-0.078	0.180	-0.301	0.058	0.000	-0.244
04/28/98	-0.245	0.520	-0.078	0.197	-0.002	0.019	0.000	0.017
04/29/98	-0.251	0.539	-0.078	0.210	-0.007	0.019	0.000	0.013
04/30/98	**0.068**	**0.577**	**-0.078**	**0.567**	0.319	0.038	0.000	0.357

to mortgage prepayments and new issuance.

As Exhibit 8 shows, the relative weight of a particular generic may change significantly in the course of a single year. Because higher coupons prepay quickly and most new issuance is at market level, the MBS index composition tends to gravitate toward current coupon. This effect is illustrated in Exhibit 9. The MBS index price tends to stay closer to par than do those of the Lehman Brothers Treasury or Corporate indexes, as the MBS weighted-average coupon follows the market yield more closely.

IV. MANAGING PORTFOLIOS AGAINST THE MBS INDEX

It is important to understand how and why MBS portfolio return calculations differ from those in the MBS index. An index measures value and changes in value of a particular market. There is no ownership of the component securities in an index (i.e., no buying and selling). Ownership is a critical factor, however, in the context of portfolio performance measurement, especially in the MBS sector. Portfolios that are benchmarked against an index are generally actively traded and are typically marked to market on a daily basis. Changes in these daily valuations are the basis of performance measurement.

We describe a few of the more significant ways in which performance measurement for an actively traded MBS portfolio differs from the Lehman Brothers MBS index return methodology. The list is not exhaustive in that it does not include some common trading practices such as dollar rolls, short positions, and hedging, but issues that are of concern to most portfolio managers are discussed here:

- Pools versus aggregates.
- Delivery variance.
- Income accrual.
- Reinvestment.
- Transactions.
- Profit and loss versus total return.

Pools versus Aggregates

The Lehman Brothers MBS index consists of a set of generic securities derived from the universe of agency-backed pools. These generics have to satisfy the rules for index inclusion. Using aggregates rather than pools makes the task of producing an index feasible, but using aggregates as proxies for pools in a portfolio provides only approximations of actual performance.

From month to month, the set of pools that maps to a particular aggregate can change. This may be due to slight changes in average origination year of the loans underlying a pool, causing some pools to drift to an aggregate with an adjacent origination year. It may also be due to new issuance during the course of the year, adding new pools to a particular aggregate. In this case,

EXHIBIT 8
Changes in Relative Weights of Selected Generics in the MBS Index

Date	MBS Index MV ($ bil.)	FNMA Convent. 30-year 8 of 1992 MV ($ bil.)	FNMA Convent. 30-year 8 of 1992 % Index MV	FNMA Convent. 30-year 7 of 1997 MV ($ bil.)	FNMA Convent. 30-year 7 of 1997 % Index MV
1/31/97	1,401.2	19.4	1.38	NA	NA
2/28/97	1,405.3	19.2	1.37	0.5	0.04
3/31/97	1,394.4	18.8	1.35	2.5	0.18
4/30/97	1,411.7	18.8	1.33	4.0	0.28
5/31/97	1,421.1	18.7	1.31	5.5	0.39
6/30/97	1,432.6	18.6	1.30	6.7	0.47
7/31/97	1,456.5	18.5	1.27	7.5	0.51
8/31/97	1,446.4	18.2	1.26	8.3	0.57
9/30/97	1,463.8	18.1	1.24	11.2	0.76
10/31/97	1,482.8	17.9	1.21	14.8	1.00
11/30/97	1,489.1	17.7	1.19	19.4	1.31
12/31/97	1,504.2	17.3	1.15	24.5	1.63
1/31/98	1,521.4	17.1	1.12	29.2	1.92
2/28/98	1,527.1	16.8	1.10	33.0	2.16
3/31/98	1,523.3	16.2	1.06	35.0	2.29
4/30/98	1,529.3	15.4	1.01	35.4	2.32

EXHIBIT 9
Price Deviation from Par for the MBS, Treasury, and Corporate Indexes, 1989-1997

	MBS	Treasury	Corporate
Average of absolute deviations of index price from par	2.72	6.23	3.80
Average of absolute values of differences between coupon and yield	0.64	1.24	0.79

an aggregate may actually grow in size from one month to the next. Therefore, it is possible that over time the particular aggregate to which a pool is mapped may no longer closely approximate the pool's characteristics.

Also, cash flows for any pool and its associated aggregate will differ. Cash flows for pools are defined by the behavior of the underlying loans. Coupons and scheduled principal are based on standard mortgage formulas, and all prepayments are passed through to the investor. Since the composition of an aggregate can change, and in particular can actually grow in size, using the cash flows of the constituent pools could result in patterns that do not make sense, such as negative amortization. Therefore, cash flows for aggregates for a given performance period are calculated based on the average WAM and prepayment rate (CPR%) of the constituent pools for that month (and *not* aggregated from the underlying pools).

Furthermore, cash flows may differ because any pool or pools in a portfolio that map to a particular aggregate are likely to be a small subset of all the pools that make up the aggregate. By definition, this subset will have a similar indicative profile (i.e., similar WAC, WAM, and WALA), but it may have a different demographic profile.

For example, the subset of pools in a portfolio may be concentrated in a small geographic area, while the pools that compose the aggregate are more geographically diverse. Demographics can play a large part in how mortgages prepay.

Delivery Variance

When pass-throughs are traded on a TBA or generic basis, the exact pools and amounts that will be delivered are not known until two days before settlement. According to current PSA requirements, good delivery can be within 1% of the original face value of the TBA trade. This aspect of the pass-through market is well understood by most participants, and traders use their delivery option to take advantage of price movements.

For example, if a trade is made at a price of 102, but the same bond is trading at 103 when the delivery is specified, a trader will seek to deliver the minimum amount allowed. Alternatively, if the price of the bond is lower when the delivery is specified than it was on the trade date, the trader will try to deliver the maximum. Similarly, a good back office takes advantage of the option to deliver the worst-performing pools (such as fast-prepaying premium-coupon securities) and keep the best (such as slow-prepaying discounts) as long as they constitute good delivery.

When mortgage pools are purchased for a portfolio in this fashion, the exact amount to be marked to market remains unknown until the allocation date two days before settlement. An estimate must then be used to calculate performance until the delivery amount is known. After delivery, calculations are done on the actual amount.

This kind of estimation is not required in the MBS index because all amounts are known and fixed for the period of performance measurement.

Income Accrual

In the MBS market, trades settle once a month according to the PSA schedule for the various classes of agency/coupons, typically around the middle of the month. Buying a mortgage pass-through results in immediate exposure of the portfolio to price risk, but there is no interest accrual until the trade settles. Between the trade date and the settlement date, the position is considered pending. After the settlement date, the position becomes an outright holding. Once an outright holding is sold, there is no more price risk associated with the position, but income continues to accrue until the settlement date of the sale. Thus, a portfolio is exposed to price risk from trade date to trade date, and accrues interest from settlement date to settlement date.[7]

In the MBS index there are no pending positions. Once a security is included in the index, it contributes to performance as an outright holding in a portfolio would. This is because in the MBS index settlement dates by convention are the same as the "trade" or pricing dates. Therefore price changes and daily accrual are included in the return calculation for the entire holding period.

When comparing performance of a portfolio against the MBS index, it is important to understand these timing differences. For the period when a pending position is not earning interest, a portfolio may be at a disadvantage relative to the index.

It is difficult to impose the MBS index date conventions on a portfolio. Active portfolio managers often execute transactions (buys or sells) and then unwind the position while it is still pending for the same settlement date.[8] As a result, there is a realized price gain or loss for the portfolio, but there is no interest income at all. This

type of trading must be taken into account by any system that calculates MBS portfolio performance, but it has no relevance in the context of the MBS index.

Reinvestment

If an MBS portfolio is at a disadvantage relative to the MBS index for those times or situations when interest is not accruing, it has an advantage over the index in reinvestment. Mortgage passthroughs have monthly cash flows that consist of interest and principal (both scheduled and unscheduled). Therefore, reinvestment of cash flows plays a much larger role in managing a mortgage portfolio than it does for other fixed-income investments that have less frequent cash flows.

The return calculations for the MBS index effectively assume a 0% reinvestment rate for cash flows from the payment date through the end of the performance period. At the end of the month, all the accumulated cash is assumed to be invested in the next month's index. This is equivalent to a delayed reinvestment into the market. Until the end of the month, though, the cash does not participate in valuations.

The magnitude of the reinvestment return that the index would have achieved depends on the rate of prepayment and on prevailing short-term interest rates. At times of high prepayment, reinvestment return is typically moderated by low interest rates. In any event, the reinvestment return forgone by the index is modest.

For example, for the MBS index in June 1998, it would have been just 0.5 bp per month, assuming reinvestment at the Federal funds rate. In 1996, slower prepayments would have brought this down to 0.3 bp per month.

In actual portfolios, cash flows are normally reinvested into the market immediately upon receipt. But even when funds are temporarily kept as cash (or, more likely, as low-risk, low-yielding cash equivalents such as U.S. Treasury bills), they remain part of the portfolio and continue to have an impact on performance.

Transactions

For return calculations, membership in the MBS index is fixed once a month (on the last business day of the previous month). Returns are calculated on this fixed set of securities (either daily or for the whole month) and are linked across month boundaries via compounding to provide performance results for longer historical time frames.

For actively traded portfolios, however, "membership" can change daily. Furthermore, positions, either pending or outright, may be traded in their entirety or in multiple lots at (potentially) different prices. These issues need to be considered when calculating portfolio returns.

If the set of securities is fixed (i.e., no transactions) for a given period of time, performance is calculated from the starting and ending market values of the security and any intervening cash flow. If the mix of securities changes, the performance period must first be broken into subperiods defined by the days on which transactions occur.[9] Then, depending on how much detail must be captured, some algorithm is used to look at all the opening values (i.e., existing positions plus any new purchases) and closing values (i.e., remaining positions plus any sales) of the securities to arrive at a set of returns.

For example, the simplest algorithm would be to calculate an average starting value or cost from all the opening positions and an average ending value from all the closing positions. If it is necessary to keep track of both realized and unrealized returns, then some algorithm for pairing positions and trades must be employed.

Profit and Loss versus Total Return

When reviewing portfolio performance, investors typically measure how much each market sector within their holdings contributes to the total. If performance is segregated in this fashion, it is sometimes useful to look at results in terms of dollars (profit and loss) rather than percentages (total return). This is true any time the basis, or the beginning market value upon which return is calculated, is either not well defined or changes.

With static portfolios, the basis is well defined and fixed, and portfolio total return can be defined as the market weighted-average of the returns of the component securities. This is equivalent to dividing the sum of the profit or loss in dollars of each security in the portfolio by the portfolio basis. When the portfolio changes over the holding period, however, this relationship breaks down.

Exhibit 10 illustrates the performance of a hypothetical mortgage portfolio over a three-year period. The initial investment of $100 million is allocated 30% to discounts, 60% to current coupons, and

EXHIBIT 10
Performance of a Hypothetical Mortgage Portfolio

	Year 1	Year 2	Year 3	Cumulative
MBS Discounts				
Allocation	30%	30%	35%	
Total Return	5.00	5.50	4.00	15.21
Profit ($ million)	1.50	1.74	1.57	4.81
MBS Current Coupons				
Allocation	60%	40%	35%	
Total Return	6.00	6.50	6.50	20.23
Profit ($ million)	3.60	2.75	2.56	8.91
MBS Premiums				
Allocation	10%	30%	30%	
Total Return	6.50	7.00	6.50	21.36
Profit ($ million)	0.65	2.22	2.19	5.06
Portfolio Allocation	100%	100%	100%	
Total Return	5.75	6.35	5.63	18.79
Profit ($ million)	5.75	6.72	6.32	18.79

10% to premiums. Each year the allocation changes, and to arrive at the cumulative return for each sector, the periodic returns are compounded. The cumulative return for the portfolio is then no longer a weighted-average of the cumulative returns of its component sectors. But the cumulative profit is still a sum of the cumulative parts. If the goal is to understand performance of the whole in terms of performance of the parts of the portfolio, it helps to use P&L units that are additive.

Lehman Brothers recently introduced a model for analyzing and explaining portfolio performance relative to an index. For an in-depth description of this model, see "Attribution of Portfolio Performance Relative to an Index" [1998]. Briefly, performance attribution involves partitioning a portfolio into those market sectors where allocation decisions are made relative to an index, and calculating the excess performance associated with each of these decisions, as well as that due to the actual securities chosen within each sector.

Profit and loss, therefore, is a reasonable framework for analyzing performance of an actively traded portfolio, either in addition to or instead of percentage return. The main disadvantage of using profit and loss is that it is difficult to rank portfolios of different sizes based on excess profit; for this, percentage return is a more appropriate measure.

V. CONCLUSION

The Lehman Brothers MBS index serves as a basis for performance evaluation and risk measurement for a large number of MBS portfolios and mortgage components of diversified portfolios. Its published returns are based on a number of common conventions that allow aggregation of results for different MBS securities and across a variety of other asset classes in the Lehman indexes. We have summarized those conventions and provided guidance for comparisons between portfolio returns and benchmark returns.

Disparate settlements, the timing of pool factor updates, cash flow delays, and evolution of outstanding balances all make the MBS return computations particularly dependent on index conventions.

Our MBS index assumes a "buy-and-hold" strategy intramonth, and changes its composition only on the last business day of the month. The dynamic nature of most portfolios makes comparisons and especially attribution of performance differences challenging.

APPENDIX
Mathematical Calculations

For the purposes of the index return calculations, there are three important days within each month:

- t_{cf} — the day on which the cash payment of interest and principal is received by the bondholders of record (1 + agency delay).
- t_{psa} — the current-month PSA settlement date for Class A, on which all mortgage securities in the index switch to the next-month settlement.
- t_f — the next business day after the day of the last factor update (from that day on, previous-month SMM are used as the current-month prepayment estimates). Currently, it is the sixteenth business day of the month (so the switch to the next-month PSA settlement always happens earlier, i.e., t_{psa} is always before t_f).

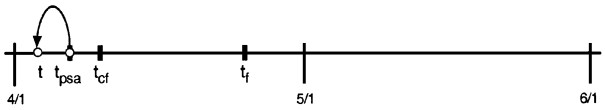
We present end-of-month return calculations as well as three cases of daily month-to-date returns calculations depending on where the index settlement date is relative to the three dates above (see Exhibit 5). In each case, we show how the PSA price is converted into the index price, and how all returns are computed.

To make notation more intuitive, we label calculation components with actual calendar months, rather than abstract subscripts, such as i and i + 1. In all formulas, we assume that calculations take place as we progress through the month of April.

For all cases we use the following:

$t_{psa}^{Apr}, t_{psa}^{May}$	PSA settlement dates for a particular MBS in April and May.
$t_{end}^{Mar}, t_{end}^{Apr}$	Last calendar days of March and April.
C	Monthly coupon (annual coupon in percent/12).
r	Daily repo rate (annualized one-month GNMA repo/360).
P(t, s)	Price at time t for settlement on s.
A(s)	Accrued interest at settlement on s.
$BV = P(t_{end}^{Mar}, t_{end}^{Mar}) + C$	Base value for all returns calculations during April.
F^{Jan}, F^{Feb}, F^{Mar}	Factors at the end of January, February, and March.
$S^{Feb} = \frac{F^{Feb}}{F^{Jan}}$	Monthly survival rate for February.
$S^{Mar} = \frac{F^{Mar}}{F^{Feb}}$	Monthly survival rate for March.

Case I. Month-to-Date Returns Calculation before t_{psa}



April settlement, February factors

This is the simplest case for index price calculation because all that is required is discounting from the PSA settlement date back to the index settlement date.[10]

$$\text{Index price } P(t,t) = \frac{P(t, t_{psa}^{Apr}) + A(t_{psa}^{Apr})}{(1+r)^{(t_{psa}^{Apr}-t)}} - A(t) \quad \text{(A-1)}$$

$$\text{Price return} = \frac{1}{BV}\left[S^{Feb}\left(P(t,t) - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-2)}$$

$$\text{Coupon return}^{11} = \frac{1}{BV}\left[S^{Feb}\left(\frac{C}{(1+r)^{(t_{cf}-t)}} + A(t) - C\right)\right] \quad \text{(A-3)}$$

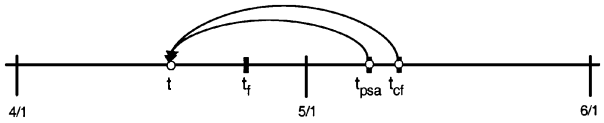
$$\text{Paydown return} = \frac{1}{BV}\left[(1-S^{Feb})\left(\frac{100}{(1+r)^{(t_{cf}-t)}} - P(t_{end}^{Mar}, t_{end}^{Mar}) + \frac{C}{(1+r)^{(t_{cf}-t)}} - C\right)\right] \quad \text{(A-4)}$$

Or, after the current month cash flow has been received:

$$\text{Coupon return} = \frac{S^{Feb}A(t)}{BV} \quad \text{(A-5)}$$

$$\text{Paydown return} = \frac{1}{BV}\left[(1-S^{Feb})\left(100 - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-6)}$$

Case II. Month-to-Date Returns Calculation between t_{psa} and t_f



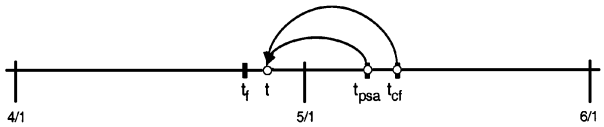
May settlement, February factors

Case II and the cases following differ from Case I in that the index price must be adjusted for the unknown future cash flow, which needs to be "reinstated."

$$\text{Index price } P(t,t) = \frac{S^{Feb}[P(t, t_{psa}^{May}) + A(t_{psa}^{May})]}{(1+r)^{(t_{psa}^{May}-t)}} + \frac{(1-S^{Feb})100 + C}{(1+r)^{(t_{cf}-t)}} - A(t) \quad \text{(A-7)}$$

All the formulas for the return calculations are the same as in Case I.

Case III. Month-to-Date Returns Calculation after t_f



May settlement, March factors

Case III differs from Case II in that the March prepayment is used to compute both the index price and returns.

$$\text{Index price } P(t,t) = \frac{S^{Mar}[P(t, t_{psa}^{May}) + A(t_{psa}^{May})]}{(1+r)^{(t_{psa}^{May}-t)}} + \frac{(1-S^{Mar})100 + C}{(1+r)^{(t_{cf}-t)}} - A(t) \quad \text{(A-8)}$$

$$\text{Price return} = \frac{1}{BV}\left[S^{Mar}\left(P(t,t) - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-9)}$$

$$\text{Coupon return} = \frac{1}{BV}\left[S^{Mar}\left(\frac{C}{(1+r)^{(t_{cf}-t)}} + A(t) - C\right)\right] \quad \text{(A-10)}$$

$$\text{Paydown return} = \frac{1}{BV}\left[(1-S^{Mar})\left(\frac{100}{(1+r)^{(t_{cf}-t)}} - P(t_{end}^{Mar}, t_{end}^{Mar}) + \frac{C}{(1+r)^{(t_{cf}-t)}} - C\right)\right] \quad \text{(A-11)}$$

Or, after the current month cash flow has been received:

$$\text{Coupon return} = \frac{S^{Mar}A(t)}{BV} \quad \text{(A-12)}$$

$$\text{Paydown return} = \frac{1}{BV}\left[(1-S^{Mar})\left(100 - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-13)}$$

Case IV. End-of-Month Returns Calculation

The only difference from Case III is that the accrued interest equals the full monthly coupon.

$$\text{Index price } P(t_{end}^{Apr}, t_{end}^{Apr}) = \frac{S^{Mar}[P(t_{end}^{Apr}, t_{psa}^{May}) + A(t_{psa}^{May})]}{(1+r)^{(t_{psa}^{May} - t_{end}^{Apr})}} + \frac{(1-S^{Mar})100 + C}{(1+r)^{(t_{cf} - t_{end}^{Apr})}} - C \quad \text{(A-14)}$$

$$\text{Price return} = \frac{1}{BV}\left[S^{Mar}\left(P(t_{end}^{Apr}, t_{end}^{Apr}) - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-15)}$$

$$\text{Coupon return} = \frac{S^{Mar}C}{BV} \quad \text{(A-16)}$$

$$\text{Paydown return} = \frac{1}{BV}\left[(1-S^{Mar})\left(100 - P(t_{end}^{Mar}, t_{end}^{Mar})\right)\right] \quad \text{(A-17)}$$

Total return is always the sum of price, coupon, and paydown returns.

ENDNOTES

The authors thank Sanjeev Jain, Prafulla Nabar, and Alan A. Sparks for helpful discussions.

[1]Over the last full five-year period (1993-1997), this number has fluctuated between 3,185 and 3,551.

[2]See "A Guide to the Lehman Global Family of Fixed Income Indices" [1998].

[3]Subtracting WALA from the current date gives the weighted-average origination date for the pool. FNMA does not report pool WALA. Because of loan curtailments (extra principal payments made by homeowners) remaining WAM cannot be used to compute WALA. Instead, for FNMA pools, original WALA (as of the pool issue date) is calculated as the original maturity minus WAM at the pool issue date. The pool weighted-average origination date is then determined by subtracting original WALA from the pool issue date.

[4]For a detailed description of TBA trading, see "Trading, Settlement, and Clearing Procedures for Agency MBS" [1992].

[5]This settlement convention for the MBS index has been in place since October 1994 (see "Revised Methodology for Calculating MBS Index Returns" [1994]). Most other Lehman Brothers indexes follow the next calendar day settlement convention.

[6]A daily return is defined as the difference between two consecutive month-to-date returns.

[7]Some systems account for all remaining accrual after a pending sale on the trade date rather than continuing to include it in daily mark-to-market reports.

[8]There is still delivery risk in this type of trading, especially if the trades are executed with different dealers.

[9]In the 1997 AIMR "Performance Presentation Standards Handbook," daily performance periods are recommended. AIMR also requires, as part of compliance, that time-weighted rates of return be used.

[10]Calculations on any particular day use the previous business day's close, so the reported returns are for the period from the beginning of the month through the previous business day.

[11]On the first day of the month, when accrued interest is zero, coupon return will be a small negative number, as the present value of C is less than C itself (see Exhibit 6).

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