
CMBSINDEXREPLICATION

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Introduction

In January 1999, Lehman Brothers introduced the CMBS Investment Grade Index¹ as a subcomponent of the Lehman U.S. Aggregate Index. As of February 2002, the CMBS Index comprised 2.2% of the market value of the Aggregate Index. Although the CMBS market is relatively small, the asset class has been growing and has attracted attention for its relative stability and desirable convexity properties.

As the CMBS market grows, investment managers evaluated against the Aggregate Index are increasingly asking whether to dedicate analyst and management resources to this asset class. An alternative is to track the CMBS Index passively while continuing to manage the other asset classes actively. Some investors have asked how they can construct a replicating proxy portfolio that will track the CMBS Index with minimal tracking error.

Unfortunately, as CMBS risk factors are not yet modeled, investors cannot effectively use Lehman's U.S. Risk Model to construct proxy portfolios containing CMBS. For investors who wish to construct such proxy portfolios, this poses an efficiency problem, as they cannot use the risk model analytically to offset CMBS exposures with other portfolio positions. Consequently, these investors often construct stand-alone CMBS proxy portfolios using other replication techniques. While this strategy is effective, it is less efficient. Even for investors who wish to replicate the CMBS Index alone, the lack of a risk model also makes replication less efficient, as there is no opportunity to take advantage of correlations among CMBS risk factors.

Nevertheless, investors can easily construct CMBS proxy portfolios using straightforward sampling techniques. We propose to replicate the Lehman CMBS Index using a technique called "stratified sampling." The first step is to stratify, or sort, the issues in the index into "buckets" according to various issue characteristics. Issues for the proxy portfolio are then selected from each of the buckets so that the exposure of the proxy portfolio to a particular characteristic matches the index's exposure within pre-specified tolerance bounds. For example, for the Credit Index, stratified sampling typically sorts the index into buckets defined by quality, sector, and duration. These characteristics are chosen because they are important factors driving the pricing of credit issues. A credit proxy portfolio is then selected so that the market value and contribution to spread duration of A-rated industrials with a modified duration between 2 and 5 years, for example, match those of the Credit Index within a few basis points. Selecting bonds for the proxy from each bucket is often facilitated using a linear optimizer. The optimizer can be set to maximize the liquidity (*i.e.*, amount outstanding) of the proxy portfolio while satisfying all of the bucket constraints.

¹ *The Lehman Brothers Commercial Mortgage-Backed Securities Index: A New Benchmark for the CMBS Market*, Lehman Brothers, January 27, 1999.

What are the important pricing characteristics of CMBS issues? Issues in the CMBS Index are priced by traders who use a matrix of nominal spreads to the swap curve.² The pricing matrix has three dimensions: quality grade (Aaa, Aa, A, Baa1& Baa2, and Baa3), average life (*e.g.*, 0-3, 3-5, 5-7, 7-9, 9-10, 10-12, 12-15, and 15-30) and dollar price (<90, >112, and two-dollar increments in between). Loan and property characteristics are not factored into the matrix. Depending on the quality grade, there may be more or fewer average life buckets. Overall, there are 564 pricing buckets. Issues in the index are then mapped to one and only one bucket in the pricing matrix. Many buckets in the pricing matrix have no bonds mapped to them. In addition, some CMBS issues having unusual characteristics are manually priced.

The CMBS pricing matrix generally reflects current market practice. Over the past few years, as the CMBS market has matured, the U.S. real estate market has been very strong. The good commercial real estate environment and diversity of collateral underlying CMBS issues have produced few large differences in spreads among issues in the same quality-average life-dollar price bucket. A CMBS proxy portfolio that matches the index across these three characteristics will most likely track the index closely. Back-testing this replication methodology produces excellent historical tracking results, as the CMBS pricing methodology has been based on the same three characteristics.

However, there is no guarantee that the CMBS market will continue to price issues as reflected in the current pricing matrix. CMBS data quality and analytics continue to improve. In addition, some investors are beginning to specialize in the CMBS asset class. As data, models, and expertise improve and as the real estate market experiences more typical cyclical behavior, CMBS issues may show more varied pricing dynamics than currently reflected in the pricing matrix. If the market's pricing conventions change and index pricing follows, then the performance of a proxy portfolio constructed to match only the quality-average life-dollar price characteristics of the index may experience increased tracking error. For example, issues with a relatively high weighting in California properties are not priced at a premium or discount to issues with a low (or "neutral") weighting. However, it is possible to imagine a market environment in which issues with a high California weighting are priced at a differential to the matrix. Investors intuitively understand this and would feel uncomfortable with a replicating CMBS portfolio that had a weighting in California properties that was significantly different than that of the index.

The challenge for CMBS replication is to define issue characteristics that may drive CMBS pricing in the future. Matching the proxy to the index across these characteristics will help keep tracking error low even as the market environment changes. In the next section, we identify those CMBS issue characteristics likely to have greater influence in CMBS pricing in the future. We then use stratified sampling to construct a proxy portfolio that closely matches the index across this

² The pricing matrix also assumes that bonds' base case prepayment expectation is 0% CPR and default expectation is 0% CDR.

broader set of characteristics. We then show that a replication strategy using this stratification would have closely tracked the index in the past. This result indicates that even if the market's pricing methodology does not change, the replication methodology we propose should nevertheless continue to track the index well. However, if the pricing methodology does change, then the proposed replication methodology should keep tracking error low.

Replication Strategy

A CMBS deal is backed by a pool of commercial mortgage loans, and each CMBS deal is divided into various issues (*i.e.*, tranches). Generally, each deal is collateralized by a diversified loan pool containing loans on properties of various types, geographic locations, and borrowers. We define a CMBS issue's exposure to a particular characteristic by calculating its deal's original principal balance weighted average of loans having that characteristic. For example, a deal's exposure to office properties would be the total original principal balances of all of the deal's loans on office properties divided by the total original principal balances of all the loans in the deal. This office percentage would then be assigned to each issue of that deal.

We choose to stratify issues in the CMBS Index across the following eight characteristics:

- 1) **Property Type.** We identify four property type buckets (office, retail-anchored, multifamily, and hotel) that are prominent property types serving as collateral for commercial loans. Through the use of stratified sampling, the proxy portfolio will have exposures to these four property types similar to those of the index. These four property types span the major sectors of the real estate market and often have different sensitivities to the economic cycle. Currently, these four property types account for 74% of the loans underlying the issues in the CMBS Index.
- 2) **Geography.** We identify the underlying property location for each loan backing CMBS deals in the index and calculate the total amount of loans by state. We then select the four largest states—CA, NY, TX, and FL—as the four geography buckets. These four states are also located in different regions of the country, which helps ensure regional diversification as well. Different states and regions can be in different phases of an economic cycle and experience different legislative, environmental, and random real estate shocks. Currently, these four states account for 41% of the loans underlying the issues in the CMBS Index. The next four largest states account for 13%.
- 3) **Performance (Delinquencies).** We choose two performance buckets: current & late less than one month and late more than one month. If the market became concerned about the performance of commercial loans, then we would want the proxy portfolio to have a delinquency profile similar to that of the index.
- 4) **Prepayment Protection.** Commercial loans have varying amounts of prepayment risk depending on the type of prepayment protection provided. The market's valuation of different types of prepayment protection can vary depending on the general interest rate and property market environment. We specify three prepayment protection buckets (currently locked out, in the yield maintenance period, and in the fixed penalty period) and we require that

the proxy portfolio closely match the CMBS Index with regard to these three prepayment protection types.

- 5) **Deal Type.** There are three general types of CMBS deals: conduit, fusion, and large loan. (Single property and single borrower deals are not part of the CMBS Index.) At times, the marketplace may put different valuations on these different deal types. Consequently, we require that the proxy portfolio have a deal type profile similar to that of the Index.

We also stratify issues in the CMBS Index according to the following three characteristics currently used by the market and the index pricing matrix:

- 6) **Dollar Price.** We define four dollar price buckets: discount (price < 98); par (price between 98 and 102); premium (price between 102 and 108); and super premiums (price greater than 108).
- 7) **Average Life.** We define three average life buckets: less than 4 years; between 4 and 8 years; and greater than 8 years.
- 8) **Quality Grade.** We define four quality buckets: Aaa, Aa, A, and Baa.

Our bucketing strategy does not create multi-dimensional buckets defined in terms of more than one characteristic (*e.g.*, Aa-hotel-current). Instead, each bucket is one-dimensional, reducing the total number of buckets to 27. However, an issue can belong to more than one bucket of a given characteristic. For example, the property type characteristic has four buckets. A given CMBS issue will have its original principal balance weighted percentage allocated across the four buckets, though some of the issue's weight will not be allocated to any of those buckets if it contains loans on less common types of properties, such as self-storage facilities.

There are other issue characteristics that could have been selected for use in stratification. For example, we could have controlled for tenant concentrations. However, it is difficult to measure tenant exposure in a commercial loan, as an underlying property often has many tenants. In addition, tenant concentrations are generally very low. Other possible characteristics are: deal trustee, deal special servicer, leasehold vs. fee simple, origination year, delinquencies at 60+ days, debt service coverage ratio, loan to value ratio, and loan originator. The CMBS replication software we have developed can be modified to incorporate these characteristics, if desired.

For each of these 27 buckets, we require that the proxy portfolio match the market value percentage within a tolerance level of 0.03 and contribution to spread duration within a tolerance level of 0.10. We also impose some additional constraints:

- a) The overall duration of the proxy portfolio must be within 0.03 of the index;
- b) We force diversification in the proxy portfolio by requiring that the maximum market value position size vary by credit quality. This feature stems from our work on sufficient diversification in a credit portfolio.³ Lower-rated credit

³ *Sufficient Diversification in Credit Portfolios*, Lehman Brothers, December 2001.

securities have a greater risk of downgrades than higher-rated securities. In addition, the impact of a downgrade can be particularly large for Baa securities. Since a proxy portfolio holds only a small subset of index bonds, the market value of any Baa bond in the proxy is likely to be much greater than the bond's weight in the index. Consequently, the impact of the Baa bond's downgrade would have a magnified impact on the proxy portfolio compared with the index. To reduce the tracking error risk due to downgrades, we force diversification in the lower quality buckets. Specifically, we follow the "7:3:1 Rule" and vary the maximum market value position size of an issue in the proxy as follows:

Quality	Maximum Market Value Position Size per Issue
Aaa	7%
Aa	7%
A	3%
Baa1 & Baa2	1%
Baa3	0%

The index contains approximately 4% in issues rated Baa1 and Baa2. Consequently, the issue size constraint will force the replication to select at least four issues from these credit categories. The index contains less than 2% in the Baa3 quality category, and we require that the proxy select no bonds rated Baa3. Given their small weight in the index and their potential to cause significant tracking error havoc due to a credit event, we disallow Baa3 securities in the proxy portfolio. In lieu of Baa3 issues, the proxy will contain a heavier weight in Baa1 and Baa2 issues so that the overall weight and contribution to spread duration of Baa issues in the proxy is within the tolerance limits; and

- c) We also restrict from the proxy portfolio any issues from CMBS deals identified as credit tenant lease (CTL) deals. CTLs are a relatively small part of the index and are often treated differently by investors. CTLs are loans that are underwritten based primarily on the quality of the tenant and the lease agreement, rather than on the property. Given their small weight in the index and the potential for high idiosyncratic risk due to non-real estate events affecting the tenant, we exclude from the proxy issues coming from CTL deals.

Replication Results

We examine the performance of the replication strategy from December 1999 through February 2002. To keep turnover low, we make the following adjustments:

- 1) **Quarterly Rebalancing.** A proxy portfolio is created each calendar quarter (at the end of the month prior to the last month in the quarter). The proxy portfolio remains unchanged until the following quarter.
- 2) **Penalize Turnover.** We use an optimizer to select bonds for the proxy in such a way as to satisfy the constraints. Within the constraints, the optimizer puts as much of the proxy's market value as possible into issues with the most market value outstanding. By directing the optimizer to select issues with relatively large market value, we aim to generate a proxy portfolio that will have relatively high liquidity. To help limit turnover, we adjust upward the

market values of issues already in the proxy so that the optimizer will be given an incentive to retain issues already in the proxy portfolio.

Results from our replication are shown in Figure 1. The Appendix shows the composition of the proxy portfolio as of December 2001.

Monthly return differences are presented in Figure 2. Figures 1 and 2 show that the proposed replication methodology has tracked the CMBS Index closely. Over the 27 month period, the average monthly return difference equals 0 bp, with a monthly tracking error of 4 bp.

To measure turnover from this strategy, we calculate the market value of new issues added to the proxy at each quarterly rebalancing plus the market value of any “add-on” positions. We then divide this sum by the market value of the entire proxy portfolio to arrive at our turnover measure. As Figure 3 shows, turnover is very low.

Figure 1. **CMBS Replication: Proxy and Index Statistics and Returns**
December 1999-February 2002

	Proxy Portfolio Return	# of Bonds in Proxy	CMBS Index Return	Return Difference (bp)
Dec-99	-0.48	28	-0.46	-2
Jan-00	-0.79		-0.79	0
Feb-00	0.93		0.95	-2
Mar-00	1.38	27	1.44	-6
Apr-00	-0.1		-0.14	4
May-00	-0.44		-0.45	2
Jun-00	2.84	25	2.82	2
Jul-00	0.73		0.75	-2
Aug-00	1.82		1.85	-2
Sep-00	1.35	26	1.4	-4
Oct-00	0.83		0.79	4
Nov-00	1.86		1.92	-6
Dec-00	2.68	28	2.69	-1
Jan-01	1.69		1.69	0
Feb-01	1.15		1.15	0
Mar-01	0.28	24	0.28	0
Apr-01	-0.2		-0.26	6
May-01	0.39		0.43	-5
Jun-01	0.1	25	0.11	0
Jul-01	2.75		2.79	-5
Aug-01	1.54		1.57	-3
Sep-01	1.89	28	1.95	-6
Oct-01	2.03		2.02	1
Nov-01	-1.73		-1.76	2
Dec-01	-0.78	25	-0.78	0
Jan-02	1.22		1.15	8
Feb-02	1.66		1.62	5

Average Monthly Outperformance = 0
Monthly Tracking Error = 4
Annualized Tracking Error = 13

Outperforming the CMBS Index

A CMBS proxy portfolio can serve as a useful starting point for strategies that try to outperform the CMBS Index. There are numerous nuances to CMBS deals that savvy investors can exploit in order to outperform the index. These investors can first construct a replicating proxy portfolio and then selectively substitute issues with similar characteristics but the potential to outperform due to some technical feature.

Lehman Brothers conducts extensive research on the potential value to bond investors of receiving yield maintenance penalties.⁴ Yield maintenance penalties are designed to compensate bond holders for lost yield in the event of a loan prepayment. A prepaying borrower is obligated to pay a yield maintenance penalty

⁴ *Prepayments in CMBS: A Matter of Penalties*, Lehman Brothers, *Global Relative Value*, September 10, 2001.

Figure 2. **CMBS Replication: Monthly Return Differences (in basis points)**
CMBS Index versus the CMBS Proxy Portfolio
December 1999-February 2002

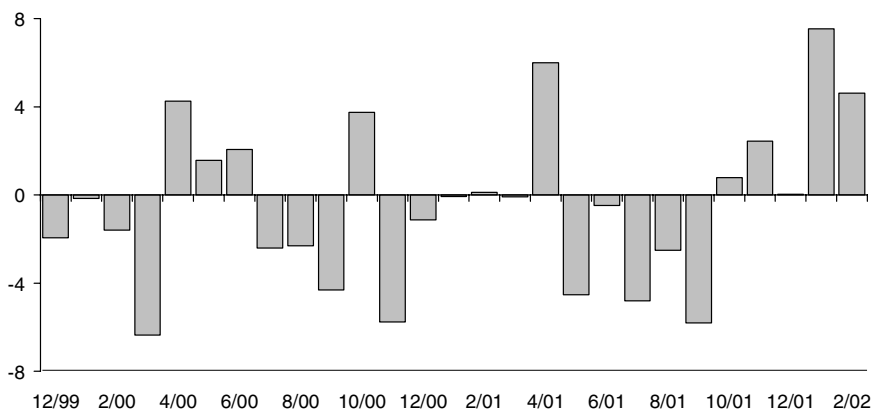


Figure 3. **CMBS Replication: Turnover Statistics**
December 1999-February 2002

	# of Bonds	# of New Bonds at Rebalancing	# of Add-On Positions at Rebalancing	Quarterly Turnover
Dec-99	28			
Mar-00	27	0	16	21%
Jun-00	25	1	20	16%
Sep-00	26	5	5	13%
Dec-00	28	5	8	18%
Mar-01	24	1	8	10%
Jun-01	25	2	16	15%
Sep-01	28	6	7	18%
Dec-01	25	0	8	10%

that roughly equals the present value of the bondholder's lost cash flows. However, the discount rate used is typically the U.S. Treasury rate flat, not the yield of the bond. This produces a potential windfall for the bondholder.

Why would the borrower prepay and pay such a yield maintenance penalty? Commercial borrowers often prepay to extract equity appreciation in their property. This additional equity can then be redeployed in the acquisition of additional properties. The value of the yield maintenance penalty is usually of secondary concern compared with the prospect of monetizing additional equity in a property.

The ability to identify issues likely to pay yield maintenance can be put to use in trying to outperform the CMBS Index. Like the market, the replication methodology does not distinguish between two bonds with similar characteristics, even if one is more likely to pay a valuable penalty. Consequently, investors can outperform the index by selectively substituting for issues in the proxy portfolio similar issues that are more likely to pay a penalty.

Summary

We have presented a replication strategy for the CMBS Index and have examined its empirical performance from December 1999 through February 2002. Based on these results, we find that the proxy portfolio has tracked the index closely, with very low turnover. In addition, the proxy portfolio is constructed in such a way as to anticipate future changes in CMBS pricing methodology that should help keep tracking error low.

Appendix: CMBS Proxy Portfolio as of December 2001

CUSIP	Issue Name	Quality	Par Amount
46625MAC	JPMCC01-CIBC A3	AAA	68400
23322BCJ	DLJCM98-CG1 A1B	AAA	67100
22540AFS	CSFB98-C1 A1B	AAA	66800
655356JF	NASC98-D6 A1B	AAA	66300
33736LAR	FULB97-C2 A3	AAA	66200
361849BV	GMACC97-C1 A3	AAA	66200
045424AN	ASC95-MD4 A1	AAA	65700
23322BFE	DLJCM99-CG2 A1B	AAA	64500
161582AB	CMFUN99-1 A2	AAA	64100
74436JEF	PSSF98-C1 A1A2	AAA	57900
22540AJM	CSFB98-C2 A2	AAA	52100
361849DY	GMACC98-C2 A2	AAA	45400
201730AD	CMAT99-C1 A4	AAA	34600
201730AE	CMAT99-C1 B	AA2	33100
617059HB	JPMC00-C9 C	A2	27100
161505EC	CCMSC00-1 B	AA2	24800
045424BF	ASC96-D2 A1	AAA	14100
201730BA	CMAT99-C2 D	A3	12200
361849BZ	GMACC97-C1 E	BAA2	9800
61746WDN	MSDWC00-PRIN D	BAA2	9800
61745MHB	MSC98-WF2 D	BAA2	9600
863572PX	LLL97-LLI E	BAA2	9600
05947UBJ	BACM00-2 G	BAA2	7500
07383FAE	BSCMS98-C1 D	BAA2	4000
61745MNB	MSC99-CAM1 E	BAA2	300

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