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Office of Thrift Supervision
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Executive Director, Supervision

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Any attachments to this document are rescinded only as they relate to national banks and federal savings associations.

MEMORANDUM FOR: Chief Executive Officers

FROM: John F. Downey
Executive Director, Supervision

SUBJECT: CMO Floaters

When valuing floating rate tranches of Collateralized Mortgage Obligations ("CMOs") or Real Estate Mortgage Investment Conduits ("REMICs"), otherwise known as "CMO floaters," savings associations should be using a methodology that properly accounts for any of the floater's interest rate caps and floors. Some institutions, however, have been using the approach contained in Thrift Bulletin 52 (i.e., the "FFIEC test") to value CMO floaters which does not account for caps and floors. This test is intended to determine the suitability of investments, and not for valuation purposes.

Beginning with the June 30, 1996 Thrift Financial Report, institutions should ensure that they determine the value of CMO floaters using a methodology that (1) accounts for any interest rate caps and floors, and (2) discounts projected cash flows using discount factors based on the zero coupon Treasury yield curve. This methodology should be used for reporting on Schedule CMR and for internal management purposes. Note, however, that Thrift Bulletin 52 remains in effect and savings associations should continue to use the methodology prescribed by the FFIEC to determine if a CMO is a suitable investment.

To assist institutions in the valuation process, OTS has developed the enclosed valuation methodology. If you have questions, please call the OTS Risk Management Division at (202) 906-6861.

Enclosure

Approach for Pricing CMO Floaters for
OTS Schedule CMR of the Thrift Financial Report

This document presents a pricing approach for estimating the market value and interest rate sensitivity of collateralized mortgage obligations (CMOs) and real estate mortgage investment conduits (REMICs) that are tied to floating-rate indices ("CMO floaters"). This approach should be used by savings associations to report the market value of their holdings of CMO floaters on Schedule CMR of the Thrift Financial Report.

Background

In December 1991, the Federal Financial Institutions Examination Council (FFIEC) issued a "Supervisory Policy Statement on Securities Activities." Among other things, that statement established a framework for identifying certain mortgage derivative securities as "high-risk mortgage securities." As part of that framework, the policy statement established a "price sensitivity test" and a methodology for estimating the price sensitivity of mortgage derivative securities. (The FFIEC policy statement was adopted by the Office of Thrift Supervision (OTS) and was issued by OTS as Thrift Bulletin 52, "Supervisory Policy Statement on Securities Activities" in February, 1992.)

A number of savings institutions use the pricing methodology contained in the FFIEC Supervisory Policy Statement to estimate the market value and interest rate sensitivity of their holdings of CMO floaters for financial reporting purposes. While the FFIEC methodology may be useful as a general indicator of interest rate sensitivity, it is not precise enough to be used as a valuation tool. The FFIEC methodology generally overstates the value of a CMO floater when interest rates increase since it does not appropriately account for any caps and floors embedded in the floater. Accordingly, beginning with the June 30, 1996 Thrift Financial Report (TFR) submission, savings institutions that have been using the FFIEC methodology for reporting the value of CMO floaters on Schedule CMR should value their floaters based on a methodology that (1) takes account of caps and floors and (2) discounts projected cash flows using the zero coupon Treasury curve and a spread to the curve. (Savings associations may continue to use the current FFIEC pricing methodology to value fixed-rate CMOs.)

Savings institutions should, however, continue to determine if a CMO floater is "high-risk" based on the current FFIEC pricing methodology. For example, if the new methodology indicates that a security would be classified as high-risk and the FFIEC methodology indicates it would be classified as low-risk, the security would be considered low-risk for the FFIEC price test.

Acceptable Methodology for Valuation of Floating-Rate CMOs

Most CMO floaters contain lifetime caps and floors. Any valuation methodology must price these embedded options to be acceptable for OTS reporting purposes. One acceptable methodology for reporting the value of CMO floaters on Schedule CMR is presented in Appendix A. This methodology employs the "Black 76 options pricing model" to price the caps and floors embedded in CMO floaters. Examples of how the methodology in Appendix A is used to price a CMO floater appear in Appendices B and C.

The methodology described in Appendix A may be used to price "plain vanilla" floaters, inverse floaters, and superfloaters. If this methodology is used, institutions holding floaters that have unusual characteristics should use the basic assumptions described in Appendix A and adjust these assumptions to account for these unusual characteristics. For example, a complex floater that changes its index at specified time periods would need additional modeling to be priced properly.

Appendix A

Methodology for Pricing Floating-Rate Collateralized Mortgage Obligations

This Appendix presents a methodology for estimating the market value and interest rate sensitivity of collateralized mortgage obligations that are tied to floating-rate indices ("CMO floaters"). This methodology may be used by savings associations to report the market value of their holdings of CMO floaters on Schedule CMR of the Thrift Financial Report.

Section I of this Appendix contains an overview of the methodology used to price a CMO floater. Section II contains the general methodology for pricing a CMO floater for various interest rate scenarios. Section III contains the methodology for valuing the lifetime interest rate cap and floor of the floater, the results of which are used in Section II. Section IV contains information that is necessary to price the floater in Section II.

I. Overview

Most CMO floaters contain both a lifetime cap and a lifetime floor. The holder of the CMO that contains a lifetime cap agrees to accept a limitation, or cap, on the interest rate they will receive on the underlying CMO. The holder of the CMO has, in effect, sold a cap. Therefore, the price of the cap must be subtracted from the price of an otherwise uncapped floater to determine the price of the CMO floater with the cap. A similar procedure is used to determine the price of a CMO floater that contains a floor, except the price of the floor is *added to*, not subtracted from, the price of the uncapped floater since the holder of the CMO has, in effect, purchased an interest rate floor. CMO floaters can, therefore, be viewed as a combination of a floating-rate instrument with no limitations on the level of its interest rate and two series of options.

To price a CMO floater with a lifetime cap and floor, first, determine the price of the CMO as if it were issued without either the cap or floor. Second, determine the price of the lifetime cap as if it were a stand-alone option contract. Third, determine the price of the lifetime floor as if it were a stand-alone option contract. Finally, determine the price of the CMO floater with a lifetime cap and floor by combining the three instruments, as follows:

$$\begin{array}{c} \text{Price of CMO Floater} \\ \text{with Cap and Floor} \end{array} = \begin{array}{c} \text{Price of Straight} \\ \text{CMO Floater} \end{array} - \begin{array}{c} \text{Price of} \\ \text{Cap} \end{array} + \begin{array}{c} \text{Price of} \\ \text{Floor} \end{array}$$

The above formula is used in the next section to determine the price of a floater in eight interest rate scenarios between -400 bp and +400 bp (the current market price will be used for the 0 bp scenario). An example of how the lifetime cap and floor are incorporated into the price of a CMO floater is shown in Appendix B.

II. Pricing CMO Floaters

This section presents a series of steps for pricing a CMO floater for eight interest rate scenarios based on the current market price of the floater. For ease of exposition, only the methodology for pricing a floater containing a lifetime cap is presented here.[1]

Step 1: Obtain a market price (bid price) for the CMO floater. This price implicitly contains the value of the lifetime cap and floor.

Step 2: Determine the value of the lifetime cap in nine interest rate scenarios (-400 bp to +400 bp) using an options pricing model, such as the Black 76 model (Section III of this Appendix describes the cap's valuation).

Step 3: Determine the price of the floater *without* its cap in the current interest rate environment (the "base case" scenario) by *adding* the value of the lifetime cap (obtained in Step 2) to the market price (obtained in Step 1). This will be called the "adjusted" floater price.

Step 4: Determine the spread to the zero coupon Treasury curve for the adjusted floater as follows:

-- Project the cash flows for the floater based on the projected index for the floater (assuming no cap) and the median prepayment speed obtained from several dealers for the underlying mortgages (see Section IV of this Appendix for information on projected indices and median prepayment speeds), and

-- Based on the adjusted floater price from Step 3 above, discount these cash flow projections using the zero coupon Treasury curve and a constant spread. Determine the spread iteratively using the discounted cash flow formula shown below:

$$\text{Adjusted Floater Price (Step 3)} = \sum_{t=1}^{N} \frac{(\text{Projected Cash Flow}_t)}{(1 + \text{Zero Coupon Rate}_t + \text{Spread})^t}$$

[1] When actually implementing the methodology, both caps and floors should be priced. The only difference in the methodology appears in Step 3 and Step 6 where the value of the lifetime floor is added to, not subtracted from, the price of the CMO floater (without the lifetime floor) to obtain its price.

Step 5: Determine the price for the adjusted floater for each of the remaining eight interest rate scenarios[2] as follows:

- For each interest rate scenario, project the cash flows for the floater (assuming no cap) based on the projected index for the floater and the prepayment speed for that scenario (do not include the cap), and

- Discount the cash flows using the zero coupon Treasury curve for that scenario, and the spread calculated in Step 4. The formula used to determine this price in each of the eight interest rate scenarios is shown below:

$$\text{Adjusted Floater Price} = \sum_{t=1}^{N} \frac{(\text{Projected Cash Flow}_t)}{(1 + \text{Zero Coupon Rate}_t + \text{Spread} + \text{Shift})^t}$$

Shift = interest rate scenario (i.e., -400 bp, -300 bp, ... +400 bp)

Step 6: For each of the eight interest rate scenarios, determine the price of the floater by subtracting the value of the lifetime cap in that scenario (that is determined in Step 2) from the price of the adjusted floater (which is not capped) in that interest rate scenario (that is determined in Step 5).

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2 Each scenario represents a parallel shift of the zero coupon Treasury curve. The amount of the shift in the eight scenarios are in 100 bp intervals from -400 bp through +400 bp (excluding the 0 bp scenario).

III. Valuing the Lifetime Cap and Floor

The value of the lifetime cap equals the sum of a series of "caplets." These caplets expire at regular intervals corresponding to the reset interval of the floater. Thus, if a 20-year security has a rate that adjusts monthly, there are 240 caplets. The following steps are used to determine the value of the lifetime cap (see Appendix C for examples on (1) how to use the Black 76 options pricing model to determine the price of each caplet and (2) how these caplet values should be adjusted to determine the value of the lifetime cap)[3]:

Step 1: Use an options pricing model, such as the Black 76 model, to determine the price of each caplet in the base case over the life of the floater (the Black 76 model produces a caplet price that is in present value terms). Assume no prepayments, defaults, or principal paydowns. Base the price of the caplet on short-term (one-month) and medium-term (ten-year) volatility projections applicable to each index.

Step 2: Determine the projected outstanding balance of principal in each period over the projected life of the CMO floater for the base case using expected prepayments, defaults, and principal paydowns.

Step 3: Divide the projected outstanding principal each period (from Step 2) by the initial principal level of the floater. The result is called the "periodic ratio."

Step 4: Multiply the "periodic ratio" for each period by the price of the caplet expiring at the end of that period. Sum the caplet values to obtain the value of the cap for the base case scenario. (This effectively adjusts the value of the caplet for the outstanding principal.)

Step 5: Repeat Steps 1 through 4 for the alternative eight interest rate scenarios (-400 bp through +400 bp).

The formula for valuing the lifetime cap for an interest rate scenario is shown below:

$$\text{Lifetime Cap Value} = \sum_{t=1}^{N} [\text{Caplet}_t] \times [\text{Periodic Ratio}_t], \text{ where}$$

Caplet_t = Price of caplet expiring in period t, assuming no prepayments, defaults, or principal paydowns.

Periodic Ratio_t = Projected floater balance outstanding in period t divided by initial principal level of floater.

N = Number of periodic payments scheduled over the term of the floater.

3 This methodology is also applied to the floor.

IV. Information for Determining the Price of the CMO Floater

The following information is necessary to determine the price of a floating-rate CMO in Sections II and III.

1. Yield Curve

The zero coupon Treasury curve should be used to discount the floater's projected cash flows and to value caps and floors in the options pricing model[4]. Any reasonable method for estimating this curve is acceptable.

2. Projected Indices and Volatilities

Implied forward rates for LIBOR and Treasury should be used to determine cash flows for floaters having those indices. (Any reasonable method can be used for determining these curves.) In projecting the forward curve for securities indexed to the COF index, the following equation (which is used in the OTS NPV Model) could be used:

$$COFI_{n,t} = .9041 * COFI_{n,t-1} + .0959 * (\text{Projected One-Year Treasury Yield}_t)$$

To determine the values for lifetime caps and floors, short-term (one-month) and mid-term (ten-year) implied volatilities should generally be used. Volatilities should be interpolated for points between the one-month and ten-year maturity points.

As of April 1, 1996, implied volatilities of 20% for the one-month maturity point and 15% for the ten-year maturity point are reasonable for the LIBOR and Treasury curves. Volatilities of 9% for the one-month maturity point and 12% for the ten-year maturity point are reasonable for the COF index. These volatilities should be updated to reflect market conditions using a reliable third-party source. This source should be documented.

For other indices, which occur infrequently, any reasonable method for projecting the forward curve and volatilities can be used.

3. Spread

The spread to Treasuries described in Step 3 of Section II above, "Pricing CMO Floaters," should be a constant spread to the zero coupon Treasury curve.

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4 A "flat yield curve approach" that bases the discount rate on a comparable average life U.S. Treasury security may not be used. In an upward sloping yield curve environment, a flat yield curve undervalues near-term cash flows and overvalues long-term cash flows.

4. Prepayment Assumptions

To estimate prepayments for the underlying mortgage collateral, use the median of prepayment rates provided by several mortgage securities dealers, as described in Thrift Bulletin 52. These prepayment assumptions will vary across interest rate scenarios. Alternative prepayment assumptions are acceptable if the underlying collateral has unique characteristics.

NOTE: In the -400 bp and +400 bp scenarios, the value of the lifetime cap and floor and the price of the uncapped floater may be approximated by extrapolating from the -300 bp and +300 bp scenarios.

Incorporating the Lifetime Cap and Floor into the Price of a CMO Floater

This Appendix shows how the lifetime cap and floor for a CMO floater are incorporated into its price for nine interest rate scenarios. In Table 1 below, a floater is initially priced in each of the interest rate scenarios without its lifetime cap or floor (column (2)). The cap and the floor are valued separately (columns (3) and (4)). The final floater price (column (5)) is equal to column (2) minus column (3) plus column (4).

Table 1 – Pricing of FNMA 1994-50 FA for Nine Interest Rate Scenarios as of April 1, 1996

Change in Interest Rates (1)	Price of CMO Without Cap or Floor (2)	Price of Cap (3)	Price of Floor[1] (4)	Price of CMO Floater (5)=(2)-(3)+(4)
-400	$100	$0	$0	$100
-300	100	0	0	100
-200	100	0	0	100
-100	100	2	0	98
0	100	5	0	95
+100	100	8	0	92
+200	100	13	0	87
+300	100	19	0	81
+400	100	26	0	74

[1] The floor has no value for most CMO floaters because it would require the index to be zero.

Valuing the Lifetime Cap and Floor for a CMO Floater

This Appendix contains two examples of how the lifetime cap and floor would be valued for pricing a CMO floater. The first example shows how the Black 76 model is used to price caplets and floorlets. The second example shows how the caplets and floorlets should be aggregated to determine the value of the lifetime cap and floor.

Pricing Caplets and Floorlets Using the Black 76 Model

The Black 76 Model is a widely accepted way to determine the prices of the caplets and floorlets that are the component parts of the lifetime cap and floor. The example below shows a simple way to price one of a series of caplets using the Black 76 model[1]. Different data inputs are necessary to price the remaining caplets.

Example

Consider a CMO floater that is indexed to LIBOR + 50 bp and has a cap rate of 8.50%. The index resets monthly. The following equation and assumptions are used to determine the price of the caplet per dollar of principal (in present value terms)[2] :

$$\text{Caplet price per dollar of principal} = te^{-r(k+1)t}[F_k N(d_1) - R_X N(d_2)]$$

where,

$$d_1 = \frac{\ln(F_k / R_X) + \sigma^2 kt / 2}{\sigma \sqrt{kt}}$$

$$d_2 = \frac{\ln(F_k / R_X) - \sigma^2 kt / 2}{\sigma \sqrt{kt}} = d_1 - \sigma \sqrt{kt}$$

The following example illustrates the above equation:

A one-month caplet is priced and it starts in one year
Settlement is in arrears
$N(d_1)$ and $N(d_2)$ are cumulative probability distributions evaluated at d_1 and d_2

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[1] Floorlets are priced using the same Black 76 methodology.

[2] The equation is a slight modification from John C. Hull, *Options, Futures, and Other Derivative Securities*, second edition, pages 375 and 376.

R_X = Adjusted cap rate = 8.50% - 0.50% = 0.08 annualized (Note: For this equation, the fixed margin of 50 basis points is subtracted from cap rate of 8.5% in order to apply the 20% volatility to a "pure" LIBOR index.)

t = Reset frequency, i.e., time between reset dates = 1 month = 0.083 years

kt = Time to the date that caplet's reference rate is determined = 12 reset periods times 0.083 years per reset period = 1 year

$(k+1)*t$ = Time that payment is made on investment = 13 reset periods times 0.083 years per reset period = 1.083 years

F_k = Forward interest rate for one-month instrument starting in one year (monthly compounded) = 7.00% = 0.07 annualized

σ^2 = Volatility of 30-day forward rate = 20% = 0.20 per annum

r = Risk-free rate of return (i.e., current one-year rate) = 6.50% = 0.065 continuously compounded

Solution:

Caplet price per dollar of principal = $0.083 * e^{-0.065*1.083}[0.07 * N(d_1) - 0.08N(d_2)]$ = 0.077 * [0.07*0.285134 - 0.08*0.221345] = \$.000175 per dollar of principal

where,

$$d_1 = \frac{\ln(0.07/0.08) + (0.20*0.20)*12*0.083/2}{0.20\sqrt{12*0.083}} = -0.56766;$$

$$N(d_1) = 0.285134$$

$$d_2 = d_1 - \sigma\sqrt{kt} = -0.56766 - (.20*\sqrt{12*0.083}) = -0.76766;$$

$$N(d_2) = 0.221345$$

Thus, the price of the caplet for the 13th month of the contract is \$.000175 per dollar of principal. The other caplets in the contract would be determined using the same formula with different data inputs. These caplets are then aggregated to determine the value of the lifetime cap for the CMO floater. This aggregation approach is described on the following page.

Valuing the Lifetime Cap of a CMO Floater[3]

Table 2 below shows an example of how the price for a lifetime cap should be determined. First, for each period, the price of the caplet per dollar of principal is determined as explained in the first example of this Appendix. (For illustrative purposes, in the example described below, a period is defined as a year. Also, the caplet price is multiplied by one hundred.) Then, for each period, the caplet is adjusted by the principal remaining in the CMO securitization in that period. This adjustment is made by determining the ratio of principal outstanding in that period (column (2)) divided by the initial principai (column (1)). This ratio (column (3)) is then multiplied by the unadjusted caplet price for the period (column (4)) to obtain an adjusted caplet price (column (5)) for that period. The adjusted caplet prices for each period are added to determine the value for the lifetime cap.

Table 2 -- Pricing the Lifetime Cap for FNMA 94-59 F
with a 200 Basis Point Increase in Interest
Rates as of April 1, 1996

	Initial Principal Amount (1)	Principal Remaining (2)	Periodic Ratio (3) = (2)/(1)	Unadjusted Caplet Price (4)	Adjusted Caplet Price (5) = (3) x (4)
Period 1	$24,065	$24,065	1.00	$0.11	$0.11
Period 2	24,065	24,065	1.00	0.48	0.48
Period 3	24,065	24,065	1.00	0.65	0.65
Period 4	24,065	24,065	1.00	0.80	0.80
Period 5	24,065	24,065	1.00	0.92	0.92
Period 6	24,065	24,065	1.00	0.93	0.93
Period 7	24,065	23,654	0.98	0.97	0.95
Period 8	24,065	21,207	0.88	1.00	0.88
Period 9	24,065	18,215	0.76	1.02	0.78
Period 10	24,065	14,841	0.62	1.00	0.62
Period 11	24,065	11,536	0.48	0.83	0.40
Period 12	24,065	8,383	0.35	0.81	0.28
Period 13	24,065	5,416	0.23	0.78	0.18
Period 14	24,065	2,650	0.11	0.75	0.08
Period 15	24,065	705	0.03	0.36	0.01
					Lifetime Cap Value = $8.07

[3] The lifetime floor would be priced the same way.