DETAILED DESCRIPTION OF OFF-BALANCE SHEET POSITIONS

Section 7.A – Financial Derivatives and Off-Balance Sheet Positions

The following types of positions are described in this chapter:

- Section 7.B — Optional commitments to originate mortgages
- Section 7.C — Firm commitments to purchase, sell, or originate mortgages or MBS
- Section 7.D — Optional commitments to purchase or sell mortgages or MBS
- Section 7.E — Interest-rate swaps
- Section 7.F — Interest-rate caps and floors
- Section 7.G — Futures
- Section 7.H — Options on futures

Information Reported on Schedule CMR

Information describing an institution s financial derivatives and off-balance sheet contracts is reported on Schedule CMR in cells CMR801 through CMR880 (see sample form in Appendix A). These cells collect five columns of information on up to 16 different positions. In addition, up to 1,000 additional positions can be reported on the Optional Supplemental Reporting pages of Schedule CMR. Each position is reported using a contract code (in column [1]) to describe the type of contract and the index it involves. For example, contract code 5006 denotes an interest rate swap on which the institution is paying fixed in exchange for 6-month LIBOR. The notional amount of each position is reported in column [2]. The information reported in the remaining columns varies by the type of contract. For example, for commitments to originate mortgages, loan origination/discount fees are reported in column [3] and the commitment rate is reported in column [4], while for interest rate caps, the contract expiration date and the strike rate are reported. If an institution has contracts for which Schedule CMR does not provide contract codes, the institution reports its own estimates of the market value of those contracts for the seven interest rate scenarios in CMR912 through CMR918.

While most of the instruments discussed in this chapter are valued using the static discounted cash flow technique, a version of the Black-Scholes formula is used to value several types of contracts. A description of that approach is provided here.

Black-Scholes Formula

The NPV Model uses Black s (1976) modification of the Black-Scholes Model.[1] Black developed this modification to estimate prices of options on futures and forward contracts on interest-bearing instruments. Black s formula allows interest rates to follow a stochastic process (otherwise interest rate options would have no value), and it accounts for the fact that such options are written on interest rates and not prices. Black s modifications were: (1) to restate interest rate options in terms of the price on zero-coupon bonds of the corresponding maturity, and (2) to capture the effect of stochastic discounting by using the future (forward) prices of the zero-coupon bonds.

[1] F. Black, "The Pricing of Commodity Contracts," Journal of Financial Economics, 3, January-March 1976, pp. 167-179. See also S. Figlewski, "Theoretical Valuation Models," in Financial Options: From Theory to Practice, S. Figlewski, W.Silber, and M. Subrahmanyam, eds., 1990, pp. 115-118.

Equation 7.A.1 - Black s Formula for Valuation of a Call Option

$$C = e^{-rt}\left[F N\left(D_f\right) - X N\left(D_f - s\sqrt{T}\right)\right]$$

Equation 7.A.2 - Black s Formula for Valuation of a Put Option

$$P = e^{-rT}\left[X N\left(-D_f + s\sqrt{T}\right) - F N\left(-D_f\right)\right]$$

where: $D_f = \dfrac{\ln\left(\dfrac{F}{X}\right) + \left(\dfrac{s^2 T}{2}\right)}{s\sqrt{T}}$

C = price of a call option
P = price of a put option
F = futures price
X = strike price of option
T = time to option expiration
r = riskless interest rate
e = exponential function
ln = natural logarithm function
N(·) = cumulative normal distribution evaluated at the quantity in parentheses
s = volatility of returns on futures contract.

The value of a call or a put option is calculated in each of the seven interest rate scenarios by substituting appropriate values for each of the formula s variables. The values of the strike price (X) and the time to expiration (T) are taken from the reporting schedule and are the same in all seven scenarios. The value of the volatility parameter, σ, is based on a 50-day moving average of the historical return volatility of the underlying futures contract. Its value is assumed to be the same in all seven scenarios. The value for the riskless interest rate (r) in the base case scenario is taken to be the zero-coupon Treasury yield with maturity T (i.e., equal to the time to option expiration). In the alternate rate scenarios, the value of r is changed by the amount of the rate shock. The value of the underlying futures or forward contract (F) also varies across interest rate scenarios and is estimated using the interest rate term structure appropriate for each scenario.

The instruments valued using Black s formula are:

- Options on interest rate futures,
- Interest rate caps and floors,
- Optional commitments to buy and sell mortgages, and
- Interest rate swaptions.

Section 7.B - Optional Commitments to Originate Mortgages

Schedule CMR Line Numbers

Optional commitments to originate mortgages are reported on the off-balance sheet page(s) of Schedule CMR and have contract codes between 1000 and 1016. In addition to a contract code that identifies the kind of optional commitment, Schedule CMR also collects the amount of the commitment, the weighted average coupon, and the amount of loan origination and loan discount fees that will be collected if each loan actually closes.

Table 7.B.2 near the end of this section reports the contract codes for these contracts.

Description of Instruments

Optional commitments to originate mortgages are contracts that obligate the reporting institution to originate mortgage loans at a specified interest rate, in which the potential borrower faces no substantial penalty for failing to take the loan[1]. Mortgage commitments have interest rates that are free to change (i.e., those that do not have an interest rate lock) are not reported on Schedule CMR. Commitments that have rate locks, but that have not received final credit approval, are reported net of those that the institution estimates based on historical experience will be denied credit[2].

Valuation Methodology

Method

The NPV Model values separately each reported position on optional commitments to originate mortgages. The fundamental approach that is used has four basic steps. First, the Model determines the value of the underlying mortgage in each of the interest rate scenarios using the appropriate look up table of mortgage prices. Second, it determines the origination fees that will be realized and origination costs that will be incurred from originating the loans. Third, it estimates the fraction of the mortgages that will actually be closed (as opposed to that fraction that will fall out of the pipeline) in each rate scenario. Finally, the Model calculates the value of the commitment, in each scenario, as: the value of the underlying mortgages in that scenario, plus origination fees net of costs, less the face value of the mortgages to be originated, all multiplied by the proportion of the mortgages that is expected to close in that scenario.

Value of Underlying Mortgages

The prices of the mortgages underlying the reported commitments position are determined by referring to the appropriate mortgage price table, based on the reported contract code. When the code is ambiguous (for example, contract code 1012 may represent 10-, 15-, or 20-year fixed rate mortgages), the Model uses as a proxy the most common type of mortgage covered by the code (see Table 7.B.3).

Aside from the commitment rate, the reporting form provides little information about the characteristics of the mortgages underlying the reported commitments. The Model, therefore, makes certain assumptions about them in order to estimate their prices.

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1 The distinguishing feature between an optional and a firm commitment to originate a mortgage is that a firm commitment requires the mortgage applicant to compensate the originator for the value of the commitment if the applicant subsequently decides not to settle on the mortgage.

2 Institutions do not deduct expected “pipeline fall-out” — cases in which the loan applicant opts not to proceed with the mortgage — from the commitment balances they report.

Fixed-Rate Mortgages

To look up prices in the price table for the fixed-rate mortgages underlying a commitment to originate, the Model needs a coupon and maturity. The coupon that it uses is the reported Weighted Average Coupon (WAC), less 10 basis points representing the assumed cost of carry. The maturity that the Model assumes for each contract code is reported in Table 7.B.3.

Based on this adjusted WAC and WARM, the Model determines the seven prices of the underlying mortgages, using the same look-up and interpolation procedure used to determine prices of existing mortgages (see Section 5.A). The value of the underlying mortgages is then calculated in each scenario by multiplying the amount committed by each price.

Adjustable-Rate Mortgages

The reported WAC of commitments to originate ARMs is adjusted in the same way as that of fixed-rate mortgage commitments. However, the rest of the process is more complicated for ARMs, because their prices depend upon a number of additional characteristics (e.g., margin, caps, floors). The Model assumes that the characteristics of the ARMs to be originated under a given commitment resemble those of the existing ARMs held by the reporting institution in its portfolio. Thus, for example, if the institution s 1-year Treasury ARMs are reported to have periodic caps and floors of 100 basis points, the ARMs underlying contract code 1006 will have the same weighted average periodic caps and floors. Table 7.B.3 reports the characteristics that are assumed to apply to the underlying mortgage instruments for each contract code.

Based on the various characteristics ascribed to the ARMs underlying the commitment, the Model uses the disaggregation approach described in Section 5.J to determine sub-balances that are consistent with the weighted average characteristics. Once the necessary characteristics have been assumed for these ARM sub-balances, the Model determines their prices in the seven interest rate scenarios using the same look up and interpolation procedure used for existing ARMs (see Section 5.K).

The value of the sub-balances is then calculated in each scenario by multiplying the amount of the sub-balance by each price. When each sub-balance has been valued in each rate scenario, their values are aggregated by scenario.

Origination Fees and Costs

For each reported optional commitment, institutions report the amount of loan origination and loan discount fees that will be collected if all loans actually close. Those fees represent cash inflows that will offset, dollar-for-dollar, the cash disbursements to be made by the institution when the mortgages close, and thus they contribute to the value of the commitment. Conversely, the institution incurs certain costs in originating loans. The Model assumes that origination costs are equal to 40 basis points of the balance of all loans that close.

Adjusting for Pipeline Fall-Out

Because optional commitments give the borrower the option of whether to close the mortgage loan, not all of the commitments will ultimately result in closed loans. Loans that do not close are said to have fallen out of the mortgage pipeline. Pipeline fall out can occur for numerous reasons, but its incidence can be expected to increase after a decline in interest rates, as commitment holders find it increasingly advantageous to renegotiate their interest rate locks or to restart the mortgage application process to obtain the lower interest rate.

To capture the effects of this variable closure rate on the value of optional commitments to originate mortgages, the Model uses the following equation:

Equation 7.B.1 - Closure Rate on Optional Commitments to Originate Mortgages

$$\text{closure}_k = 0.15 \cdot (0.93) + 0.85 \cdot \left\{ 0.6790 + 0.05838 \cdot \arctan\left[10.50 \cdot \left(1.149 - \frac{\text{coupon}}{m_k} \right) \right] \right\}$$

or, more simply,

$$\text{closure}_k = 0.7167 + 0.04962 \cdot \arctan\left[10.50 \cdot \left(1.149 - \frac{\text{coupon}}{m_k} \right) \right]$$

where: closure_k = proportion of commitment amount that will result in closed loans in interest rate scenario k

arctan = arctangent function[3]

coupon = reported commitment rate

m_k = refinancing rate in the interest rate scenario[4]

In this equation, the higher the coupon of the underlying mortgage compared to the refinancing rate, the lower will be the proportion of closed mortgages (i.e., the higher will be the fall-out rate). The equation treats the mortgage pipeline as having two segments. During the first 85 percent of the time in the pipeline, commitments are interest rate sensitive, while during the latter 15 percent, by which point closing documents have been prepared, the pipeline is insensitive to interest rate changes, with 93 percent of the balances in the pipeline assumed to close in each rate scenario. The Model treats the closure rate as a weighted average of the interest sensitive and insensitive segments of the pipeline.

Table 7.B.4 at the end of this section reports closure rates for various combinations of coupon and refinancing rate.

Valuing the Commitment

For a given scenario, the value of the reported commitment balance is calculated as: the value of the underlying mortgages in that scenario, plus the net fees to be received at closing, less the face value of the loan (principal) to be disbursed at closing, all multiplied by the proportion of loan closures in that scenario. The values of optional commitments to originate mortgages are aggregated by interest rate scenario for broadly similar types of mortgages and are presented in the Off-Balance-Sheet Positions section of the Exposure Report separately for: fixed-rate and balloon mortgages, adjustable-rate mortgages, and other mortgages.

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[3] See Section 5.A for a description of this function.

[4] In the base case interest rate scenario, the refinancing rate, m_{base}, is the net required yield on par FNMA 60-day commitments on 30-year fixed-rate mortgages, plus 25 basis points. In the alternate rate scenarios, m_k is calculated by adding or subtracting the appropriate number of basis points (+100, 200, etc.)

Example: Valuation of Optional Commitments to Originate Mortgages

Suppose that at a time when the refinancing rate (m_{base}) is 7.05%, an institution reports optional commitments to originate $1 million of 15-year fixed-rate mortgages (contract code 1012) with a WAC of 7.60 percent and loan discount fees of $15,000 if all of the underlying loans close. The estimated value of those commitments in the base case is $36,353 and in the -100 bp scenario is $53,663. They are calculated as follows.

1. *Valuing the Underlying Mortgages*

   The prices of the underlying mortgages are looked up in the 15-year FRM loan price table, of which an excerpt is shown below as Table B.1. The Model uses a WAC of 7.50% (i.e., the reported commitment rate minus 10 basis points) and assumes that the weighted average maturity of the mortgages to be originated will be 180 months. The price of such a mortgage in the base case as of the reporting date was 103.76 and was 106.85 in the -100 basis point scenario. The values of the mortgages underlying the commitment balance in those two scenarios was, therefore, $1.0376 million and $1.0685 million, respectively.

2. *Determining Origination Fees and Costs*

   If all loans close, the institution reports it will receive the $15,000 in origination fees. The Model assumes that in such circumstances origination costs will be $4,000 (= 0.0040 x $1,000,000).

3. *Approximating the Fraction of Loans That Will Close*

   Based upon a refinancing rate of 7.05%, the Model projects a closure rate of 0.748 in the base case and 0.675 in the -100 bp scenario. These are calculated as:

$$\text{closure}_k = 0.7167 + 0.04962 \cdot \arctan\left[10.50 \cdot \left(1.149 - \frac{\text{coupon}}{m_k}\right)\right]$$

$$\text{closure}_{base} = 0.7167 + 0.04962 \cdot \arctan\left\{10.50 \cdot \left[1.149 - \left(\frac{0.0760}{0.0705}\right)\right]\right\}$$

$$= 0.7167 + 0.04962 \cdot \arctan(0.0710) = 0.748$$

$$\text{closure}_{-100} = 0.7167 + 0.04962 \cdot \arctan\left\{10.50 \cdot \left[1.149 - \left(\frac{0.0760}{0.0605}\right)\right]\right\}$$

$$= 0.7167 + 0.04962 \cdot \arctan(-1.125) = 0.675$$

4. *Valuing the Commitments*

   The value of the commitments in the base case and -100 basis point scenarios would be calculated as:

$$\text{Commitment}_k = \text{closure}_k \cdot (\text{PV\_Underlying}_k + \text{Fee} - \text{Cost} - \text{Face\_Value\_Underlying})$$

$$\text{Commitment}_{base} = 0.748 \cdot (\$1{,}037{,}600 + \$15{,}000 - \$4{,}000 - \$1{,}000{,}000)$$
$$= 0.748 \cdot (\$48{,}600) = \$36{,}353$$

$$\text{Commitment}_{-100} = 0.675 \cdot (\$1{,}068{,}500 + \$15{,}000 - \$4{,}000 - \$1{,}000{,}000)$$
$$= 0.675 \cdot (\$79{,}500) = \$53{,}663$$

Table 7.B.1

Excerpt from Price Table for 15-Year Fixed-Rate Mortgage Loans

(Percentage of Underlying Balance)

WAC	WARM	Interest Rate Shock (bp)						
(%)	(mo)	-300	-200	-100	0	+100	+200	+300
7.00	36	105.15	104.28	103.42	102.26	100.92	99.55	98.17
7.00	60	106.24	105.20	104.19	102.57	100.56	98.47	96.39
7.00	90	106.92	105.79	104.66	102.57	99.88	97.06	94.27
7.00	120	107.28	106.11	104.90	102.44	99.19	95.79	92.45
7.00	144	107.46	106.27	105.01	102.30	98.68	94.90	91.21
7.00	160	107.55	106.35	105.06	102.20	98.36	94.38	90.49
7.00	180	109.86	107.94	105.82	102.19	97.72	93.17	88.78
7.50	36	105.52	104.63	103.79	102.74	101.45	100.09	98.72
7.50	60	106.70	105.63	104.67	103.26	101.36	99.30	97.23
7.50	90	107.43	106.26	105.23	103.49	100.96	98.19	95.42
7.50	120	107.82	106.60	105.53	103.53	100.50	97.18	93.85
7.50	144	108.02	106.78	105.68	103.50	100.15	96.46	92.79
7.50	160	108.12	106.87	105.75	103.47	99.93	96.04	92.17
7.50	180	110.72	108.76	106.85	103.76	99.54	95.04	90.64
8.00	36	105.71	104.80	103.95	102.98	101.74	100.41	99.05
8.00	60	106.93	105.82	104.84	103.59	101.81	99.80	97.75
8.00	90	107.69	106.47	105.41	103.91	101.57	98.89	96.15
8.00	120	108.09	106.82	105.72	104.04	101.26	98.04	94.77
8.00	144	108.29	106.99	105.88	104.07	101.01	97.45	93.83
8.00	160	108.39	107.08	105.95	104.07	100.86	97.10	93.28
8.00	180	111.19	109.17	107.28	104.57	100.64	96.25	91.88

Table 7.B.2

Contract Codes for Optional Commitments to Originate Mortgages

Contract Code	Underlying Mortgage Type
1002	1-month COFI ARMs
1004	6-month or 1-year COFI ARMs
1006	6-month or 1-year Treasury ARMs
1008	3-year or 5-year Treasury ARMs
1010	5-year or 7-year balloon or 2-step mortgages
1012	10-, 15-, or 20-year fixed-rate mortgages
1014	25- or 30-year fixed-rate mortgages
1016	All other mortgages

Table 7.B.3

Assumed Characteristics of Optional Commitments to Originate Mortgages

Contract Code	Underlying Mortgage Type	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
1002	1-mo COFI ARMs	1-mo COFI ARM	360	12 mo	500 bp	500 bp
1004	6-mo or 1-yr COFI ARMs	1-yr COFI ARM	360	6	500	500
1006	6-mo or 1-yr Treasury ARMs	1-yr Treas ARM	360	12	600	600
1008	3- or 5-yr Treasury ARMs	3-yr Treas ARM	360	12	600	600
1010	5- or 7-yr Balloons/2-Step	7-yr Balloon	84			
1012	10-, 15-, or 20-yr FRMs	15-year FRM	180			
1014	5- or 30-yr FRMs	30-year FRM[5]	360			
1016	All other mortgages	7-yr Balloon	84			

Table 7.B.4

Closure Rates for Various Coupons and Refinancing Rates

By Percent to One Decimal Place

Coupon	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
10	....	....	....	....	....	....	....	....	64.8	65.1	65.5	66.2	67.6	70.3	73.5	75.6	76.6
9.5	....	....	....	....	....	....	....	64.7	64.9	65.3	66.0	67.3	69.8	73.2	75.5	76.6	77.2
9	....	....	....	....	....	....	64.6	64.8	65.2	65.8	66.9	69.2	72.9	75.4	76.6	77.3	77.7
8.5	....	....	....	....	....	64.5	64.7	65.0	65.6	66.6	68.7	72.5	75.3	76.6	77.3	77.7	77.9
8	....	....	....	....	64.4	64.6	64.9	65.4	66.2	68.1	72.0	75.2	76.6	77.3	77.7	78.0	78.1
7.5	....	....	....	64.3	64.5	64.8	65.2	65.9	67.6	71.4	75.1	76.6	77.4	77.8	78.0	78.2	78.3
7	....	....	64.3	64.4	64.7	65.0	65.7	67.1	70.8	74.9	76.6	77.4	77.8	78.1	78.2	78.3	78.4
6.5	....	64.2	64.3	64.5	64.9	65.4	66.7	70.0	74.7	76.6	77.4	77.8	78.1	78.3	78.4	78.5	78.5
6	64.1	64.3	64.4	64.7	65.2	66.2	69.2	74.4	76.6	77.5	77.9	78.1	78.3	78.4	78.5	78.6	78.6
5.5	64.2	64.3	64.6	65.0	65.9	68.4	74.0	76.6	77.5	78.0	78.2	78.3	78.5	78.5	78.6	78.6	....
5	64.2	64.4	64.8	65.5	67.6	73.5	76.6	77.6	78.0	78.2	78.4	78.5	78.6	78.6	78.7	....	....
4.5	64.3	64.6	65.2	66.9	72.9	76.6	77.7	78.1	78.3	78.4	78.5	78.6	78.7	78.7	....	....	....
4	64.4	64.9	66.2	72.0	76.6	77.7	78.1	78.4	78.5	78.6	78.7	78.7	78.7	....	....	....	....
3.5	64.7	65.7	70.8	76.6	77.8	78.2	78.4	78.6	78.6	78.7	78.7	78.8	....	....	....	....	....
3	65.2	69.2	76.6	77.9	78.3	78.5	78.6	78.7	78.7	78.8	78.8	....	....	....	....	....	....
2.5	67.6	76.6	78.0	78.4	78.6	78.7	78.7	78.8	78.8	78.8	....	....	....	....	....	....	....
2	76.6	78.1	78.5	78.7	78.7	78.8	78.8	78.9	78.9	....	....	....	....	....	....	....	....

Refinancing Rate (m_k)

[5] Consists of same proportions of conventional and FHA/VA-insured 30-year fixed-rate mortgage loans as reported in the institution's loan portfolio.

Section 7.C - Firm Commitments to Purchase, Sell, or Originate Mortgages

Schedule CMR Line Numbers

Firm commitments to purchase, sell, or originate mortgages are reported on the off-balance sheet page(s) of Schedule CMR and have contract codes between 2000 and 2216. In addition to a contract code that identifies the nature of the firm commitment, Schedule CMR also collects the amount of the commitment, the amount of associated fees[1], the weighted average coupon of the underlying mortgages, and the weighted average price to be paid or received.

Table 7.C.2 at the end of this section lists the contract codes for these contracts.

Description of Instruments

A firm commitment to purchase or sell mortgages or mortgage backed securities (MBS) is a contract, binding on both the buyer and seller, under which a specified mortgage-related instrument will be bought or sold at a specified price. A firm commitment to originate a mortgage is a contract that obligates the reporting institution to originate a mortgage loan at a specified interest rate and that obligates the borrower to pay a substantial penalty in the event he fails to take the loan[2].

Mortgage commitments whose interest rates are free to change (i.e., those that do not have an interest rate lock) are not reported on Schedule CMR. Commitments that have rate locks, but that have not received final credit approval are reported, despite the fact that the mortgage may yet be denied, as long as the borrower would be required to pay a substantial penalty for failing to take the loan after receiving credit approval.[3]

Valuation Methodology

Method

The Model values separately each reported firm commitment position. The approach to valuing a firm commitment to purchase (or originate) has four basic steps. First, the Model determines the value of the underlying mortgages or MBS in each of the interest rate scenarios using the appropriate look up table of prices. Second, it determines whether there are any net fees or costs associated with the transaction. Third, it calculates the delivery value stipulated in the contract. Finally, the Model calculates the value of the commitment, in each scenario, as: the value of the underlying mortgages or MBS in that scenario, plus the net fees, and less the delivery value. The value of a firm commitment to sell is equal to the value of the commitment to purchase, in the same scenario, multiplied by negative one.

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1 In the case of firm commitments to originate mortgages, such fees include loan origination and discount fees to be paid by the borrower at closing. They include compensation for “buy-ups” and “buy-downs,” but not other fees collected in the loan origination process, such as application, appraisal, or title fees. For firm commitments to purchase or sell mortgages or MBS, institutions report any additional fees, net of costs.

2 The distinguishing feature between an optional and a firm commitment to originate a mortgage is that a firm commitment requires the mortgage applicant to compensate the originator for the value of the commitment if the applicant subsequently decides not to settle on the mortgage.

3 The reporting instructions for Schedule CMR instruct institutions not to deduct the expected rate of “fall out” from the commitment balances they report. If an institution has provided interest rate locks on mortgage applications that may subsequently be denied credit, the instructions state that the institution should deduct the portion of such balances that is consistent with the historical rate of credit denial on such loan applications.

Value of Underlying Mortgages

The prices of the mortgage instruments underlying the reported commitments position are determined by referring to the appropriate mortgage loan or MBS price table. The price table is chosen based upon the reported contract code. For example, prices of the mortgages underlying contract code 2102, firm commitments to purchase 1-month COFI ARM loans on a servicing released basis, would be found in the price table for 1-month COFI ARM loans. If the code is ambiguous (for example, contract code 2112, which can be used for 10-, 15-, or 20-year fixed-rate mortgages), the Model uses as a proxy the most common type of mortgage covered by the code (see Table 7.C.3).

Aside from the commitment rate, the reporting form provides little information about the characteristics of the instruments underlying the reported commitments. The Model, therefore, makes certain assumptions about those characteristics in order to estimate the value of the underlying loans or securities.

Fixed-Rate Mortgages

To look up prices for the fixed-rate mortgages or MBS underlying a commitment, the Model needs the weighted average coupon and maturity. The coupon that it uses is the reported WAC[4], less 10 basis points representing the assumed cost of carry. The maturity that the Model assumes for each contract code is listed in Table 7.C.3.

Based on the WAC and assumed WARM, the Model determines the price of the underlying instruments in the seven scenarios, using the same look-up and interpolation procedure used to determine prices of existing mortgages and MBS (see Section 5.A). The value of the underlying mortgages or MBS is then calculated for each scenario by multiplying the amount of the commitment by each price.

Adjustable-Rate Mortgages

The reported WAC of commitments involving ARMs is adjusted for the cost of carry in the same way as that of fixed-rate mortgage commitments, however, the rest of the process is more complicated for ARMs, because their prices depend upon a number of additional characteristics (e.g., margin, caps, floors). The Model assumes that the characteristics of the ARMs underlying a given commitment resemble those of the existing ARMs held by the reporting institution in its portfolio. Thus, for example, if the institution s 1-year Treasury ARMs are reported to have periodic caps and floors of 100 basis points, the ARMs underlying the reported commitment will have the same weighted average periodic caps and floors. Table 7.C.3 lists the characteristics that are assumed to apply to the underlying mortgage instruments for each contract code.

Based on the various characteristics ascribed to the ARMs underlying the commitment, the Model uses the disaggregation approach described in Section 5.J to determine sub-balances that are consistent with the weighted average characteristics. Once the necessary characteristics have been assumed for these ARM sub-balances, the Model determines their prices in the seven interest rate scenarios using the same look-up and interpolation procedure used for existing ARMs and ARM securities (see Section 5.K).

The value of the sub-balances is then calculated in each scenario by multiplying the amount of the sub-balance by each price. When each sub-balance has been valued in each rate scenario, their values are aggregated by scenario.

[4] Pricing tables for MBS are arranged in terms of the WAC of their underlying mortgages. To locate MBS prices in the tables, the model assumes that the WAC is 50 basis points greater than the MBS coupon, in the case of fixed-rate mortgage securities, and 75 basis points higher, in the case of ARM securities.

Fees and Costs

For each reported firm commitment to originate mortgages, institutions report the amount of loan origination and loan discount fees that will be collected when the loans close. Those fees represent cash in flows that will offset, dollar-for-dollar, the loan disbursements to be made by the institution at closing, and thus contribute to the value of the commitment. Conversely, the institution incurs certain costs in originating loans. The Model assumes that origination costs are equal to 40 basis points of the balance of loans that close.

For firm commitments to purchase or sell mortgage loans or MBS, only the net fees, if any, reported by the institution are included in the calculation.

Delivery Value

Each firm commitment contract defines the price at which the underlying instrument will change hands at delivery. In the case of a firm commitment to originate, the institution agrees to deliver to the borrower loan proceeds of a specified amount at par. (Discount points, if any, are reported as expected fees.) Hence, the delivery value of the contract is simply the amount of the commitment.

In the case of a firm commitment to purchase or sell mortgage loans or MBS, the delivery price stipulated by the contract is reported by the institution. The delivery value is simply the product of that delivery price and the amount of the commitment.

Valuing the Commitment

For a given scenario, the value of a firm commitment to purchase or originate is calculated as: the value of the underlying mortgages or MBS in that scenario, plus any net fees (or minus net costs) that will change hands at the completion of the transaction, less the delivery value stipulated in the contract. The value of a firm commitment to sell in that same scenario is simply negative one times the value of the commitment to purchase.

The values of firm commitments to purchase or originate mortgages and MBS are aggregated by interest rate scenario, as are the values of firm commitments to sell mortgages or MBS. They are presented on page 06 of the Exposure Report as two separate lines in the section labeled Firm Commitments.

Example: Valuation of Firm Commitments to Sell FRMs

Suppose that an institution reports firm commitments to sell $1 million of 30-year conventional fixed-rate mortgages, with a WAC of 7.10%, on a servicing-released basis (contract code 2134) for $1.010 million. (The institution would report this as a commitment price of 101.00.) The value of those commitments in the base case is $400 and in the -100 bp scenario is -$47,500. They are calculated as follows.

1. *Valuing the Underlying Mortgages*

   The prices of the underlying mortgages are looked up in the 30-year FRM loan price table, an excerpt of which is shown in Table 7.C.1. The Model uses a WAC of 7.00% (i.e., the reported commitment rate minus 10 basis points) and assumes that the weighted average maturity of the mortgages being sold is 360 months. The price of such a mortgage in the base case scenario is 100.96 and in the -100 basis point scenario is 105.75. The values of the mortgages underlying the commitment balance in those two scenarios, therefore, are $1.0096 million and $1.0575 million, respectively.

2. *Determining Net Fees or Costs*

   Because no net fees are reported by the institution, the Model assumes that no payments will change hands at completion of the transaction other than payment of the stipulated $1.01 million for the mortgages[5].

3. *Determining the Delivery Value*

   The delivery value of this commitment is calculated as the product of the reported amount of the commitment and the reported delivery price. In this example, the delivery value is $1.01 million (= $1 million x 101.00 / 100).

4. *Valuing the Commitments*

   The value of the commitments in the base case and the -100 basis point scenarios are calculated as:

$$\text{Commitment}_k = 1 \cdot (\text{PV\_Underlying}_k + \text{Net\_Fee} - \text{Delivery\_Value})$$

$$\text{Commitment}_{base} = 1 \cdot (\$1{,}009{,}600 + \$0 - \$1{,}010{,}000) = \$400$$

$$\text{Commitment}_{-100} = 1 \cdot (\$1{,}057{,}500 + \$0 - \$1{,}010{,}000) = -\$47{,}500$$

5 If this institution had yet to originate the mortgages it plans to deliver under this commitment to sell, any fees or costs associated with the origination of those mortgages would be reported separately, with commitments to originate mortgages.

Table 7.C.1
Excerpt from Price Table for 30-Year Fixed-Rate Mortgage Loans
(Percentage of Underlying Balance)

WAC	WARM	Interest Rate Shock (bp)						
(%)	(mo)	-300	-200	-100	0	+100	+200	+300
6.50	60	105.70	104.66	103.28	101.40	99.32	97.22	95.13
6.50	120	106.71	105.52	103.59	100.59	97.17	93.72	90.35
6.50	180	107.07	105.82	103.54	99.79	95.49	91.18	87.02
6.50	240	107.12	105.59	103.37	99.32	94.54	89.83	85.37
6.50	300	107.21	105.66	103.30	98.93	93.79	88.75	84.03
6.50	330	107.24	105.68	103.28	98.78	93.52	88.36	83.54
6.50	360	110.14	107.41	103.67	98.15	92.14	86.40	81.08
7.00	60	106.31	105.29	104.08	102.35	100.35	98.26	96.17
7.00	120	107.44	106.31	104.77	102.12	98.87	95.47	92.10
7.00	180	107.84	106.69	104.95	101.71	97.65	93.41	89.25
7.00	240	107.97	106.47	104.75	101.43	96.96	92.30	87.82
7.00	300	108.07	106.55	104.76	101.22	96.42	91.44	86.68
7.00	330	108.11	106.58	104.76	101.13	96.22	91.13	86.27
7.00	360	111.55	108.88	105.75	100.96	95.21	89.46	84.05
7.50	60	106.70	105.66	104.55	102.97	101.04	98.99	96.92
7.50	120	107.90	106.75	105.54	103.10	100.04	96.72	93.38
7.50	180	108.32	107.15	105.70	102.93	99.15	95.02	90.91
7.50	240	108.50	106.98	105.43	102.74	98.65	94.13	89.68
7.50	300	108.61	107.07	105.48	102.63	98.26	93.44	88.72
7.50	330	108.65	107.10	105.50	102.59	98.12	93.20	88.37
7.50	360	112.49	109.80	106.96	102.79	97.40	91.79	86.33

Table 7.C.2

Contract Codes for Firm Commitments to Purchase, Sell or Originate Mortgages

Firm Commitments to Originate Mortgage Loans

2202	originate 1-month COFI ARM loans
2204	originate 6-month or 1-year COFI ARM loans
2206	originate 6-month or 1-year Treasury ARM loans
2208	originate 3-year or 5-year Treasury ARM loans
2210	originate 5-year or 7-year Balloon or 2-Step mortgage loans
2212	originate 10-year, 15-year, or 20-year FRM loans
2214	originate 25-year or 30-year FRM loans
2216	originate all other mortgage loans

Firm Commitments to Purchase or Sell MBS

2042	purchase 1-month COFI ARM MBS
2044	purchase 6-month or 1-year COFI ARM MBS
2046	purchase 6-month or 1-year Treasury ARM MBS
2048	purchase 3-year or 5-year Treasury ARM MBS
2050	purchase 5-year or 7-year Balloon or 2-Step Mortgage MBS
2052	purchase 10-year, 15-year, or 20-year Fixed-rate MBS
2054	purchase 25-year or 30-year Fixed-rate MBS
2056	purchase all other MBS
2062	sell 1-month COFI ARM MBS
2064	sell 6-month or 1-year COFI ARM MBS
2066	sell 6-month or 1-year Treasury ARM MBS
2068	sell 3-year or 5-year Treasury ARM MBS
2070	sell 5-year or 7-year Balloon or 2-Step Mortgage MBS
2072	sell 10-year, 15-year, or 20-year Fixed-rate MBS
2074	sell 25-year or 30-year Fixed-rate MBS
2076	sell all other MBS

Firm Commitments to Purchase or Sell Mortgage Loans

Servicing Retained	**Servicing Released**	
2002	2102	purchase 1-month COFI ARM loans
2004	2104	purchase 6-month or 1-year COFI ARM loans
2006	2106	purchase 6-month or 1-year Treasury ARM loans
2008	2108	purchase 3-year or 5-year Treasury ARM loans
2010	2110	purchase 5-year or 7-year Balloon or 2-Step mortgage loans
2012	2112	purchase 10-year, 15-year, or 20-year FRM loans
2014	2114	purchase 25-year or 30-year FRM loans
2016	2116	purchase all other mortgage loans
2022	2122	sell 1-month COFI ARM loans
2024	2124	sell 6-month or 1-year COFI ARM loans
2026	2126	sell 6-month or 1-year Treasury ARM loans
2028	2128	sell 3-year or 5-year Treasury ARM loans
2030	2130	sell 5-year or 7-year Balloon or 2-Step mortgage loans
2032	2132	sell 10-year, 15-year, or 20-year FRM loans
2034	2134	sell 25-year or 30-year FRM loans
2036	2136	sell all other mortgage loans

Table 7.C.2 - continued

Contract Codes for Firm Commitments to Purchase, Sell or Originate Mortgages

Firm Commitments to Purchase or Sell Mortgage Derivative Products (MDPs)

2081	purchase low-risk floating-rate MDPs
2082	purchase low-risk fixed-rate MDPs
2083	sell low-risk floating-rate MDPs
2084	sell low-risk fixed-rate MDPs
2086	purchase high-risk MDPs
2088	sell high-risk MDPs

Table 7.C.3

Assumed Characteristics of Firm Commitments to Purchase, Sell, or Originate Mortgages

Firm Commitments to Originate Mortgage Loans

Contract Code	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
2202	1-mo COFI ARM loans	360	12 mo	500 bp	500 bp
2204	1-yr COFI ARM loans	360	6	500	500
2206	1-yr Treas ARM loans	360	12	600	600
2208	3-yr Treas ARM loans	360	12	600	600
2210	7-yr Balloon loans	84			
2212	15-year FRM loans	180			
2214	30-year FRM loans[6]	360			
2216	7-yr Balloon loans	84			

Firm Commitments to Purchase or Sell MBS

Contract Code	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
2042	1-mo COFI ARM MBS	358	10 mo	500 bp	500 bp
2044	1-yr COFI ARM MBS	358	4	500	500
2046	1-yr Treas ARM MBS	358	10	600	600
2048	3-yr Treas ARM MBS	358	10	600	600
2050	7-yr Balloon MBS	82			
2052	15-yr Fixed-rate MBS	178			
2054	30-yr Fixed-rate MBS[6]	358			
2056	7-yr Balloon MBS	82			
2062	1-mo COFI ARM MBS	358	10 mo	500 bp	500 bp
2064	1-yr COFI ARM MBS	358	4	500	500
2066	1-yr Treas ARM MBS	358	10	600	600
2068	3-yr Treas ARM MBS	358	10	600	600
2070	7-yr Balloon MBS	82			
2072	15-yr Fixed-rate MBS	178			
2074	30-yr Fixed-rate MBS[6]	358			
2076	7-yr Balloon MBS	82			

Table 7.C.3 - continued

Assumed Characteristics of Firm Commitments to Purchase, Sell, or Originate Mortgages

Firm Commitments to Purchase or Sell Mortgage Loans

Contract Code	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
2002	1-mo COFI ARM loans	360	12 mo	500 bp	500 bp
2004	1-yr COFI ARM loans	360	6	500	500
2006	1-yr Treas ARM loans	360	12	600	600
2008	3-yr Treas ARM loans	360	12	600	600
2010	7-yr Balloon loans	84			
2012	15-year FRM loans	180			
2014	30-year FRM loans[6]	360			
2016	7-yr Balloon loans	84			
2022	1-mo COFI ARM loans	360	12 mo	500 bp	500 bp
2024	1-yr COFI ARM LOANS	360	6	500	500
2026	1-yr Treas ARM LOANS	360	12	600	600
2028	3-yr Treas ARM LOANS	360	12	600	600
2030	7-yr Balloon LOANS	84			
2032	15-yr FRM loans	180			
2034	30-yr FRM loans[6]	360			
2036	7-yr Balloon loans	82			
2102	1-mo COFI ARM loans	360	12 mo	500 bp	500 bp
2104	1-yr COFI ARM loans	360	6	500	500
2106	1-yr Treas ARM loans	360	12	600	600
2108	3-yr Treas ARM loans	360	12	600	600
2110	7-yr Balloon loans	84			
2112	15-yr Fixed-rate loans	180			
2114	30-yr Fixed-rate loans[6]	360			
2116	7-yr Balloon loans	84			
2122	1-mo COFI ARM loans	360	12 mo	500 bp	500 bp
2124	1-yr COFI ARM loans	360	6	500	500
2126	1-yr Treas ARM loans	360	12	600	600
2128	3-yr Treas ARM loans	360	12	600	600
2130	7-yr Balloon loans	84			
2132	15-yr Fixed-rate loans	180			
2134	30-yr Fixed-rate loans[6]	360			
2136	7-yr Balloon loans	84			

Firm Commitments to Purchase or Sell Mortgage Derivative Products (MDPs)

2081	purchase low-risk floating-rate MDPs
2082	purchase low-risk fixed-rate MDPs
2084	sell low risk floating-rate MDPs
2086	purchase high-risk MDPs
2088	sell high-risk MDPs

Section 7.D - Optional Commitments to Purchase or Sell Mortgages and MBS

Schedule CMR Line Numbers

Optional commitments to purchase or sell mortgage instruments are reported on the off-balance sheet page(s) of Schedule CMR and have a contract code between 3000 and 3999. (Table 7.D.2 near the end of this section lists these contract codes and the types of instruments they represent.)

In addition to a contract code that identifies the nature of the optional commitment, Schedule CMR also collects the amount of the commitment, the number of days until it expires, the coupon rate or pass-through rate of the underlying mortgage instrument, and the strike price.

Description of Instruments

Optional commitments to purchase mortgages or MBS are contracts that grant the holder of the option the right, but not the obligation, to buy a specified type and amount of mortgages or MBS, with a specified WAC (for mortgages) or pass-through rate (for MBS), at a specified price (called the "strike price"), on a specified date (called the "expiration date"). Optional commitments to sell mortgages or MBS are contracts that grant the holder of the option the right, but not the obligation, to sell a specified type and amount of mortgage or MBS, with a specified WAC or pass-through rate, at a specified price, on a specified date.

Valuation Methodology

Method

The Model values separately each position in optional commitments to purchase or sell mortgages or mortgage securities reported on Schedule CMR. It uses Black's (1976) formula described in Section 7.A and the "look-up" table of mortgage or MBS prices that is appropriate for the contract being valued. (The creation of the mortgage look-up tables is described in Chapter 5.)

When the Model encounters a particular optional commitment contract code in the off-balance sheet data reported by an institution, it values the contract using the following four steps. First, it determines the type of option and the type of underlying instrument based upon the contract code. Second, the Model determines the price of the underlying mortgage or MBS in each of the 9 scenarios by "looking up" prices in the appropriate price table, using the same type of approach described in Section 5.A for fixed-rate mortgages and in Section 5.F for ARMs. Third, these prices and other appropriate parameter values are substituted into Black's (1976) formula to determine the price of the optional commitment in each rate scenario. Finally, the value of the commitment is calculated for each rate scenario by multiplying the price in that scenario by the commitment balance reported by the institution.

Assumptions About Underlying Mortgage Instruments

In general, the Model assumes that MBS are the underlying instruments for optional commitments to buy and that whole mortgage loans underlie optional commitments to sell. The specific characteristics used to estimate the value of those underlying instruments are determined as follows.

<u>Fixed-Rate Mortgages</u>

Contract codes involving fixed-rate mortgage (FRM) instruments apply to more than one specific type of mortgage (e.g., contract code 3012 applies to 10-, 15-, and 20-year FRMs). In "looking up" prices for the mortgages underlying each reported contract, the Model assumes all underlying mortgages are of a single type (e.g., for contract code 3012, all mortgages are assumed to be 15-year fixed-rate MBS). See Table 7.D.3 for a list of the types of mortgages assumed to underlie each contract code. The weighted average coupon reported for the underlying mortgage instrument is reduced by 10 basis points to represent the assumed cost of carry. Prices for each scenario are then looked up based on this adjusted weighted average coupon and the assumed maturities listed in Table 7.D.3.

Adjustable-Rate Mortgages

The Model assumes a particular type of ARM underlies each contract code (see Table 7.D.3). Because ARM prices depend on a number of characteristics in addition to coupon and maturity (e.g., margin, caps, floors), the look-up process is somewhat more complicated than for FRMs.

The only characteristic of the underlying mortgages that is reported is the WAC, the others are assumed. The Model assumes that the margin, periodic cap, and periodic floor characteristics of the mortgages underlying a particular ARM commitment resemble those of the comparable ARMs held by the reporting institution in its portfolio. (For example, if the institution's 1-year Treasury ARMs are reported to have a weighted average margin of 275 basis points, the ARMs underlying contract code 3026 [long option to sell 6-month or 1-year Treasury ARMs] are assumed also to have margins of 275 basis points.) Values assumed by the Model for the other characteristics needed to determine underlying ARM prices are shown in Table 7.D.3. As it does for FRMs, the Model reduces the reported weighted average coupon by the assumed 10 basis points cost of carry.

Next, based upon the various characteristics ascribed to the ARMs underlying the reported position, the Model uses the approach described in Section 5.J to disaggregate the commitment balance into sub-balances that are consistent with the weighted average characteristics. It then determines the 9 scenario prices for each sub-balance using the appropriate ARM price table, as described in Section 5.K. Finally, the Model calculates the price of the entire ARM commitment balance (within each scenario) as the weighted average of the sub-balance prices.

Applying Black s (1976) Formula

Black's (1976) formula, described in Section 7.A, is used to estimate the price of the optional commitment for each scenario. The price (as calculated above) of the commitment's underlying mortgage instruments is substituted into the formula as the forward price (the F variable). The reported strike price of the commitment is substituted into the X variable, and the reported time until the commitment's expiration is substituted into the T variable. For the volatility variable, (insert Greek sigma), the Model uses an estimate of the historical price volatility of the underlying type of mortgage instrument. Finally, the Model determines the appropriate risk-free rate (the r variable) for each scenario. In the base case, the risk free rate is represented by the zero-coupon Treasury yield whose maturity corresponds to the time to expiration of the optional commitment. In the alternate rate scenarios, the amount of the appropriate rate shock is added to or subtracted from the base case Treasury yield.

Valuing the Reported Position

The value of the reported optional commitment position in a particular scenario is calculated by multiplying the commitment balance reported by the institution by the price determined for that scenario using Black's formula.

The calculated values of all reported optional commitments to buy or sell mortgages or MBS are aggregated by interest rate scenario and are presented in the Off-Balance-Sheet Positions section of the IRR Exposure Report in the line labeled "Options on Mortgages & MBS."

Example: Calculating the Value of an Optional Commitment

Suppose that an institution reported an optional commitment (contract code 3032) involving $20 million of mortgages with a WAC of 7.10% and a price of par, and that the commitment expires in 30 days. Suppose that the 1-month zero-coupon Treasury yield on the quarter-end date was 3.03% and that the historical volatility of these mortgage prices was 6%. This commitment would have a value of $18,445 in the base case and a value of $468,063 in the +100 bp scenario. These values were calculated as follows.

First, the Model assumes that contract code 3032 represents an optional commitment to sell whole 15-year fixed-rate mortgage loans (i.e., the institution holds a long put option on $20 million of 15-year mortgages).

Second, the price of the underlying mortgages in each of the 7 scenarios is determined by referring to the 15-year FRM price table, an excerpt of which is shown in Table 7.D.1. The Model looks up the underlying mortgages using a WAC of 7.00% (i.e., the reported coupon less 10 basis points to adjust for the cost of carry) and assumes that the loans to be sold will have a WARM of 180 months. The table contains prices for a mortgage with those characteristics in the line indicated by the arrow. The price of the underlying mortgages, adjusted for the cost of carry, is taken to be 102.19 in the base case scenario and 97.72 in the +100 bp scenario.

Third, Black s (1976) formula is used to determine the price of the optional commitment in each scenario. The formula for a put option on a forward contract is written as:

$$P = e^{-rT}\left[X\,N\left(-D_f + s\sqrt{T}\right) - F\,N\left(-D_f\right)\right]$$

where:

$$D_f = \frac{\ln\left(\frac{F}{X}\right) + \left(\frac{s^2 T}{2}\right)}{s\sqrt{T}}$$

In the base case, F, the forward price of the underlying mortgages, is 1.0219 and, r, the risk-free rate is 0.0303, while in the +100 bp scenario, F is 0.9772 and r is 0.0403. The values of the remaining variables are constant in both scenarios. The strike price, X, is 1.0000, since the reported price was par. The time to expiration, T, is 0.0833 (= 1 month/ 12 months) and the volatility, s , of these mortgage prices is assumed to be 0.0600.

For the base case scenario, the price is calculated as:

$$D_f = \frac{\ln\left(\frac{F}{X}\right) + \left(\frac{s^2 T}{2}\right)}{s\sqrt{T}} = \frac{\ln\left(\frac{1.0219}{1.0000}\right) + \left(\frac{0.0600^2(0.0833)}{2}\right)}{0.600\sqrt{0.0833}} = 1.2597$$

$$N(-D_f) = N(-1.2597) = 1 - N(1.2597) = 1 - 0.8961 = 0.1039$$

$$N\left(-D_f + s\sqrt{T}\right) = N(-1.2423) = 1 - N(1.2423) = 1 - 0.8929 = 0.1071$$

$$P = e^{-rt}\left[XN\left(-D_f + s\sqrt{T}\right) - FN(-D_f)\right] = e^{-0.0303(0.0833)}\left[1.0000(0.1071) - 1.0219(0.1039)\right] = 0.0009223$$

Example: Calculating the Value of an Optional Commitment - continued

For the +100 basis point scenario (using F = 0.9772 and r = 0.0403):

$$D_f = 1.3229, N(-D_f) = .9071, N\left(-D_f + s\sqrt{T}\right) = .9099, \text{and}$$

$$P = e^{-.0403(.0833)}\left[1.0000\,(.9099) - .9772\,(.9071)\right] = .02340$$

Fourth, the value of the commitment is calculated for each rate scenario as the product of the commitment balance reported by the institution and the price of the optional commitment in that scenario. In the base case, the value of the position is, therefore, $18,445 (= $20 million ž 0.0009223), while in the +100 bp scenario it is $468,063 (= $20 million ž 0.02340).

Table 7.D.1

Excerpt from Price Table for 15-Year Fixed-Rate Mortgage Loans

(Percentage of Underlying Balance)

WAC	WARM	Interest Rate Shock (bp)						
(%)	(mo)	-300	-200	-100	0	+100	+200	+300
6.50	36	104.84	104.00	103.09	101.84	100.47	99.08	97.70
6.50	60	105.86	104.87	103.75	101.93	99.86	97.75	95.67
6.50	90	106.50	105.42	104.11	101.72	98.91	96.06	93.27
6.50	120	106.83	105.73	104.27	101.40	98.00	94.56	91.21
6.50	144	107.01	105.88	104.32	101.13	97.33	93.51	89.82
6.50	160	107.09	105.96	104.34	100.95	96.93	92.89	89.00
6.50	180	109.15	107.28	104.82	100.71	96.07	91.49	87.13
7.00	36	105.15	104.28	103.42	102.26	100.92	99.55	98.17
7.00	60	106.24	105.20	104.19	102.57	100.56	98.47	96.39
7.00	90	106.92	105.79	104.66	102.57	99.88	97.06	94.27
7.00	120	107.28	106.11	104.90	102.44	99.19	95.79	92.45
7.00	144	107.46	106.27	105.01	102.30	98.68	94.90	91.21
7.00	160	107.55	106.35	105.06	102.20	98.36	94.38	90.49
7.00	180	109.86	107.94	105.82	102.19	97.72	93.17	88.78
7.50	36	105.52	104.63	103.79	102.74	101.45	100.09	98.72
7.50	60	106.70	105.63	104.67	103.26	101.36	99.30	97.23
7.50	90	107.43	106.26	105.23	103.49	100.96	98.19	95.42
7.50	120	107.82	106.60	105.53	103.53	100.50	97.18	93.85
7.50	144	108.02	106.78	105.68	103.50	100.15	96.46	92.79
7.50	160	108.12	106.87	105.75	103.47	99.93	96.04	92.17
7.50	180	110.72	108.76	106.85	103.76	99.54	95.04	90.64

Table 7.D.2
Contract Codes for Optional Commitments to Purchase or Sell Mortgages or Mortgage Securities

Long Option to Buy	Long Option to Sell	Short Option to Buy	Short Option to Sell	Underlying Instrument
3002	3022	3042	3062	1-month COFI ARMs
3004	3024	3044	3064	6-month or 1-year COFI ARMs
3006	3026	3046	3066	6-month or 1-year Treasury ARMs
3008	3028	3048	3068	3-year or 5-year Treasury ARMs
3010	3030	3050	3070	5-year or 7-year Balloon or 2-step mortgages
3012	3032	3052	3072	10-, 15-, or 20-year fixed-rate mortgages
3014	3034	3054	3074	25- or 30-year fixed-rate mortgages
3016	3036	3056	3076	All other mortgages

Table 7.D.3
Assumed Characteristics of Mortgage Instruments Underlying Reported Optional Commitments

Option to BUY Mortgages or MBS
(Interpreted as option to buy MBS)

Underlying Instrument:	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
1-mo COFI ARMs	1-mo COFI ARM	358 mo	10 mo	500 bp	500 bp
6-mo or 1-yr COFI ARMs	1-yr COFI ARM	358	4	500	500
6-mo or 1-yr Treasury ARMs	1-yr Treas ARM	358	10	600	600
3- or 5-yr Treasury ARMs	3-yr Treas ARM	358	10	600	600
5- or 7-yr Balloons/2-Step	7-yr Balloon	82			
10-, 15-, or 20-yr FRMs	15-year FRM	178			
5- or 30-yr FRMs	30-year FRM[1]	358			
All other mortgages	7-yr Balloon loans	82			

Option to SELL Mortgages or MBS
(Interpreted as option to sell mortgage loans)

Underlying Instrument:	Proxy Mortgage	WARM	Paymt Reset	Dist to Life Cap	Dist to Life Flr
1-mo COFI ARMs	1-mo COFI ARM	360 mo	12 mo	500 bp	500 bp
6-mo or 1-yr COFI ARMs	1-yr COFI ARM	360	6	500	500
6-mo or 1-yr Treasury ARMs	1-yr Treas ARM	360	12	600	600
3- or 5-yr Treasury ARMs	3-yr Treas ARM	360	12	600	600
5- or 7-yr Balloons/2-Step	7-yr Balloon	84			
10-, 15-, or 20-yr FRMs	15-yr FRM	180			
5- or 30-yr FRMs	30-yr FRM[2]	360			
All other mortgages	7-yr Balloon	84			

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1 Consists of same proportions of securities backed by conventional 30-year fixed-rate mortgages and securities backed by FHA/VA 30-year fixed-rate mortgages as reported in the institution's mortgage securities portfolio (CMR026 through CMR030 and CMR046 through CMR050).

2 Consists of same proportions of conventional and FHA/VA-insured 30-year fixed-rate mortgage loans as reported in the institution's loan portfolio.

Section 7.E – Interest-Rate Swaps

Schedule CMR Line Numbers

Each swap position is reported based on a contract code. A maximum of 16 positions can be reported in CMR801 - CMR880, and up to 1,000 positions can be reported on the Optional Supplemental Reporting for Financial Derivatives and Off-Balance-Sheet Positions section of Schedule CMR. For a list of available contract codes, see Schedule CMR Instructions, Appendix B.

Each position is valued separately based on the following data that are reported on Schedule CMR: contract code, notional amount, termination date (and effective date for forward swaps), swap coupon (for fixed-for-floating swaps), and margin, if relevant.

Description of Instruments

Swaps are agreements between two parties, called counterparties, to exchange payments on the basis of some quantity of money (called notional principal). One or both of the payment streams varies with a specified interest rate index.

The types of interest-rate swaps valued by the NPV Model include:

- Fixed-for-floating amortizing and non-amortizing swaps,
- Amortizing and non-amortizing basis swaps,
- Mortgage swaps, and
- Forward swaps.

Valuation Methodology

The Model uses a discounted cash flow approach to value swaps. The present value of the two sides of a swap are calculated separately and the value of the swap is the difference between the value received and the value paid. The valuation procedure used in the Model assumes that no payments of notional principal are made by the counterparties.

Valuation of a Swap or Forward Swap

To value a swap, the Model calculates separately the present value of each side of the transaction. The swap's value is calculated as the difference between the value received and the value paid. The present value calculation for the received (or paid) side of a swap is shown in Equation 7.E.1.

Equation 7.E.1 - Present Value Equation for One Side of Swap

$$PV = \left(B_E \cdot RATE_E \cdot df_E\right) + \left(B_{E+F} \cdot RATE_{E+F} \cdot df_{E+F}\right) + \left(B_{E+2F} \cdot RATE_{E+2F} \cdot df_{E+2f}\right) + \ldots + \left(B_T \cdot RATE_T \cdot df_T\right)$$

where:

where:	PV	=	present value of one side of a swap
	E	=	month of the first payment
	T	=	termination month, i.e., the month of the last payment
	F	=	payment frequency, i.e., the number of months between payments
	B_t	=	remaining notional principal amount in month t
	$RATE_t$	=	rate that determines the payment amount in month t (in decimal form)
	df_t	=	discount factor applicable to month t

Balances (B_t)

For nonamortizing swaps, the balance in any month t (B_t) is equal to the reported notional principal amount. For amortizing swaps (including mortgage swaps), balances are assumed to amortize following a straight-line amortization schedule.

Rates ($RATE_t$)

The rate on the fixed side of a swap or forward swap is calculated based on the reported swap coupon (COUPON) and the number of months between payments (F):

$$RATE_t = \left(\frac{F}{12}\right) \cdot COUPON, \text{ for } t = E, E+F, E+2F, \ldots, T$$

The rate on the floating side(s) of a swap or forward swap is calculated based on the index rate in effect the prior payment date plus the reported margin (if any):

$$RATE_t = \left(\frac{F}{12}\right) \cdot \left(INDEX_{t-F} + MARGIN\right), \text{ for } t = E, E+F, E+2F, \ldots, T$$

The index rate used to calculate the first payment is based on historical value for the index rate. The index rates for subsequent payments are equal to the implied-forward rates for the index for each of the appropriate months.[1]

Discount Factors (df_t)

In general, a swap's cash flows are discounted by the zero-coupon index rate applicable to the month each cash flow will be received.[2] Thus, for example, both sides of a swap indexed to LIBOR are discounted by zero-coupon LIBOR. Swaps indexed to rates that do not have a term structure (e.g., the prime rate) are discounted by zero-coupon LIBOR rates. If the floating side of a swap pays according to an index plus a margin (e.g., 3-month LIBOR plus 100 basis points), the margin is reported in Schedule CMR and is used in calculating the discount factors.

Discount factors are calculated as shown in Equation 7.E.2.

Equation 7.E.2 - Discount Factors for Swaps

$$df_t = \frac{1}{\left(1 + s_t + MARGIN\right)^t}$$

where:
- df_t = present value factor for month t
- s_t = spot rate applicable to month t (in decimal, monthly form)
- MARGIN = reported margin, if any (in monthly, decimal form)

1 See Chapter 8 for a description of how the implied-forward rates are derived.

2 See Chapter 8 for a description of how zero-coupon rates are derived for rates with a term structure.

Termination Date (T)

The month of the last payment (T) is determined based on the reported termination date. For example, assume an institution reports for the March 1994 cycle a swap with a termination date equal to 9906 (i.e., the swap terminates in June, 1999). Then, T = 63 (i.e., 63 = (99 - 94) x 12 + (6 - 3)).

Payment Frequency (F)

Assumptions are made about the payment frequency (F) because it is not reported on Schedule CMR. In general, swaps indexed to a rate that has a term structure (i.e., swaps indexed to Treasury, LIBOR, or certificate of deposit rates) are assumed to have a payment frequency equal to the term of the index. For example, a pay-fixed, receive 6-month LIBOR swap is assumed to have semi-annual payments (i.e., F = 6). If the term of the index is longer than 1-year, however, the payment frequency is assumed to be annual (i.e., F = 12). Fixed-for-floating swaps indexed to the prime rate are assumed to have quarterly payments (i.e., F = 3).

First Payment Date (E)

For swaps, the month of the first payment (E) is calculated based on T and F as follows:

$$E = T - F \cdot \text{Integer}\left(\frac{T}{F}\right)$$

For example, assume the payment frequency of the swap in the example above is F = 6 (months). Then, E = 3 (i.e., 3 = 63 - 6 · Integer [63/6] = 63 - 6 x 10).

For forward swaps, the month of the first payment (E) is calculated as the reported effective date (i.e., the date the swap begins), minus the current date, plus the payment frequency (F). For example, assume an institution reports for the March 1994 cycle a forward swap with an effective date equal to 9409 (i.e., the swap begins in September, 1994) and a payment frequency of 6 months. Then, E = 12 (= 9 - 3 + 6).

Section 7.F - Interest Rate Caps and Floors

Schedule CMR Line Numbers

Interest rate caps are reported on the financial derivatives and off-balance sheet page(s) of Schedule CMR using a contract code between 6000 and 6999. Interest rate floors are reported using a contract code between 7000 and 7999. (See Table 7.F.1 at the end of this section for a list of contract codes and the types of contracts they represent.)

In addition to a contract code that identifies the nature of the cap or floor contract and the interest rate index on which it is based, Schedule CMR also collects the notional principal, the expiration date of the contract[1], and the strike rate.

Description of Instruments

An interest rate cap is a contract for which the seller of the contract pays to the buyer, on specified dates, any excess of a specified interest rate index above a specified strike rate, multiplied by a given amount of notional principal. Interest rate floors are similar to caps, but the seller pays when the index rate is less than the strike rate, with the payment being equal to the product of the notional principal and the difference between the two rates.

Valuation Methodology

Method

Each position in interest rate caps or floors reported on Schedule CMR is valued separately. The value of a cap (or floor) is estimated as the sum of the values of a series of call options (or put options) on an interest rate, using Stapleton and Subrahmanyam s modification of Black s (1976) formula.[2] This modification prevents interest rates from assuming values of less than zero.

The following sequence of events is assumed to occur for all reported caps and floors. On the exercise date of each component option, the index rate observed that day is compared to the strike rate to determine whether a payment is due the holder of the option. If the option is in-the-money on that date (i.e., the index rate exceeds the cap rate or is below the floor rate) a payment is computed as:

$$\left| (\text{index} - \text{strike}) \right| \cdot \left(\frac{\text{days in period}}{360} \right) \cdot (\text{Notional Amount})$$

where: $|\cdot|$ = absolute value function

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1 Two other types of contracts, forward caps and forward floors can also be reported. These are simply agreements that a cap or a floor contract will go into effect on a specified future date. For forward contracts, the date the contract commences is also reported on Schedule CMR.

2 F. Black, “The Pricing of Commodity Contracts,” *Journal of Financial Economics*, 3, January-March 1976, pp. 167-179. For a description of the application of Black’s (1976) model see R. Stapleton and M. Subrahmanyam, “Interest Rate Caps and Floors,” in *Financial Options: From Theory to Practice*, S. Figlewski, W. Silber, and M. Subrahmanyam, ed., 1990, pp. 220-280.

Valuation of the Component Options

The sequence of options comprising a cap or floor are assumed to expire at regular intervals that correspond to the maturity of the interest rate to which the instrument is indexed.[3] Any payment due to be made to the option holder is made one period in arrears, rather than immediately upon the availability of the index. The price of each of the options is calculated using the Black (1976) formula which requires, among other inputs, the price (F) of the forward contract on which the option is written, the strike price (X), and the price volatility (s) of the forward contract, which is estimated from the volatility of interest rates.

Forward Price

The forward contract that implicitly underlies each component option of a cap (or floor) is an agreement to buy (or sell) - on the exercise date of the option - a discount bill with a face value of $1, paying interest at the rate to which the cap (or floor) is indexed, and with a term equal to the maturity of that interest rate. (For example, the first component option of an interest rate cap written on 3-month LIBOR implicitly gives the holder the intrinsic value of an option for a bill maturing 3 months after the cap s first exercise date. The difference in the price of the bill and the strike price results in the same payment as simple interest computed at the 3-month LIBOR in effect on the exercise date times the actual days/360.)

At the exercise date, T, of a particular component option of a cap (or floor), the forward price of the underlying forward contract is calculated using Equation F.1. On the reporting date (i.e., at time t = 0), that price represents the T-months-forward price of a bill with maturity equal to m.

Equation 7.F.1 - Forward Price

$$F_T = \frac{1}{\left(1 + f_T \cdot m\right)}$$

where: F_T = forward price at time T of a $1 face value discount bill maturing at time (T+m) and paying interest at the rate of f_T

m = time until maturity of the bill

f_T = implied m-period forward rate at time T

Strike Price

At the same date (T), the option holder has the right to purchase the bill at the strike price, which is expressed as the forward price of the bill evaluated at the strike rate (x), as shown in Equation 7.F.2.

Equation 7.F.2 - Strike Price

$$X = \frac{1}{(1 + x \cdot m)}$$

where: X = forward price at option exercise date of a $1 face value discount bill with maturity

x = strike rate (in annual, decimal form)

[3] Contracts indexed to interest rates of 6-month maturity or greater (e.g., 6-month LIBOR caps) are assumed to be evaluated every 6-months. All others (including those indexed to COFI and Prime) are assumed to be evaluated every 3 months.

For bill prices to be used in the option pricing formula would require assuming that bill prices follow a geometric random walk and have a lognormal probability distribution.[4] Such an assumption would imply that interest rates have a normal distribution, which is objectionable for two reasons. First, a normal distribution would permit interest rates to have negative values. Second, it would cause the absolute volatility of interest rates to remain the same no matter what the level of interest rates.

A simple modification allows the model to capture the effect of lognormally distributed interest rates - which is a preferable assumption - by assuming that the bankers discount rate (which equals 1 minus the price of the discount bill) is lognormally distributed.[5] Rather than substituting FT and X directly into the option pricing formula, therefore, the forward price of the bill (FT) is transformed into (1-FT) and the strike price (X) is transformed into (1-X) before being substituted into the formula.

Expected Volatility

In Stapleton and Subrahmanyam s modification of Black s (1976) formula, the forward price and strike price are transformed to bankers discount rates. The volatility parameter, s_y, used in the formula is calculated from the volatility of the forward prices, s , as shown in Equation 7.F.3.

Equation 7.F.3 - Yield Volatility

$$s_y = s \cdot \frac{F_T}{\left(1 - F_T\right)}$$

Time to Expiration and Riskless Rate

As for the remaining two parameters in the option pricing formula, the time until the exercise date of the component option is substituted into the formula for the variable T, and the T-month Treasury zero-coupon yield is substituted into the formula for the riskless rate, r_T.

Valuation of the Total Cap or Floor

Prices of each component option of the cap or floor are estimated by substituting the appropriate parameter values into the Black (1976) formula as described above.[6] The price of the total cap or floor is calculated by summing the prices of the components.

The NPV Model adds one additional component to the price of the cap or floor. The Model assumes that caps and floors reported on Schedule CMR have existed long enough to have reached at least one exercise date. Hence, a payment may be due the option holder as a result of the cap or floor being in-the-money on the most recent exercise date (since such payments are assumed to be due at the next exercise date). To calculate the amount of payment due, if any, the Model determines whether the index rate exceeded the cap rate, or fell below the floor rate, at the most recent exercise date. If so, the present value of the scheduled payment, per dollar of notional principal, is calculated using to Equation 7.F.4 and is added to the aggregate price of the component options of the cap or floor.

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4 That assumption implies that the relative volatility of bill prices remains the same, while the absolute volatility changes with the level of the bill price.

5 This refinement is described in the article by R. Stapleton and M. Subrahmanyam, cited in footnote 2, above.

6 In estimating prices in the alternate rate scenarios, two changes are made. First, the forward price, FT, for a particular scenario is calculated using the forward rates applicable to that scenario. (See Chapter 8 for a description of how implied forward rates are determined in the alternate rate scenarios.) Second, the amount of the relevant rate shock is added to, or subtracted from, r_T, the riskless rate.

Equation 7.F.4 - Present Value of Payment Due From Most Recent Exercise Date

$$CF_T = \begin{cases} \dfrac{m \cdot \left[\max\left(rate_{T-m} - x, 0\right)\right]}{\left(1 + rate_t \cdot m\right)}, & \text{for a cap} \\[2ex] \dfrac{m \cdot \left[\max\left(x - rate_{T-m}, 0\right)\right]}{\left(1 + rate_t \cdot m\right)}, & \text{for a floor} \end{cases}$$

where:

CF_T	=	payment owed option holder as a result of most recent exercise date (and payable at next exercise date, at time = T
$rate_{T\text{-}m}$	=	index rate on latest exercise date (in annual, decimal terms)
T	=	time until next exercise date
m	=	time between exercise dates
x	=	strike rate (in annual, decimal terms)

Once the price of the reported cap or floor has been estimated, the value of a long position in that cap or floor is calculated by multiplying the reported notional principal amount by the price. If the reporting institution has a short position in the cap or floor, the value is multiplied by negative one.

The calculated values of all reported caps are aggregated by interest rate scenario (i.e., long and short positions are netted) and are presented in the Off-Balance-Sheet Positions section of the IRR Exposure Report (page 6) in the line labeled, Interest Rate Caps. Similarly, the aggregate value of all reported floors are reported in the line labeled, Interest Rate Floors.

Example: Calculation of the Value of a Cap s Component Options

Suppose that at the end of March an institution reports a long position in a 6-month LIBOR interest rate cap (contract code 6004), with a cap rate of 6.00%, and an expiration date 3 years away. Assume volatility is 1% per year.

The cap consists of five options (caplets), which are exercisable at the end of six months (183 days), 12 months (365 days), 18 months (548 days), 24 months (730 days), and 30 months (973 days). The first caplet is on 182 day LIBOR, the second on 183 day LIBOR, the third on 182 day LIBOR, the fourth on 183 day LIBOR, and the fifth on 182 day LIBOR. Let T_i denote the time in years to each caplet s exercise date and let m_i be the period over which each 6-month rate is applicable. The value of T_i and m_i for each caplet are as follows:

T1 = 183/365	m1 = 182/365
T2 = 365/365	m2 = 183/365
T3 = 548/365	m3 = 182/365
T4 = 730/365	m4 = 183/365
T5 = 913/365	m5 = 182/365

Now suppose that the LIBOR term structure is as shown in the table below. LIBOR zero-coupon bond prices (B_0,T) observed in the market for maturities up to three years are shown in column [2] and are converted into discount yields in column [3]. The prices and yields of the bond with maturity T_i+m_i are shown in columns [4] and [5].

Example: Calculation of the Value of a Cap s Component Options - continued

[1] Maturity (in days)	[2] Bond Price $B_{0,T}$	[3] Discount Yield	[4] Bond Price $B_{0,T+m}$	[5] Discount Yield
183	0.9704	0.0296	0.9418	0.0582
365	0.9418	0.0582	0.9139	0.0861
548	0.9139	0.0861	0.8869	0.1131
730	0.8869	0.1131	0.8606	0.1394
913	0.8606	0.1394	0.8353	0.1647
1035	0.8353	0.1647		

Column [6] shows the exercise (or strike) price, which is calculated using equation F.2:

$$x = \frac{1}{1 + x \cdot m}$$

Since LIBOR is quoted on a 360 day year, the exercise price of the first caplet is calculated as:

$$x = \frac{1}{1 + 0.06 \cdot \dfrac{182}{360}} = 0.9705$$

Forward yields implied by the zero-coupon prices above are calculated as:

$$f_{T,T+m} = \left(\frac{1 + b_{0,T+m}}{1 + b_{0,T}} \right) - 1$$

where: $b_{0,T} = \dfrac{1}{B_{0,T}} - 1$

$b_{0,T+m} = \dfrac{1}{B_{0,T+m}}$

For our example these are:

$$b_{0,T} = \frac{1}{0.9704} - 1 = 0.0305$$

$$b_{0,T+m} = \frac{1}{0.9418} - 1 = 0.0618$$

$$f_{T,T+m} = \left(\frac{1 + 0.0618}{1 + 0.0305} \right) - 1 = 0.03037$$

Forward prices can be determined from the forward yields by the following relationship:

$$F_{T,T+m} = \frac{1}{1 + f_{T,T+m}}$$

Example: Calculation of the Value of a Cap s Component Options - continued[7]

For the first caplet this is:

$$F_{T,T+m} = \frac{1}{1 + 0.03037} = 0.9705$$

or, alternatively, it may be calculated directly from the bond prices

$$F_{T,T+m} = \frac{B_{0,T+m}}{B_{0,T}} = \frac{0.9418}{0.9704} = 0.9705$$

[1] Maturity (in days)	[6] Exercise Price X	[7] Discount Yield	[8] Forward Price $F_{T,T+m}$	[9] Discount Yield
183	0.9705	0.0295	0.9705	0.0295
365	0.9704	0.0296	0.9704	0.0296
548	0.9705	0.0295	0.9705	0.0295
730	0.9704	0.0296	0.9704	0.0296
913	0.9705	0.0295	0.9705	0.0295
1035				

Each caplet is a put option, so Black s (1976) formula for valuing put options is 7.

$$P = e^{-rT}\left\{X^{y}\left[1 - N\left(D_2\right)\right] - F^{y}{}_{T,T+m}\left[1 - N\left(D_1\right)\right]\right\}$$

where:

$$D_1 = \frac{\ln\left(\frac{F^{y}{}_{T,T+m}}{X^{y}}\right) + \frac{s^{2}{}_{y}T}{2}}{s_{y}\sqrt{T}}$$

D_2 = $D_1 - s_y\sqrt{T}$

P = price of put caplet

r = the riskless rate

X^y = exercise price in yield form

$F^{y}{}_{T,T+m}$ = forward yield for period of length m starting at time

$N(\cdot)$ = cumulative normal distribution

σ_y = volatility of yields

ln = natural logarithm

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7 In substituting discount yields for the exercise price and the forward price, this formula reflects the modification suggested by Stapleton and Subrahmanyam described above.

Example: Calculation of the Value of a Cap s Component Options - continued

Following Stapleton and Subrahmanyam, we assume that LIBOR approximates the riskless rate, and e-rt=B0,T. Price volatility is transformed to yield volatility by multiplying it by the ratio of the forward price to the discount yield:

$$s_y = s \cdot \frac{R_{T,T+m}}{F^y_{T,T+m}} = 0.01 \cdot \frac{0.9705}{0.0295} = 0.329374$$

[1] Maturity	[10] Price Volatility	[11] Yield Volatility	[12] D_1	[13] D_2	[14] P
183	0.01	0.329274	0.101765	-0.06332	0.00006
365	0.01	0.327448	0.08135	-0.2461	0.00022
548	0.01	0.329274	0.065841	-0.42852	0.00049
730	0.01	0.327448	0.063583	-0.59131	0.00083
913	0.01	0.329274	0.056458	-0.76718	0.00123
1095					
				Total	0.00283

Substituting the values for the first caplet into Black s formula, the value of the caplet is calculated as:

$$P = B_{0,T}\left\{X^y\left[1-N\left(D_2\right)\right] - F^y_{T,T+m}\left[1-N\left(D_1\right)\right]\right\}$$

$$= 0.9704\left\{0.0294\left[1-N\left(-0.03274\right)\right] - 0.0295\left[1-N\left(0.049124\right)\right]\right\}$$

$$= 0.00006 \text{ or } 0.6 \text{ of a basis point}$$

The value of each of the other caplets is calculated in the same way. The results are shown in column [14] of the table. The total value of the cap is the sum of the values of its caplets, which for this example is 28.3 basis points.

Table 7.F.1

Contract Codes for Interest Rate Caps and Floors

Long Cap	Long Floor	Short Cap	Short Floor	Interest Rate Index
6002	7002	6032	7032	1-month LIBOR
6004	7004	6034	7034	3-month LIBOR
6006	7006	6036	7036	6-month LIBOR
6008	7008	6038	7038	3-month Treasury rate
6010	7010	6040	7040	1-year Treasury rate
6012	7012	6042	7042	3-year Treasury rate
6014	7014	6044	7044	5-year Treasury rate
6016	7016	6046	7046	7-year Treasury rate
6018	7018	6048	7048	10-year Treasury rate
6020	7020	6050	7050	11th District COFI
6022	7022	6052	7052	Prime rate

Section 7.G - Futures

Schedule CMR Line Numbers

Futures contracts are reported on the financial derivatives and off-balance sheet page(s) of Schedule CMR and have contract codes between 8000 and 8052. (Table 7.G.1, at the end of this section, lists the contract codes.) The only additional information collected on Schedule CMR is the amount of the contract.

Description of Instruments

Financial futures contracts are agreements to buy or sell financial instruments at a specified price for delivery or settlement at a specified future date. Both parties to futures contracts are obligated to perform on the contract.

Valuation Methodology

Method

The NPV Model assumes the maturity of all reported contracts is the nearest delivery month for that type of contract. For example, for Treasury bill futures contracts reported on the March 31 Schedule CMR, the Model assumes all contracts are for June delivery.

Futures contracts are marked-to-market on a daily basis and cash is paid to, or received from, the futures broker to adjust the position to a value of zero. As a result, all futures contracts have a value of zero in the base case interest rate scenario.

The derivation of the value of a futures contract in the alternate interest rate scenarios differs depending on whether it is a short-term contract (the underlying instrument has a maturity of three months or less), or a long-term contract (the underlying instrument has a maturity of more than three months). Both are described below.

Alternate Interest Rate Scenarios

Short-term Interest Rate Contracts

The price, P, of short-term interest rate futures contracts are quoted on the futures exchanges on an index basis as follows, where i is the annualized yield on the underlying instrument:

$$P = 100 - (i \cdot 100)$$

For example, suppose September T-bill futures are quoted on June 30 at 96.50. That value corresponds to an annualized yield of 3.50 percent.

For each of the short-term futures contracts reported on Schedule CMR, the following steps are used to estimate their economic values in the shocked rate scenarios.

1. The index price, P, for the nearby futures contract[1] is obtained after the close of the market on the quarter-end date.

2. The annualized yield is calculated as in Equation 7.G.1.

Equation 7.G.1 - Annualized Discount Yield for Short-Term Futures Contract

$$i = \frac{(100 - P)}{100}$$

3. The yield in the shocked rate scenarios is calculated as the sum of the yield in the base case plus the interest rate shock (e.g., if i = .04, then i_{+200} = 0.06).

   In low interest rate environments, the shocked yield could become negative. If so, it is set to zero.

4. For short futures positions, the economic value of the contract in each rate scenario is calculated as follows, where m is the number of days to maturity of the underlying instrument.

Equation 7.G.2 - Value of Short Position in Short-Term Futures Contract in Shocked Rate Scenario

$$\text{Value}_{\text{shocked}} = \text{Notional Amount} \cdot \left(i_{\text{shocked}} - i_{\text{base}}\right) \cdot \left(\frac{m}{360}\right)$$

Long positions are valued as the negative of their comparable short positions.

Example: Valuation of a Short Position in a 3-month T-bill Futures Contract

Suppose an institution reported a $1 million short position in 3-month T-bill futures. If the price of the nearby 3-month T-bill future were quoted as 96.50, the implied annualized yield would be 3.50 percent.

The economic value of the short position is calculated in each scenario by multiplying $1,000,000 times the shocked yield less the base case yield, times 91/360 (because the underlying Eurodollar CD future has a maturity of ninety-one days). Note that since the base case yield is 3.50 percent, the shocked yield would be negative in the -400 scenario, and thus is set equal to zero.

-300	-200	-100	base	100	200	300
-7,583	-5,055	-2,528	0	2,528	5,055	7,583

Long-term Interest Rate Contracts

The value of short positions in long-term interest rate futures contracts in the alternate rate scenarios equals the price of the underlying cheapest-to-deliver bond in the base case less the price of the cheapest-to-deliver bond in the alternate rate scenario, per 100 dollars of principal, multiplied by the notional amount. That is:

[1] Most financial futures contracts have expiration months of March, June, September, or December. The nearby contract is the one with the closest settlement date, e.g., in February, the nearby contract would be the one expiring in March.

Equation 7.G.3 - Value of Long-Term Futures Contract in Shocked Rate Scenario

$$\text{Value}_{\text{shocked}} = \frac{\left(P_{\text{base}} - P_{\text{shocked}}\right)}{100} \cdot \text{Notional Amount}$$

(Obtaining the value of the cheapest-to-deliver bond in any rate scenario is discussed in the next section.)

Long positions are valued as the negative of their comparable short positions.

Example: Valuation of a Short Position in a Treasury Bond Futures Contract

Suppose an institution reported a $10 million short position in Treasury bond features and that, at quarter-end, the prices of the cheapest-to-deliver Treasury bonds in each scenario were:

-300	-200	-100	base	+100	+200	+300
149.40	136.16	124.43	113.94	102.15	91.53	82.50

The price of the cheapest-to-deliver bond in the base case minus that in the alternate rate scenarios, per hundred dollars is:

-300	-200	-100	base	+100	+200	+300
-.3546	-.2222	-.1049	0	.1179	.2241	.3144

The $10 million short futures position would have the following values, in millions of dollars:

-300	-200	-100	base	+100	+200	+300
-3.546	-2.222	-1.049	0	1.179	2.241	3.144

Cheapest-to-Deliver Analysis

Prices for futures contracts on long-term instruments are based on the value of a hypothetical underlying bond. Other bonds with maturities and coupons different from those of the hypothetical bond may be substituted at delivery.

For example, the underlying instrument for the Treasury bond futures contract is an 8 percent coupon bond with a 20-year maturity, but any Treasury bond with a maturity exceeding 15 years may be delivered instead.

Because the price of any substitute bond is likely to differ from that of the hypothetical underlying bond, conversion factors set by the exchange are used to adjust the price of the substitute bond. The conversion factor does not completely eliminate price differences between bonds, however, and some bonds are cheaper to deliver on the contract than others. As interest rates change, different bonds become cheapest-to-deliver. Consequently, the futures price depends on the value of the cheapest-to-deliver bond.

The value of long-term interest rate futures contract in the alternate rate scenarios is obtained by performing an analysis of the cheapest-to-deliver security underlying the futures contract. For each long-term contract, the yield curve is shocked by the relevant amount for that rate scenario and the value of the cheapest-to-deliver security in that scenario is obtained.

Table 7.G.1
Contract Codes for Futures

Contract Code	Type of Futures Contract
8002	long 30-day interest rate
8004	long 3-month Treasury bill
8006	long 2-year Treasury note
8008	long 5-year Treasury note
8010	long 10-year Treasury note
8012	long Treasury bond
8014	long 1-month LIBOR
8016	long 3-month Eurodollar
8018	long 3-year Swap
8020	long 5-year Swap
8022	long MBS futures
8032	short 30-day interest rate
8034	short 3-month Treasury bill
8036	short 2-year Treasury note
8038	short 5-year Treasury note
8040	short 10-year Treasury note
8042	short Treasury bond
8044	short 1-month LIBOR
8046	short 3-month Eurodollar
8048	short 3-year Swap
8050	short 5-year Swap
8052	short MBS futures

Section 7.H - Options on Futures

Schedule CMR Line Numbers

Options on futures are reported on the financial derivatives and off-balance sheet page(s) of Schedule CMR and have contract codes between 9000 and 9100. (See Table 7.H.1 for a list of contract codes and the types of contracts they represent.)

In addition to a contract code that identifies the type of option, Schedule CMR also collects the notional principal amount of the position, the expiration date, and the strike price.

Description of Instruments

A call option on a futures contract is an agreement that grants the buyer of the option the right, but not the obligation, to acquire a long position in a futures contract at a specified price (the strike price) within a specified time period. A put option on a futures contract is an agreement that grants the buyer the right, but not the obligation, to acquire a short position in a futures contract at a specified price within a specified time period.

Valuation Methodology

Method

Each option position reported on Schedule CMR is valued separately using a price look up table appropriate for the type of instrument (e.g., 3-month Eurodollar futures options). At each quarter-end, separate tables are created for put and call options for each contract code listed in Table 7.H.1. Prices in each table are calculated for a range of strike prices and expiration dates using Black s (1976) formula, described in Section 7.A.

Calculating Price Tables

In the base case, the prices of all options on a particular futures contract are calculated based on the current price of that futures contract (the F variable in Black s formula), the relevant zero-coupon Treasury yield (the r variable), and an historical price change volatility (i.e., σ)[1]. In each of the alternate interest rate scenarios, the options prices are calculated by substituting into the F variable of the formula the price of the underlying futures contract in the relevant scenario and substituting into the r variable the zero-coupon Treasury yield that has been shocked by the amount appropriate for the rate scenario. All prices are scaled so they express the price of the option as a percentage of the contract amount.

Options involving contracts on short-term underlying assets (e.g., Treasury bill futures, 3-month Eurodollar futures) are treated somewhat differently. Prices of such futures contracts are quoted based on a price index method, where the index equals 100 minus the Treasury bill discount yield. In applying Black s formula to such contracts, the futures price (the F variable) and the strike price (the X variable) are both converted from price index form into discount yields.[2]

[1] As described below, this procedure is modified somewhat for futures options whose underlying instrument is short-term (e.g., Treasury bills).

[2] The discount yield, expressed as a decimal, equals [100 - price]/100.

The NPV Model applies Black s formula in a way that prevents interest rates from assuming negative nominal values.[3] Then in each rate scenario, the futures discount yield appropriate to that scenario is substituted for the F variable and the appropriately shocked zero-coupon Treasury yield is substituted for the r variable.

Separate price tables are created for put and call options on each of the eight types of futures contracts listed in Table 7.H.1. Each line of the table provides prices in the 9 scenarios for various combinations of strike price and contract expiration date. For example, the tables for options on Treasury bond futures provide prices for 20 strike prices (ranging from 90 to 128, in increments of 2) for each of the next four contract expiration dates.

Using the Price Tables

When the NPV Model encounters a particular contract code in the off-balance sheet data reported by an institution, it looks up prices for the reported option in the seven scenarios on the basis of the reported strike price and expiration date. (If the reported information does not match any of the table s strike prices or expiration dates, the nearest line — first, in terms of expiration and then in terms of strike price — is used.) To determine the value of the position in each of the seven scenarios, the Model multiplies the reported notional amount by the price appropriate for that scenario and divides by 100.

The net value of all reported positions in options on futures are aggregated by interest rate scenario and presented in the Off-Balance-Sheet Positions section of the IRR Exposure Report, in the line labeled Options on Futures.

Table 7.H.1

Contract Codes for Options on Futures

Long Call	Long Put	Short Call	Short Put	Underlying Instrument
9002	9026	9050	9074	30-day Fed funds rate futures
9004	9028	9052	9076	3-month Treasury bill futures
9006	9030	9054	9078	2-year Treasury note futures
9008	9032	9056	9080	5-year Treasury note futures
9010	9034	9058	9082	10-year Treasury note futures
9012	9036	9060	9084	Treasury bond futures
9014	9038	9062	9086	1-month LIBOR futures
9016	9040	9064	9088	3-month Eurodollar futures

3 For a discussion of the application of the formula, see R. Stapleton and M. Subrahmanyam, “Interest Rate Caps and Floors,” in *Financial Options: From Theory to Practice*, S. Figlewski, W. Silber, and M. Subrahmanyam, eds., 1990, pp. 220-280.