



***Federal Housing Finance Board
Office of Supervision***

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To: Federal Home Loan Bank Presidents, Chief Financial Officers, Risk Management Officers, Asset-Liability Managers, and Directors of Internal Audit

From: Stephen M. Cross
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Subject: Guidance on Value-at-Risk Modeling

Summary

This Advisory Bulletin (AB) provides guidance on a number of issues relating to the calculation of market value at risk (VaR) and market risk modeling. This document supersedes previous guidance on this topic that was contained in the Federal Housing Finance Board's (the "Finance Board") letter to presidents of the Federal Home Loan Banks dated April 11, 2002 ("April 2002 Guidance").

Specifically, this Bulletin: (1) describes and authorizes the use of a "percentage shock approach" for generating historical interest rate shock scenarios; (2) describes and authorizes the use of a new methodology for generating volatility scenarios, while withdrawing approval from a previously approved methodology; (3) modifies the previous guidance with regard to the appropriate number of paths to be used in calculating risk analytics on mortgage-related instruments; (4) extends the previous guidance by discussing the scope of instrument coverage; (5) emphasizes the importance of stress testing as a supplement to VaR analysis; and (6) reemphasizes the need to carefully review the results of your Bank's internal model as to their reasonableness.

Background

The Finance Board's capital regulations require each Bank to use an internal market risk model to estimate its market VaR. The capital regulations also require that a Bank's model incorporate scenarios that reflect changes in interest rates, interest rate volatility, and changes in the shape of the yield curve that have been observed over 120-business day periods of market stress (See 12 C.F.R. § 932.5(b)(4)(ii).) The methodology for generating yield scenarios is of the utmost importance in deriving a valid VaR calculation, as this will affect the level and shape of the yield curve, as well as interest rate spreads, all of which are significant risk factors in a fixed-income portfolio.



Guidance

Yield Scenarios

There is evidence that the size of interest-rate shocks that might be expected to occur over a given time horizon is related to the base case level of interest rates prevailing at the start of the time horizon. More specifically, one would expect larger interest shocks to occur in high interest-rate environments than in low interest rate environments. Consequently, in selecting a range of interest rate scenarios or rate shocks for purposes of estimating market risk exposure, it may be appropriate to calibrate the size or range of plausible interest rate shocks to the prevailing level of interest rates, in effect scaling them up in high interest-rate environments and scaling them down in low interest rate environments.

The April 2002 Guidance authorized the use of a “haircut approach” (see Appendix) for generating historical rate shock scenarios in a manner that scales the size of the shock to the current, or prevailing, yield environment. While that approach remains acceptable, we will also accept as an alternative to the haircut approach, a “percentage shock approach,” where interest rate shock scenarios are based on the percentage change in interest rates that have occurred over specific historical time periods. An advantage of the percentage shock approach is that implementation is less complex than with the haircut approach, which requires the use of regression analysis.

If your Bank would like to use the percentage approach to generate shock scenarios, the rate shocks must be based on six-month percentage changes in yields, applied to the base-case yield curve. Thus for each maturity point on the Treasury curve, the percentage shock and scenario rate are calculated as follows:

$$\text{Percentage shock} = \frac{[trs_rate(t=6) - trs_rate(t=0)]}{[trs_rate(t=0)]}$$

$$\text{Scenario rate} = trs_rate(base) * (1 + \text{Percentage shock})$$

where $trs_rate(t=0)$ is the beginning-of-period historical Treasury yield, $trs_rate(t=6)$ is the Treasury yield for that maturity 6 months later, and $trs_rate(base)$ is the base-case Treasury yield for that maturity. Scenario rates for other curves, e.g. CO, LIBOR, and the swap curve, are calculated similarly, using six-month percentage changes drawn from historical data for each curve respectively.

If your Bank intends to adopt the percentage shock approach to generating yield scenarios (described above), please notify the Finance Board in writing at least 30 days prior to the effective implementation date. The notification should include the algorithms and historical data used for generating the scenarios.



Volatility Scenarios

Under the Finance Board's risk-based capital regulations, any internal risk model that is used to measure market VaR must take into account changes in interest rate volatility. To assist the Banks in modeling VaR, the Finance Board provided the Banks with a methodology for generating volatility scenarios derived from linear transformations of historical volatilities. Based on subsequent analysis and discussion, we have revised our approved methodology for calculating volatility scenarios.

The revised methodology for calculating volatility scenarios includes the following features:

- Volatility scenarios are generated by applying shocks to the base case, rather than using the simulated beginning-of-period volatility as before, resolving an inconsistency with the yield scenarios.
- A multiple regression approach is used, with the 2-year and the 10-year Treasury rates as independent variables in place of the LIBOR-Treasury 3-month spread volatility. A logistic specification is used, in which the distribution of implied volatilities is assumed to lie between values falling between 0 and 100% with the parameters of the distribution dependent upon the Treasury rates.
- More volatility data are used. Data for caps and floors now goes back to 1995. Data for swaptions go back to 1997. Callable volatility dates from 1998.

Excel files illustrating the new volatility scenario methodology are available at the following URL: http://resource.fhfb.gov/http://resource.fhfa.gov/03_10_download.aspx.

Banks using the methodology contained in the April 2002 Guidance should either adopt the new methodology or propose an alternative. Your Bank must also notify the Finance Board in writing by November 30, 2003, if it intends to use the Finance Board's revised methodology to generate volatility scenarios, or an alternative methodology. Alternative methodologies are subject to Finance Board approval. If your Bank proposes to use an alternative methodology, the volatility scenarios should be based on shocks to as much of the base-case market implied volatility surface as can be reliably handled in your risk model, including short volatilities such as the 3 month by 1 year swaption and the 1-year cap. Your November 30 submittal should contain detailed documentation of any alternative methodology that will be used, including the rationale for selecting it, and any testing results. Any Finance Board approved changes in volatility methodology are to be effective for the period ending December 31, 2003. VaR calculations performed for December 31, 2003 and any subsequent dates should use the approved, revised methodology.

Modeling Instruments with Embedded Optionality

As stated in the April 2002 Guidance, your model should take account of any embedded optionality. For instruments such as callable bonds and derivatives, your model should consider the exercise of embedded options at each node for each time period evaluated. In circumstances where a fixed-rate callable consolidated obligation (CO) or advance with call or prepayment



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provisions are swapped to LIBOR, it is permissible to model the swapped CO or swapped advance as a synthetic LIBOR instrument provided that the embedded optionality is appropriately modeled. In general, this requires that a reasonable term structure model be used to build a lattice that incorporates the effects of implied volatility on option values.

As noted in the April 2002 Guidance, your Bank should use an option adjusted spread (OAS) approach to value mortgages and other instruments with embedded options. The OAS methodology should employ a robust Monte Carlo or lattice technique. The number of interest rate paths used for valuing mortgages and mortgage-related securities should be commensurate with the complexity of the instrument. Your Bank should prepare an analysis showing that the number of paths is sufficient to achieve reasonably accurate OAS or price estimates for mortgages and mortgage-related securities. Standard deviation or standard error of OAS or price estimates may be relevant metrics in this regard.

Instrument Coverage

VaR calculations for your Bank should include all assets, liabilities, and off-balance sheet positions held by the Bank. In particular, mortgage purchase commitments and structured advances should be included. You must provide the Finance Board with a listing of all instruments excluded from your Bank's VaR calculation including notional amounts, a description of embedded optionality, and the rationale for the exclusion. Where instruments are excluded due to model limitations, the Finance Board may require that you upgrade or replace your model.

Supplemental Analysis

By itself, VaR is an incomplete measure of market risk. As a matter of sound practice your Bank's VaR analysis should be supplemented with stress tests that identify potential losses under extreme market conditions, including, but not limited to, the duration of equity calculations included in the Call Report System. Your Bank should specifically assess the adequacy of capital in light of possible future financial and economic scenarios. The scenarios should include optimistic, pessimistic, and most likely forecasts. At a minimum, the analysis should show the expected change in the economic value of your Bank's equity accounts that would result from immediate parallel shifts in the yield curve. In addition, the analysis should be supplemented with non-parallel rate shocks such as a flattening and a steepening of the yield curve. It would also be useful to analyze scenarios that highlight the effect on economic capital of other key factors, including changes in prepayment speeds; changes in interest-rate volatility; changes in basis spread between FHLBank funding costs and Treasury rates, mortgage rates, and LIBOR; and changes in the credit quality of the FHLBank's investment portfolio. In formulating scenarios, it is important to include scenarios that are truly stressful. Effects on income and retained earnings as well as market value should be analyzed per AB 03-08, Capital Management and Retained Earnings. In the coming months we expect to issue further guidance regarding specific market risk management information that should be reported to the Finance Board for supervisory and monitoring purposes.

Model Reasonableness and Future Modifications



You are responsible for ensuring that your internal market risk model accurately measures the risks to which your portfolio is exposed. Your Bank's internal market risk model should be reviewed and upgraded periodically to incorporate advances in risk-modeling technology and changes in your risk exposures. You should notify the Finance Board if you have any reason to believe that your VaR calculations are significantly understating or overstating your Bank's market risk exposure. Please note, however, that Finance Board prior approval is required for each Bank's internal risk model, including subsequent material adjustments to the model pursuant to 12 C.F.R. § 932.5(d). ~~To obtain approval, you must notify the Finance Board of any proposed material changes to your model, including any changes in the software product(s) used, at least 30 days prior to the effective implementation date of any changes, and provide supporting documentation including testing results demonstrating the superiority of the modified approach.~~¹ As required under Section 932.5(d) of the Finance Board's regulations, a Bank must make any adjustments to its risk model as may be directed by the Finance Board.

As stated in the April 2002 Guidance, Monte Carlo methods of generating scenarios may be used for purposes of calculating market VaR provided that the scenarios are sufficiently robust to capture all material risks. To be acceptable, the interest rate distributions generated by Monte Carlo methods must be realistic. Historical evidence suggests that extreme movements in interest rates occur more often than is predicted using a standard normal distribution. There is also evidence that correlations between asset returns may increase during extreme events. As stated in the April 2002 Guidance, unless the Monte Carlo simulation techniques used to generate scenarios take these considerations into account, they may underestimate VaR.

Section 932.5(c) of the Finance Board's regulations states that each Bank, post implementation of its capital plan, shall conduct, at least annually, an independent validation of its internal market risk model. Section 932.5(c) further states that the validation may be carried out either by a qualified outside party, or by Bank staff not reporting to the business line responsible for conducting business transactions for the Bank. Pursuant to AB-03-7, Internal Market Risk Model Validation, each Bank that implemented its capital plan in 2002, or implements its plan during 2003, shall be expected to meet the market risk model validation requirements described in 932.5(c) beginning in calendar year 2004, and annually thereafter. The Finance Board will consider this fall whether to provide additional guidance.

Point of Contact

Notifications and other correspondence regarding issues raised in this Bulletin should be directed to William Segal, Assistant Director, Risk Modeling, (202) 408-2884, or segalw@fhfb.gov.² Mr. Segal may also be reached with any questions or comments regarding this Bulletin.

¹ Footnote added on July 22, 2016: Regulatory Interpretation 2004-RI-01, as later modified by Advisory Bulletin 2005-AB-06, superseded the requirement of explicit Finance Board approval for changes to previously approved risk models. Instead, Banks should follow the notice procedures outlined in Advisory Bulletin 2016-AB-02, which currently governs the process by which a Bank fulfills the approval requirement of Section 932.5(d).

² Footnote added on July 22, 2016: The current point of contact for this AB, Stefan Szilagyi, Manager, Risk Modeling Branch, can be reached at Stefan.Szilagyi@fhfa.gov.



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An Office of Supervision Advisory Bulletin presents guidance to the Banks on the application of legal requirements through the supervisory process. It is not a supervisory determination. Any supervisory determination implementing such guidance is subject to review pursuant to the Procedures for Review of Disputed Supervisory Determinations.

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Appendix:

“Haircut” Methodology for Generating Historical Interest-Rate Scenarios

While there are a number of techniques by which historical scenarios may be generated, Finance Board staff have designed an historical simulation approach to generating market risk scenarios. The approach consists of adjusted basis-point shocks, where each absolute basis-point shock is multiplied by a “haircut” factor taking into account that shocks are typically larger in high-rate environments, and smaller in low-rate environments such as today. This “haircut” approach uses monthly data beginning January 31, 1978 measuring 6-month changes in Treasury, Federal Home Loan Bank, LIBOR, Swap and miscellaneous other interest rates.

Under the adjusted basis point approach, the following regression is estimated for each Treasury maturity using data from 1/3/77 to the present, separately for up-shocks (which include delta=0) and down-shocks:

$$Shock = \alpha + \beta * trs_rate$$

The regression results are then utilized to forecast the expected up-shock and expected down-shock in the base case, and in each of the scenarios. These forecasts are utilized to calculate “haircuts” for the basis-point shocks as follows:

$$Haircut = \frac{Expected\ shock\ in\ base\ case}{Expected\ shock\ in\ historical\ scenario}$$

This haircut is then used to adjust the historical basis-point shock as follows:

$$Adjusted\ basis - point\ shock = Actual\ historical\ basis - point\ shock * Haircut$$

Historical basis-point shocks in non-Treasury rates (e.g. CO, LIBOR) are adjusted using haircuts for the nearest-maturity Treasury instrument. Thus, the haircut for the 3-month Treasury bill is utilized to adjust the 1-month LIBOR rate. This approach also accounts for basis risk faced by the Bank from changes in the spreads among the interest rate indices that can most affect its financial position. In adopting the final capital rule, the Finance Board specifically noted that basis risk is a material risk faced by the Banks and should be incorporated into the market risk model. See 66 Fed. Reg. 8262, 8297 (Jan. 30, 2001).

The advantage of utilizing this adjusted basis-point shock approach is that it captures the “unexpected shock”, which is the ratio of the actual shock to the expected shock as follows:

$$\frac{Adjusted\ basis - point\ shock}{Expected\ base\ case\ shock} = \frac{Actual\ historical\ shock}{Expected\ historical\ shock}$$

Thus, the proportion by which the adjusted basis shock exceeds the expected base case shock is the same proportion by which the actual historical shock exceeds the expected historical shock. These scenario shocks are then added to the base case interest rates to produce the interest rate scenarios to calculate the market value of equity.



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To aid the Banks in implementing the above-described approach, an Excel spreadsheet showing the way in which the scenarios are derived from the historical data is available from the Finance Board, as is the SAS program which calculates the haircuts.