INTRODUCTION

Sensitivity to market risk (the S component) addresses the degree to which changes in interest rates, foreign exchange rates, commodity prices or equity prices can adversely affect a financial institution's earnings or capital. For most institutions, market risk primarily reflects exposures to changes in interest rates. The S component focuses on an institution's ability to identify, monitor, manage and control its market risk, and provides institution management with a clear and focused indication of supervisory concerns in this area.

This examination guidance focuses on the nature of the examiner's qualitative assessment of a bank's interest rate risk (IRR) when rating sensitivity to market risk. In addition, examiners may use these examination guidelines when evaluating foreign exchange, commodity, or equity price risk.

This guidance is divided into the following additional sections:

- Examination Standards and Goals,
- Types of Interest Rate Risk,
- Management Responsibilities for IRR,
- IRR Measurement Methods,
- IRR Measurement System Review,
- Variance Analysis,
- Other Market Risk Factors,
- Rating Sensitivity to Market Risk, and
- Market Risk Glossary.

EXAMINATION STANDARDS AND GOALS

Joint Agency Policy Statement on Interest Rate Risk

In 1996, the FDIC and other federal banking regulators adopted the S component and issued the Joint Agency Policy Statement on Interest Rate Risk (Policy Statement). The Policy Statement identifies the key elements of sound interest rate risk management and describes prudent principles and practices for each of these elements. It emphasizes the importance of adequate oversight by a bank's board of directors and senior management and of a comprehensive risk management process. The Policy Statement also describes the critical factors affecting the agencies' evaluation of a bank's interest rate risk when making a determination of capital adequacy. The principles and practices identified in the Policy Statement describe the standards the FDIC uses to evaluate the adequacy and effectiveness of a bank's interest rate risk management and the adequacy of its capital in light of its interest rate risk profile. These standards are incorporated and reflected throughout this guidance.

FDIC examination procedures follow a risk-focused framework that incorporates the Policy Statement's guidelines and efficiently allocates examination resources. Examination scope will vary depending upon each bank's interest rate risk exposure relative to earnings and capital, and related strength of risk management processes. This section of the Manual is intended to provide a thorough background on the interest rate risk management process and examination guidance related to it. It is not an exhaustive study of IRR measurement methods. Nor will every examination entail all of the procedures and methodologies discussed.

There are three primary examination goals:

- Evaluate the interest rate risk management program,
- Determine any safety and soundness concerns, and
- Recommend corrective action when warranted.

The interest rate risk examination procedures accomplish those goals and:

- Limit examination scrutiny and resources for banks that demonstrate financial strength, effective management, and minimal IRR,
- Focus examination resources on banks that demonstrate significant interest rate risk, and
- Expedite offsite analysis.

Examination procedures for Market Risk are included in the Division of Supervision and Consumer Protection (DSC) Examination Documentation (ED) Modules and this Chapter. Refer to the ED Modules for basic examination procedures and other information.

TYPES OF INTEREST RATE RISK

Interest rate risk is the exposure of a bank's current or future earnings and capital to adverse interest rate changes. Interest rate fluctuations affect earnings by changing net interest income and other interest-sensitive income and expense levels. Interest rate changes affect capital by changing the net present value of a bank's future cash flows, and the cash flows themselves, as rates change. Accepting this risk is a normal part of banking and can be an important source of profitability and shareholder value. However, excessive interest rate risk can threaten banks' earnings, capital, liquidity, and solvency. Interest rate risk has many components, including repricing risk, basis risk, yield curve risk, option risk, and price risk.

Repricing risk results from timing differences between coupon changes or cash flows from assets, liabilities, and off-balance sheet instruments. For example, long-term fixed-rate securities funded by short-term deposits may create repricing risk. If interest rates change, then deposit funding costs will change more quickly than the yield on the securities. Likewise, the present value of the securities (i.e., their market price) will change more than the value of the deposits, thereby affecting the value of capital.

Basis risk results from weak correlation between coupon rate changes for assets, liabilities, and off-balance sheet instruments. For example, LIBOR-based deposit rates may change by 50 basis points, while Prime-based loan rates may only change by 25 basis points during the same period.

Yield curve risk results from changing rate relationships between different maturities of the same index. For example, a 30-year Treasury bond's yield may change by 200 basis points, but a three-year Treasury note's yield may change by only 50 basis points during the same time period.

Option risk results when a financial instrument's cash flow timing or amount can change as a result of market interest rate changes. This can adversely affect earnings by reducing asset yields or increasing funding costs, and it may reduce the net present value of expected cash flows.

For example, assume that a bank purchased a callable bond, issued when market interest rates were 10 percent, that pays a 10 percent coupon and matures in 30 years. If market rates decline to eight percent, the bond's issuer will call the bond (new debt will be less costly).

At call, the issuer effectively repurchases the bond from the bank. As a result, the bank will not receive the cash flows that it originally expected (10 percent for 30 years). Instead, the bank must invest that principal at the new, lower market rate.

Examples of instruments with embedded options include various types of bonds and notes with call or put provisions, loans which give borrowers the right to prepay balances, and various types of non-maturity deposit instruments which give depositors the right to withdraw funds at any time, often without penalty.

Price risk results from changes in the value of marked-to-market financial instruments that occur when interest rates change.

For example, trading portfolios, held-for-sale loan portfolios, and mortgage servicing assets contain price risk. When interest rates decrease, mortgage servicing asset values generally decrease. Since those assets are marked-to-market, any value loss must be reflected in current earnings.

Sources of Interest Rate Risk

The adequacy of a bank's IRR management system depends on its ability to identify and effectively capture all material activities and products that expose the bank to interest rate risk and then measure the specific risks presented. A review of the following items will allow examiners to identify material bank exposures and the type of risks presented.

- Interest Rate Risk Standards Analysis (IRRSA),
- Bank interest rate risk analysis, and independent review findings,
- Related bank policies and procedures,
- Balance sheet and account data,
- Strategic and business plans,
- Product pricing guidelines,
- Hedging or derivative activity, and
- Current and prior related examination findings.

Funding sources may create repricing risk, basis risk, yield curve risk, or option risk. Examiners should evaluate the fundamental relationship between funding sources and asset structure. Potentially volatile or market-based funding sources may increase interest rate risk, especially when matched to a longer-term asset portfolio. For example, fixed-rate mortgages funded by purchased Federal funds create repricing risk. Funding costs may increase substantially, while asset yields remain fixed.

Non-maturity deposits may mitigate some interest rate risk. Non-maturity deposit funding costs generally demonstrate less volatility than market interest rates. As a result, high non-maturity deposit volumes may actually reduce repricing risk and moderate overall IRR. However, significant interest rate or economic changes can rapidly alter customers' non-maturity deposit behavior.

Non-maturity deposit assumptions are crucial components of any interest rate risk measurement system and require careful review and analysis. Those assumptions should be reasonable and well supported.

Off-balance sheet derivatives may introduce complex interest rate risk exposures. Depending on the specific instrument, derivatives may create repricing, basis, yield curve, option, or price risk.

Mortgage banking operations create price risk within the loan pipeline, held-for-sale portfolio, and mortgage servicing rights portfolio. Interest rate changes affect not only current values, but also determine future business volume and related fee income.

Fee income businesses may contain IRR, particularly mortgage banking, trust, credit card servicing, and non-deposit investment sales. Changing interest rates may dramatically affect such activities.

Product pricing strategies may introduce IRR, particularly basis risk or yield curve risk. If funding sources and assets are linked to different market indices, then basis risk exists. If funding sources and assets are linked to similar indices with different maturities, then yield curve risk exists.

Embedded options associated with assets and liabilities, and off-balance sheet derivatives can create interest rate risk. Embedded options include any feature that can alter an instrument's cash flows when interest rates change. Many instruments contain various embedded options, including:

- Non-maturity deposits,
- Callable bonds,
- Structured notes,
- Derivatives,
- Mortgage loans, and
- Mortgage-backed securities (MBS).

Mortgage loans and MBSs contain prepayment options. Borrowers may prepay loan principal at any time, which alters the mortgages' cash flows and creates material interest rate risk considerations.

MANAGEMENT RESPONSIBILITIES

The board of directors must ensure that management effectively identifies, measures, monitors, and controls interest rate risk. The policies, procedures, and systems used to achieve those goals comprise the interest rate risk management program.

Although many methodologies effectively guide interest rate risk management, all programs should address:

- Board and senior management oversight,
- Strategies, risk limits, and controls,
- Risk identification and measurement,
- Monitoring and reporting, and
- Independent review.

The bank's complexity and risk profile should determine its interest rate risk management program's formality and sophistication. Less sophisticated programs may be adequate for banks that maintain basic balance sheet structures, have only moderate exposure to embedded options, and do not employ complex strategies. However, all procedures should be clearly documented and senior management should actively supervise daily operations.

More complex banks will likely need more formal, detailed interest rate risk management programs. In such cases, management should establish specific controls and produce cogent analysis that addresses all major risk exposures. At those banks, internal controls should include a more thorough independent review process for interest rate risk analysis and more rigorous requirements for separation of duties.

Board Oversight

Effective board oversight is the cornerstone of sound risk management. The board must understand the bank's risk exposures and how those risks affect current operations and strategic plans. The board's three primary interest rate risk oversight responsibilities are to:

- Establish strategy and acceptable risk tolerance levels, including policies, risk limits, and management authority and responsibility,
- Monitor interest rate risk to prevent excessive risk exposure, and
- Provide adequate interest rate risk management resources.

The board of directors is responsible for approving the overall policies of the bank with respect to interest rate risk and for ensuring that management takes the steps necessary to identify, measure, monitor, and control these risks. The board or a committee of the board should review market risk information at least quarterly. The information should be timely in nature and in sufficient detail to allow the board to understand and assess the performance of senior management in monitoring and controlling these risks, and to gauge compliance with the board-approved policies. In addition, the board or one of its committees should periodically re-evaluate significant interest rate risk management policies as well as overall business strategies that affect the interest rate risk exposure of the bank.

Senior Management Oversight

Senior management's responsibilities include both long-range and daily interest rate risk management. Senior management should:

- Implement procedures that translate the board's policies into clear operating standards,
- Maintain a measurement system that identifies, measures, and monitors interest rate risk, and
- Establish effective internal controls over interest rate risk measurement, monitoring, and reporting.

Strategies, Risk Limits, and Controls

Effective board and senior management oversight requires reasonable strategies, prudent risk limits, and clear internal controls. Internal controls should address management authority and responsibility, permissible activities, and staffing needs.

Strategies should address all relevant interest rate risk factors, such as capital, earnings, balance sheet structure, economic and interest rate forecasts, and long-term business plans. Management should develop strategies that address the board's policies and risk limits. Those strategies may incorporate off-balance sheet activities, balance sheet structure changes, product pricing guidelines, and other management tactics.

Strategy detail and formality will depend upon the bank's size, complexity, and management expertise. All related activities, including lending, deposits, and investments should be coordinated. Generally, the management committee responsible for interest rate risk should include a representative from each major product area.

Risk limits should establish the board's interest rate risk tolerance by restricting earnings and capital volatility for given interest rate movements. The board should document and approve risk limits that guide management's activities and those limits should be stringent enough to prevent exposures that create safety and soundness concerns.

Limits should reflect the bank's complexity and capital strength. Further, they should relate directly to the internal measurement system's methodology, and should specifically address interest rate risk effects on reported earnings and capital.

Management should maintain exposure within the established limits. Internal controls should ensure that when exposures exceed the risk limits, management promptly reviews the exception and reports it to the board. The board should review all policy and risk limit exceptions. However, effective limits should provide management with the flexibility to respond to changing economic conditions.

Earnings-based risk limits may include volatility restrictions on:

- Net interest margin,
- Net operating income, and
- Net income.

Capital-based risk limits may include volatility restrictions on:

- Economic value of equity and
- Regulatory capital.

Authority and responsibility should be clearly defined by identifying the individuals and/or committees responsible for managing interest rate risk and ensuring that there is adequate separation of duties in key elements of the risk management process to avoid potential conflicts of interest. Banks should have risk measurement, monitoring and control functions with clearly defined duties that are sufficiently independent from position-taking functions of the bank and which report risk exposures directly to senior management and the board of directors. The nature and scope of such safeguards should be in accordance with the size and structure of the bank. They should also be commensurate with the volume and complexity of interest rate risk incurred by the bank and the complexity of its transactions and commitments. Larger or more complex banks should have a designated independent unit responsible for the design and administration of the bank's interest rate risk measurement, monitoring, and control functions.

Permissible activities should identify the strategies and instruments that management can use to control interest rate risk. Policies should specifically describe the instruments and activities that the board authorizes and those that management may not use without prior board approval.

Staffing resources should permit effective interest rate risk management, including:

- Sufficient staff to operate measurement systems, including back-up personnel,
- Appropriate analytic expertise, and
- Adequate training and staff development.

Risk Identification and Measurement

Prudent risk management demands accurate, timely interest rate risk quantification. Although many measurement methods exist, an effective system must clearly identify, quantify, and report the bank's risks.

When evaluating IRR, well-managed banks should consider both earnings and economic value approaches. Reduced earnings, or losses, can harm capital, liquidity, and even marketplace perception. Economic value of equity (EVE) measurements provide longer-term earnings and capital analysis.

Products and activities that are new to the bank should undergo a careful pre-acquisition review to ensure that the bank understands their interest rate risk characteristics and can incorporate them into its risk management process. When analyzing whether or not a product or activity introduces a new element of interest rate risk exposure, the bank should be aware that changes to an instrument's maturity, repricing or repayment terms can materially affect the product's interest rate risk characteristics.

Risk Monitoring and Reporting

Banks should maintain systems that report interest rate risk in an accurate, timely, and informative manner. At least quarterly, senior management and the board should review those reports. However, banks that engage in complex activities or take greater risks should assess IRR more frequently. Interest rate risk reports should contain sufficient detail to permit management and the board to:

- Identify interest rate risk sources and levels,
- Evaluate key assumptions, including interest rate forecasts, deposit behavior, and loan prepayments, and
- Verify compliance with policies and risk limits.

Internal Control and Independent Review

Establishing and maintaining an effective system of controls is critical to the general safe and sound functioning the of bank and the market risk management process in particular. Banks should have adequate internal controls to ensure the integrity of their interest rate risk management process. These internal controls should promote effective and efficient operations, reliable financial reporting, and compliance with institutional policies and relevant regulations. With regard to control policies and procedures, attention should be given to appropriate approval processes, adherence to exposure limits, reconciliations, reporting, reviews, and other mechanisms designed to provide a reasonable assurance that the institution's IRR management objectives are achieved.

An important element of a bank's internal control system over its IRR management process is regular independent evaluation and review. Internal reviews of the IRR measurement system should include assessments of the assumptions, parameters, and methodologies used. Such reviews should seek to understand, test, and document the current measurement process, evaluate the system's accuracy, and recommend solutions to any identified weaknesses. The independent review should adhere to a set of minimum standards, as well as encompass the desirable scope discussed below.

Independent Review Standards

The purpose of the independent review is to ensure that the interest rate risk measurement and management processes are sound. Regardless of whether the review is performed by internal staff or external resources, it is important that these parties be independent of any operational responsibility for the measurement system. They should not have any involvement in either developing the measurement system or performing any of the routine internal control functions such as reconciling data inputs, developing assumptions, or performing variance analysis.

The scope, responsibility, and authority for the independent review should be clearly documented, encompass all material aspects of the measurement process, and be performed annually. The scope of the independent review should generally be defined by the internal audit staff and approved by the audit committee. However, subject to board approval, it is acceptable for another department of the bank, separate from the group that measures interest rate risk, to define, perform, and document the independent review. The following minimum standards apply to all institutions' review processes:

- **Independence** – Parties performing the independent review should not be involved in the interest rate risk measurement process. Institutions may use internal staff, an outsourcing arrangement, or a combination of the two, to independently appraise the measurement system. Management may find that the internal audit department, or other staff independent of the measurement system, has the knowledge and skills to perform certain aspects of the review while using external resources for other areas. When the assessment of the measurement system is outsourced, senior management and the board should assure that the procedures used meet the same standards required of an internal review.

- **Skills and Knowledge** – Senior management must ensure that individuals performing the independent review have the requisite knowledge and skills to competently assess the measurement system and its control environment.

- **Transparency** – The procedures used in the independent review of the measurement system should be clearly documented and work papers should be available to management, auditors, or examiners for review. Senior management should ensure that they have access to work papers even when external sources perform the review.

- **Communication of Results** – Procedures should be established for reporting independent review findings on an annual basis to the board or board-delegated committee for discussion and approval.

Scope of Independent Review

The independent review serves as a means to independently assess the adequacy of bank's measurement system. The level and depth of independent review performed by an institution should be commensurate with the bank's activities. More complex institutions should have a more rigorous independent review process than less complex institutions. Smaller, less complex institutions may rely upon less formal review. At a minimum each institution should have procedures in place to independently review the input process, the assumptions, and the system output reports.

System-input process review should evaluate the adequacy and appropriateness of the following:

- The level of knowledge and skill of the individuals responsible for the measurement system,
- The reconciliation of the measurement system's data to the bank's general ledger,
- The rules and methods of account aggregation used in the measurement system,
- The accurate capture of contractual terms within the measurement system, and
- The source, completeness, accuracy, and procedures for external data feeds.

Assumption reviews should address the following issues:

- The process of developing assumptions for all material asset, liability and off balance sheet exposures.
- The process for reviewing and approving key assumptions,
- The periodic review of assumptions for relevance, applicability, and reasonableness, and
- The completeness of assumption analysis and its supporting documentation.

System output and reporting assessments should include coverage of the following**:**

- The inclusion of a sufficiently broad range of potential rate scenarios,
- The accuracy of the IRR measurement, the assurance that all material exposures are captured,
- The timeliness and frequency of reporting to management and the board,
- The compliance with operating policies and approved risk limits, and
- The performance and documentation of variance analyses.

Theoretical and Mathematical Validation

The level of calculation validation depends on the complexity of an institution's activities. The complexity of many measurement systems demands specialized knowledge and skills to be able to verify the mathematical equations. Many vendors will provide clients with a certification that their measurement system calculations have been validated. Institutions relying on this method should obtain verification/certifications each time a new version of the measurement system is employed by the bank. Vendor independent reviews should meet the same minimum standards that apply to bank independent reviews.

Some vendors may be unwilling to fully share underlying calculations or code with clients. In this case it is expected that management will have compensating controls in place to reasonably assure that the measurement systems are performing accurate calculations. One method of doing so is to run parallel measurement systems using different software and compare the results of the two systems for any significant differences.

IRR MEASUREMENT METHODS

Interest rate risk measurement systems can range from simple gap measurement systems to more sophisticated programs that include stochastic modeling of data. Despite the variety in measurement systems, all systems require verifiable account data, rely heavily on assumptions, and lose precision when analyzing complex instruments or volatile markets. In general, but depending on the complexity and range of activities of the individual bank, banks should have interest rate risk measurement systems that assess the effects of rate changes on both earnings and economic value. These systems should provide meaningful measures of a bank's current levels of interest rate risk exposure, and should be capable of identifying any excessive exposures that might arise. Measurement systems should:

- Assess all material interest rate risk associated with a bank's assets, liabilities, and off balance sheet positions,
- Utilize generally accepted financial concepts and risk measurement techniques, and
- Have well-documented assumptions and parameters.

Regardless of the measurement system, its usefulness depends on the validity of the underlying assumptions and the accuracy of the basic methodologies used to model IRR exposure. In designing interest rate risk measurement systems, banks should ensure that the degree of detail about the nature of their interest sensitive positions is commensurate with the complexity and risk inherent in those positions. Most important, measurement systems are only a forecasting tool and can not flawlessly predict cash flows, earnings, or capital.

Measurement System Approaches

Interest rate risk measurement systems use an earnings approach, an economic value approach, or a blend of those two approaches.

The earnings approach focuses on risks to reported earnings, usually over a shorter-term time horizon. Typically, earnings systems estimate risk for up to two years. In addition, estimating future earnings permits regulatory capital forecasts.

The earnings approach traditionally focuses on net interest income. However, many systems now incorporate components that measure the price risk from instruments accounted for at market value or lower-of-cost or market value. Those systems estimate gains and losses from assets that include loans held for sale, trading portfolios, and mortgage servicing rights. Maturity gap analysis and simulation models are examples of earnings approaches to IRR measurement.

The economic value approach estimates the bank's economic value of equity for forecasted interest rate changes. EVE represents the net present value of all asset, liability, and off-balance sheet cash flows. Interest rate movements change the present values of those cash flows. This method assumes that all financial instruments will be held until final payout or maturity. The economic value approach might provide a broader scope than the earnings approach, since it captures all anticipated cash flows.

The economic value approach best suits banks that mark most instruments to market. At banks that value most instruments at historical cost, economic value measurements can also effectively estimate interest rate risk. However, in those banks, EVE changes might be recognized over a longer time frame (through reported earnings).

As a result, banks often blend the two approaches. Management may use an earnings approach to evaluate short-term performance and an economic approach to monitor the bank's long-term viability. Despite using different methodologies, the two approaches generally should provide a consistent view of interest rate risk exposures.

Gap Analysis

Gap systems use an accrual approach to identify risk to net interest income. Typically, gap systems identify maturity and repricing mismatches between assets, liabilities, and off-balance sheet instruments. Gap schedules segregate rate-sensitive assets, rate-sensitive liabilities, and off-balance sheet instruments according to their repricing characteristics. Then, the analysis summarizes the repricing mismatches for each defined time horizon. Additional calculations convert that mismatch into risk to net interest income. Gap analysis may identify periodic, cumulative, or average mismatches.

The most common gap ratio formula is:

$$\frac{\text{Rate-Sensitive Assets}\ ^{minus}\ \text{Rate-Sensitive Liabilities}}{\text{Average Earning Assets}}$$

Occasionally, average assets or total assets may be used in place of average earning assets. However, those denominators can underestimate interest rate risk.

The gap ratio can and should be used to calculate the potential impact on interest income for a given rate change. This is done by multiplying the gap ratio by the assumed rate change. The result estimates the change to the net interest margin.

For example, a bank has a 15% one-year average gap. If rates decline 2%, then the net interest margin will decline by 30 basis points (15% x .02). This estimate assumes a static balance sheet and an immediate, sustained interest rate shift.

Gap analysis has several advantages. Specifically, it:

- Does not require sophisticated technology.
- May be relatively simple to develop and use.
- Can provide clear, easily interpreted results.

However, gap's weaknesses often overshadow its strengths, particularly for larger, more complex banks. For example, gap analysis:

- Generally captures only repricing risk.
- May not identify intra-period repricing risk.
- Does not measure EVE.
- Generally can not analyze complex instruments.

Some gap systems attempt to capture basis, yield curve, and option risk. Multiple schedules (dynamic or scenario gap analysis) can show effects from nonparallel yield curve shifts. Additionally, sensitivity factors may be applied to account categories. Those factors assume that coupon rates will change by a certain percentage for a given change in a market index. That market index is designated as the driver rate (sophisticated systems may use multiple driver rates). Those sensitivity percentages, also called beta factors, may dramatically change the results.

Banks often use sensitivity factors to refine non-maturity deposit analysis. For example, management may determine that its MMDA cost of funds will increase 25 basis points whenever the six-month Treasury bill rate increases by one percent. Thus, management might consider only 25% of MMDA balances rate-sensitive for gap analysis. Management may expand its analysis by preparing gap schedules that assume different market rate movements and changing customer behaviors.

Gap analysis may provide sufficient interest rate risk measurements for some banks. However, gap analysis may be ineffective for banks with complex structures, sophisticated activities, or significant exposures to embedded options.

Simulation Analysis

Simulation analysis determines the effect of interest rate changes on short-term net interest income, net income, and, in some cases, EVE. Simulation models generate results for a range of possible interest rate scenarios and exposures.

Banks may vary simulation rate scenarios based on factors such as pricing strategies, balance sheet composition, and hedging activities. Simulation may also measure risk presented by non-parallel yield curve shifts. Any simulation system's accuracy, though, depends on the assumptions and data used. Inaccurate data or unreasonable assumptions render simulation results meaningless. Simulation models are often not "user friendly" and may require more data and expertise than other interest rate risk measurement systems.

Simulation systems vary greatly, both in methodology and sophistication. Some systems focus on short-term earnings, some concentrate on EVE, and others blend those views. Despite those differences, most simulation systems share two characteristics: They require advanced information systems and technical expertise.

Duration Analysis

Duration is a measure of the percentage change in the economic value of a position that will occur given a small change in the level of interest rates. It reflects the timing and size of cash flows that occur before the instrument's contractual maturity.

Macaulay duration, duration's simplest form, calculates the weighted average term to maturity of a security's cash flows. Duration, stated in months or years, always:

- Declines as time elapses,
- Equals less than maturity for instruments with payments prior to maturity,
- Equals maturity for zero-coupon instruments,
- Is lower for instruments with higher coupons., and
- Is lower for amortizing instruments.

An example of a Macaulay duration calculation can be found in the glossary for this section of the manual.

Modified duration, calculated from Macaulay duration, estimates price sensitivity for small interest rate changes. An instrument's modified duration represents its percentage price change given a small change in the level of interest rates. Thus, it serves as a proxy interest rate risk measure.

However, modified duration assumes that interest rate shifts will not change an instrument's cash flows. As a result, it does not estimate price sensitivity for instruments with embedded options (for example, callable bonds or mortgages) with an acceptable level of precision. Banks with significant option risk should not rely upon modified duration alone to measure interest rate risk.

An example of a modified duration calculation can be found in the glossary section.

Effective duration estimates price sensitivity more accurately than modified duration for instruments with embedded options and is calculated using valuation models that contain option pricing components. First, the user must determine the instrument's current value. Next, the valuation model assumes an interest rate change (usually 100 basis points) and estimates the new instrument's value, based on that assumption. The percentage change between the current and forecasted values represents the instrument's effective duration.

All duration measures assume a linear price/yield relationship. However, that relationship actually is curvilinear. Therefore, duration may only accurately estimate price sensitivity for rather small (up to 100 basis point) interest rate changes. Convexity-adjusted duration should be used to more accurately estimate price sensitivity for larger interest rate changes (over 100 basis points). An illustration and further discussion of convexity can be found in the glossary section.

EVE may be calculated using duration. For example, assume that a bank has rate sensitive assets (RSA) valued at $10,000 with a duration of 4 years and rate sensitive liabilities (RSL) valued at $9,000 with a duration of 4 years. For a 1% interest rate change, the following will occur:

- RSA value changes $400 ($10,000 x 4 x 1%),
- RSL value changes $360 ($9,000 x 4 x 1%), and
- EVE changes by $40 ($400 - $360).

Despite matching the duration of assets and liabilities, the bank's EVE changes by four percent when rates change by one percent. This results from the dollar duration gap created by the difference between RSA and RSL volume. Thus, banks that use duration to manage interest rate risk should match dollar weighted asset and liability durations, not raw duration.

Duration analysis provides significant advantages over gap analysis. Duration analysis yields a single interest rate risk number and considers all expected cash flows. Thus, duration generates a more comprehensive interest rate risk measurement. Duration analysis can provide more accuracy than maturity gap analysis for measuring and managing IRR.

Despite those advantages, duration analysis contains some significant weaknesses. Accurate duration calculations demand sophisticated accounting and information systems. Further, duration accurately measures value changes for only relatively small interest rate fluctuations. Therefore, banks must frequently update duration measures during volatile interest rate environments.

IRR MEASUREMENT SYSTEM REVIEW

Well-run insured depository institutions should have an interest rate risk measurement system appropriate to the composition of the bank's balance sheet and risk profile. The measurement system should capture all material sources of interest rate risk, and be capable of generating meaningful reports for senior management and the board of directors. Bank management should ensure that risk is measured over a probable range of potential interest rate changes, including meaningful stress situations. Further, the measurement system must be subject to appropriate internal controls and periodic independent review. The bank's IRR measurement process should be well documented and administered by individuals with sufficient technical knowledge.

A bank's interest rate risk measurement system is an indispensable facet of its risk management process. Examiners rely heavily upon the output of banks' interest rate risk measurement systems in assessing sensitivity to market risk. Accordingly, the seamless operation of such systems is critical and a review of their operation is a crucial element of the examination process. The review process should address the following items:

- Capabilities of the measurement system,
- Adequacy of system inputs,
- Reasonableness of material assumptions,
- Usefulness of system output/reports, and
- Adequacy of periodic variance analysis.

System Capabilities

The interest rate risk measurement system must capture and reliably estimate the bank's material risk exposures. Therefore, the system should consider all significant risk factors. For example, if the bank has material holdings of mortgage loans or mortgage-backed securities, then the system should incorporate prepayment projections.

Management should fully understand the measurement system, including its:

- Capabilities,
- Limitations,
- Quantitative methodology, and

- Assumptions.

System documentation should provide complete information regarding the above factors. Both purchased and internally developed systems should be supported by complete documentation. Management should be familiar with and retain all system documentation. If the system fails to adequately capture significant risks or relies on unsupported methodology, then management should correct the deficiencies in order to produce reliable interest rate risk measurements.

Many computer-based interest rate risk measurement systems are used for other management information system operations, such as strategic planning, earnings forecasts, and generation of public disclosures. The review of such measurement systems may require an analysis of the system as an aspect of the information technology (IT) component of the examination. IT topics which may need to be reviewed during the measurement system examination and coordinated with the information technology examiner include: system acquisition and development; testing and validation; system security; serviced applications; and system operation. In addition, vendor systems often require additional components (for example, an option pricing module) or periodic updates. Without the needed components, the system may not calculate accurate results. Examiners should verify that the system contains the components and updates needed to generate accurate measurements. Refer to the Federal Financial Institution Examination Council (FFIEC) IT Examination Handbooks for guidance relating to information technology review.

Adequacy of Measurement System Inputs

The system's objective data should reflect the bank's current condition. Examination of the system's inputs should focus on the process for inputting and reconciling the measurement system data, categorizing and aggregating account data, ensuring the completeness of account data, and assessing the effectiveness of internal controls and the independent review processes.

The bank's internal control process must be comprehensive enough to ensure that data inputs are accurate and complete prior to running the measurement system and generating management reports. The bank may input data into the system either manually or by using electronic data extract programs, or a combination of these approaches. Internal control procedures should be established to ensure that measurement system inputs agree with the general ledger balances and that contractual terms are accurately captured. Institutions can verify the system inputs by either having experienced personnel review them and reconcile the balances to the general ledger or by using automated software that can identify and report exception items.

In addition to capturing account balances, institutions with complex balance sheets also need to employ measurement systems that can adequately address the embedded market risk of all material on- and off-balance sheet activity. Most measurement systems allow for the following contractual terms to be entered:

- Current balance,
- Contractual principal and interest payment amounts and payment frequency,
- Contractual coupon rates (including repricing frequency),
- Contractual caps and floors,
- Contractual maturity, and
- Contractual optionality (such as securities or borrowing calls).

Account aggregation is the process of grouping together, either at the customer or sub-ledger level, accounts of similar types and cash flow characteristics. This is an important component of the data input process. Very few modeling systems have the capacity to model customer behavior at the individual account level. While not as precise as entering each individual customer account into the measurement system, account aggregation improves the measurement system's efficiencies. Typically, loans of similar rate, maturity, and type (e.g., 6%, 30-year, residential loans) are aggregated. Grouping 6%, 30-year residential loans together may be appropriate, but grouping together 6% fixed rate loans with 6% variables is not.

The degree of account aggregation will vary from one institution to another and depends on the measurement system used and the degree of precision an institution desires. Analysis should include both contractual and behavioral characteristics when determining cash flow patterns. The process of determining which accounts will be combined should be transparent, documented, and periodically reviewed. Further, requests for changes to existing groupings or for new account aggregations should be formalized and documented. Institutions should maintain documentation (similar to a chart of accounts) disclosing the characteristics of the assets, liabilities, and off-balance sheet products that the account aggregation represents.

Assumptions

Assessing the reasonableness of assumptions is a critical component of an interest rate risk measurement system review. Unreasonable assumptions render even the most complex interest rate risk measurement system ineffective. It is important that assumptions reflect management's ability to change rates, customer behaviors, and current local and macro-economic factors. Assumptions are typically derived using a combination of internal analysis and external sources. All material assumptions, regardless of the source, should be supported with analysis and documentation.

Assumptions are used to capture the following key parameters or characteristics:

- Potential or projected interest rate movements,
- Driver rate relationships,
- Non-maturity deposit (NMD) rate sensitivity, and
- Customer behaviors.

It is imperative that material assumptions be updated regularly to reflect the current market and operating environment. Further, the process for developing material assumptions should be formalized and periodically assessed (at least annually for critical assumptions). This periodic assessment of the processes and sources used to generate assumptions may prompt management to reevaluate its assumptions in order to better reflect current strategies or customer behaviors. For example, the beta factor for Money Market Deposit Accounts (MMDA) may need to change because of customers' altered perceptions on the outlook of alternative investment options.

Projected interest rate assumptions are an important component of measuring interest rate risk and may be generated by internal analysis or external sources. Internal interest rate forecasts may be derived from implied forward yield curves, economic analysis, or historical regressions. Management should have documentation of the market interest rate assumptions available for examiner review. Most institutions perform scenario analysis using "deterministic" interest rate yield curves. With the deterministic method, all interest rate scenarios are set by the user: that is, management selects which potential interest rate changes to simulate in the model. The deterministic method differs from the more complex and sophisticated "stochastic" method where multiple scenarios are generated using random path variables. (Further discussion of deterministic and stochastic methods may be found in the glossary for this section of the manual.)

Institutions with material levels of complex instruments or significant repricing mismatches should measure their risk using several yield curve scenarios, including nonparallel yield curve shifts. This enables the institution to identify its level of vulnerability to significantly flatter or steeper yield curves. Institutions that have financial instruments indexed to different or multiple yield curves must evaluate the different yield curves used. For instance, institutions with instruments tied to the Cost of Funds Index (COFI) or the London Interbank Offered Rate (LIBOR) must consider corresponding yield curves in scenario projections. Rate sensitive non-interest income earnings streams such as mortgage banking activities should also be measured under various rate scenarios.

These analyses should be performed using the base case interest rate scenario, as well as low probability rate scenarios, so that management can better estimate the impact to earnings and capital levels from stressed interest rate scenarios. The base case interest rate scenario should be consistent with other forecasts used throughout the bank's planning process. Further, interest rate scenarios modeled should remain reasonably consistent across reporting periods. Any changes in the source of interest rate forecasts between the reporting periods should be justified and documented. While similar to the budgeting process, IRR scenario analysis differs from it by measuring the potential impact of low probability events where the budget process uses management's expected or most likely rate scenario.

Driver rates are used extensively in most income simulation and EVE models. They capture the relationship between the primary market interest rates, or driver rates, and the pricing of bank products within the measurement system. While in practice there may be no direct connection between the bank's rate and the driver rate, the driver is chosen to act as proxy for management's reaction in response to market changes. This frees the bank from the need to explicitly set rates for each loan or deposit type for each projected scenario. In most cases, the bank's rate is set to move at some fraction of the driver rate, often referred to as a spread or beta factor. For example, management might specify that the rate paid on MMDAs will increase 25 basis points when the one-year Treasury bill yield increases 100 basis points. By designating these spread relationships, pricing on all products linked to that driver rate will change to reflect the relationship built into the model by management. More complex systems will use a variety of driver rates, tailored to different products. While most systems maintain static rate relationships, more sophisticated systems can alter the relationships for different interest rate environments.

Spread assumptions should be based on an analysis of the relationship between the product (e.g., MMDA) and the driver rate (e.g., Federal funds rate). Correlation analysis can be performed to quantify the historical relationship between the product and driver rates. This analysis also may be used to determine the level of basis risk when instruments are tied to different indices. For instance, if an institution enters into a leveraging strategy that is funded by borrowings tied to LIBOR and invests in U.S. Treasury securities, a correlation analysis can be performed to determine how closely these rates move together. Less correlated instruments present greater basis risk.

Non-maturity deposit (NMD) rate sensitivity is one of the most difficult and critical assumptions that bank management makes when measuring interest rate risk. The potential reactions of both management and customers are important and need to be taken into account. Just as customers have control over the level and location of their deposit accounts, management has broad control over the rates paid on these accounts. In setting rates, management must take into account a wide array of factors, including local and national competition, the bank's potential funding needs, and the relative costs of alternative funding sources. The rate movement assumptions modeled for NMDs should reflect both aspects of this relationship: management's control over rates and customers' control over their funds. Consideration should be given not only to historical correlation analysis, but also to management's intentions regarding future movements. More sophisticated systems allow for different reactions for increasing versus decreasing rates.

Customer behavior assumptions are important elements to the measurement of optionality exposure and typically have significant impacts on both sides of the balance sheet. For example, prepayment or extension risk on loans and mortgage-related securities, non-maturity deposit decay rates, and product growth are highly influenced by the direction of interest rates. Therefore, it is critical that customer behavior assumptions be reasonable and reflect each interest rate scenario measured. For example, loan prepayment assumptions should vary with the interest rate scenarios measured, such that an increasing rate environment should typically reflect lower prepayments than a declining interest rate environment.

Other market factors that influence customer behaviors include geographic location, local competition, type and sophistication of clientele (retail versus commercial customers). Behavioral assumptions may be derived from internal analysis or external sources. For instance, banks may use dealer median mortgage prepayment assumptions, when appropriate, or determine their own prepayment assumptions based on their unique portfolio characteristics.

Documentation and support of all significant assumptions, including projected rates, spreads, customer behavior, and NMD rates should be maintained and be available for examiner review. Many vendor-supported or outsourced measurement systems have only limited ability to change model assumptions, in which case documentation may be limited. Even in those cases, an analysis of the applicability of the embedded assumptions to the subject bank should be performed and maintained. More complex systems entail a vast array of assumptions, and thorough documentation of every one cannot be realistically expected. However, management should be familiar with those assumptions that represent the most sensitive aspects of the institution or model, and place the greatest emphasis on supporting and documenting them.

Model-Sensitivity Analysis

Bank management should periodically analyze the sensitivity of the model's significant assumptions. When management includes assumptions based on strategic initiatives, it is imperative that they assess the impact of not meeting projections. For instance, an institution planning to increase commercial lending by 10% using core deposit growth should assess the impact of falling short of the projected level of core deposits and having to obtain higher cost funding. The bank should, for example, measure other scenarios such as low or no growth of core deposits in order to develop an understanding of the bank's exposure to interest rate risk if projections are not achieved. Similar scenarios should be developed for alternative loan growth rates. This example again illustrates the distinction between the budgeting process and interest rate risk measurement. The budget process forecasts earnings and balance sheet changes based on most likely scenarios, while interest rate risk measurement analyzes potential exposure to low probability events.

System Management Reports

Many asset liability management systems offer an array of summary reports (such as a chart of accounts and account attribute reports) that aid management in the review of measurement system assumptions. These reports may also provide information regarding the contractual terms and parameters that have been entered into the system for various account types and financial instruments.

Many measurement systems are capable of providing summary reports detailing key model assumptions. Examiners should review a copy of these reports when analyzing a measurement system. If an institution is unable to provide assumption summaries, examiners should determine whether the absence of the report is due to measurement system limitations or bank personnel's lack of familiarity with system capabilities. Typically, measurement system user manuals will provide a list of reports that may be generated by the system.

Assumption summary reports are an important tool that management and examiners can use to ensure that assumptions have been entered into the measurement system properly. These reports can also be useful to examiners when management does not maintain adequate and separate documentation of assumptions. For example, a comparison of current assumptions can be made by reviewing historical assumption reports.

To ensure proper controls regarding significant changes to measurement system assumptions, an institution should have formalized procedures for reviewing the reasonableness of measurement system assumptions and policies that control when changes to significant assumptions are permitted.

Measurement System Results

Once both basic data and assumptions have been input, the measurement system performs calculations based on mathematical relationships and equations embedded in the system. These calculations measure the interest rate risk in the bank's assets, liabilities and off-balance sheet positions. The measurement system should generate summary reports that highlight the bank's sensitivity to changes in market interest rates given various interest rate scenarios. These reports typically indicate the change in net income or net interest income and/or economic value of equity. Some systems may provide a gap report highlighting asset/liability mismatches over various time horizons. More detailed reports may be available on some systems that can be used to test the reasonableness, consistency, and accuracy of the output. They may also assist the examiner in identifying or verifying the system's underlying assumptions. Comparative reports identifying sources of interest rate risk may also be available.

Management should have formalized procedures in place for reviewing the measurement system results and reporting to the board or a board-delegated committee. Reports provided to the board and senior management should be clear, concise, timely, and informative in order to assist the board and senior management in decision making. The results of the measurement system should also highlight deviations from board-approved interest rate risk exposure limits. Examiners should review the follow-up action and communication, if any, relevant to any material breaches in board-approved limits. Examiners may also find it helpful to review the presentations or analyses provided to senior management or board members in advance of a formal asset/liability committee (ALCO) meeting, as well as the minutes of such meetings.

VARIANCE ANALYSIS

Variance analysis can provide valuable insights into the accuracy and reasonableness of the model and is an integral part of the control process for IRR measurement and management. It is intended to help develop an understanding of the primary causes of the material variances, while also providing a means to improve the precision of the interest rate risk measurement system. Periodic variance analysis helps assure management and the board that the system is accomplishing its primary goal of providing meaningful information on the level of interest rate risk, present and planned. It also helps to validate the implementation of the IRR monitoring and measurement system at a particular institution. While a particular model may be mathematically valid and in use at numerous banks, a flawed implementation can subvert its usefulness. Variance analysis provides an opportunity to validate the implementation, as well as to providing an opportunity for a deeper understanding of both the system and its results.

IRR model variance analysis involves the identification of material differences between actual and forecasted income statement and balance sheet amounts, and then ascertaining the causes for these differences. Variances can be readily identified by direct comparison of the financial statements for a particular forecast period, or by using key financial indicators, such as Net Interest Margin, Cost of Funds, or Asset Yields comparisons.

In order to provide effective control and feedback, variance analysis should be done periodically, and no less frequently than annually. Further, management should document the analysis, highlighting the material variances and the primary causes for them, and summarize any action proposed and/or taken based on that analysis.

The potential causes for variances can be broken down into three major components–mathematics, data, or assumptions. Mathematical flaws, while relatively rare in widely available purchased systems, can occur and are generally within the purview of the independent review process, not the ongoing variance analysis. Data errors should be minimized by a robust internal control process. This will assure that the starting point for the measurement system accurately reflects all material holdings, terms, and conditions. Inaccuracies in the initial data, either in terms of dollar volumes, maturities, embedded options, or associated interest rates, can only lead to flawed results.

Assumption variances

All IRR measurement systems rely heavily on a series of assumptions and assessing the reasonableness of these assumptions is critical to ensuring the integrity of the measurement system results. Just as actual financial results can be expected to vary from forecasts, the assumptions that form the basis of that forecast can be expected to vary. Institutions should have formalized procedures for periodically identifying material difference between assumed and realized values, in order to identify the key drivers of the variance, over the time period measured. Even absent material financial variances, the model's significant assumptions should be compared to actual performance. Compensating differences may have masked important variances. For example an institution with a large mortgage portfolio may find that actual prepayment speeds were significantly higher than projected, while new loan production has replaced the run-off. In this case, there may only be an immaterial variance in the ending loan balance, but a significant variance in projected and actual prepayments. Left undetected, a repeat of such an error could lead to inaccurate modeling and inappropriate management actions.

Given the large number of assumptions inherent in all but the simplest measurement systems, a thorough review of every assumption at each measurement cycle is an unrealistic expectation. However, certain key sets of assumptions should be checked against actual behavior on a regular basis. Key assumptions that bear particular attention include those dealing with rate movements, driver rates, prepayment speeds, and account aggregation.

Interest rate movement assumptions are arguably the most obvious and common sources of variances in a measurement system. While many systems assume an instantaneous and parallel shift in interest rates, others allow for much more complex and realistic changes. Common modeling scenarios include ramped rate changes, yield curve twists, and different spread or beta factors for the up versus down rate changes. Actual yield curve changes that closely mirror those modeled are rare and not expected. Variance analysis should be used to isolate the differences attributable to rate assumptions from other factors in order to better identify and understand how those factors' influenced results for that measurement period.

Driver rate variances will occur when actual bank rate changes do not mirror the driver rate changes. Variance analysis is used to determine the significance of the difference, and should address whether it is due to lack of correlation between the subject and driver rate (i.e.; the driver moved, but the bank rate did not), or due to an inappropriate beta factor. One driver-rate assumption that commonly causes significant variances is associated with NMD rate assumptions. If the measurement system forecasted an increasing net interest margin in a rising rate environment, while the actual performance resulted in a declining margin when rates rose, the cause is generally the NMD assumptions. Many models treat NMD rates as very insensitive to yield curve changes, when actual practice is to manage these rates much more actively. This can lead to model measurements that show the bank as asset sensitive or neutral, when past performance has shown it to be liability sensitive. Periodic variance analysis will identify this discrepancy and allow management to more effectively use the IRR measurement tool. Ideally, the relationship between the subject and driver rates should be documented, and the relationship should factor in not only historical correlations but also management's intention with regard to future movements.

Prepayment speeds can be and are affected by interest rates, loan size, geographic area, credit score, and fixed versus variable rates, to name only a few factors. Larger institutions actively track internal prepayment data, while smaller institutions can obtain prepayment statistics from a wide variety of sources. Banks typically choose a readily available market proxy for an aggregated portion of their own portfolio when modeling IRR. Proper aggregation and proxy selection are key to appropriate prepayment modeling. Prepayment variance analysis will assist in ascertaining whether differences between actual and forecast results are due to the proxy's actual prepayment speeds differing from the forecast or due to the subject bank's prepayment speeds differing from the proxy's. When the proxy speed forecasts appear accurate, but bank prepayments differ significantly, management may need to select a different proxy instrument or otherwise adjust the model to better reflect the portfolio's characteristics.

Aggregation rules which are inappropriate can lead to significant variances. The larger or more varied the portfolio, the more significant the aggregation rules become, and the more likely that finer gradations can and should be used. In very large portfolios, geographic breakdowns (e.g., California versus Iowa mortgages) might be necessary for reasonably accurate modeling. Aggregation rules apply to deposit assumptions as well. CDs of different rates and maturities may react differently to changing rates. Likewise, MMDA balances should not be aggregated with jumbo savings accounts.

Many models measure static IRR, that is, what would happen to the current balance sheet if only interest rates changed. Others incorporate management projections about asset and liability growth and changes in product mix. Variance analysis in the latter instance is complicated by the need to segregate variances due to balance sheet changes from those caused by rate movements and correlations factors.

OTHER MARKET RISK FACTORS

Although interest rate risk is the principal market risk taken by most banks, other activities can dramatically increase (or reduce) a bank's exposure and sensitivity to market risk exposure.

Foreign exchange activities expose banks to the price (exchange rate) risk that results from volatile currency markets. Exchange rates depend upon a variety of global and local factors that are difficult to predict, including interest rates, economic performance, and political developments.

Commodity activities involve using contracts (including futures and options) for fungible, bulk goods, to speculate or hedge. Commodity prices depend upon many factors, including weather, economic conditions, and political developments that are exceptionally difficult to forecast.

Generally, banks should only use foreign exchange or commodity activities to control specific market risks. Management, independent of the broker/dealer, should demonstrate expertise commensurate with the activities undertaken. In addition, management should produce documented analysis that clearly details the effectiveness of all foreign exchange and commodity activities. That analysis should be prepared at least quarterly and presented to the board for its review.

Equity trading and investing creates market risk exposure, since changes in equity prices can adversely affect earnings and capital. The board and management have a responsibility to identify, measure, monitor, and control trading activity risks. Management should carefully monitor all equity investments, regularly evaluate the resulting market risk exposure, and provide timely reports to the board.

Certain restrictions on this activity are contained in Part 362 of the FDIC Rules and Regulations, "Activities and Investments of Insured State Banks" which implements Section 24 of the Federal Deposit Insurance Act (FDI Act). Section 24 prohibits an insured state bank from directly, or indirectly, acquiring or retaining any equity investment of a type that is not permissible for a national bank. National banks are generally prohibited from owning equity securities and, by extension, insured state banks are also enjoined from this activity. However, there are three exceptions to the referenced section 24 prohibition. One of these exceptions enables certain insured state banks (grandfathered banks) to retain and continue to invest in common or preferred stock, or shares of investment companies. The FDIC has extended this exception by regulation to enable banks having the grandfathered authority to hold the subject investments through majority-owned subsidiaries provided the bank is well-capitalized.

Foreign exchange, commodities, and equity trading require a high level of technical and managerial expertise. The risk management and measurement systems needed to operate them effectively are likewise highly sophisticated and require rigorous monitoring and testing. Foreign exchange, commodity, or equity speculation, absent the necessary controls and sufficient capital may be considered an unsafe and unsound practice. When necessary, contact the designated Capital Markets and Securities Specialist in your region for additional guidance.

EVALUATION OF A BANK'S SENSITIVITY TO MARKET RISK FACTOR

When evaluating the bank's market risk, examiners must consider both qualitative and quantitative factors. While taking into consideration the institution's size and the nature and complexity of its activities, the assessment should focus on the risk management process, especially management's ability to measure, monitor, and control market risk. In addition to adequate systems and controls, examiners should evaluate the potential for market risk to adversely affect earnings and capital. Consideration should also be given to the trend in the institution's recent risk measurements, the overall accuracy of the available measurements, and the presence of items with particularly volatile or uncertain interest rate sensitivity.

RATING THE SENSITIVITY TO MARKET RISK FACTOR

Changes in interest rates expose banks to the risk of loss, which may, in extreme cases, threaten the survival of the institution. The sensitivity to market risk component rates the degree to which changes in interest rates, foreign exchange rates, commodity prices, or equity prices can adversely affect a financial institution's earnings or economic capital. The S rating reflects the market risk taken, management's ability to identify, measure, monitor, and control that risk, and the financial protection provided by earnings and capital. After evaluating all of the relevant factors, one of the five following S ratings should be assigned, in accordance with Uniform Financial Institutions Rating System definitions.

Banks rated 1 have well controlled market risk and there is minimal potential that the earnings performance or capital position will be adversely affected. Risk management practices are strong for the size, sophistication, and market risk accepted by the institution. The level of earnings and capital provide substantial support for the degree of market risk taken by the institution.

Banks rated 2 have adequately controlled market risk and there is only moderate potential that the earnings performance or capital position will be adversely affected. Risk management practices are satisfactory for the size, sophistication, and market risk accepted by the institution. The level of earnings and capital provide adequate support for the degree of market risk taken by the institution.

Banks rated 3 need to improve market risk control or there is significant potential that the earnings performance or capital position will be adversely affected. Risk management practices need to be improved given the size, sophistication, and level of market risk accepted by the institution. The level of earnings and capital may not adequately support the degree of market risk taken by the institution.

Banks rated 4 have unacceptable market risk control or there is high potential that the earnings performance or capital position will be adversely affected. Risk management practices are deficient for the size, sophistication, and level of market risk accepted by the institution. The level of earnings and capital provide inadequate support for the degree of market risk taken by the institution.

Banks rated 5 have unacceptable control of market risk or the level of market risk taken by the institution is an imminent threat to its viability. Risk management practices are wholly inadequate for the size, sophistication, and level of market risk accepted by the institution.

MARKET RISK GLOSSARY

Deterministic Rate Scenarios

A method where the user specifies all future interest rate levels completely at their discretion. The following are examples of commonly used deterministic interest rate scenarios:

Rate Shock Scenario – In this scenario, the rate shock is immediate and sustained. For instance in a plus 300 basis point scenario the full effect of the rate increase would be administered immediately and remain for all time periods measured.

Rate Ramp Scenario – In this scenario, the rate movements are gradual and applied over the time period measured. For example, when measuring a 300 basis point rate increase during a 12-month period, the rate increase could be 25 basis point interest rate increases administered each month.

Stair Step Scenario – Rate shocks are administered at more infrequent time intervals over the measured period but each increment is sustained and of equal amounts. For instance, in a 300 basis point increasing rate environment measured over a one-year time period, rates may be incrementally increased 75 basis points once every quarter as opposed to monthly rate ramps.

Non-parallel yield curve shifts are set by bank management at different reflection points on the yield curve during the period measured. Again these may be performed as a rate shock, rate ramp, or stair step scenarios.

Stochastic Models

Stochastic modeling consists of the modeling of an uncertain variable over time. It recognizes that market variables, such as interest rates, exhibit a general trend (drift) and some degree of volatility around that trend. Stochastic models provide a framework for the evaluation of the impact of embedded options in financial instruments.

In the general context, constraints are usually imposed so that the model is representative of current market conditions. For example, if Treasury securities are priced using interest rate paths, a constraint may be imposed, so that, the average present value derived from all the paths, must equal the observed market price of the Treasury securities. In such a case, the model can also be classified as a Stochastic No Arbitrage Model.

Stochastic models require more sophisticated software and significant additional computer processing power as well.

Monte Carlo Simulation

A Monte Carlo simulation randomly generates a sufficiently large sample set from a reasonable population of a variable such as an interest rate. The stochastic model provides a framework for the evolution of the variable, and a Monte Carlo simulation is an application of that stochastic model. The randomness in games of chance is similar to how Monte Carlo simulation selects values at random to simulate a model. When you turn a roulette wheel, you know that one of a range of numbers will come up, but you do not know which for any particular turn. It is the same concept with Monte Carlo simulation where the variables (e.g., interest rates, security prices) have a known range of values but an uncertain value for any particular time. Monte Carlo simulations can take into account returns, volatility, correlations, and other factors. Monte Carlo programs generate thousands or millions of different scenarios by randomly changing a component for each run or iteration. Monte Carlo simulation allows the banker to simulate thousands of market-like scenarios and learn the probability of a particular outcome or a range of outcomes. Assume that the investment portfolio is run through 20,000 simulations, projecting 20,000 separate scenarios over a two-year period, and acceptable results occur 16,000 times. This means that there is an 80 percent probability that the portfolio will perform at an acceptable level. Like any financial model, the results are sensitive to underlying assumptions. The number of runs or simulations is also important. For example, a Monte Carlo model with only 500 iterations might not have been able to predict the stock market crash of 1987.

Spread Types

Static Spread – Spread, that when added to the implied forward rates, discounts the cash flows back to its observed market value. For an instrument without embedded optionality, the static spread is the best measure of return in excess of the risk-free rates provided by that instrument. For instruments with embedded optionality, it may useful to calculate a static spread ONLY as a starting point for comparison with the more appropriate mark-to-market spread measure, the option adjusted spread (OAS, defined below).

Option Adjusted Spread (OAS) – Spread, that when added to all interest rate paths generated in a Monte Carlo simulation, discounts the cash flows of an instrument back to its observed market value. This measure only applies to instruments with embedded optionality. The Static Spread applies to instruments without embedded optionality. For example, consider a mortgage backed security (MBS), which typically contains an embedded prepayment option. Assume the Static Spread is 75 basis points. The OAS would be less than the static spread of 75 basis points because the volatility of interest rates reflected in an OAS framework assigns more value to the borrower's prepayment option, thus reducing the value to the MBS investor.

OAS Process: In a stochastic valuation model, the average value generated by all the interest rate paths must equal the currently observed price of the security. The initial computation in the model is based on an assumed spread. The security value derived is compared to the observed.

Duration Calculations

Macaulay duration calculates the weighted average term to maturity of a security's cash flows. Assume a bond with three years remaining to maturity, bearing a 5% coupon rate paid annually, when a 10% yield is required.

Macaulay Duration Calculation
3 year bond, 5% coupon, 10% yield

Year	Payment	PV	x	T	PVxT
1	$50	$45.5	x	1 =	$45.5
2	$50	$41.3	x	2 =	$82.6
3	$1,050	$788.9	x	3 =	$2,366.7
		$875.7			$2,494.8

T = Time period payment is received

Macaulay Duration = 2,494.8 / 875.7
= 2.85 years

Modified duration, calculated from Macaulay duration, estimates price sensitivity for small interest rate changes.

Modified Duration Calculation
3 year bond, 5% coupon, 10% yield
Macaulay Duration = 2.85 years

$$\textbf{Modified Duration} = \frac{\text{Macaulay Duration}}{1 + (\text{Yield} / n)}$$

= 2.85 / 1.10

n = coupons per year

Modified Duration = 2.59%

The formula of the percentage change in price (Δ%) which is:

$$\Delta\% = \textit{minus} \text{ Modified Duration x } \Delta \text{ Yield x } 100$$

The minus sign recognizes the inverse relationship of price and yield. For a 100 basis point change in rates, the estimated change in price is equal to the modified duration.

Using the modified duration of 2.59% calculated above, the price of the bond would change 2.59% for every 100bp change in rates. If rates changed by only 50bp, the bond would change by 1.29%.

$$\begin{aligned}\Delta\% &= \text{Modified Duration} \times \Delta \text{ Yield} \times 100\\ &= 2.59\% \times 50\text{bp} \times 100\\ &= 2.59\% \times .5\\ &= 1.295\%\end{aligned}$$

The formula for the dollar change in price:

$\Delta\$$ = *minus* Price x Modified Duration x Δ Yield x 100

If the price of the bond had been $875.66, then its approximate change in value (price) if rates change by 50bp would be

= -$875.66 x 1.295%
= -$11.34

If rates fell, the estimated value would be $887.00, while if rates rose the estimated value would fall to $864.32.

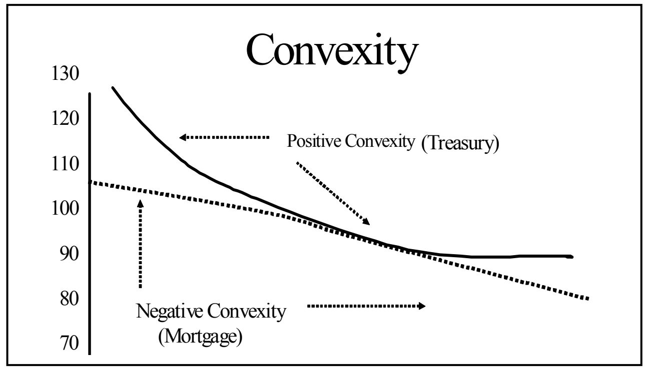
For very small changes (1 to 5 basis points) the duration based price forecast will be precise. For larger changes (100bp or more) the result will only approximate the change in price. The larger the change, the larger the approximation error. The reason for the error is the non-linear price/yield relationship, or convexity.

Convexity

Convexity describes the nonlinear price/yield relationship. Option-free instruments display positive convexity. When rates decline, a positively convex instrument's price increases at an increasing rate. When rates rise, a positively convex instrument's price decreases at a decreasing rate.

Negative convexity causes the duration of a security to lengthen when a rates rise and shorten when rates fall. Instruments that contain embedded options demonstrate negative convexity. When rates decline, a negatively convex instrument's price increases at a decreasing rate. When rates rise, the price of a negatively convex instrument will decline at an increasing rate.

As the following chart illustrates in the +200 to +300bp range, the value of the treasury security changes relatively less in value in comparison to the sample mortgage security, which declines more significantly. However, as yields decrease, the treasury security gains value at an increasing rate, while the mortgage security gains only modestly. As interest rates decline, the likelihood that borrowers will refinance (exercise prepayment option) increases. Therefore, the value of a mortgage security does not increase at the same rate or magnitude as a decline in interest rates.



Effective Duration and Effective Convexity are used to calculate bonds with embedded options. The calculation provides an approximate price change of a bond given a parallel yield curve shift. Measures of modified duration and convexity do not provide accurate calculations of price sensitivity for bonds with embedded options. Effective duration and convexity provide a more accurate view of price sensitivity since the measures allow for cash flows to change due to a change in yield. Formula:

Effective Duration $= V_{-} - V_{+} \div 2V_{O}$ (Change Y)

Effective Convexity $= V_{+} + V_{-} - 2V_{O} \div 2V_{O}$ (Change Y)^2

Where,

Change Y = Change in market interest rate used to calculate new values
V_{+} = Price if yield is increased by Change Y
V_{-} = Price if yield is decreased by Change Y
V_{O} = Initial price per $100 of par value

Assume: a three-year callable bond's current market value is $98.60 ($V_{O}$); that interest rates are projected to change by 100 basis points (Y); that the price of this bond given a 100 basis point increase in rates is $96.75 ($V_{+}$); and that the price of this bond given a 100 basis point decrease in rates is $99.98 ($V_{-}$).

To calculate effective duration and convexity:

Effective Duration $= 99.98 - 96.75 \div 2(98.60)(.01)$
$= 1.64$

Effective Convexity $= 96.75 + 99.98 - 2(98.60) \div 2(98.60)(.01)^2$
$= -23.83$

If we assume interest rates increase 100 bps, the approximate price change due to effective duration is the following:

Percentage Price Change = -Effective Duration x Yield Change
Percentage Change in Price = -1.64 x .01 = -1.64%

The approximate price change due to effective convexity is the following:

$\frac{1}{2}$ x Effective Convexity x $(\text{Yield Change})^2$
$\frac{1}{2}$ x -23.83 x $(0.01)^2$ x 100 = -0.12%

Thus this bond's price would be expected to decrease by about 1.76% given a 100 bps rise in rates:

Effective Duration	=	-1.64%
Effective Convexity	=	-0.12%
		-1.76%