National Bank of the Republic of Macedonia
Supervisory Policy Manual

Title: **MR-1** Interest Rate Risk

Date: **FINAL**

Purpose: To set out the approach which the NBRM will adopt in the supervision of licensed institutions' interest rate risk, and to provide guidance to licensed institutions on the key elements of effective interest rate risk management.

Issue Type: Supervisory Guidance

Supersedes Previous Issue: None

Application: All licensed institutions and supervision personnel

Contents:

1. Introduction

1.1. **Interest rate risk** is the current or prospective risk to earnings and capital arising from adverse movements in interest rates. This risk impacts both the earnings of an institution and the economic value of its assets, liabilities and off-balance sheet instruments. The primary types of interest rate risk to which institutions are typically exposed are: (1) ***re-pricing risk***, which arises from timing differences in the maturity (for fixed rate) and re-pricing (for variable rate) of assets, liabilities and off-balance sheet positions; (2) ***yield curve risk***, which arises from changes in the slope and shape of the yield curve; (3) ***basis risk***, which arises from imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar re-pricing characteristics; and (4) ***options risk***, which arises from the expressed or implied options imbedded in many assets, liabilities and off-balance sheet portfolios.

1.2. In their role as financial intermediaries, licensed institutions make loans, purchase securities, and take deposits with different maturities and interest rates. These activities may leave an institution's earnings and capital exposed to movements in interest rates. Changes in institutions' competitive environment, products, and services heighten the importance of prudent interest rate risk management.

1.3. Historically, the interest rate environment for institutions in Macedonia has been fairly stable. However, institutions become more exposed to interest rate volatility because of the changing character of their assets and liabilities. Each year, the financial products offered and purchased by institutions become more various and complex. Additionally, the structure of institutions' balance sheets are changing with increased holdings of longer-term assets and liabilities, whose values are more sensitive to rate changes. Such changes mean that managing interest rate risk is becoming more important and complex than just a few years ago.

1.4. Each financial transaction that an institution completes may affect its interest rate risk profile. Institutions differ, however, in the level and degree of interest rate risk they are willing to assume. Some institutions seek to minimize their interest rate risk exposure. Such institutions generally do not deliberately take positions to benefit from a particular movement in interest rates. Rather, they try to match the maturities and re-pricing dates of their assets and liabilities. Other institutions are willing to assume a greater level of interest rate risk and may choose to take interest rate positions or to leave them open. An institution can alter its interest rate risk exposure by changing investment, lending, funding and pricing strategies and by managing the maturities and re-pricings of these portfolios to achieve a desired risk profile.

1.5. The Supervisory Board (Board) and Board of Directors (Directors) should also be aware of how interest rate risk may act jointly with other risks facing the

institution. For example, in a rising rate environment, loan customers may not be able to meet interest payments because of the increase in the size of the payment or a reduction in earnings. The result will be a higher level of problem loans and higher provision expense. For an institution that is predominately funded with short-term liabilities, a rise in rates may decrease Net Interest Income at the same time credit quality problems are on the increase.

1.6. Additionally, when developing and reviewing an institution's interest rate risk profile and strategy, management should consider the institution's liquidity and ability to access various funding and derivative markets. An institution with ample and stable sources of liquidity may be better able to withstand short-term earnings pressures arising from adverse interest rate movements than an institution that is heavily dependent on wholesale, short-term funding sources that may leave the institution if its earnings deteriorate. An institution that can readily access various money and derivatives markets may be better able to respond quickly to changing market conditions than institutions that rely on customer-driven portfolios to alter their interest rate risk positions.

1.7. Finally, an institution should consider the fit of its interest rate risk profile with its strategic business plans. An institution that has significant long-term interest rate exposures (such as long-term fixed rate assets funded by short-term liabilities) may be less able to respond to new business opportunities because of depreciation in its asset base.

1.8. The adequacy and effectiveness of an institution's interest rate risk management are important in determining whether an institution's level of interest rate risk exposure poses supervisory concerns or requires additional capital. The nature and complexity of an institution's business activities and overall levels of risk should determine how sophisticated its management of interest rate risk must be. Every well-managed institution, however, will have a process that enables management to identify, measure, monitor, and control interest rate risk in a timely and comprehensive manner.

2. Supervisory Board and Board of Directors Oversight

2.1. Effective Board and Directors oversight of the institution's interest rate risk activities is the cornerstone of an effective risk management process. It is the responsibility of the Board and Directors to understand the nature and level of interest rate risk being taken by the institution and how that risk fits within the overall business strategies of the institution and the mechanisms used to manage that risk. Effective risk management requires an informed Board, capable management, and appropriate staffing.

2.2. The Board must:

- Establish and guide the institution's strategic direction and tolerance for interest rate risk and identify the senior managers who have the authority and responsibility for managing this risk.

- Monitor the institution's performance and overall interest rate risk profile, ensuring that the level of interest rate risk is maintained at prudent levels and is supported by adequate capital. In assessing the institution's capital adequacy for interest rate risk, the Board should consider the current and potential interest rate risk exposure as well as other risks that may impair capital, such as credit, liquidity, and transaction risks.
- Ensure that senior management implement sound fundamental principles that facilitate the identification, measurement, monitoring, and control of interest rate risk.
- Ensure that adequate resources are devoted to interest rate risk management. Effective risk management requires both technical and human resources.

2.3. Directors are responsible for ensuring that interest rate risk is managed for both the long range and day-to-day. In managing the institution's activities, Directors should:

- Develop and implement procedures and practices that translate the Board's goals, objectives, and risk tolerances into operating standards that are well understood by all personnel and that are consistent with the Board's intent.
- Ensure adherence to the lines of authority and responsibility that the Board has established for measuring, managing, and reporting interest rate risk exposures.
- Oversee the implementation and maintenance of management information and other systems that identify, measure, monitor, and control interest rate risk.
- Establish effective internal controls (including audit) over the interest rate risk management process.

3. Effective Risk Management Process

3.1. Effective control of interest rate risk requires a comprehensive risk management process that ensures the timely identification, measurement, monitoring, and control of risk. The formality of this process may vary, depending on the size and complexity of the institution. Regardless of the mechanism used, an institution's interest rate risk management procedures or processes should establish the following:

3.2. *Risk management policies, procedures and controls*. An institution's interest rate risk management procedures should be clearly defined and consistent with the nature and complexity of its activities. Especially important is to develop procedures that will enable management to identify the interest rate risks inherent in new services and activities and ensure that these are subject to adequate procedures and controls before being introduced or undertaken

3.3. *Responsibility and authority* for identifying the potential interest rate risk arising from new or existing products or activities; establishing and maintaining an interest rate risk measurement system; formulating and executing strategies; and authorizing policy exceptions.

3.4. *An interest rate risk measurement system* that is able to identify and quantify the major sources of interest rate risk in a timely manner.

3.5. *A system for monitoring and reporting risk exposures.* Directors and the Board, or a committee thereof, should receive reports on the institution's interest rate risk profile at least quarterly, but more frequently if the character and level of risk requires it. These reports should allow Directors and the Board to evaluate the amount of interest rate risk being taken, compliance with established risk limits, and whether management's strategies are appropriate in light of the Board's expressed risk tolerance.

3.6. *Risk limits and controls* on the nature and amount of interest rate risk that can be taken. When determining risk exposure limits, Directors should consider the nature of the institution's strategies and activities, its past performance, the level of earnings and capital available to absorb potential losses, and the Board's tolerance for risk.

3.7. *Internal control procedures (including audit).* The oversight by Directors and the Board is critical to the internal controls process. In addition to establishing clear lines of authority, responsibilities, and risk limits, management and the Board should ensure that adequate resources are provided to support risk monitoring, audit, and control functions. The persons or units responsible for risk monitoring and control functions should be separate from the persons or units that create risk exposures. The persons or units may be part of the audit, compliance, risk management, or treasury unit. If the risk monitoring and control functions are part of a treasury unit that also has the responsibility and authority to execute investment or hedging strategies, it is particularly important that a strong internal audit function and sufficient safeguards are in place to ensure that all trades are reported to senior management in a timely manner and are consistent with strategies approved by Directors.

4. Risk Management Policies, Procedures and Controls

4.1. Policies, procedures and limits (e.g., limits on fixed-rate loans and deposits, use of interest rate swaps, etc.) should be properly documented, drawn up after careful consideration of the interest rate risk associated with different types of lending, and reviewed and approved by management at appropriate level.

4.2. Institutions should also develop accurate, informative and timely management information systems for interest rate risk. This is essential both to keep senior management and, where appropriate, individual business line managers informed and to facilitate compliance with approved policies.

4.3. Institutions' policies and procedures for interest rate risk management should cover the general criteria for sound risk management controls set by the NBRM and best banking practices as well as other criteria specific to interest rate risk.

4.4. Institutions should be able to identify the interest rate risks inherent in new services and activities and ensure that these are subject to adequate procedures and controls before being introduced or undertaken.

4.5. Institutions should also develop interest rate risk measurement systems that encompass all significant causes of such risk. The systems should evaluate the effect of rate changes on earnings or economic value within the context and complexity of business activities. Such a system should be able to flag any excessive exposures.

5. Organizational Structures for Managing Interest Rate Risk

5.1. The organizational structure used to manage interest rate risk may vary, depending on the size, scope, and complexity of the institution's activities. At many larger institutions, the interest rate risk management function may be centralized in the lead bank or holding company. When an institution chooses to adopt a more decentralized structure for its interest rate risk activities, supervisors will review and evaluate how the interest rate risk profiles of all material affiliates contribute to the organization's companywide interest rate risk profile. Such an assessment is important because the risk at individual affiliates may either raise or lower the risk profile of the institution.

5.2. An institution's Board usually will delegate responsibility for establishing specific interest rate risk policies and practices to a committee. This committee may be the Finance Committee, Risk Management Committee or Asset/Liability Management Committee (ALCO). The committee usually manages the structure of the institution's business and the level of interest rate risk it assumes. It is responsible for ensuring that measurement systems adequately reflect exposure and that reporting systems adequately communicate relevant information concerning the level and sources of such exposure. To be effective, the committee should include representatives or have access to individuals from each major section of the institution that assumes interest rate risk.

5.3. The Diagram presented in Appendix C provides an example of the interest rate risk management structure of an institution. This example is not intended to be prescriptive, but provides an illustration of how interest rate risk management responsibilities can be coordinated.

6. Supervisory Review of Interest Rate Risk Management

6.1. Supervisors determine the adequacy and effectiveness of an institution's interest rate risk management process, the level and trend of risk exposure, and the adequacy of capital relative to its exposure and risk management process.

6.2. Supervisors determine, normally through discuss with management, the major sources of interest rate risk exposure and evaluate whether the institution's measurement systems provide a sufficient basis for identifying and quantifying

the major sources of interest rate exposure. They also analyze the integrity and effectiveness of interest rate risk control and management processes to ensure that practices comply with the stated objectives and risk tolerances of Directors and the Board.

6.3. In forming conclusions about the safety and soundness of the institution's interest rate risk management and exposures, supervisors consider:

- Complexity and level of risk posed by the assets, liabilities, and off-balance-sheet activities.
- Adequacy and effectiveness of Board and Directors oversight.
- Management's knowledge and ability to identify and manage sources of interest rate risk.
- Adequacy of internal measurement, monitoring, and management information systems.
- Adequacy and effectiveness of risk limits and controls that set tolerances on income and capital losses.
- Adequacy of internal reviews and audits of the interest rate risk management process.
- Adequacy and effectiveness of risk management practices and strategies as evidenced in past and projected financial performance.
- Appropriateness of the level of interest rate risk in relation to earnings, capital, and risk management systems.

7. Earnings versus Economic Perspective

7.1. To evaluate the potential impact of interest rate risk on an institution's operations, a well managed institution will consider the affect on both its earnings (the earnings or accounting perspective) and underlying economic value (the economic or capital perspective). Both viewpoints must be assessed to determine the full scope of an institution's interest rate risk exposure, especially if the institution has significant long-term or complex interest rate risk positions.

7.2. The earnings perspective considers how interest rate changes will affect an institution's reported earnings. This perspective focuses on risk to earnings in the near term, typically the next one or two years. From an earnings perspective, management would consider the effect of interest rate risk on Net Income and Net Interest Income. The movement of interest rates affects reported earnings and book capital by changing:

- Net interest income,
- The market value of trading accounts (and other instruments accounted for by market value), and
- Other interest sensitive income and expenses, such as mortgage servicing fees.

7.3. Management must also consider the effect of interest rate risk on net income and net interest income in order to fully assess the contribution of non-interest

income and operating expenses to the interest rate risk exposure of the institution. In particular, an institution with significant fee income should assess the extent to which that fee income is sensitive to rate changes.

7.4. In contrast to the earnings perspective, the economic perspective identifies risk arising from long-term re-pricing or maturity gaps. Changes in interest rates affect an institution's underlying economic value because the present value of future cash flows, and in some cases the cash flows themselves, are changed. By capturing the impact of interest rate changes on the value of all future cash flows, the economic perspective can provide a more comprehensive measurement of interest rate risk than the earnings perspective.

7.5. The future cash flow projections used to estimate an institution's economic exposure provides a *pro forma* estimate of future income generated by its current position. Because changes in economic value indicate the anticipated change in the value of future cash flows, the economic perspective can provide a leading indicator of the institution' future earnings and capital values. Changes in economic value can also affect the liquidity of assets because the cost of selling depreciated assets to meet liquidity needs may be prohibitive.

7.6. Although a powerful tool to help manage interest rate risk exposure, the economic perspective often is more difficult to quantify than the earnings perspective. Measuring risk from the economic perspective requires an estimate of the future cash flows of all financial instruments. Since many retail products, such as savings deposits and current accounts, have uncertain cash flows and indefinite maturities, measuring the risk of these accounts can be difficult and requires the institution to make numerous assumptions.

7.7. When protecting (immunizing) earnings and economic value from interest rate risk, management must make certain tradeoffs. When earnings are immunized, economic value becomes more vulnerable, and vice versa. The economic value of equity (capital), like that of other financial instruments, is a function of the discounted net cash flows (profits) it is expected to earn in the future. If an institution has immunized earnings, such that expected earnings remain constant for any change in interest rates, the discounted value of those earnings will be lower if interest rates rise. Hence, although the institution's earnings have been immunized, its economic value will fluctuate with rate changes. Conversely, if an institution fully immunizes its economic value, its periodic earnings must increase when rates rise and decline when interest rates fall. Appendix A provides further illustration of the distinctions between the earnings and economic perspectives.

8. Re-pricing Risk

8.1. As mentioned earlier, re-pricing risk arises from timing differences in the maturity (for fixed rate) and re-pricing (for variable rate) of assets, liabilities and off-balance sheet positions.

8.2. The exposure from re-pricing risk is often the most apparent source of interest rate risk for an institution. It is often gauged by comparing the volume of an institution's assets that mature or re-price within a given time period with the volume of liabilities that mature or re-price in the same time period. Some institutions intentionally take re-pricing risk in their balance sheet structure in an attempt to improve earnings. Because the yield curve is generally upward-sloping (long-term rates are higher than short-term rates), institutions can often earn a positive spread by funding long-term assets with short-term liabilities. The earnings of such institutions, however, are vulnerable to an increase in interest rates that raises its cost of funds.

8.3. Institutions whose re-pricing assets are longer than their re-pricing liabilities are said to be "liability sensitive," because their liabilities will re-price more quickly. The earnings of a liability-sensitive institution generally increase when interest rates fall and decrease when they rise. Conversely, an asset–sensitive institution (asset re-pricings shorter than liability re-pricings) will generally benefit from a rise in rates and be hurt buy a fall in rates.

8.4. Re-pricing risk is often, but not always reflected in an institution's current earnings performance. An institution may be creating re-pricing imbalances that will not be manifested in earnings until sometime into the future. An institution that focuses only on short-term re-pricing imbalances may be induced to take on increase interest rate risk by extending maturities to improve yield. When evaluating re-pricing risk, therefore, it is essential that consideration is given not only to near-term imbalances but also to long-term positions. Failure to measure and manage material long-term re-pricing imbalances can leave an institution's future earnings significantly exposed to interest rate movement.

9. Yield Curve Risk

9.1. Yield-curve risk arises from variations in the movement of interest rates across the maturity spectrum. It involves changes in the relationship between interest rates of different maturities of the same index or market (e.g., a three-month government security versus a nine-month government security). The relationships change when the shape of the yield curve for a given market flattens, steepens, or becomes negatively sloped (inverted) during an interest rate cycle. Yield curve variation can accentuate the risk of an institution's position by amplifying the effect of maturity mismatches. Certain types of structured notes can be particularly vulnerable to changes in the shape of the yield curve. For example, the performance of certain types of structured note products, such as dual index notes, is directly linked to basis and yield curve relationships. These bonds have coupon rates that are determined by the difference between market indices, such as the nine-month government securities and LIBOR. An example would be a coupon whose rate is based on the following formula: coupon equals nine-month government security rate plus 300 basis points less three-month LIBOR. Since the coupon on this bond adjusts as interest rates

change, an institution may incorrectly assume that it will always benefit if interest rates increase. If, however, the increase in three-month LIBOR exceeds the increase in the nine-month government security rate, the coupon on this instrument will fall, even if both LIBOR and government security rates are increasing. Institutions holding these types of instruments should evaluate how their performance may vary under different yield curve shapes.

10. Basis Risk

10.1. Basis risk arises from a shift in the relationship of the rates in different financial markets or on different financial instruments. Basis risk occurs when market rates for different financial instruments or the indices used to price assets and liabilities, change at different times or by different amounts. For example, basis risk occurs when the spread between the three-month government securities rate and inter-bank rate changes. This change affects an institution's current net interest margin through changes in the earned/paid spreads of instruments that are being re-priced. It also affects the anticipated future cash flows from such instruments, which in turn affects the underlying net economic value of the institution.

10.2. Basis risk can also be said to include changes in the relationship between managed rates, or rates established by the institution, and external rates. For example, basis risk may arise because of differences in the prime rate[1] and an institution's offering rates on various liability products, such as savings accounts. Because consumer deposit rates tend to lag behind increases in market interest rates, institutions with large consumer deposit base may see an initial improvement in their net interest margins when rates are rising. As rates stabilize, however, this benefit may be offset by re-pricing imbalances and unfavorable spreads in other key market interest rate relationships; and deposit rates gradually catch up to the market. (Many bankers view this lagged and asymmetric pricing behavior as a form of option risk. Whether this behavior is categorized as basis or option risk is not important so long as management understands the implications that this pricing behavior will have on the interest rate risk exposure.)

10.3. Some managers may consider using off-balance sheet derivatives to hedge interest rate risk, which also exposes the institution to basis risk. This exists because the spread relationship between cash and derivative instruments may change. For example, an institution using interest rate swaps (priced off LIBOR) to hedge its government securities portfolio may face basis risk because the spread between the swap rate and the securities may change. An institution using off-balance sheet instruments such as futures, swaps, and options to hedge or alter the interest rate risk characteristics of on-balance sheet positions needs to

[1] Prime rate is used in pricing loans and represents the rate charged on short maturity commercial loans to an institution's best, or most creditworthy, customers. Commercial and industrial loans are often priced at prime or prime plus a spread.

consider how the off-balance sheet contracts' cash flows may change with changes in interest rates and in relation to the positions being hedged or altered.

10.4. Derivative strategies designed to hedge or offset the risk in a balance sheet position will typically use derivative contracts whose cash flow characteristics have a strong correlation with the instrument or position being hedged. The institution will also need to consider the relative liquidity and cost of various contracts, selecting the product that offers the best mix of correlation, liquidity, and relative cost. Even if there is a high degree of correlation between the derivative contract and the position being hedged, the institution may be left with residual basis risk because cash and derivative prices do not always move in tandem. Institutions holding large derivative portfolios or actively trading derivative contracts should determine whether the potential exposure presents material risk to earnings or capital.

11. Option Risk

11.1. Option risk arises when an institution or its customer has the right (not the obligation) to alter the level and timing of the cash flows of an asset, liability, or off-balance sheet instrument. An option gives the option holder the right to buy (call option) or sell (put option) a financial instrument at a specified price (strike price) over a specified period of time. For the seller (or writer) of an option, there is an obligation to perform if the option holder exercises the option. The option holder's ability to choose whether to exercise the option creates an asymmetry in an option's performance.

11.2. Generally, option holders will exercise their right only when it is to their benefit. As a result, an option holder faces limited downside risk (the premium or amount paid for the option) and unlimited upside reward. The option seller faces unlimited downside risk (an option is usually exercised at a disadvantageous time for the option seller) and limited upside reward (if the holder does not exercise the option and the seller retains the premium). Options often result in an asymmetrical risk/reward profile for the institution.

11.3. If an institution has written (sold) options to its customers, the amount of earnings or capital value that it may lose from an unfavorable movement in interest rates may exceed the amount that the institution may gain if rates move in a favorable direction. As a result, the institution may have more downside exposure than upside reward. For many institutions, their written options positions leave them exposed to losses from both rising and falling interest rates. Some institutions may buy and sell options on a "stand-alone" basis. The option has an explicit price at which it is bought or sold and may or may not be linked with another institution's product.

11.4. An institution does not have to buy and sell explicitly priced options to incur option risk, however. Indeed, almost all institutions incur option risk from options that are embedded or incorporated into its products. These options are

found on both sides of the balance sheet. On the asset side, prepayment (loans) options are the most prevalent embedded option. Most residential mortgage and consumer loans give the consumer an option to prepay with little or no prepayment penalty. Institutions may also permit the prepayment of commercial loans by not enforcing prepayment penalties (perhaps to remain competitive in certain markets). A prepayment option is equivalent to having written a call option to the customer. When rates decline, customers will exercise the calls by prepaying loans, and the institution's asset maturities will shorten just when the institution would like to be extending them. And when rates rise, customers will keep their mortgages, making it difficult for the institution to shorten asset maturities just when it would like to be doing so.

11.5. On the deposit side of the balance sheet, the most prevalent option given to customers is the right of early withdrawal. Early withdrawal rights are like put options on deposits. When rates increase, the market value of the customer's deposit declines and the customer has the right to "put" the deposit back to the institution. This option is to the depositor's advantage.

11.6. As previously noted, management's discretion in pricing such products as non-maturity deposits can also be viewed as a type of option. This option usually works in the institution's favor. For example, management may peg its deposits at rates that lag market rates when interest rates are increasing and that lead market rates when they are decreasing.

11.7. The institution's products that contain interest "caps" or "floors" are other sources of option risk. Such products are often loans and may have a significant effect on an institution's rate exposure. For the institution, a loan cap is like selling a put option on a fixed income security, and a floor is like owning a call. The cap or floor rate of interest is the strike price. When market interest rates exceed the cap rate, the borrower's option moves "in the money" because the borrower is paying interest at a rate lower than market. When market interest rates decline below the floor, the institution's option moves "in the money" because the rate paid on the loan is higher than the market rate. Floating rate loans that do not have an explicit cap may have an implicit one at the highest rate that the borrower can afford to pay. In high rate environments, management may have to cap the rate on the loan, renegotiate the loan to a lower rate, or face a default on the loan. An institution's non-maturity deposits, such as savings accounts also may have implicit caps and floors on the rates of interest that the institution is willing to pay.

12. Risk Measurement

12.1. Accurate and timely measurement of interest rate risk is necessary for proper risk management and control. An institution's risk measurement system should be able to identify and quantify the major sources of interest rate risk exposure. The system also should enable management to identify risks arising from customary activities and new business. The nature and mix of business lines and the interest

rate risk characteristics of activities will dictate the type of measurement system required. Such systems will vary from institution to institution.

12.2. Measurement systems should enable the institutions to :

- Evaluate all significant interest rate risk arising from the full range of an institution's assets, liabilities and off-balance sheet positions, both trading and non-trading. If the same measurement systems and management methods are not used for all activities, an integrated view of interest rate risk across products and business lines should be available to management;
- Employ generally accepted financial models and ways of measuring risk;
- Provide accurate and timely data (in relation to rates, maturities, re-pricing, embedded options and other details) on current positions (Any manual adjustments to underlying data should be clearly documented and the nature and reasons for the adjustments should be clearly understood);
- Document the assumptions, parameters and limitations on which they are based (Material changes to assumptions should be documented, justified and approved by senior management);
- Cover all significant sources of interest rate risk, e.g., re-pricing, yield curve, basis and option (While all positions should be appropriately treated, its largest concentrations and positions should be assessed with special thoroughness, as should instruments which might have a material effect on an institution's overall position (notwithstanding that they are not major concentrations) and instruments with significant embedded or explicit options); and
- Assess exposures in different currencies.

12.3. Techniques to measure interest rate risk exposure from an earnings and economic value perspective comprise, in increasing degrees of complexity, simple calculations, static simulations using current holdings and highly sophisticated dynamic modeling techniques based on business forecasts and decisions. At a minimum, institutions should be able to use the simpler techniques for measuring interest rate risk exposure, such as producing a maturity/re-pricing schedule and carrying out a gap analysis. (Note: Gap analysis provides only a rough approximation of changes in net interest income due to its limitations.)

12.4. On the other hand, institutions having complex risk profiles should employ more sophisticated interest rate risk measurement techniques such as simulation approaches. The assumptions underlying a simulation model can sometimes make it difficult to determine how much a variable contributes to changes in the simulation results. It is therefore necessary to supplement the simulation model by additional in-depth analysis or other simulation models to isolate the risk of each variable inherent in the existing balance sheet.

12.5. Regarding positions where the behavioral maturities may differ from contractual maturities, these should be given assumed maturities or re-pricing frequencies

based on past experience of the institution and with sound empirical analysis. Such positions include demand deposits which can be withdrawn without notice, but a portion of which tend to remain with the institutions in practice (i.e., core deposits). Conversely, term deposits have contractual maturities but depositors generally have the option to make withdrawals at any time, subject to applicable penalties or charges. On the asset side, prepayment features of mortgages and mortgage-related instruments also introduce uncertainty about the timing of cash flows from these positions.

12.6. The behavioral assumptions used should be subject to periodic review. Institutions with positions in different currencies need to measure their exposure to interest rate risk in each currency. They may do so for each currency separately, on the ground that yield curves for different currencies vary. Institutions with material multi-currency exposures may, if they have the requisite skills and sophistication, decide to aggregate their exposures in certain currencies where there is assumed to be some correlation between interest rates for those currencies. Such institution should review periodically whether these assumptions remain valid and assess their potential exposure if such correlations prove invalid.

12.7. All risk measurement systems have limitations, and systems vary in the degree to which they capture various components of interest rate exposure. Many well-managed institutions as discussed previously use a variety of systems to fully capture all of their sources of interest rate exposure. The three most common risk measurement systems used to quantify interest rate risk exposure are re-pricing maturity gap reports, net income simulation models, and economic valuation or duration models. The following table (Table 1) summarizes the types of interest rate exposures that these measurement techniques address.

Table 1
Interest Rate Risk Models

	Gap Report	Earnings Simulation	Economic Valuation
Short-Term Earnings Exposure	Yes	Yes	Generally does not distinguish short-term accounting earnings from changes in economic value.
Long-Term Exposure	Yes	Limited*	Yes
Re-pricing Risk	Yes	Yes	Yes
Basis Risk	Limited*	Yes	Limited*
Yield Curve Risk	Limited*	Yes	Yes
	Limited*	Limited*	Yes

* The ability of these types of models to capture this type of risk will vary with the sophistication of the model and the manner in which management uses them.

12.8. Institutions with significant option risk may supplement these models with option pricing or Monte Carlo models. But for many institutions, especially smaller ones, the expense of developing options pricing models would outweigh the benefits. Such institutions should be able to use their data and measurement systems to identify and track, in a timely and meaningful manner, products that may create significant option risk. Such products may include non-maturity deposits, loans and securities with prepayment and extension risk, and explicit and embedded caps on adjustable rate loans. Management should understand how such options may alter interest rate exposure under various interest rate environments. Appendix B provides background information on various types of models.

12.9. Regardless of the type and level of complexity of a measurement system, management should ensure that the system is adequate to the task. All measurement systems require an institution to gather and input position data, make assumptions about possible future interest rate environments and customer behavior, and compute and quantify risk exposure. To assess the adequacy of interest rate risk measurement process, supervisors review and evaluate each of these steps.

13. Stress-testing

13.1. Institutions should measure their vulnerability to loss in stressed market conditions, including the breakdown of key assumptions, and consider those results when establishing and reviewing their policies and limits for interest rate risk.

13.2. Possible stress scenarios include:

- Historical scenarios;
- Changes in the general level of interest rates, e.g., changes in yields of 200 basis points or more in one year;
- Changes in the relationships between key market rates (i.e., basis risk);
- Changes in interest rates in individual time bands to different relative levels (i.e., yield curve risk);
- Changes in the liquidity of key financial markets or changes in the volatility of market rates; and
- Changes in key business assumptions and parameters such as the correlation between the Denar and Euro interest rates. In particular, changes in assumptions used for illiquid instruments and instruments with uncertain contractual maturities help the understanding of an institution's risk profile.

14. Limits

14.1. Institutions should establish and enforce operating limits and other practices that maintain exposures within levels consistent with their internal policies and that agree with their approach to measuring interest rate risk.

14.2. In particular, institutions should set a limit on the extent to which floating rate exposures are funded by fixed rate sources and vice versa to limit interest rate risk. In floating rate lending, institutions should limit the extent to which they run any basis risk that may arise if lending and funding are not based on precisely the same market interest rate.

14.3. Limits should be consistent with an institution's underlying approach to interest rate risk measurement and should be directed at how reported earnings and capital adequacy might be affected by changes in market interest rates. As regards to earnings, institutions should consider limits on earnings volatility in both net income and net interest income under specified interest rate scenarios so as to quantify what portion of their interest rate risk exposure arises from non-interest income.

14.4. Limits on the effect of rates on an institution's earnings and economic value should reflect the size and complexity of its positions. Simple limits such as gap limits may be adequate for institutions undertaking mainly traditional banking activities and with few holdings of long-term instruments, options, instruments with embedded options or other instruments whose value may be substantially altered by changes in market rates. More complex institutions may need to use more sophisticated limits.

14.5. Limits on interest rate risk should be related to explicit scenarios of changes in market interest rates, e.g., movements up or down of specified ranges. These ranges should constitute genuine stress conditions and should be developed in the light of historic rate volatility and time needed to unwind, restructure or hedge an institution's interest rate risk position. They can also reflect measures from the underlying statistical distribution of interest rates, e.g., earnings at risk or economic value at risk techniques. The scenarios should cover all possible sources of interest rate risk, e.g., re-pricing, yield curve, basis and option risks, and not just parallel shifts in interest rates or other simple scenarios.

Appendix A - Earnings vs. Economic Perspective: Examples

An institution's interest rate risk should not be viewed solely in terms of its effects on either economic value or earnings. These two perspectives are complementary, and both are necessary to capture interest rate risk comprehensively.

The economic perspective focuses on the value of the institution in today's interest rate environment and the sensitivity of that value to changes in interest rates. It also captures future exposure by evaluating the impact of potential rate changes on market values of all assets, liabilities, and off-balance sheet contracts. The earnings perspective, which captures the *timing* of income effects, helps risk managers determine what action to take to offset or hedge the exposure.

Example 1

A simple example illustrates the differences between earnings and economic perspectives. Consider an institution that has MKD 1,000 million in earning assets and MKD 900 million in liabilities. If the assets are earning 10 percent, the liabilities are earning 8 percent, the cost of equity is 8 percent, and the institution's net non-interest expense (including taxes) totals MKD 20 million, the economic value of the institution is MKD 100 million. One arrives at this value by discounting the net earnings of MKD 8 million (MKD 100 million in interest income less MKD 72 million in interest expense and MKD 20 million in non-interest expense) as a perpetuity at 8 percent. (Perpetuity is an annuity that pays interest forever. Its present value equals the periodic payment received divided by the discount rate.)

If net non-interest expenses are not affected by interest rates, the institution can immunize its net income and net interest income by placing MKD 100 million of its assets in perpetuities and the remainder of assets and all liabilities in overnight funds. If this is done, a general 200 basis point increase in interest rates leaves the institution's net income at MKD 8 million. The institution earns MKD 118 million on its assets (MKD 100 million perpetuity at 10 percent and MKD 900 million overnight assets at 12 percent) and incurs interest expenses of MKD 90 million (MKD 900 million at 10 percent) and non-interest expenses of MKD 20 million. The economic value of its equity, however, declines to MKD 80 million. (The net earnings of MKD 8 million are discounted as perpetuity at 10 percent).

As a result of this trade-off, many institutions that limit the sensitivity of their economic value will not set a zero risk tolerance (i.e., try to maintain current economic value at all costs) but rather will set limits around a range of possible outcomes. In addition, because institutions generally have some fixed operating expenses that are not sensitive to changes in interest rates (as in the above example); some institutions have determined that their risk-neutral position is a slightly long net asset position. The institution's fixed operating expenses, from a cash flow perspective, are like a long-term fixed rate liability that must be offset or hedged by a long-term fixed rate asset.

Example 2
In this example, the accounting perspective indicates that earnings problems will not develop until the second year in which the assets and liabilities are on the institution's balance sheet.

The institution is exposed to interest rate risk arising from the re-pricing gap between a four-year asset and a one-year liability. Both instruments are accounted for on an historic cost basis.

Table 2 illustrates the expected annual income and cash flows for this institution, assuming that interest rates remain at their current levels. The example uses the following simplifying assumptions:

- The institution has equity capital of MKD 200 million.
- The institution has a four-year note carrying an 8 percent coupon. The face amount is MKD 1,200 million and the current market value is par. The note pays interest annually.
- The institution funds the note with a one-year certificate of deposit (CD) with a face amount of MKD 1,000 million. The current rate on the CD is 6 percent and interest is paid annually.
- The institution pays all of its income to shareholders as dividends and pays no taxes. It has no other income or operating expenses.
- At the end of the fourth year, the institution plans to liquidate and distribute any residual equity to shareholders.

Under this scenario, the institution expects to earn MKD 36 million each year on the spread between its asset and liability. Shareholders would receive MKD 36 million in dividends in each year. At the end of the fourth year, the institution receives approximately MKD 1,200 million in cash from the note but must pay out approximately MKD 1,000 million in cash to the CD customer. Because all of the institution's net income was distributed as dividends, the equity available to shareholders equals the original equity of MKD 200 million.

Table 2 – Expected Cash Flows and Income
Stable Interest Rates
(In millions of Denars)

	Initial Cash Outlay & Book Values	Cash Flows			
		Year 1	Year 2	Year 3	Year 4
Note	-1,200	96	96	96	1,296
CD	1,000	-60	-60	-60	-1,060
Net Income		36	36	36	36
Dividends		-36	-36	-36	-36
Equity	200				-200

Table 3 shows the present value of the asset, liability, dividend, and equity cash flows, assuming that interest rates do not change. The note's cash flows are discounted at 8

percent and the CD cash flows are discounted at 6 percent. The present values for dividends (net income) and equity reflect the differences in the present value of the note and CD cash flows. These residual cash flows imply an internal rate of return on the institution's equity of 18 percent. Note that if interest rates stay at their current level, the present value of the expected cash flows equals the par value of the instruments.

Table 3 – Present Value of Expected Cash Flows and Income
Stable Interest Rates
(In millions of Denars)

	Net Present Values	Present Value of Cash Flows			
		Year 1	Year 2	Year 3	Year 4
Note	1,200	88.9	82.3	76.2	952.6
CD	-1,000	-56.6	-53.4	-50.4	-839.6
Dividends & Equity	-200	-32.3	-28.9	-25.8	-113.0

Because this institution is funding a four-year asset with a one-year liability, it is exposed to rising interest rates.

Table 4 illustrates what happens to cash flows and net income if interest rates were to immediately rise by 200 basis points. The reported earnings in year one remain unchanged because the institution has locked in its funding rates for the first year. After year one, however, the CD re-prices by 200 basis points to a new rate of 8 percent. As a result, net income for the remaining three years will decline by MKD 20 million per year. The cumulative net income and the corresponding dividends paid to shareholders over the four-year period declines from MKD 144 million to MKD 84 million.

Table 4 – Expected Cash Flows and Income
200-Basis-Point Rise
(In millions of Denars)

	Cash Flows			
	Year 1	Year 2	Year 3	Year 4
Note	96	96	96	1,296
CD	-60	-80	-80	-1,080
Net Income	36	16	16	16
Dividends/Equity	-36	-16	-16	-216
Change in Net Income vs. Stable Rate Scenario	0	-20	-20	-20

Table 5 illustrates the present value of expected cash flows under the new rate scenario. Note that the present value of both the note and the CD decline. The decline in the present value of the note reflects the fact that, although the cash flows from the note remain constant, those cash flows are now discounted at a higher (10 percent) rate. In

essence, the institution has forgone more profitable investment opportunities and now holds a note that offers below-market returns.

As in the previous table, the present value of net income, dividends, and equity represents the difference between the present values of the note and CD cash flows. The table shows that the net economic value of the institution declines by MKD 57.6 million in comparison with net economic value in the stable rate scenario. This decline in net economic value represents the decline in the present value of future cash flows.

Table 5 – Present Value of Expected Cash Flows and Income
200-Basis-Point Rise
(In millions of Denars)

	Net Present Values	Present Value of Cash Flows			
		Year 1	Year 2	Year 3	Year 4
Note	1,123.9	87.3	79.3	72.1	885.2
CD	-981.5	-55.6	-68.6	-63.5	-793.8
Dividends & Equity	-142.4	-31.7	-10.7	-8.6	-91.4
Change in Equity vs. Stable Rate Scenario	**-57.6**				

These examples illustrate that if an institution evaluates its earnings exposure over only a short time horizon, it may incorrectly assume that it has little or no exposure. This institution shows no earnings exposure for the first 12 months. Yet, as the example illustrates, earnings in future periods may decline significantly if interest rates increase.

The change in the economic value of equity (as measured by the change in the present value of the institution's assets less the present value of its liabilities) can be a leading indicator of the expected decline in future earnings and capital.

Appendix B – Interest Rate Risk Measurement Tools

GAP Reports

A common measurement of re-pricing risk is to calculate earnings-at-risk over a variety of time frames and rate scenarios. A well managed institution will establish earnings-at-risk limits that are designed to control the exposure of an institution's projected future reported earnings in specified rate scenarios. A limit is usually expressed as a change in projected earnings (in Denars or percent) over a specified time horizon and rate scenario. Institutions typically compute their earnings-at-risk limits relative to one of the following target accounts: net interest income (NII), net operating income (pre-loan loss provision expense), or net income.

The appropriate target account may vary and generally depends upon the nature and sources of the institution's earnings exposure. For some institutions, most if not all of their earning volatility will occur in their net interest margin. For these institutions, NII may be an appropriate target. In constructing a limit based on NII, however, management should consider and understand how variations in the margin may affect the bottom-line earnings performance. An institution with substantial overhead expenses, for example, may find that relatively small variations in its margin results in significant changes to its net income.

Gap (maturity or re-pricing) limits are designed to reduce the potential exposure to an institution's earnings or capital from changes in interest rates. The limits control the volume or amount of re-pricing imbalances in a given time period. These limits often are expressed by the ratio of rate-sensitive assets (RSA) to rate-sensitive liabilities (RSL) in a given time period. A ratio greater than one suggests that the institution is asset-sensitive and has more assets than liabilities subject to re-pricing. All other factors being constant, the earnings of such an institution generally will be reduced by falling interest rates. An RSA/RSL ratio less than one means that the institution is liability-sensitive and that its earnings may be reduced by rising interest rates. Other gap limits that institutions use to control exposure include gap-to-assets ratios, gap-to-equity ratios, and Denar limits on the net gap.

Although gap ratios may be a useful way to limit the volume of an institution's re-pricing exposures, the NBRM does not believe that, by themselves, they are an adequate or effective method of communicating the institution's risk profile to senior management or the Board. Gap limits are not estimates of the earnings (net interest income) that the institution has at risk. For an institution that relies solely on gap measures to control its interest rate exposure, its senior management and Board should also understand the level of earnings and capital at risk that are implied by its gap exposures (imbalances).

Gap reports stratify all of an institution's assets, liabilities, and off-balance sheet instruments into maturity segments (time bands) based on the instrument's next re-pricing or maturity date. Balances within a time band are then summed (assets are reported as positive amounts and liabilities as negative amounts) to produce a net gap position for each time band. Risk is measured by the size of the gap (the amount of net

imbalance within a time band) and the length of time the gap is open. Within a given time band, an institution may have a positive, negative, or neutral gap.

An institution has a negative gap and is "liability sensitive" when more liabilities re-price within a given time band than assets. An institution that is liability-sensitive, such as the institution described in the gap report in Table 6, usually benefits from falling interest rates. (The gap report in Table 6 is a simplified example. In practice, most gap reports will contain many more line items and additional time bands.)

An institution whose assets equal liabilities within a time band is said to have a "neutral" gap position. An institution in a "neutral" gap position is not free of exposure to changes in interest rates, however. Although the institution's re-pricing risk may be small, it can still be exposed to basis risk or changes in rate relationships.

Table 6
Sample Gap Report Schedule

	< 1 Mo.	1 - 3 Mos.	3 - 6 Mos.	6 - 12 Mos.	> 1 Year	Total
Loans	100	10	20	45	55	230
Investments		5	5	10	90	110
Other Assets	5				15	20
Total Assets	105	15	25	55	160	360
Non-maturity Deposits	-65				-80	-145
CDs and Other Liabilities	-35	-35	-45	-30	-40	-185
Total Liabilities	-100	-35	-45	-30	-120	-330
Equity						-30
Net Periodic Gap	5	-20	-20	25	40	0
Cumulative Gap	5	-15	-35	-10	-25	0
RSA/RSL	1.05	.42	.56	1.8	1.3	
Cumulative RSA/RSL	1.05	.89	.81	.95	1.1	

As a general rule, all assets, liabilities, and off-balance sheet items should be included in an institution's gap report. However, less complex institutions, at a minimum, should include all earning assets and interest-paying liabilities in their gap reports.

If the institution operates in currencies other than the Denar, it should prepare a separate gap report for each foreign currency. Why? Interest rates in different countries can move in different directions, and the volatility of such interest rates can differ considerably as well. A significant currency position would be one that represents at least 10 percent of total assets. However, many institutions avoid open positions or re-pricing imbalances in their foreign currencies, and thus, separate interest rate gap reports for those currencies may not be needed.

An institution must decide how many time bands it will use in its gap report. In general, the narrower the time bands, the more accurate the risk measure. After management has stratified the institution's assets, liabilities, and off-balance sheet instruments into time bands, it must measure net interest income (NII) at risk. The formula to translate gaps into the amount of net interest income at risk, measuring exposure over several periods, is:

(Periodic gap) x (change in rate) x (time over which the periodic gap is in effect) = change in NII

This formula can be illustrated by applying it to the sample gap report shown in Table 6 and calculating the change in the institution's net interest income for an immediate 200-basis-point increase in rates. For example, the institution has a negative gap of MKD 20 million in the one-month to three-month time band. This means that more liabilities than assets will re-price or mature during this time frame. Hence, for the remaining 10 months of the institution's 12-month time horizon, the institution will have MKD 20 million more of liabilities than assets that have re-priced at higher (200 basis points higher) rates.

As shown in Table 7, the increase in rates reduces the institution's earnings for the 10-month period by approximately MKD 333 thousand. The cumulative earnings effect of the institution's re-pricing imbalances over the 12-month horizon is a reduction in net interest income of approximately MKD 362.5 thousand.

Table 7
Sample Net Interest Income Sensitivity Calculation

Time Band	Size of Gap (In millions of Denars)	Basis Point Change	Part of Year Gap Is in Effect*	Impact on Annualized NII (In thousands of Denars)
< 1 Month	5	200	11.5/12	95.8
1 - 3 Months	-20	200	10/12	-333.3
3 - 6 Months	-20	200	7.5/12	-250.0
6 - 12 Months	25	200	3/12	125.0
Total				-362.5

* Assumes all re-pricings occur at midpoint of time band

It is important to stress that this method of measuring an institution's net interest income at risk is very crude and employs numerous simplifying assumptions, including the following:

- All re-pricing and maturities within a time band occur simultaneously (as in the above formula), typically at the beginning, middle, or end of the period.
- All maturing assets and liabilities are reinvested at overnight rates.
- No other new business is booked.
- There is an instantaneous change in the overnight rate to a new and constant level.
- All interest rates move the same amount.

Having an understanding of an institution's earnings-at-risk and overall sensitivity to interest rate risk allows a determination of how stable, or potentially unstable, earnings performance might be over the next year. Depending on the interest rate environment, high earnings-at-risk or sensitivity to interest rate risk causes concern about the institution's ability to provide sufficient internal capital growth if the institution is planning or experiencing rapid asset growth.

Limitations of Gap Reports

Basis Risk

The focus of a gap report is on the level of net re-pricings. The assumption is that within a given time band, assets and liabilities fully offset or "hedge" each other. In practice, however, assets and liabilities price off different yield curves or indices and do not move at all points together.

To facilitate an interpretation of basis risk, some institutions group instruments with similar basis relationships into separate line items within the report and report average

rates and yields on those groups. For example, within a 30- to 60-day time band, the re-pricing imbalance for accounts tied to CD rates could be reported as one line item, followed by balances tied to government securities yield curve. This approach provides a rough approximation of the degree of basis risk present in the balance sheet.

Alternatively, some institutions prepare *beta-adjusted*[2] gap reports in an attempt to measure basis risk. In this type of report, the re-pricing balance for each account type is multiplied by a factor that approximates the correlation between that account's pricing behavior and a benchmark market interest rate. For example, the report could compare the pricing behavior for all accounts to the interbank rate. If the analysis revealed that the institution's pricing on time deposit accounts moves 50 basis points for every 100-basis-point movement in the interbank rate, 50 percent of such balances would be shown as short-term rate-sensitive, and the remaining balances would be assigned a longer maturity.

Even beta-adjusted gap reports, however, do not always provide a complete picture of an institution's basis risk because the correlation between account pricing and market interest rates may not be the same for rising and declining interest rate environments or even for similar rate environments at different points in time. In such cases, an institution may need to formulate different correlations or "beta" factors for each rate scenario it develops. Given the limitations of gap reports, intuition and judgment are required when using them to quantify the exposure of earnings to changes in interest rates.

Yield Curve Risk

To measure an institution's cumulative re-pricing risk over several periods or time bands, most users of gap reports simply sum the gaps across each time band to produce a net cumulative gap position. Implicit in this act is an assumption that movements in interest rates will be perfectly correlated across the time bands and will move in a parallel fashion. This assumption can be amended by applying different weights to each time band. For example, gaps in the shorter time bands could be weighted more heavily than those in the longer time bands because short-term interest rates are usually more volatile and usually move by larger amounts than long-term rates.

The pattern of an institution's re-pricing gaps across the various time bands can provide an indication of exposure to changes in yield curve shapes. Suppose an institution that is liability sensitive (has negative gaps) in the short- and long-term time bands and asset sensitive in the intermediate time bands is exposed to a flattening of the yield curve when

[2] beta
(1) The Greek letter used by mathematicians to label the degree of sensitivity to changes in one variable to changes in another. The name for correlation of the changes.
(2) beta-adjusted gap - Gap reports modified to mollify the errors caused by basis risk. The essential concept of beta-adjusted gap is that all interest rates do not change by the same amounts, but that there is an identifiable relationship, a correlation, between changes in various interest rates. Some rates are more sensitive to change than other rates. In beta-adjusted gap analysis, the volumes of assets and liabilities subject to re-pricing are weighted to reflect the historical sensitivity of the yields or costs of those assets and liabilities relative to some benchmark yield or cost.

short-term rates go up and long-term rates remain stable. The institution's net interest margin deteriorates as the rates on its short-term liabilities increase. Because long-term rates remain stable, however, the market value of its long-term liabilities remain constant. Hence, the institution will not benefit from a decline in the expected future value of its long-term obligations.

Option Risks
As noted in earlier discussions, it is difficult to capture option risks with gap reports. Options introduce an asymmetrical and nonlinear element to an institution's risk profile. Although techniques such as preparing multiple gap reports and reporting options by their delta-equivalent[3] values attempt to overcome some of these weaknesses, they are unable to fully capture all of the dimensions of option risk. To do so, an institution that has significant option risk must supplement its gap reports with simulation or option pricing models.

Intra-Period Gaps
Although gap reports rely on stratifying balances into broad time bands, they do not detect imbalances within those bands. Some institutions have partly overcome this weakness by reporting the weighted average re-pricing maturity within each time band. Another method is to reduce the width of the bands.

New Business
Many gap reports consider only the institution's current financial positions. These reports are called "static" reports because they capture only the risk that arises from the existing balance sheet structure and do not incorporate any assumptions about new business. Some institutions may also prepare "dynamic" gap reports. Typically, these reports are generated from the institution's earnings simulation models and show how the "gap" would appear at some point in the future, after new business assumptions are incorporated into the risk measure.

Bank Simulation Models
Simulation models may be used for measuring interest rate risk arising from current and future business scenarios. They can be used to measure risk from either an earnings or economic perspective. The models "simulate" or project risk exposure under a variety of assumptions and scenarios and, thus, can be used to isolate sources of risk exposure or quantify certain types of risk. To do so, an institution performs a series of simulations and applies different assumptions and scenarios to each simulation.

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[3] delta
(1) The Greek letter used by mathematicians to refer to change or the quantity of change.
(2) The price sensitivity of an option. The change in an option's price divided by the change in the price of the underlying instrument. As an option becomes deeper in the money, its delta gets closer to 1.0. As an option get further out of the money, its delta gets closer to zero. However, the change is nonlinear - the delta changes faster when the option is close to being in the money. The rate of change in an option's delta is called the option's gamma.

In general, earnings simulation models are more dynamic than gap analyses and market valuation simulations. Whereas gap and market valuation models generally take a "snapshot" of the risk inherent in an institution's balance sheet structure at a particular point in time, most earnings simulation models evaluate risk exposure over a period of time, taking into account projected changes in balance sheet structures, pricing, and maturity relationships, and assumptions about new business.

Institutions often use simulation models to analyze alternative business decisions and to test the effect of those decisions on its risk profile before implementation. Institutions also use simulation models in budgeting and profit planning processes.

Construction of a Simulation Model
Most simulation models are computer-based models that perform a series of calculations under a range of scenarios and assumptions. From data on the institution's current position and managerial assumptions about future interest rate movements, customer behavior, and new business, a simulation model projects future cash flows, income, and expenses. These assumptions include different loan growth and funding plan scenarios and other assumptions about how assets and liabilities will be replaced. The main components of a simulation model are presented in Table 8 below.

Table 8
Earnings Simulation Model
Basic Structure

MODEL STRUCTURE			
Accounting & Business Rules	**FORECAST ASSUMPTIONS**		
Chart of Accounts	Volumes	**CALCULATIONS**	
Data	Rates	Duration or Market Value	**ANALYSIS**
	Maturities	GAP	Financial Reports
		Simulation	Scenario Analysis
			Graphics

Data from an institution's general ledger and transaction systems generally provide information on the institution's current position for each portfolio in the model's chart of accounts. This information is similar to that used for a gap report and includes current balances, rates, and re-pricing and maturity schedules. New business and reinvestment plans, which are generally more subjective, are based on management's assumptions. Those assumptions might be derived from historical trends, business plans, or econometrics models. Both market interest rates and business mix are forecasted.

Forecasts of interest rates involve forecasts of their direction, the future shape of the yield curve, and the relationship between the various indices that the institution uses for pricing products.

The potential exposure is estimated by calculating how a change in rates will affect the value, income, and expense of the institution's current and forecasted financial positions.

The output of a typical simulation model consists of:
1) Future balance sheet and income statements under a number of interest rate and business-mix scenarios;
2) An analysis of the impact of the different scenarios on the value of the target account; and
3) Graphical representations of the analysis that are often used to communicate results to senior management and the Board.

Measurement of Risk
The greater the interest rate risk, the greater the change in the value of a targeted account under different interest rate scenarios. The target account is usually net interest income or net income. Many simulation models also are capable of measuring changes in the market value of equity. Several business-mix and rate scenarios usually are run. Rate scenarios often include rising, flat, and declining rates, as well as a most probable scenario.

A typical summary report that may be generated by an earnings simulation model shows variation in net interest income under alternative interest rate scenarios using a flat rate scenario as a base. Similar reports are often developed to show how net interest income might vary with alternative business mixes and strategies.

Advantages of Simulation Models
Simulation models allow some of the assumptions underlying gap reports to be amended. For instance, gap reports assume a one-time shift in interest rates. Simulation models can handle varying interest rate paths, including variations in the shape of the yield curve.

Gap reports usually assume the improbable; such as all current assets and liabilities run off and are reinvested overnight. Simulation models can be more realistic. A simulation model can accommodate various business forecasts and allow flexibility in running sensitivity analyses. For instance, basis risk can be evaluated by varying the spreads between the indices the institution uses to price its products.

Perhaps the strongest advantage of simulation models is that they can present risk in terms that are meaningful and clear to senior management and the Board. The results of simulation models present risk and reward under alternative rate scenarios in terms of net interest income, net income, and present value (economic value of equity). These terms are basic financial fundamentals that are readily understood by management.

Simulation models can vary greatly in their complexity and accuracy. As the cost of computing technology has declined, simulation models have improved. Some simulation models can:

- Handle the intermediate principal amortizations of products such as installment loans.
- Handle caps and floors on adjustable rate loans and prepayments of mortgages or mortgage-backed securities under various interest rate scenarios (embedded options).
- Handle nonstandard swaps and futures contracts.
- Change spread relationships to capture basis risk.
- Model a variety of interest rate movements and yield curve shapes.
- Test for internal consistency among assumptions.
- Analyze economic risk as well as risk to interest income.

Limitations of Simulation Models

Although offering greater versatility than the alternatives, simulation is not always objective. A simulation can misrepresent the institution's current risk position because it relies on management's assumptions about future business.

The myriad of assumptions that underlie most simulation models can make it difficult to determine how much a variable contributes to changes in the value of the target account. For this reason, many institutions supplement their earnings simulation measures by isolating the risk inherent in the existing balance sheet using gap reports or measurements of risk to the economic value of equity.

In measuring their earnings at risk, many institutions limit the evaluation of their risk exposures to the following two years because interest rate and business assumptions that project further are considered unreliable. As a result, institutions that use simulation models with horizons of only one or two years do not fully capture their long-term exposure. An institution that uses a simulation model to measure the risk solely to near-term earnings should supplement its model with gap reports or economic value of equity models that measure the amount of long-term re-pricing exposures.

Economic Value Sensitivity and Duration Models

Techniques that measure economic value sensitivity can capture the interest rate risk of the institution's business mix across the spectrum of maturities. Economic value sensitivity systems generally compute and measure changes in the present value of the institution's assets, liabilities, and off-balance-sheet accounts under alternative interest rate scenarios.

Construction of Economic Value Models

Most economic value measurement systems are a form of simulation model. Typically, these models first estimate the current or "base case" present value of all of the institution's assets, liabilities, and off-balance sheet accounts. The model projects the amount and timing of the cash flows that are expected to be generated by financial

instruments under the "base case" interest rate scenario. These cash flows are then discounted by an appropriate discount factor to arrive at a net present value.

For the "base case" scenario, the institution's net economic value equals the present value of expected cash flows from assets, minus the present value of expected cash flows from liabilities, plus or minus the present value of expected cash inflows from off-balance sheet positions.

To measure the sensitivity of the institution's economic exposure to changes in interest rates, the model then performs similar calculations of expected discounted cash flows for alternative interest rate scenarios. The level and timing of cash flows for products with option features will often vary with each rate scenario being evaluated. For example, the rate of mortgage prepayments increases as interest rates decrease.

Measurement of Risk

For alternative scenarios, the change in net economic value from the "base case" represents the interest rate sensitivity of the institution's net economic value. The greater the change in net economic value, the greater the potential risk exposure.

Duration[4]

Many economic sensitivity models also compute the duration of an institution's financial instruments. Duration is a measure of the sensitivity of market values to small changes in interest rates. If interest rates increase, the market value of a fixed income instrument will decline. Duration indicates by how much. The duration of a fixed income instrument that has no option features is the percentage change in the market value of the instrument from a change in market rates. For instance, the market value of a bond with duration of five will decline by roughly 0.5 percent if interest rates increase by 10 basis points.

Before advances in computing technology made simulations of net present values under multiple interest rate scenarios feasible, some institutions used duration as a proxy for estimating the net economic value of their institution. Duration is still used by many managers as a basis for evaluating the relative risks of different financial instruments, portfolios, or investment strategies.

Duration incorporates an instrument's remaining time to maturity, the level of interest rates, and intermediate cash flows. If a fixed income instrument has only one cash flow, as a zero coupon bond does, duration will equal the maturity of the instrument: a zero coupon bond with five years remaining to maturity has duration of five years. If coupon

[4] Duration was derived from calculus by Frederick Macaulay in 1938 as a means to compare the maturities of instruments with differing payment structures, such as amortizing versus non-amortizing bonds. This became known as Macaulay's duration. Later, this measure was modified to express the price sensitivity of a bond to a given percentage change in interest rates; this is known as "modified duration." Modified duration is simply duration divided by (1 + (market yield/ the number of coupon payments per year)). In this section, the term duration will refer to modified duration and will focus on its use as a measure of market value sensitivity.

payments are received before maturity, the duration of the bond declines, reflecting the fact that some cash is received before final maturity. For example, a five-year 10 percent coupon bond has a duration of 4.2 years in a 10 percent interest rate environment. Duration is calculated by weighting the present value of an instrument's cash flows by the time to receipt of those cash flows.

Properties of Duration

In general, duration exhibits the following characteristics:

- The higher the duration, the greater the price sensitivity of the instrument to changes in market interest rates.
- For two instruments with the same maturity, a high-coupon instrument will have a lower duration than a low-coupon instrument and will also be less price sensitive. A larger proportion of a high coupon's cash flows will be received sooner and thus the average time to receipt of the cash flows will be less.
- A given fixed income instrument will have a higher duration in a low interest rate environment than in a high interest rate environment.
- Duration may be positive or negative. A fixed rate instrument would have a positive duration, and an increase in interest rates would generally decrease the market value of the instrument. Mortgage servicing rights and interest-only (IO) mortgage-backed securities generally have a negative duration, since an increase in interest rates would decrease the prepayment speed of the underlying mortgages, increasing the market value of the instruments.
- Durations are additive when weighted by the amount of the contract. For example, if a portfolio consists of two bonds of equal market value, one with a duration of six and the other with a duration of two, the duration of the portfolio would be four.

Duration Can Measure the Exposure of a Portfolio of Instruments

Duration can measure the exposure of the economic value of a single contract or a portfolio of contracts carried at market value. The duration of a portfolio of contracts can be calculated by computing the weighted average maturity of all the cash flows in the portfolio individually. However, because the duration of individual instruments is usually readily available, most institutions estimate the duration of a portfolio of contracts by weighting the durations of the individual contracts and summing them.

Many institutions use duration to measure and limit the risk of a portfolio of fixed income contracts. This measurement is much more precise than simply limiting the amount of securities with certain maturities an institution may hold. Duration also allows portfolio managers to combine the risks of different contracts based on their price sensitivity and to hedge the net risk of the portfolio.

Duration Can Measure the Economic Value of Equity

Some institutions use duration to measure or hedge the sensitivity of the economic value of their portfolio equity to changes in interest rates. The duration of equity is derived from the duration of all assets, liabilities, and off-balance-sheet contracts.

To understand how the duration of equity measures risk, the economic value of portfolio equity may be viewed as a net bond position. Assets are analogous to long bond positions with positive durations, and liabilities are analogous to short bond positions with negative durations. Duration indicates whether the economic value of the net bond position (or portfolio equity) will increase or decrease with a change in rates. An institution with long-term assets funded by short-term liabilities will generally have a duration of equity that is positive. The economic value of portfolio equity of this institution will decline as interest rates rise. An institution with short-term assets funded with long-term liabilities will generally have a negative duration of equity. The economic value of this institution will increase as interest rates rise. The higher the duration of an institution's equity (whether the number is positive or negative), the more sensitive is its economic value to changes in rates.

Advantages of Duration

Duration is a useful tool for setting risk limits either on the net economic value of the institution or for selected portfolios, such as investment portfolios. Some institutions attempt to limit their economic exposures through simple position limits, which are usually based on maturity. Such limits, however, do not precisely assess the sensitivity of market values to changes in rates, something limits based on duration can do.

Limits based on duration analysis are best expressed in terms of Denar changes in market or economic value. Duration measures the percentage change in value rather than the actual Denar change. To calculate exposure of the account at risk (the economic value of equity), an institution must weight the durations of assets, liabilities, and off-balance sheet accounts by their economic values.

Limitations of Duration

Duration as a measure of the sensitivity of economic value also has limitations:

- Macaulay and modified duration accurately measure changes in value for small and generally parallel changes in interest rates. However, modified duration can not measure changes in value for nonparallel changes in interest rates, and there is no practical method by which effective duration can measure nonparallel shifts. The margin of error, which increases with the size of the interest rate change, is called **convexity**.
- The duration of different instruments will change at different rates as time passes (duration drift). In other words, in a portfolio hedged for duration the effectiveness of the hedge will diminish over time.
- Macaulay and modified duration assume that the expected cash flows of a fixed income instrument will not change with interest rate movement. Hence, these duration measures are not accurate for instruments with embedded options, which often grow more sensitive to interest rates as rates rise. In other words, an instrument that declines in value by 1 percent for a 100-basis-point increase in interest rates might decline by 3 percent for a 200-basis-point increase and by 6 percent for a 300-basis-point increase.

Monte Carlo Simulation

Monte Carlo simulation measures the probable outcomes of events, such as a movement in interest rates, that have a random or stochastic[5] element. The simulation models discussed previously measure the value of the institution under a limited number of interest rate scenarios. Such approaches are "deterministic" because the possible interest rate paths are predetermined and controlled by the model user. Although deterministic models are valuable, their outcomes depend on the interest rate scenarios. If actual interest rates differ from assumptions, the risk to the institution may be substantially different from the measured risk.

The outcome of a Monte Carlo simulation is less preordained than that of a deterministic simulation because its statistical modeling technique generates thousands of randomly determined interest rate paths. These interest rate paths result in a distribution of possible interest rate scenarios. The value of the institution or the institution's portfolios is then evaluated for each of the possible interest rate paths, yielding a range of possible values or outcomes.

Construction of a Monte Carlo Simulation

Formulating the average Monte Carlo model is quite complex:
(1) The first step is to develop the underlying probability distribution for interest rates that will generate the random interest rate paths. Typically, the current forward yield curve is used to anchor the probability distribution.

(2) A model generates a multitude of random interest rate paths (typically several thousand). However, certain properties are usually built into this process to ensure that the mean (average) interest rate generated is consistent with the current structure of interest rates and that the dispersion (distribution) of possible interest rates is consistent with observed volatility. These properties are important to ensure that the model does not introduce the possibility of "risk-free" arbitrage. Essentially, the properties assume that markets efficiently and fairly price securities, such that one cannot construct instruments with equivalent risk and higher returns than what the market commands.

(3) The cash flows corresponding to each of the randomly developed interest rate paths are calculated. That is, management specifies the relationships between the interest rates and the cash flows of the institution's portfolios. For example, the institution would develop a prepayment function that relates mortgage prepayments with each interest rate path. Once adjusted for prepayments and other interest-rate effects, the cash flows are said to be "option-adjusted."

(4) The option-adjusted cash flows for each rate path are discounted by the risk-free rate to obtain their net present value. All of these outcomes are summed, and the total is

[5] Stochastic - A term used to describe outcomes based on uncertain relationships. The process of change in a variable resulting from change in a parameter. For example, option adjusted spread measures of yield and Monte Carlo models of interest rate risk are stochastic measures. A method of modeling changes that allows for a range of possible outcomes. Sometimes called probabilistic. The opposite of deterministic.

divided by the total number of rate paths evaluated to produce an expected net present value for the distribution. If the cash flows have been adjusted correctly and the interest rate paths correctly reflect market expectations about the distribution of possible future interest rates outcomes, this expected net present value represents the "base case" market price. If the model's assumptions are accurate, the cash flows have been adjusted for all risks, and the market for the instrument under consideration operates according to the underlying theory (which assumes risk neutral valuation), this "base case" price should be within a few basis points of observable market prices. If the net present value does not match the market price, common practice is to add a fixed spread known as the option-adjusted spread (OAS)[6] to the risk-free rate.

(5) After obtaining the "base case" price in step 4, the current forward yield curve is "shocked" for each of the interest rate scenarios that managements consider in their risk analysis. For example, if management is evaluating its risk for a parallel 200-basis-point increase in rates, it would shift the underlying distribution of interest rates (developed in step 1) by 200 basis points such that the expected mean (average) is 200 basis points higher across the maturity spectrum. Steps 2, 3, and 4 are then repeated, except that the "market price" that results represents the price that would result if interest rates were to change as assumed for that rate scenario.

Advantages of Monte Carlo Simulation

Monte Carlo simulation is a powerful risk analysis tool because it alone, of the tools so far discussed, can accurately and clearly adjust risk estimates for optionality and convexity. The capital markets employ Monte Carlo techniques to price interest rate derivative products and residential mortgage products using OAS analysis. Institutions can employ Monte Carlo techniques to understand and evaluate current market pricing as well as their economic value at risk. This technique provides managers with a valuable tool for measuring and managing interest rate risk.

Limitations of Monte Carlo Simulation

Monte Carlo simulations, like all interest rate risk measurement systems, are only as good as the data and assumptions underlying the analysis. Two critical assumptions in Monte Carlo analysis are the process used to derive the interest rate paths and the cash flow relationships developed for each interest rate path. If these assumptions are faulty, the results of the simulation will be suspect. Monte Carlo simulations are complicated to develop and require substantial computing technology. To correctly derive and apply this modeling process, an institution must have staff members with considerable expertise in financial and statistical theory.

[6] The Option Adjusted Spread (OAS) describes the market premium over a model including two types of volatility: variable interest rates and variable prepayment rates. Designing such models in the first place is complicated because prepayment variations are a behavioral function of the stochastic interest rate. (They tend to go up as interest rates come down.) OAS is a term with considerable use across Mortgage Back Securities finance. The definition here is based on Lakhbir Hayre's *Mortgage Backed Securities* text book.

Model Exposure

Regardless of the type of model used, institutions should take care to minimize model exposure. Financial models fall into error for many reasons. Users may make incorrect assumptions about deposit behavior or about changes in the spread between interest rates. They may select a model that is not appropriate for all parameters. A model that provides reasonable results for a certain range of inputs may fail to do so for extreme assumptions. Some model users misuse good models; for example, they evaluate an insufficient number of paths, in the process sacrificing accuracy for the sake of speed. When designers fail to provide adequate documentation, they increase the possibility that future changes to the model will result in errors.

Appendix C - Proposed Organizational Structure for Interest Rate Risk Management

SUPERVISORY BOARD

Approving interest rate strategy and policies

Oversight of Risk Management Committee/ ALCO activities

Risk Management Committee/ALCO/ SENIOR MANAGEMENT

Interest rate risk policy review

Implementing strategy and policies

Establishing Interest rate risk policies and manuals

Oversight over Interest rate risk management

Monitoring the efficiency of Interest rate risk management process and giving recommendations for its improvement

BANK TREASURY

Day-to-Day Interest rate risk management:

- Optimizing the cash position of the institution;
- Short- and long-term liquidity planning;
- Providing necessary liquidity to business units;
- Accessing inter-bank market and local and international foreign exchange markets; and
- Managing inter-bank liquidity.

MIDDLE OFFICE

- Recommending interest rate risk management methodologies;
- Monitoring limit/exceptions (target interest rate risk ratios, duration mismatch limits, re-pricing interest rate risk gap limits, etc.);
- Stress-testing (interest rate risk analysis under normal and stress scenarios, including techniques and behavioral assumptions); and
- Maintaining Management Reporting systems for interest rate risk.

BACK OFFICE

- Measuring and reporting interest rate risk exposures

INTERNAL AUDIT AND COMPLIANCE

- Auditing the interest rate risk management process;
- Ensuring compliance with internal policies, legal, regulatory requirements and prudential limits.