*References in this guidance to national banks or banks generally should be read to include federal savings associations (FSA). If statutes, regulations, or other OCC guidance is referenced herein, please consult those sources to determine applicability to FSAs. If you have questions about how to apply this guidance, please contact your OCC supervisory office.

Internal Control, Review, and Audit of the Risk Management Process

A bank's internal control structure is critical to the safe and sound functioning of the organization generally, and to its interest rate risk management process in particular. Establishing and maintaining an effective system of controls, including the enforcement of official lines of authority and the appropriate separation of duties, are two of management's more important responsibilities. Individuals responsible for evaluating risk monitoring and control procedures should be independent of the function they are assigned to review.

Effective control of the interest rate risk management process includes independent review and, where appropriate, internal and external audit. The bank should conduct periodic reviews of its risk management process to ensure its integrity, accuracy, and reasonableness. Items that should be reviewed and validated include:

- The adequacy of, and personnel's compliance with, the bank's internal control system.
- The appropriateness of the bank's risk measurement system given the nature, scope, and complexity of its activities.
- The accuracy and completeness of the data inputs into the bank's risk measurement system.
- The reasonableness and validity of scenarios used in the risk measurement system.
- The validity of the risk measurement calculations. The validity of the calculations is often tested by comparing actual versus forecasted results.

The scope and formality of the review and validation will depend on the size and complexity of the bank. At large banks, internal and external auditors may have their own models against which the bank's model is tested. Banks with complex risk measurement systems should have their models or calculations validated by an independent source C either an internal risk control unit of the bank or by outside auditors or consultants.

The findings of this review should be reported to the board annually. The report should provide a brief summary of the bank's interest rate risk measurement techniques and management practices. It also should identify major critical assumptions used in the risk measurement process, discuss the process used to derive those assumptions and provide an assessment of the impact of those assumptions on the bank's measured exposure.

Earnings versus Economic Perspectives -- A Numerical Example

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

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

Table 1 illustrates the expected annual income and cash flows for this bank, assuming that interest rates remain at their current levels. The example uses the following simplifying assumptions:

- The bank has equity capital of $200 million.
- The bank has a four-year note carrying an 8 percent coupon. The face amount is $1.2 million and the current market value is par. The note pays interest annually.
- The bank funds the note with a one-year certificate of deposit with a face amount of $1 million. The current rate on the CD is 6 percent and interest is paid annually.
- The bank 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 bank plans to liquidate and distribute any residual equity to shareholders.

Under this scenario, the bank expects to earn $36,000 each year on the spread between its asset and liability. Shareholders would receive $36,000 in dividends in each year. At the end of the fourth year, the bank receives approximately $1.2 million in cash from the note but must pay out approximately $1 million in cash to the CD customer. Because all of the bank's net income was distributed as dividends, the equity available to shareholders equals the original equity of $200,000.

Table 1 – Expected Cash Flows and Income
Stable Interest Rates
(In thousands of dollars)

	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 2 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 bank'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 2 – Present Value of Expected Cash Flows and Income
Stable Interest Rates
(In thousands of dollars)

	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 bank is funding a four-year asset with an one-year liability, it is exposed to rising interest rates. Table 3 illustrates what happens to the bank's cash flows and net income if interest rates were to immediately rise by 200 basis points. The bank's reported earnings in year one remain unchanged because the bank has locked in its funding rates for the first year. After year one, however, the CD reprices by 200 basis points to a new rate of 8 percent. As a result, the bank's net income for the remaining three years will decline by $20,000 per year. The bank's cumulative net income and the corresponding dividends paid to shareholders over the four-year period declines from $144,000 to $84,000.

Table 3 – Expected Cash Flows and Income
200-Basis-Point Rise
(In thousands of dollars)

	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 4 illustrates the present value of the bank's 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 bank 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 bank declines by $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 the bank's future cash flows.

Table 4 – Present Value of Expected Cash Flows and Income
200-Basis-Point Rise
(In thousands of dollars)

	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 a bank evaluates its earnings exposure over only a short time horizon, it may incorrectly assume that it has little or no exposure. This bank shows no earnings exposure for the first 12 months. Yet, as the example illustrates, the bank's 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 bank's assets less the present value of its liabilities) can be a leading indicator of the expected decline in future earnings and capital.

Large Bank Risk Assessment System for Interest Rate Risk

Quantity of Interest Rate Risk

Evaluation Factors

Examiners should consider the following evaluation factors in making risk assessments. These evaluation factors, which are not a mandatory checklist, offer an overview of issues that can assist the examiner in making decisions within the risk assessment system (RAS).

When assessing the quantity of interest rate risk in an institution, examiners should consider:

- The size and stability of net interest margins and sensitive fee income.
- The component and aggregate levels of interest rate risk including repricing, basis, yield curve, and option risk relative to earnings and capital.
- Interest rate risk over both the tactical and strategic horizons.
- The vulnerability of earnings and capital under meaningful rate changes such as gradual rate shifts and yield curve twists. The appropriateness of the scenarios should be evaluated in the context of the current rate environment. Rate scenarios of sufficiently wide variability will be necessary to provide meaningful analysis (i.e., evaluation of repricing risk with a fed funds rate change of at least 200 basis points over a 12-month time horizon).
- The character of risk such as the volume and price sensitivity of various products.
- The complexity of risk positions such as the optionality of mortgage products, changing value of servicing portfolios, etc.
- The relative volume of and prospects for continued support from low-cost and stable funding sources, especially nonmaturity deposits.

Summary Assessment

Review of these factors should allow examiners to assess the quantity of interest rate risk as:

- **High** – Exposure reflects significant repricing risk; high levels of basis risk; undue yield curve risk; or significant levels of option risk. Mismatched positions are long-term and costly to hedge. The probability of substantial volatility in earnings or capital due to the movement of interest rates is high.
- **Moderate** – Exposure reflects repricing risk, basis risk, yield curve risk, and option risk that, collectively, are maintained at manageable levels. Mismatched positions may be long-term, but are effectively hedged. Substantial volatility in earnings or capital due to the movement of interest rates is not anticipated.
- **Low** – Exposure reflects little repricing risk and minimal exposure to basis risk and yield curve risk. Options positions are clearly identified and well-managed. Mismatched positions are short-term and unlikely to cause earnings or capital volatility due to the movement of interest rates.

Quality of Interest Rate Risk Management

Evaluation Factors

Examiners should consider the following evaluation factors in making risk assessments. These evaluation factors are

not mandatory checklists, but rather an overview of issues that can assist the examiner in making decisions within the RAS.

Elements of interest rate risk management can be grouped into four broad categories: policies, processes, personnel, and control systems. When assessing the quality of interest rate risk management examiners should consider:

Whether policies are:

- Comprehensive, including whether they:

  –Establish responsibilities and accountabilities.
  –Specify desired limits and positions.

- Consistent with the strategic direction and risk tolerance levels.
- Approved by the board or an appropriately delegated committee, as necessary.

Whether a process exists for:

- Communicating policies and expectations to appropriate personnel.
- Approving and monitoring compliance with policy limits.
- Providing timely production and use of management information.
- Independently measuring and analyzing risk in all significant activities from interest rate movements using a variety of scenarios.
- Ensuring that risk positions are appropriately adjusted for changing market conditions and that management has sufficient expertise and market access to flexibly adjust risk levels.
- Controlling the accuracy, completeness, and integrity of data.
- Testing the reasonableness and validity of assumptions.
- Independently validating models and other measurement tools.

Whether personnel:

- Understand the source of risk, strategic direction, risk tolerance limits, and policies.
- Exhibit technical and/or managerial competency appropriate to the complexity of products.
- Are sufficient in number and skills for current and anticipated levels of risk.
- Are adequately compensated so that turnover is limited and stability is fostered.
- Demonstrate a commitment to training, development, and continuing education programs.
- Demonstrate a commitment to providing an effective performance management program.
- Ensure independence, expertise, and competency of staff performing control functions such as loan review or audit.

Whether control systems are designed to provide:

- Timely, accurate, and informative management information.
- Independent and effective feedback on compliance with policies and operating procedures. Control systems should be consistent with the complexity of the activities, but, at a minimum, should include internal and/or external audit reviews.

Summary Assessment

A review of these factors should allow examiners to assess the quality of interest rate risk management as:

- Weak – Responsible officials do not understand, or have chosen to ignore, key aspects of interest rate risk. Management does not anticipate or take timely and appropriate actions in response to changes in market conditions. Knowledge of interest rate risk may be concentrated in too few individuals in the organization. The interest rate risk management process is deficient. The process is overly simplistic in light of the relative size and complexity of the bank's on- and off-balance sheet exposures. Management information at various levels in the organization exhibits significant weaknesses. Limit structures are not reasonable, or do not reflect an understanding of the risks to earnings and the economic value of equity. Staff responsible for monitoring risk limits and measuring exposures is not independent from staff executing risk-taking decisions.

- Acceptable – Responsible officials reasonably understand the key aspects of interest rate risk. Management adequately responds to changes in market conditions. Knowledge of interest rate risk exists at appropriate levels throughout the organization. The interest rate risk management process is adequate. Measurement tools and methods may have minor weaknesses, but are appropriate given the size and complexity of the bank's on- and off-balance sheet exposures. Management information at various levels in the organization is, for the most part, timely, accurate, complete, and reliable. Limit structures are adequate to control the risk to earnings and the economic value of equity under defined and reasonable interest rate scenarios. Staff responsible for monitoring risk limits and measuring exposures are independent from staff executing risk-taking decisions.

- Strong – Responsible officials fully understand all aspects of interest rate risk. Management anticipates and responds well to changes in market conditions. Interest rate risk is well understood at all appropriate levels of the organization. The interest rate risk management process is effective and proactive. Measurement tools and methods enhance decision making by providing meaningful and timely information under a variety of defined and reasonable rate scenarios. Few, if any, weaknesses or deficiencies exist. Management information at various levels of the organization is timely, accurate, complete, and reliable. Limit structures provide clear parameters for risk to earnings and the economic value of equity under a variety of defined and reasonable interest rate scenarios. Staff responsible for monitoring risk limits and measuring exposures are independent from staff executing risk-taking decisions.

Community Bank Risk Assessment System for Interest Rate Risk

Evaluation Factors

Examiners should consider the following evaluation factors in making risk assessments. These evaluation factors, which are not a mandatory checklist, offer an overview of issues that can assist the examiner in making decisions within the RAS.

- The size and stability of net interest margins and sensitive fee income.
- The component and aggregate levels of interest rate risk including repricing, basis, yield curve, and option risk relative to earnings and capital.
- Interest rate risk over both the short- and long-term.
- The vulnerability of earnings and capital under meaningful rate changes such as gradual rate shifts and yield curve twists. The appropriateness of the scenarios should be evaluated in the context of the current rate environment. Rate scenarios of sufficiently wide variability will be necessary to provide meaningful analysis (i.e., evaluation of repricing risk with a fed funds rate change of at least 200 basis points over a 12-month time horizon).
- The character of risk such as the volume and price sensitivity of various products.
- The complexity of risk positions such as the optionality of mortgage products, changing value of servicing portfolios, etc.
- The relative volume of and prospects for continued support from low-cost and stable funding sources, especially nonmaturity deposits.
- Whether policies or limits are approved by the board or an appropriately delegated committee, as necessary.
- How policies or limits are communicated to responsible staff.
- The existence of timely, accurate, and informative management information to monitor positions and sensitivity.
- Whether a process exists for independently measuring and analyzing risk in all significant activities from interest rate movements using a variety of scenarios.
- Whether risk positions are appropriately adjusted for changing market conditions.
- Whether management has sufficient expertise and market access to flexibly adjust risk levels.
- Testing the reasonableness and validity of assumptions and models, as necessary.
- The level and skill of management and staff.
- The existence of proper control mechanisms to monitor the accuracy of information, proper accounting treatment, and compliance with policies or laws.

Summary Assessment

Review of those factors should allow examiners to assess aggregate interest rate risk as (see next page):

As of January 12, 2012, this guidance applies to federal savings associations in addition to national banks.*

Interest Rate Risk ***Low***	**Interest Rate Risk** ***Moderate***	**Interest Rate Risk** ***High***
Responsible officials fully understand all aspects of interest rate risk.	Responsible officials reasonably understand the key aspects of interest rate risk.	Responsible officials do not understand, or choose to ignore, key aspects of interest rate risk.
Management anticipates and responds well to changes in market conditions.	Management adequately responds to changes in market conditions.	Management does not anticipate or take timely and appropriate actions in response to changes in market conditions.
Knowledge of interest rate risk is well understood at appropriate levels in the institution.	Knowledge of interest rate risk exists at appropriate levels in the institution.	Knowledge of interest rate risk may be concentrated in too few individuals.
Responsibility for monitoring risk limits and measuring exposures is independent from those executing risk-taking decisions.	Responsibility for monitoring risk limits and measuring exposure is independent from those executing risk-taking decisions.	Responsibility for monitoring risk limits and measuring exposures is not independent from those executing risk-taking decisions.
Exposure reflects little repricing risk and minimal exposure to basis risk and yield curve risk. Options positions are clearly identified and well-managed.	Exposure reflects repricing risk, basis risk, yield curve risk, and option risk that, collectively, are maintained at manageable levels.	Exposure reflects significant repricing risk, high levels of basis risk, undue yield curve risk, or significant levels of option risk.
Mismatched positions are short-term.	Mismatched positions may be long-term, but are effectively hedged.	Mismatched positions are long-term and costly to hedge.
The mismatches are unlikely to cause earnings or capital volatility due to the movement of interest rates.	Substantial volatility in earnings or capital due to the movement of interest rates is not anticipated.	The probability of substantial volatility in earnings or capital due to the movement of interest rates is high.
The interest rate risk management process is effective and proactive.	Interest rate risk management process is adequate.	Interest rate risk management process is deficient.
Measurement tools and methods enhance decision making by providing meaningful and timely information under a variety of defined and reasonable rate scenarios.	Measurement tools and methods have minor weaknesses, but are appropriate given the size and complexity of the bank's on- and off-balance sheet exposures.	The process is overly simplistic in light of the relative size and complexity of the bank's on- and off-balance sheet exposures.
Management information systems are timely, accurate, complete, and reliable.	Management information is, for the most part, timely, accurate, complete and reliable.	Management information systems contain significant weaknesses.
Limit structures provide clear parameters for risk to earnings and the economic value of equity under a variety of defined and reasonable interest rate scenarios.	Limit structures are adequate to control the risk to earnings and the economic value of equity under defined and reasonable interest rate scenarios.	Limit structures are not reasonable or do not reflect an understanding of the risks to earnings and the economic value of equity.

Common Interest Rate Risk

Gap Reports

Gap reports are commonly used to assess and manage interest rate risk exposure C specifically, a bank's repricing and maturity imbalances. However, as explained later in this appendix, a basic gap report can be an unreliable indicator of a bank's overall interest rate risk exposure. Although a simple gap report does not identify and quantify basis risk, yield curve risk, and option risk, bankers have modified gap reports to do so.

Gap reports stratify all of a bank's assets, liabilities, and off-balance-sheet instruments into maturity segments (time bands) based on the instrument's next repricing 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.

Using properly prepared gap reports, a bank can identify and measure short- and long-term repricing imbalances. With this information, a bank can estimate its earnings and economic risks within certain constraints. Gap reports can be particularly useful in identifying the repricing risk of a bank's current balance sheet structure before assumptions are made about new business or how to effectively reinvest maturing balances.

Within a given time band, a bank may have a positive, negative, or neutral gap. A bank will have a positive gap when more assets reprice or mature than liabilities. Because this bank has more assets than liabilities subject to repricing, the bank is said to be "asset sensitive" for that time band. An asset- sensitive bank is generally expected to benefit from rising interest rates because its assets are expected to reprice more quickly than its liabilities.

Table 1
Sample Gap Report Schedule

	< 1 Mo.	1 - 3 Mos.	3 - 6 Mos.	6 - 12 Mos.	1 - 2 Yrs.	2 - 3 Yrs.	> 3 Yrs.	Total
Loans	100	10	20	45	5	20	30	230
Investments		5	5	10	20	20	50	110
Other Assets	5						15	20
Total Assets	105	15	25	55	25	40	95	360
Nonmaturity Deposits	-65				-30		-50	-145
CDs and Other Liabilities	-35	-35	-45	-30	-10	-10	-20	-185
Total Liabilities	-100	-35	-45	-30	-40	-10	-70	-330
Equity								-30
Net Periodic Gap	5	-20	-20	25	-15	30	25	0
Cumulative Gap	5	-15	-35	-10	-25	5	30	0

A bank has a negative gap and is "liability sensitive" when more liabilities reprice within a given time band than assets. A bank that is liability-sensitive, such as the bank described in the gap report in table 1, usually benefits from falling interest rates. (The gap report in table 1 is a simplified example. In practice, most gap reports will contain many more line items and additional time bands.)

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

Traditionally, most bankers have used gap report information to evaluate how a bank's repricing imbalances will affect the sensitivity of its net interest income for a given change in interest rates. The same repricing information, however, can be used to assess the sensitivity of a bank's net economic value to a change in interest rates.

Construction of a Gap Report

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

A bank also should consider including potential repricings or maturities of all nonearning assets and non-interest-bearing liabilities in its reports. Nonearning assets such as nonaccrual loans, for example, may at some point be collected or renegotiated, and then become repriceable. Non-interest-bearing liabilities (demand deposit account balances) also should be included in a bank's gap report even though such deposits do not bear an explicit rate of interest. Such deposits are included because their maturity or run-off exposes the bank to interest rate risk. (The bank may need to replace the deposits with interest-bearing sources of funds such as NOW accounts, certificates of deposits, or federal funds purchased.)

If the bank operates significant books in currencies other than the dollar, it should prepare a separate gap report for each book. 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 book would be one that represents at least 10 percent of total business. Many banks avoid open positions or repricing imbalances in their foreign currency books. If this is the bank's policy, gap reports for those currencies may not be needed.

Number of Time Bands

A bank 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. To measure risk to earnings, the report should have at least monthly detail over the first year and quarterly over the second. If a gap report is used to capture long-term exposures and risk to economic value, the time bands should extend to the maturity of the last asset or liability.

Time bands for distant time periods, say, beyond 10 years, may be relatively wide C five years, for example. These wider time frames are justified because the change in interest rate sensitivity is small for maturities beyond 10 years. In other words, a bank's use of wide time bands beyond 10 years will not usually cause it to misestimate its interest rate risk exposure for items in those time bands.

Reporting of Off-Balance-Sheet Items

A gap report that does not include off-balance-sheet interest rate positions does not fully measure a bank's interest rate risk profile. All material positions in off-balance-sheet instruments whose value can be affected by interest rates should be captured in a gap report. Such instruments include interest rate contracts, such as swaps, futures, and forwards; option contracts, such as caps, floors, and options on futures; and firm forward commitments to buy or sell loans, securities, or other financial instruments.

Off-balance-sheet instruments are often reported in a gap report using two entries to reflect how the instruments alter the timing of cash flows. The two entries of the contract are offsetting: one entry is the notional principal amount of the contract reported as a positive dollar value, and the other is an offsetting negative entry. If the off-balance-sheet position generally increases in value when interest rates fall (e.g., long futures, pay-floating swap, long call option, and short put option positions), the first entry is reported with a negative value and the second entry is reported with a positive value. Conversely, if the position generally increases in value when interest rates rise (e.g., short futures, pay-fixed swap, short call option, and long put option positions), the first entry is positive and the second is negative. This slotting reflects the impact of an off-balance-sheet instrument on the effective maturity of an asset on the balance sheet.

For example, if a bank has a $100 million five-year interest swap in which it receives a fixed rate and pays three-month Libor, the bank would report a positive $100 million in the five-year time band and a negative $100 million in the three-month time band. This treatment reflects the fact that the bank is Along" a fixed rate payment (as if it owned a fixed rate asset) and "short" a floating-rate payment (as if it had a floating-rate liability).

A long futures position would increase a bank's asset maturity, while a short futures position would decrease its asset maturity. Hence, a long position in a 10-year Treasury note future that expires in five months would be reported as a negative entry in the time band that covers five-month maturities and a positive entry in the time band that covers a 10-year instrument.

As discussed in the next section, option instruments such as caps and floors pose special problems for gap reports. Because most gap reports usually assume a static interest rate environment at the current level of interest rates, they ignore caps and floors until the strike rate is hit. Suppose a bank has a long position in a 10-year interest rate cap. Before the strike rate is hit, the report would show the position as a floating rate liability and would ignore the cap; after the strike rate is hit, the position becomes a 10-year fixed rate liability.

Reporting of Options-Related Positions

Many consumer products have embedded options in them because the customer has the right to change the terms of a contract or to act when warranted by market conditions. When a customer "exercises" the option, the bank loses a valuable asset that will no longer pay interest. Since these products are germane to a bank's interest rate risk exposure, institutions should incorporate them into their gap reports.

In a product with an embedded option, the cash flows will depend on the path of interest rates; different interest rate paths need to be considered because the dates of the option's exercise will change accordingly, affecting cash flows. A single gap report gives an incomplete picture of products with embedded options because it allows for only one repricing date.

Three methods of incorporating options exposures into gap reports are popular with banks. An examiner encountering a bank using another method should analyze the approach to determine whether it properly incorporates the asymmetrical impact of options on future net interest income and economic value.

The first method either recognizes that the cap is in full effect for the remaining life of the product or ignores it for that same period. The following example illustrates this all-or-nothing approach to a cap on a floating rate loan: The bank has a 10-year $100,000 floating rate loan that reprices every six months but is subject to a 12 percent lifetime cap (the rate on the loan cannot exceed 12 percent). The all-or-nothing approach would consider the loan a six-month floating rate loan when rates are below 12 percent. If rates equal or exceed 12 percent, the loan becomes a fixed rate loan with a 10-year repricing maturity.

This approach has several weaknesses. First, the method does not correctly reflect the exposure of net interest income to future changes in interest rates. For example, when the loan is slotted as a six-month repricing asset and funded with a six-month CD, the gap report would not indicate any interest rate risk. If interest rates were to rise above 12 percent, however, the loan could not reprice further but the funding costs on the CD could continue to rise, and interest rate margins would decline. Second, this treatment does not suggest how this exposure may be hedged. Neither hedging the asset as a six-month floating rate asset nor hedging it as a 10-year fixed rate asset would be appropriate.

A better approach would be for the bank to prepare two gap reports, one for a high-rate scenario and the other for a low-rate scenario. Under the high-rate scenario, the cap would be "binding" and the gap report would show the capped loans as fixed rate assets. Under the low-rate scenario, the gap report would show the loan as a floating rate asset.

A bank could use similar approaches to measure prepayment option risks associated with fixed rate residential mortgage loans. Under the high-rate scenario, the weighted average lives of the fixed rate mortgages would be extended in the gap report, reflecting the effect of slower prepayments. Under the low-rate scenario, the weighted lives would be shortened, reflecting faster prepayments. Comparing the gaps between the two schedules provides an indication of the amount of option risk the bank faces.

Although this second method provides a way to assess how embedded options may alter a bank's repricing imbalances under alternative interest rate scenarios, it also has limitations. Like the all-or-nothing approach, this method suggests that an option has value only when it becomes binding or is in the money. In reality, an option has value throughout its life. The value of the option will depend on such factors as the time to expiration of the option, the distance from the strike price, and the volatility of interest rates.

A third approach for incorporating options into gap reports varies the value of the option according to the change in the value of the underlying instrument. This is done by incorporating the delta-equivalent value of the option into the gap report. The delta-equivalent value of an option, a mathematically derived weighting between 0 percent and 100 percent, reflects the probability that the option will go in the money.

In the illustration of the loan with the 12 percent lifetime cap described above, the bank could "strip" the cap from the loan and treat the cap and loan as two separate instruments. The bank would report the loan as a six-month floating rate loan and the cap as an off-balance-sheet instrument, based on the cap's delta-equivalent value. The delta-equivalent value would equal the delta of the cap times the notional value of the cap (in this case, the principal amount of the loan, or $100,000).

The cap in this example would have a delta between 50 percent and 100 percent when rates are greater than 12 percent. The high level of the delta indicates a high probability of the cap being effective over the life of the loan. If market rates were at 8 percent, however, the delta would be much lower, reflecting a lower probability that the cap will be effective over the life of the loan.

The delta approach also has limitations. The delta of an option changes in a nonlinear fashion with the passage of time and with the level of interest rates. As a result, the delta value of an option is valid only for small changes in interest rates, and this value changes over time.

Measuring Risk to Net Interest Income

After a bank has stratified the bank's assets, liabilities, and off-balance-sheet instruments into time bands and determined how it will treat embedded options, 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 1 and calculating the change in the bank's net interest income for an immediate 200-basis-point increase in rates. For example, the bank has a negative gap of $20 million in the one-month to three-month time band. This means that more liabilities than assets will reprice or mature during this time frame. Hence, for the remaining 10 months of the bank's 12-month time horizon, the bank will have $20 million more of liabilities than assets that have repriced at higher (200 basis points higher) rates. As shown in table 2, the increase in rates reduces the bank's earnings for the 10-month period by approximately $333,000. The cumulative earnings effect of the bank's repricing imbalances over the 12-month horizon is a reduction in net interest income of approximately $362,500.

Table 2
Sample Net Interest Income Sensitivity Calculation

Time Band	Size of Gap (In Millions of Dollars)	Basis Point Change	Part of Year Gap Is in Effect*	Impact on Annualized NII (In Thousands of Dollars)
< 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 repricings occur at midpoint of time band

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

- All repricing 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. The sensitivity of the results to these assumptions can be tested by using simulation models.

Measuring Risk to Economic Value

Gap reports may be used to measure the exposure of a bank's net economic value to a change in interest rates. To do so, a bank multiplies the balances in each time band by a price sensitivity factor that approximates, for a given change in interest rates, the percentage change in the present value of an instrument with similar cash flow and maturity characteristics. For example, consider a bank that has $10 million of two-year Treasury notes slotted in the time band covering from two years to three years in its gap report. To estimate the market value sensitivity of those balances to a 200-basis-point increase in market interest rates, a banker would multiply those balances by a factor that approximates the change in the present value of a two-year Treasury note for a 200-basis-point movement in rates. The present value of a note with a 7.5 percent coupon would decline 3.6 percent for such a rate movement. Hence, the estimated decline in the market value of the bank's $10 million two-year Treasury note would be approximately $360,000 ($10 million times negative 3.6 percent).

Similar price sensitivity factors can be applied to other types of instruments and time bands. The exposure of the bank's

net economic value would be the sum of the weighted balances.

Limitations of Gap Reports

Basis Risk

The focus of a gap report is on the level of net repricings. 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 bankers 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 repricing imbalance for accounts tied to CD rates could be reported as one line item, followed by balances tied to the Treasury curve. This approach provides a rough approximation of the degree of basis risk present in the balance sheet.

Alternatively, some banks prepare *beta-adjusted* gap reports in an attempt to measure basis risk. In this type of report, the repricing 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 federal funds rate. If the analysis revealed that the bank's pricing on money market deposit accounts moves 50 basis points for every 100-basis-point movement in the federal funds 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 a bank'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, a bank 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 a bank's cumulative repricing 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 a bank's repricing gaps across the various time bands can provide an indication of the bank's exposure to changes in yield curve shapes. Suppose a bank 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 short-term rates go up and long-term rates remain stable. The bank'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 bank 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 a bank's risk profile. Although techniques such as preparing multiple gap reports and reporting options by their delta-equivalent values attempt to overcome some of these weaknesses, they are unable to fully capture all of the dimensions of option risk. To do so, a bank 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 bankers have partly overcome this weakness by reporting the weighted average repricing maturity within each time band. Another method is to reduce the width of the bands.

New Business

Many gap reports used by banks consider only the bank's current financial positions. These reports are called "static" reports because they capture only the risk that arises from the bank's existing balance sheet structure and do not incorporate any assumptions about new business. Some banks may also prepare "dynamic" gap reports. Typically, these reports are generated from the bank's earnings simulation models and show how the bank's "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 a bank's risk exposure under a variety of assumptions and scenarios and, thus, can be used to isolate sources of a bank's risk exposure or quantify certain types of risk. To do so, a bank performs a series of simulations and applies different assumptions and scenarios to each simulation.

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 a bank'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.

Banks often use simulation models to analyze alternative business decisions and to test the effect of those decisions on a bank's risk profile before implementation. Banks 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 bank'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 a bank's assets and liabilities will be replaced. The main components of a simulation model are presented in the table below.

Earnings Simulation Model
Basic Structure

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

Data from a bank's general ledger and transaction systems generally provide information on the bank'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 repricing 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 bank uses for pricing products.

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

Table 3 illustrates the type of summary report that may be generated by an earnings simulation model. The report 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.

Table 3
Net Interest Income Sensitivity
(In millions of dollars)

	NII Flat	Change in NII	
		Up 200 BP	Down 200 BP
Qtr 1	100	-5	5
Qtr 2	90	-5	5
Qtr 3	95	-10	15
Qtr 4	110	-10	15
Total	395	-30	40

A bank might have risk limits that restrict losses in the account at risk for a defined interest rate scenario over a certain period of time. For example, the bank in the table above might limit losses in annual net interest income from a 200 basis point change in rates to 10 percent of its base net interest income.

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 C that 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 bank 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 boards of directors. 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 bank 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 market or 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 bank's current risk position because it relies on management's assumptions about the bank's 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 banks 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 bankers 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, banks that use simulation models with horizons of only one or two years do not fully capture their long-term exposure. A bank 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 repricing exposures.

Economic Value Sensitivity and Duration Models

Techniques that measure economic value sensitivity can capture the interest rate risk of the bank's business mix across the spectrum of maturities. Economic value sensitivity systems generally compute and measure changes in the present value of the bank'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 bank'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 the bank's financial instruments under the Abase 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 bank's net economic value equals the present value of expected cash flows from the bank's assets, minus the present value of expected cash flows from the bank's liabilities, plus or minus the present value of expected cash inflows from the bank's off-balance-sheet positions.

To measure the sensitivity of the bank'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 bank's net economic value. The greater the change in net economic value, the greater the potential risk exposure of the bank.

Table 4 illustrates the type of output that is generated by economic value sensitivity models. In this example, the economic value of the bank's equity would be adversely affected by a rise in interest rates. For example, if rates rose by 200 basis points, the present value of the bank's assets would decline by $2.5 million, whereas the present value of the bank's liabilities would decline by only $1.5 million. As a result, the bank's net economic value would decline by $1 million from the base scenario.

Table 4
Sample Output of Economic Value Simulation Model

Interest Rate Scenario
(In thousands of dollars)

	Down 200 BP	Down 100 BP	Base Case	Up 100 BP	Up 200 BP
PV of Assets	$55,000	$54,500	$53,500	$52,000	$51,000
Change	$1,500	$1,000	$0	($1,500)	($2,500)
PV of Liabilities	$ 49,000	$48,700	$48,000	$ 47,000	$46,500
Change	$1,000	$700	$0	($1,000)	($1,500)
PV of Equity	$ 6,000	$5,800	$5,500	$5,000	$4,500
Change	$500	$300	$0	$(500)	($1,000)

Duration [1]

Many economic sensitivity models also compute the duration of a bank'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 a 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 bankers used duration as a proxy for estimating the net economic value of their institution. Duration is still used by many bank managers as a basis for evaluating the relative risks of different financial instruments, portfolios, or investment strategies.

1 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 nonamortizing 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.

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 a duration of five years. If coupon 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. Table 5 illustrates the calculation of the Macaulay and modified durations of a $100,000 two-year note that pays interest semiannually, has a 7.5 percent coupon, and was purchased at par to yield 7.5 percent. This note has a modified duration of 1.82. If rates were to increase 100 basis points, the value of this note would be expected to decline by approximately 1.82 percent.

Table 5
Sample Duration Calculation

Period (t)	Cash Flow	PV of $1 at 3.75 percent*	PV of CF	t x PV of CF
1	$3,750	0.96386	$3,614	$3,614
2	$3,750	0.92902	$3,484	$6,968
3	$3,750	0.89544	$3,358	$10,074
4	$103,750	0.86307	$89,544	$358,176
Total			$100,000	$378,832
Macaulay Duration: $378,832/$100,000 = 3.79 semiannual periods or 1.89 years				
Modified Duration: 1.89/(1+(7.50%/2) = 1.89/(1+0.0375) = 1.82				
* A 3.75% coupon and discount rate is used, because the semiannual payment of interest.				

The calculations in table 5 do not adjust the expected cash flows of the bond to changes in interest rates. Hence, this calculation (modified duration) is not valid for instruments, such as callable bonds and mortgage-backed securities, whose options will change their cash flows as interest rates move. To correct for this problem, many banks use what has become known as "effective duration." Effective duration is derived by using simulation techniques to calculate the change in price of an instrument for a given change in interest rates. The concepts of effective duration and convexity are discussed in more detail in a later section.

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 banks estimate the duration of a portfolio of contracts by weighting the durations of the individual contracts and summing them.

Many banks 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 a bank 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.

Table 6 illustrates how duration may be used to calculate the interest rate risk of a portfolio of fixed income contracts.

Table 6
Duration of a Portfolio of Instruments

Instrument	Yield to Maturity	Price/Amount	Modified Duration	Weighted Duration
7.5% coupon, 2-year note	10%	$95,567	1.80	.60
8% coupon, 5-year note	10%	$92,278	3.98	1.28
10% coupon, 10-year note	10%	$100,000	6.23	2.16
Duration of Portfolio:				4.04

The weighted duration of the portfolio is 4.04. If interest rates were to increase by 1 percent, the market value of the portfolio would decline by about approximately 4.04 percent or $11,629.

Duration Can Measure the Economic Value of Equity

Some banks 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 C or portfolio equity C will increase or decrease with a change in rates.

A bank 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 bank will decline as interest rates rise. A bank with short-term assets funded with long-term liabilities will generally have a negative duration of equity. The economic value of this bank will increase as interest rates rise. The higher the duration of a bank'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 bank or for selected portfolios, such as investment portfolios. Some banks 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 dollar changes in market or economic value. Duration measures the percentage change in value rather than the actual dollar change. To calculate exposure of the account at risk (the economic value of equity), a bank 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.

Convexity and Effective Duration

Banks can adjust modified duration to overcome some of the problems of convexity. Effective duration incorporates changes in cash flow that occur in instruments with options. (Convexity reflects a nonlinear shift in the price/yield relationships of instruments with and without options.) However, effective duration is useful only for a specific interest rate change. To obtain an instrument's effective duration, calculate its present values at two different market yields and obtain the percentage change in price (PV_+ and PV_-). Divide the absolute difference between the two present values by the bond's original (base-case) market price (PV) times the assumed change in yield (y) times two:

$$\frac{(PV_- - PV_+)}{2PVy}$$

The resulting number is the instrument's effective duration.

For example, a bank can calculate the effective duration of a Government National Mortgage Association security after a 100-basis-point rise in interest rates. Assume the security is currently trading at par to yield 7 percent. The bank first estimates the present value of the security if interest rates increase to 8 percent. In calculating this present value the bank takes into account that the cash flows of this security will increase because prepayments will slow. The present value at 8 percent (PV_+) is $94. Then the bank estimates the present value at 6 percent (PV_-), taking into account the decrease in cash flows because the rate of prepayment is higher. The present value at 6 percent (PV_-) is $104. The bond's effective duration [($104 - $94 / 2 (100) (.01)] is 5. In other words, the bond's value will decline by approximately 5 percent for the 100-basis-point increase in interest rates.

(The formula used to estimate an option-free fixed income instrument's convexity is provided in a technical note at the end of this appendix.)

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 element.

The simulation models discussed previously measure the value of the bank 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 bank 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 bank or the bank'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 Arisk-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, the bank specifies the relationships between the interest rates and the cash flows of the bank's portfolios. For example, the bank 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 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) 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 banks consider in their risk analysis. For example, if the bank 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. The resulting estimates are used to fill in a report such as the one illustrated in table 4.

Advantages of Monte Carlo Simulation

Monte Carlo simulation is a powerful risk analysis tool because it alone, of the tools discussed in this booklet, 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. Banks can employ Monte Carlo techniques to understand and evaluate current market pricing as well as their economic value at risk. This technique provides banks with a valuable tool for measuring and managing interest rate risk. "Investment Securities" in the *Comptroller's Handbook* discusses how to compare securities using OAS analysis.

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, a bank must have staff members with considerable expertise in financial and statistical theory.

Model Exposure

Regardless of the type of model used, banks 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.

Technical Note: Calculating Convexity

The convexity of an option-free fixed income instrument is measured by the following formula:

$$\text{Convexity (in periods)} = \frac{1(2)PVCF_1 + 2(3)PVCF_2 + 3(4)PVCF_3 + \ldots + n(n+1)PVCF_n}{(1+y)^2 \times PVTCF}$$

Where:

$PVCF_t$ = Present value of the cash flow in period *t* discounted at the prevailing period yield
t = Period when the cash flow is expected to be received
n = Number of periods until maturity
PVTCF = Total present value of the bond

One can estimate how much, in percent, convexity can change the price of an option-free instrument:

$$\text{Approximate change in price (in percent)} = (.5) \times \text{convexity (in years)} \times (\text{yield change})^2 \times 100$$

Table 7 calculates the convexity of the 7.5 percent coupon bond shown in table 5 and how much, in percent, this convexity will change the bond's price.

Table 7
Sample Convexity Calculation

Period (t)	t(t+1)	$PVCF_t$	t(t+1) $PVCF_t$
1	2	$3,614	$7,228
2	6	$3,484	$20.904
3	12	$3,358	$40,296
4	20	$89,544	$1,790,880
Total		$100,000	$1,859,308
$(1+y)^2 \times PVTCF = (1.0375)^2 \times \$100,000 = \$107,640.62$			
Convexity (semiannual) =($1,859,308)/($107,640.62) = 17.27			
Convexity (in years) = (convexity in periods)/(# of periods)^2 = 17.27/4 = 4.318			
Change in price (in percent) because of convexity after a 100-basis-point increase in rates: $(.5)(4.318)(.01)^2 \times 100 = .02\%$			

The total change in price, in percent, of the 7.5 coupon bond after a 100-basis-point move can now be estimated by summing the changes caused by modified duration and convexity. (For option-free bonds, convexity will always have a positive effect on price, and duration will have a negative effect.) Thus, the 7.5 coupon bond is estimated to decline by 1.80 percent (duration of minus 1.82 percent plus convexity of 0.02 percent) after a 100-basis-point increase in rates. If rates decrease by 100 basis points, the bond is estimated to increase in price by 1.84 percent (duration of 1.82 percent plus convexity of 0.02 percent).

Interest Rate Risk Models: In-House or Vendor?

A bank may either design and develop risk measurement models internally or purchase them from an outside vendor. Developing an in-house model (if the bank has the ability) is often preferable because the model can be tailored to the bank's unique business mix.

To develop its own model, a bank must be able to commit sufficient money and staff members to ensure the integrity of the model's design and algorithm and to maintain the model. Because as few as one or two employees may come to be the bank's acknowledged experts on the in-house model, management should ensure that there is sufficient documentation to enable others to maintain and support the model in the absence of these key employees.

Using a model developed by a third-party vendor can reduce resource requirements, as well as start-up times and costs. For banks with limited staff resources, some vendor models may offer a fuller and more comprehensive risk measurement system than what the bank could develop internally. The use of vendor models may free the bank's staff from programming efforts and allow more resources to be devoted to the qualitative issues of interest rate risk management.

But some banks have found even external models costly to implement. Vendor models may not be able to capture all of the types of instruments the bank holds or all facets of a bank's risk exposure. Vendor models can become "black boxes" to inexperienced users, who obtain output without fully understanding the modeling process. This imperfect knowledge can produce undetected errors and misleading or incorrect results.

Before selecting a model, a bank must determine what model features it needs and examine alternative packages based on those needs. Above all, management should consider the ability of bank personnel to understand and update the model. Selecting a model that is too complex for staff members can stymie interest rate risk management.

The OCC expects banks to have systems in place that can identify, measure, monitor, and control the major sources of the bank's interest rate risk exposure. A bank's model should be able to handle every type of financial instrument (on- and off-balance-sheet) that the bank uses. For example, the model selected by a bank holding adjustable rate mortgages should be able to handle periodic and lifetime caps on interest rates, different prepayment estimates, as well as the calculation of amortization schedules.

Management should ensure that the reports generated by the model are easy to prepare and interpret. If the bank will use the model in its budgeting and planning process, the model should be able to track and compare actual results with projections.

Banks should consider the type of hardware needed to run the model or software package. Will the model be run on a personal computer or the bank's mainframe? How long will it take to run the model? Will the model expend so much computer time that the production of other computer-generated reports will be compromised?

When considering models supplied by outside vendors, management should evaluate the financial strength of the vendor as well as the support the vendor will provide. Bank management should find out whether the vendor will supply initial and ongoing support using hotlines, training, and consultants; how frequently the software will be updated, how the bank will obtain the updates, and how the vendor validates models and new software releases; and how the vendor supports older releases of a product that has been updated.

How easy is it for model users to discover and track errors? A model that can flag inconsistent data, say, when a user inputs a level of maturity balances that exceeds outstanding current balances, facilitates the early discovery of errors. Comprehensive documentation on the model's operation should help track errors.

Bank management should also consider:

- Whether the bank needs a menu-driven system or one that is programming oriented. Although menus are generally more user-friendly, systems with programming capabilities may be more flexible.
- The number of accounts and different products that a model can accommodate to ensure that the model meets the bank's current and projected needs.
- Whether the bank as well as the vendor can add or modify accounts analyzed by the model.
- Whether the time periods (months, quarters, years) that the model can project fit the structure of the bank's balance sheet.
- How many interest rate scenarios the model can run and whether the scenarios are generic or can be specified by

the bank.
- How many "driver" market interest rates and yield curves the model allows.
- Whether the process by which data is input into the model preserves the data's accuracy and integrity. Management should consider how much data must be inputted and whether it must be manually entered or can be extracted directly from the bank's operating systems. In a multibank holding company structure, management also should consider whether the model permits the consolidation of data.
- The types of analyses that the model is capable of producing, such as gap reports and comparisons of net income under alternative interest rate scenarios.
- Whether the model can calculate duration and market valuations.
- Whether the vendor has staff members who can prepare special reports at the bank's request in addition to standard reports.

Nonmaturity Deposit Assumptions

Background

The assumptions a bank makes about nonmaturity deposits, such as demand deposit accounts (DDA), negotiable order of withdrawal (NOW) accounts, savings accounts, and money market demand accounts (MMDA), are probably the most important ones to be made in developing gap, simulation, and economic valuation models. These deposits usually represent a large proportion of a bank's funding base.

Banks make different assumptions about the repricing sensitivity and maturity structure of nonmaturity deposits. For example, some banks consider MMDAs to be fully rate-sensitive and assign them a short maturity because the bank may at any time elect to change the rates paid on those funds. Other banks liken MMDAs to fixed rate funds with longer maturities because management generally does not change the rate paid on the deposits.

Some banks view their nonmaturity deposits as products with embedded options whose maturity or repricing will depend on the behavior of customers and competitors and the pricing policies of bank management. Because of these embedded options, management's assumptions can change with the interest rate scenario.

The OCC does not dictate which assumptions or methods banks must use to assess the interest rate sensitivity of their deposits. Instead, the OCC encourages bank management to study the behavior of the bank's deposit accounts and develop assumptions and treatments based on how these deposits will perform under various interest rate scenarios. As important as these assumptions are in determining a bank's overall interest rate risk profile, bank management should periodically conduct sensitivity analyses on them. From these analyses, management should learn whether deposits that do not behave as assumed could hurt the bank's performance. If there is a reasonable possibility of a clearly adverse outcome, the bank should develop contingency plans. Examiners should review these analyses and plans.

Because the expected performance of these deposits will vary with a bank's competitive market, its position in that market, and its customer base, examiners should not expect every bank to treat its deposit balances the same. Examiners should determine whether the bank has analyzed its depositor base, and formulated and documented assumptions that are reasonable given the bank's past performance and its current marketing, funding, and pricing strategies.

Analyzing Nonmaturity Deposits

A bank's nonmaturity deposit base is sensitive to circumstances at the bank, in the bank's competitive market, and in the general economy. Such circumstances include:

- **The bank's need for funds and its ability to use alternative funding sources.** For example, in a period of low loan demand, a bank may change its pricing policies to allow some of its nonmaturity deposits to run off. As loan demand increases, a bank seeking to increase liquidity may raise its rates in order to attract more deposits.
- **The bank's pricing structure and customer base.** Using a variety of implicit and explicit pricing structures for its core deposits, a bank can tailor pricing for certain parts of its customer base. For example, a bank may waive certain account fees for retail customers who maintain minimum balance requirements. Commercial customers may be given an "earnings allowance" for demand deposit balances kept in lieu of paying account analysis fees. "Tiered" pricing strategies divide a bank's customer base between high-balance, rate-sensitive customers and low-balance, rate-insensitive customers. The demographics of the bank's customer base may help a bank to determine the rate sensitivity of its depositors.
- **The bank's marketing and strategic plans for its deposit products.** Many banks increasingly cluster their retail products in menus, each of which can be marketed to a segment of the customer base. In developing and planning marketing strategies, these banks may view individual products as having life cycles or market niches that influence how the bank will position and price them in the future. For example, bank management may decide to let a certain deposit product become less rate sensitive over time, and to introduce a new, more rate sensitive deposit product to customers who are more likely to move balances when interest rates change.

- **The number and type of competitors within the bank's market.** The pricing behavior of competitors will likely influence the degree and speed with which a bank will respond to changes in market interest rates. As consumers become more knowledgeable and comfortable with alternative investments, a bank's competitive market expands. Increasingly, a bank competes not only with other banks or thrifts for deposits but also with investment houses, mutual funds, and even entities that advertise their rates and services over the Internet.

- **The general level and trends of market interest rates.** Market interest rates, such as the rate that a depositor could earn by investing in Treasury securities, help to determine the "opportunity cost" to the bank's customer of maintaining bank balances. The opportunity cost of holding demand deposit balances, for example, is relatively low when market interest rates are low. As market interest rates rise, so does the opportunity cost of holding "excess" demand deposit balances. As the spread between market interest rates and the rates a bank pays on its nonmaturity deposits widens, there may be increasing incentives for bank customers to switch funds.

- **Product development and changes in financial institution regulation.** The development of new financial products and changes in banking laws can have a dramatic effect on the structure of a bank's deposit base and the behavior of depositors. For example, the elimination of regulation Q and the advent of MMDAs significantly changed the composition of a bank's deposits. When analyzing nonmaturity deposits, banks should consider any impending legislation or new products that would significantly alter the marketplace and force the bank to change its assumptions about customer behavior.

Establishing Assumptions about Nonmaturity Deposits

To determine the appropriate assumptions for its nonmaturity deposits, management should analyze carefully the bank's depositor base and the demographics of its market. Then it should assess how the circumstances described above and any other relevant factors will influence the level of deposits and the rates offered on them. Management also should consider how these factors could affect the bank's deposit base differently in alternative interest rate scenarios.

The tools bankers use to analyze deposits may vary with the size and sophistication of the bank. Larger banks will typically use tools such as regression analyses and attrition studies to help devise assumptions about deposits. The methods of smaller banks may be similar but less robust statistically.

Identifying Noncore Balances

Although bankers and regulators often refer to all the balances in a bank's DDAs, MMDAs, NOWs, and savings accounts as core balances, these accounts generally hold both core (long-term, more stable) and noncore (short-term, more temporary) balances. As a first step in analyzing its balances, bank management should isolate the amount of current balances (if any) that are "excess" or temporary balances.

Seasonal and cyclical influences cause deposit balances at many banks to fluctuate around a long-term trend line. Examples of such fluctuations may include:

- Seasonal inflows and outflows associated with business or consumer activity within the bank's market. For example, banks in resort areas or agricultural communities may have pronounced seasonal peaks and troughs in their nonmaturity deposits. Banks with sizable corporate balances may see balances temporarily increase at the end of the year or quarter. Banks serving large retirement communities may have balances that peak monthly as social security checks are deposited.

- Cyclical buildup of nonmaturity deposits. In periods of low interest rates, such increases reflect the lower "opportunity costs" that depositors incur to maintain these balances. As market interest rates rise or other investment opportunities, such as mutual funds, become more attractive, this accumulation is likely to erode as deposits shift into other products or leave the bank.

Temporary, seasonal, or cyclical inflows are often the balances that are most likely to leave the bank or move to another of the bank's funding vehicles, such as retail CDs. As a result, banks often view these balances as relatively short-term deposits. In a gap report, a bank might place these balances in a short-term (six months or less) time band. In a simulation model, a bank may forecast the departure of these balances or their shift into other products.

Estimating the Effective Maturity of Core Balances

A more difficult task when analyzing nonmaturity deposits is devising assumptions for the core balances. In developing these assumptions, bank management should consider the effect that changes in market interest rates have on the level

of deposits and the rates the bank pays on them.

Interest Rate Effect

The deposit rates offered by many banks lag market interest rates and move in smaller increments than market rates do. Bank management often has deposit rates follow market rates more slowly when rates are increasing and more quickly when rates are declining. As a result, the effective maturity of the bank's deposits will tend to be longer when rates are rising and shorter when rates are falling.

Banks often place implicit caps and floors on nonmaturity deposit rates. (Some bankers and industry analysts do not acknowledge the existence of caps and floors.) A floor, which is the lowest rate a bank will pay on a deposit, reduces the implicit benefit of the deposit to the bank when interest rates are falling. A cap, which is the highest rate it will pay, raises the benefit of the deposit to the bank when interest rates are rising.

Effect on Balances

When the spread between what a bank is paying a depositor and what the depositor can earn somewhere else gets too large, the depositor will leave the bank or move to a higher-rate investment at the bank. By tracking this spread and managing the "opportunity costs" to depositors of maintaining relatively low-paying balances, bank management can influence its level of nonmaturity deposits. (Bankers often estimate opportunity costs by calculating the spread between what a customer can earn on an alternative investment outside the bank and the rate being offered by the bank.)

Past and Future

Experience should guide bank management in developing its assumptions about nonmaturity deposits. What effect has the movement of interest rates had in the past on the spread between market rates and the bank's deposit rates? What effect have changes in the spread had on the level of core deposits? Management should also be guided by the outlook for the bank. How will expected changes in the bank's competitive environment and customer base affect its pricing behavior? Persons developing assumptions should work with marketing and retail managers to get their opinions on pricing strategies.

Incorporating Assumptions into Risk Measurement

Using one method or another, banks incorporate the effect of market interest rates on deposit rates and balances into their interest rate risk measurements. Four of these methods are discussed below.

Rate Sensitive and Rate Insensitive in Gap Reports

Some banks that use gap reports stratify their nonmaturity deposits across a number of time bands. The bank's noncore or temporary balances are often reported in the shorter time bands (e.g., six months or less). The remaining balances are sometimes separated into interest sensitive and interest insensitive components.

To determine the interest sensitive portion of balances, the bank may project that it will match in deposit rates a certain percentage of market-rate movements. For example, the bank may decide that if market interest rates rise by 200 basis points, it will increase its MMDA rate by 75 basis points. This increase in its MMDA rate represents approximately 37 percent of the movement in market rates, suggesting that 37 percent of the bank's MMDA accounts are effectively rate sensitive. This portion of the bank's MMDA balances would then be reported in the shorter time bands of the bank's gap report.

Although non-interest-bearing deposits do not pay interest explicitly, a bank may determine that a portion of these balances are responsive to changes in market interest rates. For example, many corporate DDA customers maintain compensating demand balances or balances held in lieu of service charge fees. The balances are often associated with corporate cash management and account analysis services. The level of compensating balances held by corporate customers is typically driven by the earnings allowance assigned by the bank, which, in turn, often depends on market interest rates, such as the prevailing short-term CD rate. Because the level of balances will vary with this allowance rate, compensating balances are often viewed as rate sensitive in the bank's gap report.

After the bank has stratified its rate sensitive and noncore balances into shorter maturity bands, it must then determine how to treat the remaining balances in its gap report. The maturity attributed to these balances is especially important when evaluating whether the bank's nonmaturity deposits hedge the bank's economic exposure. By attributing a long maturity to these balances, bank management is assuming that the balances will not reprice or migrate to other deposit

products when market interest rates change. These balances generally will be available to fund some of the bank's long-term assets.

Accordingly, the stability of the portion of nonmaturity balances that a bank considers to be rate insensitive is a critical assumption in the bank's interest rate risk measurement process. Nevertheless, banks determine maturity in many different ways. For example, a bank can:

- **View the entire remaining balance of long-term deposits as insensitive and assume that these balances effectively never reprice or mature.** Arguments provided to support such a treatment often point to the bank as an ongoing business. Under this approach the bank assumes that maturing balances (balances that become unavailable to the bank because of demographic factors such as customers moving or dying) are replaced by new customers and accounts. Sensitivity analyses should be conducted on this assumption to ensure that the bank could withstand the impact on earnings and liquidity of balances leaving the bank or migrating to other bank products.
- **Spread balances across a number of maturity bands, based on assumptions about customer attrition over time.**
- **View the remaining balances as fairly insensitive but set a maximum allowable maturity beyond which all remaining balances are assumed to run off or shift to an alternative investment.** Banks adopting this view often point to the difficulty of predicting customer behavior and industry, competitive, and regulatory conditions. These uncertainties, they suggest, warrant some limit on the maturity assumed for nonmaturity deposits.

Pricing Spreads and Balance Mix in Net Income Simulation Models

A bank developing an earnings simulation model will usually incorporate cap/floor effects and the effect of market rates on deposit rates and balances. Most simulation models will do so through the model's pricing and volume relationships. For example, the model may establish a different pricing relationship between MMDAs and rising interest rates than between MMDAs and falling rates. When rates rise 200 basis points, MMDA rates might increase by 75 basis points; when rates fall 200 basis points, MMDA rates might decrease by 125 basis points. If the bank has a lagged pricing response for its nonmaturity deposits, the speed and amount of the lag may vary with the level and direction of rates. (The lag could be larger and longer when rates are increasing.) Some banks may include an "equilibrium" reset process so that, over time, the spread between the bank's deposit rate and market rates maintains a certain stability.

To reflect the effect of market rates on deposit balances, a bank using simulation models will often lower the level of balances in a deposit category or add new balances according to the rate scenario. In the example above, because the bank's MMDA rates are expected to be less responsive in a rising rate environment, the model may lower the level of balances in the rising rate scenario.

Because the time horizon used by most earnings simulation models is two years, many banks using simulation models do not make explicit assumptions about how their nonmaturity deposits will behave over a longer period of time or for their effective maturity. However, for the reasons cited in the discussion regarding the treatment of deposits in gap reports, it is important for management to consider this issue. Implicitly, bank management is probably making some assumption about the maturity of these deposits when it is making decisions about its overall balance sheet structure and the term of investments and loans it wishes to hold.

Replicating Portfolio Analyses

Some larger banks have found it helpful to think of their nonmaturity deposit accounts as a portfolio of instruments that have different interest rate and maturity characteristics, reflecting the different pricing and strategies for account segments. To estimate the effective maturity of this portfolio of accounts, the bank performs various statistical studies on how closely a hypothetical portfolio, composed of instruments with known maturities and repricing characteristics, tracks the observed performance (e.g., level and speed of rate changes when market rates move) of the bank's deposit accounts. For example, a bank may determine that changes in a hypothetical portfolio with a mix of three-month Treasury bills and 10-year Treasury notes most closely matches the observed changes in the bank's savings rates. The bank would then use the duration or effective maturity of this hypothetical portfolio to estimate the maturity of its savings deposits.

Market Value Approach

Some banks use a market value approach to value their nonmaturity deposits. Unlike the portfolio analysis described above, the market value approach uses the duration and convexity of the deposit account cash flows themselves rather than a portfolio of instruments whose performance mirrors that of the deposits. The bank determines a market or economic value of its nonmaturity deposits by discounting the projected cash flows associated with the deposits. Models estimate the deposit cash flows for various interest rates scenarios based on the historical sensitivity of the deposits.

Funds Transfer Pricing

Some banks may centralize the management of interest rate risk in a unit of the bank, usually the treasury unit, using a funds transfer pricing system. Funds transfer pricing allows the bank to transfer the impact on earnings of changing interest rates from individual business lines to the central unit. The earnings of the business lines can then be traced more directly to the business decisions of management. Funds transfer pricing also induces line managers to make pricing decisions that are consistent with the interest rate risk management objectives of ALCO and treasury. (Banks often use funds transfer pricing to evaluate and enhance the performance of business units.)

The transfer pricing system removes interest rate risk profits and losses from individual business units. Banks can use several methods to determine the price of transferred funds. Using a "gap approach," a bank can group its assets and liabilities based on the maturity and repricing characteristics of the instruments and assign a transfer rate to each group. Alternatively, the treasury unit of a bank could assign a cost or earnings rate to every transaction. For example, treasury assigns a cost of funds to the commercial lending units for loans. A fixed rate, five-year loan might be assigned a cost-of-funds equivalent to the rate paid by the bank to borrow five-year money. The treasury will assign an earnings credit to the deposit or retail unit for the funds raised. In this way, the treasury unit acts as a middleman between the lending and retail units.

Under a transfer pricing system, profits and losses arising from interest rate mismatches are transferred to a central unit, generally the treasury department. The treasury, which is responsible for funding the loans, may either match-fund the loans or maintain the repricing mismatch. If loans are matched-funded, no interest rate risk is assumed by either the lending units or treasury. If treasury decides to maintain the mismatch, perhaps funding a five-year fixed rate loan with a one-year deposit, the unit would earn the difference between its actual funding costs and what it has charged the lending units. For example, if treasury charges the lending units 10 percent for five-year funds and raises one-year money at 9 percent, treasury would earn a 1 percent spread. Obviously, the treasury unit has assumed interest rate risk. If rates were to rise, the spread earned could decline or even become negative.

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