

PRINCIPLES FOR THE MANAGEMENT OF INTEREST RATE RISK¹ **(January 1997)**

Summary

1. As part of its on-going efforts to address international bank supervisory issues, the Basle Committee is issuing the attached paper for comment by banks and other financial market participants on the management of interest rate risk. In this as in many other areas sound controls are of crucial importance. It is essential that banks have a comprehensive risk management process in place, that effectively identifies, measures, monitors and controls interest rate risk exposures, and that is subject to appropriate board and senior management oversight. The attached paper describes each of these elements, drawing upon experience in member countries and principles established in earlier publications by the Committee. The objective of the paper is to outline a number of principles for use by supervisory authorities when evaluating banks' interest rate risk management.

2. The supervisory capital requirements established by the Basle Committee will, as from end-1997, cover interest rate risk in the trading activities of banks.² This paper is intended to set out principles of more general application for the management of interest rate risk, independent of whether the positions are part of the trading book or reflect banks' non-trading activities.

3. In developing these principles, the Committee has drawn not only on supervisory guidance in member countries but also on the comments of the banking industry on the Committee's earlier paper, issued for consultation in April 1993.³ In addition, the present paper incorporates many of the principles contained in the guidance issued by the Committee for derivatives activities,⁴ which are reflected in the qualitative parameters for model-users in the recently published capital standards for market risk.

4. These principles are intended to be of general application, based as they are on practices currently used by many international banks, even though their specific application will depend to some extent on the complexity and range of activities undertaken by individual banks. Supervisory authorities should, therefore, use them to re-assess their own supervisory methods and procedures for monitoring how banks control interest rate risk. While the exact

1 Although still technically a consultative paper subject to changes in the light of comments still to be received, this paper is included in the present volume because of the importance the Committee attaches to the sound management of interest rate risk.

2 *Amendment to the Capital Accord to Incorporate Market Risks*, January 1996.

3 *Measurement of Banks' Exposure to Interest Rate Risk*, April 1993.

4 *Risk Management Guidelines for Derivatives*, July 1994.

approach chosen by individual supervisors will depend upon a host of factors, including their on-site and off-site supervisory techniques and the degree to which external auditors are also used in the supervisory function, **all members of the Basle Committee agree that the principles set out here provide the standards to be used by national supervisory authorities in evaluating the adequacy and effectiveness of a bank's interest rate risk management.**

5. The Basle Committee is also distributing this paper to supervisory authorities worldwide in the belief that the principles presented will provide a useful framework for prudent supervision of interest rate risk. More generally, the Committee wishes to emphasise that sound risk management practices are essential to the prudent operation of banks and to promoting stability in the financial system as a whole.

6. This paper also provides supervisory authorities with a framework for obtaining information on interest rate risk. It broadly describes the types of basic information that should be available to supervisory authorities to help them in evaluating banks' interest rate risk exposures. This information can then be used in a variety of ways by supervisory authorities to provide quantitative assessments of the interest rate risk faced by banks.

7. After careful consideration of the comments received on the April 1993 proposal, the Committee has set out principles for sound interest rate risk management, rather than establishing a more standardised measure for interest rate risk. The Committee will, however, keep the need for such more standardised measures under review and may, at a later stage, revisit its approach in this area. In that context, the Committee is aware that industry techniques for measuring and managing interest rate risk are continuing to evolve, particularly for products with uncertain cash flows or repricing dates, such as many mortgage-related products and retail deposits.

8. Even though the Committee is not currently proposing capital charges specifically for interest rate risk, all banks should have enough capital to support the risks they incur, including those arising from interest rate risk. Individual supervisors may, of course, decide to apply capital charges to their banking system in general or to individual banks that are more extensively exposed to interest rate risk, or whose risk management processes are unsatisfactory.

9. The Committee stipulates in the five sections III to VII of the paper the following twelve principles for banking supervisory authorities to apply in assessing banks' management of interest rate risk:

A. The role of the board and senior management

Principle 1:

In order to carry out its responsibilities, the board of directors in a bank should approve interest rate risk management policies and procedures, and should be informed regularly of the interest rate risk exposure of the bank.

Principle 2:

Senior management must ensure that the structure of the bank's business and the level of interest rate risk it assumes are effectively managed, that appropriate policies and procedures are established to control and limit these risks, and that resources are available for evaluating and controlling interest rate risk.

Principle 3:

Banks should have a risk management function with clearly defined duties that reports risk exposures directly to senior management and the board of directors and is sufficiently independent from the business lines of the bank. Larger or more complex banks should have units responsible for the design and administration of the bank's interest rate risk management system.

B. Policies and procedures

Principle 4:

It is essential that banks' interest rate risk policies and procedures be clearly defined and consistent with the nature and complexity of their activities. These policies should address the bank's exposures on a consolidated basis and, as appropriate, also at the level of individual affiliates.

Principle 5:

It is important that banks identify the risks inherent in new products and activities and ensure these are subject to adequate procedures and controls before being introduced or undertaken. Major hedging or risk management initiatives should be approved in advance by the board or its appropriate delegated committee.

C. Measurement and monitoring system

Principle 6:

It is essential that banks have interest rate risk measurement systems that capture all material sources of interest rate risk and that assess the effect of interest rate changes in ways which are consistent with the scope of their activities. The assumptions underlying the system should be clearly understood by risk managers and bank management.

Principle 7:

Banks must establish and enforce operating limits and other practices that maintain exposures within levels consistent with their internal policies.

Principle 8:

Banks should measure their vulnerability to loss under stressful market conditions - including the breakdown of key assumptions - and consider those results when establishing and reviewing their policies and limits for interest rate risk.

Principle 9:

Banks must have adequate information systems for monitoring and reporting interest rate exposures to senior management and boards of directors on a timely basis.

D. Independent controls

Principle 10:

Banks must have adequate internal controls for their interest rate risk management process and should evaluate the adequacy and integrity of those controls periodically. Individuals responsible for evaluating control procedures must be independent of the function they are assigned to review.

Principle 11:

Banks should periodically conduct an independent review of the adequacy and integrity of their risk management processes. Such reviews should be available to relevant supervisory authorities.

E. Information for supervisory authorities

Principle 12:

The G-10 supervisory authorities will obtain from banks sufficient and timely information with which to evaluate their level of interest rate risk. This information should take appropriate account of the range of maturities and currencies in each bank's portfolio, as well as other relevant factors, such as the distinction between trading and non-trading activities. Other supervisory authorities are recommended to obtain similar information.

10. Comment was invited on all aspects of this paper, including the two Annexes, by 15th April 1997.

I. Sources and effects of interest rate risk

1. Interest rate risk is the exposure of a bank's financial condition to adverse movements in interest rates. Accepting this risk is a normal part of banking and can be an important source of profitability and shareholder value. However, excessive interest rate risk can pose a significant threat to a bank's earnings and capital base. Changes in interest rates affect a bank's earnings by changing its net interest income and the level of other interest-sensitive income and operating expenses. Changes in interest rates also affect the underlying value of the bank's assets, liabilities and off-balance-sheet instruments because the present value of future cash flows (and in some cases, the cash flows themselves) change when interest rates change. Accordingly, an effective risk management process that maintains interest rate risk within prudent levels is essential to the safety and soundness of banks.

2. Before setting out some principles for interest rate risk management, a brief introduction to the sources and effects of interest rate risk might be helpful. Thus, the following sections describe the primary forms of interest rate risk to which banks are typically exposed. These include repricing risk, yield curve risk, basis risk and optionality, each of which is discussed in greater detail below. These sections also describe the two most common perspectives for assessing a bank's interest rate risk exposure: the earnings perspective and the economic value perspective. As the names suggest, the earnings perspective focuses on the impact of interest rate changes on a bank's near-term earnings, while the economic value perspective focuses on a bank's underlying value.

1. Sources of interest rate risk

1. **Repricing risk:** As financial intermediaries, banks encounter interest rate risk in several ways. The primary and most often discussed form of interest rate risk arises from timing differences in the maturity (for fixed rate) and repricing (for floating rate) of bank assets, liabilities and off-balance-sheet (OBS) positions. While such repricing mismatches are fundamental to the business of banking, they can expose a bank's income and underlying economic value to unanticipated fluctuations as interest rates vary. For instance, a bank that funded a long-term fixed rate loan with a short-term deposit could face a decline in both the future income arising from the position and its underlying value if interest rates increase. These declines arise because the cash flows on the loan are fixed over its lifetime, while the interest paid on the funding is variable, and increases after the short-term deposit matures.

2. **Yield curve risk:** Repricing mismatches can also expose a bank to changes in the slope and shape of the yield curve. Yield curve risk arises when unanticipated shifts of the yield curve have adverse effects on a bank's income or underlying economic value. For instance, the underlying economic value of a long position in 10-year government bonds hedged by a short position in 5-year government notes could decline sharply if the yield curve steepens, even if the position is hedged against parallel movements in the yield curve.

3. **Basis risk:** Another important source of interest rate risk (commonly referred to as basis risk) arises from imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar repricing characteristics. When interest rates change, these differences can give rise to unexpected changes in the cash flows and earnings spread between assets, liabilities and OBS instruments of similar maturities or repricing frequencies. For example, a strategy of funding a one-year loan that reprices monthly based on the one-month US Treasury Bill rate, with a one-year deposit that reprices monthly based on one-month Libor, exposes the institution to the risk that the spread between the two index rates may change unexpectedly.

4. **Optionality:** An additional and increasingly important source of interest rate risk arises from the options embedded in many bank assets, liabilities and OBS portfolios. Formally, an option provides the holder the right, but not the obligation, to buy, sell, or in some manner alter the cash flow of an instrument or financial contract. Options may be stand-alone instruments such as exchange-traded options and over-the-counter (OTC) contracts, or they may be embedded within otherwise standard instruments. While banks use exchange-traded and OTC-options in both trading and non-trading accounts, instruments with embedded options are generally most important in non-trading activities. They include various types of bonds and notes with call or put provisions, loans which give borrowers the right to prepay balances, and various types of non-maturity deposit instruments which give depositors the right to withdraw funds at any time, often without any penalties. If not adequately managed, the asymmetrical payoff characteristics of instruments with optionality features can pose significant risk, particularly to those who sell them, since the options held, both explicit and embedded, are generally exercised to the advantage of the holder and the disadvantage of the seller. Moreover, an increasing array of options can involve significant leverage which can magnify the influences (both negative and positive) of option positions on the financial condition of the firm.

2. Effects of interest rate risk

1. As the discussion above suggests, changes in interest rates can have adverse effects both on a bank's earnings and its economic value. This has given rise to two separate, but complementary, perspectives for assessing a bank's interest rate risk exposure.

2. **Earnings perspective:** In the earnings perspective, the focus of analysis is the impact of changes in interest rates on accrual or reported earnings. This is the traditional approach to interest rate risk assessment taken by many banks, particularly in the past. Variation in earnings is an important focal point for interest rate risk analysis because reduced earnings or outright losses can threaten the financial stability of an institution by undermining its capital adequacy, by shaking market confidence, and by weakening liquidity.

3. In this regard, the component of earnings that has traditionally received the most attention is net interest income (i.e. the difference between total interest income and total

interest expense). This focus reflects both the importance of net interest income in banks' overall earnings and its direct and easily understood link to changes in interest rates. However, as banks have expanded increasingly into activities that generate fee-based and other non-interest income, a broader focus on overall net income - incorporating both interest and non-interest income and expenses - has become more common. The non-interest income arising from many activities, such as loan servicing and various asset securitisation programmes, can be highly sensitive to market interest rates. For example, some banks provide the servicing and loan administration function for mortgage loan pools in return for a fee based on the volume of assets it administers. When interest rates fall, the servicing bank may experience a decline in its fee income as the underlying mortgages prepay. In addition, even traditional sources of non-interest income such as transaction processing fees are becoming more interest rate sensitive. This increased sensitivity has led both bank management and supervisors to take a broader view of the potential effects of changes in market interest rates on bank earnings.

4. ***Economic value perspective:*** Variation in market interest rates can also affect the economic value of a bank's assets, liabilities and OBS positions. Thus, the sensitivity of a bank's economic value to fluctuations in interest rates is a particularly important consideration of shareholders, management and supervisors alike. The economic value of an instrument represents an assessment of the present value of its expected net cash flows, discounted to reflect market rates. By extension, the economic value of a bank can be viewed as the present value of bank's expected net cash flows, defined as the expected cash flows on assets minus the expected cash flows on liabilities plus the expected net cash flows on OBS positions. In this sense, the economic value perspective reflects one view of the sensitivity of the net worth of the bank to fluctuations in interest rates.

5. Since the economic value perspective considers the potential impact of interest rate changes on the present value of all future cash flows, it provides a more comprehensive view of the potential long-term effects of changes in interest rates than is offered by the earnings perspective. This comprehensive view is important since changes in near-term earnings - the typical focus of the earnings perspective - may not provide an accurate indication of the impact of interest rate movements on the bank's overall positions.

6. ***Embedded losses:*** The earnings and economic value perspectives discussed thus far focus on how future changes in interest rates may affect a bank's financial performance. When evaluating the level of interest rate risk it is willing and able to assume, a bank should also consider the impact that past interest rates may have on future performance. In particular, instruments that are not marked to market may already contain embedded gains or losses due to past rate movements. These gains or losses may be reflected over time in the bank's earnings. For example, a long-term fixed-rate loan entered into when interest rates were low and refunded more recently with liabilities bearing a higher rate of interest will, over its remaining life, represent a drain on the bank's resources.

II. Sound interest rate risk management practices

1. Sound interest rate risk management involves the application of four basic elements in the management of assets, liabilities and off-balance-sheet instruments:

- Appropriate board and senior management oversight;
- Adequate risk management policies and procedures;
- Appropriate risk measurement and monitoring systems; and
- Comprehensive internal controls and independent external audits.

2. The specific manner in which a bank applies these elements in managing its interest rate risk will depend upon the complexity and nature of its holdings and activities as well as on the level of interest rate risk exposure. What constitutes adequate interest rate risk management practices can therefore vary considerably. For example, less complex banks whose senior managers are actively involved in the details of day-to-day operations may be able to rely on relatively basic interest rate risk management processes. However, other organisations that have more complex and wide-ranging activities are likely to require more elaborate and formal interest rate risk management processes, to address their broad range of financial activities and to provide senior management with the information they need to monitor and direct day-to-day activities. Moreover, the more complex interest rate risk management processes employed at such banks require adequate internal controls that include audits or other appropriate oversight mechanisms to ensure the integrity of the information used by senior officials in overseeing compliance with policies and limits. The individuals involved in the risk management process or the risk management units must be sufficiently independent from the business lines to ensure an adequate separation of duties and the avoidance of conflicts of interest.

3. As with other risk factor categories, the Committee believes that interest rate risk should be monitored on a consolidated basis, to include interest rate exposures in subsidiaries. However, while consolidation provides a comprehensive measure, in respect of interest rate risk it may underestimate risk when positions in one affiliate offset positions in another. This is because a conventional accounting consolidation may allow theoretical offsets between such positions from which a bank may not in practice be able to benefit because of legal or operational constraints. Management should recognise the potential for consolidated measures to understate risks in such circumstances.

III. Board and senior management oversight of interest rate risk⁵

Effective oversight by a bank's board of directors and senior management is critical to a sound interest rate risk management process. It is essential that these individuals are aware of their responsibilities with regard to interest rate risk management and that they adequately perform their roles in overseeing and managing interest rate risk.

1. Board of directors

1. The board of directors has the ultimate responsibility for understanding the nature and the level of interest rate risk taken by the bank. The board should approve broad business strategies and significant policies that govern or influence the interest rate risk of the bank. It should review the overall objectives of the bank with respect to interest rate risk and should ensure the provision of clear guidance regarding the level of interest rate risk acceptable to the bank. The board should also approve policies and procedures that identify lines of authority and responsibility for managing interest rate risk exposures.

2. Accordingly, the board of directors is responsible for approving the overall policies of the bank with respect to interest rate risk and for ensuring that management takes the steps necessary to identify, measure, monitor, and control these risks. The board or a specific committee of the board should periodically review information that is sufficient in detail and timeliness to allow it to understand and assess the performance of management in monitoring and controlling these risks in compliance with the bank's board-approved policies. Such reviews should be conducted regularly, being carried out more frequently where the bank holds significant positions in complex instruments. In addition, the board or one of its committees should periodically re-evaluate significant interest rate risk management policies and procedures as well as overall business strategies that affect the interest rate risk exposure of the bank.

3. The board of directors should encourage discussions between its members and senior management - as well as between senior management and others in the bank - regarding the bank's interest rate risk exposures and management process. Board members need not have detailed technical knowledge of complex financial instruments, legal issues, or of sophisticated risk management techniques. They have the responsibility, however, to ensure that senior management has a full understanding of the risks incurred by the bank and

5 This section refers to a management structure composed of a board of directors and senior management. The Committee is aware that there are significant differences in legislative and regulatory frameworks across countries as regards the functions of the board of directors and senior management. In some countries, the board has the main, if not exclusive, function of supervising the executive body (senior management, general management) so as to ensure that the latter fulfils its tasks. For this reason, in some cases, it is known as a supervisory board. This means that the board has no executive functions. In other countries, by contrast, the board has a broader competence in that it lays down the general framework for the management of the bank. Owing to these differences, the notions of the board of directors and the senior management are used in this paper not to identify legal constructs but rather to label two decision-making functions within a bank.

that the bank has personnel available who have the necessary technical skills to control these risks.

Principle 1:

In order to carry out its responsibilities, the board of directors in a bank should approve interest rate risk management policies and procedures, and should be informed regularly of the interest rate risk exposure of the bank.

2. Senior management

1. Senior management is responsible for ensuring that the bank has adequate policies and procedures for managing interest rate risk on both a long-term and day-to-day basis and that it maintains clear lines of authority and responsibility for managing and controlling this risk. Management is also responsible for maintaining:

- appropriate limits on risk taking;
- adequate systems and standards for measuring risk;
- standards for valuing positions and measuring performance;
- a comprehensive interest rate risk reporting and interest rate risk management review process; and
- effective internal controls.

2. Interest rate risk reports to senior management should provide aggregate information as well as sufficient supporting detail to enable management to assess the sensitivity of the institution to changes in market conditions and other important risk factors. Senior management should also review periodically the organisation's interest rate risk management policies and procedures to ensure that they remain appropriate and sound. Senior management should also encourage and participate in discussions with members of the board and - where appropriate to the size and complexity of the bank - with risk management staff regarding risk measurement, reporting and management procedures.

3. Management should ensure that analysis and risk management activities related to interest rate risk are conducted by competent staff with technical knowledge and experience consistent with the nature and scope of the bank's activities. There should be sufficient depth in staff resources to manage these activities and to accommodate the temporary absence of key personnel.

Principle 2:

Senior management must ensure that the structure of the bank's business and the level of interest rate risk it assumes are effectively managed, that appropriate policies and procedures are established to control and limit these risks, and that resources are available for evaluating and controlling interest rate risk.

3. Independent risk management function

1. Banks should establish a risk management function for monitoring their interest rate risk. This function should provide reasonable assurance that all activities and all aspects of interest rate risk are covered by a bank's risk management system. It should be separated from and sufficiently independent of the business lines to avoid conflicts of interest and ensure adequate separation of duties. The risk management function may be part of a more general operations, audit, compliance, risk management or treasury unit. Moreover, it should report risk exposures directly to both senior-level management and the board of directors. The personnel charged with measuring and monitoring interest rate risk should have a well-founded understanding of all the types of interest rate risk faced throughout the bank. Compensation policies for these individuals should be adequate to attract and retain personnel qualified to assess the risk.
2. Larger or more complex banks should have a unit for designing and administering a bank's interest rate risk management system. The size and scope of such a unit should be in accordance with the size and the structure of the bank. It should also be commensurate with the volume and complexity of interest rate risk incurred by the bank and the complexity of its transactions and commitments.

Principle 3:

Banks should have a risk management function with clearly defined duties that reports risk exposures directly to senior management and the board of directors and is sufficiently independent from the business lines of the bank. Larger or more complex banks should have units responsible for the design and administration of the bank's interest rate risk management system.

IV. Adequate risk management policies and procedures

1. Banks should have clearly-defined policies and procedures for limiting and controlling interest rate risk. These policies should address the bank's exposures not only on a consolidated basis but also, as appropriate, at specific affiliates or other units of the bank. Such policies and procedures should delineate lines of responsibility and accountability over interest rate risk management decisions and should clearly define authorised instruments, hedging strategies and position-taking opportunities. Interest rate risk policies should also identify quantitative parameters that define the level of interest rate risk acceptable for the bank. Where appropriate, such limits should be further specified for certain types of instruments, portfolios, and activities. All interest rate risk policies should be reviewed periodically and revised as needed.
2. Management, whether through policies or operating procedures, should define the structure of managerial responsibilities and oversight, including lines of authority and responsibility for developing strategies and tactics used in managing the bank's interest rate

risk exposure. Individuals and/or committees responsible for interest rate risk management decisions should be clearly identified. In addition, management should define the specific procedures and approvals necessary for exceptions to policies, limits, and authorisations.

3. A policy statement identifying the types of instruments and activities that the bank may employ or conduct is one means whereby management can communicate their tolerance of risk. If such a statement is prepared, it should clearly identify permissible instruments, either specifically or by their characteristics, and should also describe the purposes or objectives for which they may be used. The statement should also delineate a clear set of institutional procedures for acquiring specific instruments, managing portfolios, and controlling the bank's aggregate interest rate risk exposure.

Principle 4:

It is essential that banks' interest rate risk policies and procedures be clearly defined and consistent with the nature and complexity of their activities. These policies should address the bank's exposures on a consolidated basis and, as appropriate, also at the level of individual affiliates.

4. Products and activities that are new to the bank should undergo a careful pre-acquisition review to ensure that the bank understands their interest rate risk characteristics and can incorporate them into its risk management process. When analysing whether or not a product or activity introduces a new element of interest rate risk exposure, the bank should be aware that changes to an instrument's maturity, repricing or repayment terms can materially affect the product's interest rate risk characteristics. To take a simple example, a decision to buy and hold a 30-year treasury bond would represent a significantly different interest rate risk strategy for a bank that had previously limited its investment maturities to less than 3 years. Similarly, a bank specialising in fixed-rate short-term commercial loans that then engages in residential fixed-rate mortgage lending should be aware of the optionality features of the risk embedded in many mortgage products that allow the borrower to prepay the loan at any time with little, if any, penalty.

5. Prior to introducing a new product, hedging, or position-taking strategy, management should ensure that adequate operational procedures and risk control systems are in place. The board or its appropriate delegated committee should also approve major hedging or risk management initiatives in advance of their implementation. Proposals to undertake new instruments or new strategies should contain these features:

- a description of the relevant product or strategy;
- an identification of the resources required to establish sound and effective interest rate risk management of the product or activity;
- an analysis of the reasonableness of the proposed activities in relation to the bank's overall financial condition and capital levels; and

- the procedures to be used to measure, monitor and control the risks of the proposed product or activity.

Principle 5:

It is important that banks identify the interest rate risks inherent in new products and activities and ensure these are subject to adequate procedures and controls before being introduced or undertaken. Major hedging or risk management initiatives should be approved in advance by the board or its appropriate delegated committee.

V. Risk measurement and monitoring system

In general, but depending on the complexity and range of activities of the individual bank, banks should have interest rate risk measurement systems that assess the effects of rate changes on both earnings and economic value. These systems should provide meaningful measures of a bank's current levels of interest rate risk exposure, and should be capable of identifying any excessive exposures that might arise.

1. Interest rate risk measurement

1. Measurement systems should:

- assess all material interest rate risk associated with a bank's assets, liabilities, and OBS positions;
- utilise generally-accepted financial concepts and risk measurement techniques; and
- have well-documented assumptions and parameters.

2. A bank's interest rate risk measurement system should address all material sources of interest rate risk including repricing, yield curve, basis and option risk exposures. In many cases, the interest rate characteristics of a bank's largest holdings will dominate its aggregate risk profile. While all of a bank's holdings should receive appropriate treatment, measurement systems should evaluate such concentrations with particular rigor. Interest rate risk measurement systems should also provide rigorous treatment of those instruments which might significantly affect a bank's aggregate position, even if they do not represent a major concentration. Instruments with significant embedded or explicit option characteristics should receive special attention.

3. A number of techniques are available for measuring the interest rate risk exposure of both earnings and economic value. Their complexity ranges from simple calculations to static simulations using current holdings to highly sophisticated dynamic modelling techniques that reflect potential future business and business decisions.

4. The simplest techniques for measuring a bank's interest rate risk exposure begin with a maturity/repricing schedule that distributes interest-sensitive assets, liabilities and OBS positions into "time-bands" according to their maturity (if fixed rate) or time remaining to

their next repricing (if floating rate). These schedules can be used to generate simple indicators of the interest rate risk sensitivity of both earnings and economic value to changing interest rates. When this approach is used to assess the interest rate risk of current earnings, it is typically referred to as *gap analysis*. The size of the gap for a given time-band - that is, assets minus liabilities plus OBS exposures that reprice or mature within that time-band - gives an indication of the bank's repricing risk exposure.

5. A maturity/repricing schedule can also be used to evaluate the effects of changing interest rates on a bank's economic value by applying sensitivity weights to each time-band. Typically, such weights are based on estimates of the *duration* of the assets and liabilities that fall into each time-band, where duration is a measure of the percent change in the economic value of a position that will occur given a small change in the level of interest rates. Duration-based weights can be used in combination with a maturity/repricing schedule to provide a rough approximation of the change in a bank's economic value that would occur given a particular set of changes in market interest rates.

6. Many banks (especially those using complex financial instruments or otherwise having complex risk profiles) employ more sophisticated interest rate risk measurement systems than those based on simple maturity/repricing schedules. These *simulation techniques* typically involve detailed assessments of the potential effects of changes in interest rates on earnings and economic value by simulating the future path of interest rates and their impact on cash flows. In *static simulations*, the cash flows arising solely from the bank's current on- and off-balance-sheet positions are assessed. In a *dynamic simulation* approach, the simulation builds in more detailed assumptions about the future course of interest rates and expected changes in a bank's business activity over that time. These more sophisticated techniques allow for dynamic interaction of payments streams and interest rates, and better capture the effect of embedded or explicit options.

7. Regardless of the measurement system, the usefulness of each technique depends on the validity of the underlying assumptions and the accuracy of the basic methodologies used to model interest rate risk exposure. In designing interest rate risk measurement systems, banks should ensure that the degree of detail about the nature of their interest-sensitive positions is commensurate with the complexity and risk inherent in those positions. For instance, using gap analysis, the precision of interest rate risk measurement depends in part on the number of time-bands into which positions are aggregated. Clearly, aggregation of positions/cash flows into broad time-bands implies some loss of precision. In practice, the bank must assess the significance of the potential loss of precision in determining the extent of aggregation and simplification to be built into the measurement approach.

8. Estimates of interest rate risk exposure, whether linked to earnings or economic value, utilise, in some form, forecasts of the potential course of future interest rates. For risk management purposes, banks should incorporate a change in interest rates that is sufficiently large to encompass the risks attendant to their holdings. Banks should consider the use of

multiple scenarios, including potential effects in changes in the relationships among interest rates (i.e. yield curve risk and basis risk) as well as changes in the general level of interest rates. For determining probable changes in interest rates, simulation techniques could, for example, be used. Statistical analysis can also play an important role in evaluating correlation assumptions with respect to basis or yield curve risk.

9. The integrity and timeliness of data on current positions is also a key component of the risk measurement process. A bank should ensure that all material positions and cash flows, whether stemming from on- or off-balance-sheet positions, are incorporated into the measurement system on a timely basis. Where applicable, these data should include information on the coupon rates or cash flows of associated instruments and contracts. Any manual adjustments to underlying data should be clearly documented, and the nature and reasons for the adjustments should be clearly understood. In particular, any adjustments to expected cash flows for expected prepayments or early redemptions should be well-reasoned and such adjustments should be available for review.

10. In assessing the results of interest rate risk measurement systems, it is important that the assumptions underlying the system be clearly understood by risk managers and bank management. In particular, techniques using sophisticated simulations should be used carefully so that they do not become "black boxes", producing numbers that have the appearance of precision, but that in fact are not very accurate when their specific assumptions and parameters are revealed. Key assumptions should be recognised by senior management and risk managers and should be re-evaluated at least annually. They should also be clearly documented and their significance understood. Assumptions used in assessing the interest rate sensitivity of complex instruments and instruments with uncertain maturities should be subject to particularly rigorous documentation and review.

11. When measuring interest rate risk exposure, two further aspects call for more specific comment: the treatment of those positions where behavioural maturity differs from contractual maturity and the treatment of positions denominated in different currencies. Positions such as savings and sight deposits may have contractual maturities or may be open-ended, but in either case, depositors generally have the option to make withdrawals at any time. In addition, banks often choose not to move rates paid on these deposits in line with changes in market rates. These factors complicate the measurement of interest rate risk exposure, since not only the value of the positions but also the timing of their cash flows can change when interest rates vary. With respect to banks' assets, prepayment features of mortgages and mortgage-related instruments also introduce uncertainty about the timing of cash flows on these positions. These issues are described in more detail in Annex A, which forms an integral part of this text.

12. Banks with positions denominated in different currencies can expose themselves to interest rate risk in each of these currencies. Since yield curves vary from currency to currency, banks generally need to assess exposures in each. Banks with the necessary skills

and sophistication, and with material multi-currency exposures, may choose to include in their risk measurement process methods to aggregate their exposures in different currencies using assumptions about the correlation between interest rates in different currencies. A bank that uses correlation assumptions to aggregate their risk exposures should periodically review the stability and accuracy of those assumptions. The bank also should evaluate what its potential risk exposure would be in the event that such correlations break down.

Principle 6:

It is essential that banks have interest rate risk measurement systems that capture all material sources of interest rate risk and that assess the effect of interest rate changes in ways which are consistent with the scope of their activities. The assumptions underlying the system should be clearly understood by risk managers and bank management.

2. Limits

1. The goal of interest rate risk management is to maintain a bank's interest rate risk exposure within self-imposed parameters over a range of possible changes in interest rates. A system of interest rate risk limits and risk-taking guidelines provides the means for achieving that goal. Such a system should set boundaries for the level of interest rate risk for the bank and, where appropriate, should also provide the capability to allocate limits to individual portfolios, activities or business units. Limit systems should also ensure that positions that exceed certain predetermined levels receive prompt management attention. An appropriate limit system should enable management to control interest rate risk exposures, initiate discussion about opportunities and risks, and monitor actual risk-taking against predetermined risk tolerances.

2. A bank's limits should be consistent with its overall approach to measuring interest rate risk. Aggregate interest rate risk limits clearly articulating the amount of interest rate risk acceptable to the bank should be approved by the board of directors and re-evaluated periodically. Such limits should be appropriate to the size, complexity and capital adequacy of the bank. Depending on the nature of a bank's holdings and its general sophistication, limits can also be identified with individual business units, portfolios, instrument types or specific instruments. The level of detail of risk limits should reflect the characteristics of the bank's holdings including the various sources of interest rate risk to which the bank is exposed.

3. Limit exceptions should be made known to appropriate senior management without delay. There should be a clear policy as to how senior management will be informed and what action should be taken by management in such cases. Particularly important is whether limits are absolute in the sense that they should never be exceeded or whether, under specific circumstances, which should be clearly described, breaches of limits can be tolerated

for a short period of time. In that context, the relative conservatism of the chosen limits may be an important factor.

4. Regardless of their level of aggregation, limits should be consistent with the bank's overall approach to measuring interest rate risk and should address the potential impact of changes in market interest rates on reported earnings and the bank's economic value of equity. From an earnings perspective, banks should explore limits on the variability of net income as well as net interest income in order to fully assess the contribution of non-interest income to the interest rate risk exposure of the bank. Such limits usually specify acceptable levels of earnings volatility under specified interest rate scenarios.

5. The form of limits for addressing the effect of rates on a bank's economic value of equity should be appropriate for the size and complexity of its underlying positions. For banks engaged in traditional banking activities and with few holdings of long-term instruments, options, instruments with embedded options, or other instruments whose value may be substantially altered given changes in market rates, relatively simple limits on the extent of such holdings may suffice. For more complex banks, however, more detailed limit systems on acceptable changes in the estimated economic value of equity of the bank may be needed.

6. Interest rate risk limits may be keyed to specific scenarios of movements in market interest rates, such as an increase or decrease of a particular magnitude. The rate movements used in developing these limits should represent meaningful stress situations, taking into account historic rate volatility and the time required for management to address exposures. Limits may also be based on measures derived from the underlying statistical distribution of interest rates, such as earnings at risk or economic value-at-risk techniques. Moreover, specified scenarios should take account of the full range of possible sources of interest rate risk to the bank including mismatch, yield curve, basis and option risks. Simple scenarios using parallel shifts in interest rates may be insufficient to identify such risks.

Principle 7:

Banks must establish and enforce operating limits and other practices that maintain exposures within levels consistent with their internal policies.

3. Stress testing

The risk measurement system should also support a meaningful evaluation of the effect of stressful market conditions on the bank. Stress testing should be designed to provide information on the kinds of conditions under which the bank's strategies or positions would be most vulnerable, and thus may be tailored to the risk characteristics of the bank. Possible stress scenarios might include abrupt changes in the general level of interest rates, changes in the relationships among key market rates (i.e. basis risk), changes in the slope and the shape of the yield curve (i.e. yield curve risk), changes in the liquidity of key financial markets or

changes in the volatility of market rates. In addition, stress scenarios should include conditions under which key business assumptions and parameters break down. The stress testing of assumptions used for illiquid instruments and instruments with uncertain contractual maturities is particularly critical to achieving an understanding of the bank's risk profile. In conducting stress tests, special consideration should be given to instruments or markets where concentrations exist as such positions may be more difficult to liquidate in stressful situations. Banks should consider "worst-case" scenarios in addition to more probable, but less extreme, events. Management and the board of directors should periodically review both the design and the results of such stress tests, and ensure that appropriate contingency plans are in place.

Principle 8:

Banks should measure their vulnerability to loss under stressful market conditions - including the breakdown of key assumptions - and consider those results when establishing and reviewing their policies and limits for interest rate risk.

4. Interest rate risk monitoring and reporting

1. An accurate, informative, and timely management information system is essential for managing interest rate risk exposure, both to inform management and to support compliance with board policy. Reporting of risk measures should be regular and should clearly compare current exposure to policy limits. In addition, past forecasts or risk estimates should be compared with actual results to identify any modelling shortcomings.

2. Reports detailing the interest rate risk exposure of the bank should be reviewed by the board on a regular basis. While the types of reports prepared for the board and for various levels of management will vary based on the bank's interest rate risk profile, they should, at a minimum include the following:

- summaries of the bank's aggregate exposures;
- reports demonstrating the bank's compliance with policies and limits;
- results of stress tests including those assessing breakdowns in key assumptions and parameters; and
- summaries of the findings of reviews of interest rate risk policies, procedures, and the adequacy of the interest rate risk measurement systems, including any findings of internal and external auditors and retained consultants.

Principle 9:

Banks must have adequate information systems for monitoring and reporting interest rate exposures to senior management and boards of directors on a timely basis.

VI. Comprehensive controls

1. A bank's interest rate risk management process should be an extension of its overall structure of internal controls. Properly structured, a system of internal controls should promote effective and efficient operations, reliable financial and regulatory reporting, and compliance with relevant laws, regulations, and institutional policies. In determining whether internal controls meet those objectives, banks should consider the general control environment of the organisation; the process for identifying, analysing and managing interest rate risk; the adequacy of management information systems; and adherence to control activities such as approvals, confirmations and reconciliations.

2. An important element of a bank's internal controls involving interest rate risk is comprehensive evaluation and review by management. Management should ensure that the various components of the bank's interest rate risk management process are regularly reviewed and evaluated by individuals who are independent of the function they are assigned to review. Although procedures for establishing limits and for operating within them may vary among banks, periodic reviews should be conducted to determine whether the organisation complies with its interest rate risk policies and procedures. Positions that exceed established limits should receive the prompt attention of appropriate management and should be resolved according to the process described in approved policies. Periodic reviews of the interest rate risk management process should also address any significant changes in the nature of instruments acquired, limits, and internal controls that have occurred since the last review.

Principle 10:

Banks must have adequate internal controls for their interest rate risk management process and should evaluate the adequacy and integrity of those controls periodically. Individuals responsible for evaluating control procedures must be independent of the function they are assigned to review.

3. Reviews of the interest rate risk measurement system should include assessments of the assumptions, parameters, and methodologies used. Such reviews should seek to understand, test, and document the current measurement process, evaluate the system's accuracy, and recommend solutions to any identified weaknesses. The results of this review, along with any recommendations for improvement, should be reported to the board and acted upon in a timely manner. Since measurement systems may incorporate one or more subsidiary systems or processes, banks should ensure that multiple component systems are well-integrated and consistent with each other in all critical respects.

4. The frequency and extent to which a bank should re-evaluate its risk measurement methodologies and models depends, in part, on the particular interest rate risk exposures created by holdings and activities, the pace and nature of market interest rate changes, and the

pace of innovation with respect to measuring and managing interest rate risk. At a minimum banks should review their underlying interest rate risk measurement methodologies and interest rate risk management process annually - and more frequently as market conditions dictate.

5. Banks, particularly those with complex risk exposures, are encouraged to have their measurement systems reviewed by external auditors or other knowledgeable outside parties. In such cases, reports written by external auditors or other outside parties should be available to relevant supervisory authorities. It is essential that any external reviewer be assured that the bank's risk measurement system is sufficient to capture all material elements of interest rate risk. Such a reviewer should consider the following factors in making the risk assessment, (which are, of course, also relevant to internal reviews):

- the quantity of interest rate risk, for example:
 - the volume and price sensitivity of various products;
 - the vulnerability of earnings and capital under differing rate changes including yield curve twists;
 - the exposure of earnings and economic value to various other forms of interest rate risk, including basis and optionality risk.
- the quality of interest rate risk management, for example:
 - whether the bank's internal measurement system is appropriate to the nature, scope, and complexities of the bank and its activities;
 - whether the bank has an independent risk control unit responsible for the design of the risk management system;
 - whether the board of directors and senior management is actively involved in the risk control process;
 - whether internal policies, controls and procedures concerning interest rate risk are well-documented and complied with;
 - whether the assumptions of the risk management system are well-documented, data are accurately processed, and data aggregation is proper and reliable;
 - whether the organisation has adequate staffing to conduct a sound risk management process.

Principle 11:

Banks should periodically conduct an independent review of the adequacy and integrity of their risk management processes. Such reviews should be available to relevant supervisory authorities.

VII. Monitoring of interest rate risk by supervisory authorities

1. Supervisory authorities should, on a regular basis, obtain sufficient information to assess individual banks' interest rate risk exposures. Such information could be obtained

through standardised reports that are submitted by banks, through on-site examinations, or by other means. The precise information obtained could differ among supervisors, but should enable the supervisor to assess the level and direction of a bank's interest rate exposure. Such information may be generated from the bank's internal measures or from more standardised reports. As a minimum, supervisors should have enough information to identify and monitor banks that have significant repricing mismatches.

2. A supervisory reporting framework that collects information on a bank's positions by remaining maturity or time to next repricing is one method that supervisors may use for this purpose. Under such an approach, a bank would categorise its interest-sensitive assets, liabilities and OBS positions into a series of repricing time-bands or maturity categories. In addition, the information should identify the balances by specific types of instruments that differ significantly in their cash flow characteristics. For example, supervisors may want to collect additional information on those positions, where the behavioural maturity is different from the contractual maturity. Reviewing the results of a bank's internal model, perhaps under a variety of different assumptions, can also be highly informative.

3. Banks operating in different currencies can expose themselves to interest rate risk in each of these currencies. Supervisory authorities, therefore, may want banks to analyse their exposures in different currencies separately, at least when exposures in different currencies are material.

4. Another difficult question is the extent to which interest rate risk should be viewed on a whole bank basis or whether the trading book, which is marked to market, and the banking book, which is often not, should be treated separately. As a general rule, it is desirable for any measurement system to incorporate interest rate risk exposures arising from the full scope of a bank's activities, including both trading and non-trading sources. Supervisors may want to obtain more specific information on how trading and non-trading activities are measured in a bank and whether they are incorporated into a single measurement system. They should also ensure that interest rate risk in both trading and non-trading activities is properly managed and controlled.

5. A meaningful analysis of interest rate risk is only possible if the supervisor receives the relevant information regularly and on a timely basis. Since the risk profile in the traditional banking business changes less rapidly than in the trading business, quarterly or semi-annual reporting of the former may be sufficient for many banks. Some of the factors that supervisors may wish to consider when designing a specific reporting framework are described in greater detail in Annex B, which forms an integral part of this text.

Principle 12:

The G-10 supervisory authorities will obtain from banks sufficient and timely information with which to evaluate their level of interest rate risk. This information should take appropriate account of the range of maturities and currencies in each

bank's portfolio, as well as other relevant factors, such as the distinction between trading and non-trading activities. Other supervisory authorities are recommended to obtain similar information.

Interest rate risk measurement techniques

1. This annex provides a brief overview of the various techniques used by banks to measure the exposure of earnings and of economic value to changes in interest rates. The variety of the techniques ranges from calculations that rely on simple maturity and repricing tables, to static simulations based on current on- and off-balance-sheet positions, to highly sophisticated dynamic modelling techniques that incorporate assumptions about the behaviour of the bank and its customers in response to changes in the interest rate environment. Some of these general approaches can be used to measure interest rate risk exposure from both an earnings and an economic value perspective, while others are more typically associated with only one of these two perspectives. In addition, the methods vary in their ability to capture the different forms of interest rate exposure: the simplest methods are intended primarily to capture the risks arising from maturity and repricing mismatches, while the more sophisticated methods can more easily capture the full range of risk exposures.

2. As this discussion suggests, the various measurement approaches described below have their strengths and weaknesses in terms of providing accurate and reasonable measures of interest rate risk exposure. Ideally, a bank's interest rate risk measurement system would take into account the specific characteristics of each individual interest-sensitive position, and would capture in detail the full range of potential movements in interest rates. In practice, however, measurement systems embody simplifications that move away from this ideal. For instance, in some approaches, positions may be aggregated into broad categories, rather than modelled separately, introducing a degree of measurement error into the estimation of their interest rate sensitivity. Similarly, the nature of interest rate movements that each approach can incorporate may be limited: in some cases, only a parallel shift of the yield curve may be assumed or less than perfect correlations between interest rates may not be taken into account. Finally, the various approaches differ in their ability to capture the optionality inherent in many positions and instruments. The discussion in the following sections will highlight the areas of simplification that typically characterise each of the major interest rate risk measurement techniques.

1. Repricing schedules

1. The simplest techniques for measuring a bank's interest rate risk exposure begin with a maturity/repricing schedule that distributes interest-sensitive assets, liabilities and off-balance-sheet positions into a certain number of predefined time-bands according to their maturity (if fixed rate) or time remaining to their next repricing (if floating rate). Those assets and liabilities lacking definitive repricing intervals (e.g. sight deposits or savings accounts) or actual maturities that could vary from contractual maturities (e.g. mortgages with an option

for early repayment) are assigned to repricing time-bands according to the judgement and past experience of the bank.

2. **Gap analysis:** Simple maturity/repricing schedules can be used to generate simple indicators of the interest rate risk sensitivity of both earnings and economic value to changing interest rates. When this approach is used to assess the interest rate risk of current earnings, it is typically referred to as gap analysis. Gap analysis was one of the first methods developed to measure a bank's interest rate risk exposure, and continues to be widely used by banks. To evaluate earnings exposure, interest rate sensitive liabilities in each time-band are subtracted from the corresponding interest rate sensitive assets to produce a repricing "gap" for that time-band. This gap can be multiplied by an assumed change in interest rates to yield an approximation of the change in net interest income that would result from such an interest rate movement. The size of the interest rate movement used in the analysis can be based on a variety of factors, including historical experience, simulation of potential future interest rate movements, and the judgement of bank management.

3. A negative, or liability-sensitive, gap occurs when liabilities exceed assets (including off-balance-sheet positions) in a given time-band. This means that an increase in market interest rates could cause a decline in net interest income. Conversely, a positive, or asset-sensitive, gap implies that the bank's net interest income could decline as a result of a decrease in the level of interest rates.

4. These simple gap calculations can be augmented by information on the average coupon on assets and liabilities in each time-band. This information can be used to place the results of the gap calculations in context. For instance, information on the average coupon rate could be used to calculate estimates of the level of net interest income arising from positions maturing or repricing within a given time-band, which would then provide a "scale" to assess the changes in income implied by the gap analysis.

5. Although gap analysis is a very commonly used approach to assessing interest rate risk exposure, it has a number of shortcomings. First, gap analysis does not take account of variation in the characteristics of different positions within a time-band. In particular, all positions within a given time-band are assumed to mature or reprice simultaneously, a simplification that is likely to have greater impact on the precision of the estimates as the degree of aggregation within a time-band increases. Moreover, gap analysis ignores differences in spreads between interest rates that could arise as the level of market interest rates changes (basis risk). In addition, it does not take into account any changes in the timing of payments that might occur as a result of changes in the interest rate environment. Thus, it fails to account for differences in the sensitivity of income that may arise from option-related positions. For these reasons, gap analysis provides only a rough approximation to the actual change in net interest income which would result from the chosen change in the pattern of interest rates. Finally, most gap analyses fail to capture variability in non-interest revenue and expenses, a potentially important source of risk to current income.

6. **Duration:** A maturity/repricing schedule can also be used to evaluate the effects of changing interest rates on a bank's economic value by applying sensitivity weights to each time-band. Typically, such weights are based on estimates of the duration of the assets and liabilities that fall into each time-band. Duration is a measure of the percent change in the economic value of a position that will occur given a small change in the level of interest rates.⁶ It reflects the timing and size of cash flows that occur before the instrument's contractual maturity. Generally, the longer the maturity or next repricing date of the instrument and the smaller the payments that occur before maturity (e.g. coupon payments), the higher the duration (in absolute value). Higher duration implies that a given change in the level of interest rates will have a larger impact on economic value.

7. Duration-based weights can be used in combination with a maturity/repricing schedule to provide a rough approximation of the change in a bank's economic value that would occur given a particular change in the level of market interest rates. Specifically, an "average" duration is assumed for the positions that fall into each time-band. The average durations are then multiplied by an assumed change in interest rates to construct a weight for each time-band. In some cases, different weights are used for different positions that fall within a time-band, reflecting broad differences in the coupon rates and maturities (for instance, one weight for assets, and another for liabilities). In addition, different interest rate changes are sometimes used for different time-bands, generally to reflect differences in the volatility of interest rates along the yield curve. The weighted gaps are aggregated across time-bands to produce an estimate of the change in economic value of the bank that would result from the assumed changes in interest rates.

8. Alternatively, an institution could estimate the effect of changing market rates by calculating the precise duration of each asset, liability and off-balance-sheet position and then deriving the net position for the bank based on these more accurate measures, rather than by applying an estimated average duration weight to all positions in a given time-band. This would eliminate potential errors occurring when aggregating positions/cash flows. As another variation, risk weights could also be designed for each time-band on the basis of actual percent changes in market values of hypothetical instruments that would result from a specific scenario of changing market rates. That approach - which is sometimes referred to as

6 In its simplest form, duration measures changes in economic value resulting from a percentage change of interest rates under the simplifying assumptions that changes in value are proportional to changes in the level of interest rates and that the timing of payments is fixed. Two important modifications of simple duration are commonly used that relax one or both of these assumptions. The first case is so-called modified duration. Modified duration - which is standard duration divided by $1 + r$, where r is the level of market interest rates - is an elasticity. As such, it reflects the percentage change in the economic value of the instrument for a given percentage change in $1 + r$. As with simple duration, it assumes a linear relationship between percentage changes in value and percentage changes in interest rates. The second form of duration relaxes this assumption, as well as the assumption that the timing of payments is fixed. Effective duration is the percentage change in the price of the relevant instrument for a basis point change in yield.

effective duration - would better capture the non-linearity of price movements arising from significant changes in market interest rates and, thereby, would avoid an important limitation of duration.

9. Estimates derived from a standard duration approach may provide an acceptable approximation of a bank's exposure to changes in economic value for relatively non-complex banks. Such estimates, however, generally focus on just one form of interest rate risk exposure - repricing risk. As a result, they may not reflect interest rate risk arising - for instance - from changes in the relationship among interest rates within a time-band (basis risk). In addition, because such approaches typically use an average duration for each time-band, the estimates will not reflect differences in the actual sensitivity of positions that can arise from differences in coupon rates and the timing of payments. Finally, the simplifying assumptions that underlie the calculation of standard duration means that the risk of options may not be well-captured.

2. Simulation approaches

1. Many banks (especially those using complex financial instruments or otherwise having complex risk profiles) employ more sophisticated interest rate risk measurement systems than those based on simple maturity/repricing schedules. These simulation techniques typically involve detailed assessments of the potential effects of changes in interest rates on earnings and economic value by simulating the future path of interest rates and their impact on cash flows.

2. In some sense, simulation techniques can be seen as an extension and refinement of the simple analysis based on maturity/repricing schedules. However, simulation approaches typically involve a more detailed breakdown of various categories of on- and off-balance-sheet positions, so that specific assumptions about the interest and principal payments and non-interest income and expense arising from each type of position can be incorporated. In addition, simulation techniques can incorporate more varied and refined changes in the interest rate environment, ranging from changes in the slope and shape of the yield curve to interest rate scenarios derived from Monte Carlo simulations.

3. In *static simulations*, the cash flows arising solely from the bank's current on- and off-balance-sheet positions are assessed. For assessing the exposure of earnings, simulations estimating the cash flows and resulting earnings streams over a specific period are conducted based on one or more assumed interest rate scenarios. Typically, although not always, these simulations entail relatively straightforward shifts or tilts of the yield curve, or changes of spreads between different interest rates. When the resulting cash flows are simulated over the

entire expected lives of the bank's holdings and discounted back to their present values, an estimate of the change in the bank's economic value can be calculated.⁷

4. In a *dynamic simulation* approach, the simulation builds in more detailed assumptions about the future course of interest rates and the expected changes in a bank's business activity over that time. For instance, the simulation could involve assumptions about a bank's strategy for changing administered interest rates (on savings deposits, for example), about the behaviour of the bank's customers (e.g. withdrawals from sight and savings deposits) and/or about the future stream of business (new loans or other transactions) that the bank will encounter. Such simulations use these assumptions about future activities and reinvestment strategies to project expected cash flows and estimate dynamic earnings and economic value outcomes. These more sophisticated techniques allow for dynamic interaction of payments stream and interest rates, and better capture the effect of embedded or explicit options.

5. As with other approaches, the usefulness of simulation-based interest rate risk measurement techniques depends on the validity of the underlying assumptions and the accuracy of the basic methodology. The output of sophisticated simulations must be assessed largely in the light of the validity of the simulation's assumptions about future interest rates and the behaviour of the bank and its customers. One of the primary concerns that arises is that such simulations do not become "black boxes" that lead to false confidence in the precision of the estimates.

3. Additional issues

1. One of the most difficult tasks when measuring interest rate risk is how to deal with those positions where behavioural maturity differs from contractual maturity (or where there is no stated contractual maturity). On the asset side of the balance sheet, such positions may include mortgages and mortgage-related securities, which can be subject to prepayment. In some countries, borrowers have the discretion to prepay their mortgages with little or no penalty, a situation that creates uncertainty about the timing of the cash flows associated with these instruments. Although there is always some volatility in prepayments resulting from demographic factors (such as death, divorce, or job transfers) and macroeconomic conditions, most of the uncertainty surrounding prepayments arises from the response of borrowers to movements in interest rates. In general, declines in interest rates result in increasing levels of prepayments, as borrowers refinance their loans at lower yields. In contrast, when interest rates rise unexpectedly, prepayment rates tend to slow, leaving the bank with a larger than anticipated volume of mortgages paying below current market rates.

7 The duration analysis described in the previous section can be viewed as a very simple form of static simulation.

2. On the liability side, such positions include so-called non-maturity deposits such as sight deposits and savings deposits, which can be withdrawn, often without penalty, at the discretion of the depositor. The treatment of such deposits is further complicated by the fact that the rates received by depositors tend not to move in close correlation with changes in the general level of market interest rates. In fact, banks can and do administer the rates on the accounts with the specific intention of managing the volume of deposits retained.

3. The treatment of positions with embedded options is an issue of special concern in measuring the exposure of both current earnings and economic value to interest rate changes. In addition, the issue arises across the full spectrum of approaches to interest rate measurement, from simple gap analysis to the most sophisticated simulation techniques. In the maturity/repricing schedule framework, banks typically make assumptions about the likely timing of payments and withdrawals on these positions and "spread" the balances across time-bands accordingly. For instance, it might be assumed that certain percentages of a pool of 30-year mortgages prepay in given years during the life of the mortgages. As a result, a large share of the mortgage balances that would have been assigned to the time-band containing 30-year instruments would be spread among nearer term time-bands. In the simulation framework, more sophisticated behavioural assumptions could be employed, such as the use of option-adjusted pricing models to better estimate the timing and magnitude of cash flows under different interest rate environments. In addition, the simulations can incorporate the bank's assumptions about its likely future treatment of administered interest rates on non-maturity deposits.

4. As with other elements of interest rate risk measurement, the quality of the estimates of interest rate risk exposure depends on the quality of the assumptions about the future cash flows on the positions with uncertain maturities. Banks typically look to the past behaviour of such positions for guidance about these assumptions. For instance, econometric or statistical analysis can be used to analyse the behaviour of a bank's holdings in response to past interest rate movements. Such analysis is particularly useful to assess the likely behaviour of non-maturity deposits, which can be influenced by bank-specific factors such as the nature of the bank's customers and local or regional market conditions. In the same vein, banks may use statistical prepayment models - either models developed internally by the bank or models purchased from outside developers - to generate expectations about mortgage-related cash flows. Finally, input from managerial and business units within the bank could have an important influence, since these areas may be aware of planned changes to business or repricing strategies that could affect the behaviour of the future cash flows of positions with uncertain maturities.

Monitoring of interest rate risk by supervisory authorities

1. This annex provides a brief overview of some of the factors that supervisory authorities might consider in obtaining and analysing information on individual banks' exposures to interest rate risk. As discussed in Section VII of the text, supervisory authorities should obtain information sufficient to assess banks' exposures to interest rate risk in a timely fashion. Such information may be obtained through on-site examinations, through reports that are submitted by banks on a regular basis, or through other means.

2. While the precise information that is obtained will differ across supervisory authorities, one approach that some may adopt is a reporting framework that collects information on a bank's positions by remaining maturity or time to next repricing. Under such an approach, a bank would categorise its interest-sensitive assets, liabilities and off-balance-sheet positions into a series of repricing time-bands or maturity categories. The two sections that follow discuss the considerations that a supervisor should take into account in specifying the number of time-bands and the grouping of positions in the reporting framework. The final section of this annex describes some general approaches that supervisory authorities may wish to consider in analysing the information that is obtained through such a reporting framework.

1. Time-bands

1. If a reporting framework is used in which information is collected by time to next repricing, the number and specific categories of time-bands chosen should be sufficient to provide supervisors with a reasonable basis for identifying potentially significant repricing mismatches. The bands, however, could vary materially across countries, both in number and in range, depending on the lending and investing practices and experiences of banks in individual markets.

2. The accuracy of a measurement system crucially depends on the precision with which maturities of the positions and cash flows are recorded in the system. For cash flows whose maturity is unambiguous, the most precise approach is to use the exact maturity date. Any aggregation of positions/cash flows in time-bands or zones necessarily implies a loss of information and a lower degree of precision. For this reason, the number of time-bands in a maturity ladder framework always reflects a decision regarding the necessary level of precision and the cost of pursuing greater accuracy. Supervisory authorities could use the maturity ladder in the standardised approach of the Amendment to the Capital Accord as a starting point when developing a reporting framework that meets their particular needs. The breakdown can, of course, be modified by regulators either in a general way or in a specific way for banks where the nature of business activities warrants or justifies a different reporting form.

2. Items

1. As with the time-bands, the breakdown of assets and liabilities could differ among supervisors. A reporting system should include information for all rate-sensitive assets, liabilities and OBS positions, and should also identify balances, by specific types of instruments, when those instruments have or may have materially different cash flow characteristics. Specific attention should be given to items whose behavioural maturities differ from contractual maturities such as savings deposits and in some countries mortgage-related instruments. Further information on these issues is provided in Annex A. If the volume of these positions is significant, they should be reported separately so as to facilitate an assessment of the underlying options risk in the bank balance sheet structure.

2. The measurement of interest rate risks may be more difficult if a bank is engaged in trading activities. As a general rule, it is desirable for any measurement system to incorporate interest rate risk exposures arising from the full scope of a bank's activities, including both trading and non-trading sources. Supervisors may wish to permit banks that manage their interest rate risk exposures on an integrated basis to aggregate trading and non-trading positions in the overall reporting framework. Nevertheless, it is important to recognise that in many countries different accounting rules may apply to the trading book and the traditional banking book. Under these accounting rules, losses in the trading book may not always be offset by profits in the banking book if the latter are unrealised. Furthermore, unlike the banking book, the composition of the trading portfolio changes significantly from week to week or even day to day because it is managed separately and according to a different (shorter) risk horizon than the banking book. This means that a hedge that is present on a given day may disappear a few days later. Supervisors should, therefore, review the risk management practices and information systems of banks that conduct material trading activities and should obtain the information necessary to ensure that interest rate risk in both trading and non-trading activities is properly managed and controlled. Supervisors may also wish to ask for a separate reporting of interest rate risk positions in the trading book.

3. Supervisory analysis

1. With a reporting framework designed along these lines regulators should have at their disposal a flexible tool for the analysis of interest rate risk. Since the framework only specifies basic information to be collected, it allows a more flexible use by regulators than a reporting system with pre-specified scenarios and assumptions.

2. By obtaining basic information, supervisors can perform an independent analysis of a bank's exposure and can develop their own views regarding the institution's interest rate risk profile. Risk analysis could use different interest rate scenarios such as parallel shifts, a flattening or steepening of the yield curve or its inversion with rate changes of different

magnitude either based on statistical probabilities or a worst-case analysis. For banks with important exposures in foreign currencies, calculations based on different assumptions on correlations between interest rates in different currencies can be useful. With respect to instruments with behavioural maturities regulators can make calculations based on their own assumptions and compare the results with banks' own judgements.

3. The focus of regulators' quantitative analysis can either be the impact of interest rate changes on current earnings or on the economic value of the banks' portfolio. In conducting their analysis information about average yields on assets and liabilities in each time-band may be useful and regulators may wish to collect such information in addition to pure position data.

4. Depending on their overall approach, regulators may carry out this type of analysis either on a case-by-case basis or as part of a broader system designed to identify outliers with apparently excessive risk-taking.

5. By varying the parameters as described, regulators gain more insight into an institution's risk profile than with a reporting system that reduces the complexity of interest rate risk to a single number. In doing so, regulators can become more familiar with the sensitivity of risk measures to changes in the underlying assumptions, and the evaluation process may produce as many insights as the quantitative result itself.

6. Regardless of the extent of a regulator's own independent quantitative analysis, a bank's own interest rate risk measure, whether reported as part of a basic supervisory reporting system or reviewed as part of an individual assessment of a bank's risk management, is an important consideration in the supervisory process. Reviewing the results of a bank's internal model can be highly informative, but can also be a difficult process because of the multitude of assumptions and modelling techniques that are important, but which need to be made transparent to supervisors. To be most useful, the information received should indicate the contribution of principal elements of a bank's portfolio to the risk profile under different assumptions with respect to interest rate changes and the market response. Finally, any quantitative analysis should be supplemented by a review of internal management reports in order to gain greater insights into management's evaluation and management of risks, its methods for measuring exposures, and factors not reflected in the information available in the limited reporting to supervisors.