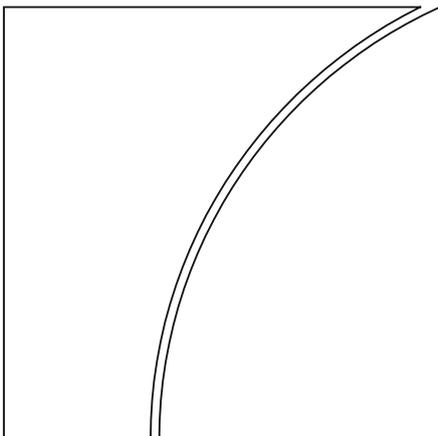# Basel Committee on Banking Supervision

Standards

Interest rate risk in the banking book

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BANK FOR INTERNATIONAL SETTLEMENTS

This publication is available on the BIS website (www.bis.org).

Contents

Executive summary

1.   Interest rate risk in the banking book (IRRBB) is part of the Basel capital framework's Pillar 2 (Supervisory Review Process) and subject to the Committee's guidance set out in the 2004 *Principles for the management and supervision of interest rate risk* (henceforth, the IRR Principles).[1] The IRR Principles lay out the Committee's expectations for banks' identification, measurement, monitoring and control of IRRBB as well as its supervision.

2.   The Committee has decided that the IRR Principles need to be updated to reflect changes in market and supervisory practices since they were first published, and this document contains an updated version that revises both the Principles and the methods expected to be used by banks for measuring, managing, monitoring and controlling such risks.

3.   These updated Principles were the subject of consultation in 2015, when the Committee presented two options for the regulatory treatments of IRRBB: a standardised Pillar 1 (Minimum Capital Requirements) approach and an enhanced Pillar 2 approach (which also included elements of Pillar 3 – Market Discipline).[2] The Committee noted the industry's feedback on the feasibility of a Pillar 1 approach to IRRBB, in particular the complexities involved in formulating a standardised measure of IRRBB which would be both sufficiently accurate and risk-sensitive to allow it to act as a means of setting regulatory capital requirements. The Committee concludes that the heterogeneous nature of IRRBB would be more appropriately captured in Pillar 2.

4.   Nonetheless, the Committee considers IRRBB to be material, particularly at a time when interest rates may normalise from historically low levels. The key updates to the Principles under an enhanced Pillar 2 approach are as follows:

- Greater guidance has been provided on the expectations for a bank's IRRBB management process, in particular the development of shock and stress scenarios (Principle 4) to be applied to the measurement of IRRBB, the key behavioural and modelling assumptions which banks should consider in their measurement of IRRBB (Principle 5) and the internal validation process which banks should apply for their internal measurement systems (IMS) and models used for IRRBB (Principle 6).

- The disclosure requirements under Principle 8 have been updated to promote greater consistency, transparency and comparability in the measurement and management of IRRBB. Banks must disclose, among other requirements, the impact of interest rate shocks on their change in economic value of equity (ΔEVE) and net interest income (ΔNII), computed based on a set of prescribed interest rate shock scenarios.

- The supervisory review process under Principle 11 has been updated to elaborate on the factors which supervisors should consider when assessing the banks' level and management of IRRBB exposures. Supervisors could also mandate the banks under their respective jurisdictions to follow the standardised framework for IRRBB (eg if they find that the bank's IMS does not adequately capture IRRBB). The standardised framework has been updated to enhance risk capture.

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[1]   www.bis.org/publ/bcbs108.htm.

[2]   www.bis.org/bcbs/publ/d319.pdf.

- Supervisors must publish their criteria for identifying outlier banks under Principle 12. The threshold for the identification of an "outlier bank" has also been tightened, where the outlier/materiality test(s) applied by supervisors should at least include one which compares the bank's ΔEVE with 15% of its Tier 1 capital, under a set of prescribed interest rate shock scenarios. Supervisors may implement additional outlier/materiality tests with their own specific measures. There is a strong presumption for supervisory and/or regulatory capital consequences, when a review of a bank's IRRBB exposure reveals inadequate management or excessive risk relative to a bank's capital, earnings or general risk profile.

5.   Consistent with the scope of application of the Basel II framework, the proposed framework would be applied to large internationally active banks on a consolidated basis. Supervisors have national discretion to apply the IRRBB framework to other non-internationally active institutions.[3]

6.   The document is structured as follows. Section I provides an introduction to IRRBB. Section II presents the revised Principles, which replace the 2004 IRR Principles for defining supervisory expectations on the management of IRRBB. Principles 1 to 7 are of general application for the management of IRRBB, covering expectations for a bank's IRRBB management process, in particular the need for effective IRRBB identification, measurement, monitoring and control activities. Principles 8 and 9 set out the expectations for market disclosures and banks' internal assessment of capital adequacy for IRRBB respectively. Principles 10 to 12 address the supervisory approach to banks' IRRBB management framework and capital adequacy. Section III states the scope of application and Section IV sets out the standardised framework which supervisors could mandate their banks to follow, or a bank could choose to adopt. The Annexes provide a set of terminology and definitions that will provide a better understanding of IRRBB to both banks and supervisors (Annex 1) and further details on the standardised interest rate shocks (Annex 2).

7.   The banks are expected to implement the standards by 2018.[4]

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[3]   See BCBS, *International Convergence of Capital Measurement and Capital Standards: A Revised Framework – Comprehensive Version*, June 2006.

[4]   For avoidance of doubt, this means that, for banks whose financial year ends on 31 December, the relevant disclosures would have to be made in 2018, based on the information as at 31 December 2017.

I.   Introduction on IRRBB

8.   IRRBB refers to the current or prospective risk to the bank's capital and earnings arising from adverse movements in interest rates that affect the bank's banking book positions. When interest rates change, the present value and timing of future cash flows change. This in turn changes the underlying value of a bank's assets, liabilities and off-balance sheet items and hence its economic value. Changes in interest rates also affect a bank's earnings by altering interest rate-sensitive income and expenses, affecting its net interest income (NII). Excessive IRRBB can pose a significant threat to a bank's current capital base and/or future earnings if not managed appropriately.

1.   Definition of IRRBB

9.   Three main sub-types of IRRBB are defined for the purposes of these Principles:

(a)   *Gap risk* arises from the term structure of banking book instruments, and describes the risk arising from the timing of instruments' rate changes. The extent of gap risk depends on whether changes to the term structure of interest rates occur consistently across the yield curve (parallel risk) or differentially by period (non-parallel risk).

(b)   *Basis risk* describes the impact of relative changes in interest rates for financial instruments that have similar tenors but are priced using different interest rate indices.

(c)   *Option risk* arises from option derivative positions or from optional elements embedded in a bank's assets, liabilities and/or off-balance sheet items, where the bank or its customer can alter the level and timing of their cash flows. Option risk can be further characterised into automatic option risk and behavioural option risk.

All three sub-types of IRRBB potentially change the price/value or earnings/costs of interest rate-sensitive assets, liabilities and/or off-balance sheet items in a way, or at a time, that can adversely affect a bank's financial condition. Annex 1 provides a more detailed description of IRRBB and its management techniques.

2.   Credit spread risk in the banking book (CSRBB)

10.   While the three sub-types listed above are directly linked to IRRBB, CSRBB is a related risk that banks need to monitor and assess in their interest rate risk management framework. CSRBB refers to any kind of asset/liability spread risk of credit-risky instruments that is not explained by IRRBB and by the expected credit/jump to default risk.

3.   Economic value and earnings-based measures

11.   While the economic value and earnings-based measures share certain commonalities, the Committee observes that most commercial banks primarily utilise the latter for IRRBB management, whereas regulators tend to endorse the former as a benchmark for comparability and capital adequacy. The Committee acknowledges the importance of managing IRRBB through both economic value and earnings-based measures. If a bank solely minimises its economic value risk by matching the repricing of its assets with liabilities beyond the short term, it could run the risk of earnings volatility.

II. The revised IRR Principles

1. Principles for banks

Principle 1: IRRBB is an important risk for all banks that must be specifically identified, measured, monitored and controlled. In addition, banks should monitor and assess CSRBB.

Background

12.　　IRRBB is an important risk that arises from banking activities, and is encountered by all banks. It arises because interest rates can vary significantly over time, while the business of banking typically involves intermediation activity that produces exposures to both maturity mismatch (eg long-maturity assets funded by short-maturity liabilities) and rate mismatch (eg fixed rate loans funded by variable rate deposits). In addition, there are optionalities embedded in many of the common banking products (eg non-maturity deposits, term deposits, fixed rate loans) that are triggered in accordance with changes in interest rates.

Expectations

13.　　All banks must be familiar with all elements of IRRBB, actively identify their IRRBB exposures and take appropriate steps to measure, monitor and control it.

14.　　Banks must identify the IRRBB inherent in products and activities, and ensure that these are subject to adequate procedures and controls. Significant hedging or risk management initiatives must be approved before being implemented. Products and activities that are new to a bank must undergo a careful preacquisition review to ensure that the IRRBB characteristics are well understood and subject to a predetermined test phase before being fully rolled out. Prior to introducing a new product, hedging or risk-taking strategy, adequate operational procedures and risk control systems must be in place. The management of a bank's IRRBB should be integrated within its broader risk management framework and aligned with its business planning and budgeting activities.

15.　　In identifying, measuring, monitoring and controlling IRRBB, banks should also ensure that CSRBB is properly monitored and assessed.

Principle 2: The governing body [5] of each bank is responsible for oversight of the IRRBB management framework, and the bank's risk appetite for IRRBB. Monitoring and management of IRRBB may be delegated by the governing body to senior management, expert individuals or an asset and liability management committee (henceforth, its delegates). Banks must have an adequate IRRBB management framework, involving regular independent reviews and evaluations of the effectiveness of the system.

Risk management framework

16.　　The governing body has responsibility for understanding the nature and the level of the bank's IRRBB exposure. The governing body should approve broad business strategies as well as overall policies with respect to IRRBB. It should ensure that there is clear guidance regarding the acceptable level of IRRBB, given the bank's business strategies.

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[5]　　This refers to the body that supervises management. The structure of bank boards differs among countries. See the *Corporate Governance Principles for Banks* published by the Committee in July 2015.

17.   Accordingly, the governing body is responsible for ensuring that steps are taken by the bank to identify, measure, monitor and control IRRBB consistent with the approved strategies and policies. More specifically, the governing body or its delegates are responsible for setting:

- appropriate limits on IRRBB, including the definition of specific procedures and approvals necessary for exceptions, and ensuring compliance with those limits;

- adequate systems and standards for measuring IRRBB;

- standards for measuring IRRBB, valuing positions and assessing performance, including procedures for updating interest rate shock and stress scenarios and key underlying assumptions driving the institution's IRRBB analysis;

- a comprehensive IRRBB reporting and review process; and

- effective internal controls and management information systems (MIS).

18.   The governing body or its delegates should oversee the approval, implementation and review of IRRBB management policies, procedures and limits. The governing body should be informed regularly (at least semiannually) on the level and trend of the bank's IRRBB exposures. It should regularly review timely information that is sufficiently detailed to allow it to understand and assess the performance of its delegates in monitoring and controlling IRRBB in compliance with policies approved by the governing body. Such reviews should be carried out more frequently when the bank runs significant IRRBB exposures or has positions in complex IRRBB instruments.

19.   While governing body members do not need individually to have detailed technical knowledge of complex financial instruments, or of quantitative risk management techniques, they should understand the implications of the bank's IRRBB strategies, including the potential linkages with and impact on market, liquidity, credit and operational risk. Some of the members should have sufficient technical knowledge to question and challenge the reports made to the governing body. Governing body members are responsible for ensuring that senior management has the capability and skills to understand IRRBB, and that adequate resources are devoted to IRRBB management.

Delegation

20.   Many governing bodies delegate the task for developing IRRBB policies and practices to senior management, expert individuals or an asset and liability management committee (ALCO). In the case of an ALCO, it should meet regularly and include representatives from each major department connected to IRRBB.

21.   The governing body should clearly identify its delegates for managing IRRBB and, to avoid potential conflicts of interest, should ensure that there is adequate separation of responsibilities in key elements of the risk management process. Banks should have IRRBB identification, measurement, monitoring and control functions with clearly defined responsibilities that are sufficiently independent from risk-taking functions of the bank and that report IRRBB exposures directly to the governing body or its delegates.

22.   The governing body's delegates for IRRBB should include members with clear lines of authority over the units responsible for establishing and managing positions. There should be a clear communication channel to convey the delegates' directives to these line units.

23.   The governing body should ensure that the bank's organisational structure enables its delegates to carry out their responsibilities, and facilitates effective decision-making and good governance. The governing body should encourage discussions between its members and its delegates – as well as between its delegates and others in the bank – regarding the IRRBB management process. The risk management

and strategic planning areas of the bank should also communicate regularly to facilitate evaluations of risk arising from future business.

Internal controls

24. Banks should have adequate internal controls to ensure the integrity of their IRRBB management process. The internal controls should promote effective and efficient operations, reliable financial and regulatory reporting, and compliance with relevant laws, regulations and bank policies.

25. With regard to IRRBB control policies and procedures, banks should have appropriate approval processes, exposure limits, reviews and other mechanisms designed to provide a reasonable assurance that risk management objectives are being achieved.

26. In addition, banks should have in place regular evaluations and reviews of their internal control system and risk management processes. This includes ensuring that personnel comply with established policies and procedures. Such reviews should also address any significant changes that may affect the effectiveness of controls (including changes in market conditions, personnel, technology and structures of compliance with exposure limits), and ensure that there are appropriate escalation procedures for any exceeded limits. Banks should ensure that all such evaluations and reviews are conducted regularly by individuals and/or units that are independent of the function they are assigned to review. When revisions or enhancements to internal controls are warranted, there should be an internal review mechanism in place to ensure that these are implemented in a timely manner.

27. Banks should have their IRRBB identification, measurement, monitoring and control processes reviewed by an independent auditing function (such as an internal or external auditor) on a regular basis. In such cases, reports written by internal/external auditors or other equivalent external parties (such as consultants) should be made available to relevant supervisory authorities.

Principle 3: The banks' risk appetite for IRRBB should be articulated in terms of the risk to both economic value and earnings. Banks must implement policy limits that target maintaining IRRBB exposures consistent with their risk appetite.

28. Banks should have clearly defined risk appetite statements[6] that are approved by the governing body and implemented through comprehensive risk appetite frameworks, ie policies and procedures for limiting and controlling IRRBB. The risk appetite framework should delineate delegated powers, lines of responsibility and accountability over IRRBB management decisions and should clearly define authorised instruments, hedging strategies and risk-taking opportunities. All IRRBB policies should be reviewed periodically (at least annually) and revised as needed.

Policy limits

29. Policy limits set by the governing bodies should be consistent with the bank's overall approach for measuring IRRBB. Aggregate risk limits, clearly articulating the amount of IRRBB acceptable to the governing body, should be applied on a consolidated basis and, as appropriate, at the level of individual affiliates. Limits may be associated with specific scenarios of changes in interest rates and/or term structures, such as an increase or decrease of a particular size or a change in shape. The interest rate movements used in developing these limits should represent meaningful shock and stress situations, taking into account historical interest rate volatility and the time required by management to mitigate those risk exposures.

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[6] A risk appetite statement is a written articulation of the aggregated level and types of IRRBB exposures that a bank will accept, or avoid, in order to achieve its business objectives.

30.   Policy limits should be appropriate to the nature, size, complexity and capital adequacy of the bank, as well as its ability to measure and manage its risks. Depending on the nature of a bank's activities and business model, sub-limits may also be identified for 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 the bank's IRRBB exposures. Banks with significant exposures to gap risk, basis risk or positions with explicit or embedded options should establish risk tolerances appropriate for these risks.

31.   The governing body or its delegates should approve major hedging or risk-taking initiatives in advance of implementation.[7] A dedicated set of risk limits should be developed to monitor the evolution of hedging strategies that rely on instruments such as derivatives, and to control mark-to-market risks in instruments that are accounted for at market value. Proposals to use new instrument types or new strategies (including hedging) should be assessed to ensure that the resources required to establish sound and effective IRRBB management of the product or activity have been identified, that the proposed activities are in line with the bank's overall risk appetite, and procedures to identify, measure, monitor and control the risks of the proposed product or activity have been established.

32.   There should be systems in place to ensure that positions that exceed, or are likely to exceed, limits defined by the governing body or its delegates should receive prompt management attention and be escalated without delay. There should be a clear policy on who will be informed, how the communication will take place and the actions which will be taken in response to an exception.[8]

Principle 4: Measurement of IRRBB should be based on outcomes of both economic value and earnings-based measures, arising from a wide and appropriate range of interest rate shock and stress scenarios.

Economic value and earnings-based measures

33.   Banks' IMS should capture all material sources of IRRBB and assess the effect of market changes on the scope of their activities. In addition to the impact of an interest rate shock on its economic value, a bank's policy approach should take into account its ability to generate stable earnings sufficient to maintain its normal business operations.

34.   Banks should pay attention to the complementary nature of economic value and earnings-based measures in their risk and internal capital assessments, in particular in terms of:

- *outcomes*: economic value measures compute a change in the net present value of the bank's assets, liabilities and off-balance sheet items subject to specific interest rate shock and stress scenarios, while earnings-based measures focus on changes to future profitability within a given time horizon eventually affecting future levels of a bank's own equity capital;

- *assessment horizons*: economic value measures reflect changes in value over the remaining life of the bank's assets, liabilities and off-balance sheet items, ie until all positions have run off, while earnings-based measures cover only the short to medium term, and therefore do not fully

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[7]   Positions related to internal risk transfers between the banking book and the trading book should be properly documented.

[8]   Limits could be absolute in the sense that they should never be exceeded or of whether, under specific circumstances, breaches of limits can be tolerated for a predetermined short period of time.

capture those risks that will continue to impact profit and loss accounts beyond the period of estimation; and

- *future business/production*: economic value measures consider the net present value of repricing cash flows of instruments on the bank's balance sheet or accounted for as an off-balance sheet item (ie a run-off view). Earnings measures may, in addition to a run-off view, assume rollover of maturing items (ie a constant balance sheet view) and/or assess the scenario-consistent impact on the bank's future earnings inclusive of future business (ie a dynamic view). [9]

Interest rate shock and stress scenarios

35.   Banks' IMS for IRRBB should be able to accommodate the calculation of the impact on economic value and earnings of multiple scenarios, based on:

(i)   internally selected interest rate shock scenarios addressing the bank's risk profile, according to its Internal Capital Adequacy Assessment Process (ICAAP);

(ii)   historical and hypothetical interest rate stress scenarios, which tend to be more severe than shock scenarios;

(iii)   the six prescribed interest rate shock scenarios set out in Annex 2; and

(iv)   any additional interest rate shock scenarios required by supervisors.

Developing internal interest rate shock and stress scenarios

Roles and objectives

36.   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 IRRBB.

37.   A bank should develop and implement an effective stress testing framework for IRRBB as part of its broader risk management and governance processes. This should feed into the decision-making process at the appropriate management level, including strategic decisions (eg business and capital planning decisions) of the governing body or its delegates. In particular, IRRBB stress testing should be considered in the ICAAP, requiring banks to undertake rigorous, forward-looking stress testing that identifies events of severe changes in market conditions which could adversely impact the bank's capital or earnings, possibly also through changes in the behaviour of its customer base.

38.   A bank's stress testing framework for IRRBB should be commensurate with its nature, size and complexity as well as business activities and overall risk profile. The framework should include clearly defined objectives, scenarios tailored to the bank's businesses and risks, well documented assumptions and sound methodologies. The framework will be used to assess the potential impact of the scenarios on the bank's financial condition, enable ongoing and effective review processes for stress tests and recommend actions based on the stress test results. IRRBB stress tests should play an important role in the communication of risks, both within the bank and externally with supervisors and the market through appropriate disclosures.

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[9]   A dynamic view can be useful for business planning and budgeting purposes. However, dynamic approaches are dependent on key variables and assumptions that are extremely difficult to project with accuracy over an extended period and can potentially hide certain key underlying risk exposures.

Selection process for shock and stress scenarios

39. The identification of relevant shock and stress scenarios for IRRBB, the application of sound modelling approaches and the appropriate use of the stress testing results require the collaboration of different experts within a bank (eg traders, the treasury department, the finance department, the ALCO, the risk management and risk control departments and/or the bank's economists). A stress-testing programme for IRRBB should ensure that the opinions of the experts are taken into account.

40. Banks should determine, by currency, a range of potential interest rate movements against which they will measure their IRRBB exposures. Management should ensure that risk is measured under a reasonable range of potential interest rate scenarios, including some containing severe stress elements. In developing the scenarios, banks should consider a variety of factors, such as the shape and level of the current term structure of interest rates and the historical and implied volatility of interest rates. In low interest rate environments, banks should also consider negative interest rate scenarios and the possibility of asymmetrical effects of negative interest rates on their assets and liabilities.

41. A bank should consider the nature and sources of its IRRBB exposures, the time it would need to take action to reduce or unwind unfavourable IRRBB exposures, and its capability/willingness to withstand accounting losses in order to reposition its risk profile. A bank should select scenarios that provide meaningful estimates of risk and include a range of shocks that is sufficiently wide to allow the governing body or its delegates to understand the risk inherent in the bank's products and activities. When developing interest rate shock and stress scenarios for IRRBB, banks should consider the following:

- The scenarios should be sufficiently wide-ranging to identify parallel and non-parallel gap risk, basis risk and option risk. In many cases, static interest rate shocks may be insufficient to assess IRRBB exposure adequately. Banks should ensure that the scenarios are both severe and plausible, in light of the existing level of interest rates and the interest rate cycle.

- Special consideration should be given to instruments or markets where concentrations exist, because those positions may be more difficult to liquidate or offset in a stressful market environment.

- Banks should assess the possible interaction of IRRBB with its related risks, as well as other risks (eg credit risk, liquidity risk).

- Banks should assess the effect of adverse changes in the spreads of new assets/liabilities replacing those assets/liabilities maturing over the horizon of the forecast on their NII.

- Banks with significant option risk should include scenarios that capture the exercise of such options. For example, banks that have products with sold caps or floors should include scenarios that assess how the risk positions would change should those caps or floors move into the money. Given that the market value of options also fluctuates with changes in the volatility of interest rates, banks should develop interest rate assumptions to measure their IRRBB exposures to changes in interest rate volatilities.

- Banks should specify, in building their interest rate shock and stress scenarios, the term structure of interest rates that will be incorporated and the basis relationship between yield curves, rate indices etc. Banks should also estimate how interest rates that are administered or managed by management (eg prime rates or retail deposit rates, as opposed to those that are purely market-driven) might change. Management should document how these assumptions are derived.

42. In addition, forward-looking scenarios should incorporate changes in portfolio composition due to factors under the control of the bank (eg the bank's acquisition and production plans) as well as external factors (eg changing competitive, legal or tax environments); new products where only limited historical

data are available; new market information and new emerging risks that are not necessarily covered by historical stress episodes.

43. Further, banks should perform qualitative and quantitative reverse stress tests[10] in order to (i) identify interest rate scenarios that could severely threaten a bank's capital and earnings; and (ii) reveal vulnerabilities arising from its hedging strategies and the potential behavioural reactions of its customers.

Principle 5: In measuring IRRBB, key behavioural and modelling assumptions should be fully understood, conceptually sound and documented. Such assumptions should be rigorously tested and aligned with the bank's business strategies.

Background

44. Both economic value and earnings-based measures of IRRBB are significantly impacted by a number of assumptions made for the purposes of risk quantification, namely:

- expectations for the exercise of interest rate options (explicit and embedded) by both the bank and its customers under specific interest rate shock and stress scenarios;

- treatment of balances and interest flows arising from non-maturity deposits (NMDs);

- treatment of own equity in economic value measures; and

- the implications of accounting practices for IRRBB.

Hence, when assessing its IRRBB exposures, a bank should make judgments and assumptions about how an instrument's actual maturity or repricing behaviour may vary from the instrument's contractual terms because of behavioural optionalities.

Common products with behavioural optionalities

45. Common products with behavioural optionalities include:

(i) Fixed rate loans subject to prepayment risk – Banks should understand the nature of prepayment risk for their portfolios and make reasonable and prudent estimates of the expected prepayments. The assumptions underlying the estimates and where prepayment penalties or other contractual features affect the embedded optionality effect should be documented. There are several factors that are important determinants of the bank's estimate of the effect of each interest rate shock and stress scenario on the average prepayment speed. Specifically, a bank must assess the expected average prepayment speed under each scenario.

(ii) Fixed rate loan commitments – Banks may sell options to retail customers (eg prospective mortgage buyers or renewers) whereby, for a limited period, the customers can choose to draw down a loan at a committed rate. Unlike loan commitments to corporates, where drawdowns strongly reflect characteristics of automatic interest rate options, mortgage commitments (ie pipelines) to retail customers are impacted by other drivers.

(iii) Term deposits subject to early redemption risk – Banks may attract deposits with a contractual maturity term or with step-up clauses that enable the depositor at different time periods to modify the speed of redemption. The classification scheme should be documented, whether a term deposit is deemed to be subject to redemption penalties or to other contractual features that preserve the cash flow profile of the instrument.

(iv) NMDs – Behavioural assumptions for deposits that have no specific repricing date can be a major determinant of IRRBB exposures under the economic value and earnings-based measures. Banks

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[10] See Principle 9 of the *Principles of sound stress testing practices and supervision* published by the Committee in May 2009.

should document, monitor and regularly update key assumptions for NMD balances and behaviour used in their IMS. To determine the appropriate assumptions for its NMDs, a bank should analyse its depositor base in order to identify the proportion of core deposits (ie NMDs which are unlikely to reprice even under significant changes in interest rate environment). Assumptions should vary according to depositor characteristics (eg retail/wholesale) and account characteristics (eg transactional/non-transactional).

46.   Modelling assumptions should be conceptually sound and reasonable, and consistent with historical experience. Banks must carefully consider how the exercise of the behavioural optionality will vary not only under the interest rate shock and stress scenario but also across other dimensions. For instance, considerations may include:

Product	Dimensions influencing the exercise of the embedded behavioural options
Fixed rate loans subject to prepayment risk	Loan size, loan-to-value (LTV) ratio, borrower characteristics, contractual interest rates, seasoning, geographical location, original and remaining maturity, and other historical factors. Other macroeconomic variables such as stock indices, unemployment rates, GDP, inflation and housing price indices should be considered in modelling prepayment behaviour.
Fixed rate loan commitments	Borrower characteristics, geographical location (including competitive environment and local premium conventions), customer relationship with bank as evidenced by cross-products, remaining maturity of the commitment, seasoning and remaining term of the mortgage.
Term deposits subject to early redemption risk	Deposit size, depositor characteristics, funding channel (eg direct or brokered deposit), contractual interest rates, seasonal factors, geographical location and competitive environment, remaining maturity and other historical factors. Other macroeconomic variables such as stock indices, unemployment rates, GDP, inflation and housing price indices should be considered in modelling deposit redemption behaviour.
NMDs	Responsiveness of product rates to changes in market interest rates, current level of interest rates, spread between a bank's offer rate and market rate, competition from other firms, the bank's geographical location and demographic and other relevant characteristics of its customer base.

47.   In addition, banks with positions denominated in different currencies can expose themselves to IRRBB in each of those currencies. Since yield curves vary from currency to currency, banks generally need to assess exposures in each currency. Banks with the necessary skills and sophistication, and with material multicurrency exposures, may choose to include, in their IMS, methods to aggregate their IRRBB in different currencies using assumptions about the correlation between interest rates in different currencies.

48.   Further, banks should consider the materiality of the impact of behavioural optionalities within floating rate loans. For instance, the behaviour of prepayments arising from embedded caps and floors could impact the banks' economic value of equity.

49.   Banks should be able to test the appropriateness of key behavioural assumptions, and all changes to the assumptions of key parameters should be documented (eg by comparing the economic value of equity measured under their IMS with the standardised framework in Section IV). Banks should periodically

perform sensitivity analyses for key assumptions to monitor their impact on measured IRRBB. Sensitivity analyses should be performed with reference to both economic value and earnings-based measures.

50.   The most significant assumptions underlying the system should be documented and clearly understood by the governing body or its delegates. Documentation should also include descriptions on how those assumptions could potentially affect the bank's hedging strategies.

51.   As market conditions, competitive environments and strategies change over time, the bank should review significant measurement assumptions at least annually and more frequently during rapidly changing market conditions. For example, if the competitive market has changed such that consumers now have lower transaction costs available to them for refinancing their residential mortgages, prepayments may become more sensitive to smaller reductions in interest rates.

Principle 6: Measurement systems and models used for IRRBB should be based on accurate data, and subject to appropriate documentation, testing and controls to give assurance on the accuracy of calculations. Models used to measure IRRBB should be comprehensive and covered by governance processes for model risk management, including a validation function that is independent of the development process.

Measurement systems and data integrity

52.   Accurate and timely measurement of IRRBB is necessary for effective risk management and control. A bank's risk measurement system should be able to identify and quantify the major sources of IRRBB exposure. The mix of a bank's business lines and the risk characteristics of its activities should guide management's selection of the most appropriate form of measurement system.

53.   Banks should not rely on a single measure of risk, given that risk management systems tend to vary in how they capture the components of IRRBB. Instead, banks should use a variety of methodologies to quantify their IRRBB exposures under both the economic value and earnings-based measures, ranging from simple calculations based on static simulations using current holdings to more sophisticated dynamic modelling techniques that reflect potential future business activities.

54.   A bank's MIS should allow it to retrieve accurate IRRBB information in a timely manner. The MIS should capture interest rate risk data on all the bank's material IRRBB exposures. There should be sufficient documentation of the major data sources used in the bank's risk measurement process.

55.   Data inputs should be automated as much as possible to reduce administrative errors. Data mapping should be periodically reviewed and tested against an approved model version. A bank should monitor the type of data extracts and set appropriate controls.

56.   Where cash flows are slotted into different time buckets (eg for gap analyses) or assigned to different vertex points to reflect the different tenors of the interest rate curve, the slotting criteria should be stable over time to allow for a meaningful comparison of risk figures over different periods.

57.   Banks' IMS should be able to compute economic value and earnings-based measures of IRRBB, as well as other measures of IRRBB prescribed by their supervisors, based on the interest rate shock and stress scenarios set out in paragraph 35. It should also be sufficiently flexible to incorporate supervisory-imposed constraints on banks' internal risk parameter estimates.

Model governance process

58.   The validation of IRRBB measurement methods and assessment of corresponding model risk should be included in a formal policy process that should be reviewed and approved by the governing body or its delegates. The policy should specify the management roles and designate who is responsible

for the development, implementation and use of models. In addition, the model oversight responsibilities as well as policies including the development of initial and ongoing validation procedures, evaluation of results, approval, version control, exception, escalation, modification and decommission processes need to be specified and integrated within the governance processes for model risk management.

59.   An effective validation framework should include three core elements:

- evaluation of conceptual/methodological soundness, including developmental evidence;
- ongoing model monitoring, including process verification and benchmarking; and
- outcomes analysis, including backtesting of key internal parameters (eg stability of deposits, prepayments, early redemptions, pricing of instruments).

60.   In addressing the expected initial and ongoing validation activities, the policy should establish a hierarchical process for determining model risk soundness based on both quantitative and qualitative dimensions such as size, impact, past performance and familiarity with the modelling technique employed.

61.   Model risk management for IRRBB measures should follow a holistic approach that begins with motivation, development and implementation by model owners and users. Prior to receiving authorisation for usage, the process for determining model inputs, assumptions, modelling methodologies and outputs should be reviewed and validated independently of the development of IRRBB models. The review and validation results and any recommendations on model usage should be presented to and approved by the governing body or its delegates. Upon approval, the model should be subject to ongoing review, process verification and validation at a frequency that is consistent with the level of model risk determined and approved by the bank.

62.   The ongoing validation process should establish a set of exception trigger events that obligate the model reviewers to notify the governing body or its delegates in a timely fashion, in order to determine corrective actions and/or restrictions on model usage. Clear version control authorisations should be designated, where appropriate, to model owners. With the passage of time and due to observations and new information gained over time, an approved model may be modified or decommissioned. Banks should articulate policies for model transition, including change and version control authorisations and documentation.

63.   IRRBB models might include those developed by third-party vendors. Model inputs or assumptions may also be sourced from related modelling processes or sub-models (both in-house and vendor-sourced) and should be included in the validation process. The bank should document and explain model specification choices as part of the validation process.

64.   Banks that purchase IRRBB models should ensure there is adequate documentation of their use of those models, including any specific customisation. If vendors provide input for market data, behavioural assumptions or model settings, the bank should have a process in place to determine if those inputs are reasonable for its business and the risk characteristics of its activities.

65.   Internal audit should review the model risk management process as part of its annual risk assessment and audit plans. The audit activity should not duplicate model risk management processes, but should review the integrity and effectiveness of the risk management system and the model risk management process.

Principle 7: Measurement outcomes of IRRBB and hedging strategies should be reported to the governing body or its delegates on a regular basis, at relevant levels of aggregation (by consolidation level and currency).

66. The reporting of risk measures to the governing body or its delegates should be regular and should compare current exposure with policy limits. In particular, reporting should include the results of the periodic model reviews and audits as well as comparisons of past forecasts or risk estimates with actual results to inform potential modelling shortcomings on a regular basis. Portfolios that may be subject to significant mark-to-market movements should be clearly identified within the bank's MIS and subject to oversight in line with any other portfolios exposed to market risk.

67. While the types of reports prepared for the governing body or its delegates will vary based on the bank's portfolio composition, they should include at least the following:

- summaries of the bank's aggregate IRRBB exposures, and explanatory text that highlights the assets, liabilities, cash flows, and strategies that are driving the level and direction of IRRBB;

- reports demonstrating the bank's compliance with policies and limits;

- key modelling assumptions such as NMD characteristics, prepayments on fixed rate loans and currency aggregation;

- results of stress tests, including assessment of sensitivity to key assumptions and parameters; and

- summaries of the reviews of IRRBB policies, procedures and adequacy of the measurement systems, including any findings of internal and external auditors and/or other equivalent external parties (such as consultants).

68. Reports detailing the bank's IRRBB exposures should be provided to the bank's governing body or its delegates on a timely basis and reviewed regularly. The IRRBB reports should provide aggregate information as well as sufficient supporting detail to enable the governing body or its delegates to assess the sensitivity of the bank to changes in market conditions, with particular reference to portfolios that may potentially be subject to significant mark-to-market movements. The governing body or its delegates should review the bank's IRRBB management policies and procedures in light of the reports, to ensure that they remain appropriate and sound. The governing body or its delegates should also ensure that analysis and risk management activities related to IRRBB are conducted by competent staff with technical knowledge and experience, consistent with the nature and scope of the bank's activities.

Principle 8: Information on the level of IRRBB exposure and practices for measuring and controlling IRRBB must be disclosed to the public on a regular basis.

69. The level of IRRBB exposure should be measured and disclosed. Specifically, banks must disclose the measured ΔEVE and ΔNII under the prescribed interest rate shock scenarios set out in Annex 2. Disclosure should be in the format of Tables A and B below. Banks should use their own IMS to calculate the IRRBB exposure values, unless otherwise instructed by their national supervisor. Section IV provides a standardised framework that the banks may adopt as their IMS. As well as providing quantitative disclosure, banks should provide sufficient qualitative information and supporting detail to enable the market and wider public to:

(i)   monitor the sensitivity of the bank's economic value and earnings to changes in interest rates;

(ii)   understand the primary assumptions underlying the measurement produced by the bank's IMS; and

(iii)   have an insight into the bank's overall IRRBB objective and IRRBB management.

70. In order to improve comparability between banks' disclosed levels of IRRBB, exposures should be calculated on the following basis:

(i) ΔEVE

    (a) Banks should exclude their own equity from the computation of the exposure level.

    (b) Banks should include all cash flows from all interest rate-sensitive assets,[11] liabilities and off-balance sheet items in the banking book in the computation of their exposure. Banks should disclose whether they have excluded or included commercial margins and other spread components in their cash flows.

    (c) Cash flows should be discounted using either a risk-free rate [12] or a risk-free rate including commercial margins and other spread components (only if the bank has included commercial margins and other spread components in its cash flows). Banks should disclose whether they have discounted their cash flows using a risk-free rate or a risk-free rate including commercial margins and other spread components.

    (d) ΔEVE should be computed with the assumption of a run-off balance sheet, where existing banking book positions amortise and are not replaced by any new business.

(ii) ΔNII

    (a) Banks should include expected cash flows (including commercial margins and other spread components) arising from all interest rate-sensitive assets, liabilities and off-balance sheet items in the banking book.

    (b) ΔNII should be computed assuming a constant balance sheet, where maturing or repricing cash flows are replaced by new cash flows with identical features with regard to the amount, repricing period and spread components.

    (c) ΔNII should be disclosed as the difference in future interest income over a rolling 12-month period.

71. In addition to the required disclosures in Tables A and B, banks are encouraged to make voluntary disclosures of information on internal measures of IRRBB that would assist the market in interpreting the mandatory disclosure numbers.

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[11] Interest rate-sensitive assets are assets which are not deducted from Common Equity Tier 1 (CET1) capital and which exclude (i) fixed assets such as real estate or intangible assets as well as (ii) equity exposures in the banking book.

[12] The discounting factors must be representative of a risk-free zero coupon rate. An example of an acceptable yield curve is a secured interest rate swap curve.

Table A

Purpose: To provide a description of the risk management objectives and policies concerning IRRBB.	
Scope of application: Mandatory for all banks within the scope of application set out in Section III.	
Content: Qualitative and quantitative information. Quantitative information is based on the daily or monthly average of the year or on the data as of the reporting date.	
Frequency: Annual.	
Format: Flexible.	

	Qualitative disclosure
a	A description of how the bank defines IRRBB for purposes of risk control and measurement.
b	A description of the bank's overall IRRBB management and mitigation strategies. Examples are: monitoring of EVE and NII in relation to established limits, hedging practices, conduct of stress testing, outcomes analysis, the role of independent audit, the role and practices of the ALCO, the bank's practices to ensure appropriate model validation, and timely updates in response to changing market conditions.
c	The periodicity of the calculation of the bank's IRRBB measures, and a description of the specific measures that the bank uses to gauge its sensitivity to IRRBB.
d	A description of the interest rate shock and stress scenarios that the bank uses to estimate changes in the economic value and in earnings.
e	Where significant modelling assumptions used in the bank's IMS (ie the EVE metric generated by the bank for purposes other than disclosure, eg for internal assessment of capital adequacy) are different from the modelling assumptions prescribed for the disclosure in Table B, the bank should provide a description of those assumptions and of their directional implications and explain its rationale for making those assumptions (eg historical data, published research, management judgment and analysis).
f	A high-level description of how the bank hedges its IRRBB, as well as the associated accounting treatment.
g	A high-level description of key modelling and parametric assumptions used in calculating ΔEVE and ΔNII in Table B, which includes: For ΔEVE, whether commercial margins and other spread components have been included in the cash flows used in the computation and discount rate used. How the average repricing maturity of non-maturity deposits in (1) has been determined (including any unique product characteristics that affect assessment of repricing behaviour). The methodology used to estimate the prepayment rates of customer loans, and/or the early withdrawal rates for time deposits, and other significant assumptions. Any other assumptions (including for instruments with behavioural optionalities that have been excluded) that have a material impact on the disclosed ΔEVE and ΔNII in Table B, including an explanation of why these are material. Any methods of aggregation across currencies and any significant interest rate correlations between different currencies.
h	(Optional) Any other information which the bank wishes to disclose regarding its interpretation of the significance and sensitivity of the IRRBB measures disclosed and/or an explanation of any significant variations in the level of the reported IRRBB since previous disclosures.

	Quantitative disclosures
1	Average repricing maturity assigned to NMDs.
2	Longest repricing maturity assigned to NMDs.

Table B

Scope of application: Mandatory for all banks within the scope of application set out in Section III.		
Content: Quantitative information.		
Frequency: Annual, as at the bank's financial year-end.		
Format: Fixed.		
Accompanying narrative: Commentary on the significance of the reported values and an explanation of any material changes since the previous reporting period.		

In reporting currency	ΔEVE		ΔNII	
Period	**T**	**T–1**	**T**	**T–1**
Parallel up				
Parallel down				
Steepener				
Flattener				
Short rate up				
Short rate down				
Maximum				
Period	**T**		**T–1**	
Tier 1 capital				

Definitions

For each of the supervisory prescribed interest rate shock scenarios, the bank must report for the current period and for the previous period:

(i)   the change in the economic value of equity based on its IMS, using a run-off balance sheet and an instantaneous shock or based on the result of the standardised framework as set out in Section IV if the bank has chosen to adopt the framework or has been mandated by its supervisor to follow the framework; and

(ii)   the change in projected NII over a forward-looking rolling 12-month period compared with the bank's own best estimate 12-month projections, using a constant balance sheet assumption and an instantaneous shock.

Principle 9: Capital adequacy for IRRBB must be specifically considered as part of the Internal Capital Adequacy Assessment Process (ICAAP) approved by the governing body, in line with the bank's risk appetite on IRRBB.

72.   Banks are responsible for evaluating the level of capital that they should hold, and for ensuring that this is sufficient to cover IRRBB and its related risks. The contribution of IRRBB to the overall internal capital assessment should be based on the bank's IMS outputs, taking account of key assumptions and risk limits. The overall level of capital should be commensurate with both the bank's actual measured level of risk (including for IRRBB) and its risk appetite, and be duly documented in its ICAAP report.

73.   Banks should not only rely on supervisory assessments of capital adequacy for IRRBB, but should also develop their own methodologies for capital allocation, based on their risk appetite. In determining the appropriate level of capital, banks should consider both the amount and the quality of capital needed.

74.   Capital adequacy for IRBBB should be considered in relation to the risks to economic value, given that such risks are embedded in the bank's assets, liabilities and off-balance sheet items. For risks to future earnings, given the possibility that future earnings may be lower than expected, banks should consider capital buffers.

75.   Capital adequacy assessments for IRRBB should factor in:

- the size and tenor of internal limits on IRRBB exposures, and whether these limits are reached at the point of capital calculation;

- the effectiveness and expected cost of hedging open positions that are intended to take advantage of internal expectations of the future level of interest rates;

- the sensitivity of the internal measures of IRRBB to key modelling assumptions;

- the impact of shock and stress scenarios on positions priced off different interest rate indices (basis risk);

- the impact on economic value and NII of mismatched positions in different currencies;

- the impact of embedded losses;

- the distribution of capital relative to risks across legal entities that form part of a capital consolidation group, in addition to the adequacy of overall capital on a consolidated basis;

- the drivers of the underlying risk; and

- the circumstances under which the risk might crystallise.

76.   The outcomes of the capital adequacy for IRRBB should be considered in a bank's ICAAP and flow through to assessments of capital associated with business lines.

2.   Principles for supervisors

Principle 10: Supervisors should, on a regular basis, collect sufficient information from banks to be able to monitor trends in banks' IRRBB exposures, assess the soundness of banks' IRRBB management and identify outlier banks that should be subject to review and/or should be expected to hold additional regulatory capital.

77.   Supervisors should, on a regular basis, collect sufficient information from banks to assess their IRRBB exposures. While the precise information obtained could differ among supervisors, the amount of information collected should at least allow the supervisor to assess the IRRBB exposures of the bank and to identify and monitor outlier banks under Principle 12.

78.   Supervisors should ensure that the collection of information is comparable and consistent across the banks that they supervise. Supervisors should have discretionary powers to collect additional information to assess banks' IRRBB in line with Principle 11, including the sensitivity of their IMS calculations to changes in key assumptions. For example, supervisors may collect information on:

(a)   the modelling of NMDs for IMS purposes and the sensitivity of a bank's economic value and earnings to changes in NMD assumptions;

(b)   the impact of assumptions used regarding products with behavioural optionalities;

(c)   the treatment of own equity in internal calculations and the extent to which this impacts the ΔEVE number disclosed under Principle 8;

(d)   repricing gaps of cash flows associated with their interest rate-sensitive assets, liabilities and off-balance sheet items (by significant currencies);

(e)   exposures to automatic interest rate options;

(f)   the types of yield curve used for IMS purposes;

(g)   the level of ΔEVE if calculated using the standardised framework set out in Section IV; and

(h)   economic value and earnings-based measures for interest rate shock and stress scenarios in addition to those prescribed in Annex 2 (including results based on banks' internally developed or other interest rate shock or stress scenarios).

79.   Jurisdictions that intend to perform an off-site review of their banks' IRRBB should put in place adequate reporting schemes to enable peer comparison of banks and identification of banks for additional on-site work.

Principle 11: Supervisors should regularly assess banks' IRRBB and the effectiveness of the approaches that banks use to identify, measure, monitor and control IRRBB. Supervisory authorities should employ specialist resources to assist with such assessments. Supervisors should cooperate and share information with relevant supervisors in other jurisdictions regarding the supervision of banks' IRRBB exposures.

Assessment

80.   Supervisors should regularly evaluate the adequacy, integrity and effectiveness of a bank's IRRBB management framework and assess whether its practices comply with the stated objectives and risk tolerances set by its governing body, and with supervisory expectations as set out in Principles 1 to 7. Supervisors should take into account a bank's size and complexity at the time of assessment.

81.   Supervisors should evaluate whether a bank's IMS provides a sufficient basis for identifying and measuring IRRBB, taking note particularly of the key assumptions that affect the measurement of IRRBB. Supervisors should request and evaluate information about significant model or policy changes that have occurred between their regular reviews and concentrate their efforts on reviewing the most material models and policies.

82.   Supervisors should review regularly the outputs from the bank's IMS, including the bank's IRRBB exposures (both economic value and earnings-based measures) based on the internal calculations using at least the prescribed interest rate shock scenarios specified in Annex 2, as well as any additional interest rate shock and stress scenarios they determine should be assessed. Supervisors may also form their evaluation of a bank's IMS by applying supervisory estimates which they have developed. Supervisors should also review the information disclosed by banks under Principle 8.

83.   When reviewing the bank's IRRBB exposures and forming conclusions about the quality of the bank's IRRBB management, supervisors should at a minimum, consider:

- the complexity and level of risk posed by the bank's assets, liabilities and off-balance sheet activities;

- the adequacy and effectiveness of oversight by the bank's governing body or its delegates;

- a bank's knowledge and ability to identify and manage the sources of IRRBB;

- the adequacy of internal validation of IRRBB measures, including sensitivity analysis and backtesting, in particular where changes in key modelling parameters have occurred;

- the adequacy of internal monitoring and of the bank's MIS;

- the effectiveness of risk limits and controls that set tolerances on economic value and earnings;

- the effectiveness of the bank's IRRBB stress testing programme;

- the adequacy and frequency of the internal review and audit of the IRRBB management process, including independent model validation and oversight of model risk;

- the adequacy and effectiveness of IRRBB management practices as evidenced by past and projected financial performance;

- the effectiveness of hedging strategies used by the bank to control IRRBB; and

- the appropriateness of the level of IRRBB (including embedded losses) in relation to the bank's capital, earnings and risk management systems.

84.   Supervisors should assess the adequacy of a bank's capital relative to its IRRBB exposures (against expectations set out in Principle 9) to determine whether the bank requires more detailed examination and should potentially be subject to additional capital requirements and/or other mitigation actions. This assessment need not be limited to the outlier/materiality test set out in Principle 12.

85.   The supervisory evaluation should be undertaken both on a standalone basis and by making comparisons with peer banks – in particular, supervisors should compare the key behavioural and strategic assumptions being made by banks within their jurisdictions, to determine whether they can be justified with regard to the economic environment and business model. Supervisors should ensure that the information they review is comparable and consistent across the banks that they supervise.

Resources

86.   Supervisors should employ specialist resources to assist with the assessment of IRRBB levels and controls in the banks that they supervise. Supervisory bodies should:

(i)   ensure that line supervisors are appropriately trained and sufficiently knowledgeable to identify all relevant aspects of IRRBB in the banks that they regulate; and

(ii)   employ an adequate number of IRRBB specialists.

Supervisory cooperation

87.   Supervisors should cooperate and share information with relevant supervisors in other jurisdictions regarding the supervision of banks' IRRBB, in particular for banks with operations across multiple jurisdictions. Sharing of such information could take place on a bilateral or multilateral basis (eg through supervisory colleges). The information shared could include supervisory experiences from assessing and monitoring a bank's IRRBB in different parts of its group, modelling assumptions made by banks, any impediments experienced during the supervision process, rules/criteria established to evaluate

the capital that banks would need for IRRBB, and examples of good practices observed in the banks' management of IRRBB.

Principle 12: Supervisors must publish their criteria for identifying outlier banks. Banks identified as outliers must be considered as potentially having undue IRRBB. When a review of a bank's IRRBB exposure reveals inadequate management or excessive risk relative to capital, earnings or general risk profile, supervisors must require mitigation actions and/or additional capital.

88.   Supervisors must publish their criteria for identifying an outlier bank, defined in terms of the outlier/materiality test(s) used by the supervisor. The supervisor should implement at least one outlier/materiality test that compares the bank's maximum ΔEVE, under the six prescribed interest rate shock scenarios set out in Annex 2, with 15% of its Tier 1 capital, computed in line with the disclosure requirements in Principle 8.

89.   Supervisors may also implement additional outlier/materiality tests, provided these tests are applied throughout their jurisdiction in the same form. The additional outlier/materiality tests could use a different capital measure (eg Common Equity Tier 1 (CET1) capital, amount by which regulatory capital exceeds the bank's minimum requirements) or capture the bank's IRRBB relative to earnings. For the additional outlier/materiality tests, the threshold for defining an outlier bank should be at least as stringent as 15% of Tier 1 capital.

90.   Banks identified by supervisors under their criteria as outliers must be considered as potentially having undue IRRBB and subject to review.

91.   All banks are expected to hold adequate capital for the risks they undertake. With regard to IRRBB, supervisors should evaluate whether the bank has adequate capital and earnings that are commensurate with its level of short-term and long-term IRRBB exposures, as well as the risk those exposures may pose to its future financial performance. Supervisors should consider the following factors:

- The ΔEVE under a variety of shocked and stressed interest rate scenarios. Where a bank's EVE is significantly sensitive to interest rate shocks and stresses, the supervisor should evaluate the impact on its capital levels arising from financial instruments held at market value, and potential impact should banking book positions held at historical cost become subject to market valuation. Supervisors should, in their assessment, consider the impact of key assumptions on the ΔEVE calculated, including those related to the inclusion/exclusion of commercial margins, the bank's actual equity allocation profile, the stability of NMDs and prepayment optionality.

- The strength and stability of the earnings stream and the level of income needed to generate and maintain normal business operations. A high level of IRRBB exposure is one that could, under a plausible range of market scenarios, result in the bank reporting losses or curtailing normal dividend distribution and business operations. In such cases, management should ensure that the bank has sufficient capital to withstand the adverse impact of such events until it can implement mitigating actions such as reducing exposures or increasing capital.

92.   When a supervisor determines that a bank's IMS is deficient in its measurement of IRRBB, the supervisor should require the bank to improve its IMS and/or use the standardised framework set out in Section IV to compute its IRRBB in terms of ΔEVE.

93.   A bank could also be considered to have excessive risk relative to earnings if its shocked ΔNII was such that the bank would not have sufficient income to maintain its normal business operations.

94.   When a national supervisor concludes that a bank's management of IRRBB is inadequate or that it has excessive risk relative to its capital or earnings, or its general risk profile, the supervisor must require the bank to take one or more of the following actions:

- reduce its IRRBB exposures (eg by hedging);

- raise additional capital;

- set constraints on the internal risk parameters used by a bank; and/or

- improve its risk management framework.

95.   The reduction in IRRBB and/or the expected higher level of capital should be achieved within a specified time frame, to be established taking into consideration prevailing financial and economic conditions, as well as the causes of IRRBB exposure exceeding the supervisory threshold.

III.   Scope of application and implementation timeline

Scope of application

96.   The application of the framework follows the scope of application set out in the Basel II framework.[13] The framework should be applied to all large internationally active banks on a consolidated basis, but may also be used for other banks and on any subset of entities of internationally active banks, so as to ensure greater consistency and a level playing field between domestic and cross-border banks.

97.   The implementation of these principles should be commensurate with the bank's nature, size and complexity as well as its structure, economic significance and general risk profile. This requires that supervisors gauge their responses where appropriate for banks with low IRRBB profiles. In particular, supervisors will focus on systemic risks that are inherent in large, complex or internationally active banks.

Implementation timeline

98.   The banks are expected to implement the standards by 2018. Banks whose financial year ends on 31 December would have to provide the disclosure in 2018, based on information as of 31 December 2017.

IV.   The standardised framework

99.   Supervisors could mandate their banks to follow the framework set out in this section, or a bank could choose to adopt it.

1.   Overall structure of the standardised framework

100.   The steps involved in measuring a bank's IRRBB, based solely on EVE, are:

- *Stage 1*. Interest rate-sensitive banking book positions are allocated to one of three categories (ie amenable, less amenable and not amenable to standardisation).

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[13]   See *International Convergence of Capital Measurement and Capital Standards: A Revised Framework – Comprehensive Version*, June 2006, www.bis.org/publ/bcbs128.pdf.

- *Stage 2*. Determination of slotting of cash flows based on repricing maturities. This is a straightforward translation for positions amenable to standardisation. For positions less amenable to standardisation, they are excluded from this step. For positions with embedded automatic interest rate options, the optionality should be ignored for the purpose of slotting of notional repricing cash flows.[14]

  For positions that are not amenable to standardisation, there is a separate treatment for:

(a) *NMDs* – according to separation of core and non-core cash flows via the approach set out in paragraphs 109 to 114.

(b) *Behavioural options* (fixed rate loans subject to prepayment risk and term deposits subject to early redemption risk) – behavioural parameters relevant to the position type must rely on a scenario-dependent look-up table set out in paragraphs 123 and 128.

- *Stage 3*. Determination of ΔEVE for relevant interest rate shock scenarios for each currency. The ΔEVE is measured per currency for all six prescribed interest rate shock scenarios.

- *Stage 4*. Add-ons for changes in the value of *automatic* interest rate options (whether explicit or embedded) are added to the EVE changes. Automatic interest rate options sold are subject to full revaluation (possibly net of automatic interest rate options bought to hedge sold interest rate options) under each of the six prescribed interest rate shock scenarios for each currency. Changes in values of options are then added to the changes in the EVE measure under each interest rate shock scenario on a per currency basis.

- *Stage 5*. IRRBB EVE calculation. The ΔEVE under the standardised framework will be the maximum of the worst aggregated reductions to EVE across the six supervisory prescribed interest rate shocks.

2. Components of the standardised framework

2.1 Cash flow bucketing

101. Banks must project all future notional repricing cash flows arising from interest rate-sensitive:

- *assets*, which are not deducted from Common Equity Tier 1 (CET1) capital and which exclude (i) fixed assets such as real estate or intangible assets and (ii) equity exposures in the banking book;

- *liabilities* (including all non-remunerated deposits), other than CET1 capital under the Basel III framework; and

- *off-balance sheet items*;

onto (i) 19 predefined *time buckets* (indexed numerically by k) as set out in Table 1, into which they fall according to their repricing dates, or onto (ii) the *time bucket midpoints* as set out in Table 1, retaining the notional repricing cash flows' maturity. Alternative (ii) requires splitting up notional repricing cash flows between two adjacent maturity bucket midpoints.

102. A notional repricing cash flow $\mathrm{CF}(k)$ is defined as:

- any repayment of principal (eg at contractual maturity);

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[14] That is, the embedded automatic interest rate option is stripped out from the process of slotting notional repricing cash flows in Stage 2 and treated together with other automatic interest rate options under Stage 4.

- any repricing of principal; repricing is said to occur at the earliest date at which either the bank or its counterparty is entitled to unilaterally change the interest rate, or at which the rate on a floating rate instrument changes automatically in response to a change in an external benchmark; or

- any interest payment on a tranche of principal that has not yet been repaid or repriced; spread components of interest payments on a tranche of principal that has not yet been repaid and which do not reprice must be slotted until their contractual maturity irrespective of whether the non-amortised principal has been repriced or not.

  The date of each repayment, repricing or interest payment is referred to as its repricing date.

103.   Banks have the choice of whether to deduct commercial margins and other spread components from the notional repricing cash flows, using a prudent and transparent methodology.

104.   Floating rate instruments are assumed to reprice fully at the first reset date. Hence, the entire principal amount is slotted into the bucket in which that date falls, with no additional slotting of notional repricing cash flows to later time buckets or time bucket midpoints (other than the spread component which is not repriced).

Table 1. The maturity schedule with 19 time buckets for notional repricing cash flows repricing at t^{CF}. The number in brackets is the time bucket's midpoint

	Time bucket intervals (M: months; Y: years)							
Short-term rates	Overnight (0.0028Y)	O/N< t^{CF} ≦1M (0.0417Y)	1M< t^{CF} ≦3M (0.1667Y)	3M< t^{CF} ≦6M (0.375Y)	6M< t^{CF} ≦9M (0.625Y)	9M< t^{CF} ≦1Y (0.875Y)	1Y< t^{CF} ≦1.5Y (1.25Y)	1.5Y< t^{CF} ≦2Y (1.75Y)
Medium-term rates	2Y< t^{CF} ≦3Y (2.5Y)	3Y< t^{CF} ≦4Y (3.5Y)	4Y < t^{CF} ≦ 5Y (4.5Y)	5Y< t^{CF} ≦6Y (5.5Y)	6Y< t^{CF} ≦7Y (6.5Y)			
Long-term rates	7Y< t^{CF} ≦8Y (7.5Y)	8Y < t^{CF} ≦ 9Y (8.5Y)	9Y < t^{CF} ≦ 10Y (9.5Y)	10Y< t^{CF} ≦ 15Y (12.5Y)	15Y< t^{CF} ≦ 20Y (17.5Y)	t^{CF} > 20Y (25Y)		

2.2   Process for slotting and decomposing banking book instruments

105.   All notional repricing cash flows associated with interest rate-sensitive assets, liabilities and off-balance sheet items, for each currency, are allocated to the prescribed time buckets or time bucket midpoints (henceforth, denoted by $CF_{i,c}(k)$ or $CF_{i,c}(t_k)$ under interest rate shock scenario i and currency c) based on their amenability to standardisation.

Process for positions that are amenable to standardisation

106.   Notional repricing cash flows can be slotted into appropriate time buckets or time bucket midpoints based on their contractual maturity, if subject to fixed coupons, or into the next repricing period if coupons are floating. Positions amenable to standardisation fall into two categories:

1.   *Fixed rate positions*: such positions generate cash flows that are certain till the point of contractual maturity. Examples are fixed rate loans without embedded prepayment options, term deposits without redemption risk and other amortising products such as mortgage loans. All coupon cash flows and periodic or final principal repayments should be allocated to the time bucket midpoints closest to the contractual maturity.

2. *Floating rate positions*: such positions generate cash flows that are not predictable past the next repricing date other than that the present value would be reset to par. Accordingly, such instruments can be treated as a series of coupon payments until the next repricing and a par notional cash flow at the time bucket midpoint closest to the next reset date bucket.

107. Positions amenable to standardisation include positions with embedded automatic interest rate options where the optionality (whether sold or bought) should be ignored for the purpose of slotting of notional repricing cash flows.[15] That is, the stripped-out embedded automatic interest rate option must be treated together with explicit automatic interest rate options. Supervisors may allow banks to categorise other positions as amenable to standardisation and ignore the optionality if it can be shown to be of immaterial consequence.

Process for positions that are less amenable to standardisation[16]

108. For explicit automatic interest rate options, as well as embedded automatic interest rate options[17] that are separated or stripped out from the bank's assets or liabilities (ie the host contract), the methodology for automatic interest rate options is described in paragraphs 130 and 131.

Process for positions not amenable to standardisation

109. Positions not amenable to standardisation include (i) NMDs, (ii) fixed rate loans subject to prepayment risk and (iii) term deposits subject to early redemption risk.

3. Treatment of NMDs

110. Under the standardised framework, banks should first separate their NMDs according to the nature of the deposit and depositor. Banks should then identify, for each category, the core and non-core deposits, up to the limits specified in Table 2. Finally, banks should determine an appropriate cash flow slotting for each category, in accordance with the average maturity limits specified in Table 2.

(a) NMD categories

111. NMDs must be segmented into retail and wholesale categories. Retail deposits are defined as deposits placed with a bank by an individual person. Deposits made by small business customers and managed as retail exposures are considered as having similar interest rate risk characteristics to retail accounts and thus can be treated as retail deposits (provided the total aggregated liabilities raised from one small business customer are less than €1 million). Retail deposits should be considered as held in a transactional account when regular transactions are carried out in that account (eg when salaries are regularly credited) or when the deposit is non-interest bearing.[18] Other retail deposits should be

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[15] For example, a floating rate loan or debt security with a floor would be treated as if there were no floor; hence it would be treated as if it fully repriced at the next reset date, and its full outstanding balance slotted in the corresponding time band. Similarly, a callable bond issued by a bank at a fixed yield would be treated as if it matured at its longest contractual term, ignoring the call option.

[16] A common feature of these positions is *optionality* that makes the timing of notional repricing cash flows uncertain. This optionality introduces a non-linearity, which suggests that delta-equivalent approximations are imprecise for large interest rate shock scenarios.

[17] An example of a product with embedded automatic interest rate options is a floating rate mortgage loan with embedded caps and/or floors. Notional repricing cash flows for those loans are treated as a fixed rate loan until the next repricing date, thereby ignoring the option, which instead is treated like a separate automatic interest rate option.

[18] A specific category may be introduced for non-remunerated deposits, subject to supervisory approval.

considered as held in a non-transactional account. Deposits from legal entities, sole proprietorships or partnerships are captured in wholesale deposit categories.

(b) Separation of NMDs

112. Banks should distinguish between the stable and the non-stable parts of each NMD category using observed volume changes over the past 10 years. The stable NMD portion is the portion that is found to remain undrawn with a high degree of likelihood. Core deposits are the proportion of stable NMDs which are unlikely to reprice even under significant changes in the interest rate environment. The remainder constitutes non-core NMDs.

113. Banks are required to estimate their level of core deposits using this two-step procedure for each deposit category, and then to aggregate the results to determine the overall volume of core deposits subject to imposed caps as shown in Table 2.

(c) Cash flow slotting

114. NMDs should finally be slotted into the appropriate time bucket or time bucket midpoint. Non-core deposits should be considered as overnight deposits and accordingly should be placed into the shortest/overnight time bucket or time bucket midpoint.

115. Banks should determine an appropriate cash flow slotting procedure for each category of core deposits, up to the maximum average maturity per category as specified in Table 2.

Table 2. Caps on core deposits and average maturity by category

	Cap on proportion of core deposits (%)	Cap on average maturity of core deposits (years)
Retail/transactional	90	5
Retail/non-transactional	70	4.5
Wholesale	50	4

4. Treatment of positions with behavioural options other than NMDs

116. The treatment set out in this section applies only to behavioural options related to retail customers. Where a wholesale customer has a behavioural option that may change the pattern of notional repricing cash flows, such options must be included within the category of automatic interest rate options.[19]

Standardised framework for positions with behavioural options other than NMDs

117. The standardised framework is applied to fixed rate loans subject to prepayments and term deposits subject to early redemption risk. In each case, the customer has an option, which, if exercised, will alter the timing of a bank's cash flows. The customer's exercise of the option is, among other factors, influenced by changes in interest rates. In the case of the fixed rate loan, the customer has an option to

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[19] An example of such an option would be a puttable fixed coupon bond issued by the bank in the wholesale market, for which the owner has the right to sell the bond back to the bank at a fixed price at any time.

repay the loan early (ie prepay); and for a fixed-term deposit, the customer may have an option to withdraw their deposit before the scheduled date.

118.   Under the standardised framework, the optionality in these products is estimated using a two-step approach. Firstly, baseline estimates of loan prepayments and early withdrawal of fixed-term deposits are calculated given the prevailing term structure of interest rates.[20]

119.   In the second stage, the baseline estimates are multiplied by scenario-dependent scalars that reflect the likely behavioural changes in the exercise of the options

Fixed rate loans subject to prepayment risk

120.   Prepayments, or parts thereof, for which the economic cost is not charged to the borrower, are referred to as uncompensated prepayments. For loan products where the economic cost of prepayments is never charged, or charged only for prepayments above a certain threshold, the standardised framework for fixed rate loans subject to prepayments set out below must be used to assign notional repricing cash flows.

121.   Banks must determine or supervisors prescribe the baseline conditional prepayment rate ($CPR_{0,c}^p$) for each portfolio p of homogeneous prepayment-exposed loan products denominated in currency c, under the prevailing term structure of interest rates.

122.   The conditional prepayment rate (CPR) for each portfolio p of homogeneous prepayment-exposed loan products denominated in currency c, under interest rate scenario i, is given as:

$$CPR_{i,c}^p = \min(1, \gamma_i \cdot CPR_{0,c}^p)$$

where $CPR_{0,c}^p$ is the (constant) base CPR of a portfolio p of homogeneous prepayment-exposed loans given in currency c[21] and given the prevailing term structure of interest rates. γ_i is a multiplier applied for scenario i as given in Table 3.

123.   Prepayment speeds vary according to the interest rate shock scenario. The multipliers (γ_i) reflect the expectation that prepayments will generally be higher during periods of falling interest rates and lower during periods of rising interest rates.

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[20]   These baseline parameter estimates may be determined by the bank subject to supervisory review and approval, or prescribed by the supervisor.

[21]   Alternatively, the base CPR may also vary over the life of each loan in the portfolio. In that case, it is denoted as $CPR(\mathrm{k})_{0,c}^p$ for each time bucket k or time bucket midpoint t_k.

Table 3. CPRs under the shock scenarios

Scenario number (i)	Interest rate shock scenarios	γ_i (scenario multiplier)
1	Parallel up	0.8
2	Parallel down	1.2
3	Steepener	0.8
4	Flattener	1.2
5	Short rate up	0.8
6	Short rate down	1.2

124.   The prepayments on the fixed rate loans must ultimately be reflected in the relevant cash flows (scheduled payments on the loans, prepayments and interest payments). These payments can be broken up into scheduled payments adjusted for prepayment and uncompensated prepayments:[22]

$$CF_{i,c}^P(k) = CF_{i,c}^S(k) + CPR_{i,c}^p \cdot N_{i,c}^p(k-1)$$

where $CF_{i,c}^S(k)$ refers to the scheduled interest and principal repayment, and $N_{i,c}^p(k-1)$ denotes the notional outstanding at time bucket $k–1$. The base cash flows (ie given the current interest rate yield curve and the base CPR) are given by $i=0$, while the interest rate shock scenarios are given for $i=1$ to 6.

Term deposits subject to early redemption risk

125.   Term deposits lock in a fixed rate for a fixed term and would usually be hedged on that basis. However, term deposits may be subject to the risk of early withdrawal, also called early redemption risk. Consequently, term deposits may only be treated as fixed rate liabilities and their notional repricing cash flows slotted into the time buckets or time bucket midpoints up to their corresponding contractual maturity dates if it can be shown to the satisfaction of the supervisor that:

- the depositor has no legal right to withdraw the deposit; or

- an early withdrawal results in a significant penalty that at least compensates for the loss of interest between the date of withdrawal and the contractual maturity date and the economic cost of breaking the contract.[23]

126.   If neither of these conditions is met, the depositor holds an option to withdraw and the term deposits are deemed to be subject to early redemption risk. Further, if a bank issues term deposits that do not meet the above criteria to wholesale customers, it must assume that the customer will always exercise the right to withdraw in the way that is most disadvantageous to the bank (ie the deposit is classified as an automatic interest rate option).

127.   Banks must determine or supervisors prescribe the baseline term deposit redemption ratio $TDRR_{o,c}^p$ applicable to each homogeneous portfolio p of term deposits in currency c and use it to slot the notional repricing cash flows. Term deposits which are expected to be redeemed early are slotted into the overnight time bucket ($k=1$) or time bucket midpoint (t_1).

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[22]   For simplicity, we have assumed there is no annual limit on prepayments. If a bank has an annual limit on uncompensated prepayments, this limit will apply.

[23]   However, often penalties do not reflect such an economic calculation but instead are based on a simpler formula such as a percentage of accrued interest. In such cases, there is potential for changes to profit or loss arising from differences between the penalty charged and the actual economic cost of early withdrawal.

128.   The term deposit redemption ratio for time bucket k or time bucket midpoint t_k applicable to each homogeneous portfolio p of term deposits in currency c and under scenario i is obtained by multiplying $TDRR_{o,c}^p$ by a scalar u_i that depends on the scenario i, as follows:

$$TDRR_{i,c}^p = \min(1, u_i \cdot TDRR_{o,c}^p)$$

where the values of the scalars u_i are set out in Table 4.

Table 4. Term deposit redemption rate (TDRR) scalars under the shock scenarios

Scenario number (i)	Interest rate shock scenarios	Scalar multipliers u_i
1	Parallel up	1.2
2	Parallel down	0.8
3	Steepener	0.8
4	Flattener	1.2
5	Short rate up	1.2
6	Short rate down	0.8

129.   The notional repricing cash flows which are expected to be withdrawn early under any interest rate shock scenario i are described as:

$$CF_{i,c}^p(1) = TD_{0,c}^p \cdot TDRR_{i,c}^p$$

where $TD_{0,c}^p$ is the outstanding amount of term deposits of type p.

5.   Automatic interest rate options

130.   This section describes the method for calculating an add-on for automatic interest rate options, whether explicit or embedded.[24, 25] This applies to sold automatic interest rate options. Banks have a choice to either include all bought automatic options or include only automatic options used for hedging sold automatic interest rate options:

1.   For each sold automatic option o in currency c, the value change, denoted $\Delta FVAO_{i,c}^o$, is calculated for each interest rate shock scenario i. The value change is given by:

  (i)   an estimate of the value of the option to the option holder,[26] given:

    a.   a yield curve in currency c under the interest rate shock scenario i; and

    b.   a relative increase in the implicit volatility of 25%;

    minus

  (ii)   the value of the sold option to the option holder, given the yield curve in currency c at the valuation date.

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[24]   The most important automatic interest rate options likely to occur in the banking book are caps and floors, which are often embedded in banking products. Swaptions, such as prepayment options on non-retail products, may also be treated as automatic interest rate options, as, in cases where such options are held by sophisticated financial market counterparties, the option holder will almost certainly exercise the option if it is in their financial interest to do so.

[25]   Any behavioural option positions with wholesale customers that may change the pattern of notional repricing cash flows are considered as embedded automatic interest rate options for the purposes of this subsection.

[26]   This estimate requires a methodology approved by the supervisor.

2. Likewise, for each bought automatic interest rate option q, the bank must determine the change in value of the option between interest rate shock scenario i and the current interest rate term structure combined with a relative increase in the implicit volatility of 25%. This is denoted as $\Delta\text{FVAO}_{i,c}^q$.

3. The bank's total measure for automatic interest rate option risk under interest rate shock scenario i in currency c is calculated as:

$$KAO_{i,c} = \sum_{o=1}^{n_c} \Delta FVAO_{i,c}^o - \sum_{q=1}^{m_c} \Delta FVAO_{i,c}^q$$

where n_c (m_c) is the number of sold (bought) options in currency c.

131. If the bank chooses to only include bought automatic interest rate options that are used for hedging sold automatic interest rate options, the bank must, for the remaining bought options, add any changes in market values reflected in the regulatory capital measure of the respective capital ratio (ie CET1, AT1 or total capital) to the total automatic interest rate option risk measure $KAO_{i,c}$.

6. Calculation of the standardised EVE risk measure

132. First, the loss in economic value of equity $\Delta EVE_{i,c}$ under scenario i and currency c is calculated for each currency with material exposures, ie those accounting for more than 5% of either banking book assets or liabilities, as follows:

1. Under each scenario i, all notional repricing cash flows are slotted into the respective time bucket $k \in \{1,2,\dots,K\}$ or time bucket midpoint $t_k, k \in \{1,2,\dots,K\}$. Within a given time bucket k or time bucket midpoint t_k, all positive and negative notional repricing cash flows are netted[27] to form a single long or short position, with the cancelled parts removed from the calculation. Following this process across all time buckets or time bucket midpoints leads to a set of notional repricing cash flows $CF_{i,c}(k)$ or $CF_{i,c}(t_k), k \in \{1,2,\dots,K\}$.[28]

2. Net notional repricing cash flows in each time bucket k or time bucket midpoint t_k are weighted by a continuously compounded discount factor:

$$DF_{i,c}(t_k) = \exp\big(-R_{i,c}(t_k) \cdot t_k\big)$$

that reflects the interest rate shock scenario i in currency c as set out in Annex 2, and where t_k is the midpoint of time bucket k. This results in a weighted net position, which may be positive or negative for each time bucket. The cash flows should be discounted using either a risk-free rate[29] or a risk-free rate including commercial margin and other spread components (only if the bank has included commercial margins and other spread components in its cash flows).

3. These risk-weighted net positions are summed to determine the EVE in currency c under scenario i (excluding automatic interest rate option positions):

$$EVE_{i,c}^{nao} = \sum_{k=1}^{K} CF_{i,c}(k) \cdot DF_{i,c}(t_k) \text{ (maturity buckets) or}$$

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[27] Intra-bucket mismatch risk arises as notional repricing cash flows with different maturity dates, but falling within the same time bucket or time bucket midpoint, are assumed to match perfectly. This is mitigated by introducing a high number of time buckets (ie K=19).

[28] Note that, depending on the approach taken for NMDs, prepayments and products with other embedded behavioural options, the notional repricing cash flows may vary by scenario i (scenario-dependent cash flow products).

[29] The discounting factors must be representative of a risk-free zero coupon rate. An example of an acceptable yield curve is a secured interest rate swap curve.

$$EVE_{i,c}^{nao} = \sum_{k=1}^{K} CF_{i,c}(t_k) \cdot DF_{i,c}(t_k) \text{ (maturity bucket midpoints)}$$

4. Then, the full change in EVE in currency c associated with scenario i is obtained by subtracting $EVE_{i,c}^{nao}$ from the EVE under the current interest rate term structure $EVE_{0,c}^{nao}$ and by adding the the total measure for automatic interest rate option risk $KAO_{i,c}$, as follows:

$$\Delta EVE_{i,c} = \sum_{k=1}^{K} CF_{0,c}(k) \cdot DF_{0,c}(t_k) - \sum_{k=1}^{K} CF_{i,c}(k) \cdot DF_{i,c}(t_k) + KAO_{i,c} \text{ (maturity buckets) or}$$

$$\Delta EVE_{i,c} = \sum_{k=1}^{K} CF_{0,c}(t_k) \cdot DF_{0,c}(t_k) - \sum_{k=1}^{K} CF_{i,c}(t_k) \cdot DF_{i,c}(t_k) + KAO_{i,c} \text{ (maturity bucket midpoints)}$$

Finally, the EVE losses $\Delta EVE_{i,c} > 0$ are aggregated under a given interest rate shock scenario i and the maximum loss across all interest rate shock scenarios is the EVE risk measure.[30]

$$\text{Standardised EVE risk measure} = \max_{i \in \{1,2,\dots,6\}} \left\{ \mathbf{max}\left(\mathbf{0}; \sum_{c: \underbrace{\Delta EVE_{i,c} > 0}_{\textit{loss in currency } c}} \underbrace{\Delta EVE_{i,c}}_{} \right) \right\}$$

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[30] National supervisors would, however, be allowed to prescribe a different method of currency aggregation for their banks, if the national supervisor is able to support, with evidence, that such a method would remain in line with the jurisdiction's appetite for IRRBB.

Annex 1

Interest rate risk and its measurement techniques[31]

1.   Definition of IRRBB

1.1   What is IRRBB?

IRRBB refers to the current or prospective risk to a bank's capital and to its earnings, arising from the impact of adverse movements in interest rates on its banking book.

Excessive IRRBB can pose a significant threat to a bank's current capital base and/or future earnings if not managed appropriately. Changes in interest rates can affect the underlying economic value of the bank's assets, liabilities and off-balance sheet instruments, because the present value of future cash flows (and, in many cases, the amounts of cash flows themselves) change when interest rates change. Changes in interest rates also affect a bank's earnings by increasing or decreasing its NII and the level of other interest rate-sensitive income and operating expenses.

1.2   Accounting and IRRBB

Fundamentally, there are two distinct methods for valuing banking book items, namely:

(a)   *"amortised" (or "historical") cost*, where values are based on initial cost less accumulated depreciation, taking account of the expected life/maturity of the item; and

(b)   *"fair" (or "market") value*, where values are based on market prices (where available) or on the net present value of expected cash flows, discounted at the prevailing rate (where no market price is available).

For items held at amortised cost, market interest rate changes do not significantly impact profit recognition or accounting values for existing instruments (significant changes in values would be from impairment that needs to be recognised as a permanent diminution in value). Income/cost on items held at amortised cost therefore emerges over time in line with maturity-adjusted cash flows.[32]

Accounting values of fair valued instruments can vary significantly from period to period, due to changes to external factors (eg interest rate changes can impact both the expected future cash flows and the discount rate used for calculation purposes). Income and cost are recognised either through profit and loss (P&L) or through equity, on the basis of changes to embedded value.

Since most IRRBB economic value measures aim to estimate the change in economic value under shocks and stresses, the presence or absence of higher/lower accounting values for amortised cost instruments is effectively ignored, as is the emergence of profit over time. It is therefore important to note that a loss in economic value does not automatically equate with accounting losses for this element of the banking book. Conversely, for assets held at fair value/mark-to-market, changes in interest rates directly affect current accounting values, and thus have an immediate impact on both P&L and available capital.

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[31]   This purpose of the Annex is to provide a set of terminology and definitions that will provide a better understanding of IRRBB to both banks and supervisors.

[32]   However, the accounting value may not be the same as the balance that needs to be managed for IRRBB purposes, because of the impact of *effective interest rate calculations* and the treatment of loan loss provisions.

1.3   Components of interest rates

Every interest rate earned by a bank on its assets, or paid on its liabilities, is a composite of a number of price components – some more easily identified than others. Theoretically, all rates contain five elements:

1.   The *risk-free rate*: this is the fundamental building block for an interest rate, representing the theoretical rate of interest an investor would expect from a risk-free investment for a given maturity.

2.   A *market duration spread*: the prices/valuations of instruments with long durations are more vulnerable to market interest rate changes than those with short durations. To reflect the uncertainty of both cash flows and the prevailing interest rate environment, and consequent price volatility, the market requires a premium or spread over the risk-free rate to cover duration risk.

3.   A *market liquidity spread*: even if the underlying instrument were risk-free, the interest rate may contain a premium to represent the market appetite for investments and the presence of willing buyers and sellers.

4.   A *general market credit spread*: this is distinct from idiosyncratic credit spread, and represents the credit risk premium required by market participants for a given credit quality (eg the additional yield that a debt instrument issued by an AA-rated entity must produce over a risk-free alternative).

5.   *Idiosyncratic credit spread*: this reflects the specific credit risk associated with the credit quality of the individual borrower (which will also reflect assessments of risks arising from the sector and geographical/currency location of the borrower) and the specifics of the credit instrument (eg whether a bond or a derivative).

In theory these rate components apply across all types of credit exposure, but in practice they are more readily identifiable in traded instruments (eg bonds) than in pure loans. The latter tend to carry rates based on two components:

•   The *funding rate,* or a *reference rate* plus a *funding margin*: the funding rate is the blended internal cost of funding the loan, reflected in the internal funds transfer price (for larger and more sophisticated banks); the reference rate is an externally set benchmark rate, such as Libor or the federal funds rate, to which a bank may need to add (or from which it may need to subtract) a funding margin to reflect its own all-in funding rate. Both the funding rate and the reference rate incorporate liquidity and duration spread, and potentially some elements of market credit spread. However, the relationship between the funding rate and market reference rate may not be stable over time – this divergence is an example of basis risk.

•   The *credit margin* (or *commercial margin*) applied: this can be a specific add-on (eg Libor + 3%, where the 3% may include an element of funding margin) or built into an administered rate (a rate set by and under the absolute control of the bank).

In practice, decomposing interest rates into their component parts is technically demanding and the boundaries between the theoretical components cannot easily be calculated (eg changes to market credit perceptions can also change market liquidity spreads). As a result, some of the components may be aggregated for interest rate risk management purposes.

Changes to the *risk-free rate, market duration spread, reference rate and funding margin* all fall within the definition of IRRBB. C*hanges to the market liquidity spreads and market credit spreads* are combined within the definition of CSRBB. The diagram below gives a visual representation of how the various elements fit together.

Figure 1 – Components of interest rates
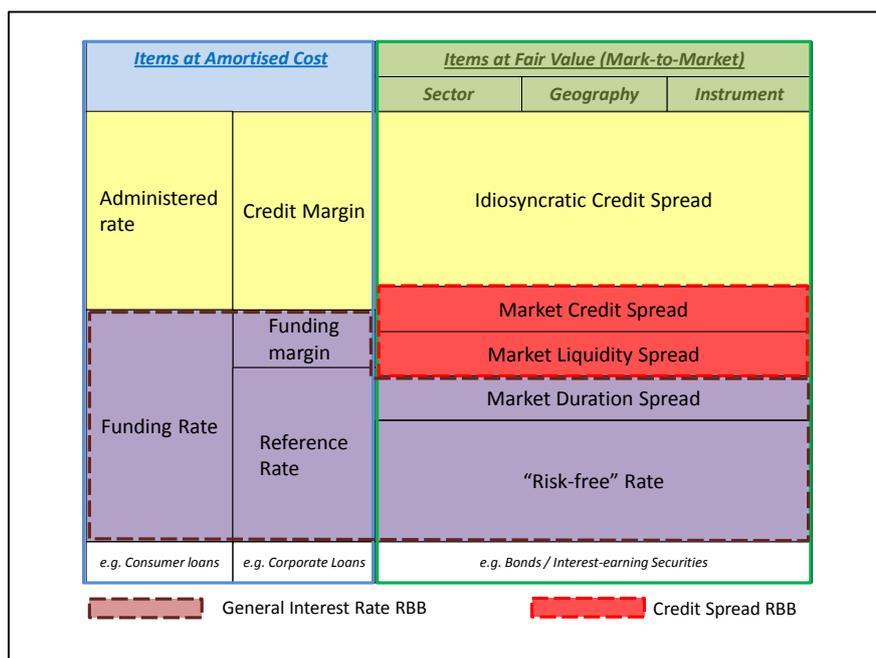
1.4 IRRBB and CSRBB

The main driver of IRRBB is a change in market interest rates, both current and expected, as expressed by changes to the shape, slope and level of a range of different yield curves that incorporate some or all of the components of interest rates.

When the level or shape of a yield curve for a given interest rate basis changes, the relationship between interest rates of different maturities of the same index or market, and relative to other yield curves for different instruments, is affected. This may result in changes to a bank's income or underlying economic value.

CSRBB is driven by changes in market perception about the credit quality of groups of different credit-risky instruments, either because of changes to expected default levels or because of changes to market liquidity. Changes to underlying credit quality perceptions can amplify the risks already arising from yield curve risk. CSRBB is therefore defined as any kind of asset/liability spread risk of credit-risky instruments which is not explained by IRRBB, nor by the expected credit/jump-to-default risk.

This document focuses mainly on IRRBB. CSRBB is a related risk that needs to be monitored and assessed.

1.5 Types of IRRBB driven by yield curve shifts

IRRBB derives from three fundamental aspects relating to the level and structural characteristics of interest rates, and the effects on these of changes to yield curves, namely the (i) gap, (ii) basis and (iii) optionality. These aspects of interest rate risk can occur simultaneously, and therefore need to be managed holistically.

- *Gap risk* arises from the term structure of banking book instruments, and describes the risk arising from the timing of instrument rate changes. Since rate resets on different instruments occur at different tenors, the risk to the bank arises when the rate of interest paid on liabilities increases before the rate of interest received on assets, or reduces on assets before liabilities. Unless hedged in terms of tenor and amount, the bank may be exposed to a period of reduced or negative interest margins, or may experience changes in the relative economic values of assets

and liabilities. The extent of gap risk depends also on whether changes to the term structure of interest rates occur consistently across the yield curve (parallel risk) or differentially by period (non-parallel risk).[33]

- *Basis risk* describes the impact of relative changes in interest rates for financial instruments that have similar tenors but are priced using different interest rate indices (bases) (eg an asset priced off Libor funded by a liability priced off US Treasuries). It arises from the imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar rate change characteristics. For the purposes of this Annex, IRRBB is defined as excluding changes in idiosyncratic credit margins.

- *Option risk* arises from option derivative positions or from the optional elements embedded in many bank assets, liabilities and off-balance sheet items, where the bank or its customers can alter the level and timing of their cash flows. For IRRBB purposes, option risk can be broken down into two distinct but related sub-types:

  o *automatic* option risk arising from standalone instruments, such as exchange-traded and over-the-counter option contracts, or explicitly embedded within the contractual terms of an otherwise standard financial instrument (eg a capped rate loan) and where the holder will almost certainly exercise the option if it is in their financial interest to do so; and

  o *behavioural* option risk arising from flexibility embedded implicitly or within the terms of financial contracts, such that changes in interest rates may effect a change in the behaviour of the client (eg rights of a borrower to prepay a loan, with or without penalty, or the right of a depositor to withdraw their balance in search of higher yield).

In addition to the pure economic risks that can arise from changes to the level and structure of interest rates, risks can arise from:

(a) *currency mismatches*, ie where the interest rate risks are in addition to normal exchange rate risks (this falls within a wider definition of basis risk); or

(b) *accounting treatment* of risk positions, ie where interest rate hedging activity may achieve the desired economic effect, but fail to achieve hedge accounting treatment.

2.   Measurement of IRRBB

2.1   Introduction

There are two complementary methods of measuring the potential impact of IRRBB:

(a)   changes in *expected earnings* (earnings-based measures); and

(b)   changes in *economic value* (EV, or EVE when measuring the change in value relative to equity).

The two methods are complementary in that:

- both measures reflect the impact of changing cash flows arising from changing interest rates;

- the change in expected earnings is reflected in the change in economic value; and

- they are affected by common assumptions.

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[33]   This may sometimes be referred to as "yield curve risk".

The key differences between the measures include:

- *Outcome measure*: EV measures compute a change in the net present value of the balance sheet under an interest rate stress. In undertaking such a calculation, a decision has to be made about whether the outcome should be computed as a change in the theoretical economic value of equity (EVE) – in which case, equity is either excluded from the EV calculation or included with a very short (overnight) duration; or whether the outcome should measure the change in economic value other than for assets representing equity – in which case, equity is either included with the same duration as the assets which it is deemed to be financing, or else both equity and its portfolio of financed assets are excluded (this is earnings-adjusted EV). EVE and earnings-adjusted EV are therefore specific forms of an EV measure. All EV measures can be expressed relative to equity, but EVE includes the change to equity value that would result from revaluing under stress its own financed portfolio of assets. Earnings-based measures focus on changes to future profitability. To the extent that future earnings eventually affect levels of future equity, the two measures are aligned, but the value changes estimated include adjustments to net income that occur beyond the horizon for earnings measures.

- *Time horizon*: EV measures reflect changes in value relative to equity over the remaining life of the balance sheet, ie until all positions have run off. Earnings-based measures cover only the short to medium term, and therefore do not capture in full those risks that will continue to impact profit and loss accounts beyond the period of estimation.

- *Future transactions*: EV measures usually just focus on changes to cash flows of instruments already on the balance sheet. Earnings-based measures can be based on balance sheet run-off, or a static balance sheet, but more sophisticated or dynamic models tend to consider the impact of new business/production that is expected to be written in the future, as well as the run-off of existing business.

2.2 Earnings-based measures

For earnings-based measures, the focus for analysis is the impact of changes in interest rates on future accrued or reported earnings.

The component of earnings that has traditionally received the most attention is NII, ie the difference between total interest income and total interest expense, taking account of hedging activity (eg via derivatives). This focus reflects both the importance of NII in banks' overall earnings and its direct link to changes in interest rates.[34]

An earnings-based measure offers the possibility of measuring risk under a range of different time horizons. The normal focus is on the short/medium-term horizon (typically one to three years, no more than five years), to limit the cumulative impact of underlying assumptions and the complexity of the calculations. As a consequence, an earnings-based measure is better suited to measuring the short- and medium-term vulnerabilities of the bank to IRRBB, assuming that it is able to continue in business (a going-concern viewpoint).

An earnings-based measure is therefore commonly used to assess the ability of a bank to generate stable earnings over a medium-term horizon, which will allow it to pay a stable level of dividend and reduce the beta on its equity price and therefore reduce its cost of capital. Hence, it is a measure in line with internal management and asset and liability management objectives.

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[34] Note, however, that, as some banks have expanded increasingly into activities that generate fee-based and other non-interest income, a broader focus on operating earnings/overall net income, incorporating both interest and non-interest income and expenses, has become more common.

In order to be able to calculate changes in expected earnings under different interest rate shocks and stress scenarios, an institution will need to be able to project future earnings under both the expected economic scenario that informs its corporate plan, and the interest rate shock and stress scenarios so that the differences can be measured. Such projections involve a range of further assumptions about client/market behaviour, and the bank's own management response to the evolving economic climate, including:

- the volume and type of new/replacement assets and liabilities expected to be originated over the evaluation period;

- the volume and type of asset and liability redemptions/reductions over that period;

- the interest rate basis and margin associated with the new assets and liabilities, and with those redeemed/withdrawn; and

- the impact of any fees collected/paid for exercise of options.

In practical terms, this may result in modelling of earnings under three different states:

(a)   *run-off balance sheet*: existing assets and liabilities not replaced as they mature, except to the extent necessary to fund the remaining balance sheet;

(b)   *constant balance sheet*: total balance sheet size and shape maintained by assuming like-for-like replacement of assets and liabilities as they run off; and

(c)   *dynamic balance sheet:* incorporating future business expectations, adjusted for the relevant scenario in a consistent manner, ie this is the most meaningful approach.

2.3   Change in economic value (EV)

Under an economic value approach, the measure of IRRBB is the theoretical change in the net embedded market value of the whole banking book.

The EV of a tradable instrument is its present value (PV). In the absence of embedded options, the PV of the instrument is determined from its contractual cash flows, which are discounted to reflect current market rates. As a first implication, instruments with short-term or variable rate cash flows have a present value that more nearly equals their face value (ie their *carrying value*). As a second implication, a change in market rates would not change the EV of such instruments. Third, the PV of an interest rate-sensitive instrument with uncertain contractual cash flows can only be valued on the basis of assumptions about behaviour and timing, which will tend to vary dependent upon external factors.

Applying the concept of EV to the whole balance sheet of a bank is more challenging: the banking book contains assets and liabilities that are accounted for at held-to-maturity valuation, and for which there may not be observable market prices (eg loans and receivables are not as readily marketable and their market value cannot be determined directly). Moreover, there may be embedded under- and overvaluations in the book on a mark-to-market basis, representing income or costs that will emerge in future reported earnings. In addition, margins on loans may be very heterogeneous, thus making determination of an appropriate discount rate problematic, and the cash flows that are being valued are subject to variation depending upon customer behaviour in response to rate changes (and customers may not behave as might rationally be expected). Finally, there may be structural positions (eg assets held to stabilise return on non-maturity deposits and/or equity) which will produce a significant change in value

under EV measurement, but where the risk measured is a direct corollary of risk reduction from an earnings volatility perspective.[35]

To avoid the complexity of measuring total EV, banks typically therefore focus on measuring the level of change to the net present value of the relevant balance sheet items, based on existing or adjusted cash flows that are revalued in line with the interest rate shock and stress scenarios. The change in the valuation is a measure of the level of IRRBB, and can be compared with the current value of equity to determine the change to the EVE.

3. Key considerations and assumptions

Both measures of IRRBB are significantly impacted by assumptions made for the purposes of risk quantification:

- the range of shocks to the possible changes in the level, slope and shape of interest rate yield curves that are required to produce an IRRBB effect on EV or earnings, and the economic stress scenarios that would be consistent with these shocks;

- expectations for the exercise of options (explicit and implicit) by both the bank itself and its customers under the given scenarios;

- treatment in risk quantifications of balances and interest flows arising from NMDs;

- the bank's own determination of the implied investment term of the bank's own equity capital liability; and

- the implications for IRRBB of adopted accounting practices.

3.1 Interest rate shocks and scenarios

In order to produce a quantitative estimate of IRRBB, it is necessary to assume a shock to current interest rate levels, which would allow the change in EV or earnings, and ultimately the effect on equity, to be computed. The size and shape of the shock will determine the measured outcome, and a range of shocks may be needed to identify all the potential facets of IRRBB (eg basis risks would not be captured by shocks that assume only parallel shifts of similar quantum in all yield curves). Designing interest rate change scenarios that are relevant to the business and sufficiently stressful is a key element of IRRBB management.

3.2 Exercise of options

Behaviour of option positions is one of the key set of assumptions that drive risk quantification measures. The approach taken by banks generally differs between automatic options, where the customer and bank can assume that the exercise of options will be based on rational expectations, and behavioural options, where behaviour will not always be rational and behavioural assumptions need to be used instead.

Automatic option positions can therefore be valued on the basis that exercise will always (and only) occur when there is financial benefit (with valuation based on standard financial modelling techniques and the results are fed into EV estimates). The rational expectation that the options will be

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[35] For example, a bank with $100 of capital could manage its earnings volatility by investing all capital in a long-dated fixed rate government security – which would lock in a consistent income but produce economic value risk if market rates changed and the mark-to-market value of the security declined. If its aim was to achieve economic value stability, it could invest its capital in the overnight market, but its earnings would then fluctuate with market interest rates. It is not possible for it to eliminate both EV and earnings risks simultaneously, so a trade-off is needed.

exercised can also be readily fed into forward projections of interest margin under earnings-based measures.

Behavioural option positions require more complex analysis of expected outcomes, since customers may exercise some options even when it is not in their financial interest to do so, or may not exercise options even when it would be to their benefit. The most complex area of behavioural analysis is for prepayment options on loans: the right to redeem early may be included voluntarily in a loan contract, or imposed on the lender by operation of national law; there may or may not be early redemption penalties payable, but again the size of these penalties may not reflect the actual economic costs and benefits involved (eg if limited by law or by operation of customer redress policy); and customers may choose to redeem for other reasons than the availability of a new loan at lower cost (eg due housing prices, borrowers' demographics, changing family composition, tax changes).

However, not all borrowers will act irrationally, and exercise of early redemption options will tend to have a detrimental effect on either an EV or an earnings-based measurement, ie in a classic case of convexity risk, borrowers will tend to repay fixed rate borrowings when rates fall (so that they can borrow again at a lower rate) and retain fixed rate positions when market rates rise (so that banks are unable to lend at the higher rates). In order to manage this redemption or extension risk, banks model their books to establish how much should be hedged, and for what period, in order to match their best expectations of cash flows. Such behavioural modelling is clearly prone to error, and needs frequent updating so that hedge positions can be adjusted. Therefore, when using economic value and earnings-based measures, banks need to review and adjust their calculations to account for any expected behaviours.

3.3   Commercial margins

The use of economic value and earnings-based measures involves estimating cash flows, but the content and treatment is different: for EV measures, all existing balance sheet items (both principal and interest flows) are discounted at a relevant rate, whereas NII measures include all cash flows, including all margins and principal flows from expected future business, and are normally not discounted.

3.4   NMDs

NMDs are liabilities of the banks in which the depositor is free to withdraw at any time since they have no contractually agreed maturity date. Notwithstanding, NMD balances have historically proved to be relatively stable in practice, even when market rates change, and balances lost can usually be replaced with new deposits at the same rate – so, overall, NMDs behave differently to other more rate-sensitive funding.[36] Any interest paid on NMDs is usually at rates significantly below those paid for wholesale or larger-denomination deposits, so NMD balances have historically represented an important source of stable and cost-effective funding.[37]

In considering IRRBB, the focus for some banks is therefore primarily on managing the risk of earnings volatility arising from NMDs. In order to achieve this, banks first identify core deposits, ie that element of NMDs that can be considered to be particularly stable under different interest rate scenarios so that a behavioural maturity can be ascribed specifically to them and matching assets allocated to stabilise earnings. In assessing core balances, banks discount those elements of transactional accounts

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[36]   A subset of NMDs is non-interest bearing current accounts, where balances may fluctuate but are generally not interest bearing: current account customers hold balances mainly for transactional purposes, and are more sensitive to service levels.

[37]   However, NMD sensitivity may have increased as a result of the sustained period of accommodative monetary policy in some of the world's largest economies.

which are subject to regular fluctuation (withdrawal followed by re-deposit) and overall seasonality of the NMD book.

The matching book of assets may then be managed dynamically to adjust for changes in levels of core deposits, and to maintain a constant maturity in line with expected behaviour and the bank's risk appetite. Although the behavioural maturity may be determined to be very long, the matching asset position carries risk to a bank's EV since, being fixed rate and of some duration, the net present value of this portfolio will vary with general interest rates. The maturity profile chosen will therefore be a compromise between protection of earnings for an extended period and increased risk to EV that could materialise on a shock event (eg a deposit run on NMDs, failure of the bank). Internal risk measures can be used to evaluate the extent and impact of the compromise made.[38]

3.5   A bank's own equity capital liability

In the same way as with NMDs, a bank's own equity capital liability represents an important source of structural risk and endowment return – in accounting terms, equity is the net value of assets less liabilities, so it represents assets for which there are no funding liabilities. Equity usually has a cost in the form of a dividend (although not in the case of mutual or cooperative organisations), and banks therefore seek to stabilise the earnings that can be made on assets funded by equity.

The technique involves defining net equity capital that is eligible for behavioural treatment – some assets are non-interest bearing (eg land and buildings) and may be considered to be financed by equity, so the value of equity available for behavioural treatment may be reduced accordingly.[39] Since equity capital has no contractual price reset date, banks determine their own strategies for managing the earnings volatility that arises from it using techniques similar to those for NMDs. Given that equity may be written down as a result of losses, regulators will normally focus on the EVE risk associated with any earnings profile ascribed to equity that may materialise as losses under stress events.

4.   Quantifying IRRBB

4.1   Introduction

As described in Section 2 of this Annex, there are two complementary measures of IRRBB. This section describes the main quantification techniques that are used by banks in order to monitor and manage the level of IRRBB inherent in their business models.

4.2   Quantifying change in economic value (EV)

Change in economic value can be measured using a variety of techniques, the most common of which are:

- *PV01*: present value of a single basis point change in interest rates based on gap anaylsis;

- *EVE*: economic value of equity; and

- *EVaR*: economic value-at-risk.

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[38]   One common technique for achieving a constant maturity profile is a *replicating portfolio* of matching assets that produces a moving average fixed return in line with the risk appetite (eg a portfolio where one sixtieth of the total is reinvested each month for five years fixed will deliver a weighted average maturity of 2.5 years and a moving average of the five-year rate).

[39]   Banks may also determine that a portion of equity should remain invested short-term as a buffer against losses that may be incurred under a more general business stress.

The techniques differ in their complexity and ability to capture different types of interest rate sensitivity (gap risk (parallel and non-parallel), yield curve risk, basis risk and option risk). Multiple measures of EV sensitivity therefore produce a better overall understanding of risks embedded in the banking book.

Gap analysis can be used to derive the duration profile of the banking book or, equivalently, the profile of the present value of a single basis point change in interest rates (PV01). Gap analysis allocates all relevant interest rate-sensitive assets and liabilities to a certain number of predefined time buckets according to their next contractual reset date. The analysis also allocates equity, NMDs, prepaying loans or other instruments with future cash flows subject to customer behaviours according to general/behavioural assumptions regarding their maturity or reset date. It then measures the arithmetic difference (the gap) between the amounts of assets and liabilities in each time bucket, in absolute terms. Each time bucket gap can be multiplied by an assumed change in interest rates to yield an approximation of the change in NII that would result from an increase in interest rates. This method gives a visual impression of the risk exposure dispersion relative to the repricing profile, reflecting exposures to parallel as well as non-parallel gap risk. It does not, however, quantify this risk.[40] The measure assumes that all positions within a particular time bucket mature and reprice simultaneously, ignoring potential basis risks within the gaps.

EV measures mainly focus on valuing the cash flows arising from existing assets and liabilities under different future interest scenarios, ignoring future business flows. The change in EV (ie the change in the NPV of future cash flows as a result of a change in rates) can be calculated across all types of assets and liabilities. When a change in the EV of the whole banking book is calculated, the outcome is highly influenced by the treatment of the bank's own equity capital liability in the calculation. There are two possible approaches:

(i)   Since accounting equity is the net residual figure that arises from subtracting total liabilities from total assets (including off-balance sheet items), measuring the change in the net present value of those assets and liabilities under a stressed interest rate scenario shows the actual level of risk to the economic value of equity. In this calculation, therefore, no rate or term is applied to equity itself, which is therefore excluded, and the NPV outcome is compared with the starting value of equity in order to measure the proportionate size of the change. This is the EVE measure.

(ii)   Given that equity finances surplus assets that earn an endowment return for the bank, the change in value of any asset portfolio that has been created to reduce the volatility of earnings on equity is not a relevant EV risk for the bank (ie it has taken the EV risk specifically to hedge earnings risk). In this calculation, therefore, equity is included in the calculation and treated as having the same interest rate/term characteristics as the portfolio of assets that hedges the earnings on it. The NPV outcome is still compared with the starting value of equity, but measures only risks arising from non-structural positions. This measure is *earnings-adjusted EV*.

EVE measures the theoretical change in the net present value of the balance sheet excluding equity. The measure therefore depicts the change in equity value resulting from an interest rate shock. Under this method, the value of equity under alternative stress scenarios is compared with the value under a base scenario. All cash flows from on-balance sheet and off-balance sheet interest rate-sensitive items in the banking book may be included in the computation. The market value of equity is computed as the present value of asset cash flows, less the present value of liability cash flows, without including assumptions on the interest rate sensitivity of equity. For internal measurement purposes, a bank may complement its computation of EVE with a separate earnings-adjusted EV model that uses assumptions about the investment term of equity, whereby its interest rate sensitivity is taken into account.

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[40]   A variant of the technique, modified duration, could be applied, which shows the relative change in the market value of a financial instrument corresponding to marginal parallel shift of the yield curve (eg by 1 percentage point). The weakness of this technique is that it measures only marginal shifts of the yield curve and works only for parallel shifts.

The accuracy of the measure is extremely dependent upon the precision of the cash flows calculated, and on the discount rates used in the calculation. When the expected cash flows are calculated, any likelihood that the size and the timing of future cash flows may differ between scenarios depending upon customer behaviour in reaction to the rate environment needs to be considered.

Depending on its specific design, an EV/EVE measure can capture all types of interest rate sensitivity. Gap risk (parallel and non-parallel) will be captured depending on the specific yield curve risk used in the alternative scenario. In computing EV, a full revaluation of automatic options would be normal under each of the alternative scenarios, so automatic option risk measurement is an integral part of a standard EV measure. Behavioural optionality can also be captured if stressed behavioural assumptions are used in alternative scenarios. Banks can then compute the EV effect of a change in customer behaviour either separately or in conjunction with a yield curve shift.

EV is a technique that can also be used to estimate basis risk in the banking book, either in isolation, or when combined with a general yield curve shift or with a change in assumed parameters. Basis risk can be measured by designing a scenario under which there is a divergence in the different base rates to which a bank is specifically sensitive.

Economic value at risk (EVaR) measures the expected maximum reduction of market value that can be incurred under normal market circumstances over a given time horizon or holding period and subject to a given confidence level. For calculation of EVaR in the banking book, the changes in the market value of the banking book and thus of the equity are computed for a set of alternative yield curve scenarios. When the EVaR approach is applied to the banking book, the time horizon is normally consistent with the economic model of the banking book. The standard VaR approach comprises three different techniques: historical simulation, variance-covariance approach[41] and Monte Carlo simulation.

EVaR models are suited to capture all types of interest rate sensitivity such as EVE. However, EVaR measurement techniques have their limitations. EVaR is designed for normal market circumstances and does not adequately assess tail risk. Both historical VaR and variance-covariance VaR are backward-looking methods which are prone to missing the tail events that carry significant risks. The Monte Carlo simulation method is very demanding in terms of technology and computational power.

4.3   Earnings-based measures

Earnings-based measures look at the expected increase or reduction in NII over a shorter time horizon (typically one to three years, up to a maximum five years) resulting from interest rate movements that are composed of either a gradual or a one-time large interest rate shock. The change in NII is the difference in the expected NII between a base scenario and an alternative, more stressful scenario. The base case scenario reflects the bank's current corporate plan in projecting the volume, pricing and repricing dates of future business transactions. Interest rates used for resetting transactions in the base scenario can be derived from market expected rates or from spot rates. The rate for each instrument will also contain appropriate projected spreads and margins

In assessing the possible extent of change in NII, banks can use models to predict the path of rates and the run-off of existing assets and liabilities. Earnings measures can be differentiated according to the complexity of their forward calculations of income, from simple run-off models which assume that existing assets and liabilities mature without replacement, to constant balance sheet models which assume that assets and liabilities are replaced like for like, to the most complex dynamic models which reflect the changes in the volumes and types of business that will be undertaken (or not undertaken) in differing interest rate environments, with the expected level of prices in those circumstances.

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[41]   Under this approach, interest rates of different tenors are derived from historical observations of changes and a variance-covariance matrix is constructed to account for the correlations between the rate shocks across tenors.

An earnings-based measure analyses the interest rate risk profile of the banking book in a detailed way tailored to the bank's specific circumstances. As it can account for new business, it reflects a full going-concern perspective. Depending on the design of the alternative scenarios, this method is able to capture all different types of interest rate risk sensitivity. Banks are able to incorporate fully the cash flow changes that occur under alternative scenarios due to automatic options.

However, the results of the modelling are highly sensitive to assumptions about customer behaviour as well as to the anticipated management responses to different rate scenarios. Earnings-based measures cover a relatively short time horizon, so changes in earnings falling beyond the observation period are ignored (including those arising from any behavioural treatment of NMDs and/or equity that involves long-term structural positions to reduce earnings volatility). Last but not least, earnings-based measures do not necessarily identify the risks to capital that can arise from revaluation of available-for-sale portfolios.

Annex 2

The standardised interest rate shock scenarios

Banks should apply six prescribed interest rate shock scenarios to capture parallel and non-parallel gap risks for EVE and two prescribed interest rate shock scenarios for NII. These scenarios are applied to IRRBB exposures in each currency for which the bank has material positions. In order to accommodate heterogeneous economic environments across jurisdictions, the six shock scenarios reflect currency-specific absolute shocks as specified in Table 1 below. For the purposes of capturing the local rate environment, a historical time series ranging from 2000 to 2015 for various maturities[42] was used to derive each scenario for a given currency.

Under this approach, IRRBB is measured by means of the following six scenarios:

(i)   parallel shock up;

(ii)   parallel shock down;

(iii)   steepener shock (short rates down and long rates up);

(iv)   flattener shock (short rates up and long rates down);

(v)   short rates shock up; and

(vi)   short rates shock down

The final calibration of the interest rate shock size determined by the Basel Committee at the time of publication is as follows:

Table 1. Specified size of interest rate shocks $\bar{R}_{shocktype,c}$

	ARS	AUD	BRL	CAD	CHF	CNY	EUR	GBP	HKD	IDR	INR
Parallel	400	300	400	200	100	250	200	250	200	400	400
Short	500	450	500	300	150	300	250	300	250	500	500
Long	300	200	300	150	100	150	100	150	100	350	300

	JPY	KRW	MXN	RUB	SAR	SEK	SGD	TRY	USD	ZAR
Parallel	100	300	400	400	200	200	150	400	200	400
Short	100	400	500	500	300	300	200	500	300	500
Long	100	200	300	300	150	150	100	300	150	300

Given Table 1, the instantaneous shocks to the risk-free rate for parallel, short and long, for each currency, the following parameterisations of the six interest rate shock scenarios should be applied:

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[42]   Jurisdictions may under national discretion, deviate from the initial 16-year period if it better reflects their idiosyncratic circumstances.

(i)   *Parallel shock for currency c*: a constant parallel shock up or down across all time buckets.

$$\Delta R_{parallel,c}(t_k) = \pm \bar{R}_{parallel,c}$$

(ii)   *Short rate shock for currency c*: shock up or down that is greatest at the shortest tenor midpoint. That shock, through the shaping scalar $S_{short}(t_k) = (e^{\frac{-t_k}{x}})$, where x=4, diminishes towards zero at the tenor of the longest point in the term structure.[43, 44]

$$\Delta R_{short,c}(t_k) = \pm \bar{R}_{short,c} \cdot S_{short}(t_k) = \pm \bar{R}_{short,c} \cdot e^{\frac{-t_k}{x}}$$

(iii) *Long rate shock for currency c (note: this is used only in the rotational shocks)*: Here the shock is greatest at the longest tenor midpoint and is related to the short scaling factor as: $S_{long}(t_k) = 1 - S_{short}(t_k)$.

$$\Delta R_{long,c}(t_k) = \pm \bar{R}_{long,c} \cdot S_{long}(t_k) = \pm \bar{R}_{long,c} \cdot \left(1 - e^{\frac{-t_k}{x}}\right)$$

(iv)   *Rotation shocks for currency c*: involving rotations to the term structure (ie *steepeners* and *flatteners*) of the interest rates whereby both the long and short rates are shocked and the shift in interest rates at each tenor midpoint is obtained by applying the following formulas to those shocks:

$$\Delta R_{steepener,c}(t_k) = -0.65 \cdot |\Delta R_{short,c}(t_k)| + 0.9 \cdot |\Delta R_{long,c}(t_k)|.$$

$$\Delta R_{flattener,c}(t_k) = +0.8 \cdot |\Delta R_{short,c}(t_k)| - 0.6 \cdot |\Delta R_{long,c}(t_k)|.$$

National supervisors may, at their discretion, set floors for the post-shock interest rates under the six interest rate shock scenarios, provided the floors are not greater than zero.

Examples

Short rate shock: Assume that the bank uses the standardised framework with K=19 time bands and with t_K=25 years (the midpoint (in time) of the longest tenor bucket K), and where t_k is the midpoint (in time) for bucket k. In the standardised framework, if k=10 with t_k=3.5 years, the scalar adjustment for the short shock would be $S_{short}(t_k) = (e^{\frac{-3.5}{4}}) = 0.417$. Banks would multiply this by the value of the short rate shock to obtain the amount to be added to or subtracted from the yield curve at that tenor point. If the short rate shock was +100 bp, the increase in the yield curve at t_k=3.5 years would be 41.7 bp.

Steepener: Assume the same point on the yield curve as above, t_k=3.5 years. If the absolute value of the short rate shock was 100 bp and the absolute value of the long rate shock was 100 bp (as for the Japanese yen), the change in the yield curve at t_k=3.5 years would be the sum of the effect of the short rate shock plus the effect of the long rate shock in basis points: $-0.65 \cdot 100bp \cdot 0.417 + 0.9 \cdot 100bp \cdot (1 - 0.417) = +25.4bp$.

Flattener: The corresponding change in the yield curve for the shocks in the example above at t_k=3.5 years would be: $+0.8 \cdot 100bp \cdot 0.417 - 0.6 \cdot 100bp \cdot (1 - 0.417) = -1.6bp$.

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[43]   The value of x in the denominator of the function $e^{\frac{-t_k}{x}}$ controls the rate of decay of the shock. This should be set to the value of 4 for most currencies and the related shocks unless otherwise determined by national supervisors.

[44] t_k is the midpoint (in time) of the kth bucket and t_K is the midpoint (in time) of the last bucket K. There are 19 buckets in the standardised framework, but the analysis may be generalised to any number of buckets.

Recalibrations over time

The Committee acknowledges that shock sizes of different currencies should reflect local conditions in a timely manner. For this reason, the Committee will review the calibration of the interest rate shock sizes (eg every five years).

Derivation of the interest rate shocks in Table 1

In order to derive the shocks described in Table 1, the following general steps are taken:

Step 1. Generate a 16-year time series of daily average interest rates for each currency c. The average daily interest rates from the year 2000 (3 January 2000) to 2015 (31 December 2015) are contained in Table 2. The average local percentile of the rate series is determined by calculating the average rate across all daily rates in time buckets 3m, 6m, 1Y, 2Y, 5Y, 7Y, 10Y, 15Y and 20Y.

Table 2. Average interest rates by currency

	ARS	AUD	BRL	CAD	CHF	CNY	EUR	GBP	HKD	IDR	INR
Average	3363	517	1,153	341	183	373	300	375	295	1,466	719

	JPY	KRW	MXN	RUB	SAR	SEK	SGD	TRY	USD	ZAR
Average	89	471	754	868	360	330	230	1,494	329	867

Step 2. The global shock parameter is prescribed based on the weighted average of the currency-specific shock parameters: $\bar{\alpha}_i$. The shock parameter for scenario i is a weighted average of the $\alpha_{i,c,h}$ across all currencies and defined as α_i. The following baseline global parameters are obtained:

Table 3. Baseline global interest rate shock parameters

Parallel	$\bar{\alpha}_{parallel}$	60%
Short rate	$\bar{\alpha}_{short}$	85%
Long rate	$\bar{\alpha}_{long}$	40%

Applying the α_i from Table 3 to the average long-term rates from Table 2 results in the revised interest rate shocks by currency for parallel, short and long segments of the yield curve in Table 4.

Table 4. Revised interest rate shocks $\Delta \tilde{R}_{shocktype,c}$

	ARS	AUD	BRL	CAD	CHF	CNY	EUR	GBP	HKD	IDR	INR
Parallel	2,018	310	692	204	110	224	180	225	177	880	431
Short	2,858	440	980	290	155	317	255	319	251	1,246	611
Long	1,345	207	461	136	73	149	120	150	118	586	288

	JPY	KRW	MXN	RUB	SAR	SEK	SGD	TRY	USD	ZAR
Parallel	53	283	452	521	216	198	138	896	197	520
Short	75	401	641	738	306	280	196	1,270	279	737
Long	35	188	301	347	144	132	92	597	131	347

However, the proposed interest rate shock calibration can lead to unrealistically low interest rate shocks for some currencies and to unrealistically high interest rate shocks for others. In order to ensure a minimum level of prudence and a level playing field, a floor of 100 bp and variable caps (denoted as $\Delta \bar{R}_j$) are set for the scenarios concerned, those caps being 500 bp for the short-term, 400 bp for the parallel and 300 bp for the long-term interest rate shock scenario. Supervisors may, applying national discretion, set a higher floor under the local interest rate shock scenarios for their home currency.

The change in the risk-free interest rate for shock scenario j and currency c can be defined as:

$$\bar{R}_{j,c} = \max\left\{100, \min\left\{\Delta \tilde{R}_{j,c}, \Delta \bar{R}_j\right\}\right\},\ [45]$$

where $\Delta \bar{R}_j = \{400, 500, 300\}$, for j=*parallel*, *short* and *long*, respectively.

Applying the caps and floors to the shocks described in Table 4 results in the final set of interest rate shocks by currency that is shown in Table 1.[46]

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[45] In the case of rotation shock scenarios, $\Delta \tilde{R}_{j,c}(t_1)$ cannot exceed 500 bp and $\Delta \tilde{R}_{j,c}(t_K)$ cannot exceed 300 bp.

[46] Supervisors may also, applying national discretion, set a zero or negative lower bound for the post-shock interest rates, where:

$$\tilde{R}_{j,c}(t_k) = max\{\tilde{R}_{0,c}(t_k) + \Delta \tilde{R}_{j,c}(t_k), [zero\ or\ negative\ lower\ bound\ set]\}$$