

**Good practices on using behavioural models for
measuring interest rate risk in the banking book**

The HKMA conducted a recent review of the behavioural models used by authorized institutions (AIs) for measuring IRRBB and the corresponding controls, in the light of the lessons learnt from the 2023 Banking Turmoil in the US and Europe¹. The review focused on AIs' models used for estimating the proportion of core deposits in their non-maturity deposits (NMDs) and the corresponding behavioural maturity. This annex summarises the key observations on the approaches and good practices adopted by the reviewed AIs. AIs using or intending to use behavioural models for measuring IRRBB, including but not limited to NMD-related models, should give due consideration to these observations and good practices, and take steps to strengthen their approaches as appropriate with a view to enhancing the reliability and accuracy of their IRRBB measurements.

I. Model governance and senior management oversight

Key observations

Most of the reviewed AIs had put in place a framework to govern the adoption of behavioural models with the aim of generating reliable IRRBB measurements. These AIs' model governance frameworks in general encompassed a specific set of policies and procedures (P&Ps), documentation, model validation both before and after implementation, ongoing monitoring, reporting on model outputs and performance, and senior management oversight. The breadth and depth of the AIs' frameworks, however, varied.

Good practices

1. *Well-established P&Ps* – The reviewed AIs that demonstrated strong governance had set out clear P&Ps covering the development, validation, monitoring and use of behavioural models. Roles and responsibilities of the relevant parties including the three lines of defence and senior management had been clearly defined in these P&Ps to ensure consistency and accountability in model risk management. These AIs also reviewed their P&Ps regularly (e.g. once a year) to ascertain their ongoing appropriateness.
2. *Adequate senior management oversight* – Senior management play an important role in an AI's risk governance. In some reviewed AIs, the senior management exercised effective oversight of behavioural models, not only received and

¹ The 2023 Banking Turmoil in the US and Europe revealed that inappropriate use of behavioural models by banks for measuring their interest rate risk in the banking book (IRRBB) could lead to substantial underestimation of banks' risk exposures. This in turn would undermine the effectiveness of bank supervisors in their ongoing surveillance of banks' risk profile and assessment of the need to take supervisory actions in order to maintain or enhance the safety and soundness of the banks concerned.

rigorously reviewed reports on model outputs, performance and related analyses, but also critically challenged various aspects of the behavioural models, such as key assumptions, reasonableness of outputs, justifications for adopting overlays or changes to model parameters, etc.. These senior management were also actively involved in the relevant approval processes (e.g. model changes and overlays), and were fully aware of the model limitations and uncertainty surrounding the modelled behavioural maturities. They had given timely steer to mitigate model risks arising from, for instance, emerging trends and unexpected changes in depositor behaviours and interest rate environment.

3. *Comprehensive documentation* – Good practices have been observed amongst the reviewed AIs which maintained thorough model documentation detailing the methodologies and assumptions, data sources, options considered and choices made during the model development process, validation approaches and limitations of the adopted models. In addition to this static type of documentation, these AIs produced elaborated reports on model validation and ongoing monitoring, as well as maintained proper records of senior management discussion and sign-offs. These AIs' documentation provided clear audit trails of all key aspects of their behavioural models, enabling them to demonstrate to the HKMA their compliance with the relevant regulatory requirements and laying down a solid foundation for future model enhancements.
4. *Effective internal audit function (IAF)* – An effective IAF is an essential element contributing to robust governance of behavioural models. To support the IAF to discharge its responsibility in this regard, some of the reviewed AIs had strengthened the talent pool of their IAF by, for instance, recruiting audit staff with relevant expertise (e.g. model development, validation and model risk governance) or providing adequate training to their existing IAF staff members to equip them with the relevant knowledge. These AIs' audit work was in general more in-depth and thorough. In addition, some of the reviewed AIs had included controls over behavioural models as a regular item in their annual audit plans to ascertain the ongoing adherence to and effectiveness of the established governance framework. Some of the AIs also hired external auditors to review their behavioural models and the relevant controls on a regular basis to supplement the work performed by the IAF.

II. Modelling approaches

Key observations

Most of the reviewed AIs had adopted a modelling approach that met the minimum requirements stipulated in the HKMA's Supervisory Policy Manual module IR-1 on "Interest Rate Risk in the Banking Book" (SPM IR-1). Some of the AIs conducted additional analyses and adopted modelling approaches that exceeded these minimum requirements in order to accurately capture depositors' behaviours in their IRRBB measurements.

Good practices

5. *Granular segmentation of NMDs* – Characteristics of different types of NMDs may trigger distinct depositor responses when interest rates change. Even within the same type of NMDs, depositors may behave differently depending on their characteristics. Granular segmentation of deposits can potentially improve model accuracy by capturing the heterogeneity of these characteristics in NMDs such that depositor behaviours in each of the identified segments are more aligned.

Good practices have been observed amongst the reviewed AIs which conducted comprehensive analyses to segment their NMDs with a sufficient level of granularity. Segmentation criteria considered by these AIs included demographics or business sectors of depositors, account features, outstanding balances, currencies of deposits, relationships between the AIs and depositors, transaction frequency as well as other variables that indicated or influenced depositor behaviours. These AIs also assessed the economic plausibility of their segmentation criteria and the resulting behavioural maturities generated by their models, e.g. a segment characterised by a stable relationship between the AI and depositors was expected to have a relatively long behavioural maturity. They also compared and analysed the segmentation of NMDs for measuring IRRBB with their observations from and practices on liquidity risk management. If there were substantial unexplainable discrepancies, the AIs concerned had investigated and refined the NMD segmentation where necessary.

6. *Incorporation of forward-looking elements into modelling* – Modelling of depositor behaviours relying solely on historical data may not provide adequate predictive power due to the evolving operating environment for AIs as well as changes in the AIs' own business strategies. In particular, the growing digitalisation of banking services and shifts in interest rate environment may undermine the reliability of model outputs that are estimated based on historical data. The HKMA observed good practices amongst the reviewed AIs which had incorporated forward-looking elements into their modelling processes, such as market and macroeconomic trends, competitors' actions and reactions, their own business strategies, technological advancement and penetration of digital banking, and changes in regulatory requirements and depositor preferences. Where necessary, some of these AIs had exercised expert judgement conservatively in order to mitigate the drawbacks of using historical data in modelling.
7. *Scenario-specific modelling of interest rate effects on NMDs* – Depositor preferences for different types of deposits may shift considerably under different interest rate shock scenarios. For instance, when interest rates increase, depositors tend to hold more term deposits than savings deposits in order to obtain higher yields. Conversely, falling interest rates could prompt customers to favour more liquid savings deposits over term deposits. As one of the good practices contributing to more accurate IRRBB measurements, some of the reviewed AIs had incorporated into their behavioural models the potential changes in deposit mix under the standardised interest rate shock scenarios set out in SPM IR-1.

III. Model performance monitoring and validation

Key observations

Most of the reviewed AIs conducted model validation at least once a year, while a few of them reviewed their models every 2 to 3 years. The latter's practices were found to be inadequate, as their model outputs might have become inaccurate but remained undetected in the fast-changing environment nowadays. When conducting regular model reviews and performance monitoring, most of the AIs backtested the model outputs against actual outcomes and assessed the underlying economic rationale for the deviations to validate the reliability of their models. A few AIs relied on other analyses that did not directly evaluate the model performance, and upon the HKMA's advice, had taken enhancement measures to perform backtesting.

Good practices

8. *Regular monitoring of performance and independent validation* – Depositor behaviours are dynamic, resulting in evolving model performance over time. Good practices have been observed amongst the reviewed AIs which regularly monitored the performance of their behavioural models through backtesting and sensitivity analyses (e.g. how IRRBB measurements shift as model assumptions or outputs change). By establishing a clear set of model performance indicators and tolerance thresholds, these AIs could effectively detect deterioration in model performance or shifts in depositor behaviours, and take timely remedial actions when necessary. In addition, these AIs conducted independent validation not only when the models were first developed, but also as an ongoing exercise after the models had been put into use. This helped track the known model limitations and identified new issues that might arise, and ascertained the ongoing appropriateness and relevance of the assumptions underpinning the models, especially as economic conditions and depositor behaviours evolved.
9. *Ad hoc model review* – Relying solely on periodic model review is insufficient due to the dynamic nature of the banking environment. For instance, abrupt increases in interest rates may prompt depositors to move their monies to higher-yielding accounts. Shifts in the competitive landscape (e.g. introduction of new deposit products by the AI itself or by other AIs) may also lead to different behavioural patterns that may not be adequately captured by the existing models. In such circumstances, conducting ad hoc model reviews is essential to timely evaluate the reliability of the existing models. Some of the reviewed AIs had established specific conditions (both quantitative and qualitative) that triggered ad hoc model reviews to ensure that they could respond to market changes and maintain the reliability and relevance of their models. These AIs also used expert judgement to initiate ad hoc reviews to address circumstances not covered by the specified conditions.

IV. Use of model outputs

Key observations

As part of their IRRBB management process, most of the reviewed AIs regularly reported model outputs to their senior management and relevant committees for review and discussion. Some of these AIs also used the model outputs in formulating strategies for hedging IRRBB and managing deposits, rather than using the model outputs merely for regulatory reporting.

Good practices

10. *Comprehensive reporting to inform decision making* – An AI which has strong model governance and endeavours to maintain the reliability of its models tends to have high confidence in using the model outputs in risk management and formulation of business strategies. Amongst the reviewed AIs, some had distinguished themselves by recognising the interplay between depositor behaviours and business strategies, and put in place a framework to integrate the model outputs into their decision-making processes. These AIs provided senior management with reports that were more comprehensive than those with the basic model outputs, and included detailed analyses which allowed the senior management to gain insight into the potential outcome of their strategies. By analysing the model outputs (e.g. through sensitivity analyses), the senior management could better understand potential risks and opportunities, and dynamically adjust the strategies as appropriate.

V. Third-party vendor or group-level models

Key observations

Some of the reviewed AIs that belong to international banking groups had adopted behavioural models developed by their head offices for consistency and operational efficiency. Many other reviewed AIs had opted for models developed by third-party vendors in order to leverage external expertise to enhance their capabilities for measuring depositor behaviours and hence IRRBB. These AIs in general demonstrated that they had a good understanding of the models adopted from their head offices or third-party vendors.

Good practices

11. *Bank- and jurisdiction-specific calibration and adaptations* – Amongst the reviewed AIs which had adopted group or third-party vendor models, good practices have been observed from some of them that these AIs' own data had been used to calibrate these models. In addition, adaptations had been made to these models to take account of jurisdiction-specific considerations such as regulatory requirements, competitive environment and market conditions. These enabled the models to capture the unique behavioural patterns and depositor profiles specific to the AIs, enhancing their relevance and accuracy.

12. *In-house independent validation and effective oversight* – The reviewed AIs using group-level or third-party vendor models had established dedicated in-house teams to conduct independent validation of these models. Good practices have been observed for some AIs that their in-house validation teams rigorously challenged the model assumptions, methodologies and outputs, ensuring they align with the AIs' specific needs. These AIs had put the group-level or third-party vendor models under their model risk governance framework, which included regular reviews, performance monitoring and audits. They had also implemented feedback protocol to facilitate discussions with representatives of their head offices or vendors regarding model performance, emerging issues and potential enhancements that might be made to the models to maintain their ongoing appropriateness.