



Building a robust model risk management framework

Banks rely on various quantitative and qualitative techniques for complex decision-making in almost all the areas they operate in. Quantitative and qualitative techniques that help banks to make financial decisions are often referred to as models. According to the supervisory guidelines on model risk management (MRM) SR 11-7,¹ 'A model consists of three components: an information input component, which delivers assumptions and data to the model; a processing component, which transforms inputs into estimates; and a reporting component, which translates the estimates into useful business information.'

With advancement in technology and availability of big data, financial markets and regulatory expectations have become more sophisticated and complex in the last decade. Banks need to implement more models with advanced modelling techniques to make critical business decisions in an ever-evolving economic, geopolitical, and regulatory scenario. This makes banks heavily reliant on numerous models for day-to-day activities, exposing them to significant model risk. Since models use a set of assumptions as part of the model methodology to process the input data and provide meaningful estimates, there is always some amount of uncertainty involved in using them. This is referred to as model risk, namely the risk of loss resulting from the use of inappropriate or incorrect models for the decision-making process.

The global financial crisis of 2008 revealed the risks posed by the incorrect and inappropriate usage of models. However, even after the crisis, there have been instances where large financial institutions have suffered either from huge monetary losses or adverse costs in terms of bad strategic decisions due to model risk. To address this, financial regulators around the globe have issued various stringent comprehensive guidelines for banks to ensure effective MRM. Some of the key regulations that provide guidance on various MRM activities are listed in the table given below.

Table 1: Key regulations which emphasise the model risk area

Office of Comptroller of the Currency (OCC) 2000–16 bulletin on risk modeling	In 2000, the OCC ² issued regulatory guidelines regarding financial models targeting risks that creep in due to improper testing and model validation.
SR 11-7	In April 2011 ³ , supervisory guidance on MRM was added to the foundations of MRM by expanding on previous guidelines and focusing on model development, implementation and validation.
Targeted review of internal models (TRIM)	In 2017 ⁴ , the European Central Bank (ECB) issued a TRIM guide calling attention to their views on appropriate supervisory practices required towards credit risk, market risk and counterparty credit risk models. The consolidated version after public consultation and revised ECB guide to internal models was released in 2019. ⁵
Fundamental review of the trading book (FRTB)	Annexure D of the FRTB consultative document ⁶ provides the principles that banks must consider for the data used in the expected shortfall models and prescribes to demonstrate the evidence which supports that all the principles were followed by the banks. In 2019 ⁷ , the Basel Committee on Banking Supervision (BCBS) layout revised standards for minimum capital requirements for market risk along with guidelines for internal model approach.
Prudential Regulation Authority (PRA)-CP6/22 – Model risk management principles for banks	PRA in their regulatory guidance on the MRM principles for banks in the consultation document CP6/22, 2022 ⁸ proposed key MRM principles with an aim to strengthen policies and procedures used by banks to control/manage model risk.
The Central Bank of the UAE (CBUAE) (MMG and MMS)	The CBUAE has prescribed the modelling requirements for licensed banks in the UAE and issued Model Management Standards (MMS) ⁹ and Model Management Guidance (MMG). ¹⁰ These regulations are effective from 24 December 2022.

These regulations give direction and provide guidelines to the banks for improving the MRM framework. However, banks face various challenges in their attempts to set up an efficient MRM framework due its complexity and the increasing number of models. This article aims to discuss some of the key challenges that banks face in setting up a robust MRM framework including some potential mitigants to effectively tackle these challenges based on regulatory guidance and industry best practices.

Challenges and best practices for building a robust MRM framework

A few key challenges of the MRM domain are discussed below:

01 Model input data quality

Verification of input data quality plays a crucial role in monitoring model risks. A model with poor data quality, high uncertainties, complex data structures and interdependencies between models increases the probability of errors and has an adverse impact on the model's output. Banks face challenges in effectively monitoring the input data quality due to the increased complexity of the models and usage of several data sources.

Regulatory guidance

Prudential Regulation Authority (PRA)¹¹ prescribes the following guidelines to assess the model input data quality:

- Input data selected for modelling should be apt for intended use and consistent with selected/approved methodology.
- Model data should not have any inappropriate bias and must comply with data privacy and other relevant regulations.
- Furthermore, modifications or usage of proxies that are made to source data should be documented.

Supervisory guidelines on MRM SR 11-7¹² prescribes the following guidelines for the model input data:

- Banks should focus on performing rigorous assessment of the model input data to verify the data quality and ensure accurate and complete documentation around model inputs.
- The model documentation must include all the pertinent data assumptions, alterations made for required model development and its potential limitations.

TRIM 2017¹³ prescribes that the data quality standards must cover the following data quality dimensions:

- **Completeness:** The values in the data should be available for each respective attribute where required in the model.
- **Accuracy:** The input data should be accurate and have no errors.
- **Consistency:** Data should be consistent with other data sources, i.e. a given dataset can be matched/checked with any other data source of the firm which provides similar data of the institution.
- **Timeliness:** The relevant data should be up to date.
- **Uniqueness:** The overall data should be free from any duplication or other transformations of the source data.
- **Validity:** The input data is based on standardised classification systems.
- **Availability/Accessibility:** Data must be available to relevant stakeholders.
- **Traceability:** Data must be traceable.

The MMS¹⁴ issued by the CBUAE also prescribes that the data quality review should consider characteristics such as completeness, accuracy, consistency, timeliness, uniqueness and traceability of the data.

Potential mitigants/best practices

The following best practices should be considered to ensure appropriate model input data quality:

- Sufficient data quality checks must be performed on the input data used for model development, calibration and use.
- Data proxies used during the model development must be documented in detail with sufficient rationale in the model documentation.
- The key data elements (KDEs) used in the model development, calibration and use must be documented including the data owners of these KDEs in the model documentation.
- The data limitations observed during the model development process must be documented including the impact of these limitations on the model outputs and the mitigants considered to limit the impact of these data limitations.
- Design enough key performance indicators (KPIs) for assessing various aspects of the model input data such as completeness, accuracy, timeliness, consistency, uniqueness, validity, availability, traceability, format checks, etc.
- The monitoring frequency of the input data KPIs must be decided considering the model use frequency to ensure that all the data quality issues are caught early on.
- All data owners should perform a periodic attestation of all data sources confirming that the data is suitable for the proposed model purpose, calibration or use.
- Model owners should document the evidence of data quality checks (e.g., logs) ensuring that sufficient checks are performed on the input data and that data is of appropriate quality.



02 Tiering models by risk rating

With the increasing dependency on model inventories and regulatory requirements to include all models in the MRM framework, it is essential for banks to establish a sound MRM framework with an appropriate model risk tiering approach to ensure an effective use of the firm resources. However, identifying an ideal model risk rating is a complex process and requires the assessment of the risk posed by each model. In addition to this, banks must determine risk ratings for all types of models used across all divisions of the bank. This poses a challenge for the banks to appropriately quantify various risk factors of the model to determine the accurate model risk ratings.

Regulatory guidance

According to SR 11-7, 'Model risk should be managed like other types of risk. Banks should identify the sources of risk and assess the magnitude. Model risk increases with greater model complexity, higher uncertainty about inputs and assumptions, broader use, and larger potential impact'.¹⁵

The PRA¹⁶, in its MRM principles set out for banks, highlights the model identification and its correct risk classification to minimise model risk.

The MMS¹⁷ issued by the CBUAE prescribes that, 'At a minimum, institutions must create two groups referred to as Tier 1 and Tier 2 models, with Tier 1 models being more critical than Tier 2 models'.

Potential mitigants/best practices

The following best practices can be considered to effectively classify the models based on their risk and allocate resources efficiently:

- A categorisation approach can be followed to categorise all the models in the inventory into 4 risk rating classes. These risk rating classes can be labelled as either (a) tier-1, tier-2, tier-3 and tier-4, or (b) high, medium, low and immaterial.
- A framework for model risk tiering considering qualitative factors, quantitative factors and the complexity of the model can be created:
 - **Quantitative factors:** Consider quantitative factors such as model exposure in the risk tiering methodology where the exposure metric quantifies the potential impact of the model failure and can be measured as the percentage of bank assets/liabilities, tier 1 capital, projected PnL, risk-weighted assets (RWA), etc.
 - **Qualitative factors:** Consider qualitative factors of the model which include regulatory purposes, business impact, extensiveness of usage, interconnectedness of the model, etc.
 - **Complexity:** Assess the complexity of models across various dimensions such as model inputs, methodology, implementation and use.
- The MRM framework should cover all the model types used across the bank with additional considerations and guidelines for the various model types used in the bank.

03 Validation of vendor models

With increasing regulatory requirements and the need for different types of models, banks rely on third-party vendors to provide modelling solutions. This helps banks to reduce the cost and complexity involved in developing all models in-house and provides them with access to expert knowledge of the vendors as vendors generally keep updating their models in-keeping with the latest modelling techniques and regulatory requirements (e.g. anti-money laundering models). However, external vendor models do not provide as much transparency as in-house models as they are proprietary to the vendor. Banks have to rely on the documentation provided by vendors which often only provides basic information on model methodology due to their intellectual nature and this hampers the understanding of the models. For example, lack of sufficient information on the implemented model parameters may result in inappropriate use of the model. This poses a big challenge for banks to carry out MRM activities for vendor models, especially model validation, as lack of adequate information regarding model methodology significantly affects the model validation activities due to minimal insights into the actual model methodology and implementation.

Regulatory guidance

The regulations do not provide any relaxations on the level of rigour at which the model validation has to be carried out on vendor models. The supervisory guidelines on MRM SR 11-7¹⁸ state that, 'All model components, including input, processing, and reporting, should be subject to validation; this applies equally to models developed in-house and to those purchased from or developed by vendors or consultants'.

Potential mitigants/best practices

The following approaches should be kept into consideration to validate the vendor models effectively:

- Have a robust and transparent process for selecting vendor models assessing the model requirements and suitability of the vendor model to the required purpose.
- Develop clear and comprehensive guidelines that outline the key steps and processes for performing validation of vendor models, including roles and responsibilities of various stakeholders.
- Analyse the gaps in vendor model documentation related to model methodology, data sources and assumptions, wherever possible, including the vendor's own test analyses that hinder model validation activities, and have discussions with the vendor model development teams to understand these gaps.
- Separate the list of model testing that can only be implemented/performed with the help of vendors and request the vendor to perform those tests on behalf of the model validators.
- Classify all the model tests into 'must have' and 'good to have' categories based on the level of importance of the model tests to deal with the situations where the vendor is not able to implement certain tests on their systems.
- For independent testing, if an alternative test is not possible, testing done by model developers should be implemented on portfolios with different attributes to test the model for the entire range of portfolios.
- Replication of model outputs should be done, if possible, as it can be an effective way to test the stability and effectiveness of the implementation of a model.
- Benchmarking the model outputs with other standard sources, if available, would also help in providing an appropriate assessment of the model performance. Backtesting the vendor model results using the historical data helps in assessing the accuracy and reliability of the model.
- Ongoing monitoring and review of vendor model performance ensures that the model continues to provide accurate and reliable results over time, in all market conditions and remains aligned with the bank's needs and objectives.

04 Validation issue management

Based on the independent review performed, the model validation team raises validation issues for the concerns observed. To ensure that the model risk is adequately captured, all the validation issues should be sufficiently analysed for appropriate risk evaluation and remediation. However, given the huge number of models and complex interdependencies between them, banks may face challenges in managing various aspects of validation issues including tracking the impact of validation issues on downstream models, documentation of validation issues of all the models in the model inventory and creating a framework for validation issue management.

Regulatory guidance

MMS¹⁹ issued by the CBUAE prescribes the following guidelines for the observations noted during the validation exercise, 'Observations must be graded according to an explicit scale including, but not limited to, 'high severity', 'medium severity' and 'low severity'. The severity of model findings must reflect the degree of uncertainty surrounding the model outputs, independently of the model materiality, size or scope. As a second step, this degree of uncertainty should be used to estimate Model Risk, since the latter is defined as the combination of model uncertainty and materiality'.

Potential mitigants/best practices

The following approach can be considered for an effective validation issue management:

- A validation issue management framework should be developed providing clear guidelines on how to determine the criticality of the issues, remediation timelines, need for mitigating/compensating controls till the issues are remediated, etc.
- Validation issues should be graded and categorised into high, medium and low criticality based on the impact the issue contributes to the overall model risk.
- The remediation timeline must be set based on the criticality of the validation issue and by considering the actual time required for addressing the issue concerns.
- The details of validation issues including issue description, remediation proposed by a model owner, remediation timelines, compensating/mitigation controls should be clearly documented in the model inventory. Tracking all validation issues in a centralised model repository will help in identifying the impact of the issues on downstream models.
- If any new validation issues are raised for a particular model, this information must be communicated to all the downstream model stakeholders to ensure that this risk is accounted for in the downstream models.



05 Model governance and inventory management

Model inventory plays an important role in the overall model governance of the banks. Model inventory is a comprehensive list of all the models which are used within a bank, along with relevant information about each model, such as its purpose, input and output variables, stakeholders, performance metrics, known model assumptions, limitations, weaknesses and open validation issues. Model inventory is a centralised repository of information about all the models used with a bank, which helps banks in maintaining compliance with the regulatory requirements and tracking the performance of the models. Given the rapid increase in the number of models used, banks may face challenges in maintaining an accurate and dynamic model inventory which may impact the overall model governance.

Regulatory guidance

The supervisory guidelines on MRM SR 11-7²⁰ states that, 'Banks should maintain a comprehensive set of information for models implemented for use, under development for implementation, or recently retired. While each line of business may maintain its own inventory, a specific party should also be charged with maintaining a firm-wide inventory of all models, which should assist a bank in evaluating its model risk in the aggregate'.

Potential mitigants/best practices

The following points should be considered to create an effective model governance framework and model inventory platform:

- Identify all the different types of models that are used in the bank to determine the specific features and capabilities that have to be implemented on the model inventory platform.
- Create a centralised database for model inventory platform where all the information related to the models can be stored.
- Implement a flexible search and filtering process providing the users with the ability to search and filter the model inventory based on various criteria such as model name, model type, etc.
- For each model in the model inventory, assign a unique model ID and include all the following key details at minimum: basic model details, stakeholder information, risk rating details, model owner submissions, model validator reviews, model change log, model documentation and interdependencies.
- Set up an attestation process wherein the relevant model stakeholders will review the model information in the model inventory and attest whether the information is accurate and complete.
- Implement versioning and history tracking so that users can see how a particular model has evolved over time. This also helps in identifying trends and patterns in the model performance and assess the impact of the changes made on the overall performance.
- Implement robust security and access controls to ensure that only authorised users can access/modify the model information in the model inventory. Set up controls in place to prevent unauthorised access to the model inventory platform.
- Set up a model governance division which oversees the overall implementation and maintenance of the model governance framework in the banks.
- The board of the bank plays a vital role in the model governance and hence, the board should be actively involved in designing the overall governance policy of the MRM framework. Some of the important roles of the board in the model governance framework are approving the model governance policies, ensuring compliance of these governance policies with regulatory requirements, providing oversight and review of the overall model governance activities and allocating adequate resources to support effective model governance.

06 Identification of models

Banks use numerous quantitative techniques for various purposes but not all these techniques are models. Quantitative techniques that are completely deterministic in nature (e.g. no assumptions are involved and no probabilistic scenarios are involved, etc.) must be categorised as tools. Model owners would typically prefer to have a smaller number of models in the firm inventory as a greater number of models in the inventory increases their scope of work. On the other hand, model validators, the second line of defense, prefer to be assured that all the models are appropriately identified in the model inventory and sufficient validation activities have been carried out in compliance with all the applicable internal and regulatory requirements for model validation. This poses a challenge for banks in effectively identifying and segregating all the models from the tools.

Regulatory guidance

The MMS²¹ issued by the CBUAE defines model as, 'A quantitative method, system, or approach that applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates'.

Potential mitigants/best practices

Banks can consider the following points to appropriately identify the models:

- Create a detailed framework for mitigating the uncertainty in identifying models and clearly document it in the firm's global MRM framework.
- A general guidance for quantitative techniques is that all statistical techniques which are completely deterministic in nature with no assumptions or probabilistic nature can be classified as tools unless there are any specific regulatory requirements to define these deterministic techniques as models.
- Even for the deterministic techniques that are classified as tools, there should be a process of independent verification to ensure appropriate and accurate implementation.

The list of challenges discussed in this article are not exhaustive, but cover the key challenges banks face in the MRM process. A few other challenges that banks might face in implementing a robust MRM framework are validation of expert-based judgement models, implementing MRM framework for the artificial intelligence (AI) models and developing models for quantifying climate risks.

The road ahead for banks

The challenges in implementing robust MRM frameworks are multifaceted, and banks require a comprehensive approach to address them. From implementing an effective model governance framework to ensuring adequate data quality and effective model validation, banks should continuously monitor, validate and update their models to reduce the risks associated with model usage and make more informed business decisions. To setup an effective MRM framework, banks need to adapt to the dynamic regulatory environment and keep their MRM framework up to date and abide by all the requirements prescribed by the regulators. They should also maintain detailed policy documentation addressing all the aspects of the MRM framework and ensure that all the relevant internal and external stakeholders involved in the MRM process are fully aware of these guidelines.

Banks should adopt hybrid operating models and bring in external support with relevant subject matter experts to tackle the complex challenges in the model risk domain. This will enable them to strengthen their MRM framework in line with regulatory expectations and industry best practices.

References

1. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
2. https://ithandbook.ffeic.gov/media/resources/3676/occ-bl2000-16_risk_model_validation.pdf
3. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
4. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/trim_guide.en.pdf
5. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.guidetointernalmodels_consolidated_201910~97fd49fb08.en.pdf
6. <https://www.bis.org/bcbs/publ/d436.pdf>
7. <https://www.bis.org/bcbs/publ/d457.pdf>
8. <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/consultation-paper/2022/june/model-risk-management-principle-for-banks.pdf>
9. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/00aarr3a/model-management-standards-attach-to-notice-5052-2022.pdf>
10. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/uojm3fy3/model-management-guidance-attach-to-notice-5052-2022.pdf>
11. <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/consultation-paper/2022/june/model-risk-management-principle-for-banks.pdf>
12. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
13. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/trim_guide.en.pdf
14. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/00aarr3a/model-management-standards-attach-to-notice-5052-2022.pdf>
15. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
16. <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/consultation-paper/2022/june/model-risk-management-principle-for-banks.pdf>
17. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/00aarr3a/model-management-standards-attach-to-notice-5052-2022.pdf>
18. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
19. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/00aarr3a/model-management-standards-attach-to-notice-5052-2022.pdf>
20. <https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf>
21. CBUAE (© Central Bank of the UAE) <https://www.centralbank.ae/media/00aarr3a/model-management-standards-attach-to-notice-5052-2022.pdf>

About PwC

At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 152 countries with over 328,000 people who are committed to delivering quality in assurance, advisory and tax services. Find out more and tell us what matters to you by visiting us at www.pwc.com.

PwC refers to the PwC network and/or one or more of its member firms, each of which is a separate legal entity. Please see www.pwc.com/structure for further details.

© 2023 PwC. All rights reserved.

Contact us



Manish Maini

Partner – Risk Consulting
PwC India
manish.maini@pwc.com



Venkata Subba Bharath Kumar Miriyala

Senior Associate – Risk Consulting
PwC India
venkata.subba.bharath.kumar.miriyala@pwc.com



Vikash Jaiswal

Director – Risk Consulting
PwC India
vikash.jaiswal@pwc.com



Mayank Pachauri

Senior Associate – Risk Consulting
PwC India
mayank.pachauri@pwc.com



Siddharth Khandagale

Senior Manager – Risk Consulting
PwC India
siddharth.khandagale@pwc.com



Kartik Mohan

Associate – Risk Consulting
PwC India
kartik.mohan@pwc.com



Shreyans Ranka

Manager – Risk Consulting
PwC India
shreyans.ranka@pwc.com

pwc.in

Data Classification: DC0 (Public)

In this document, PwC refers to PricewaterhouseCoopers Private Limited (a limited liability company in India having Corporate Identity Number or CIN : U74140WB1983PTC036093), which is a member firm of PricewaterhouseCoopers International Limited (PwCIL), each member firm of which is a separate legal entity.

This document does not constitute professional advice. The information in this document has been obtained or derived from sources believed by PricewaterhouseCoopers Private Limited (PwCPL) to be reliable but PwCPL does not represent that this information is accurate or complete. Any opinions or estimates contained in this document represent the judgment of PwCPL at this time and are subject to change without notice. Readers of this publication are advised to seek their own professional advice before taking any course of action or decision, for which they are entirely responsible, based on the contents of this publication. PwCPL neither accepts or assumes any responsibility or liability to any reader of this publication in respect of the information contained within it or for any decisions readers may take or decide not to or fail to take.

© 2023 PricewaterhouseCoopers Private Limited. All rights reserved.

KS/March 2022-M&C 26327