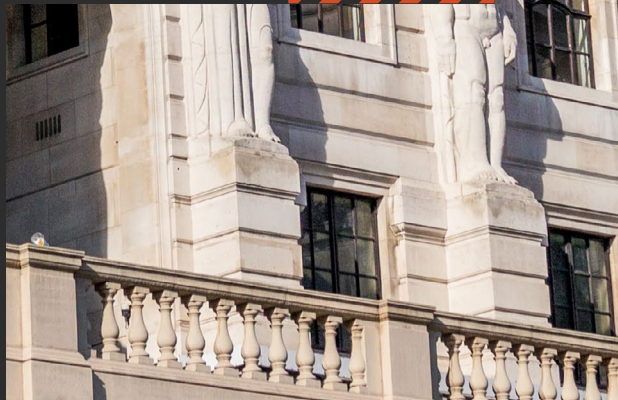
March 2024

Model risk management (MRM) in banks

New regulations, challenges and the way forward



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Introduction

Banks depend on multiple qualitative and quantitative methodologies to assist in their decision-making process in several areas. Moreover, the ever-increasing business complexities and regulatory demands have aggravated the importance of models in the financial sector. Banks use models in different business functions ranging from asset management, front-office trading systems, wholesale, and retail banking to risk management.

As per the Federal Reserve, model refers to a quantitative method, system or approach that applies statistical, economic, financial or mathematical theories, techniques and assumptions to process input data into quantitative estimates. Models meeting this definition might be used for analysing business strategies, informing business decisions, identifying and measuring risks, valuing exposures, instruments or positions, conducting stress testing, assessing adequacy of capital, managing client assets, measuring compliance with internal limits, maintaining the formal control apparatus of the bank, or meeting financial or regulatory reporting requirements, and issuing public disclosures. The definition also covers quantitative approaches whose inputs are partially or wholly qualitative or based on expert judgment, provided that the output is quantitative in nature.[1]

Model usage is accompanied by model risk, the consequences of which can include both financial and reputational loss, poor business choices, and irrational decision making.

The Fed states that model risk occurs primarily for two reasons:

(1) A model may have fundamental errors and produce inaccurate outputs when viewed against its design objective and intended business uses.

(2) A model may be used incorrectly or inappropriately, or there may be a misunderstanding about its limitations and assumptions.[2]

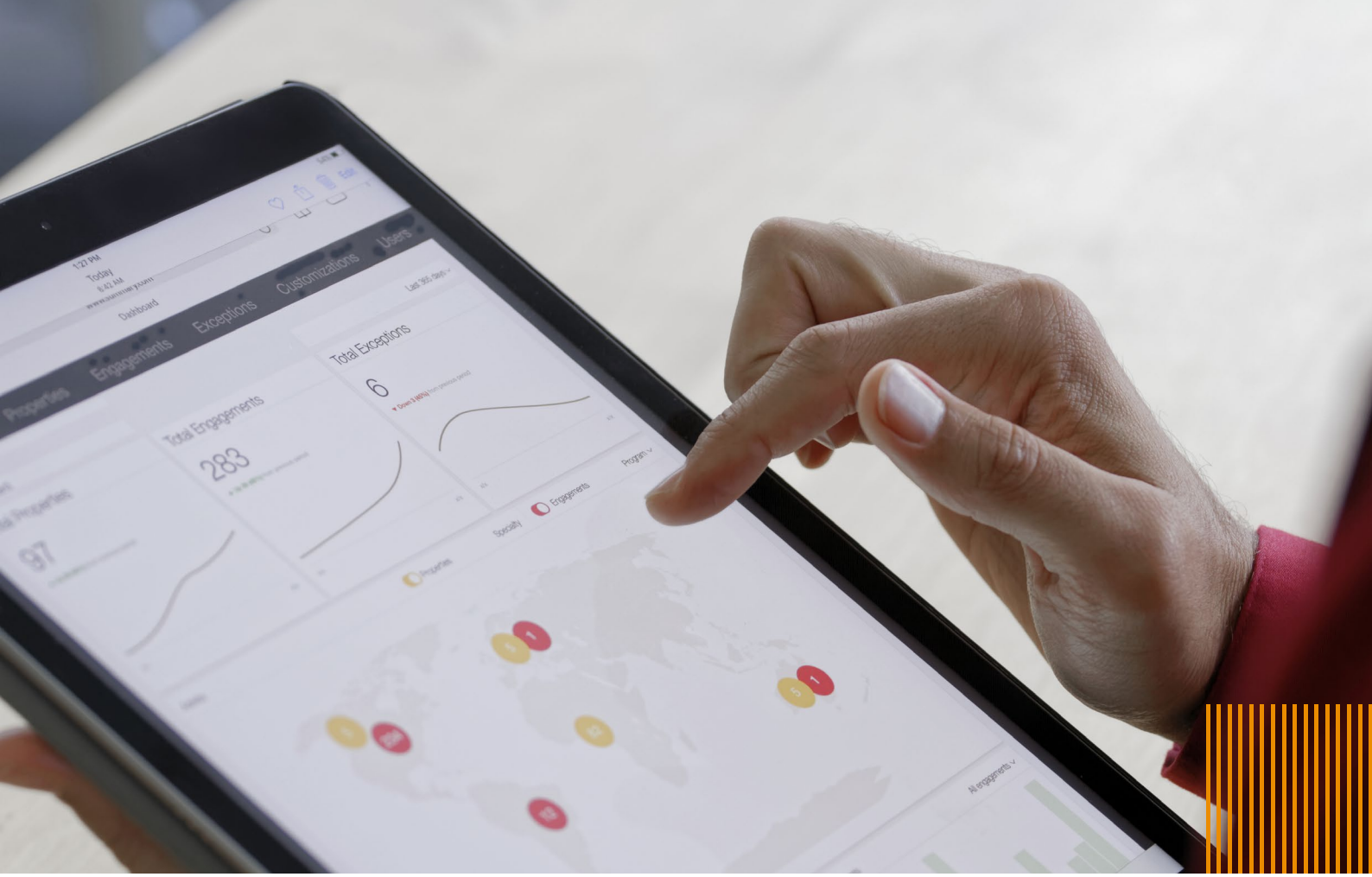
In light of these factors, it is safe to say that banking organisations need an active model risk management function to address, reduce and mitigate the adverse consequences of model-based decisions. Now, with the advent of artificial intelligence (AI) and machine learning (ML) technologies, models are increasingly becoming more sophisticated. Therefore, as the materiality and complexities of models differ in these functions, it becomes difficult to tailor an MRM framework that fits all. There are also ever-evolving expectations from regulators from banks with respect to their MRM framework.

Owing to the changing regulations in risk management and capital requirements, banks need to revamp their existing model landscape and the processes around model development and validation. With the new models becoming more complex in nature, financial institutions also require more robust MRM frameworks to identify, assess and control model risk. With regard to this, regulators have intensified their efforts to standardise MRM practices across financial institutions.

In this paper, we explain the challenges faced by banks due to new regulatory requirements with respect to model risk and how these challenges can be navigated. We also touch upon how changing regulations have an impact on all segments of a model risk lifecycle – such as model identification, development, validation, performance monitoring, adjustments and governance.

1 SR 11-7: Guidance on Model Risk Management, Federal Reserve, 2011

2 SR 11-7: Guidance on Model Risk Management, Federal Reserve, 2011



Model lifecycle

Model identification and classification	Model development	Independent model validation	Model performance monitoring	Model risk mitigants
• Define model requirements. • Identify risks. • Identify model inter-dependencies. • Record the model in the model inventory.	• Design the model. • Determine the methodology. • Identify model weaknesses and limitations. • Conduct development testing. • Document the specifications	• Review model risk rating. • Perform model testing including conceptual soundness, benchmarking, sensitivity analysis and stress testing. • Conduct annual review. • Facilitate periodic revalidation.	• Conduct periodic review of model performance. • Define key performance indicators (KPIs) and thresholds. • Notify model validators regarding any breaches in model performance.	• Document post-model adjustments. • Outline approval process for material adjustments. • Check for exceptions and enable escalation processes.

Governance

- Establish a strong MRM framework.
- Define roles and responsibilities of various functions.
- Enable senior management oversight and report model risk.
- Liaise with the three lines of defence to streamline validation and audit process.

Evolving expectations from regulators

US regulators were the first to publish model risk guidelines in 2011 – i.e. SR 11-7. Since then, European Central Bank (ECB), Prudential Regulatory Authority (PRA) and Central Bank of United Arab Emirates (CBUAE) have also published various guidelines for MRM.

ECB issued targeted review of internal model (TRIM)[3] and ECB Guide to internal models (EGIM).[4] PRA issued model risk framework for stress testing models used for ICAAP in 2018 (SS3/18).[5] CBUAE issued the final Model Management Standards and Guidance (MMS&G) in December 2022. Achieving this level of standards will make UAE banks at par with the risk management practices of global banks and US/EU regulatory practices.

Recently, PRA has published its final requirements for an effective MRM framework in policy statement (PS6/23) which will come into force on 17 May 2024 and be applicable to all regulated UK incorporated banks, which have internal model approval.

PRA is also planning to release MRM guidelines for firms which do not use internal models for capital calculation. Moreover, European Banking Authority (EBA) has issued a consultation on the validation of internal rating-based (IRB) models. These guidelines are said to be more prescriptive than the existing SR11-7 guidelines[6] which were issued by the Federal Reserve, and hence will require major efforts from banks to be compliant with the same. These evolving regulations are important to banks in the US, UK, EU and middle-eastern regions.

In the following sections, we've focused on the changing landscape of regulatory expectations along each stage of the model lifecycle.

1. Model identification and classification

Model definition

PRA has prescribed a model definition that is much broader than the existing model definition used by UK incorporated banks. PRA's model definition includes quantitative methods that produce quantitative or qualitative outputs. This ensures that recommendation systems in client services and other AI/ML models that deliver qualitative outputs are within the scope of the MRM policy.[7]

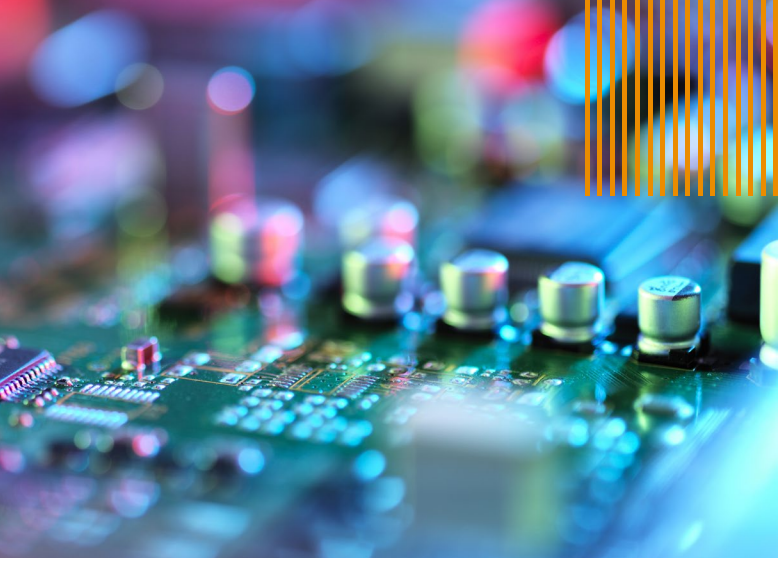
In addition to this, PRA asks firms to consider the possibility of applying relevant aspects of the MRM framework to material deterministic quantitative methods – such as decision-based rules or algorithms that are not classified as models and have a material bearing on business decisions. These include systems that are made up of complex inter-dependent networks comprising components like electronic trading systems, financial crime and/or anti-money laundering systems.[8]

Banks need to update their model inventory to cover details like the model limitations, assumptions, linkages to upstream and downstream models, adjustments made after using the model along with the reasons, and information about models that are no longer in use.

What do banks need to do?

Model identification drive should be conducted to identify new models. This can be achieved by familiarising various business heads with the MRM framework and conducting sessions to identify potential models in their respective business units. This exercise is expected to increase the number of models in the inventory.

3 Targeted Review of Internal Models, ECB, April 2021
4 ECB Guide to internal models, ECB, Oct 2019
5 SS 3/18 Model Risk Management Principles for stress testing, PRA, April 2018
6 SR 11-7: Guidance on Model Risk Management, Federal Reserve, 2011
7 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023
8 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023



Model inventory

PRA expects a robust model inventory that captures a detailed end-to-end model lifecycle such as purpose, use cases, outputs, operating boundaries, change log, post-model adjustments before implementation and decommissioned models including rationale for decommissioning. Many banks may not have such a detailed model inventory. Moreover, PRA requires banks to record the interconnected data sources and alternate data sources. Model adjustments during the development process should be recorded in model inventory, including how the adjustments should be calculated over time.

What do banks need to do?

Banks need to upgrade their model inventory significantly to include extensive features such as model limitations, assumptions, linkages to upstream and downstream models, post-model adjustments and rationale and decommissioned models.

Model tiering

Firms need to employ risk-based tiering to prioritise model validation activities and other risk controls through the model lifecycle. The tiering approach needs to be consistent across the firm and should consider materiality and complexity as factors for determining the model tier. To comply with the same, PRA has prescribed a range of factors – for example, complexity introduced by interconnected data sources and uncertainty of alternative and unstructured data should reflect in model-tier classification.[9]

2. Model development

Scope

New types of models will come under the purview of the MRM framework. These will include ML models used for client recommendations, and material deterministic quantitative methods such as electronic trading systems and financial crime models. These models will need to be developed, documented and validated as per the firms' MRM policy.

Model identification drive should be conducted in order to identify new models. This can be achieved by familiarising various business heads with the MRM framework and conducting sessions to identify potential models in their respective business units. This activity is likely to raise the count of models listed in the inventory.

The EGIM highlights the importance of consistent implementation of internal model-related tasks within a banking group. Inconsistencies in implementing these tasks can lead to inadequate risk coverage measured by internal models at the group level.

The CBUAE expects dedicated and consistent documentation which must be produced for each step of the model life cycle. Therefore, institutions need to create proper standards for documenting models.

What do banks need to do?

Frequency of ongoing performance assessments (OPAs) should be aligned with the frequency of model monitoring. Expectations from regulators with respect to continuous performance assessment has increased, and banks need to establish clear guidelines for the frequency of OPAs, KPIs and their thresholds, as well as outline proper escalation processes.

9 SS1/23 – Model risk management principles for banks 2023, PRA, May 2023

Data

PRA has proposed that the potential limitations of data due to non-representativeness should be considered for model risk classification. Linked data sources and the use of different or unorganised data also need to be recorded in the model inventory and considered in model tier classification.

Model development testing

PRA has proposed that model owners should conduct sensitivity testing to determine the boundaries of model operation, under which the model performance is expected to be acceptable. Models should be compared to alternative or challenger models, which are alternative implementations of the same theory. The extent to which comparisons against challenger models or other benchmarks are conducted should be considered in the model's tier classification to reflect higher model uncertainty.[10]

Model adjustments

Model adjustments during the model development process need to be recorded in the model inventory along with adequate rationale and justification. Model developers also need to record how they have calculated these adjustments. Recurring model adjustments, which are material in nature, should be assessed. Moreover, firms need to identify if there are significant flaws with the model.

3. Independent model validation and performance monitoring

Independent validation

Firms should have a validation process that provides ongoing, independent and effective challenges to enhance model development and usage. Due to wider model definitions, there will be an increase in validation efforts as new models will come under the MRM framework. Firms will need to expand their model validation functions to hire resources with the right level of expertise. ECB expects all internal models and estimates used within an organisation to undergo two types of validation processes: Initial validation and periodic validation, both of which will be based on model tiering. Periodic validation will require a larger number of resources. For the most part, PRA's expectations from the validation function aligns with the current US regulations and practices.

The CBUAE prescribes that validation scope must cover both qualitative as well as quantitative validations. If insufficient data is available to perform the quantitative validation, the validation process should be flagged as incomplete to the model oversight committee, which should then decide regarding the usage of the model in light of the uncertainty and the risks associated with a partially validated model.[11]

Performance monitoring

PRA expects banking organisations to have comprehensive testing as a part of performance monitoring, including assessment of validity of parameter estimates, assessment of assumptions, and changes in products, exposures, clients, or market conditions. Models with dynamic recalibration should be monitored properly in order to ensure that insignificant changes due to recalibration do not accumulate into a material change in model output over time. Banks will thus require significant efforts to enhance their model performance monitoring framework.

The frequency of ongoing performance assessments (OPAs) should be commensurate with how often the models are monitored.

The expectation from regulators with respect to continuous performance assessment has increased, and banks need to establish clear guidelines for frequency of OPAs, KPIs and their thresholds, as well as a proper escalation process.

Data quality governance framework for IRB models

In the supervisory handbook on validation of IRB models, EBA states that the validation function holds a critical role in evaluating and upholding the integrity of a financial institution's rating system.

10 SS1/23 – Model risk management principles for banks 2023, PRA, May 2023

11 Model Management Guidance, CBUAE, November 2022

The validation function is tasked with assessing input data quality, overseeing model development and production environments, and closely monitoring the implementation of the rating system within the IT infrastructure. The institution must ensure that its IT and data governance capabilities are robust enough to effectively manage various financial risks, encompassing data aggregation, consistent data quality, and implementation and monitoring of IRB rating systems.

The validation function needs a comprehensive understanding of the institution's IT setup and the full spectrum of data quality checks related to IRB rating systems. Moreover, it requires independent access to relevant data and databases, separate from the credit risk control unit, along with the capacity to extract and manipulate data.

Additionally, the function verifies the accurate incorporation of internal ratings and risk parameters into IT systems, ensuring compliance with documented specifications. More importantly, it ensures that the integration of the rating system into IT systems aligns with the standards and faithfully reproduces the documented rating system under review. Through these responsibilities, the validation function guarantees the dependability, accuracy and regulatory compliance of the institution's IRB rating systems and associated IT framework.

4. Model risk mitigants

Firms need to establish a consistent firm-wide process for application of post-model adjustments (PMAs) which should be documented in firms' policies and procedures and include a governance and control framework. Documentation of PMAs also need to be enhanced and their use should be properly justified and linked to model limitations. Moreover, PMAs should be subject to independent review, including root cause analysis, to ensure that they are not applied due to significant model deficiencies.

Firms should have escalation matrix in place so that the key stakeholders (model owners, users, validation function and senior management) are promptly made aware of any model exceptions.

5. Model governance

PRA expects firms to enhance their model governance framework significantly. Increased individual accountability is a key focus of PRA as outlined in supervisory statement SS28/15. PRA also places clear and specific responsibility with boards with respect to model risk. This is a big ask, considering board members may not necessarily have the required risk management background.

Board of directors' responsibilities:

PRA expects the board of directors to take a bigger responsibility in managing the firm's model risk. These include:

- providing challenges to the output of the most material models
- understanding the capabilities and limitations of the models and the operating boundaries under which model performance is acceptable
- determining the potential impact of poor model performance and mitigants in place.

Furthermore, PRA expects the board to set model risk appetite that is proportionate to the nature and type of models used. Although PRA has clarified that the board can delegate these responsibilities to sub-committees or the senior management, the ultimate responsibility still lies with the board.

Hence, firms need to start apprising their boards with the necessary information and training. Firms may also need to form appropriate reporting structure to keep the board informed through committees or senior management.

Senior management function (SMF)

To strengthen accountability, PRA has proposed a new SMF which will be responsible for the overall MRM framework. PRA has clarified that the responsibility of SMF will be additional and complementary to the responsibilities of SMF holders for the business, risk and control functions. It has further clarified that certain duties of SMF may be delegated, and firms also have the flexibility to appoint more than one SMF.[12]

Similarly, the CBUAE prescribes that institutions must establish a model oversight committee that will act as the reporting entity for the stakeholders at all stages of the model life cycle. This committee, separate from current risk management groups, needs to be formed in order to oversee all models within the institution, thus aiming to fully manage model risk. The committee should meet regularly, once every quarter at minimum, and report directly to the senior management and the board. It's important that this committee stays neutral and is not influenced by any business interests. Additionally, it should serve as a central platform for discussing, making or suggesting further action on key modelling decisions, which must then receive final approval from the board.[13]

Third-party consultants

Modelling strategy must clearly articulate the potential contribution of third-party consultants to the development, management and validation of models. The strategy for outsourcing – including aspects like data, systems, calibration and methodology design – must be clearly laid out and explained. If any modelling tasks are outsourced, institutions need to put systems in place to maintain control over the crucial parts of the modelling process.[14,15]

Institutions must always remain the owners of their models, under all circumstances. They must remain accountable for all modelling choices, even after support from a third-party consultant for any of the steps in the model life cycle.

Financial reporting to audit committee

Banks need to regularly conduct self-assessment of its effectiveness of MRM framework and provide the report to audit committee.

12 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023
13 Model Management Standards, CBUAE, November 2022
14 SS 2/21 - Outsourcing and third-party risk management, PRA, March 2021,
15 PS7/21 – Outsourcing and third-party risk management, PRA, March 2021

Challenges for AI/ML models

Changes in market structure, climate risk management efforts and ML techniques, will pose major challenges and offer significant opportunities for banks in MRM.

Therefore, modelling teams and risk managers must adapt their tools to unfamiliar economic conditions. One ongoing challenge is to strengthen linkages between well-understood economic factors and model outputs for these new class of models. However, applying MRM principles to AI/ML models might still pose some challenges. Some of these challenges are outlined below:

- AI/ML models can be highly complex, and explaining how they produce outputs can be difficult – firms could benefit from PRA and other regulators by giving practical examples of the level of explanation expected.[15]
- A greater collaboration across relevant areas in the firm where AI/ML systems are used can be beneficial due to the cross-functional nature of these systems.
- Banks need to upskill their staff by setting up periodic training sessions so that they can develop and validate AI/ML models. The workforce should be well-equipped to understand the soundness of the underlying economic rationale behind the model.
- Due to the dynamic nature of AI/ML models – i.e. they change and/or recalibrate frequently – there may be additional challenges around ensuring adequate oversight and review.
- As AI/ML model complexity increases, monitoring of model performances becomes increasingly important and challenging.[16]
- Use of AI/ML models can raise ethical challenges including fairness and bias, which could increase conduct and reputational risks. Better management and oversight of such risks may be needed in the MRM process where this risk is identified.[17]
- Banks need to find a balance between model performance and explainability. They need to:
  - include excessive number of variables or avoid variables with no significant predictive ability.
  - avoid using unstructured data unless it has been judged and approved by the data quality framework.

15 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023

16 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023

17 PS6/23 – Model risk management principles for banks 2023, PRA, May 2023

Navigating regulatory challenges

Banks will need to enhance their MRM framework and policies to become compliant with the regulatory expectations. Some of these areas are listed below.

1. Establish model identification process

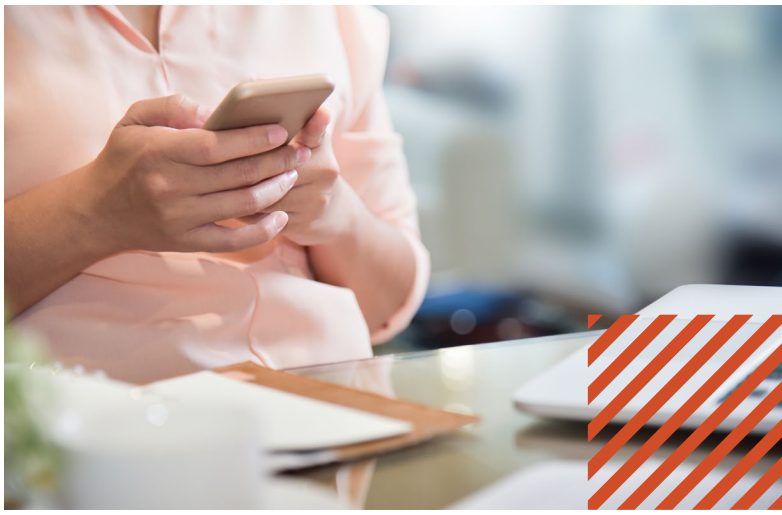
Firms need to establish a consistent firm-wide process for application of post-model adjustments (PMAs) which should be documented in firms' policies and procedures and include a governance and control framework. Documentation of PMAs also need to be enhanced and their use should be properly justified and linked to model limitations. Moreover, PMAs should be subject to independent review, including root cause analysis, to ensure that they are not applied due to significant model deficiencies.

Firms should have escalation matrix in place so that the key stakeholders (model owners, users, validation function and senior management) are promptly made aware of any model exceptions.

2. Upgrade model inventory tool

Model inventory in most banks is not very comprehensive as regulators would expect. Therefore, banks either need to revamp their existing inventory or create a new one to make it exhaustive. Several additional fields such as decommissioned models, inter-connectedness of models capturing linkages to upstream and downstream, post-model adjustments, and model operating boundaries need to be added. Some factors that banks need to consider are as follows:

- New models need to be identified and recorded in model inventory. Many new model owners may not be aware of this process.



- Granularity of information to be recorded in model inventory needs to be determined.
- Standardisation of information recorded in model inventory will improve efficiency and comparability across models.
- Model inventory should record information as well as be able to generate meaningful model risk reports for senior management – for e.g. reporting on issues with material models.

3. Revise model governance process

PRA expects banks to have a robust model governance process with increased accountability of senior management and board of directors on MRM. Hence the role of SMF(s) become very important. Banks need to identify personnel who have the right expertise. Moreover, banks need to familiarise the board with the material and complex models. They also need to understand the underlying risks and limitations on models. Although, the board of directors is expected to delegate this responsibility to senior management, it is necessary to apprise them of model risks on a regular and timely basis.

4. Data quality governance framework

Banks need to ensure a proper and effective data quality framework which covers assessment of data quality dimensions, full data life cycle from data entry to reporting, and have both current and historical application databases.

Banks also need to set up an independent data quality function as a second line of defence which ensures that quality data is used between hosts and databases.

5. Expansion of model validation expertise

Banks will need to add the capacity and expertise to validate new models which come under the MRM framework. Dealing with a much broader scope of models, they will need to apply a standard that consistently manages the risks across very different model types and their uses – for e.g. anti-money laundering (AML) and financial crime compliance (FCC) models are traditionally built using expert-driven rules which are not considered as models. However, banks are increasingly using ML techniques for AML/FCC models, which will require these systems to be brought under the MRM framework. Similarly, the use of ML is also increasing in IRB models.[18] ML models can produce parameter estimates that are not easily understood, especially when the model's structure is complex and hard to interpret.

As the use of AI/ML models increases across functions, banks will need to upskill their resources so that they are able to challenge these models. Since these models require highly specialised skills, banks may need to establish new teams with more focus on AI/ML model validation.

ML models are like a black box, much less transparent and more complicated than traditional tools like regression analyses and decision trees. The existing risk

management and governance framework may thus be deficient and require further enhancements. Banks can also develop interpretability techniques to overcome challenges with respect to complexity problems such as:

- graphical tools depicting effect of explanatory variable on the model
- feature importance techniques
- variable impact analysis on prediction of the model using Shapley values.

Way forward

There are multi-faceted challenges in implementing a robust MRM framework, and banks require an extensive and thorough approach to address them. Banks need to upgrade their model identification and inventory processes and implement an effective model governance framework. Moreover, they need to adapt to the dynamic regulatory environment and keep their MRM framework up to date and comply with all the requirements prescribed by the regulators. They should also keep comprehensive documentation of policies covering every aspect of the MRM framework and ensure that all internal and external stakeholders involved are fully informed about these guidelines and following them.

18 Discussion paper on Machine learning in IRB models, EBA, 2021

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