

## MODEL RISK MANAGEMENT

### Core Analysis Procedures

*Examiners are to consider these procedures but are not expected to perform every procedure at every institution. Examiners should complete only the procedures relevant for the institution's activities, business model, risk profile, and complexity. If needed, based on other identified risks, examiners can complete additional procedures not included below. References to laws, regulations, supervisory guidance, and other resources are not all-inclusive.*

#### References

- *Interagency Guidelines Establishing Standards for Safety and Soundness (FRB: [12 CFR 208, Appendix D-1](#); FDIC: [12 CFR 364, Appendix A](#))*
- *Supervisory Guidance on Model Risk Management (FDIC: [FIL-22-2017](#))*
- *Guidance on Model Risk Management (FRB: [SR 11-7](#))*

#### Considerations and Background

The purpose of this module is to assist examiners in assessing whether model risk management (MRM) practices are appropriate in relation to the institution's risk exposure, business activities, complexity, and extent of model use. Additionally, this ED Module will assist examiners in determining the impact of model processes and use on the overall health of the institution and implications to CAMELS/Composite ratings. This module should be applied as appropriate taking into account each institution's size, nature, and complexity, as well as the extent and sophistication of its use of models. In general, it may not be applicable to community institutions.

Institutions routinely utilize models for a broad range of activities. Appropriate risk management practices are necessary to mitigate the risk of incorrect or misused decisions that are based on models that may impact the safety and soundness of the institution or result in apparent violations (and associated fines and penalties) of consumer protection or other regulations. Implementation of appropriate MRM practices is consistent with safety and soundness standards, which require, among other things, appropriate internal controls, information systems, and internal audit systems. If model risk is low and complexity and extent of model use is limited, examiners should not criticize an institution that does not address all aspects noted in this ED Module, particularly if the lack thereof does not contribute to weaknesses or potential weaknesses in risk management practices. Furthermore, each institution is unique, and while some or all elements discussed below may be critical to managing risk for some institutions, they may not be necessary for all institutions. Consideration of what is appropriate to address in MRM programs is based on the institution's model use, model risk, relative complexity, business activities, corporate culture, and overall institutional structure.

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. 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. The definition of model also covers quantitative approaches whose inputs are partially or wholly qualitative or based on expert judgment, provided that the output is quantitative in nature.<sup>1</sup>

Model Risk is the potential for adverse consequences from decisions based on incorrect or misused model outputs and reports. Model risk can lead to financial loss, or poor business and strategic decision-making.<sup>2</sup>

<sup>1</sup> Supervisory Guidance on Model Risk Management, FIL-22-2017 (June 7, 2017)

<sup>2</sup> Supervisory Guidance on Model Risk Management, FIL-22-2017 (June 7, 2017)

## Findings and Conclusions

*Document findings and conclusions here, and include a summary of these findings and conclusions in the appropriate Primary or Supplemental modules.*

## Preliminary Review

**1. Review prior examination reports and workpapers, the examination planning memorandum, internal and external audit reports, and file correspondence for an overview of any previously identified MRM findings or concerns.**

**2. Identify how models are used at the institution, including purpose(s), materiality of model use(s), and potential model risk.**

## Policies and Procedures

- 3. Determine whether management has established appropriate policies and procedures to address MRM commensurate with risk, complexity, and materiality of models used, as well as the institution's complexity, business activities, and overall institutional structure.<sup>3</sup> Perform a sample review to determine whether practices align with the institution's policies and procedures. Consider whether policies and procedures appropriately:**
- **Define *model* and *model risk*, including whether:**
    - The definition of models includes qualitative models
    - Non-models, such as tools or calculators, are addressed
  - **Outline a framework for assessing model risk**
  - **Describe requirements for models based on the level of model risk**
  - **Detail the duties and responsibilities of model developers, owners, users, validators, model risk managers, auditors, committees, and the board**
    - Assess whether model validators are required to be independent from the model development function
    - Determine whether reporting lines are reasonable
  - **Require a minimum amount of risk information be presented to a committee or the Board, and whether the required information is sufficient to enable adequate oversight**
  - **Establish standards for model development, model implementation, model use, and model validation (refer to Procedure 19 for additional detail on policy review for model validation)**

<sup>3</sup> If model use at an institution is limited to use of a small number of vendor models, separate and distinct MRM policies and procedures may not be necessary if vendor model selection, use, and validation are incorporated in other relevant policies and procedures.

- **Outline ongoing monitoring and testing requirements, such as frequency (which may be based on level of model risk), thresholds/targets for model accuracy, and required actions if model performance deteriorates**
- **Outline standards for selecting vendor models, and that may require:**
  - **Developmental evidence from the vendor explaining the product components, design, and intended use to determine whether the model is appropriate for the institution**
  - **Testing results from the vendor that show the model works as expected**
  - **Clearly documented model limitations and assumptions from the vendor**
  - **Ongoing performance monitoring and outcomes analysis from the vendor**
  - **Institution validation of its use of the model, including sensitivity analysis and benchmarking**
  - **Clear documentation and assessment of institution customization or data and assumptions used to build the model**
  - **Internal ongoing monitoring and outcomes analysis of the model performance using the institution's outcomes**
- **Define audit requirements including timing and scope minimums, and assess whether audit requirements differ if model development or validation activities are conducted internally versus externally**
- **Receive periodic review and approval from the board or a designated committee**

#### **Model Identification and Inventory**

**4. Determine how the institution identifies models. For institutions with significant model use,<sup>4</sup> determine whether the institution's policies or procedures provide for model identification.**

**5. Determine whether the institution maintains a comprehensive model inventory for models in use, under development, and recently retired. If there are models in use that are not on the model inventory or identified by management, assess management's rationale for not including them. A comprehensive model inventory may include the following:**

- **A description of the model's purpose and intended use**
- **The model's risk level assigned by the institution**
- **Restrictions on model use**
- **An identifier of whether models are implemented, under development, or retired**
- **Date of implementation or date of retirement**
- **Types and sources of inputs and underlying components of a model (inputs and components could range from data, such as national GDP, to underlying models, such as a probability of default model contributing to an overall allowance model)**
- **Model outputs**
- **Whether models are functioning properly**
- **Date model was last updated or revised**
- **Whether the model adheres to policy**

<sup>4</sup> For institutions with minimal model use, risk, complexity, or that only use a small number of vendor models, the process may be informal. For institutions that are more complex, with multiple departments and business lines, the process may be more involved and formal.

- Date the model was last validated and the next planned validation date
- Names of model developers, owners, and validators
- Timeframe that the model is expected to remain valid

### Vendor Models

6. For vendor models, determine whether practices align with the requirements set forth in the institution's policies and procedures. Assess whether model documentation includes support for the vendor model selection. Support may include:
- Developmental evidence from the vendor explaining the product components, design, and intended use
  - Management assessment to determine whether the model is appropriate for the institution
  - Testing results from the vendor that show the model works as expected
  - Clearly documented model limitations and assumptions from the vendor
7. Determine whether ongoing risk management practices for vendor models align with the institution's policies and procedures. Ongoing practices may include the following:
- Reviewing ongoing performance monitoring and outcomes analysis from the vendor
  - Validating the use of the model, including sensitivity analysis and benchmarking
  - Maintaining clear documentation and assessments of institution customization or data assumptions used to build the model
  - Periodic monitoring and outcomes analyses of model performance using the institution's outcomes

### Model Development

8. Determine whether the institution's model documentation aligns with the requirements set forth in the institution's policies and procedures. Model development documentation may include:
- Clear statements of purpose and intended use
  - Descriptions of the design, theory, and logic underlying the model, that may be supported by published research and sound industry practice
  - Explanation and rationale for the methodologies and processing components selected to implement the model design and theory
  - Alternative modeling approaches that were considered
  - Assessments of quality and relevance of data used for model development
  - Descriptions of the types and extent of model testing during development to ensure consistent model performance (testing may include backtesting, benchmarking, and sensitivity analyses)
  - Explanations of the merits, limitations, and assumptions used in the model

9. Consider whether limitations are so severe that the model is conceptually unsound.

<b>10. Determine whether the model uses judgmental or qualitative assumptions or adjustments and whether the assumptions or adjustments, including any overlays, are well documented and supported (e.g., business reasoning or analysis). Assess whether the assumptions are intuitive from a business or financial perspective.</b>
<b>Data</b>
<b>11. Assess the reasonableness of model documentation for selecting data and describing data sources. Documentation may include:</b> <ul style="list-style-type: none"> <li>• Data sources and the relevance of the data sources</li> <li>• For external data, description of how the data was selected to match the institution's products, services, geographic footprint, and general strategic plan, and whether management provides <ul style="list-style-type: none"> <li>○ Support that the data selected makes conceptual sense for the estimations</li> <li>○ Support and rationale for using external data and the source selected</li> </ul> </li> <li>• Support for the data used, including time periods</li> <li>• Whether there are sufficient observations in the data to create a model</li> <li>• Data accuracy and quality assessments performed during model development and validation</li> <li>• Details about the controls over the data</li> </ul>
<b>12. Determine whether the modeler has the ability to change the data and whether there are additional quality control checks to ensure data integrity.</b>
<b>13. Evaluate whether data was transformed for use in the model and whether the transformations were documented and appropriate. When data is transformed, review:</b> <ul style="list-style-type: none"> <li>• Whether the transformation makes conceptual sense</li> <li>• The complexity of the transformation and whether it was necessary</li> <li>• Documented rationale for the transformation</li> <li>• Data accuracy checks after the transformation</li> </ul>
<b>14. Determine whether the data was segmented appropriately. Evaluate whether:</b> <ul style="list-style-type: none"> <li>• The segmentation makes conceptual sense</li> <li>• The data was split into training and testing data sets, and if so, assess: <ul style="list-style-type: none"> <li>○ The reasonableness of the training and testing split</li> <li>○ The techniques used to split the data</li> </ul> </li> <li>• Any data was excluded, and if so, assess:</li> </ul>

<ul style="list-style-type: none"> <li>○ Rationale for the exclusion</li> <li>○ Potential for sampling bias</li> <li>• The model documentation discusses outliers and details how outliers were handled (e.g., excluded)</li> </ul>
<p><b>15. Assess the institution's approach to remediating missing data, and determine whether the approach is appropriate and well supported. Consider whether:</b></p> <ul style="list-style-type: none"> <li>• There are gaps in data or data is missing <ul style="list-style-type: none"> <li>○ If data is missing, evaluate how management handles the missing data</li> </ul> </li> <li>• Documentation explains the impacts of missing data and whether missing data is a limitation</li> </ul>
<p><b>Variables and Coefficients<sup>5</sup></b></p>
<p><b>16. Assess management's documented process for variable selection to ensure it is understandable and repeatable. Determine whether documentation discusses:</b></p> <ul style="list-style-type: none"> <li>• Justification for inclusion</li> <li>• Interpretation</li> <li>• Significance</li> <li>• Sensitivity of the model to a variable or variable type</li> <li>• Any proxy variables used, the rationale for using those proxies, and whether the use of proxies creates any statistical bias</li> <li>• The omission of any variables, if applicable, and whether that omission could create any statistical bias</li> <li>• Business lines involved in the variable or model selection</li> <li>• Results of any variable testing to determine whether any variables are superfluous, extraneous, or redundant</li> </ul>
<p><b>17. Determine whether the coefficients are intuitive and directionally consistent.</b></p>
<p><b>18. Assess model testing during model development and determine whether the test results support model use.</b></p>
<p><b>19. Determine whether model results are reasonable. Consider whether:</b></p> <ul style="list-style-type: none"> <li>• Model results are intuitive and directionally consistent (e.g., in a strongly stressed macroeconomic environment other real estate owned balances increase, which is consistent with the institution's historical data)</li> </ul>

<sup>5</sup> Not all models have coefficients, while some simpler/noncomplex models have one (or limited) variable(s).

- Management relies on large overlays to adjust model results and whether overlays are reasonable
- Model results are overridden and replaced with expert judgment
- Overrides are disclosed to model users and are reasonably supported (e.g. an override due to the model failing or producing results that were lower than historical experience)

### Model Validation

**20. Determine whether the institution has policies and procedures that appropriately define model validation, outline validation requirements, describe roles and responsibilities of validation participants, and provide/establish controls for validated models. Determine whether the institution's model validation practices align with the requirements set forth in the institution's policies and procedures. Policies and procedures may address:**

- Model validation requirements prior to first use
- Identification of models subject to validation
- Periodic review requirements
- Minimum scope and testing standards/procedures for validations
  - Scope standards may change depending on model risk
- Validation requirements for both internal models and external/vendor models
- A framework for model validation grades (e.g., pass, pass with conditions, and fail) or finding or issue severity (e.g., low, medium, and high)
  - Different levels of findings or issues may have different implications (e.g., the grades may be tied directly to findings)
- Definitions for different grades (e.g., pass vs conditional pass)
- Timelines and prioritization for remediation of findings
- Procedures for repeat findings<sup>6</sup>
- Key decision parameters, including when re-development is required
- Circumstances under which validation personnel are allowed to change the grade of the model (if applicable)

**21. Determine whether the same policies and procedures (including validation templates) are used for internal and external validations.**

**22. Determine whether the validators have appropriate knowledge, skills, and expertise to perform validations. Consider reviewing validator resumes and contracts with third parties.**

<sup>6</sup> Finding severity may increase if issues are not resolved timely

<p><b>23. Assess validation independence.<sup>7</sup> Determine whether validators are incentivized to withhold findings or are inappropriately influenced by business line personnel or developers with regard to validation results.</b></p>
<p><b>24. Determine whether validation reports are complete and reflect effective challenge of the model and development process. Validation reports may include:</b></p> <ul style="list-style-type: none"> <li>• A detailed and sufficient scope, including whether the scope is limited by the model's risk grade</li> <li>• An opinion on the relevance of the data used to build the model and quantitative aspects of the model such as formula or variable selections</li> <li>• An opinion on the appropriateness of qualitative assumptions or expert judgment inputs or overlays</li> <li>• An assessment of whether the model is performing as expected</li> <li>• An evaluation of conceptual soundness which covers the documentation, as well as empirical evidence supporting the methods used and the variables selected in the design and quantification of the model</li> <li>• A list of assumptions or limitations excluded from the development documentation and the impact those assumptions or limitations may have on the overall model</li> </ul>
<p><b>25. Determine whether validations are performed in accordance with an established schedule. Evaluate the reasons for any validation delays, whether delays are appropriate, and whether delays are reported to a senior management group or committee.</b></p>
<p><b>26. Evaluate validation results and findings. Determine whether:</b></p> <ul style="list-style-type: none"> <li>• Validation results are communicated effectively and timely</li> <li>• Examiners identified any critical findings that validators did not</li> <li>• Severity of findings is appropriately reflected and not adjusted to enable a model to pass</li> <li>• Models receiving a rating of conditional pass have specific conditions for use</li> </ul>
<p><b>27. Determine whether any model that received a rating of fail is still in use, and if so, assess the reasoning.</b></p>
<p><b>28. Determine whether validation findings are remediated timely and whether remediation work is assessed independently for completeness. Consider whether:</b></p> <ul style="list-style-type: none"> <li>• Findings are tracked on a centralized system</li> </ul>

<sup>7</sup> Validation activities may be conducted by internal personnel or third parties, but it is important that they be independent from model development or subject to an independent review that sufficiently mitigates conflict of interest. A fundamental internal control is not allowing the business line or model developers to develop or modify the validation scope.



- Findings are remediated within required timeframes, and if not, whether the reasons for delays are documented
- There are consequences when findings are not resolved timely, or there are repeat issues (repeat issues may affect the model risk score or model validation grade)
- Validators or an independent third party confirm that a finding has been remediated by a developer

### Ongoing Monitoring

**29. Determine whether the ongoing monitoring framework is sufficient to confirm that the model is appropriately implemented and is being used and performing as intended. Evaluate the appropriateness of the reporting of ongoing monitoring, including who reviews the ongoing monitoring results. Ongoing monitoring may include:<sup>8</sup>**

- Process verification checks to ensure all components are functioning as designed
- Evaluation of model performance to assess whether there is any deterioration
  - Performance may be evaluated against established benchmarks
- Historical and new data assessments for accuracy, completeness, quality, and relevancy
- A review of qualitative adjustments or overrides
- Procedures to determine when adjustment, redevelopment, or replacement is necessary based on changes in products, exposures, activities, clients, or market conditions, which may include reviewing new empirical evidence or theoretical research

**30. If deterioration is identified, evaluate the process for redevelopment.**

### Change Control

**31. Determine whether sufficient change control policies and procedures are in place and whether change control processes impact the model life cycle, particularly validation. If applicable, evaluate the change management log and determine whether:**

- Materiality thresholds exist for when changes must be input onto the log (e.g., changes to computer code or data may be required to be logged but minor narrative edits in documentation may not)
- Access controls exist and are appropriate (e.g., who can make changes on the log or who can make changes to a model)
- Management maintains a quality control or audit check on the logs to ensure that all required changes are input
- Prior or backup versions are required to be retained in the institution's systems
- Models are required to be re-validated if material changes are made and whether "material" is defined

<sup>8</sup> The extent and frequency of ongoing monitoring may vary depending on model type or risk grade.

Testing
<p><b>32. Assess the testing performed during validations, annual reviews, and ongoing monitoring. Considerations for testing include:</b></p> <ul style="list-style-type: none"> <li>• How tests and model components are selected for testing</li> <li>• The type of testing performed (e.g., backtesting, benchmarking, and sensitivity analysis) <ul style="list-style-type: none"> <li>○ If certain tests cannot be performed, review management’s documentation as to why the tests are not possible</li> </ul> </li> <li>• Procedures for testing third party models</li> <li>• Who internally is required to review the test results and whether they have sufficient expertise to perform the review and are independent of the model development process</li> <li>• The existence and content of testing templates or formal testing plans</li> <li>• Whether testing encompasses all products and applications for the model</li> <li>• Whether test results are within error tolerance levels established by policies or procedures, and if not, whether management has a plan to address the breaches</li> <li>• The impact of assumptions or qualitative adjustments</li> <li>• The appropriateness of sensitivity tests and whether sensitivity tests: <ul style="list-style-type: none"> <li>○ Determine whether small changes in inputs or parameters affect outputs</li> <li>○ Model simultaneous changes to inputs and parameters</li> </ul> </li> <li>• When testing has revealed models that are inaccurate or unstable, whether the conditions that prompted deterioration are noted as a limitation</li> <li>• An appropriate reporting process for test results</li> <li>• How testing results are used</li> </ul>
Audit
<p><b>33. Evaluate the effectiveness of the MRM audit program.<sup>9</sup> Assess whether the audit of MRM is independent and whether auditors have sufficient expertise to review the MRM function.</b></p>
<p><b>34. Evaluate the quality and content of the MRM Audit. An MRM audit may include a review of:</b></p> <ul style="list-style-type: none"> <li>• The overall effectiveness of the MRM framework</li> <li>• A test of various controls, such as change control processes</li> <li>• The appropriateness of an institution’s policies and procedures for MRM, and the institution’s compliance with policies and procedures</li> <li>• Records of model use and validation</li> <li>• The accuracy and completeness of the model inventory and model identification process</li> <li>• The reliability of data used or an assessment of the institution’s data quality control processes</li> </ul>

<sup>9</sup> If the institution does not have a formalized or centralized MRM program, consider this procedure in relation to individual model use.

<p><b>35. Evaluate the appropriateness of reporting and tracking of audit findings.</b></p> <ul style="list-style-type: none"> <li>• Assess whether audit reports and finding remediation progress reports are presented to the board or a designated committee</li> <li>• Determine whether audit results are communicated in a timely manner and findings are tracked until remediated</li> </ul>
<b>Oversight and Governance</b>
<p><b>36. Determine whether governance and reporting provide sufficient oversight over the MRM function given the size and complexity of the institution and the institution's overall model risk.<sup>10</sup> Appropriate governance can be evaluated by determining whether:</b></p> <ul style="list-style-type: none"> <li>• The Board or an assigned committee periodically receives reports on model risk activities</li> <li>• The MRM framework is consistent across the entire institution</li> <li>• The MRM function or MRM manager reports to the appropriate level of management and has sufficient independence</li> <li>• The culture at the institution puts undue pressure on model validation activities to pass models or limit findings</li> <li>• The framework includes defined roles and responsibilities for clear communication of model limitations and assumptions, as well as the authority to restrict model usage</li> </ul>
<b>End of Core Analysis</b>

<sup>10</sup> If the institution does not have a formalized or centralized MRM program, consider this procedure in relation to individual model use.