

Auditing Model Risk Management

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What is Model Risk?

Financial institutions rely heavily on financial and economic models for a wide range of applications — such as risk management, valuation, and financial / regulatory reporting. The level of sophistication of models used for such applications varies widely from relatively simple spreadsheet tools to complex statistical models applied to millions of transactions.

Model usage exposes a financial institution to model risk — which typically involves the possibility of a financial loss, incorrect business decisions, misstatement of external financial disclosures, or damage to the company's reputation arising from:

1

Possible errors in the model design and development process (including the design and development of changes to existing models) — such as errors in the data, theory, statistical analysis, assumptions, or computer code underlying a model.

2

Misapplication of models, or model results, by model users.

3

Use of models whose performance does not meet company standards.

4

Possible errors in the model production process — such as errors in data inputs and assumptions, or errors in model execution.

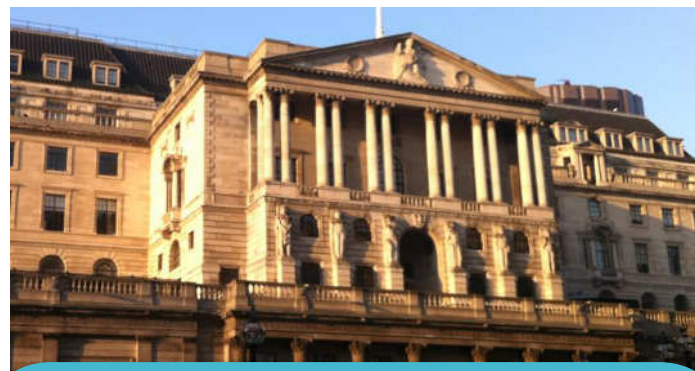
Model Risk Management

Risks

- Numerous, high-profile, examples of model risk resulting in significant losses due to insufficient attention to model limitations.
- Advances in business and technology have increased the number and complexity of quantitative models as an input to management decision-making in large banks.
- Executive Management and Boards of Directors are expected to understand these risks.

Benefits

- Strong model risk management and robust effective challenge, including independent model validation and audit reduce the likelihood of erroneous model output or incorrect interpretation of model results.
- Robust controls and assumption transparency enable better decision making.
- Consistent application of model risk management provides confidence in Executive Management and Boards of Directors.
- Proactive response to increasing regulatory expectations for model risk management.

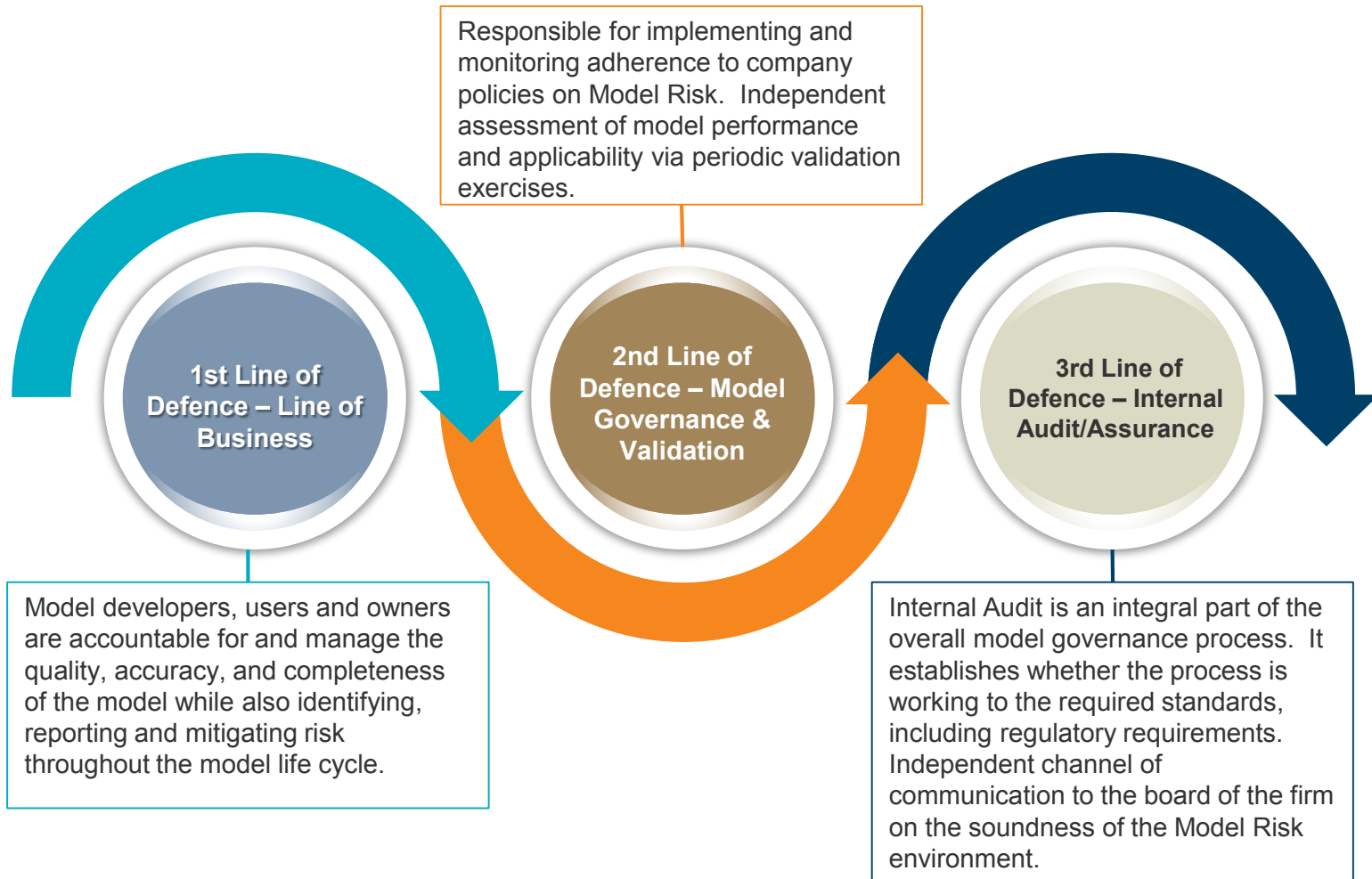


- PRA expects firms to be prudent in their use of quantitative models given the inherent difficulties with risk measurement.
- Models, and their output, should be subject to effective, ongoing and independent validation to ensure that they are performing as anticipated.

– The Prudential Regulation Authority's approach to banking supervision, June 2014

Three Lines of Defence

The three lines of defence approach is designed to ensure validity and accuracy



Model Risk Management is Key in all three Lines of Defence

Typical applications of models in financial institutions

Lines of Defence	Credit Risk	Market Risk	Operational Risk	Stress Testing	Economic Capital & Basel/ Solvency II	Anti-Money Laundering
1st Line – Line of Business Model users and owners are accountable for and manage the quality, accuracy, and completeness of the model and identify, reporting and mitigate risk throughout the model life cycle.	✓	✓	✓	✓	✓	✓
2nd Line – Model Governance and Validation Model Validators and other Risk Managers develop and implement programmes to establish controls for model risk management. Periodic model validation is completed by the second line of defence.	✓	✓	✓	✓	✓	✓
3rd Line – Internal Audit/Assurance Internal Audit tests controls for model risk management and evaluates adherence to company policies and regulatory expectations.	✓	✓	✓	✓	✓	✓

Examples of Regulatory Guidance

2011 – 12: Supervisory Guidance on Model Risk Management (OCC 2011-12/ Fed SR 11 - 7)

- The purpose of this document is to provide comprehensive guidance for banks on effective model risk management.
- Defines “Effective Challenge” as critical analysis by objective, informed parties who can identify model limitations and assumptions and produce appropriate changes.
- Effective challenge depends on a combination of incentives, competence, and influence

2012: The Internal Audit Function in Banks (BIS)

- Risk management includes the assessment of risk processes, measures, assessments of all bank activities.
- The Basel Committee addresses the role of an independent and qualified internal audit function as being critical to sound governance.

2014: EBA Supervisory Review & Evaluation Process (SREP) EBA/CP/2014/14

- Includes Model Risk the supervisory review process
- Assess exposure to Model Risk
- Determine level of awareness of the reviewed institution’s senior management

2015 – 17: TRIM (ECB)

- Increase consistency of model outputs across institutions
- Institutions should have sound model inventories and model risk management processes
- General principles and independence requirements for Internal Audit

2017: Model Risk Management Principles for Stress Testing CP 26/17 (PRA)

- Focus especially on the annual stress test exercises and resulting capital requirements
- Recognises often separate stress test models and their unique role

Guidance for Effective Challenge of Model Risk Management

Model Development, Implementation, and Use

- Developers should consider models' impact on business performance from user feedback and should factor in suggestions and criticism from sources independent of the business
- Existence of effective challenge is required to identify model limitations and assumptions

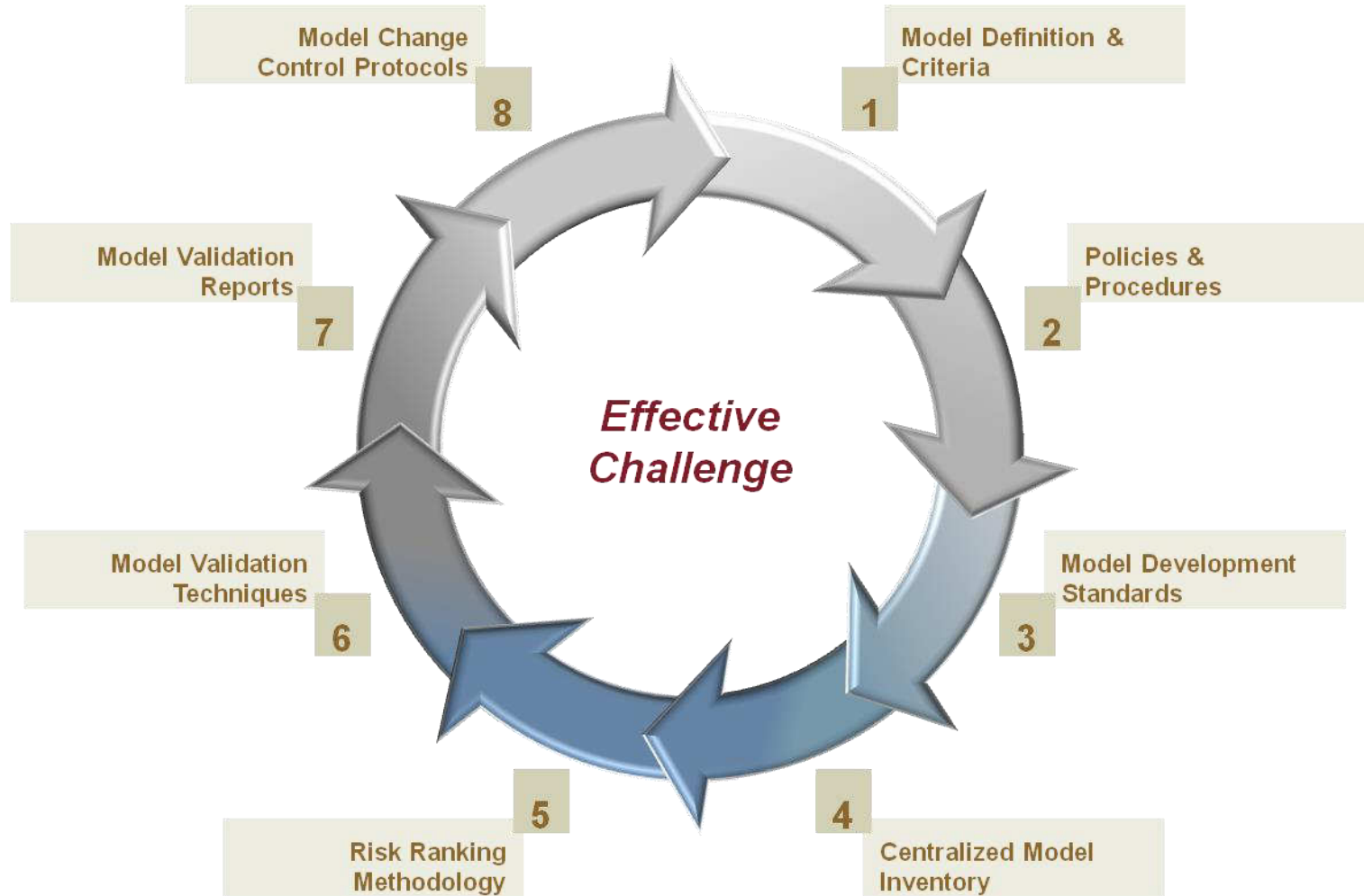
Model Validation

- Validation of models should be performed by a function independent of the developers
- Each model should be reviewed at least annually to assess material changes and whether validation activities are sufficient.
- Models should be validated for conceptual soundness including the validity of assumptions, limitations, and outcomes
- Models from 3rd party vendors should be evaluated for appropriateness to the institution's situation and require ongoing monitoring by the institution and the vendor

Model Governance, Policies, and Controls

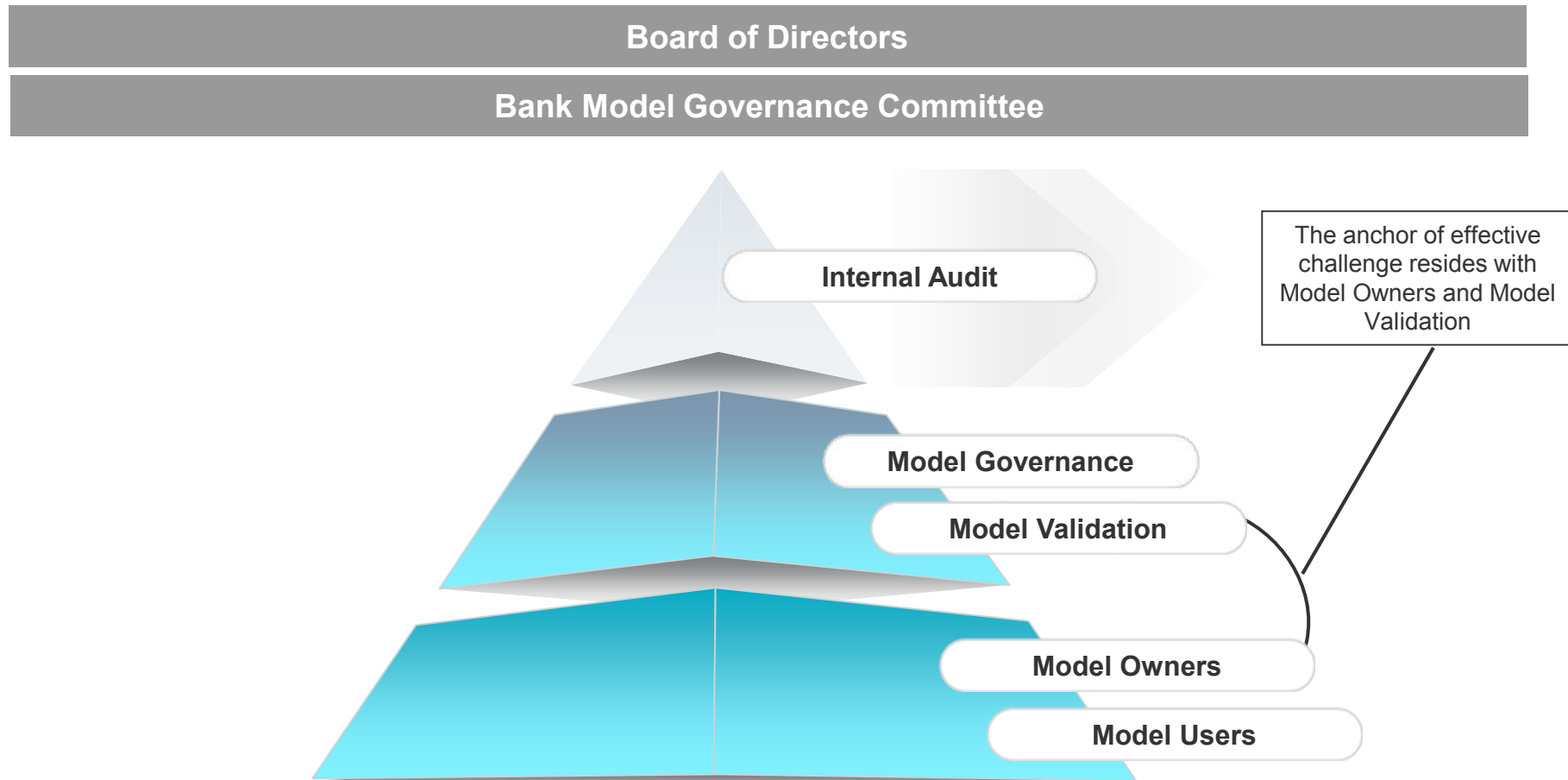
- Board and Senior Management should support effective challenge through establishment of a robust model risk framework that includes policies and procedures outlining the roles and responsibilities for model validation and quality assurance functions
- Risk Management functions are responsible for managing model validation and review processes to ensure effective challenge occurs
- Internal Audit evaluates the design and effectiveness of controls for model risk management and communicates audit findings to the business for remediation
- Use of external resources for model validation, compliance, or audit requires clear lines of communication to internal parties for identified issues

Model Governance Framework



Model Risk Governance Structure

Multiple regulatory guidelines require that all quantitative models are supported by a strong model risk governance framework



Roles in Model Risk Management

Model Validation and Internal Audit ensure controls are designed adequately and implemented effectively to reduce the likelihood of erroneous model output or incorrect interpretation of model results.

Activity Players	Development	Implementation	Production	Reporting	Validation
Model Developers	<ul style="list-style-type: none"> Code Document assumptions, theory, and testing 	<ul style="list-style-type: none"> Conduct user acceptance tests (UAT) 	<ul style="list-style-type: none"> Monitor performance 	<ul style="list-style-type: none"> Support user interpretation of model results 	<ul style="list-style-type: none"> Provide code and documentation
Independent Validators	<ul style="list-style-type: none"> None (maintain independence) 	<ul style="list-style-type: none"> Review implementation 	<ul style="list-style-type: none"> Periodic reviews 	<ul style="list-style-type: none"> Ensure model reports are used appropriately 	<ul style="list-style-type: none"> Evaluate Conceptual soundness, outcomes analysis, Ongoing monitoring
Internal Audit	<ul style="list-style-type: none"> Evaluate adequacy of development guidelines Test completeness of development documentation 	<ul style="list-style-type: none"> Test systems development life cycle 	<ul style="list-style-type: none"> Evaluate model risk monitoring controls 	<ul style="list-style-type: none"> Evaluate completeness of reports 	<ul style="list-style-type: none"> Evaluate design adequacy of validation guidelines Test effectiveness of validations

First and Second Lines of Defence High Level Responsibilities

As the first line of an institution's "three lines of defence", lines of business and users are responsible for ensuring that models are properly developed, implemented, and used. Model owners ensure that models in use have undergone appropriate validation and approval processes, promptly identify new or changed models, and provide all necessary information for validation activities .

Line of Business - 1st Line of Defence

Roles	Responsibilities
Model Owner	<ul style="list-style-type: none">• Responsible for model risk associated with business strategies.• Accountable for model use and performance within bank model risk management policy and procedures.• Managing model development, implementation, approval and use.• Ensuring models in use have undergone appropriate validation and approval processes, promptly identify new or changed models, and provide all necessary information for validation activities
Model User & LOB	<ul style="list-style-type: none">• Maintaining models, model controls and challenging model assumptions.• Identifying needs for new models and approving requests for new models.

Model Governance & Model Validation - 2nd Line of Defence

Roles	Responsibilities
Model Governance	<ul style="list-style-type: none">• Formalizing and approving model risk management activities with policies and the procedures to implement them.• Updating policy to ensure that model risk management practices remain appropriate and are current with changes in market conditions, bank products and strategies, bank exposures and activities, and practices in the industry.• Developing and maintaining document and quality standards across the organization.
Model Validation	<ul style="list-style-type: none">• Guiding the scope and prioritization of model validation and performing validations of models.• Communicating validation issues and problems to relevant individuals and business users throughout the organization, including senior management, with a plan for corrective action.• Authority to restrict the use of models and monitor any limits on model usage.

Internal Audit's (3rd Line of Defence) role in Effective Challenge

As the third line of an institution's "three lines of defence", Internal Audit is the independent function responsible for providing assurance that the policies, procedures, and internal controls designed by the lines of business and their support functions are effectively designed and operating to manage model risk. Regulators increasingly expect Internal Audit to play a critical role in challenging the robustness and validity of Senior Management's model risk management framework, processes, and controls.

Internal Audit – 3rd Line of Defence

Roles	Responsibilities
Internal Audit	<ul style="list-style-type: none">• Ensuring that model risk is included in annual audit plans that adequately cover auditing of matters with regulatory impacts (i.e., risk management, capital adequacy and liquidity control functions)• Offering an independent validation of the internal controls established for model development, usage, and validation• Evaluating the timeliness, frequency, and completeness of model validation activities• Determining if model owners and control groups understand model risk policies and comply with them• Assessing if the model risk framework sufficiently addresses model risk for individual models and at an aggregate level• Reporting of model-related audit findings to Senior Management, Board of Directors, and regulators• Tracking of audit and regulatory issues through remediation

Model Audit Approach – 2nd Line Review

Process	Test of Design	Test of Effectiveness	Sample Size (#)
Organisation structure / roles and responsibilities		N/A	N/A
Risk reports submitted to the Board and/or Senior Management			
Development standards & documentation			
Identification			
Risk rating			
Usage			
Performance metrics & thresholds			
Issues closure / extension			
Change management			
Adjustments / overrides			
Annual review			
Validation			

Model Audit Approach – Validation Test of Effectiveness

Assumptions

- Did the validation team evaluate if all key assumptions/inputs subject to monitoring?
- Did the validation team evaluate the impact on outputs of model assumptions?
- Did the validation team evaluate whether the assumptions are consistent with those used in other corporate models?

Theory

- Did the validation team provide an adequate process by which models are developed and updated?
- Did the validation team chose all of the proper variables?
- Did the validation team ensure that the model has the correct functional form?

Data

- Did the validation evaluate if the data filtering/corrections were reasonable?
- Did the validation team check that the data represents key population characteristics?
- Did the validation team evaluate if the extraction, transformation, and loading processes were effective?

Implementation

- Did the validation team ensure that the system and user acceptance testing is adequate?
- Did the validation team ensure that general IT controls, e.g. change management, access, etc. exist?
- Did the validation team provide consistent development code and production code?

Usage

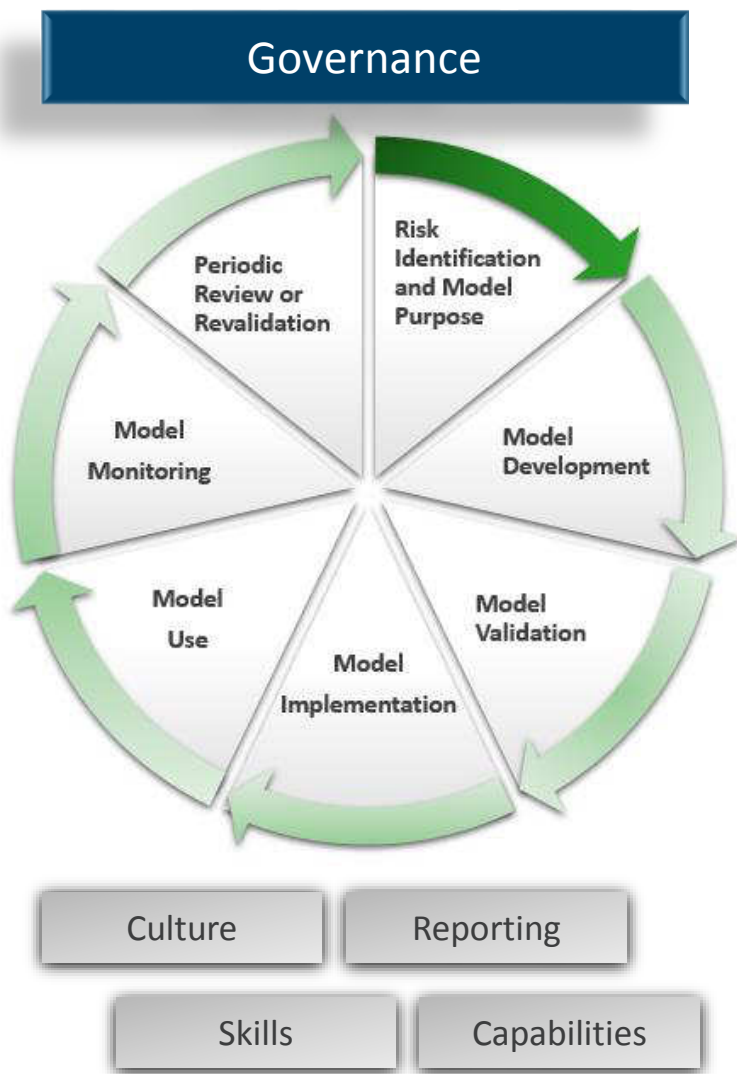
- Did the validation team assess the appropriate use of the model?
- Did the validation team help users understand the model output?
- Did the validation team share output testing with the users?
- Did the validation team communicate limitations to the users?

Performance

- Did the validation team ensure that the metrics and thresholds are adequate and linked to business impacts?
- Did the validation team provide a sufficient process to resolve poor model performance?
- If different metrics were used, did the validation team check if model performance would be evaluated differently?

Key Audit Activities & Considerations

Model Lifecycle: Key Audit Activities... (1)

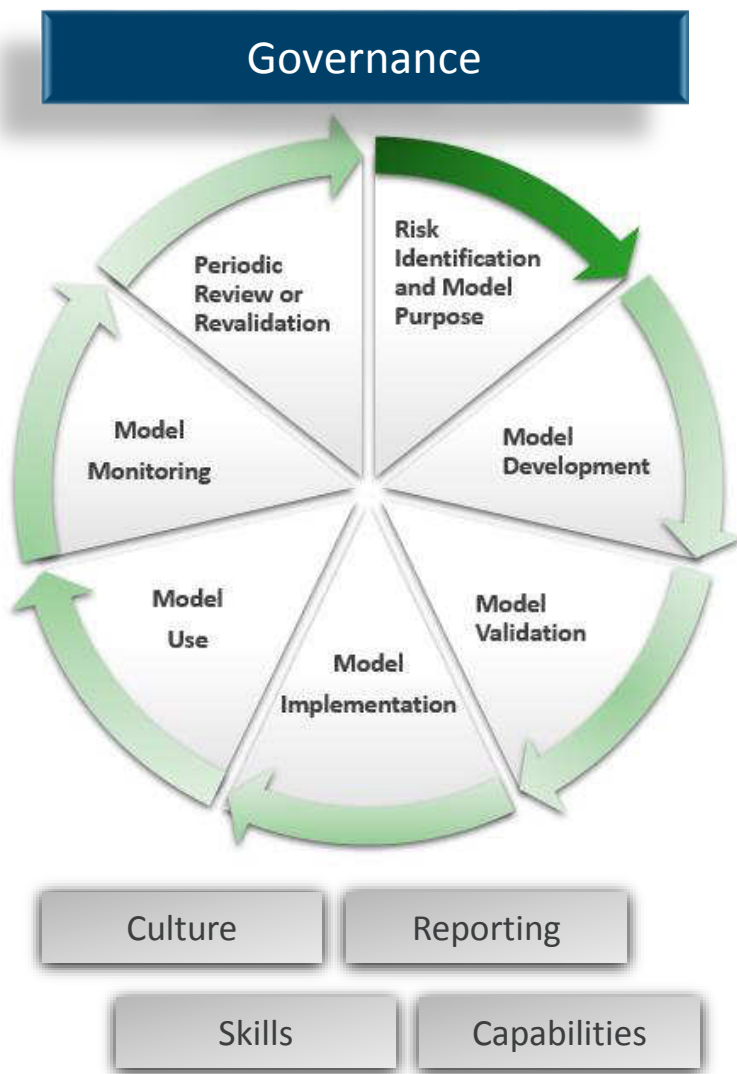


Model Governance, Policies & Controls

- Gap analysis of Model Development, Validation and Governance Policies against regulatory expectations
- Assessment of the policies to verify that the key roles and responsibilities have been clearly defined
- Verify that adequate documentation standards are also in place for eliminating key person risk
- Review the inventory definition and management guidelines
- Review that adequate controls are in place for models and MRM processes.



Model Lifecycle: Key Audit Activities... (2)

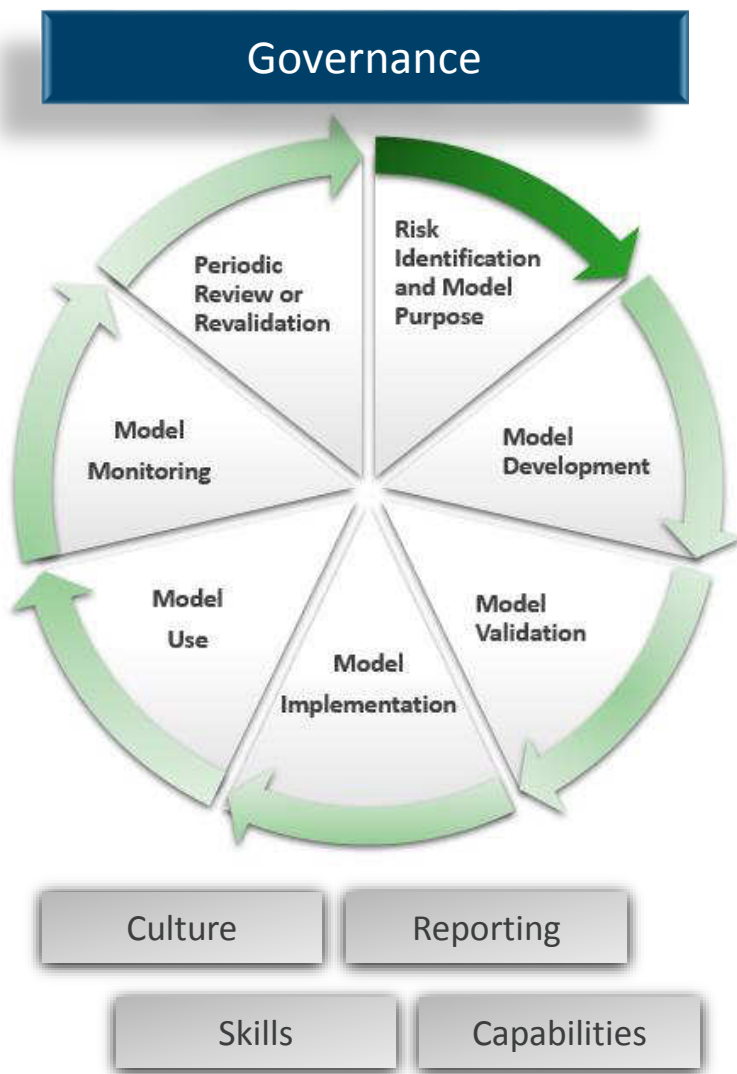


Model Development, Implementation & Use

- Assess the controls in place for testing the robustness of the model development and use process. The key components to review include:
 - ❖ Model Purpose and Use
 - ❖ Relevance and Accuracy of data
 - ❖ Conceptual soundness of Model framework, theory and logic
 - ❖ Model Performance
 - ❖ Scenario analysis
 - ❖ Model implementation
 - ❖ Model Governance and Use
- Assessment is based on developing a model controls test sheet covering the above areas



Model Lifecycle: Key Audit Activities... (3)



Model Validation

- Assess the controls in place for testing the effective challenge of the model validation: The key review components include validation areas relevant to:
 - ❖ Comprehensiveness and completeness of model document
 - ❖ Independent testing of the accuracy of the reported results
 - ❖ Assessment if the test results are in-line with the expectations
 - ❖ Benchmarking
 - ❖ Independence in identifying and reporting findings
- Assessment is again based on a model controls test sheet



Audit Considerations: Governance, Policies and Controls

- ❑ Inventory Definition and Management
- ❑ Clarity in Roles and Responsibilities of Model Owners vs. Model Users
- ❑ Model Risk Rating and KRIs– Objectivity vs Subjectivity
- ❑ Adequate Skills and Resource availability
- ❑ Clear guidelines for new validation vs revalidation vs model changes

- ❑ Development and Validation policies Gaps:
 - Guidance on how to apply, document and govern overrides or overlays
 - Guidance on thresholds for assessing and monitoring model performance
 - Guidance on model replication vs code review
 - Benchmarking and Challenger models

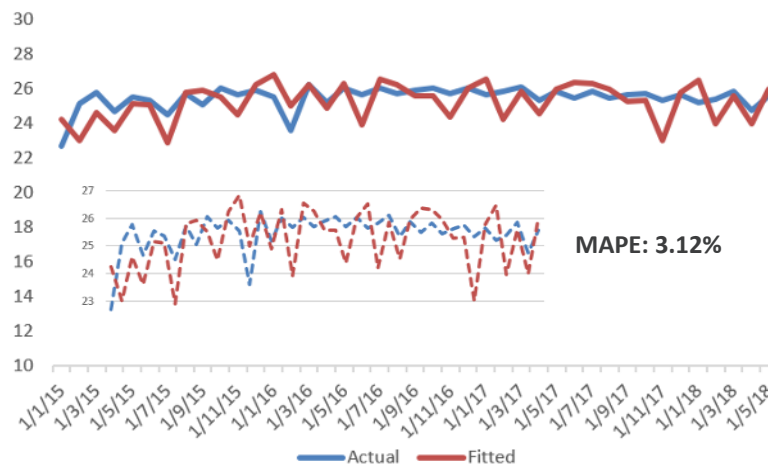
Sample Inventory:

Model ID	Model Name	Model Description	Model Owner	Risk Rating	Last Reviewed	Review Status	Overlays
231	Employee Fraud Model	For ranking and detecting fraud conducted by employees	John, Smith	Low	30/06/2015	Approved	
456	VaR model	Reg. capital for structured products	David, Graham	High	30/06/2017	Approved	5 MM base case
763	Origination Scorecard	Credit origination strategies	Lydia, Doe	Medium	30/06/2016	Decommissioned	

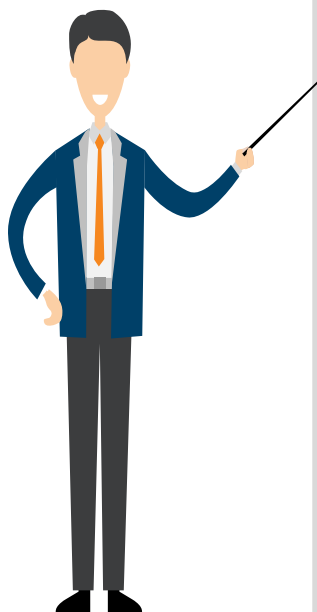
Sample Risk Rating Design:

- Is the model used for *Critical Decisions*?
 - Is the *Portfolio Size* above or below the threshold?
 - *Significant model changes* since last year?
 - *Qualitative Adjustment* of risk rating?

Sample Performance Thresholds:



Audit Considerations: Development, Implementation & Use



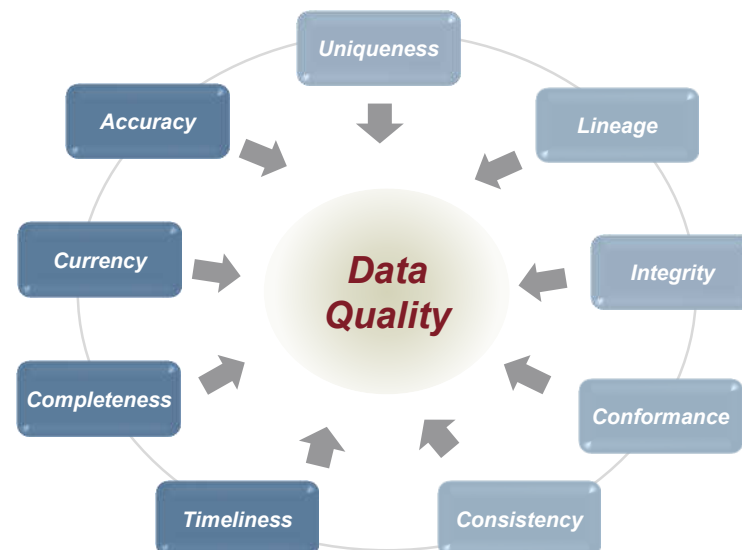
- Granularity of the model controls and tests?
 - ✓ Development vs Implementation
 - ✓ Granularity within each model area
- Is there adequate documentation on model dataset definition and creation?
 - ✓ Business vs. Model Development
 - ✓ Model Development's role in the ensuring data accuracy and integrity
- Is the documentation on model theory and logic sufficient?
 - ✓ Comparison with alternate methodologies/frameworks
 - ✓ Discussion of leading industry practices
- Is variable exclusion/ model selection rationale clearly documented?
- Are the dependencies on feeder models sufficiently discussed?

Audit Considerations: Model Validation



- ☐ Are validation activities independent from model development?
- ✓ Validation findings documented
- ✓ Model development choices prelude model validation
- ☐ How did MV challenge the construction and accuracy of the model datasets?
- ☐ How did MV challenge the accuracy of model development testing results?
- ☐ How did MV challenge the use or necessity of using model overlays?
- ☐ Has benchmarking analysis been done to challenge the proposed model choices?
- ☐ Is the scope of revalidation in compliance with the policies?

EFFECTIVE CHALLENGE?



Q&A

Contact

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