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Emerging Trends in Model Risk Management

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Introduction

Financial institutions rely more and more upon advanced mathematical, statistical and numerical models to measure and manage risk and manage their businesses.[1] Models are used to calculate economic capital charges for various types of exposure, subject to different risk types – such as credit, market, or operational. Through their individual components the bank's current liquidity position is projected under alternative scenarios, as well as the projection of the balance sheet and income statements for use in stress testing.[2]

Banks are also modeling many key elements of business planning and development, such as the appropriate bundling of product features, customer or on-customer income, or churn rates.

As the use of these models increases, so does the possibility that any particular model may not properly capture financial risk. Model error refers to the simplification or approximation of reality within models, incorrect or missing assumptions, incorrect design processes, and errors in measurement or estimation. Model misuse is the application of models outside the use for which they were designed and/or intended.

As a result, the danger stemming from rare yet plausible occurrences might be understated, as such occurrences might not appear in reference data sets or in historical data patterns.

In order to mitigate potential emerging risks, the discipline of model risk management (MRM) has evolved over the years to support emerging regulatory and business agendas. Until recently, industry MRM efforts have focused upon the management of risk for individual models; now, however, we are seeing more institutions focus on quantifying and aggregating enterprise-wide model risk.

Regulatory Guidance

As the use of complex models has become prevalent in the industry, regulators have continued to push financial institutions to invest in model risk management, with focus on establishing comprehensive frameworks for active model risk management including robust development, validation and monitoring capabilities.

In this regard, a high proportion of bank decisions are automated through decision models, which can be statistical in nature, or a methodology that constitutes a rule-set.[3] There are several areas in which we see this trend manifest itself. For example, an increased use of electronic trading platforms known as algorithmic trading that execute trade commands which have been pre-programmed (e.g., through timing, price or volume), and can be initiated with manual intervention.[4]

At this time, supervisory guidance on model risk management is limited, and the regulations published to date tend to be based on principles; that is, they lack specificity in how to define and treat model risk.

In the US, the Federal Reserve and the Office of the Comptroller of the Currency (OCC) combined to publish the Supervisory Guidance on Model Risk Management, which lays out basic principles for model risk management:[5]

- Model risk is to be managed like other risks, in that model risk managers should identify the sources of risk, assess the likelihood of occurrence and the severity of any specific model failure.
- As with other types of risk, model risk can never be eradicated, only controlled by effective risk management, including comprehensive model development and rigorous model validation.
- Institutions should establish an MRM framework that is approved and overseen by senior management and the board of directors.
- A well-documented and structured approach to model development and validation can be useful in managing model risk, but is not a substitute for the continuous process of improving models.
- Prudent use of models is likely to involve elements such as conservative adjustments, stress testing or capital buffers, but an over-reliance on such elements may lead to the misuse of models.
- There are many potential sources of model risk and therefore institutions should consider the interaction of these factors and try to quantify the aggregated model risk that results from their combination.

Within this framework, there are elements of good governance that should be observed. In particular, in our view the three elements of model ownership (identification and measurement of the model risk to which the institution is exposed); model control (setting limits, following up and independently validating models); and model compliance (establishing processes to help perform ownership and control rules in accordance with accepted policies) are essential.

Overall, the supervisors expect institutions to create MRM frameworks that feature model development and validation criteria which are formalized, promote careful model use, establish criteria to assess model performance, and define policy governance for consistent implementation of framework and applicable standards of documentation. This holistic approach to model risk management continues to be adopted by the financial services industry, and we expect it to become increasingly prevalent as more institutions use such an approach.

Model Risk Governance Framework

As seen in Figure 1 below, the organizational structure for MRM should establish clear lines for development and monitoring and provide the right incentives while promoting cross-functional involvement in model risk discussions.

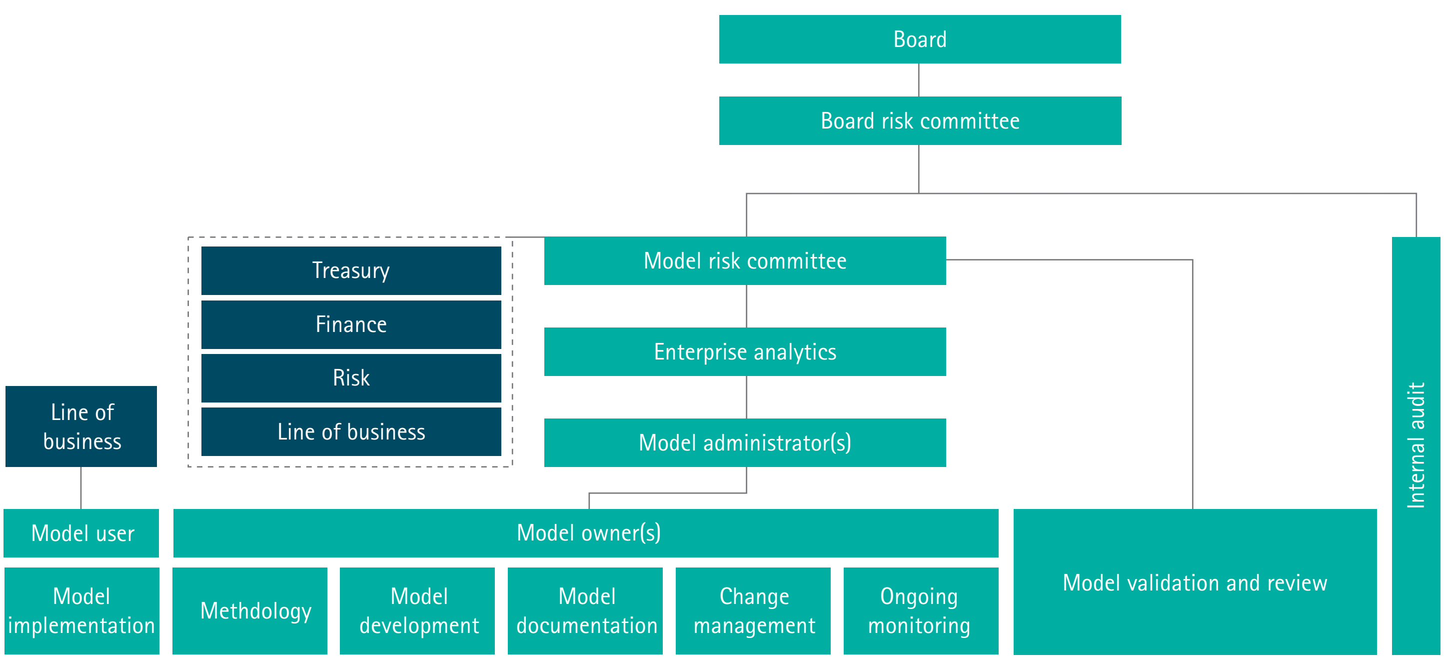
In our view, these are the key roles involved in the model governance process:

- **Model Owner.** Ideally a person is assigned responsibility for developing or maintaining a model, including documenting the model. The model owner will also lead the model implementation process, along with the model user. The model owner is usually responsible for ongoing model monitoring.
- **Model User.** The model user has responsibility for the use of a model for business purposes. Each model can have multiple model users.
- **Model Administrator.** The model administrator is usually the supervisor of the model owner and may be responsible for assisting the model owner with certain governance responsibilities.

  The model administrator guides the model developers in his or her team to complete the model documentation, complying with the model validation department's model document template.
- **Model Validation and Review.** Independent from the model owner, a validation unit is assigned the responsibility to implement and oversee the model validation and review functions and the model governance program on a daily basis.
- **Model Risk Committee.** This is the senior management committee with responsibility for overseeing the model governance program. The committee reports on risk issues and trends to the risk committee of the board, or takes other action as appropriate.
- **Internal Audit.** The internal audit function undertakes the independent review of all model risk and governance activities.

While some overlaps may occur among the roles of model owners, model users and model administrators, the model validation, model risk committee and internal audit functions should remain independent.

Figure 1. Model Risk and Governance Framework



Source: Accenture, August 2015

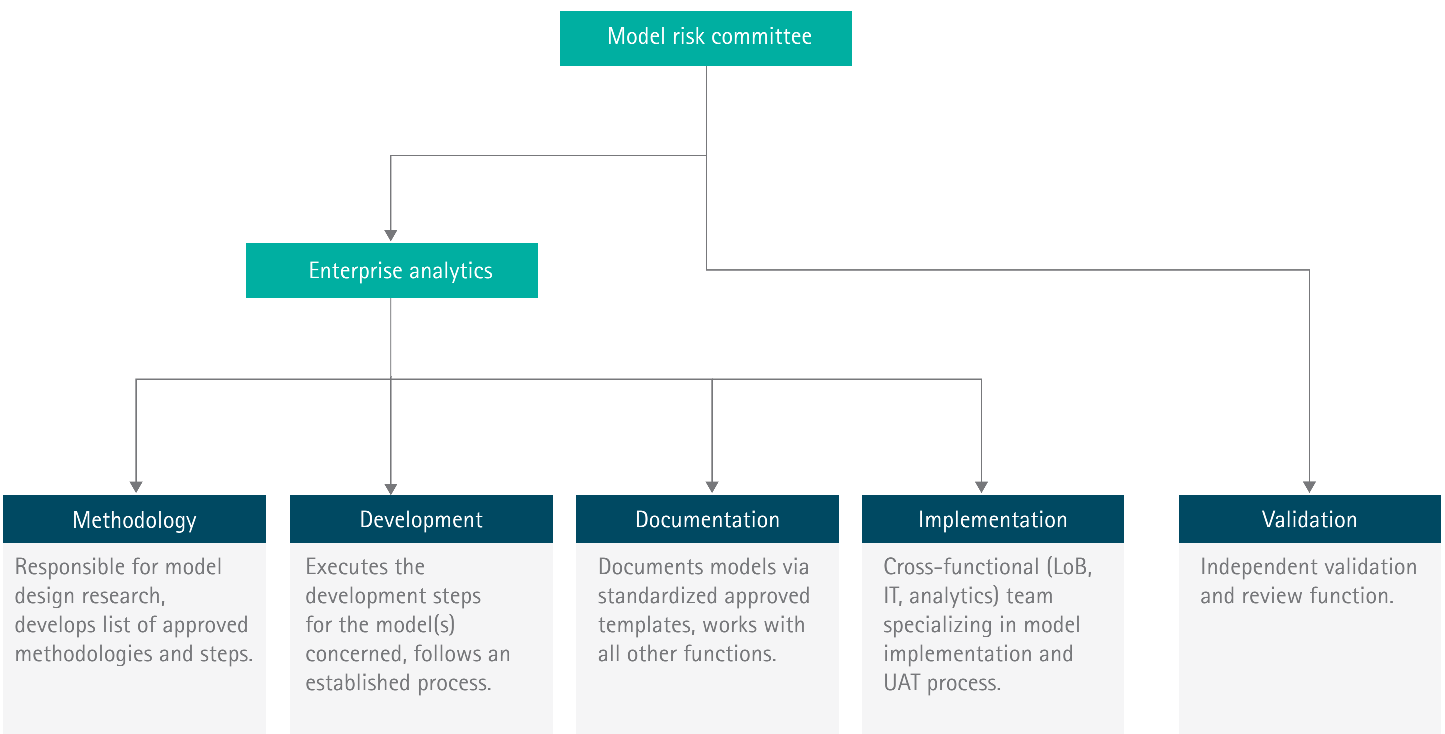
The Analytics Function

As seen in Figure 2 below, the preferred approach to setting up an efficient modeling function is to have a modular team structure with specialized groups and/or centers of excellence addressing different aspects of the model lifecycle.

A well-structured analytics function should follow an ordered process including:

- Methodology design, including model design research and development.
- Execution of the development process under a well-defined and established process.
- Documentation development of model design and testing using standardized approved templates across lines of business (LoB) and risk types.
- Implementation of a set of processes that leverages cross-functional teams specializing in model implementation and user acceptance testing (UAT).
- Reporting of model risk rating and inventory.

Figure 2. Proposed Analytics Function



Source: Accenture, August 2015

The Validation Function

Finally, the key part of a model risk management framework in our view is establishing a strong and independent validation function. This function should be able to address the quantitative and qualitative review of models across the five broad areas of data, methodology, documentation, processes and governance. Figure 3 highlights some of the key themes that should be considered by the validation team while going through the process.

As institutions continue to build out their validation function, they should consider the following building blocks:

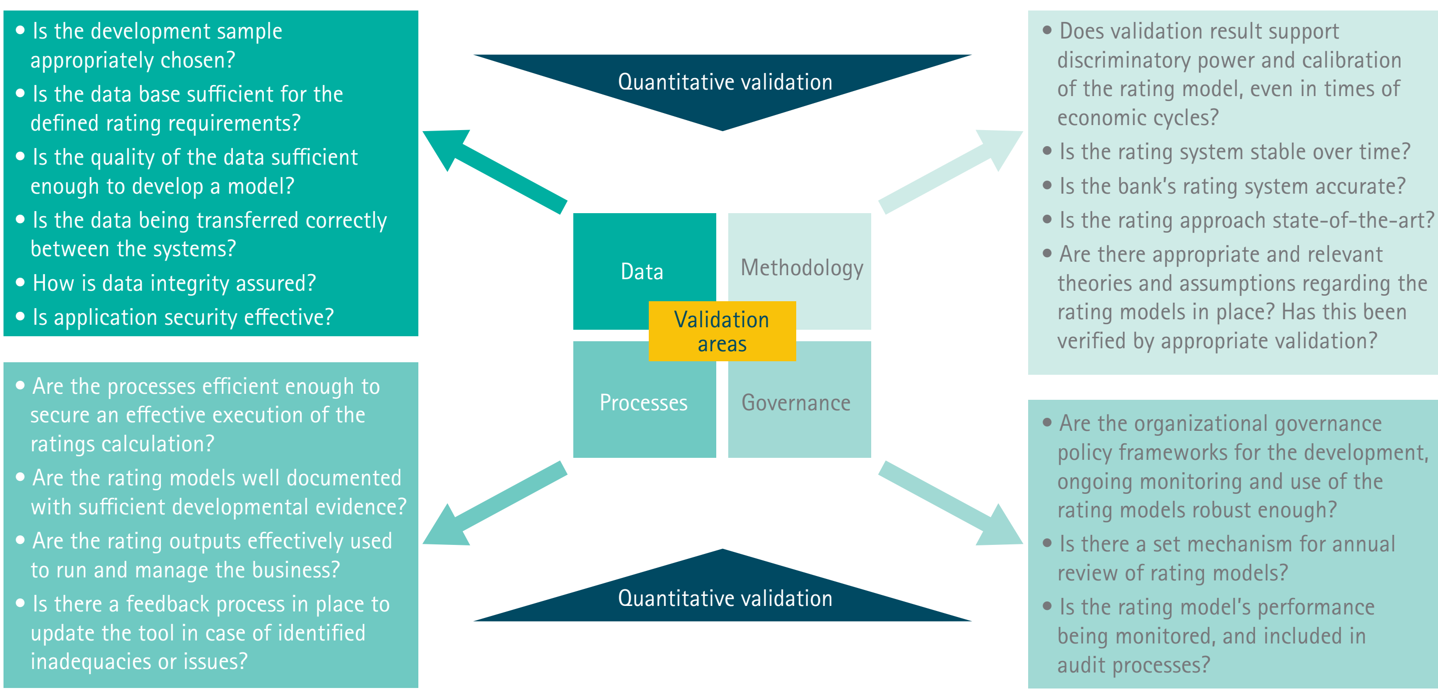
a) Well established policies and procedures to support consistent execution across all validations.

b) Access and appropriate alignment of a strong pool of human capital with specialized skill sets to help drive the validation for all internal and vendor-based models.

c) Access to a wide variety of tools and applications such as centralized model submission capabilities, standardized documentation templates, and reporting tools for better governance and control.

An emerging trend in model validation is with regard to models for stressed capital (e.g., as used in applications such as Comprehensive Capital Analysis and Review (CCAR) or the Dodd-Frank Act stress test (DFAST)), currently at an early phase of development as compared to other types of models, such as methodologies for measuring market Value-at-Risk (VaR) or credit default prediction.[6]

Figure 3. Model Validation



Source: Accenture, August 2015

Various techniques exist to help validate a stressed capital model, each capable of informing on the robustness of a few of the desired model properties. Note that some validation techniques are effective in the examination of only certain properties, where by effective we mean the ability of a test to detect departures from a desired state of affairs. For example, many validation procedures exist that effectively assess risk sensitivity (e.g., does the stressed capital model reflect the state of the economy?). Yet, in measuring the accuracy of economic capital (i.e., is the estimator of the loss distribution quantile estimate predictively accurate?), few techniques are available to do this reliably. When used in combination and in an environment of controls and model governance, a broad set of validation techniques could offer more substantial evidence regarding performance of a stressed capital model.

There still remains in our view much scope for the industry to enhance the robustness of its validation practices. These can inform on how well stressed capital models are calibrated, in particular for cases where the assessment of overall capital is an important application of the model (e.g., to set a financial institution's total risk "budget"), as opposed to situations where it is not (e.g., where the model is used to establish the relative risks of different LoB).

Compared to just over a decade ago, we are seeing a heightened supervisory focus on the validation of stressed capital models.[7] Based on our work in this area, stressed capital model parameter harmonization and cross-bank benchmarking are now viewed by regulators as weak points in model development. On the positive side, supervisors may have the impression that banks are doing well with respect to quantifying risk on a relative basis (i.e., between LoB or risk types) and producing models that exhibit sensitivity to risk factors (e.g., to the state of the economy). Although there is scope for practices to improve further, the signs of progress in these areas are moderately encouraging.

In other respects, we believe industry validation practices are weak, particularly when the total capital adequacy of the bank and the overall calibration of the model is an important consideration. It is recognized within the industry that this validation task is intrinsically difficult since it typically requires the evaluation of high quantiles of loss distributions over long periods combined with data scarcity, and coupled with technical difficulties such as tail estimation. We also feel validation practices will depend on what the model is being used for. Nevertheless, weaknesses in validation practices targeted at the evaluation of overall performance might result in banks operating with inappropriately calibrated models.

This could be of concern if the assessment of overall capital adequacy is an important application of the model. Improvements in these areas could include further benchmarking and industry-wide exercises, backtesting, profit and loss analysis and stress testing.

Additionally, institutions should recognize that when validation is partially or improperly completed, users of those models and senior management should be informed of the situation. Such communication is in our view necessary so that model users and senior management understand that there is greater uncertainty around the models' output and that the model output should be treated with greater conservatism. In that vein, model users and senior management should understand and explore the potential costs of using models that have not been validated (i.e., if key assumptions in the models prove to be inaccurate).

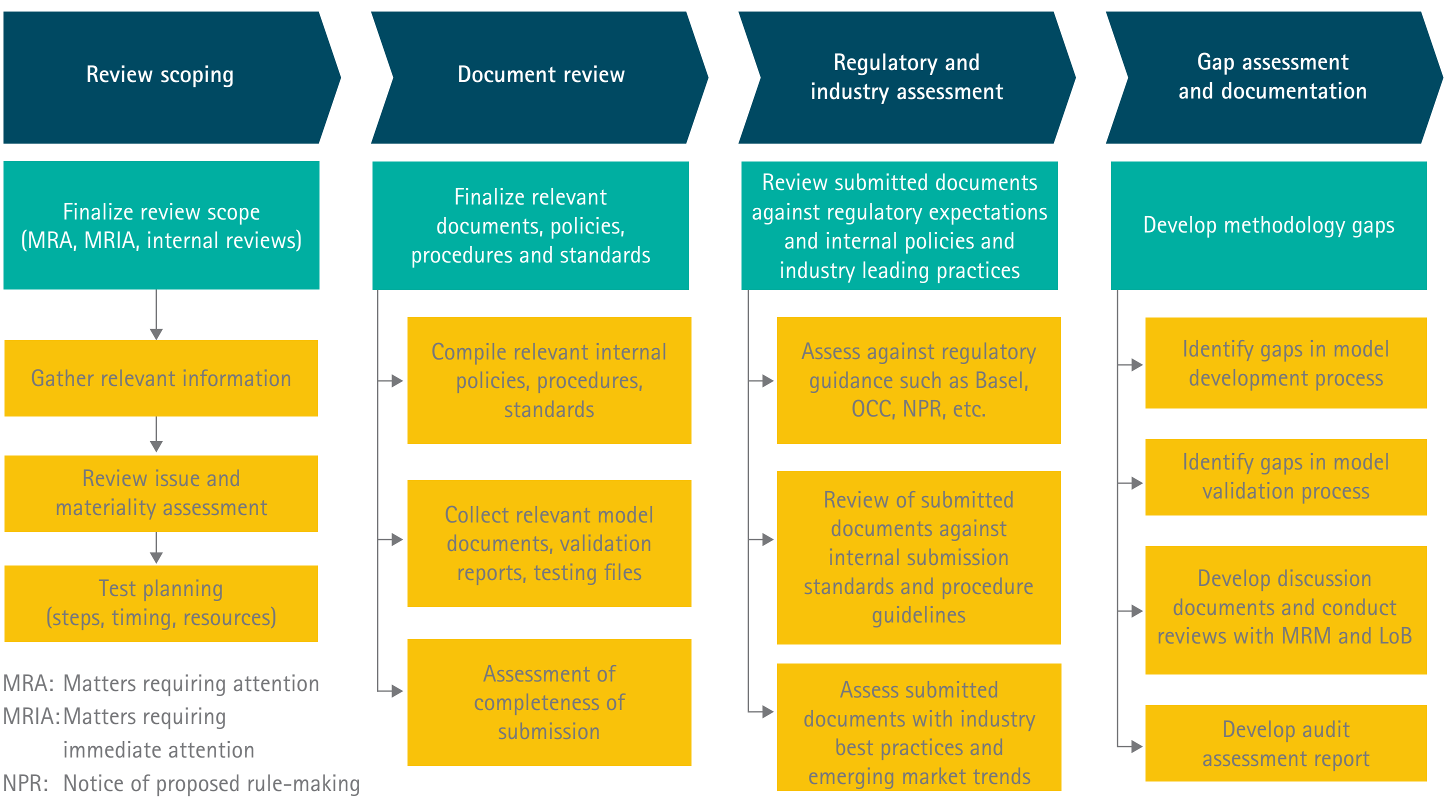
The Audit Function

A key development in the industry is the active involvement of the internal audit function in managing model risk. As the focus on capital and liquidity management has gained prominence, it has put incremental pressure on financial institutions to revisit their audit function's operating models. As the third line of defense to manage risk, the audit function is increasingly expected to perform self-testing that should challenge the model's conceptual design, data reliability, and risk management controls. In this capacity, the role of auditing and self-testing is not to duplicate model risk management activities, but rather to assess how effectively a model risk management framework meets business and regulatory requirements. Figure 4, shows a suggested framework for conducting a MRM audit review.

The incremental expectations have created in our view a staffing challenge for internal audit functions looking for talent with specialized skills in model development, validation and in-depth knowledge of existing and emerging regulations.

Another emerging trend in model audit is the paradigm of real-time audit. Traditionally, internal audit would become involved toward the end of the process, after the review of the model development process by independent validation. In this new model, internal audit have check-point reviews as model developers remediate issues raised by MRM or by regulators, independently of the model validation process. This allows the audit to be more closely involved across the entire model development and validation lifecycle as opposed to limited involvement at the end of the process. In response to the increased expectations placed on audit functions, institutions should consider developing MRM relevant audit processes and policies and build a dedicated team with specialized quantitative skills across credit, market and operational risks.

Figure 4. Audit Review Framework



MRA: Matters requiring attention
MRIA: Matters requiring immediate attention
NPR: Notice of proposed rule-making

Source: Accenture, August 2015

Identification, Quantification and Mitigation of Model Risk

Defining a Model

One of the major conceptual issues in model risk management is defining what constitutes a model. According to supervisory guidance, any quantitative method, methodology or set of rules could be a model; but a more rigorous definition might state that a model applies statistical, economic, financial, or mathematical theories, techniques or assumptions to transform input data into quantitative estimates.

Generally, the model has three components:

1. **Inputs.** These inputs may take the form of data (either "hard" or based on opinions of subject matter specialists), hypotheses or assumptions.
2. **Processing apparatus.** This is a method, technique, system or algorithm for transforming model inputs into model outputs; it may be statistical, mathematical or judgmental.
3. **Reporting component.** This is the system for converting model outputs into a form that is useful for making business decisions.

Supervisory guidance also indicates that a model also encompasses quantitative approaches in which the inputs are partially or completely qualitative or specialist-based, although the output is quantitative in nature. The concept of a model, therefore, is far broader than the concept of an algorithm; the model includes elements of judgment and specialist-based knowledge.

The definition of a model is still subject to interpretation, however. Institutions have to decide for themselves what is within the scope of a model and what is subject to model risk and affected by model risk policies and supervisory guidance. A precise definition of this scope will not usually be available, so specialist, subjective judgment will remain an important part of the process. Supervisory guidance dictates that this includes a structured set of policies and processes to determine what is defined as a model that is subject to full validation, as opposed to tools and calculators which may be cataloged but not subject to full validation requirements.

Model Monitoring Framework: Risk Rating and Inventory

A risk rating systems for models is essential, along with a comprehensive model inventory. The level of review applied to each model should be commensurate with the risk posed by the model. More frequent and more extensive review steps should be applied to the most complex and most high-impact models.

Similarly, a model inventory should be an organized, enterprise-level repository of all models within the organization, or, at a minimum, of all Tier 1 and Tier 2 models.

The Federal Reserve notes in its CCAR guidelines that banks with lagging practices were unable to identify all models in their capital computation process (see Figure 5).[8]

To be effective, model monitoring should be regular and comprehensive, covering all aspects of model performance (not just discrimination performance). A "traffic light" system for model diagnostics has been shown to work well in this area as shown in Figure 6. When a change in models is required, the change management process should incorporate model risk management and the complexity of the change as inputs. Change management should have standardized processes for change recommendation (deciding when a change is required) as well as for execution. This should also include a periodic review process, to be carried out at least annually or when there is a significant change to a model or to the applicable portfolio, to assess if a full model validation should be performed.

Figure 5. Model Monitoring: Risk Rating and Inventory

Model risk rating

The level of review applied to each model should be commensurate with the level of risk posed by the model; more frequent and more extensive review steps will be applied to the most complex and highest impact models.

Model risk		Level of concern: Low	Med	High
Tier 1	High materiality, external disclosure/ regulatory impact	Qualification	Finding	Finding
Tier 2	High materiality	Comment	Qualification	Finding
Tier 3	Other	Comment	Comment	Qualification

Model inventory

A model inventory should be an organized enterprise level repository of all models within the organization or at a bare minimum of all Tier 1 and 2 models. The Fed notes in its CCAR guidelines that banks with lagging practices were unable to identify all models in their capital computation process.

Contents of a good model inventory
Model name and description
Version number (if applicable)
Model owner
Business unit
Model status
Risk type
Model documentation available or not and if available where is it located
Model tier
Status (in development, being validated, in production, etc.)
Production system/platform(s) and production system/platform owner(s)
Date of the most recent independent validation or the expected completion date
Validation status

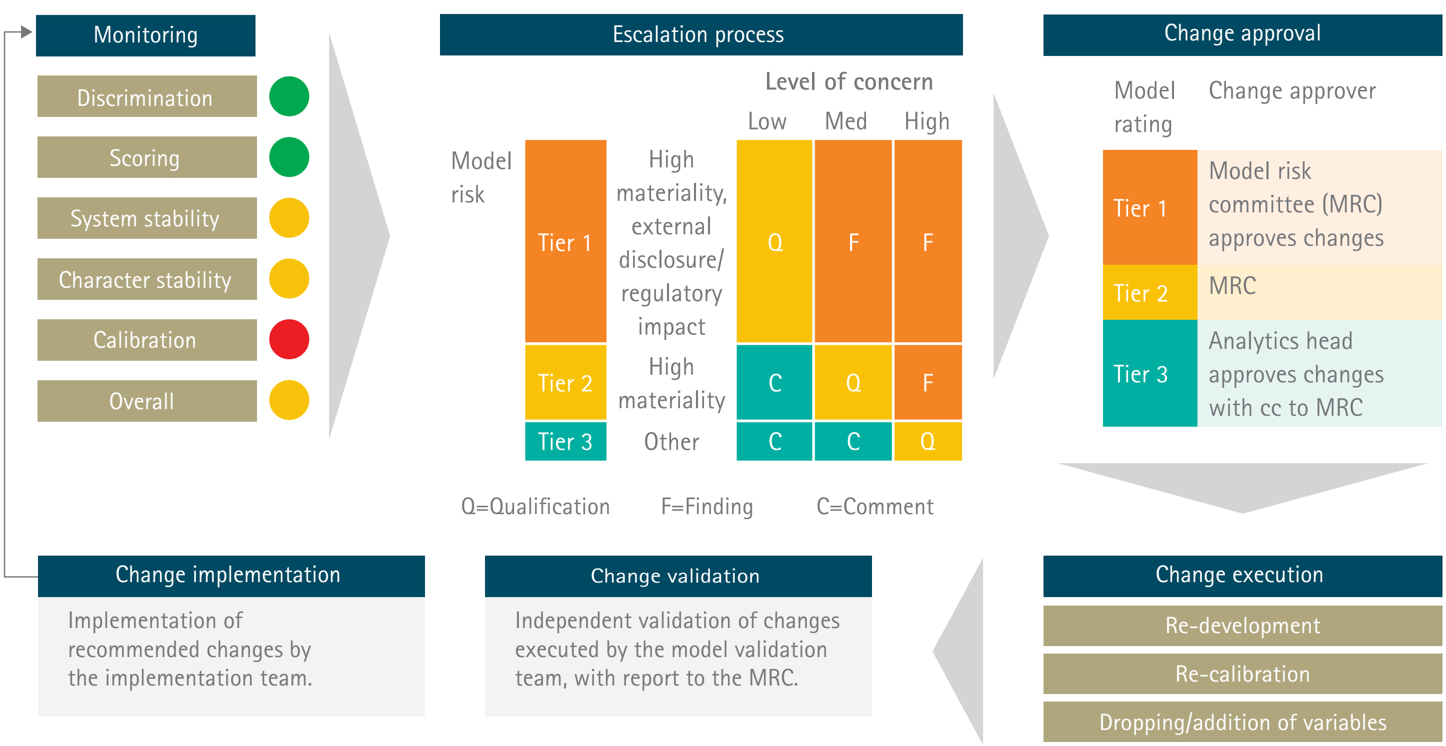
Source: Accenture, August 2015

Within the three major areas of model risk – identification, quantification and mitigation – there are a number of key factors which firms should be able to isolate and address. In identification, for example, these elements can include data errors, missing variables, insufficient time periods and insufficient sample size. There may be unresolved issues related to computational complexity or uncertainty about the parameters of a sample. The model may be used for the wrong purpose or the model itself might be incorrectly designed.

In quantification, firms should be aware of the sensitivity of model output to the exclusion of variables, or to the incorrect use of data points and/or time periods. There may be errors in statistical estimation or in the use of market benchmarks. Teams involved in quantification should be able to measure decay in predictive power between re-estimations, and to measure the impact of not using the model at all.

In mitigation, a data quality assurance process is an essential element. Other keys to mitigation include a quantitative capital buffer for model risk, a conservative approach to measuring inputs, estimates and outputs, and model backtesting and stress testing. Mitigation efforts also require a strict model control environment, proper governance and ongoing monitoring via limits, alerts and other techniques.

Figure 6. Model Change Management



Source: Accenture, August 2015

Measurement and Aggregation of Model Risk

Measuring and aggregating model risk is a new and rapidly evolving field; multiple methodologies are under consideration but none has yet been established as a standard (see Figure 7).

Approaches include:

1. Model Risk Scorecard

The firm creates a qualitative scorecard that considers inherent model risk factors and model risk mitigation activities to present an aggregate view of model risk across the institution.

With this approach, each inventoried model is assessed based on factors such as inherent model risk, model risk mitigation and overall model risk.

- Inherent risk factors include model complexity, higher uncertainty about inputs and assumptions, broader use and larger potential impact.
- Model risk mitigation factors include ongoing model risk management by model owners (the first line of defense) in areas such as model performance monitoring, ongoing model benchmarking and ongoing model backtesting, as well as MRM control functions (the second line of defense) such as model validation and other model control activities.

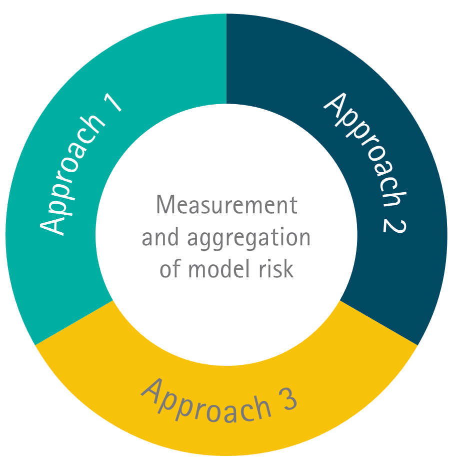
Figure 7. Measurement and Aggregation of Model Risk

Approach 1
Model risk scorecard

A qualitative scorecard approach that considers inherent model risk factors and model risk mitigation activities to present an aggregate view of model risk across an institution.

Approach 2
Advanced operational risk

A quantitative approach to model risk aggregation based in part on the event and scenario modeling techniques of the Advanced Measurement Approach (AMA) to operational risk.



Approach 3
Model uncertainty

A bottom-up, quantitative approach to measuring model risk based on model risk sensitivity and model risk control activities such as benchmarking, backtesting, consideration of alternative modeling techniques, and corresponding impact.

Source: Accenture, August 2015

Overall model risk is a function of inherent model risk and model risk mitigation activities; used to measure and monitor model risk for individual models and in the aggregate, and for periodic reporting to senior management and the board.

The model risk scorecard can effectively aggregate model risk across the institution and can leverage existing model inventory and risk classifications. It provides clear and easy-to-understand reporting tools for senior management, and can be rolled out relatively quickly. However, while it aggregates model risk, it does not attempt to quantify it. Scores, weights and overall results are subjective, and this approach has little ability to capture model interdependence.

2. Advanced Operational Risk

This is a quantitative approach to model risk aggregation based in part on the event and scenario modeling techniques of the AMA to model risk. This approach views model risk as a function of the frequency and severity of potential model risk events, based on a combination of historical experience and scenario analysis.

This approach is empirically grounded and subject to model validation, and it aggregates and quantifies model risk in a coherent manner. Institutions already using AMA can leverage existing infrastructure and processes. Historical model risk event data tends to be sparse, so scenario-based frequency and severity estimates are often subjective and judgment-based. Distributional assumptions are also subjective and could affect outcomes. Finally, in our view this approach is more complex to implement, especially without an existing AMA infrastructure.

3. Model Uncertainty

The firm uses a bottom-up, quantitative approach based on model risk sensitivity and model risk control activities such as benchmarking, backtesting, consideration of alternative modeling techniques, and corresponding impact. This approach uses information from multiple sources and translates model risk into metrics such as profit and loss (P&L) or capital impact.

Model uncertainty can provide bottom-up quantification of risk for individual models, and it establishes a more rigorous and less subjective measurement of model risk. It can be used to capture model interdependence and also as input for estimating economic capital for model risk. Its disadvantages include the subjectivity of measurement and aggregation assumptions; the time and resources needed to develop individual, model-specific approaches; and the need for ongoing performance of model control activities such as benchmarking, backtesting, and external data comparisons to perform effective maintenance.

Conclusion

Models can be tremendously helpful to financial services firms. As the use of models increases, however, so does model risk. This is an area in which the potential impact of flawed modeling can be great, and it is also an area receiving more regulatory attention and scrutiny.

Firms can benefit from a structured approach to model risk that incorporates both a framework for developing and testing of models as well as effective governance of matters such as model validation, inventory and aggregation. When properly designed and implemented, models should be a valuable resource for financial institutions, but firms need well-conceived programs to improve models' utility while identifying, quantifying and mitigating their potential risk.

Reference

1. A classic example in the field of credit risk is the structural modeling framework, which underlies any of the leading models used in the industry (e.g., JP Morgan Chase & Co's CreditMetrics), the classic reference being Merton, R., 1974, "On the pricing of corporate debt: The risk structure of interest rates," Journal of Finance 29(2): 449–470. Access at: http://dspace.mit.edu/bitstream/handle/1721.1/1874/SWP-0684-14514372.pdf?sequence=1.

2. Refer to the following regulatory guidance; "Principles for Sound Stress Testing Practices and Supervision - Consultative Paper," The Basel Committee on Banking Supervision, May 2009. Access at: http://www.bis.org/publ/bcbs155.htm. Academic, "A coherent framework for stress testing," Jeremy Berkowitz, Journal of Risk, Winter 1999/2000. Access at: https://www.risk.net/data/basel/pdf/basel_jor_v2n2a1.pdf.

3. "Automated Decision Making Comes of Age," Thomas H. Davenport and Jeanne G. Harris, MIT Sloan Management Review, July 2005. Access at: http://sloanreview.mit.edu/article/automated-decision-making-comes-of-age/.

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