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Best Practices for Effective Model Risk Management

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ABSTRACT

Financial institutions rely heavily on quantitative and qualitative models for risk management, balance-sheet stress testing, and various business analyses and decision support functions. Investment decisions and business strategies are largely driven by estimates computed from such models. Recent financial crises and adverse financial impacts at high-profile banks, attributed variously to model misuse and faulty assumptions, have emphasized the need for a more rigorous governance process over the entire model lifecycle. Regulators have stepped in to assist banks with enhanced guidance and regulations for effective model risk management (MRM). Effective model risk management is more than developing a good model. SAS® Model Risk Management provides a robust framework to comprehensively manage an inventory of models including various relationships between them. In this paper we present best practices in model risk management learned from implementation projects at US banks and interactions with industry practitioners. These best practices help firms that are setting up an MRM framework or are enhancing their existing practices.

INTRODUCTION

Models are analytical entities that use theories and concepts from statistics, economics, and mathematics for computing an output (quantitative estimates) based on certain explanatory input variables. Figure 1 below depicts the three essential components of a model:

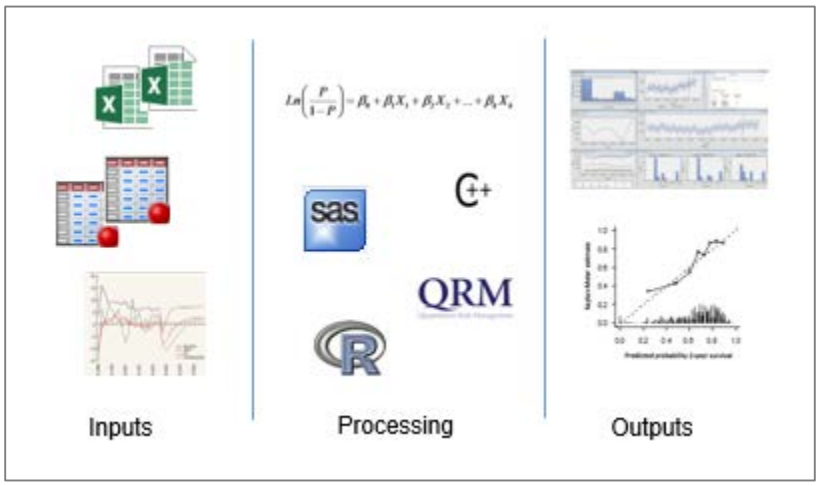


Figure 1. Components of a Model

A model definition also covers quantitative methods with partial qualitative inputs such as expert judgment that produce a quantitative output. The quantitative outputs are then interpreted in a manner that facilitates the making of useful business decisions.

Financial institutions rely heavily on quantitative models for risk management, balance-sheet stress testing, and various business analyses and decision support functions. Models are popular in business analysis since they rely more on data that represent real-world situations rather than relying purely on human judgment [4]. While the core component of a model is the quantitative method or the theory, in practice achieving a successful model output requires successful execution of many other aspects of model lifecycle, such as design, validation, and use. It is also very important to understand model capabilities and limits.

Analytical models are the DNA of a financial institution's business. As such, their development and usage needs to be informed by a well-structured control environment. Banks are exposed to model risk and

financial and reputational loss, due to decisions based on incorrect or misused model outputs. A heavy reliance on complicated and poorly specified models was one of the primary causes of the 2008 credit crisis.

After the crisis, regulatory focus on models has substantially increased. The Federal Reserve regulation SR 11-7 [4] mandates bank holding companies (BHCs) to manage and control risk associated with models by using rigorous design, implementation, and validation techniques. Banks are now required to periodically submit to regulators and auditors documented evidence of compliance with model governance policies and procedures, model approvals by management, and evidence of effective challenges and their resolution.

Banks are under tremendous pressure to incorporate a formal model risk management program to identify, monitor, and manage risk arising from any point across the model lifecycle. Ineffective MRM programs lack adequate information systems, stringent model governance policies and procedures, and support and buy-in from all stakeholders. Banks constantly encounter data integrity problems due to inadequate system controls and run the risk of errors due to manual data consolidation from multiple sources. With these types of challenges, it is nearly impossible to develop and maintain an accurate and coherent model inventory database that would then serve as a basis for performing various model governance functions.

The following sections describe in detail the different aspects of an MRM framework, and describe how the SAS® Model Risk Management solution can help financial institutions develop a robust MRM program. We also present some of the best practices that are currently followed at various banks for effective MRM.

OVERVIEW OF MODEL RISK MANAGEMENT

WHAT IS MODEL RISK?

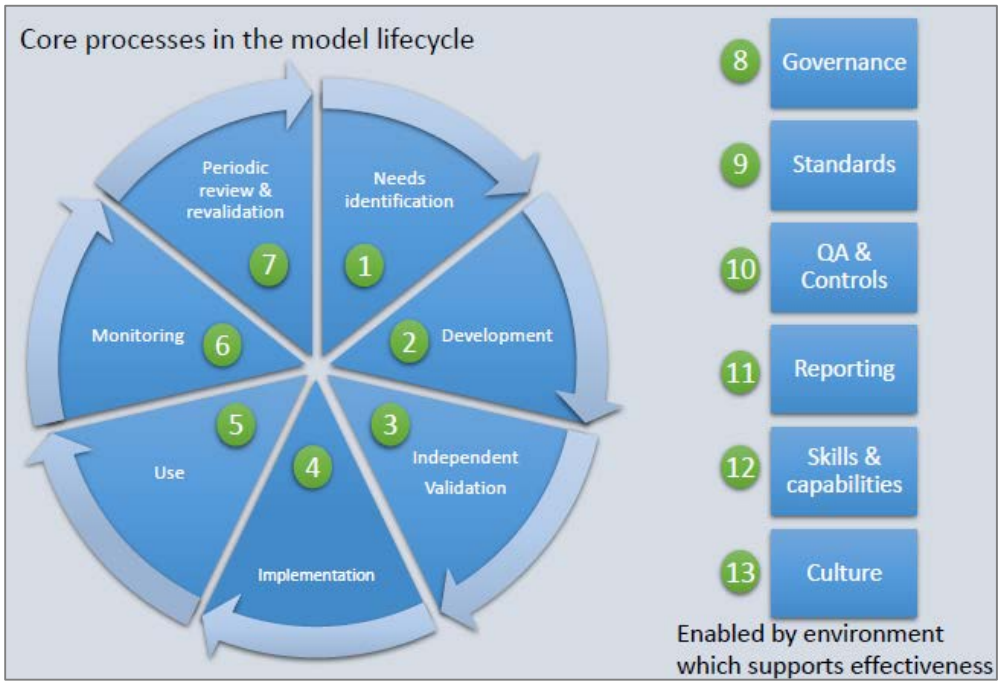
Banks have long relied on in-house or vendor provided models for their capital planning, credit decisioning, and risk management functions [2]. However, scant attention was paid to identifying and managing the sources of risk associated with these models. Only after the 2008 financial crisis did the Federal Reserve emphasize model risk management as a key component of CCAR (Comprehensive Capital Analysis and Review) processes [3].

There are a number of things that can go wrong in the design, development, testing, implementation, and usage of models. This can lead to adverse outcomes due to decisions made using incorrect model outputs [4]. Equally often, model estimates are incorrectly interpreted, leading to decisions resulting in adverse financial impacts. These potential adverse consequences, resulting from incorrectly functioning models or decisions based on incorrect or misused model outputs, make up *model risk*. Model risk can lead to financial loss, damage a bank's reputation, and result in the loss of shareholder value. It has been observed that model risk occurs primarily due to two reasons [4]:

1. A model is fundamentally wrong due to incorrect data, the wrong design, the wrong application of theory, an error in the mathematical calculations, or wrong assumptions. Any of these errors will produce incorrect estimates, which when applied against the business objectives, will inevitably result in decisions leading to potentially adverse impacts
2. The model design and development is fundamentally correct but the model is misused or misapplied. A model designed for a specific situation can pose high model risk when used in a different environment with different assumptions. It is very important to define the limitations and scope for a model.

MODEL LIFECYCLE

To understand the sources of model risk requires a thorough understanding of the lifecycle of a model. A model goes through various stages in its lifecycle with different activities performed by different stakeholders at each stage. Figure 2 displays a typical model lifecycle.



Source: Adopted from Effective Challenge in Model Risk Management,RiskMinds 2015 [7]

Figure 2. Model Lifecycle

When managing model risk, SR 11-7 supervisory guidance suggests that stakeholders adopt the principle of "effective challenge" of models that are driven by incentives, competence, and influence. This means critical and objective analysis of models should be performed by an independent validation group that is not involved in the model development process. This group of model validators should have the right technical knowledge and modeling skills, and should also have the necessary agency in raising the challenges based on facts and figures [4].

Even with robust validation controls, model risk can be mitigated but not eliminated. The drivers of model risk exist at each stage of the model lifecycle. For example, the design methodology that is identified for model development might not be appropriate, in which case there is risk creeping into the process at an early stage in the lifecycle. Another example is using incorrect data for development in the model development stage.

Controls and guidelines need to be established to measure and address model risk at every stage of the model lifecycle. Example controls and measures include conducting a conceptual soundness assessment during design phase, conducting peer reviews during development stage, establishing limits on model use, and conducting ongoing monitoring and maintenance reviews frequently after a model is implemented. There are a number of controls, some of which are discussed later in the paper, which should be incorporated in the MRM framework.

MODEL INVENTORY

A key requirement of SR 11-7 is for BHCs to maintain an accurate and complete model inventory within the entire firm, with a comprehensive set of information about models across all of its life stages. The model inventory should contain a consolidated record of all models with related risks, inputs, and outputs, intended uses,controls and stakeholders. In addition to tracking a model individually, a well-maintained model inventory can help in evaluating a firm's aggregate model risk [4].

ORGANIZATION STRUCTURE

Model risk should be managed as a separate risk discipline just like credit, market, and operational risk [8]. A key component of the MRM framework is the structuring of roles, responsibilities, and accountabilities for decision making, risk control, and governance. There are several ways in which an organization can setup roles. However, it is important that reporting lines and incentives are clear. In a typical MRM framework, the "three lines of defense" model is widely adopted. This model provides a simple and effective way to enhance communication and control in risk management and clarifies essential roles and duties. According to this model the stakeholders are classified into three main groups:first-line, second-line and third-line of defense (Figure 3).

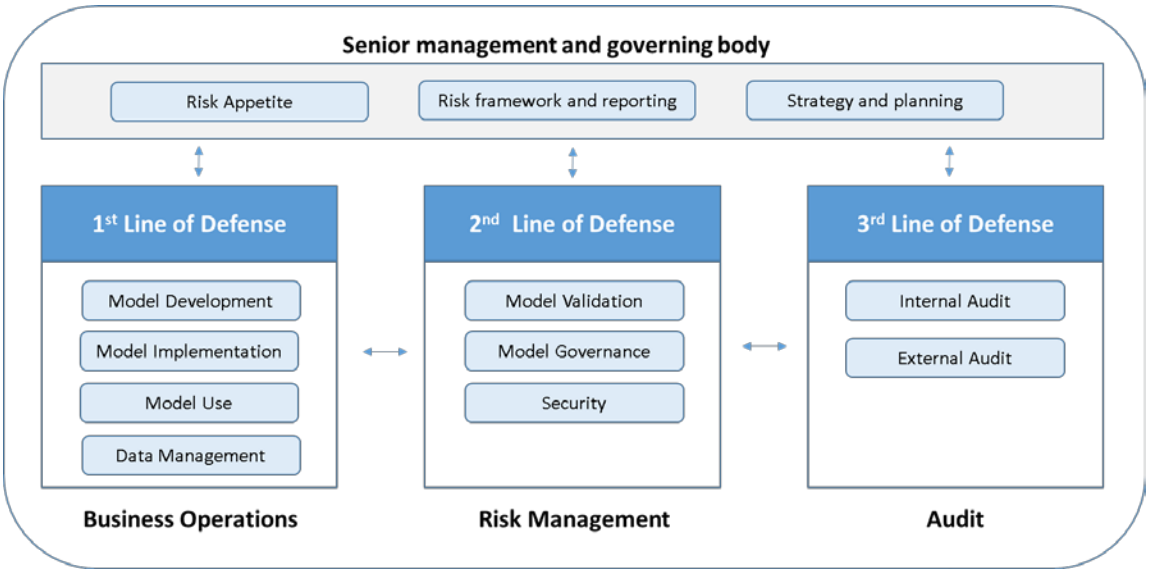


Figure 3. Three Lines of Defense for MRM

In addition to these three lines of defense, a so-called zeroth line of defense oversees all these three lines for effectiveness. This line of defense includes the board of directors, senior management, and the risk committee. Each of these groups should coordinate carefully to ensure that risk and control processes operate as intended.

MEASURING MODEL RISK

Model risk cannot be effectively managed without an appropriate yardstick of measurement. A risk rating methodology that provides sufficient explanatory power is an essential component of MRM framework. Thus, if a model risk rating is "red", it should be straightforward to understand the reasons why by quickly delving into the underlying aspects of the model that justify this rating. Supervisory guidance requires banks to measure and manage model risk in a manner similar to how they manage other types of risk. A quantitative measurement of models is a challenge for banks due to the volume and diversity of models and data that they manage. However, such a framework allows for an effective comparison of model risk (at a model level) and can allow for an easy estimation of aggregate model risk.

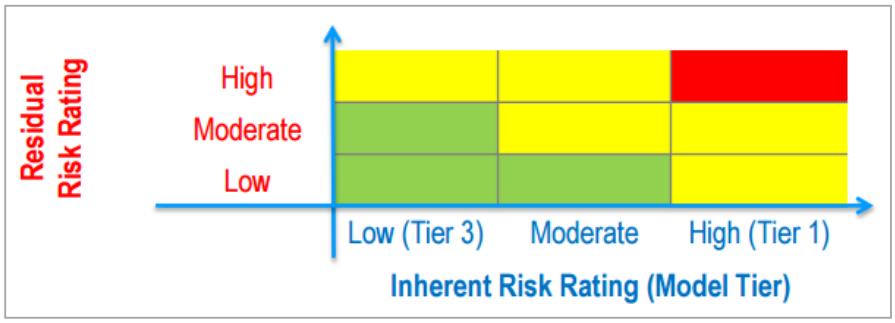
Model risk, like any other risk, consists of two components: inherent risk and residual risk.

Inherent risk is the risk associated with model use with no mitigating controls in place. Inherent risk is due to model limitations and assumptions. Inherent risk increases with greater model complexity, higher uncertainty about inputs and assumptions, broader use, and larger potential impact. Inherent risk cannot be completely eliminated but can be mitigated using a strong internal control framework that helps govern the entire model lifecycle.

A risk-based approach can be used to tier models for prioritizing MRM activities. Models can be classified as Tier 1, Tier 2, and Tier 3, based on materiality, criticality, and level of reliance on model output. A Tier 1 model has high criticality and materiality compared to a Tier 2 model. Hence, the model risk for a Tier 1 model is greater than model risk for a Tier 2 model.

Residual risk is the risk that remains after the controls are taken into account. It is tied to model performance and is measured periodically by validating the model and assessing the effectiveness of the control environment. Residual risk could be driven by the number and type of findings from model validation and model performance. Model-specific metrics such as system stability index and performance measures like Gini, AUC, KS statistics can be used to quantitatively assess the model performance which in turn contributes to the measurement of model risk. Residual risk is typically measured as High, Medium, or Low.

Model risk can be identified and measured effectively as a model goes though its life cycle and as more evidence is captured on model performance. An overall model risk can be derived using inherent and residual risk for a model as shown in Figure 4.



Source: Adopted from Model Risk Management, GARP 2014 [10]

Figure 4 Model Risk Measurement Matrix

A model with high residual risk rating and high (Tier 1) inherent risk rating scores high on model risk. Model owners cannot reduce the inherent risk but can reduce residual risk by improving controls and remediating findings [10]. In addition to measurement of risk at model level, banks should regularly measure aggregate model risk in order to understand the health of the model inventory.

Many banks have started realizing that MRM is more than just regulatory compliance and is a must-have business function. MRM involves culture change and adoption of best practices to measure and mitigate risk associated with using the models. What banks need is a disciplined and aligned model development and implementation process, effective management of the validation cycle, and a well-defined model usage process supported by strong governance polices, controls, and the management structure. This can be achieved by establishing a strong MRM framework that fits into the broader risk management of the organization.

SAS® MODEL RISK MANAGEMENT

The SAS® Model Risk Management supports the full model lifecycle in a single solution. It supports the needs of all four lines of defense – including an integrated dashboard application that allows senior management to access all aspects of every model in the inventory including inter-model relationships. The end-to-end model lifecycle support includes (but is not limited to) the following processes:

- Initiating a request for a new model
- Capturing the business and technical requirements for the proposed model
- Approval for the development of the model
- Staged development of the model
- Managing documents including access and version control
- Support for managing the validation cycle including initiation and management of effective challenges
- Change management including support for versioning of models
- Monitoring model usage and model performance
- Managing retirement and introduction of challenger model to replace the incumbent
- Ad hoc in-system correspondence among stakeholders
- Built-in configurable workflow management for each stage of the model lifecycle

- Periodic model attestation process to ensure that only approved models are in production
- MRM dashboarding providing an ergonomic user experience to navigate through the lifecycle of the entire model inventory
- Full integration of Dashboard reports with Microsoft Office® applications

Figure 5 presents the SAS® Model Risk Management solution ecosystem with primary MRM operational processes (labeled 1-10) and elements of core systems functionality (labeled A-D).

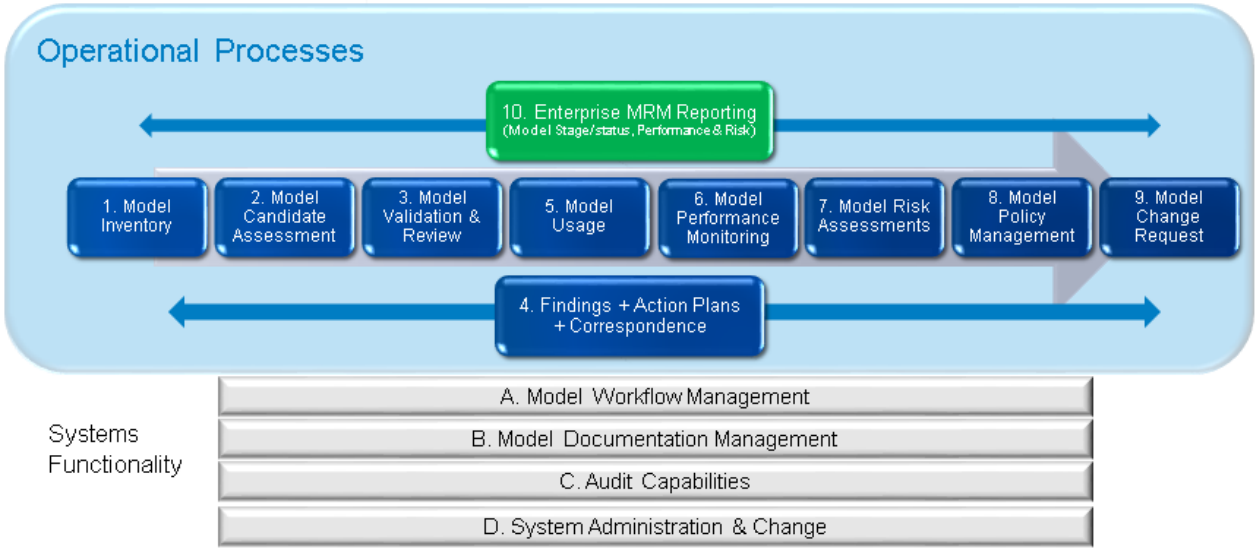
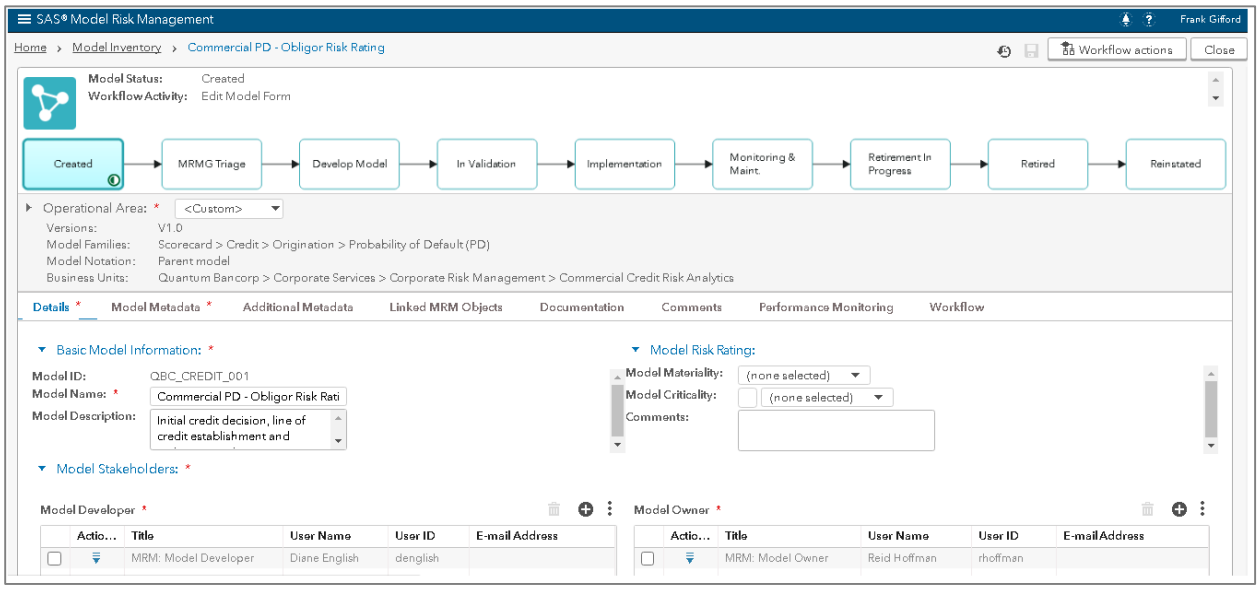


Figure 5. SAS® Model Risk Management Conceptual Architecture

Each model lifecycle object (the blue boxes in Figure 4) has a separate screen to capture object information, a separate workflow, and a document repository. For example, the model change request process is implemented with a dedicated workflow involving personnel from the first line and second line of defense. Documentation related to change management can be stored in the respective change management instance screen. The solution allows the capability for confirming and validating the accuracy of the model inventory. This in turn can facilitate fact-based conversations with regulators in defense of the model quality.



Display 1. The Home Page of a Sample Model in SAS® Model Risk Management

SAS® Model Risk Management is a user-friendly, web-based solution that facilitates the entry, collection, transfer, storage, tracking, and reporting of models that are drawn from multiple lines of business across an organization. Display 1 shows the complete detail of a model in a tabbed interface. Each tab exposes a different aspect of the model and in the particular the **Linked MRM Objects** tab exposes the relationships between the model and the other elements of the MRM framework.

SYSTEMS CAPABILITIES OF SAS® MODEL RISK MANAGEMENT

A modern enterprise-class solution such as SAS® Model Risk Management needs to conform to bank-specific MRM policies, methodology, model metadata information, and other related needs. The SAS solution is uniquely designed, using business user level configuration mechanisms, to allow the bank to make "delta enhancements" without requiring IT programming. This configuration work spans the areas of 360^0 linking (introduced below), dashboarding, workflow management, and user entitlements.

360^0 LINKING

While it starts as a single entity, the model can expand its family (the content created for the model) over time and can be linked to other types of entities such as model validation reviews, new model uses, findings, remediation plans, child models, and so on. SAS® Model Risk Management enables linking of one type of MRM object with another. For example, by linking findings with models, decision makers and other interested parties can track the effectiveness of the model in reducing risk for a particular finding. A true holistic risk view of the model can only be achieved by a true model X-ray navigation. This is 360^0 linking – the ability to have a 360^0 view of a model, a 360^0 view of a finding, and so on.

Figure 6 shows the model as the center of the universe with connections to all possible related entities that are captured in the system. And this linking is not restricted only to models. In SAS® Model Risk Management, any object can be linked to any other object. For example, a finding can be linked to a model review, or a policy exception can be linked to a model. The latter allows a model to be used prior to validation for a period specified in the associated policy exception.

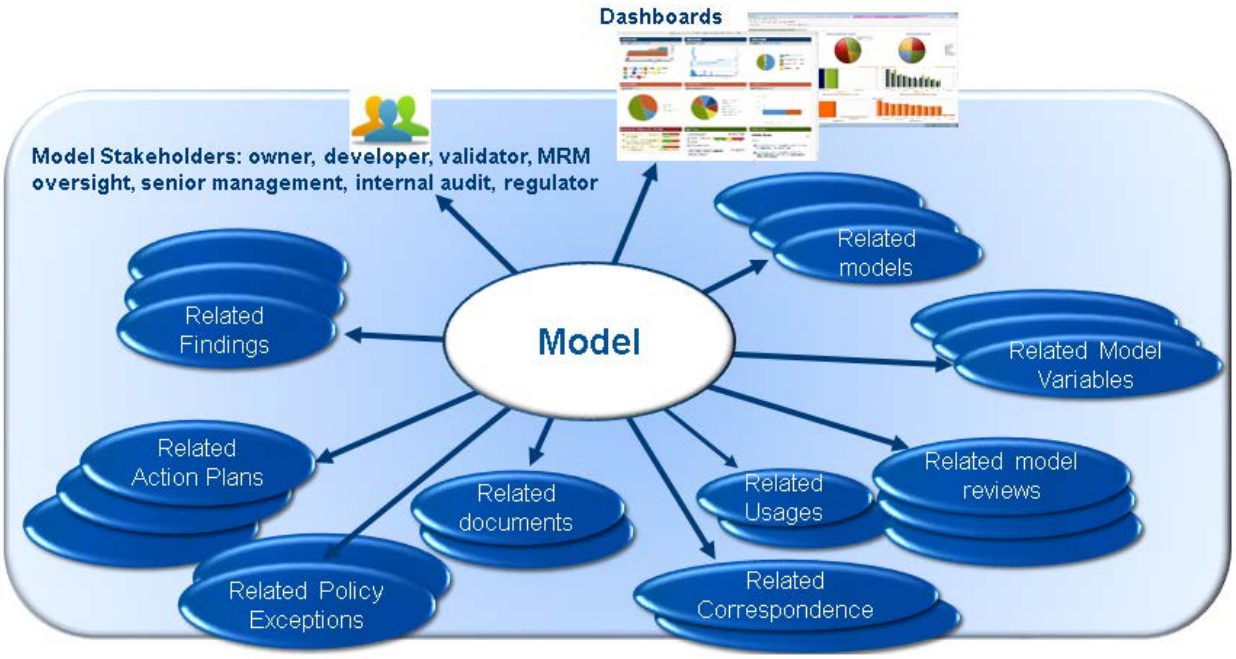


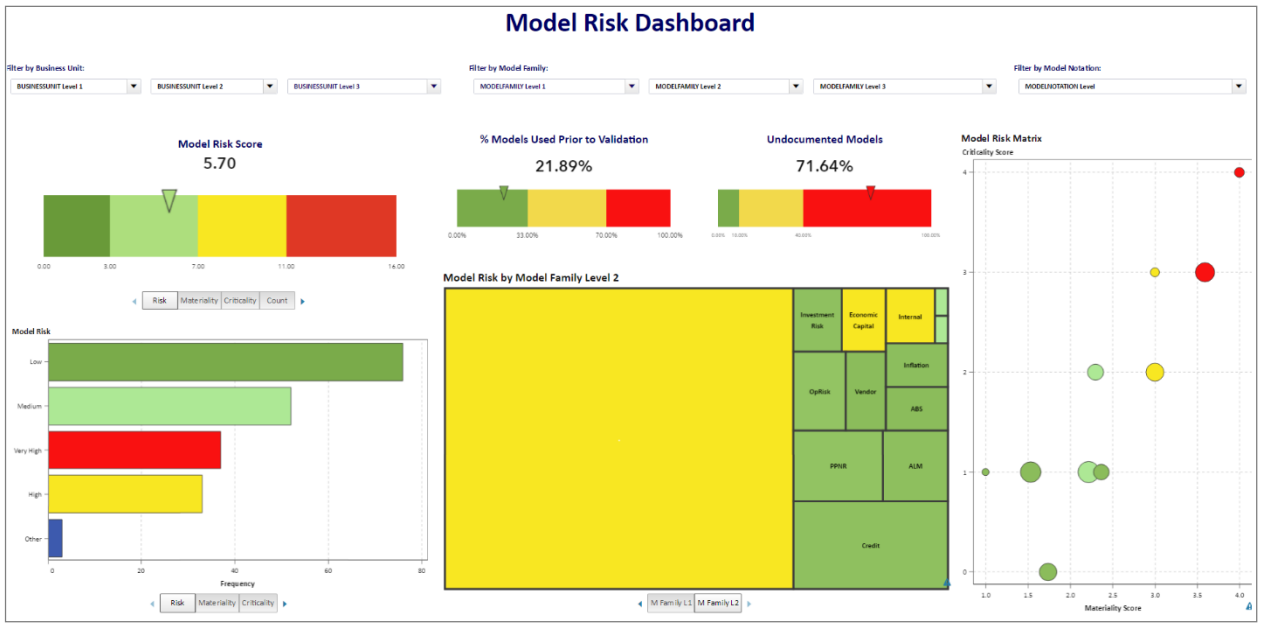
Figure 6. Universe of a Model with Links to Other Objects in SAS® Model Risk Management

MRM DASHBOARDING

The SAS® Model Risk Management solution comes with built-in dashboards that are created to meet and satisfy reporting needs of key decision making users responsible for the bank's MRM program. It allows executives to explore and understand how the MRM processes are performing at different levels within the bank. The dashboards have prebuilt performance metrics to support reporting needs of a typical risk management business function.

With model performance tracking and monitoring dashboards, senior management can get a firm grasp of model risk and the measures needed to mitigate this risk. The solution facilitates construction and dissemination of interactive dashboards with report designer capability for effective top-down model risk reporting. The drill-down capability of the reporting platform facilitates the drill-down into the drivers of model risk across model families, business units, product lines, and processes or any other dimension of interest

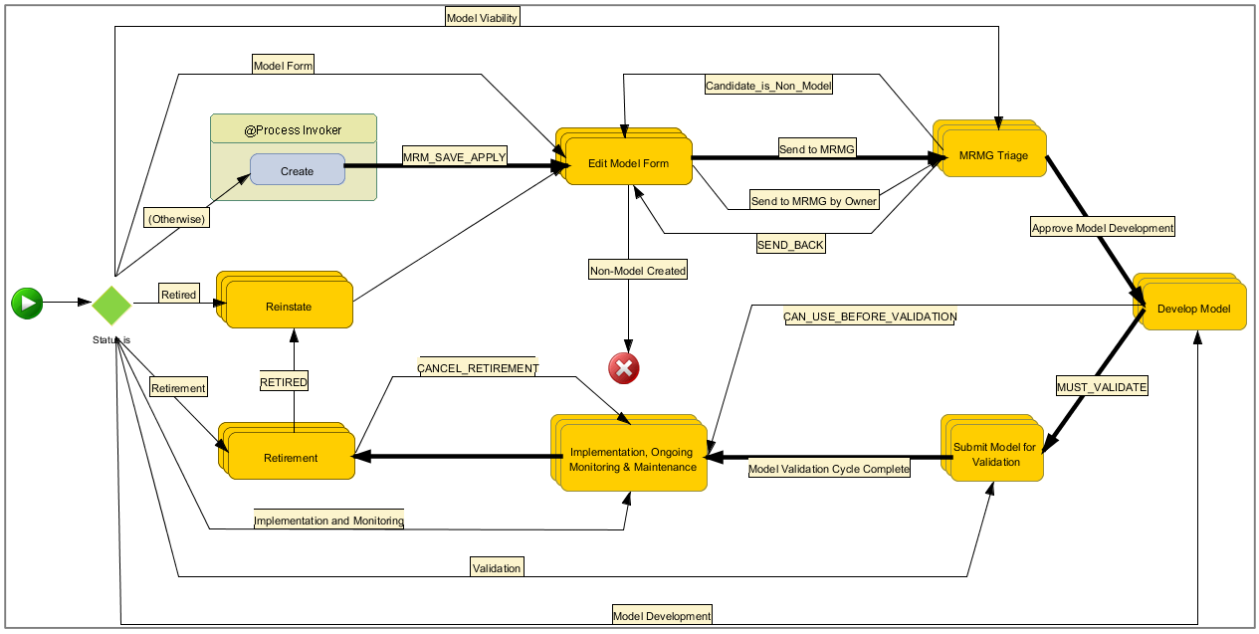
Display 2 shows a part of the Model Risk dashboard with metrics such as Model Risk Score, percentage of models used prior to validation, percentage of undocumented models and other information. Every part of this display is a hotspot which can be clicked on for more detailed information.



Display 2. Model Risk Dashboard in SAS® Model Risk Management

WORKFLOW MANAGEMENT

One of the key pillars of SAS® Model Risk Management solution is the workflow technology that runs the show in the background. The solution comes with pre-defined workflows that enables the tracking of model governance actions across the model lifecycle. The workflow also sends out automated alerts/notifications at each stage transition to the appropriate stakeholders. The workflows are flexible and can be customized to a bank's specific processes using a point and click tool called SAS® Workflow Studio. Display 3 represents a high-level view of the model inventory workflow as it spans the entire model lifecycle.



Display 3. Model Inventory Workflow in SAS® Model Risk Management

BEST PRACTICES IN MODEL RISK MANAGEMENT

Many large financial institutions acknowledge and understand the importance of MRM. Best practices in MRM have been evolving day-by-day. Many smaller banks have been adopting these practices to enhance their model risk management efforts. The best practices outlined below were informed by implementing SAS® Model Risk Management and interactions with practitioners at various US banks.

CANDIDATE ASSESSMENT

Business managers in a bank use different computational tools, for example, a spreadsheet that estimates an output using closed-form formula, to support their business operations and decision making. However, not all tools are models. In order to give a model the right attention and to ensure it meets organizational and regulatory criteria for a model, the tool/candidate needs to pass a "What's a model?" test. The SR 11-7 guidance offers a set of five tests that candidates must pass[4]. Many banks augment this with bank-specific criteria to qualify a candidate as a model. In general, all tests must be passed before a candidate is qualified as a model or not.

A non-model is sometimes referred to as a user-defined tool (UDT) or end-user computing (EUC). The SAS solution provides a receptacle to manage an inventory of these non-models. In cases where one or more non-models provide a service to a managed analytical model, that relationship is memorialized via a 360-link described above.

SAS® Model Risk Management provides a questionnaire incorporating the above model-definition criteria typically completed by the second line of defense (Model Risk Management Group or MRMG). MRMG uses the model candidate information provided by the model owner to answer the questions. The candidate assessment process helps in tracking how the model candidate assessment was conducted and why the model candidate met or did not meet the model criteria. The assessment process therefore facilitates accountability and creates a traceable information stream for auditing and reporting purposes.

MODEL REQUEST PROCESS

An enterprise-class MRM framework includes the ability for designated users to initiate a request for a new model. This request articulates the need for a new model, business impact of the model, a problem definition of what the model needs to do, what inputs it would consume, the time-frame by which the model needs to be available, and so on., This information is very useful in documenting the actual use case underlying the introduction of the new model and serves as developmental evidence during later

auditing. These conversations are lost in emails or tracked in an independent database or never otherwise tracked. It is very essential to capture all such conversations and store them, in context, for future audit purposes.

The MRM correspondence feature (an in-system email) and a new model request capability in SAS® Model Risk Management can be used to track and record all developmental evidence of a model. This process helps the first line of defense to properly conduct and handle model development project activities. Once again, a previously disconnected function is systematized into a workflow-enabled process, in this case from the start of a model's lifecycle.

MODEL DEVELOPMENT

The model development process is usually very rigorous in all banks. But one of the most critical aspect of development is model documentation. The purpose and use of the model should be clearly defined and supported by published research and best practices. Good documentation provides a detailed commentary on a model's design, methodology, scope, assumptions, and limits.

The quality of data used during development and testing is of utmost importance. This testing should identify the conditions under which a model is most stable, where it performs poorly, and should consider the suitability of the data it is using. Testing of a model should include comparisons to alternate approaches or baseline models. Model developers should use multiple checkpoints during the development process, such as peer reviews and model owner sign-offs, to ensure that the model is being developed as intended.

SAS® Model Risk Management allows for the easy implementation of a workflow process with necessary checkpoints and controls. In addition to controls, the workflow can be used to alert other stakeholders on what is coming. For example, at different stages of model completion (25% complete, 50% complete, and 75% complete) the model validation group can be notified to prepare for and schedule validation activities for this model.

MULTIPLE TYPES OF MODEL REVIEWS

Since the publication of SR 11-7, it has been well understood that evaluation of conceptual soundness, ongoing monitoring, and outcomes analysis form the bedrock of model validation. However, validation activities need the right rigor and flexibility to be useful. Models should be subject to critical review using multiple types of review during different stages of the model lifecycle. All components of the model (inputs, method, outputs) should be thoroughly validated. Validators should evaluate the conceptual soundness, stability, and appropriateness of the model, regardless of whether the model has been developed in-house or sourced from an external vendor.

Different types of reviews conducted at some of the banks include: full scope/comprehensive validation, initial validation, limited validation, annual review, model monitoring, performance review, change validation, and usage validation. Most, not all, of these reviews are done by an independent group (typically the MRMG) separate from model developers and users.

The validation team should also have high expertise, skills, and requisite knowledge because of varying model complexity. Validators should be familiar with the intended use of the model and should have knowledge about model application business line. Validators should be given enough authority to challenge model developers' work and should have sufficient influence to address any issues and deficiencies identified during validation. If the deficiencies are too severe, the validators should be provided with authority to reject the use of the model or allow the usage conditionally.

ONGOING MONITORING

A core aspect of validation process is ongoing monitoring. After the initial implementation of model in production system, there can be many change requests, new usages, and varying market conditions that can test a model's assumptions and scope of use. To ensure that a model is used as intended, it needs to be reviewed periodically even after implementation. The frequency of monitoring might change, depending on the complexity and nature of the model..

SAS® Model Risk Management enables you to create and track different types of reviews with separate forks in the workflow for each type of review. For example, every monitoring and maintenance review, conducted by the first line of defense, should be reviewed by model validators. The monitoring and maintenance workflow starts with the first line of defense and then moves to the second line once the first line completes the validations and submits the report. Whereas an Annual Review is another type of review with a workflow that involves model owners and MRMG. Model review processes when supported by systems and systematized through a disciplined workflow can solve many challenges and enables seamless integration among all parties for effective model governance function.

POLICIES AND PROCEDURES

Every risk management function requires strong policies and procedures that foster discipline and control how different activities are conducted within an organization. The policies should establish an enterprise-wide definition of model risk and a framework for the management of that risk for the bank, while simultaneously conforming to regulatory guidance. Banks should set up policies and procedures that align with their complexity, corporate culture, and organization structure. These should serve as an internal guidance on various activities of the model lifecycle. The policies and procedures should be approved and regularly reviewed by senior management. It is highly critical to regularly update these policies to ensure they are relevant to changing market conditions, regulations, business objectives, and product lines.

Policy Management is one of the components of SAS® Model Risk Management. This component enables you to record and track all policies in an organization, assign policy owners, and assign timelines for policy validity. The policy communication, commitment to comply and change management are undertaken using workflow-based approvals.

POLICY EXCEPTIONS

An exception to an MRM related policy is created for a number of reasons: a model must be used prior to validation, to enable restricted usage of a marginally fit model, and so on. Banks need to aim at minimizing the number of policy exceptions for models. As far as possible, models should not be permitted for use without proper validation. Often the need for a policy exception occurs due to improper scheduling, delayed projects, lack of resources for validation, and so on. High priority models, such as Tier 1 and Tier 2, should only be allowed to use a policy exception with proper oversight and risk mitigation plans.

SAS® Model Risk Management has mechanisms to create and track policy exceptions, in the context of a containing model, and define thresholds and limits around number of exceptions created. The solution enables you to set up workflow-based approvals and send notifications and alerts to inform respective stakeholders when policy exceptions are initiated, approved, or rejected. Proper reporting of policy exceptions is essential for senior management. Better scheduling of activities using alerts and notifications can prevent resource constraints, minimizing the need for policy exceptions.

APPROVALS AND SIGN-OFFS

Effective MRM is achieved with effective governance, not only by the second line of defense but also by governance by appropriate actors at each stage of the model lifecycle. For example, approval of a candidate as a model might involve a multiple level approval process where the model owner first approves the documentation and information recorded by model developers and then MRMG approves models for development, whereas approving a model for development might only involve one level of approval from MRMG.

NOTIFICATIONS AND ALERTS

Various activities involving different types of stakeholders take place in the lifecycle of a model. When models move between these stages, all stakeholders, especially the ones with action items, need to be notified. Keeping all the stakeholders informed on the precise status of a model will ensure better planning and scheduling of activities. For example, model validators can better plan the validation activities when they are informed about the model development status with an indication on when it is likely to be completed.

Built-in workflows for each process in SAS® Model Risk Management are based on de facto industry best practices that have predefined approval and sign-off checkpoints.. At each workflow stage transition, the actors at the next stage receive email notification with details of the task they need to accomplish imminently.

DOCUMENTATION

Documentation related to models (design documents, development methodology, limitations and assumptions, validation reports, and so on) are of critical importance. Regulators require hundreds of pages of documentation regularly for different types of submissions. Documentation serves as an evidence for various decisions made during each step in the model lifecycle. Rigorous protocols and controls that mandate document completion at the end of appropriate model life stages should be established. For vendor or third-party models, banks should ensure that appropriate documentation is made available from the vendor to assist the bank in thorough validation.

SAS® Model Risk Management provides the capability to attach documents at the module level. For example, documents related to validation can be captured and accessed within a validation module screen. Pre-defined templates can be created and made available to developers and validators through the application. Tags can be assigned to document for further classification, which enable easy search and retrieval. Different versions of the same document can be maintained to track the history of changes.

TRACKING CORRESPONDENCE

Ad hoc communication happens all the time for various reasons among the stakeholders of the model. This could be MRMG communicating with model developers and model owners on day-to-day activities, validators talking to modeling team on validation results and, internal audit requesting and reviewing model inventory attestation reports from MRMG, and so on. Typically, this correspondence can take place via email, phone conversation, in a review meeting, or in a hallway. Wherever possible this correspondence should be recorded and attached to the model for future reference and audit purposes.

SAS® Model Risk Management enables you to capture ad hoc conversations at any point during the lifecycle of a model. Such conversations can be entered into the system via text-based messages with optional document attachments. Furthermore, and this is where it departs significantly from regular email, MRM Correspondence facilitates conversations with model-specific stakeholders by *linking* it to various models, model reviews, findings, and so on, using 360^0 linking.

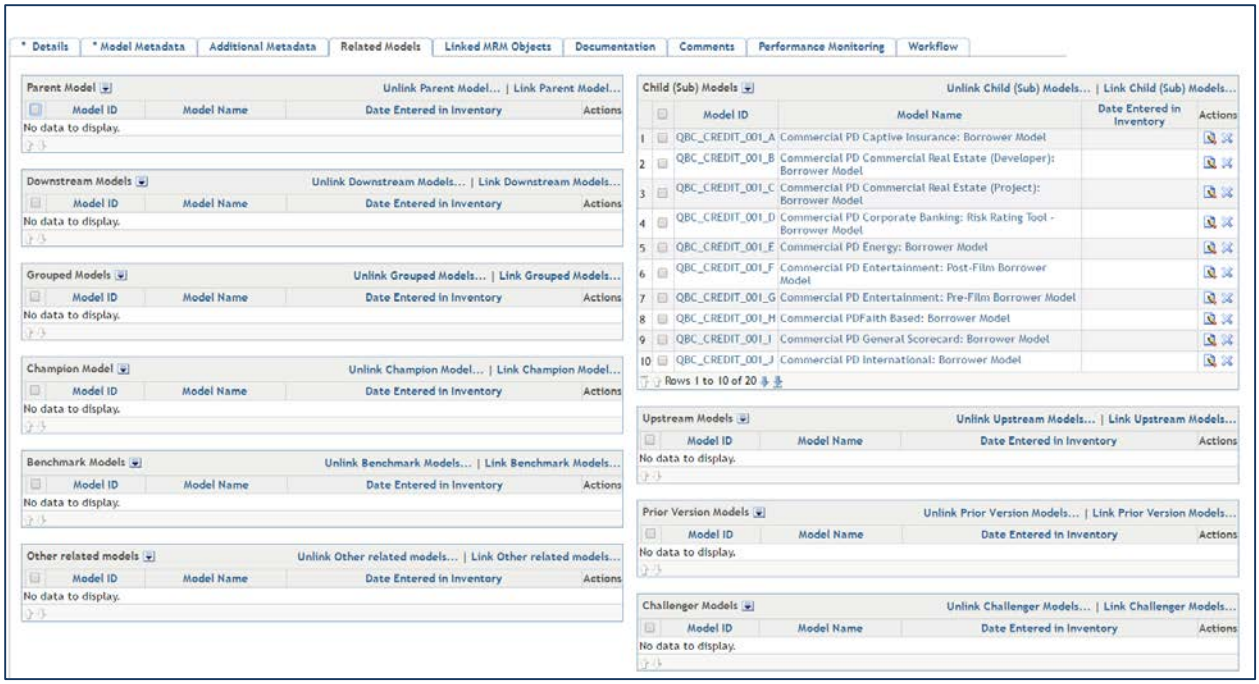
FINDINGS

In model risk management, findings are issues or effective challenges noticed in the course of a model review that present potential shortcomings in the model. Findings could include problems identified in the model documentation, computational issues, or data limitations. Action plans are concrete measures typically developed to mitigate or respond to findings. Every finding should have a well-defined severity level. Depending on the severity level, the model use could either be stopped or allowed only under stringent guidelines/constraints until those findings are resolved.

Findings can be logged, tracked, and prioritized within SAS® Model Risk Management. Capability to monitor them by severity and resolution date helps MRMG make critical decisions related to the model. Using in-built workflows, accountability on the related action plans can be achieved with much success.

INTER-MODEL RELATIONSHIPS

A model can be related to another model in various ways. A model that does not inform any business decisions independently but serves as an input to another model is called a sub-model. Models and sub-models work together to produce the end result. A "system of models" should be defined which clearly identifies all relationships between models. The relationships between models are sometimes identified as "parent/child", "upstream/downstream", and so on. Models could also be linked to show which is a champion and which is a challenger.



Display 4. System of Models Screen for a Sample Model in SAS® Model Risk Management

Validation and review of a model should include all sub-components of that model. The idea of "system of models" is essential in order to calculate the aggregate risk of models. The 360^0 linking capability of SAS® Model Risk Management enables you to specify relationships between different models, as shown in Display 4. This helps in tracking the causal effect one model could have on others.

CHANGE MANAGEMENT

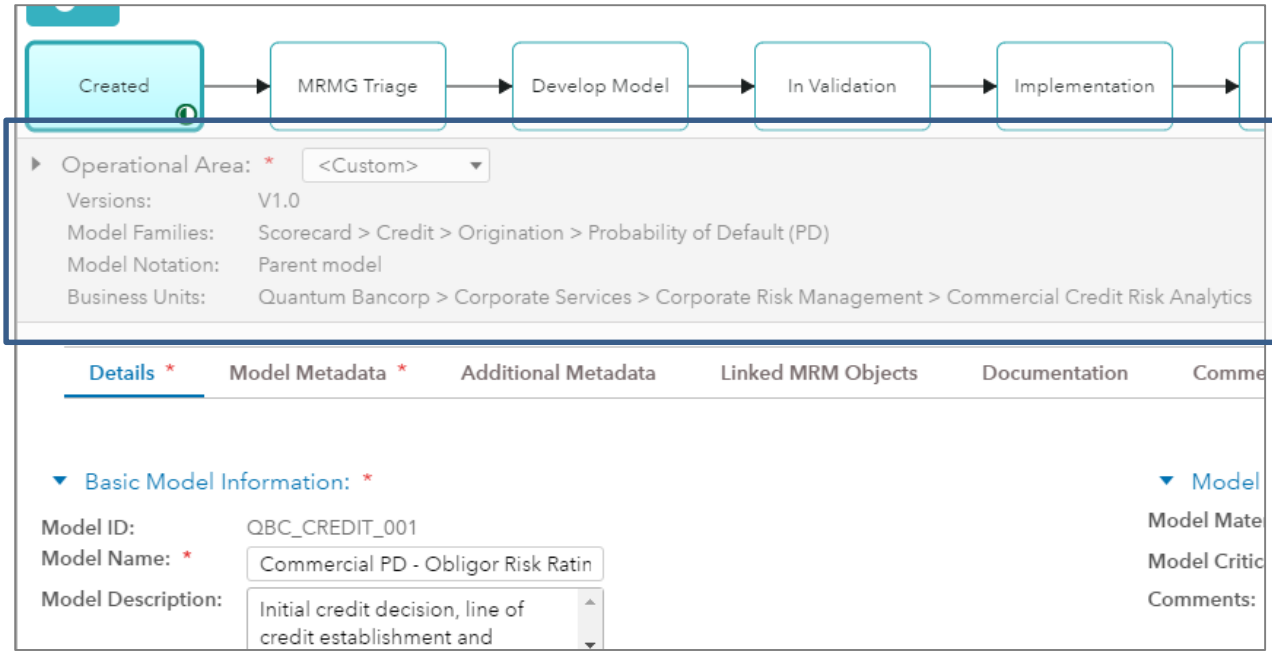
Models undergo different type of changes for various reasons such as changes in explanatory variables, model requiring recalibration, changes in model usage, technology platform change and many more. Uncontrolled and inappropriate changes to model code, application platform, and model use can lead to severe consequences in model performance. Both the first line and second line are responsible for systematically assessing the impact of a model change. All changes should be subject to appropriate review and validation by using the proper approval workflow. Material model changes should result in a new version of the model and incremental effects of the change should be tracked and monitored. It is highly critical to document all model changes and link such a document with a new version of the model

All change requests follows a thorough check and approval process within SAS® Model Risk Management. The level of scrutiny on the requests is determined by the materiality of the change.

MODEL CLASSIFICATION TAGS

Models need to be properly classified and tagged. Classifying models the right way has plenty of benefits in managing and reporting on the models. Some of the popular model classification tags include business unit, model family, model type, geography, regulation, product line, and so on. The universe of models gets bigger every day with so many artifacts created for the model. Retrieval of the right information becomes easy when models are tagged on various dimensions. The slicing and dicing of the data becomes possible making report generation very easy.

In SAS® Model Risk Management, you can use dimensions to place more security around model accessibility. The solution comes with many ready-to-use, industry standard dimensions. Display 5 shows dimensions (operational area) for a sample model in SAS® Model Risk Management.



Display 5. Operational Area (Dimensions) for a Sample Model in SAS® Model Risk Management

START SMALL AND SCALE

The establishment of a complete MRM program requires time and resources. More than setting up a system, it involves a culture change. In order to make the program a successful endeavor, a best practice is to start small with setting up policies, controls and systems around the key activities in the model lifecycle, and then expand the scope to include the complete lifecycle . Another approach is to initially start with policies around high material models and then expand the coverage to all models. This will allow the governance team to slowly get up to speed with what works best for the organization, and it also gives the governance team time to adopt industry best practices.

The modular nature of SAS® Model Risk Management immensely helps organizations in scaling it as needed. Whether the need is only managing model inventory, or to identify and manage all risks associated with models, SAS® Model Risk Management provides the right capabilities to gradually increase its usage to help increase the chance of much easier adoption within an organization.

CONCLUSION

MRM is no longer an option anymore for banks. It has become a regulatory necessity for all financial institutions. Financial institutions have started realizing the benefits of MRM and are establishing model risk governance as a core business function. Banks should build sound development, implementation, use, and validation practices. A robust and sustainable risk management framework, with strong governance and controls, is needed to effectively measure, monitor, and mitigate model risk. However, incorporating such a framework requires buy-in from senior management, a resource strategy, adoption of new information systems, and an enterprise-wide culture change. The framework needs to be flexible and should be scalable to address strategic, regulatory, and market changes. To start with, banks can adopt and customize best practices that are followed by other banks in the industry and then expand the coverage of governance to all modeling activities in order to optimize the MRM framework.

SAS® Model Risk Management is a one-stop-shop solution that comes with industry standard model risk management processes and several capabilities to address supervisory guidance on model risk management. SAS® Model Risk Management centralizes model-inventory management, document management and source code control, and provides decentralized access and a complete model-validation process. The solution's dashboards bring together an aggregated view of a bank's entire system of models to pinpoint areas of concern and opportunity.

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