Model Risk Ranking and Validation Scoping

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Industry evolution, along with regulatory directives, has shifted econometric modeling within key roles to all important areas in banking. Models are employed at all levels and functions in the financial services industry: origination, portfolio management, interest rate risk, credit loss, marketing, AML, fraud detection, etc. This is all in the name of quantifying risk to best manage it along with keenly understanding the borrowers in order to set polices and strategy.

Improved risk measurement seeks to provide optimal management and lending decisions aimed at profit maximization. Measuring and managing the risk versus merely mitigating the risk is the core goal. As internal modeling of bank-specific portfolio risk becomes more of the industry standard, even for regional and community banks, a number of model challenges are apparent. Certain quantitative functions and models have more risk. Identification of risks and classification of models is paramount to a risk-based approach that will apply limited resources to the appropriate validation activities. Validation scoping is directly linked to a model's relative risk and classification. In this paper we describe a Model Risk Management (MRM) strategy for model validation, review regulatory guidance, demonstrate risk tier classification and the associated depth (scope) and frequency of validation activities based on this strategy.

This briefing provides a perspective and strategy for model risk management through model risk ranking. We describe a tiering approach based on relative risk, tied to a depth (scope) and frequency for validation activities commensurate with that risk.

These methods are valuable to manage validation efforts across numerous models and to ensure models are performing as expected and produce useful and reasonably accurate outcomes. A secondary result is that using a risk-based methodology to focus model risk management efforts, including validation, creates an effective challenge and defensible solution consistent with regulatory guidelines.

As a leader in Model Risk Management, Montana Analytics has been active in developing models and utilizing rigorous analytical methods for examining models since 2002.

Introduction

Most financial firms use explicit procedures and decision tools to assign models to risk tiers. This classification helps focus limited resources towards validation efforts of the correct depth and frequency.

Quantitative modeling, also referred to as statistical or econometric modeling, has played an important part in the financial services industry with its role increasing over time. The increase in importance can be attributed to better data availability and more efficient tools to construct models and perform analyses. This evolvement has made measuring and modeling risk easier, which is then in turn used to shape strategy and policies. However, a critical reliance on numerous models creates its own set of challenges.

1. Model Risk Ranking Approach

1.1. Model Risk and Past Errors

Broad model usage introduces model risk. Model errors can lead to unexpected outcomes. Outcomes range from more benign ones such as small mis-valuations of immaterial portfolios that do not impact capital levels to large income losses such as the following:

- Deutsche Bank, 1992: Assumed Black-Scholes was a good model for options—and lost about $500,000,000.
- Long-Term Capital Management, 1998: Assumed correlations between assets were stable (Gaussian copula, no contagion); losses estimated at over $4.5 billion and required arranged bailout by Fed
- Subprime mortgage originators and investors, 2007-2008: Assumed the rising trend in the US housing market would continue or at least stabilize. Instead, a large decline in home prices caused high levels of mortgage delinquencies and foreclosures that resulted in a significant devaluation of loans and MBS and failed banks.

The ever-increasing usage of models across all areas of business therefore requires a comprehensive model risk management strategy.

1.2. Regulatory Guidance for Model Risk

Financial regulators recognized the risk that models pose long ago by issuing specific guidance on Model Risk Management (MRM). The primary banking financial regulators (OCC, Federal Reserve, FDIC) published their seminal guidance in 2011[1]. Other US financial regulators, the Federal Housing Finance Agency[2] and the NCUA[3],

[1] OCC: *Supervisory Guidance on Model Risk Management*, Advisory Bulletin 2011-12, Board of Governors of the Federal Reserve System, Office of the Comptroller of the Currency, April 4, 2011. (SR 11-7). http://www.occ.gov/news-issuances/bulletins/2011/bulletin-2011-12a.pdf

[2] Federal Housing Finance Agency ADVISORY BULLETIN 2013-07, Model Risk Management Guidance, https://www.fhfa.gov/SupervisionRegulation/AdvisoryBulletins/Pages/AB-2013-07-Model-Risk-Management-Guidance.aspx

[3] *NCUA Supervisory Letter 13-12, Enterprise Risk Management,* https://www.ncua.gov/regulation-supervision/letters-credit-unions-other-guidance/enterprise-risk-management-erm

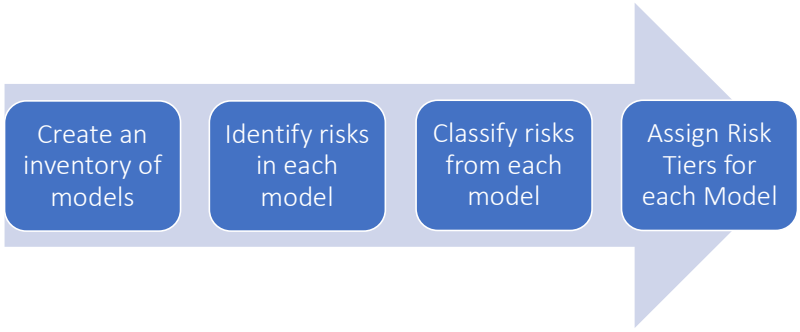
also published MRM guidance in 2013. The FDIC's FIL-22-2017[4] adopted the FRB SR11-7 model risk guidance in 2017. Regulators have regularly incorporated MRM requirements into most financial regulations since issuance of these initial regulations.

Though the level of detail regarding specific steps to take for MRM varies, the principles are consistent across the agencies. At a high-level, the guidance speaks to the necessity to identify where and how models are used along with understanding their associated risks. For the purposes of this paper, the definition of a model is consistent with the OCC definition from their 2011 guidance:

> *"… the term model refers to a quantitative method, system, or approach that applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates."*

The guidance establishes a set of concepts that includes materiality of risk to enable classification of models. A comprehensive MRM approach is needed to manage numerous models and appropriately prioritize the highest risk models. Several high-level steps are necessary to ultimately classify the risk in each model using a tiered approach as shown in Figure 1:

Figure 1: High-level steps to risk rank models



The natural first step to managing model risk is to establish a model inventory. Some banks may have only 10-15 models for key financial computations. However, large institutions may have over 300 models in an inventory. There is quickly a need to apply a risk-based approach to ration a fixed set of resources to conduct model risk management and focus validation efforts.

Various strategies are needed to manage model risk but one activity used by all financial institutions is model validations performed by a party independent of the model owners and developers. All of the regulatory guidance on MRM includes expectations regarding model validation activities but they are not explicitly tied to the risk of a given model. As a result, firms must establish policies regarding the depth and frequency of a validation as an in-depth inspection on every model annually is not expected nor feasible.

[4] FDIC Adoption of Supervisory Guidance on Model Risk Management, June 7, 2017_fil17022, https://www.fdic.gov/news/financial-institution-letters/2017/fil17022.html

1.3. Model Risks

In order to manage model risk, one must know the models and their associated risks. Next, defining and categorizing the risks posed by each model should be documented. Model risk may come from several areas or types of risk:

- Data limitations, availability, quality of data
- Estimation methods, incorrect model design, approximations, poor assumptions, incorrect estimators
- Inappropriate use or using a model beyond its design, lack of updates or re-calibration

There are various ways to classify risks posed by models from their applicable activities but there is no standard industry taxonomy for the various risks. However, the Federal Reserve ("Fed") and the OCC have both defined risk categories for supervisory purposes so it's instructive to briefly review their definitions. The Fed[5] defined six high-level risk categories for use in the supervision of large institutions, while the OCC[6] has defined eight high-level risk categories. Figure 2 shows the mapping of the risk categories between the Regulators.

Figure 2: Types of Risk defined by the Fed and OCC for general bank supervision

Fed	OCC
Credit	Credit
Market*	Interest Rate
	Price
Liquidity	Liquidity
Operational	Operational
Legal	Compliance
	Strategic
Reputation	Reputation

** Market Risk also has a Foreign Exchange risk component*

Risk categories are not mutually exclusive as any product or service may expose an institution to multiple risks so identification of the risks within the bank portfolio must be a factor in the evaluation of them. The OCC risk breakdown is more granular when compared to the Fed and is closer in practice as to how many financial institutions and market participants define sources of risk for management reporting and responsibilities.

Quantifying the risk from the models is a critical step. Though a given model may contain multiple types of risk as noted above, a common practice is to express all risks together, rather than attributing them separately.

A risk rating often follows in the process since this allows firms to concentrate their resources toward managing model risk. Model risk ranking or tiering was implemented by many banks after the release of 2011 MRM guidance by the primary US bank financial regulators. The FHFA's 2013 MRM guidance explicitly discusses risk ranking models:

[5] Framework for Risk-Focused Supervision of Large Complex Institutions (August 8, 1997).

[6] See "Large Bank Supervision" booklet of the Comptroller's Handbook (Jan. 2010) and confirmed in OCC-2014-001-file nr-occ-2014-117a.

"Policies and procedures should provide clear guidelines for developing model classifications or risk rankings. A model's complexity, business impact and the extensiveness of use generally determine its risk ranking or classification."

Note that the guidance is governance-based in that is expects clear policies and procedures exist for risk rankings. This guidance does mention factors that can be included in the ranking process. A thorough discussion of the factors included in risk rankings is beyond the scope of this briefing but a few high-level points warrant attention:

- Exposure - Materiality of outputs
    - Can be measured on revenues, expenses, balance sheet changes (e.g., valuation, ALLL)
- Dependence - Application - Usage of the model
    - (e.g., business decisions, regulatory reporting, risk management, financial statements)
- Model complexity - uncertainty
    - More complex models generally associated with higher errors and risk

1.4. Model Risk Tiering

Since these above concepts are not always precise, categorizing models into tiers is a common industry practice. Firms generally tier model risk into several categories, often 3-4, that translate into a Low, Medium, High grade for each model. This tiering process has become the standard among financial institutions in implementing a model risk management process and is encouraged by the regulators. The tiering process is generally achieved using decision trees or scorecards.

Decision trees are more general and quite useful. This can simply be thought of as triage. Here is a basic example that assumes Low, Medium, High tiers in risk ranking:

1. Does the model measure risk or financial value?
    - If so, initial classification is Medium.
2. Is the model used for key business decisions, regulatory or financial reporting?
    - If so, classification is High.
3. Is the financial exposure (aka materiality) Low or High?
    - Staff will need to gather exposure data and review all models to determine a reasonable level of exposure to be considered High risk.
    - Exposure can be measured on an absolute basis in dollars or as percentage of applicable financial statement item (e.g., balance sheet, income) to assess materiality.
    - If Low, the model is a Medium-Tier. If High, then High-Tier.

Scorecards assign each factor a point value and all point values from the factors are summed up for the model, then the risk rating is mapped to established tier categories. Scorecards can be a basic 3x3 matrix assuming three risk tiers or a more complex analysis of numerous risk factors that may produce a 0-100 "ranking".

2. Model Validation Scope and frequency

2.1. Model Validation Scoping Overview

As mentioned above, there are different depths or scope for model validations. Different scopes are necessary as it is not possible or expected to assess every model component in the model inventory annually. Many models don't need such frequent examinations either as the underlying populations and market conditions won't warrant frequent changes and the performance will be within the expected range for some time after implementation.

It is also imperative that a party independent of the model owners/developers performs such assessments as this is consistent with regulatory guidelines. This should also provide value to the organization through independent views that potentially improve the modeling process and its accuracy. This independent assessment and an appropriate validation scope provide what is termed an "effective challenge" in regulatory parlance to the model owners so regulators and stakeholders will be satisfied with this portion of a firm's MRM policy and process.

2.2. Model Validation: High-Level Scoping Concepts

First, it's helpful to define that a model consists of three components (from OCC 2011 MRM guidance):

- Information input component: delivers assumptions and data to the model
- Processing component: transforms inputs into estimates
- Reporting component: translates the estimates into useful business information

Guidance further describes the comprehensive steps that are necessary in a validation to properly evaluate a model. It is very clear that a high-risk model or a newly-adopted model be thoroughly examined, preferably before it is implemented.

An effective validation framework should include three core elements per regulatory guidance:

1. Evaluation of conceptual soundness, including developmental evidence
2. Ongoing monitoring, including process verification and benchmarking
3. Outcomes analysis, including back-testing

It follows then that a full-scope validation is an in-depth scope that assesses all three core elements across the three components of a model, inputs, processing and reporting. Other areas include documentation of the model, operational procedures, the IT software implementation and the model update process.

Also described is the need to consider these validation efforts as an on-going endeavor. Ongoing validation activities help to ensure that changes in model, markets, exposures or business practices do not create new model limitations. The general consensus in the industry suggests that "Periodic" validations be adopted when a model has already been examined in-depth and "Change" validations be used if any material changes have occurred.

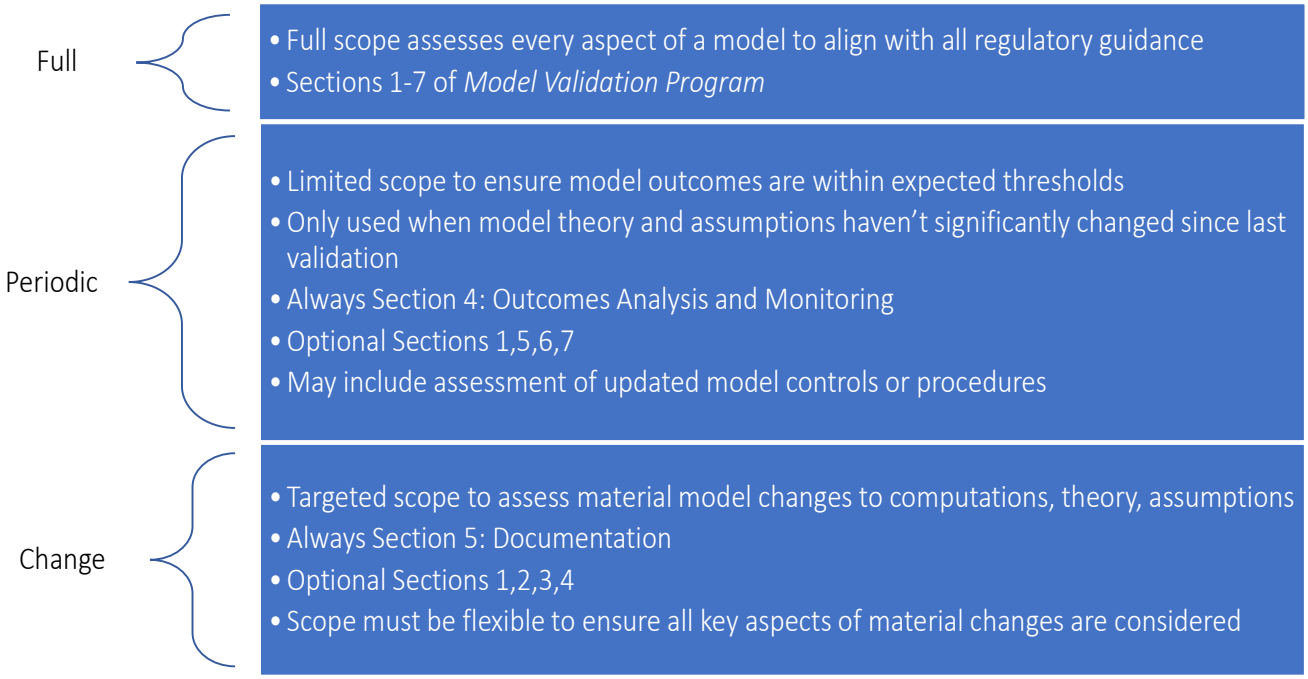
2.3. Model Validation: Defining Scope

As noted above, there are different validation scopes for different purposes, based largely on model risk ranking and changes since the prior validation. The Montana Analytics *Model Validation Program* (the "*Program*") consists of seven specific modules intended to fully examine all model components and satisfy regulatory guidance for a full-scope validation. There are numerous examination points within each module:

1. Data Inputs & Assumptions Verification
2. Model Theory, Logic and Assumptions
3. Model Code & Mathematics
4. Outcome Analysis and Monitoring
5. Documentation
6. Model Security & Change Control
7. Operating Procedures

Limited scope validations are also considered and address on-going validations. Here we define a "Periodic" and a "Change" validation. Figure 3 presents well accepted scoping definitions tied to regulatory guidance, industry practices, and the *Program*.

Figure 3: Validation Scope and what is included in each type



Full Scope Validation

The term "Full Scope Validation" is intended to assess all aspects of a model consistent with industry concepts: Conceptual soundness, Ongoing monitoring, Outcomes Analysis. This ensures the scope is in alignment with the comprehensive regulatory guidance and internal policies so it includes all seven sections of Montana Analytics *Model Validation Program*.

- Assess every aspect of a model to align with all Regulatory Guidance
- Assess Conceptual soundness: theory and assumptions for all equations, statistical developmental evidence, mathematical recalculations
- Assess Ongoing monitoring: model monitoring process and policies, action plan steps if thresholds exceeded per policy, may include process verification
- Assess Outcomes analysis: backtesting, sensitivity analysis, benchmarking thresholds comparison; action plan steps if thresholds exceeded per policy
- Is critical for newly developed models and warranted before a model goes into production

Periodic Validation

The "Periodic Validation" is intended to be a limited scope of activities to be utilized after a Full Scope Validation has been performed. The "Periodic Validation" review focuses on the model's outcomes and monitoring analysis to ensure the model is performing as intended within established thresholds so the primary focus is just one module in the *Program*.

- Limited scope to ensure model outcomes are within expected thresholds with reasonable outcomes
- Only used when model theory and assumptions haven't significantly changed since last validation
- Assess Ongoing monitoring: model monitoring process and policies, action plan steps if thresholds exceeded per policy, may include process verification
- Assess Outcomes analysis: backtesting, benchmarking thresholds comparison; action plan steps if thresholds exceeded per policy
- Assessment may suggest updates to model or additional validation activities

Change Validation

Lastly, the "Change Validation" focuses on significant updates to the modeling process so this can include changes to various parts of the modeling process: theory, assumptions, outcomes, data input controls, etc. Therefore, multiple modules of the *Program* may be in-scope.

- Targeted scope to assess a material model change to conceptual soundness (theory, assumptions), calculations, model outcomes
- Scope varies to ensure all aspects of a material model change are assessed
- Focus should be on material changes but, can be difficult to determine how much to cover
- Should include comparison of before/after outcomes and attribution of change in results

2.4. Matching Validation Scope and Frequency to Risk Tier

Now that the scope for each model validation type is established, the question is to how to apply this to a given model inventory over time. Many institutions assess their models on approximately a three-year cycle with higher risk models examined annually and the lower risk models every 2-3 years. As discussed above, it's not feasible or necessary to examine each model annually. Once firms establish a risk-ranking, deciding the scope and frequency of the validation is the next step.

The primary goal of the MRM risk ranking framework is the alignment of validation depth and frequency to a risk-based tiering classification to focus resources appropriately on mitigating model risk. An example illustrates a framework for this. Here we simply assume a bank classifies model risk rankings into three tiers: High, Medium, Low. Figure 4 presents a way to assign validation scope and frequency to the model risk-ranking, assuming a three-year review cycle.

Figure 4: Example of Validation Depth (Scope) and Frequency Matched to Model Risk Tier

Risk Tier	Full Scope Validation	Periodic Validation	Change Validation
High Risk	• First year if new Vendor or proprietary in-house model • Frequency: every 2 years	• Frequency: Years when not doing Full validation	• Frequency: Based upon materiality of change. If material then Validation can be focused or Full.
Medium	• First year if new Vendor or proprietary in-house model • Frequency: every 3 years	• Frequency: Years when not doing Full validation	• Frequency: Based upon materiality of change.
Low Risk	• None or once upon implementation	• Frequency: Annually review Tier classification	• Frequency: As necessary per material changes

The assignments in Figure 4 are just one way to approach this. However, it has been our experience that using such a classification method will be satisfactory to regulatory examiners and effectively manage model risk.

The scope for a particular model can vary over the assumed three-year cycle as shown in Figure 5. For example, implementing a new ALM model, which is critical to all banks and rated in the highest risk tier, would require a Full Validation (year one). The model performs within expectations over the next year with stable performance, monitored outcomes within thresholds and no changes to key assumptions or theory updates in year two. A validation schedule for this ALM model may look like this:

- Year 1: Full Scope Validation
- Year 2: Periodic Validation
- Year 3: Change Validation, or another Full Validation

Summary

Models are employed at all levels and functions in the financial services industry and their usage should only increase in the future. Model risk has led to significant errors over the years, many of which have bankrupt numerous firms. Managing model risk to avoid such outcomes is important. However, it is also crucial to stay competitive with shrewd peers and remain compliant with model risk management regulatory guidance.

Regulators expect firms to have a comprehensive model risk management program. Risk ranking of models using logical criteria based on the model's usage and materiality is an important step to this process. A risk-ranking approach is promoted here as it is consistent with industry practice and accepted by regulators. Risk-Tiering is a method to focus limited resources on the highest-risk models more frequently and with broader scope.

Model validation is a key activity to manage model risk and a methodology to assess models based on a risk-tiering approach is presented. Guidelines and an example illustrate the depth (or scope) and frequency for examining a model appropriately based on its risk rank. Similar processes are observed at institutions exhibiting best practices and have shown to be effective in managing model risk.

