

Modeling the Future:

RMA Survey of Model Risk Management,
Vendor Model Validation, and Third-Party
Model Risk Management



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EXECUTIVE SUMMARY

Models permeate the financial services industry. Model risk management (MRM) has evolved in parallel, but not always at the same pace.

April 2011 was a watershed moment for model risk management. That month, the Federal Reserve Board (FRB) and the Office of the Comptroller of the Currency (OCC) published the [Supervisory Guidance for Model Risk Management](#) (MRM Guidance), which was adopted, verbatim, in 2017 by the Federal Deposit Insurance Corporation (FDIC). This guidance provided a structure for firms to review their existing practices and to establish comprehensive model risk management frameworks. Firms of all sizes have made material advances in model control practices since that date.



To assess the current state of the industry, the Risk Management Association conducted the Survey of Model Risk Management, Vendor Model Validation, and Third-Party Model Risk Management (the survey) during the fourth quarter of 2021. Sixty-two firms participated, a respondent pool that represents a cross-section of the industry along the dimensions of asset size and primary prudential regulator.

Our survey revealed that the composition of model inventories varies widely between quantitative models, qualitative models, and critical calculators, but is positively correlated with asset size. Quantitative model counts ranged from the single digits to 800. However, most firms reported qualitative model and critical calculator counts below quantitative model totals. Several firms reported that they had no qualitative models and no critical calculators at all.

Model and non-model inventory counts were correlated with firm asset size, but with greater variance around the trend. The greater variance in counts also suggests greater disparity in definitions and inventorying practices. From post-survey conversations with respondents, it is clear larger firms have invested relatively more attention in controls for these “less- or non-quantitative objects.” Smaller firms have only within the last three years expanded their inventories in this direction and had dialogue with their regulators on MRM’s role with respect to this domain.

Clearly, MRM has significant stature within the firm, with most teams reporting directly into the chief risk officer. But our survey revealed great differences in the sizes of model validation staffs. Firms reported dedicated staff size that ranged from zero to 300, again highly correlated with firm asset size. Those that report “zero” get by with partial allocations, dual-hatting of personnel, and third-party validations.

Surprisingly, the majority of firms reported they already were at their “ideal” validation staffing levels or would hire just one or two full-time employees to reach ideal. Controlling for one large outlier, average hiring would be just below two FTEs. Asked what challenges they faced to expand validation capabilities, firms gave the top two answers as “talent” (72% of respondents) and “cost” (63%).

Model risk support staff queries also yielded a range of opinions. Firms reported MRM-dedicated support staff ranging from zero to 107 FTEs. (Support staff typically manage model inventories, workflows, and similar tasks). A sizable number reported fewer than three support FTEs. The gap to ideal was, on average, about one FTE. The correlation of support staff to firm asset size was lower, we think indicating more disparate organizational structures for MRM support functions than validation functions.

Reliance on vendor models seems to decrease as a firm's total assets increase. Seventy-five percent of firms under \$25 billion report that more than 50% of their models are vendor models; whereas, at least 75% of firms over \$50 billion report that fewer than 50% are vendor models.

Smaller firms also report proportionally more reliance on third-party validations, with the majority of firms under \$25 billion reporting that more than 50% of their models are third-party-validated. The preponderance of firms larger than \$25 billion report that 25% or less of their models are third-party-validated.

Sixty percent of firms reported that models in the top model risk tier require validation "every two years." In subsequent conversations, all firms that indicated they had two or three-year validation requirements also stated they require an annual "health check." This health check typically includes a review of model changes, ongoing performance monitoring issues, or unresolved validation issues and can trigger earlier review.

The survey consists of 58 substantive questions which, in composite, provide rich insights into the state of the industry with respect to model risk management. The pages that follow provide an overview of the findings. Complete results will be made available to all survey respondents.

Key Findings

At a Glance

65% reported that the model risk management function reports directly into the chief risk officer.

89% of 61 respondents stated that they classify at least one vendor-supplied "tool."

0 to 107 – number of FTEs dedicated to model risk management.

60% reported that models in the top model risk tier undergo validation "every two years."

100% of firms report at least one quantitative model, 60% at least one qualitative model, and 60% at least one critical calculator.

The Historical Context - Milestones in the Development of Modern Financial Models

The history of financial development in the 20th and 21st centuries incorporates a progression of modeling innovations, advances, and setbacks. Second-line-of-defense model risk management practices and regulations have evolved in response to those events.

Finance has always required a mastery of numbers. Money and banking, even in its simplest form, required the development of abstract concepts to manipulate intangible claims: money (as unit of denomination, store of value, and a means of exchange), time-value, and risk. These concepts require translation into tools which integrate them in ways that are coherent with theory, that correspond to real-world observations, and that are useful to the practitioner. Fundamentally, financial management requires models.

Though it can be argued that banks and broker-dealers had used models of one sort or another for centuries, our modern idea of financial models took shape with the development of portfolio theory in the 1960s, which was to a large degree in parallel with the development of modern computers. Ideas and models like the Sharpe Ratio and the Capital-Asset Pricing Model (CAPM) provided a framework to make sense of expected returns and risks across disparate assets and liabilities. Risks became quantifiable, measured by price variances and correlations. In time, practice caught up with theory. New instruments allowed the isolation of cash flows, values, and the underlying market variables that drive risk and return. These could be decomposed and recomposed into ever more customized instruments. The pricing of risk became more systematic. The application of quantitative models accelerated.

A take-off moment was the 1973 publication by Fischer Black and Myron Scholes of their formula for pricing options (also accredited to Robert Merton, whose work paralleled and expanded on their own). Their "risk-neutral framework" proved conceptually coherent and widely useful not just for pricing call and put options contracts, *per se*, but for valuing corporate liabilities and, as time would show, creating, hedging, and valuing an array of compound securities and derivatives.

Modeling accelerated further in the 1980s with the development of the derivatives market. In 1981, Salomon Brothers famously arranged the first major cross-currency swap between IBM and the World Bank. The swap, analogous to an exchange of back-to-back loans, essentially allowed the counterparties to exchange their comparative spread advantages in specific, national financial markets. The swap was not overly complex to model, but its execution marked a watershed event in financial engineering.

During the 1980s, financial modeling received a boost when personal computers were introduced onto almost every professional desktop in the financial industry. The new computing power enabled almost anyone with the talent to develop some form of model on their desktop. Controls inherent in slow-moving, large-scale IT code development no longer applied. Senior managers did their best to keep up through supervisory reviews.

In 1989, Stephen Kealhofer, John McQuown, and Oldrich Vasicek founded KMV Corporation. KMV provided a practical implementation of Robert Merton's extensions on the Black-Scholes-Merton model. KMV captured both individual security default risk as well as the composite risk of portfolios. The success of KMV marked a turning point in quantitative credit modeling. Starting in the 1980s, the core concepts were applied to a widening field of asset classes and instrument designs. (NB: KMV was sold to Moody's in 2002.)

Innovation continued apace and accelerated throughout the 1990s. Secondary markets for residential mortgages burgeoned and financial engineers carved up mortgage portfolio cash flows into multiple tranches with various cash flow priorities and credit seniorities.

In 1994, J.P. Morgan & Co. set the precedent for a standard form of corporate credit default swap (CDS) that would soon permeate the secondary market for credit. The CDS paved the way for synthetic collateralized debt obligations (CDOs), securities on corporate underlyings similar to mortgage securities. Securitizations flourished into the early 2000s.

Model innovation was not limited to valuation and structuring. Firms used the same fundamental finance theory to create portfolio risk management tools. Banks like J.P. Morgan and Bankers Trust built the first Value-at-Risk (VaR) models, aimed at consolidating and summarizing the risks of whole trading portfolios using summary statistics that integrate all species of exposure (interest rates, equity prices, commodities, currencies) and all species of contracts (bonds, stocks, loans, deposits, derivatives).

Regulatory applications of models followed closely. In 1997, the traditional rules-based Basel Accord on Bank Capital was amended to permit firms to use internally developed VaR models to calculate the minimum required regulatory capital on the trading portfolio.

New techniques and more, cheaper computing power meant that the extension of models was unstoppable. Quantitative modeling extended its reach into every corner of valuation, assessment, and management, and onward into regulatory capital and public disclosure of risks to investors and the public.



The Origins of Independent Model Risk Management

Model risk management developed in fits and starts with the evolution of quantitative modeling. Originally, most model controls were either traditional IT “change controls” that focused on robust implementation, or conceptual reviews by business-line senior managers who were in the direct chain of command.

By the early 1990s, risk management organizations in large trading banks and broker dealers recognized the value of an independent review. To start, in most firms, market risk managers primarily filled the role, part time. Market risk managers typically were relatively quantitative by training and had often come to risk management from stints in the front office.

Throughout our timeline of financial services modeling, model risk management always developed fastest after losses from particular model failures. Since the early days, as experience accumulated, episodic valuation and hedging mishaps have driven firms toward more systematic model controls.

A seminal moment was the U.S. yield curve backup of 1994. Of particular note, a number of high-profile customers suffered outsized losses on interest rates derivatives and sued their dealers (for example: Orange County, California, vis-à-vis Merrill Lynch and Procter and Gamble and Gibson Greeting Cards vis-à-vis Bankers Trust). It marked a particular, headline-grabbing mishap with derivatives. Derivatives valuation was front and center for firms, the press, and the regulators. Several firms were moved to establish or reinforce their *independent* model risk management capabilities. They hired an increasing number of mathematicians, physicists, and other quantitatively trained staff, externally or from among the “desk quants” in the business lines, to focus on quantitative model review. However, model risk management was, typically, not yet a distinct unit within risk management, or at least not as operationally mature as the traditional risk units like market risk management and credit risk management.

A series of market events in the 1990s and early 2000s exposed a number of model weaknesses. Each *post-mortem* revealed the need to go deeper on the assumptions on which failing models were built: assumptions regarding the availability and liquidity of hedging instruments in crises, the inferential power of parameters calibrated looking backward on history, and the validity of modeling simplifications like price or default correlations across multiple derivative underlyings. Experience revealed that assumptions and simplifications that were valid or of negligible effect in benign markets can turn massively influential during market stress. Early model risk management was formed through these events. In the process, senior managers came to understand the value of up-front investment in the quantitative teams needed to perform formal and rigorous independent review to head off problems before they eventuate.



The Watershed Moment: The Subprime Mortgage Crisis

The mortgage crisis of 2007 to 2009 is the crucial event that shaped model risk management as we now know it. As the mortgage market collapsed in the third and fourth quarters of 2007, it became clear that the models for rating and valuing mortgage collateralized debt obligations had played a material role. Losses were orders of magnitude larger than models projected. Valuation models broke down and, in many cases, failed to produce useful output during the height of the crisis. Going into the event, valuation models and historical prices fed capital models that produced probability-based loss numbers ludicrously below the losses realized on sub-prime mortgage securitizations. In sum, models developed and calibrated *ex ante* in benign markets failed to countenance the market conditions that eventuated. As a result, in the aftermath of the crisis, all quantitative modeling practices were in the regulators' sights and became subject for reform.

The proximate outcome was the issuance in April 2011 of the document *Supervisory Guidance on Model Risk Management*¹ by the Federal Reserve and the Office of the Comptroller of the Currency. This document has become the canon against which financial firms large and small judge their model risk management programs. The document covers the full spectrum of model risk management activities: development; implementation and use; validation; evaluation of conceptual soundness; ongoing monitoring; outcomes analysis; and governance, policies, and controls—including the auditing of the model risk program. It places heavy emphasis on formal, thorough documents of models and validations, and recommends rigorous model-identification processes and model control tracking via an exhaustive model inventory.

In the wake of the mortgage crisis, the major prudential regulators were able to give the MRM guidance teeth by applying it actively in their oversight and examination activities. The guidance was used to structure their in-depth examinations of the major broker-dealers that became banks or were acquired by banks in the post-crisis reforms. The guidance became the framework for the examination of internal-model applications under the Basel capital rules, and a key component of the technical review of large banks' Comprehensive Capital Analysis and Review (CCAR) stress-testing programs.

¹ FRB Supervisory Letter SR 11-7 or OCC Bulletin 2011-12.

All large banks had to “up their game” in a very short time. Most increased their model risk management staff materially, established formal, documented model risk frameworks, and made their model risk management units independent and senior within the chief risk officer departments. The goal was to foster the stature needed to pose effective challenge and enforce modeling standards in the businesses and among model developers.

The scope of model uses expanded as well. Earlier model risk management emphasis tended to be on intensively used models in market, credit, asset-liability management, and liquidity risk at large commercial and capital markets banks. After things had stabilized in the wake of the subprime crisis and once the CCAR program was up and running, attention steadily expanded to cover the entire universe of models, encompassing models used in retail credit, operational risk, Bank Secrecy Act/Anti-Money Laundering monitoring, fraud detection, and myriad other processes needed to run a bank.

The FDIC also adopted the same model risk guidance, *verbatim*, in 2017, and, in a formal way, model risk management has become an integral part of the examinations of banks of all sizes. The Fed, OCC, and FDIC have made the guidance the centerpiece of an effort to encourage banks to adopt a greater formalism in their controls around models of all types. In our conversations with smaller banks, in particular, they reveal that they have considerable investments still to make, but the regulators are balanced in their expectations and are explicitly managing to the principle, articulated in the MRM guidance, that “practical application of this guidance should be customized to be commensurate with a bank’s risk exposures, its business activities, and the complexity and extent of its model use.”

At the time of this writing, it is fair to say that the pace of modeling innovation has not slowed. The development of models and technology, which now include artificial intelligence and machine learning models and cover newly integrated risks like climate risk, present new challenges to MRM disciplines. Banks have an independent interest to continue investment in their model risk management capabilities, and, assuredly, the regulators will continue to press banks to integrate all new developments into their model risk frameworks.

The survey results which follow provide an overview of the state of model risk management at this time and expectations for the near-term.



Milestones in Modeling and Modeling Risk	Dates	Development of Model Risk Management		
Sharpe Ratio and Capital Asset Pricing Model	mid-1960s			Model control mostly through 1st line of defense supervision and IT controls
First mortgage pass-through	1968			
Black-Scholes-Merton Model	1973			
First cross-currency swap	1981			
First collateralized mortgage obligation	1983			
Widescale introduction of desktop computers	mid/late-1980s			
VAR and RAROC models KMV credit modeling firm founded	late 1980s-early 1990s			Increasing 2nd line of defense oversight, often embedded in market, credit, operational risk units
VAR models permitted for Basel reg capital	1998			
Russian Default Collapse of hedge fund LTCM	1998-1999			
Mortgage crisis Great Recession begins	2007-2009			
Fed stress testing programs begin (CCAR in 2011)	2009			Increasing dedicated, independent model validation and governance, including board oversight
<i>Supervisory Guidance on the Management of Model Risk</i> issued by Fed and OCC (FDIC adopts in 2017)	2011			
Firms of all sizes and complexity invest in formal, independent model risk management, covering all model uses and all functions	2012-Present			

CONCLUSION

This RMA Survey of Model Risk Management, Vendor Model Validation, and Third-Party Model Risk Management white paper highlights key findings from both the survey and from post-survey conversations with participating banks. In some areas, as noted, the results of the survey were inconclusive and warrant further study. RMA plans to publish additional analyses on model risk management and our findings to provide more context around results. In addition, we expect to update and repeat the survey on a regular basis in the future. We are hopeful this will provide insight into the evolution of model risk management and will allow the incorporation of new developments and challenges as they arise. In short, this is just the beginning of a rich conversation that will monitor and shape the future of model risk management in the financial services industry.

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