

Model Risk Management: Key Considerations for Challenging Times

By Richard R. Pace

Model definition, roles and responsibilities, cross-functional coordination and model validation are among the challenges.

Model risk management stands at the forefront of risk management for many of today's financial services firms. In this article, I review the current state of model risk management by focusing on the following two areas:

- Model risk management was not a prominent topic a few years ago—what has changed? What has motivated the increased attention paid to this area over the last few years?
- Although model risk management has made significant inroads to corporate risk management functions, there have been, and still are, significant challenges in building a truly effective model-risk management program. What are some of these challenges, and how are companies addressing them?

Why the Focus on Model Risk Management?

The emphasis on model risk management began officially in the national banking area with the May 1997 release of the Office of the Comptroller of the Currency's (OCC) 1997-24 Risk Bulletin that expressed concerns by OCC examiners that the risks associated with the use of credit scoring models were not being effectively managed by national banks. Specifically, the OCC found the following:¹

- Bank staff that were inadequately trained to monitor effectively the credit scoring model's performance
- Deficient bank management information systems that impeded tracking, monitoring

and validating the credit scoring model at development and revalidating the model over time

- Improper application of credit scoring models on products, subsets of the applicants or in geographic areas for which they were not developed without verifying effectiveness
- Inconsistent use of credit scoring models, including excessive overrides
- Use of credit scoring models that include characteristics that may be discriminatory, may possibly have a disparate impact on a prohibited basis or raise other Equal Credit Opportunity Act or Fair Housing Act concerns

In response to these concerns, the OCC provided specific expectations and guidance to bank management to improve risk management in this area—in particular, the OCC expected bank management to accomplish the following:

- Understand the credit scoring models thoroughly.
- Use credit scoring models for their intended purpose.
- Validate or revalidate the credit scoring models' performance regularly.
- Review tracking reports—including the performance of overrides.
- Take appropriate corrective action when the credit scoring models' performance deteriorates, which could include reviewing lending strategies to determine their effect on the credit scoring model; actively managing the credit

Richard Pace is a Principal with the Financial Services Regulatory practice of PricewaterhouseCoopers LLP, McLean, Virginia. Contact him at ric.pace@us.pwc.com.

scoring model cutoff strategies; or developing a new credit scoring model.

- **Ensure the credit scoring models' compliance with fair lending regulations.**

Three years later, the OCC communicated expanded concerns about model risk (beyond the credit scoring area) through its issuance of Risk Bulletin 2000-16 on Model Validation. In this publication, the OCC noted the following:

The OCC has observed several instances in which decision makers either relied on erroneous price or exposure estimates, or on an overly broad interpretation of model results, with serious consequences for their bank's reputation and profitability. There are many more instances in which the incorrect use of models created the potential for large losses, which were avoided only fortuitously. This problem is generally referred to as "model risk."²

Unlike Risk Bulletin 1997-24, this risk bulletin focused more broadly on models used in banks' risk management processes, for example, the following:

- Interest rate, credit, operations and market-risk management models
- Economic capital models
- Allowance for loan and lease loss models
- Financial valuation models
- Models generating assumptions that feed into the above models

After the release of OCC Risk Bulletin 2000-16, large banks gradually adopted its guidance, which encompasses development of a formal model-validation policy; development and implementation of model-validation procedures; and, for independent reviews, specific model-validation elements.³

Formal Model-Validation Policy

The institution should develop a formal model-validation policy to ensure that a bank's model-validation efforts are consistent with senior management's view of the proper trade-off between costs and benefits. This policy should address the following specific elements:

- **Independent review.** The personnel performing model validation should be as independent as possible from the personnel who construct the model.

- **Defined responsibility.** The responsibility for model validation should be formal and defined. In addition, policies should specify that, before a model can enter production, (1) the independent model-validation unit or external reviewer must document the model-validation tests and the reasons for concluding that the model is valid, and (2) internal audit must verify that no models enter production without formal approval by the validation unit.

- **Model documentation.** At the corporate level, a catalog of models and their applications should be maintained. The policy should require documentation for specific models that is adequate to facilitate independent review, training of new staff and clear thinking by the model developer. The most rigorous policies require documentation that is sufficiently detailed to allow the precise replication of the model being described.

- **Ongoing validation.** Best practices for validation policies require that all changes in the modeling process be documented and submitted for independent review. A useful practice is to allow model changes only periodically and only after independent review and approval by the appropriate level of the bank's decision makers. It is useful for a bank to store multiple copies of model code to facilitate disaster recovery as well as to monitor assumption changes. Models should be subjected to change-control procedures, so that code cannot be altered except by approved parties.

- **Audit oversight.** The formal policy should clearly specify that internal audit is responsible for ensuring that the model validation and model-validation units adhere to the formal policy.

Model-Validation Procedures

The institution should develop and implement effective model-validation procedures, such as the following:

- **Comparison of the model's results against those from other models.** At the time a model begins to produce outputs, model developers and validators should compare its results against those of comparable models, market prices or other available benchmarks.

- **Comparison of model predictions against subsequent real-world events.** Once in use, model estimates should continually be compared to actual results, a procedure referred to as back testing, out-of-sample testing and similar terms.
- **Independent review of the logical and conceptual soundness of the model.**

Validation Elements for Independent Reviews

For independent reviews, OCC Risk Bulletin 2000-16 specifies the following validation elements:

- **Data.** Auditing of the internal and external data inputs is an indispensable and separate element of a sound model-validation process and should be explicitly included in the bank's policy.
- **Assumptions.** Whether drawn from public sources or from the bank's own research, important behavioral assumptions should be routinely compared to actual portfolio behaviors.
- **Theory.** Regardless of the qualifications of the model developers, an essential element of model validation is independent review of the theory that the bank uses.
- **Code and mathematics.** Most models, such as those that operate in spreadsheets, have relatively simple code and equations, which can be cheaply tested by the independent construction of an identical model. For more complex models, independent construction of an identical model may be too costly. These situations require alternative practices such as line proofreading of the code or comparing model results to the results from a second, well-validated "benchmark" model.

Model Risk Framework Extends Beyond National Banks

Since the issuance of OCC Risk Bulletin 2000-16, other federal regulatory agencies have either formally or informally embraced the OCC's expectations for model risk management in their supervisory activities. See, for example, the following publications:

- *Model Governance*, FDIC SUPERVISORY INSIGHTS, Winter 2005.

- *Valuation and Modeling Processes*, BANK HOLDING COMPANY SUPERVISION MANUAL, Division of Banking Supervision and Regulation, Board of Governors of the Federal Reserve System, Section 2128.06.3.
- *Model Risk*, OFFICE OF FEDERAL HOUSING ENTERPRISE OVERSIGHT SUPERVISION HANDBOOK, at 54–58.
- *Model Documentation and Validation*, ADVISORY BULLETIN 2006-AB-02, Federal Housing Finance Board Office of Supervision.
- *Validation*, Risk-Based Capital Standards: Advanced Capital Adequacy Framework—Basel II; Final Rule, 72 FR 235.

In addition, the focus on model risk management has expanded outside of depository institutions to other nonsupervised financial services companies. In some cases, this adoption was in response to the discovery of a significant model error; in other cases, the adoption was based on a desire to evolve the company's risk management function to new best practices.

While the OCC's risk bulletins provided the impetus for initial industry adoption of model-risk management principles, it was a new regulation—the Sarbanes-Oxley Act of 2002 and, in particular, Section 404 on internal controls (404)—that intensified and broadened the industry's focus on model risk management, particularly for models used to generate material financial estimates that fed into a company's financial statements, such as the following:

- Various reserve estimates
- Fair-value estimates
- Critical accounting assumptions
- Financial disclosures

While Section 404 did not require a model-risk management program, many companies recognized that such a program would be an effective company-level control against model risk.

What Are the Challenges Associated with an Effective Model-Risk Management Program?

Companies face a number of challenges in building an effective model-risk management program that not only remains consistent with the guidance in

OCC Risk Bulletin 2000-16 but also addresses internal control requirements of Sarbanes-Oxley. These include model definition, roles and responsibilities, cross-functional coordination and model validation.

Model Definition

The first major challenge is defining the scope of a model-risk management program. A company must fundamentally define what constitutes a “model” and determine which models fit within the range of its program. While this may seem simple, it is actually complex in practice and has a significant impact on program success. Questions that arise during this phase of program development include the following:

■ **Is every spreadsheet application a model?**

One point of view is that since spreadsheets, by their very nature, perform mathematical calculations, they should be considered “models” and, therefore, be included within the scope of a model-risk management program. For some companies, however, this could be an enormous undertaking as thousands of spreadsheets may be used throughout the organization. An alternative point of view is that spreadsheets that perform basic mathematical calculations—with no underlying judgments, assumptions or estimation methodologies—should be covered by alternative control processes outside of the model-risk management program (such as by an “end user computing policy” or “spreadsheet policy” whose compliance is periodically tested by internal audit). The scope of the model-risk management program, therefore, would be more narrowly focused on spreadsheet-based models that require more specialized oversight due to their production of uncertain values based on judgments, assumptions and/or a range of alternative estimation methods or approaches.

■ **What about computer programs that perform complex calculations?** Similar to the spreadsheet discussion above, not all complex calculations necessarily fall within the scope of a model-risk management program. This does not mean that such calculations should not have proper controls (they certainly should); rather, companies may wish to determine which of these computer programs should be subject to standard informa-

tion technology (IT) general control processes and which should receive more specialized treatment under a model-risk management program. One consideration in this decision is whether the complex calculations generate uncertain values based on judgments, assumptions and/or a range of alternative computational approaches and, therefore, need additional oversight by model specialists (those trained in finance, economics, statistics, *etc.*).

■ **Must a statistical component exist within every model?** Some companies may adopt a very narrow definition of a “model” to include only those that generate estimates based on statistical analyses (for example, a regression-based model). Such an approach, however, may exclude other important nonstatistical financial or risk estimates needing enhanced model-risk oversight.

Finally, it is crucial to determine if the model risk management should be limited to formal “models” or if it should also cover the integrity of management’s ad hoc estimates—particularly those that may be used to override existing model results. For example, for a number of companies, material ad hoc/on-top adjustments to model-based estimates (such as loan-loss reserves) typically fall outside the scope of model-risk management programs. However, since these adjustments are typically quantified by modeling personnel and sometimes employ complex data processing and estimation methodologies, they frequently involve significant “model-type” risks. Therefore, management should either scope the independent review of these adjustments into its model-risk management program or employ appropriate control processes to ensure the reasonability and accuracy of these computations.

While there is no single right answer to the question “what is a model?” how one answers this question has a significant impact on the resources needed to implement an effective model-risk management program. In addition, even if a company adopts a narrower scope for its program, it is important to ensure that there are other effective control processes (such as an end user computing policy or spreadsheet policy and effective IT general controls) to mitigate the risks associated with “model-like” entities that are excluded from the program scope.

Roles and Responsibilities

Most models do not operate in isolation. They are integrated into larger computing systems and interface with other software and databases in order to produce a specific end result. Consequently, another challenge associated with designing an effective program involves determining appropriate roles and responsibilities for the company's model-risk specialists (those individuals responsible for independent model validation) as well as other important company constituencies. For example:

- One of the more significant risks associated with models used in financial reporting is that the model specification might conflict with applicable accounting policies and/or generally accepted accounting principles (GAAP). For example, a company's accounting policy may specify that only certain types of loan-related expenses may be included in its Statement of Financial Accounting Standards (SFAS) No. 5, *Accounting for Contingencies* (FAS-5), loan-loss reserve. However, the company's model development group may be unaware of this policy and inadvertently include estimates for all loan-related expenses in its loan-loss reserve model thereby producing reserve estimates that may be materially overstated. Because model-risk specialists tend not to be CPAs, it is debatable whether they should be responsible for addressing this particular risk. Nevertheless, this risk is very real and needs to be addressed within the company's model-risk management program, perhaps through the delegation of this responsibility to appropriate accounting or other finance personnel.
- A company must decide to what extent its model-risk specialists will have responsibility for platform risks. Clearly, unauthorized changes to computer programs that implement models present a very real and relevant model risk, but it is important to discern whether this risk falls within the purview of the company's IT function or the model-validation unit. Other matters that require decisions about jurisdiction include ensuring that model production programs are well secured, that these programs are executed without failure and that applicable operational risks such as the integrity of interfaces with up-

stream and downstream databases or manual data handoffs are appropriately mitigated.

- In delineating the responsibilities of its model-validation unit, a company should consider whether the unit will be accountable for data input quality and whether it will have jurisdiction over the use of model results in downstream financial and/or risk management processes. If not, then it is important for the model-risk management program to assign these roles and responsibilities to appropriate functional units. For example, specific business units may be assigned responsibility for the integrity of specific data inputs that feed into a model. In addition, owners of downstream processes can be assigned responsibility for ensuring the complete and accurate transfer of model results into these processes.

Cross-Functional Coordination

Decisions affecting roles and responsibilities lead naturally into the next major challenge: cross-functional coordination. As noted above:

- Many models integrate into larger computing systems with both upstream and downstream processes generating additional model-related risks. For example, models may be fed by data that have gone through complex upstream processing, and model results may be fed into downstream accounting engines (such as those that implement FAS-91, *Accounting for Nonrefundable Fees and Costs Associated with Originating or Acquiring Loans and Initial Direct Costs of Leases—an amendment of FASB Statements No. 13, 60, and 65 and a rescission of FASB Statement No. 17* (amortization); FAS-5 (loan-loss reserves); FAS-140, *Accounting for Transfers and Servicing of Financial Assets and Extinguishments of Liabilities—a replacement of FASB Statement No. 125*; etc.).
- An effective model-risk management program assigns roles and responsibilities to the company's model-risk specialists as well as to other important company constituencies.

This diffusion of roles and responsibilities for managing the entire set of risks associated with an "end-to-end" model process requires effective cross-functional coordination to ensure integrity to the final model system output. While responsibility for

this coordination role can be assigned in many ways (for example, a management committee or the risk management group), the following points should be considered:

- All end-to-end model-related risks (as noted above) should be identified across functional areas, documented and have appropriately designed controls. For each end-to-end model process, a good practice is to develop comprehensive process flows, document key risk areas, design and map appropriate controls to each of the key risks and assign specific control responsibilities.
- Formalize and assign responsibility for coordinating this end-to-end control system.
- Assign specific duties to the model-validation unit and to other functional units involved in the end-to-end control processes.

Model Validation

It can be challenging to define model validation and to determine how a company might put this concept into practice. Although this is an area for which there is no one right answer, some important points should be considered:

- In defining model-validation procedures, some companies may adopt an overly literal interpretation of OCC Risk Bulletin 2000-16 guidance and, therefore, focus only on the generic model-risk categories of “data,” “assumptions,” “theory” and “code and mathematics,” as well as very narrowly on the model “black box.” In practice, however, model risks are frequently more nuanced than these generic categories. As discussed above, model applications span more than just the core model component to include important upstream and downstream data processing activities. Adopting validation procedures that are too narrowly focused can omit important risk areas and lead to ineffective model-risk management. Alternatively, customizing model-validation procedures based on a comprehensive model-specific risk assessment often produces superior risk mitigation.
- A company’s model-validation procedures should be made formal to ensure consistency in execution and in evaluating model-validation results. The procedures should not be overly prescriptive, however, in order to leave room

for sufficient flexibility in validation scope and approach (which should be driven by the model-specific risk assessments noted above).

- To ensure ongoing model validity, a company should regularly back-test model results (that is, compare predicted values to actual outcomes) and establish acceptable model prediction error thresholds. For models used in financial reporting, the company may find that blind adherence to statistically based error thresholds may conflict with the views of finance/accounting people when evaluating model performance. For example, (1) wide thresholds and large prediction errors that modelers may find statistically reasonable may not be acceptable to accounting/finance personnel who may be concerned that such errors could signal a potential material misstatement; and (2) modelers may adopt a longer-term action plan to address evidence of potential model-performance deterioration, while accounting personnel may not be comfortable using the results of such models in current financial statements.
- A validation approach for third-party models must be determined. Although an increasing number of vendors are providing information to support their customers’ validation needs, such as model back-testing results, technical specifications, *etc.*, this information is generally not sufficient by itself to address relevant model risks.
- Since most model-validation reviews invariably result in findings, a company must ensure that it has an appropriate corrective action process that strikes the right balance between the needs of the business and the criticality of the model review findings. Effective corrective action processes generally include the following: (1) clear criteria to differentiate the criticality of model-validation findings; (2) clear criteria and responsibilities for model approval; (3) appropriate decision escalation processes based on degree of model risk; (4) appropriate time frames (adjusted for criticality) for the model owner to address model-validation findings; (5) effective reporting of model-validation findings, approval decisions and outstanding corrective actions to senior management; (6) regular follow-up with

continued on page 57

necessary) and communicating both internally and to the investing public effectively throughout the process. Taking these steps when faced with a difficult financial reporting challenge can help to ensure a well-thought-out answer and a successful conclusion to the issue for management, the bank and its constituents.

Endnotes

- ¹ Where a Bank is not subject to the requirements of the Securities Exchange Act of 1934, the audit committee will generally want to conduct sufficiently robust and independent inquiry into allegations of wrong doings prior to the issuance of the bank's financial statements.

CDOs and the Credit Crisis

continued from page 32

December 2004, forthcoming in the REVIEW OF FINANCIAL STUDIES); John Y. Campbell, Jens Hilscher and Jan Szilagyi, *In Search of Distress Risk* (working paper, Harvard University, June 2007, forthcoming in the JOURNAL OF FINANCE); R. Jarrow, Mark Mesler and Donald R. van Deventer, KAMAKURA DEFAULT PROBABILITIES TECHNICAL GUIDE, KAMAKURA RISK INFORMATION SERVICES, VERSION 4.1 (memorandum, Kamakura Corporation, Jan. 25, 2006).

- ³ For more on the implicit assumptions of the copula method and their impact on valuation, see R. Jarrow and Donald R. van Deventer, *Synthetic CDO Equity: Short or Long Correlation Risk?* (2008, forthcoming in the JOURNAL OF FIXED INCOME) and R. Jarrow, Li Li, Mark Mesler and Donald R. van Deventer, *CDO Valuation: Fact or Fiction* (2007, forthcoming in THE DEFINITIVE GUIDE TO CDOs, Risk Publications).
- ⁴ Calculations were done by the Kamakura Risk Information Services KRIS-CDO service using 500,000 iterations and reduced-form default probabilities distributed by Kamakura Corporation.
- ⁵ Susanne Craig and Randall Smith, *Merrill's Risk Manager, New Chief John Thain on What Led to the Losses and Why He's Hiring Goldman Sachs Executives*, WALL ST. J., Jan. 18, 2008, at C1.
- ⁶ My host was a managing director of the financial institutions group at Salomon Brothers.

Model Risk Management

continued from page 38

model owners on outstanding correction actions; and (7) independent validation of model owners' corrective actions.

Conclusion

While model risk management has come a long way over the last decade, it is still an evolving area where significant challenges exist.

Endnotes

- ¹ ©2008 PricewaterhouseCoopers LLP. All rights reserved. "PricewaterhouseCoopers" refers to PricewaterhouseCoopers LLP or, as the context requires, the PricewaterhouseCoopers global network or other member firms of the network, each of which is a separate and independent legal entity. The information contained in this document is for general guidance on matters of interest only. Given the changing nature of laws, rules and regulations, there may be omissions or inaccuracies in information contained in this document. This document is provided with the understanding that PricewaterhouseCoopers is not herein engaged in rendering legal, accounting, tax or other professional advice and services. It should not be used as a substitute for consultation with professional accounting, tax, legal or other competent advisors who have been provided with all pertinent facts relevant to your particular situation. Before making any decision or taking any action, you should consult a competent professional advisor. See OCC Risk Bulletin 97-24, *Credit Scoring Models*, May 20, 1997, at 1.
- ² See OCC Risk Bulletin 2000-16, *Model Validation*, May 30, 2000, at 2.
- ³ See OCC Risk Bulletin 2000-16, *Model Validation*, May 30, 2000, at 2-7.