This article is from a PricewaterhouseCoopers publication entitled

Insurancedigest

Sharing insights on key industry issues*

Americas edition • February 2009

Model validation: The new control imperative

AUTHORS: MARY ELLEN COGGINS AND NICK RANSON

As the current economic crisis has shown, model risk is a real and present danger. Design flaws, inappropriate assumptions, poor data quality, and incorrect interpretation of model results can lead to a host of problems. What is worse, errors may remain undetected for long periods of time. However, as Maryellen Coggins and Nick Ranson explain, there are model validation techniques that can help insurers manage model risk and defuse ticking time bombs.

The physicist and 'father of the A-bomb' J. Robert Oppenheimer once said of Albert Einstein 'any man whose errors take ten years to correct is quite a man.' Unfortunately, the same cannot be said about the often highly complex models that are used in the insurance industry today. Indeed, one of the major risks arising from the use of these models is that errors may remain undetected for long periods, during which time many key decisions may have been taken on the basis of the model results.

One particularly dangerous cause of undetected model errors lies not with the models themselves, but with the way the models are used. Even if the theory underlying a model is 'correct,' it still may produce inappropriate results. This may occur, for example, if the assumptions applied in the model are unreasonable or if the limitations of the model results are not fully understood.

A recent *New York Times* article[1] examined the sub prime crisis, and stated, 'The models, according to finance experts and economists, did fail to keep pace with the explosive growth in complex securities… But the larger failure, they say, was human – in how the risk models were applied, understood and managed.'

Background

Recent changes in the global capital, regulatory, and ratings environments are resulting in a greater emphasis on the use of internal models to demonstrate an understanding of risk exposures, analyze business strategies, and estimate fair values of insurance and financial instruments. The increasing use of these complex models is exposing organizations to a previously unprecedented level of 'model risk.' In particular, design flaws, inappropriate assumptions, poor data quality, and incorrect interpretation of model results can lead to sub-optimal decisions in areas such as business planning, product pricing, liability hedging and strategic capital management and allocation.

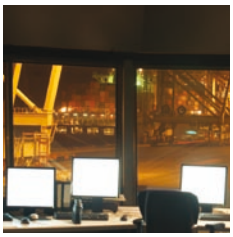
The situation is exacerbated since, in many areas, the quantitative modeling techniques being used are still in their infancy. In addition, the complexity of some of the models often means that only a small number of employees fully understand their operation and, as such, these 'black boxes' are subject to limited independent scrutiny.

A robust model validation framework, including independent validation of high-risk models, can help mitigate this increasing model risk. It can also facilitate a deeper understanding of a model's purpose, uses, and limitations, providing management with increased confidence to consider the model results in support of key strategic decisions, which previously would have been taken without the benefit of this additional information.

Model risk in the insurance industry

There are various factors driving the increasingly important role of internal models within the insurance industry. These include:

- The growth of products that require complex valuation models;
- The resulting risk management requirements arising from these more sophisticated products;
- The increasing use of models by senior management to assess business unit performance and thus impact the strategic planning, budgeting and limit-setting processes;
- Similarly, the increasing use of models as a guidance tool for risk-based product pricing and as a key variable in determining incentive-based compensation; and



The complexity of some of the models often means that only a small number of employees fully understand their operation; as a result, these 'black boxes' are subject to limited independent scrutiny.

1 'In Modeling Risk, the Human Factor Was Left Out' by Steve Lohr, *New York Times* November 5, 2008.

- The greater information demands arising as part of the external disclosures to investors and rating agencies.

All of the above factors result in increased exposure to model risk, for example through:

- Inadequate inputs (e.g. questionable data quality, flawed assumptions);
- Invalid internal logic (e.g. lack of sound methodology or mathematical techniques, inconsistency with market practice, programming errors); and
- The inappropriate application of model results (e.g. through a misunderstanding of a model's limitations).

Examples of model risk

We do not have to look far to see recent examples of model risk manifesting itself as tangible losses in the financial services sector, or to envisage other areas where it may strike again.

The most prominent example is, of course, the subprime meltdown. We will never know to what extent this problem may have been avoided if stronger model governance frameworks had been in place across the banking industry. However, one significant contributing factor to the issue was the extensive reliance placed on complex valuation models whose assumptions, methodology and limitations were not always fully understood by senior management within the impacted organizations. Had the models been more fully understood, it seems less likely such a high volume of securitized subprime investments would have been written.

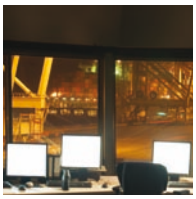
Another example is the losses arising from the 2005 hurricane season within the property and casualty insurance sector. Companies that placed absolute reliance on their catastrophe models without also considering expert judgment were exposed to significantly larger losses than those which also integrated expert judgment and oversight within their pricing and reserving processes.

On the life side, the increasing use of complex hedging models to help mitigate the risk of

FIGURE 1 **Potential impact of errors in representative insurance models:**

Type of model	Purpose of model	Potential areas impacted by serious model errors
• Pricing and operating complex products	• Getting design and price right • Putting the right hedging in place	• Financial performance • Customer satisfaction • Reputation
• Measuring exposure to risk, capital management	• Measuring economic capital • Managing exposure to risk	• Enterprise risk management • Capital management • Financial performance
• Supporting investment decisions	• Enabling good investment decisions	• Financial performance • Risk management
• Valuing tradable assets	• Mark-to-market of investment portfolio • Financial reporting	• Financial reporting • Compliance and risk management
• Valuation of a company that is the subject of a takeover or a merger	• Establishing a rational price or range of prices for the company to help investors decide whether to support the takeover or merger	• Investors, with large gains by one group at the expense of another group
• Valuing insurance liabilities (e.g. outstanding claims) and measuring regulatory capital requirements	• Measuring an uncertain liability affecting reported financial performance • Measuring capital to comply with regulatory rules	• Financial reporting • Financial performance • Capital adequacy

Source: PricewaterhouseCoopers



guarantees on ever more sophisticated products presents a possible future example. Companies need to ensure they are not placing blind reliance on these hedging models without appropriate oversight, for example to ensure:

- The models are functioning as intended;
- The results are being used and interpreted in accordance with the purpose for which they were generated; and
- There are appropriate controls outside the model (e.g. limits on new business volumes).

A particular area of concern around these models should focus on their reliability in a 'paradigm shift' environment. For example, around a third of participants in a recent PwC survey on ERM in the global insurance industry[2] stated that the hedging of their guarantees on annuity business was less than 90% effective. While this may not seem unreasonable, it is important to understand the extent to which the unhedged exposure may drive the resulting financial impact in extreme scenarios or under a paradigm shift, such as a major long-term change in the level or structure of interest rates. It is often in these scenarios that protection from hedging is most important.

So, what lessons can be learned from this? In short, modeling is an important part of risk management, but modeling risks is not the same as managing them. Understanding this is the first step in managing model risk.

Managing model risk

Given the significance of model risk to an insurer, what can be done to effectively manage it? Model risk management requires the design and implementation of a robust model governance framework. Such a framework should incorporate several key elements, including:

- A descriptive model validation policy;
- Defined roles and responsibilities around model ownership and validation;
- A comprehensive enterprise-wide model inventory with 'high-risk' models identified;
- Testing to help ensure the high-risk models are functioning as intended;
- Stated expectations for independent model reviewers;
- A process for validating and approving new models prior to their use;
- Ongoing monitoring of model performance; and

- Formal requirements around model documentation, controls and periodic validation.

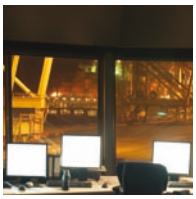
Once developed, an insurer's model governance framework should be routinely reviewed and updated to meet the evolving needs of the insurer and to ensure it effectively incorporates changes in the complexity of the models required to meet the needs of the organization.

For many insurers, the head of risk management or the chief risk officer (CRO) would be the most logical 'owner' of the model validation function. Each complex model would continue to have specific functional model owners who would be responsible for

2 'Does ERM matter? Enterprise risk management in the insurance industry - A global study' published in June 2008.

A formal model governance framework helps mitigate model risk by mandating periodic validation of high-risk models. Key elements of a best practice model validation framework include:

- Establishment of a model validation policy (approved by the Board and/or senior management) requiring periodic validation of key models and outlining:
  - The definition of a 'model' that will be applied in the framework
  - Definition of roles and responsibilities relating to model development, ownership, and validation
  - Segregation of duties, organizational structure, and reporting relationships for the model validation function
  - The role of internal audit (e.g. as owners of the model validation function or playing a 'third line of defense' in the model risk management framework by testing the processes applied by the model validation function)
  - Ongoing validation and back-testing requirements for existing models, including the selection of models for validation and the frequency of reviews
  - Guidance around key elements of the methodology, standards, and approach to be applied in model validations
  - Guidelines for the reporting of model risk exposures and findings arising from model validations
- Development of a comprehensive enterprise-wide model inventory, capturing information such as:
  - Model purpose and uses
  - Model owner
  - Model developer(s)
  - Model approver (and date of approval)
  - Model user(s)
  - Model version number
  - Whether the model is vendor-supplied or internally developed
  - Model platform
  - Date of last independent model validation (if any)
  - Criteria to be used for risk assessment of models
- Independent risk assessment to identify 'high-risk' models (i.e. those with the greatest potential financial or strategic impact from an error or misinterpretation of results), based on criteria such as:
  - Purpose and use of the model
  - High-level qualitative assessment of the potential impact of serious errors in using the model for this purpose in relevant areas (e.g. financial performance, customer satisfaction, reputation, compliance with regulations, risk management, financial reporting, statutory obligations, strategy and financial condition)
  - Model complexity and dependencies on other processes
  - Qualitative assessment of comfort over data inputs and assumptions applied in the model
  - Current level of confidence in the model (e.g. a recent validation increases confidence)
  - Qualitative assessment of controls surrounding the model
- Use of independent reviewers (including external specialists where appropriate) to validate high-risk models at appropriate intervals
- Documentation of a governance framework summarizing ownership of the model register and model validation program (e.g. internal audit or the CRO) and guidance around the model validation process (selection of models, frequency of reviews, validation approach)
- Approval process for new models to be validated before use
- Requirements around model documentation and change control between periodic independent validations



compliance with the model governance policy created by the CRO, and for ensuring that periodic model validations are performed. It is essential that the technical experts assigned to perform the model validation are independent from those individuals responsible for the model development and/or model management and updates. Since certain complex models may be 'owned' by the CRO (e.g. the economic capital model), the CRO would also need to identify an independent team of technical experts to perform periodic model validation. Internal Audit can then provide a 'third line of defense' by ensuring that compliance with the model governance policy has been enforced and confirming that all significant validation findings have been addressed.

Model validation

In light of the recently highlighted failures of financial services institutions to develop an understanding of the business purpose and limitations of complex models upon which they relied, senior management teams and boards of directors will have increased expectations for the validation of complex models. This is likely to include seeking solid evidence that complex models have undergone rigorous review and that model limitations are well understood. In addition, as insurers' ERM programs become increasingly important components of the financial strength assessments performed by rating agencies and regulators, evidence that complex risk and economic capital models have undergone robust periodic model validation will become essential.

For example, the New York State Insurance Department recently issued Circular letter No. 25 regarding Financial Condition Stress Testing. This notifies companies that the Department 'will be commencing a review of insurers' financial stress testing and scenario analyses.' It goes on to state 'Any models utilized by insurers also may be reviewed by the Department. In addition, the Department will evaluate how such models are independently reviewed within the company by risk management professionals, internal auditors, external auditors, and/or consulting firms.'

While few standards for model validation have been formally established for the insurance industry, insurers can be guided by the broad regulatory guidelines established for the banking industry. For example, the US Comptroller of the Currency Administrator of National Banks in its bulletin 'OCC 2000-16' identified the following goals of model validation:

- Decision-makers should understand the meaning and limitations of a model's results;
- Model results should be tested against actual outcomes;
- A reasonable effort should be made to audit model inputs, with input errors addressed in a timely fashion;
- Model oversight should be commensurate with the materiality of the risk;
- Model validation should be independent from model construction;
- Responsibility for the model validation process should be clearly defined; and
- Models should be subject to change-control procedures.

An independent model validation process should ensure a model complies with the insurer's model governance policy and confirm that the evolving requirements of company boards, senior management and external stakeholders have been satisfied. The more technical components of model validation involve ensuring that a model's methodology, operation and reporting are appropriate. In addition, validation of model methodology and model operation should provide satisfactory answers to the following questions:

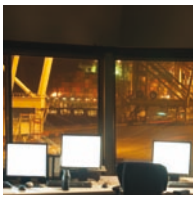
- Is the model purpose well articulated and understood?
- Is the model methodology practical, based upon mathematics that represent good current practice? Are the limitations of the methodology understood?
- Does the model represent the business drivers and risk factors that are relevant and material?
- Does the model reflect regulation and evolving industry practice?
- Are the model assumptions grounded in past experience, and when appropriate, do they take into account future outlooks and likely trends?
- Are expected outcomes periodically compared with actual outcomes?
- Are assumptions promptly modified to reflect changes in risk profiles, products, and other relevant factors?
- Are model inputs appropriate, complete, and understood?
- Do model outputs provide the type of result and reporting needed to meet the stated model purpose?
- Are the measures used to convey model results coherent, stable, and appropriate?
- Does the model rely on high-quality data?
- Is the model operation well controlled?
- Is there adequate model testing, including back-testing, stress testing, and benchmarking?
- Are the model results adequately challenged and analyzed?

Importantly, model validation also requires an assessment of the reporting and use of model results. Specifically, model validation should confirm that model results are clearly stated and understood by the decision-maker, that sensitivities and uncertainties are documented with the implications explained, that model limitations are clearly stated, and that insights derived from the model are conveyed effectively.

Conclusion

Without appropriate oversight, governance, and control, reliance on highly complex models may prove to be an 'atomic bomb' for the insurance industry – a view that J. Robert Oppenheimer would surely consider to be a fitting conclusion.

Specific examples of model risk and potential controls to help mitigate these risks include: □



	Example model risk	Potential controls
1. Model foundation & oversight	Inconsistency with the model's business purpose Inappropriate model governance	Training to help ensure users understand the purpose and applicability of model results (including key assumptions and any reliances or limitations around the results) Technical model documentation and training for model operators Model change controls including segregation of duties, formal test procedures, and documentation requirements
2. Assumptions & inputs	Inadequate controls around processes used to determine model assumptions Other inappropriate model inputs	Sign-off requirements around the development, review, and approval of assumptions Reasonableness and sensitivity testing of key assumptions (e.g. mortality, expense, and economic) Reconciliation controls to help ensure the accuracy, completeness, and timeliness of input assumptions, including controls to ensure the correct assumption sets are applied when the model is run Similar controls over other non-data inputs (e.g. economic scenario generators), including any assumptions used to derive these inputs
3. Data management & verification	Inadequate controls around processes used to collect, deliver and store data	Data quality controls (e.g. data entry checks and permitted data ranges) Reconciliations to check the completeness, and accuracy of processes used to generate model points or other compressed or representative data files Reconciliation controls to help ensure the accuracy, completeness, and timeliness of input data Sample testing of data quality, accuracy, and completeness IT controls to protect data stored and used within the model
4. Model performance & accuracy	Inappropriate model methodology Model methodology inconsistent with relevant industry rules and guidance Inconsistency between model specification and the computer code that transforms inputs into estimates	Independent review of methodology and approach underlying the model, together with any relevant mathematical or statistical results Model testing (including single model point and aggregate results testing) to ensure the model code appropriately reflects underlying methodology and model specifications Analytical review of results for representative sample of data inputs, including testing of various scenarios if appropriate Back-testing and calibration-testing procedures where appropriate Potentially validate model results against independent recalculation for appropriate samples Results benchmarking (e.g. versus other similar models)
5. Outputs & results	Inadequate controls in place around processes used to analyze and distribute results from the model Inappropriate reporting of model output to senior management	Analysis of model results prior to distribution Reconciliation controls around the aggregation of model results with other results or manual adjustments, and the population of results into other systems Independent review and benchmarking of frequency, content, and target audience of model output reporting Request feedback from the users of reports and ensure model is appropriately updated to reflect relevant feedback (e.g. to improve usability of results or to correct errors in the model)

AUTHORS

Mary Ellen Coggins

Director, Assurance and Business Advisory Services
PricewaterhouseCoopers (US)
Tel: 1 617 530 7427
mary.ellen.j.coggins@us.pwc.com

Nick Ranson

Director, Actuarial & Insurance Management Solutions
PricewaterhouseCoopers (US)
Tel: 1 646 471 9040
nick.ranson@us.pwc.com

PricewaterhouseCoopers provides industry-focused assurance, tax, and advisory services to build public trust and enhance value for its clients and their stakeholders. More than 155,000 people in 153 countries across our network share their thinking, experience and solutions to develop fresh perspectives and practical advice.

For additional copies please contact Amy Rose, PricewaterhouseCoopers (US), on 1 646 741 7630 or at amy.n.rose@us.pwc.com.
Previous editions are available fro

pwc.com

Designed by studioec4 19705 (02/09).