Internal models for insurance companies: Components, considerations and benefits

IBM

Executive summary

Insurance companies today are facing a number of new challenges – market volatility, low yields and regulatory pressures - related to Enterprise Risk Management (ERM.) Firms are attempting to incorporate risk analytics into business decisions allowing them to align around insights, act to optimize outcomes, and ultimately transform their business processes. More specifically, the current economic climate is forcing firms to evaluate their balance sheets under a wide range of new economic scenarios while at the same time continuing to manage the risk of their liability products and seeking out new investment strategies to boost asset returns. On top of this, new insurance regulations around the globe are placing a greater emphasis on enterprise risk management by mandating new reporting requirements (International Financial Reporting Standards (IFRS)), new capital requirements (Solvency II) and requiring management to take responsibility for risk assessments (Own Risk and Solvency Assessment (ORSA)).

Some regulatory regimes have introduced the concept of standard models that adopt prescribed approaches to calculating solvency capital. Such models are considered too restrictive to add much value to an insurer seeking to go beyond regulatory compliance and achieve the benefits of adopting an internal model for ERM. Therefore, the remainder of this article focuses on the steps, challenges and benefits of building an internal model for ERM.

An internal model based on a scenario simulation framework can help firms address many of the ERM benefits. At the core, a simulation based internal model allows an insurance company to revalue its balance sheet across economic scenarios and calculate many key risk analytics.

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However, a strong internal model also promotes a common risk culture throughout the organization allowing the firm to align activities to optimize results. Over time, a firm that is using ERM to optimize results can transform its business process and gain significant competitive advantages

One model, multiple uses

An internal model is a simulation-based representation of the entire balance sheet. All material risks that impact the value of the firm must be captured in a manner that makes it possible to revalue the firm across tens or hundreds of thousands of economic scenarios. The results of the simulation can be used for multiple purposes, but the most common usage is to measure and analyze economic and/or regulatory capital. Solo level capital calculations can be aggregated across the business lines or legal entities to produce a firm-wide or group capital number. Additionally, firm-wide capital can be attributed back to the sub-entities to measure capital adjusted performance. A scenario based model allows for sensitivity analysis and for what-if analysis: the capital to be re-run under different assumptions such as rising interest rates, a growth in product sales, or divesting a business line. The same model can also be used to manage investment risk, improve Asset Liability Management (ALM) process, and provide inputs to Mergers and Acquisitions Analysis (M&A) analysis. Moreover, the results of an internal model can be used to collaborate and communicate with external stakeholders, such as ratings agencies, stock analysts and shareholders.

Key challenges

Key challenges to developing an internal model include defining the model, managing organizational matters and creating the most appropriate model architecture.

1. Model definition

The definition of an internal model comprises the following five basic steps:

- Define reporting hierarchy and risk exposures. Create a reporting hierarchy that represents the organization and define the risks that are relevant at each level of the hierarchy.
- Model risk exposures. Select the appropriate model for each risk. Different models are typically selected for different risk types such as underwriting risk, market risk, credit risk, operational risk or catastrophic risk.
- Revalue balance sheet and aggregate all the risk. Simulate the risk for a large number of economic scenarios. During the simulation all the risks are aggregated together to create a total view of the balance sheet.
- Measure and allocate capital. Calculate the capital for the solo entity levels and aggregate it up the reporting hierarchy for diversified capital numbers at the country, legal entity or group level. Attribute the diversified capital down the reporting hierarchy to the individual business units or products allowing for capital adjusted comparisons.
- Reporting. Create reports and dashboards that can be used to analyze the results.

The goal is to create a model where end users trust the results enabling the end users to use the results as input to business decisions.

Workflow is used to automate the collection of data inputs, control the execution of the model, and provide the ability to audit the system. It is important that the model can be run in a repeatable way with different starting assumptions. It must also be possible to audit the system to verify the data inputs and system configuration.

2. Organizational challenges

Multiple teams in the organization including actuarial, finance, risk, and IT all have a role to play in any internal model project. One major hurdle is the challenge of getting all these groups to agree on responsibilities and timelines.
This involves resolving issues around modeling decisions, reporting requirements, performance, and cost. It also requires determining the dependencies between the internal model and other systems and processes and deciding which team is responsible for delivering each of the required inputs. Finally all stakeholders must agree on an operating model to help ensure that reports are delivered in a timely manner.

3. Model architecture

Implementing a successful internal model requires a significant investment of budget, time and effort. When implementing an internal model it is helpful to think about the architecture as components in four major areas:

a) Data management
b) Risk modeling
c) Risk aggregation
d) Workflow, controls and audit

a) Data management

Data management is the process of collecting a consistent set of data required to run the internal model. However; in many organizations, the required data is found in many locations: existing databases, calculated by other systems, commingled with models, and in flat files and spreadsheets.

One common approach to manage the data is to define a data model for all the inputs and outputs from the internal model and given the amount of data, a data warehouse is often created to serve as the repository of all the data. The design of the data model and data warehouse should be extended to consider the source and format of each data element and incorporate the tools and processes to transform the data. Other considerations to evaluate are the need to re-run data from historical reporting periods (i.e., re-run the calculations from the end of last year), the need to run what-if analysis by changing model assumptions and inputs, and the need for controls around the data to track all updates and modifications.

Often the demands of the internal model requirements mean that the insurer ends up with a much better data story, including a centralized data warehouse, automated data collection, consistent data, secure data, data and model separation and a data archival process.

Furthermore, data elements are often either incomplete or redundant across the various sources and lack of data control and archiving make it difficult to rerun data from different periods.

b) Risk modeling

One of the key challenges in building an internal model is selecting the appropriate model for each risk type. There are basically three options for model choices: model the risk directly in the system, create a proxy model for the risk in the system, or model the risk outside the system and include it during the risk aggregation phase.

Depending on the firm and the risk type, different modeling approaches may be appropriate.

b1) Asset modeling

The standard approach to modeling assets is the direct approach. There are industry standard models for valuing most asset types, many of which are closed form equations that can be easily simulated across tens or hundreds of thousands of economic scenarios. In order to improve system performance, it is possible to group or bucket some asset types without significant loss of accuracy. For a small percentage of asset types, other modeling approaches may be applied. One consideration when using the direct approach is that the economic scenarios used to simulate the balance sheet must include all relevant risk factors. For assets, the relevant risk factors include interest rates, market indices, FX rates, volatilities, etc.

b2) Liability modeling

A main challenge of modeling liabilities is the sheer scale of modeling required due to the fact that most liability models are either stochastic or simulation based. As a result, running a liability model over tens or hundreds of thousands of economic scenarios has dramatic implication on performance and/or system hardware costs. As a consequence, there are multiple approaches for modeling liabilities for the purpose of an internal model, each with different tradeoffs.

- Use the direct approach and run nested stochastic simulation. This approach will be the most accurate. However it means running existing liability models through the economic scenarios, which is very compute-intensive, making it difficult to complete the simulation in an acceptable time window. Usually, this approach is only used for a small number of liabilities.
- Develop light weight liability models. In this option, an existing model is cut down so that it runs faster. The final model is still stochastic, but it might eliminate unnecessary calculations or make implying assumptions. As a result it runs in an acceptable time window.
- Use liability cash flows or values from existing systems and proxy methodology. For this option, which is often used for the life business, the existing liability models are run for a limited number of economic scenarios, such as 50, 500 or 1000. The cash flows or values are extracted for each scenario and an approximation technique is run to create a proxy model that reproduces the cash flows under each scenario. The "proxy model" is then used in the final simulation of the balance sheet.

  - Replicating portfolios –The main idea of a replicating portfolio is to find a portfolio of assets whose cash flows are equal to the cash flows of a target liability under a small scenario set. This is achieved by generating the cash flows for both a target liability and for a portfolio of assets under the small scenario set and running an optimization problem to find the portfolio weights that minimizes the difference between the target liability cash flows and the asset cash flows. The asset portfolio is then used as a proxy to represent the liability when simulating the balance sheet over the large economic scenario set. Because asset models are quite fast, the performance is improved.
  - Curve fitting –The main idea of curve fitting is similar to replicating portfolios; improve the performance by determining an equation for valuing the liability. Similar to replicating portfolios, the value of a target liability is calculated for a small number of scenarios. The next step is to specify an equation that determines the value of the target liability as a function of the risk factors and then running a regression to determine the coefficients of the equation. This step is repeated until an equation and coefficients are found that best matches the value of the liability across the small scenario set. Finally the equation is used as a proxy model for the liability when simulating the balance sheet over the large economic scenario set.
- Use empirical loss distributions from existing systems. This approach is typically used for modeling insurance risks and property and casualty risks. A significant number of scenarios are run outside the system to calculate a loss distribution for the specific risk. The loss distribution is incorporated into the internal model during the risk aggregation stage.

c) Aggregating risk

A key challenge in building an internal model is to combine or aggregate different loss distributions into a single distribution that can be used to measure economic or regulatory capital. The individual loss distributions can be calculated by the internal model or can be calculated in other external systems. Often, market and credit risk distribution are calculated directly in the internal model while insurance and other risk distributions are calculated outside the model and included by aggregation. Examples of insurance and other risks are:

- Operational risk
- Life risk (for example, mortality risk or lapse risk)
- Non-life risk (for example, catastrophic risk or premium risk)
- Health risk

The Copula approach is the most popular method for aggregating different types of risk into a single distribution that can be used to calculate capital. The random variables included in the Copula typically include the risk factors used by the valuation models included in the internal model as well as risk drivers for distributions calculated outside the system. The risk drivers are simply Uniform[0,1] random variables that are used to extract loss values from the externally calculated distributions using an inverse function. For many risk factors, time series data can be used to calculate the correlations, but for some risk factors and the risk drivers, expert judgment must be used to determine the initial correlations.

The Copula is then used to generate a consistent set of economic scenarios where each individual scenario contains a correlated set of risk factors and risk drivers. Because the risk factors on the economic scenarios are correlated, the individual losses are additive and it is possible to calculate an integrated loss distribution across all the risk types. It is common to use 100,000 or more scenarios generated with the Copula approach to determine the firm wide integrated loss distribution. The fact that expert judgment plays such an important role in determining the correlations and cross correlations of many risk factors and risk drivers, it is common practice to set these to zero as a way to eliminate diversification effects for these risk factors and risk drivers. Stressing the correlations and recalculating the capital is also recommended.

d) Establishing workflow and managing the reporting cycle

Establishing workflow and governance is not without challenge, but these challenges can be overcome with dedication, organizational buy-in and persistence so that the insurer can reap the benefits of internal models. Insurers need to be able to run capital models in a repeatable manner and in a short time frame when the period closes, for example, a target may be 10 - 15 days after the close of the quarter. In addition, when models are used beyond regulatory reporting to make business decisions, there might be requests to rerun these models with slightly different assumptions. Managing the process of running and rerunning the capital calculations in a reliable and repeatable manner requires establishing workflow and governance around the execution of the model.

Workflow and governance involves managing the multiple aspects of the process. Key areas are:

- Data management, which includes ensuring that the correct data is loaded and it is valid, approved and complete
- User permissions, which includes controlling the operations a user can perform, controlling the data a user can access and ensuring that multiple user actions cannot collide
- Audit capabilities, which includes reviewing the data used to generate the reports and reviewing the user actions used to create the reports
- Report management, which includes producing reports on time and ensuring that they are accurate

It is easy to underestimate the time and effort required to create a strong workflow and governance around model execution. It is often considered a lower priority to the analytical calculations, but will have big impact on the system. Allowing the model to be easily rerun with changes to the assumptions and inputs will provide management with the ability to assess many management decisions and answer key questions from regulators and auditors. What if business for a particular product doubles? What if we stop selling a product? What inputs went into the calculation? Who signed off on the inputs? What inputs have the biggest effect on the capital?

By allowing different users to access different data elements, it is possible to distribute the workload across many users which can shorten the time required to run the model (for more detail see IBM paper: *Workflow, Governance and Reporting: Insights into addressing the challenges of Solvency II Pillars 2 and 3 from leading European insurers*.)[1]

Internal modeling has its advantages

The main benefits of internal models to calculate capital include:

- **Capital savings.** Because of all the scenarios that are run and the aggregation of risk, it is possible for insurers to relax conservative assumptions in existing models, which commonly leads to a reduction in capital of 20 - 40 percent.
- **Capital allocation.** With internal modeling, it is possible to allocate capital down the company hierarchy to business units, lines of business, products and more – so that it is possible for more people in the organization to look at things on a risk-adjusted basis. This is a major benefit since decision makers can get an even better understanding of what is really going on, for example where capital is being consumed.
- **Risk transparency.** Internal modeling promotes a common understanding of the risks facing an insurance organization, provides forward projections of risk and enables the ability to run sensitivity and stress test analyses. As a result, it is possible to run what-if scenarios for events such as interest rate increases, a country defaulting on its debt and more. Typically, this capability either does not exist with legacy models or they are too slow for timely decision making.
- **Risk-based decision making**. Regulatory reporting is the primary goal, but once the system is in place senior management often start asking questions that they did not ask beforehand. This creates demand for new insights to help senior management weigh the risks against the benefits of adding a new product, selling a business unit or estimating a risk exposure incorrectly.

Conclusion

The key components of internal capital modeling include data management, model and systems selection, workflow, controls and audit. Modeling all the risk types on the balance sheet typically requires different techniques, but the end result is a model that integrates assets and liabilities, includes a shared risk and compliance framework and aggregates risks. This makes an internal model an ideal tool for risk management. When internal modeling is used for risk management, the benefits include capital savings, capital allocation, risk transparency and risk-based decision making.

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1. IBM Paper: Workflow, Governance and Reporting: Insights into addressing the challenges of Solvency II Pillars 2 and 3 from leading European insurers.

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