OLIVER WYMAN

Financial Services

LESSONS LEARNED FROM INTERNAL MODEL DEVELOPMENT

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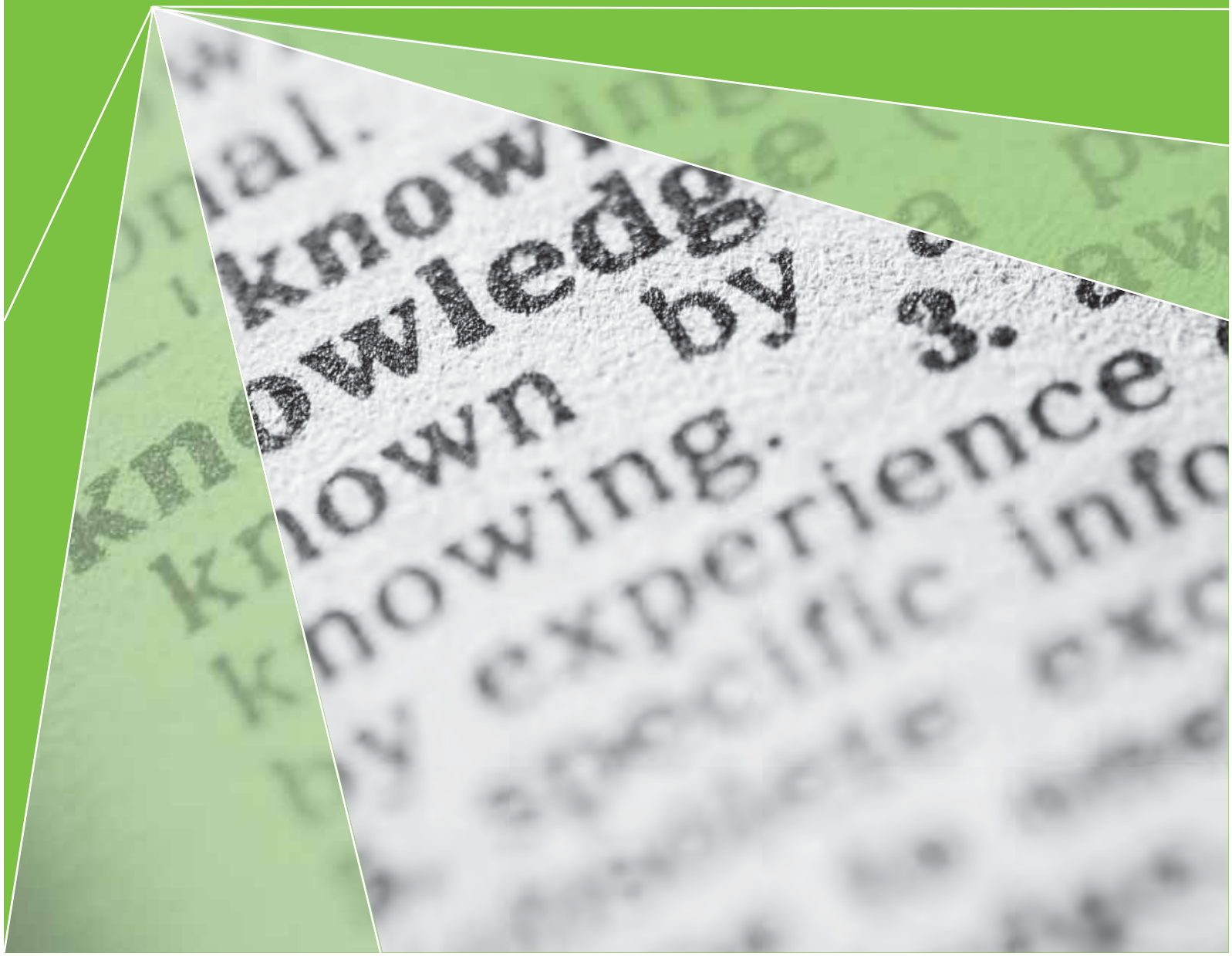
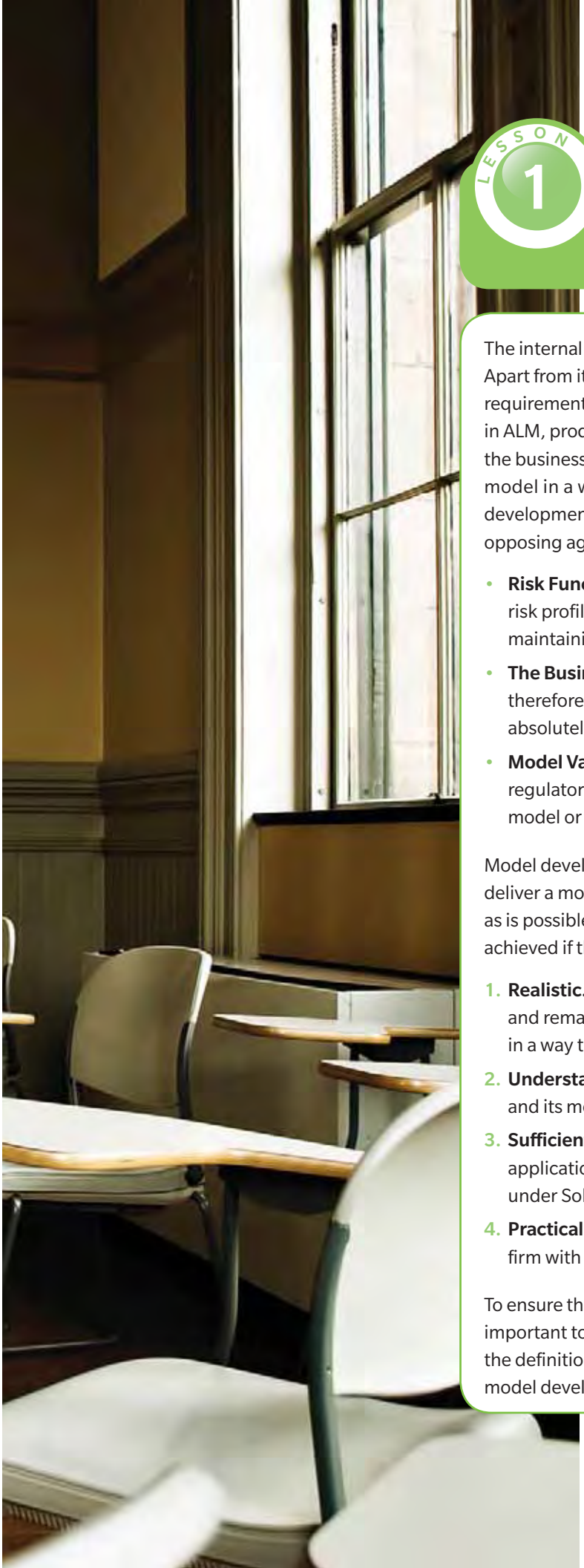


MARSH & McLENNAN COMPANIES

Oliver Wyman has worked with a number of major insurers in developing aspects of their internal models including model design, detailed build, documentation, management education, model review, capital optimisation, programme review and cost-cutting. During this time we have encountered many issues and learned valuable lessons. In this article we focus on the aspects related to designing and optimising internal models used to address the Pillar 1 quantitative requirements of Solvency II and to determine the Solvency Capital Requirement (SCR). We give a summary of the key issues and how they can be addressed over the course of the coming 6-18 months before the models go live.



LESSON 1

IT'S A BALANCING ACT

The internal model will be used in many areas of the business. Apart from its core purpose of determining the regulatory capital requirements, the model output will also be used to make decisions in ALM, product design, pricing, compensation or other parts of the business. Naturally, all involved parties will try to shape the model in a way that suits them best. This opens up the model development process to a large group of stakeholders, often with opposing agendas:

- **Risk Functions:** Is interested in a model that reflects the risk profile of the business as accurately as possible, while maintaining usability of the model
- **The Business:** Is interested in remaining competitive and therefore does not want higher capital requirements than absolutely necessary
- **Model Validation Teams:** Want to ensure compliance with regulatory requirements. If in doubt, they will reject (parts of) the model or demand more conservatism to be on the safe side.

Model developers are caught in the middle. They are expected to deliver a model (on time) that (i) addresses all internal views as far as is possible and that (ii) is approved by the regulators. This can be achieved if the model is:

1. **Realistic.** The model must reflect the risk profile of the business, and remain in line with the firm's view on how risky the world is in a way that is justifiable to the public and the regulator
2. **Understandable.** Those that use the model have to buy into it and its methodology to make the model a credible steering tool
3. **Sufficient.** The model needs to facilitate the business applications that are needed to steer and operate the business under Solvency II
4. **Practical.** The model must be operated and maintained by the firm with the current or future know-how and man-power.

To ensure the internal model fulfils all the criteria above, it is important to get the development process right, starting with the definition of the team that is tasked with (particular parts of) model development.

LESSON 2 — INVOLVE THE RIGHT PEOPLE

To facilitate an efficient process the company should ensure that all stakeholders and relevant experts are included early on. This is important for all aspects of the model development process, starting from the initial scoping phase all the way to the final model review and capital optimisation phase, before the model goes live. We have seen many cases in which stakeholders were brought into the development process too late, and where they challenged modelling decisions that had already been made, slowing down the process considerably.

To avoid this, every part of the model development process should start with identifying the right team structure and working style of the model development team. This will equip the team with the right firepower to kick-off their work. When required, experts should be consulted to ensure that modelling decisions are able to withstand internal or external challenge. Regular feedback loops with senior management should be planned in order to avoid nasty surprises late in the process or to seek guidance at difficult times.

In companies where internal model development has been driven predominantly by Risk or Actuarial, with limited interaction with other parts of the business, now is the time to bring all internal modelstakeholders onboard, to get their buy-in well before the model goes live.

LESSON 3 — START BY DEFINING THE TARGET END-DATE

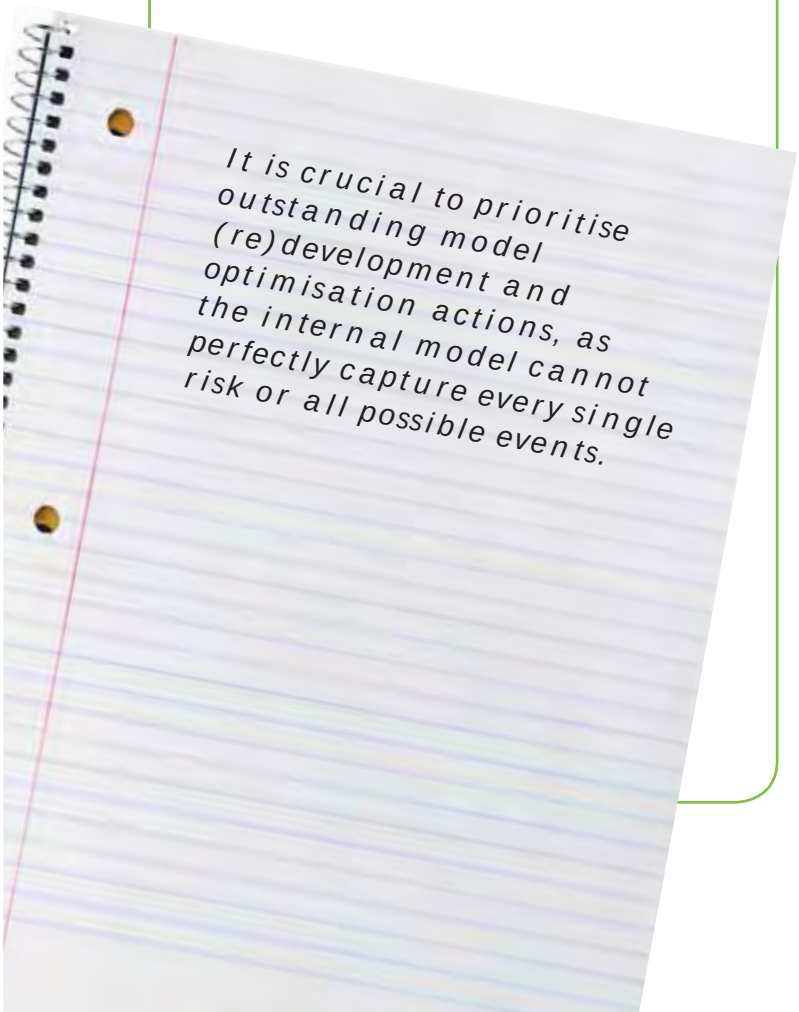
Companies can choose between a large number of software vendors, model set-ups and methodologies. But foresight is needed to avoid potential dead ends later on, for example:

- The Economic Scenario Generator (ESG) of the vendor may not feature the desired model for a certain risk type, in which case trade-offs are required in the calibration phase, often resulting in additional conservatism
- A model based on instantaneous shocks reduces run time, but it also makes it difficult to credibly incorporate certain management actions, such as the impact of dynamic hedging
- Certain business applications may look at different percentiles than the 1-in-200 percentile. In such cases it will be important also to look at other percentiles when calibrating the model.

To avoid show stoppers or unnecessary loops later on in the process the team should first strive to understand the different views and needs of management and model users with regard to (particular parts of) the internal model and future business applications. From this they should derive a set of assessment criteria that can be used to compare alternative model frameworks and methodologies. This will facilitate an informed decision on the final model, where all stakeholders are aware of the associated advantages and limitations of the future model.

LESSON 4 MAKE SURE EVERYONE IS ON THE SAME PAGE

A large number of different model components are developed as part of an internal model. We have seen many examples of confusion around scope of individual model components, leading to inefficiency in the model sign-off and validation processes. It is important to ensure that there is a clear picture of how each individual component of the internal model fits together, and what is covered in each model component.



LESSON 5 DON'T MISS THE WOOD FOR THE TREES

It is very easy for technically-minded model developers to get excited about model components, risk types and issues that are technically challenging, but immaterial in the big picture. It is crucial to prioritise (outstanding) model (re)development and optimisation actions, as the internal model cannot perfectly capture every single risk or all possible events.

Important items and significant risks should be modelled with a high degree of precision. Less material items or risks can be modelled more simplistically. Metrics that could be considered as a basis for this prioritisation include:

- Output from the existing version of the internal model if already available, such as technical provisions, stand-alone Solvency Capital Requirement (SCR) for a given risk type and combined SCR for a group of risk types
- Market value of investments in asset classes that are sensitive to a given risk type
- Gross written premium (GWP) that is sensitive to a given risk type
- Standard formula SCR with respect to a given risk type
- Risk measures from existing business applications, e.g. Greeks, observed losses.

The next steps for the model development team are then to develop the individual modules of the internal model, starting with a definition of principles to guide the modelling work.

LESSON 6 — DEFINE AND STICK TO A SET OF PRINCIPLES

A common challenge that model developers face is the large number and diversity of the risk types to capture and the different formats in which historic data is available. Model developers could be tempted to investigate the best possible methodology for each single model component based on the data that is available. However, there is the risk that model developers start "boiling the ocean" without guidelines on how to structure and approach a problem. Furthermore, this could result in a model that is internally inconsistent, or in a model that is difficult to understand and therefore likely to be rejected by the model users.

To mitigate these risks the model development team should agree upfront on a list of high-level modelling and calibration principles that (i) provide guidance and ensure consistency across the model components and risk types and that (ii) leave sufficient space to adapt the methodology of a given model component to the individual risk characteristics and data available. Principles that could be agreed on are:

- Rules determining the trade-off between model complexity and model granularity/accuracy
- Rules for determining data sources
- Rules for determining length of time series and data frequency
- Sets of distributions that are tested in the calibration phase
- Sets of statistical tests that are used in the analyses.

LESSON 7 — MAKE SURE THE DATA IS ROBUST

In our experience the choice of data is one of the most contested items in model development. Data is particularly easy to challenge (both internally and externally) and therefore typically one of the first points that model users, model validation teams or the regulators criticise if results do not look as expected or as desired.

Therefore, model developers have to ensure that the data they use is appropriate for the model component being (re)developed in order to minimise the risk of model rejection.

- **Choice of data source:** Is this a credible data provider and are there any issues with how the data is collected or generated by the provider?
- **Choice of index:** Does the index composition reflect the risk on the balance sheet that we want to model?
- **Length of time series:** Are there any structural breaks in the historic data that make (parts of) the data irrelevant for a particular analysis?
- **Comparison with alternative data sets:** Are there any inconsistencies with alternative, but similarly credible, data sets and how can they be explained?

Once the best source of data has been chosen, model developers parameterise the given module of the internal model. Lessons #8, #9 and #10 are particularly important for the calibration and parameterisation process.

LESSON 8 STRIKE A BALANCE BETWEEN SIMPLICITY AND FIT

Modelling all risks and all items of the balance sheet explicitly and with full accuracy is not always the best thing to do. This can result in spurious accuracy on the one hand and a rejection by the model users on the other. For example:

Example 1: When deciding on the granularity of a certain risk module, model developers should think about whether a given asset class warrants a separate set of shocks, or whether it can be subsumed within other asset classes; in particular as data quality and availability decreases with increasing granularity, thereby reducing the explanatory power of associated analyses.

Example 2: There are a huge number of possible distributions to choose from to calibrate a 1-in-200 event based on available data. It is very tempting to choose an exotic distribution that fits existing data well. However, in most cases available data is not sufficiently robust to parameterise a 1-in-200 event, no matter which distribution is used. Model developers should not fool themselves by choosing exotic distributions that happen to fit the existing data well, but are not related to the economic intuition around a certain risk type.

Ultimately, an internal model needs to pass the use test. Hence, it is important to use a methodology and distributional assumptions that are understandable for business users. It is important to capture key characteristics of observed risk behaviour, without making things too complicated.

LESSON 9 MAKE SURE THE CALIBRATION IS ROBUST ACROSS A SET OF POSSIBLE APPROACHES

As with data, it is easy to challenge parameter estimates by criticising the statistical methods used, if the model output does not look as desired by a given group of stakeholders. It is therefore important to ensure robustness of the calibration results. Calibration results could be tested against the following:

- Results derived based on alternative, but similarly credible, estimation methods (e.g., a different goodness-of-fit test or a different test for mean reversion)
- Results based on alternative, but similarly credible data sets (e.g. an index on the same asset class from a different data provider)
- Results based on adjusted time series (e.g. mid-month instead of end-of-month data or data covering only the last X years).

LESSON 10

LEAVE ROOM FOR EXPERT JUDGEMENT (WITHIN REASON)

The best statistical algorithm does not necessarily yield results that are meaningful from an economic perspective. This is true in particular for the calibration of the internal model, where the aim is to estimate 1-in-200, one-year out tail events, based on data that typically dates back no longer than a few years.

All calibration results should therefore be sanity checked by experts. For this process to be meaningful, some ability to override makes sense. This should happen based on a set of rules that are determined before reviewing calibration results to avoid "cherry picking". If deciding on these questions is not straight forward, model developers should collect evidence to allow experts to make such assessments. Rules could be determined around the following questions:

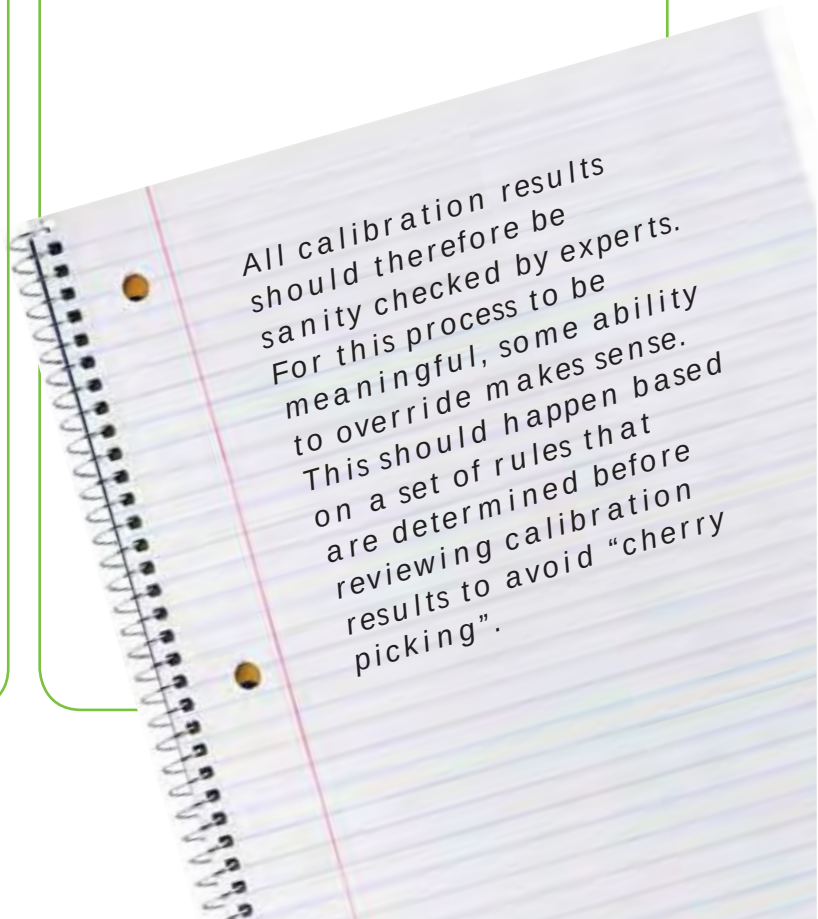
- How severe have past years been with respect to a given risk type, e.g. has 2008 been a 1-in-25, a 1-in-50 or a 1-in-100 event for this particular risk type?
- How does a given risk type compare to other risks? Do we expect more or less volatility compared to other risks?
- How do we compare against the standard formula? Do we want to be more conservative or less conservative in a particular module?

LESSON 11

MAKE SURE YOUR CAPITAL REQUIREMENTS ARE NOT TOO CONSERVATIVE WHERE IT MATTERS

In cases of uncertainty or technical limitations model developers and model validation teams often err on the side of conservatism. This can result in capital requirements that are too high, thereby negatively affecting the competitiveness of the company.

In particular for large risks it is important to be precise rather than conservative to avoid capital requirements that are too high. Furthermore, it is important tounderstand the potential levers for reducing capital requirements, such as the exact specification and modelling of management actions, the countercyclical/matching premium or the loss absorbing capacity of deferred tax. Depending on the nature of the model, capital requirements can often be reduced by 5-10% with limited effort, without negatively affecting the appropriateness of the model.



BE AWARE OF THE LIMITATIONS OF YOUR MODEL

A general limitation of all internal models is that model development starts with the historical data observed. As such, the model may not cover all possible adverse future outcomes and it may not be appropriate in a different (macro-)economic environment.

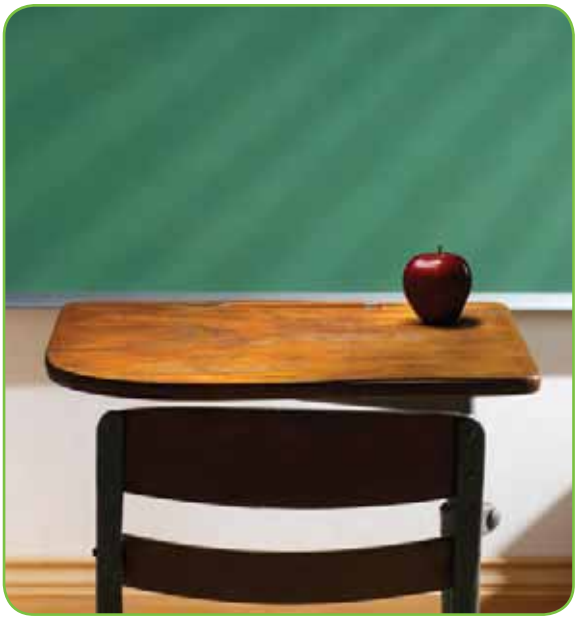
It is important to clearly identify the limitations of the model and to define trigger points at which recalibration or redevelopment is required. Furthermore, it is important to complement the model with a deterministic stress-testing component as part of Pillar 2 risk management to check capital coverage for specific adverse scenarios that are not covered in the stochastic calculations (such as a break-down of the Eurozone). Based on this firms can then develop and test realistic contingency plans or identify strategic opportunities.

CONCLUSION

There is no "cookie cutter' approach to internal model development - firm characteristics and stakeholder requirements are an important driver in internal models

To succeed in this exercise it is important to follow an interactive, principle driven process in which the target end state and interim steps are clearly defined from the start. Nonetheless, trade-offs will have to be made along the way for numerous reasons. Firms should ensure that the implications of these trade-offs are well known and understood, and that they do not imply too conservative capital requirements.

We at Oliver Wyman have gained a wealth of experience in addressing these challenges, in numerous internal model development projects, from model scoping all the way to model implementation, model audit and capital optimisation.



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