KPMG

Model risk management

A sound practice for meeting current challenges

1. Background and Motivation

The global financial crisis showed that controls and governance frameworks associated with valuation, risk and other operating models can be fragmented, incomplete or unreliable. Therefore, regulators have increased scrutiny to ensure that financial institutions maintain effective and sustainable model risk management programmes. In this context, models are not only meant to be valuation and risk models, but also other models used for business decision or financial reporting.

According to CRD IV, Article 85, all institutions need to implement policies and processes to evaluate and manage the exposure to model risk. In addition, there are specific requirements for valuation models (e.g. Pillar 2, PruVal) and further requirements for internal risk models (e.g. IRBA, IMM, IMA, AMA).

Definition of model risk

There are different ways of defining model risk. A regulatory definition has been provided in CRD IV, Article 3.1.11, which defines model risk as the potential loss an institution may incur as a consequence of decisions that could be principally based on the output of internal models, as a result of errors in the development, implementation or use of such models.

Thus model risk affects many business operations within a bank and can have negative consequences, such as financial losses due to inaccurate product pricing, underestimation of market, credit or other risks leading to high unexpected losses in the future, or liquidity shortages resulting from inadequate modelling assumptions in the liquidity gap analysis.

To operationalize model risk management, the very general CRD definition needs to be further specified. Banks might (1) specify the sources of model risk and (2) describe the possible consequences. A sample of such specification could be:

Model risk sources:

- Flaws in model design and/or implementation
- Incorrect use of the models, misinterpretation of model outputs
- Flaws in model input data

Consequences of model risk:

- Incorrect business decisions leading to losses (e.g. mispricing of products, false lending decisions, mistakes in risk exposure limitation)
- Misstatements in financial statements (e.g. incorrect asset valuation)
- Misstatement in capital requirements calculation (RWA or economic capital) – over-/underestimation of capital requirements, misallocation of economic capital
- Misstatement of the bank's liquidity position

The relationship of model risk and operational risk is still being discussed within the industry. Some banks (and to some extent regulators as well) consider model risk as a specific type of operational risk. Larger and more advanced banks consider model risk as a distinct risk category.

A comprehensive model risk management approach

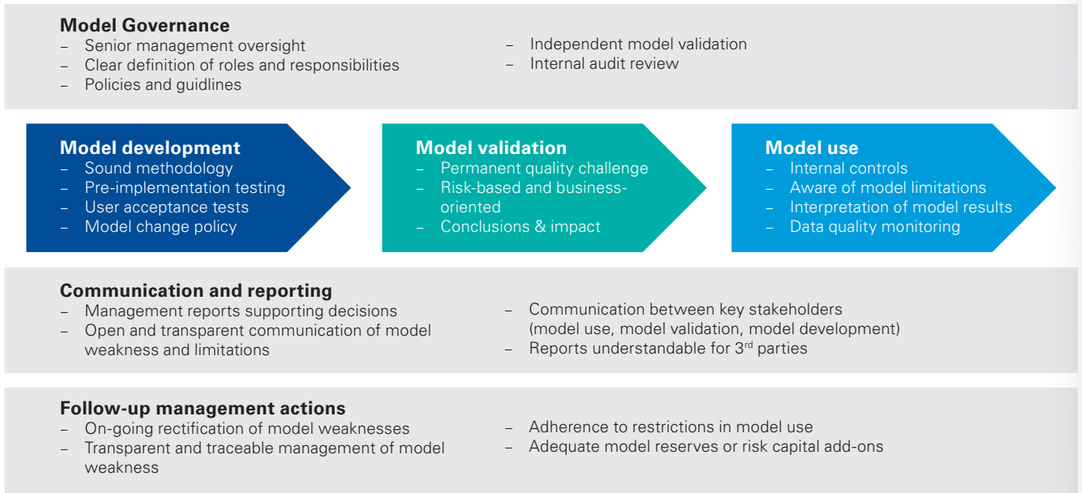
Solid model risk management should not only be incumbent upon model validation, but rather should represent a comprehensive approach incorporating all model stakeholders. These stakeholders may include model developers, model users as well as a model validation team. Such an approach can go beyond enhancing transparency in model issues by also enhancing the effectiveness of detecting model issues. Furthermore, a sound model risk management framework is required by regulators and also, as mentioned above, helps prevent financial losses.

2. General approach of model risk management

In this chapter we outline how a sound model risk management should generally be established within the typical lifecycle of a model (model development, model validation, model use). We also look at some organizational issues like model governance, reporting and follow-up management actions.

A model risk management framework should consist of the following components:

Model risk management framework



Model governance

Usually, model risk management is carried out across different departments within a bank. One key question here is how model risk governance is organized: centrally (one governance for all model types) or locally (different governances for different model types). Arguments for centralized governance include consistency in the applied standards for model risk management (model development, approval, validation, documentation etc.), higher transparency of model risk management processes, comparability of model risks and model weaknesses, unified reporting etc. In centralized governance, a chief model risk officer or a model risk committee established at mid-management level involving all relevant model stakeholders might be responsible for the overall model risk management.

On the other hand, there are also arguments for "local" model risk management. For example, models are heterogeneous, so that one unified framework does not adequately apply to all of them. Furthermore, decentralized governance might fit into the existing organizational structure better, as different model types are usually applied in different departments (e.g. valuation models in the finance division, rating models in a credit risk function).

No matter if the governance is central or local, there should be a model risk policy regulating the definition of model risk, scope of model risk management, roles and responsibilities, model inventory, model approval and change process, model validation and management of model weaknesses. Furthermore, it is important to involve senior management. A management reporting process should take place at least quarterly to ensure sufficient management oversight, which is also required by regulators. It is also import to involve internal auditing as a third line of defence, in order to assess the overall effectiveness of the model risk management framework

Moreover, each model should be assigned to a model owner. The owner is typically the (head of an) organizational unit, i.e. the main user of the model. If one model is used by several organizational units, there might be two or more owners, each responsible for its particular area of use. Responsibilities of a model owner may include initiation of new model development/purchase due to changes in business or regulation, initiation of model approval process, ensuring that model use is compliant with model limitations, maintaining model inventory, etc. In short, the model owner acts as the first point of contact when it comes to model issues.

Model development

Model development represents the very beginning of the model lifecycle and depends fundamentally on the quality and know-how of the model development team. The model development team should be familiar with best practice models and have a good understanding of the bank's business and the market environment. The model choice should always follow a structured process in which different alternative models are considered. The process of choosing or rejecting a model should not be driven by personal preferences of the model developers, but rather by objective criteria and a structured assessment of the model suitability. If a model is purchased from third party vendors, it is imperative that bank staff have a deep understanding of the model and are aware of its weaknesses and restrictions in use.

When it comes to the development of a model, not only the process of designing the model is important, but also the documentation of key decisions surrounding the model in a form that is understandable and auditable for third parties. Moreover, the bank should maintain a model change policy with clear severity assessment of the model change.

Finally, in order to ensure an accurate and smooth implementation of the model, banks need to have rigorous pre-implementation testing procedures and comprehensive user acceptance tests in place. This should be supported by a transparent versioning process that enables alignment of model documentation with the actual implementation.

Model validation

After a model has been implemented, banks should have initial and regular (e.g. annual) model validation procedures in place to ensure that the model is conceptually sound and adequately captures all material risks, particularly with regard to potential changes in market practice (e.g. change to OIS discounting) or market environment since implementation or since the last review. The frequency of model validation commonly depends on model risk classification (low/medium/high). Model validation should be performed by staff that are independent from the model development team. All validation tests and validation results should be reviewed and assessed independently. Furthermore, the principle of "effective challenge" of the models is the ultimate indicator of an independent validation. In this context, effective challenge means that the model is subject to such a critical analysis that potential model weaknesses are likely to be detected. All important model aspects such as simplifying assumptions, methodology "shortcuts" and input data have to be challenged critically. Unfortunately, in our practical experience, we have seen numerous validation reports that look more like a justification of the model's correctness than a critical review.

Regarding model validation methods, a risk-oriented validation and a structured self-assessment process are two efficient ways to identify model weaknesses. In a risk-oriented validation, the important portfolios are identified first. All subsequent validation tests are only performed for those portfolios. In this context it is crucial to interpret the test results and draw clear conclusions supporting business decisions.

Too many validation tests without conclusions for model use or suggestions of model improvement do not help management to understand the model better, but only raise questions about the purpose of the tests.

Furthermore, there should be an on-going monitoring process that incorporates model output analyses, including the comparison of model outputs, to corresponding actual outputs, assessment of accuracy of estimates or forecasts, use of qualitative and quantitative testing etc.

Lastly, the scope of model validation, i.e. validation frequency, validation tests and acceptance criteria should be defined and documented in a policy or guideline. Also, key model stakeholders – including the business units – should be involved in the validation process to promote transparency and increase quality of the model validation. Our experience shows that validations are sometimes still performed by an isolated team of technical experts only.

Model use

Equally important to the properly developed and adequately validated models is their appropriate usage. All model users have to be aware of model limitations and restrictions in use.

Our practical experience shows that data quality controls of model inputs can sometimes be insufficient, or that model users are not always aware of the model weaknesses and limitations. Therefore, they tend to use the model beyond its boundaries, i.e. either for purposes it was not intended or validated, or they continue to use the original model even when market conditions have changed and the model performance has deteriorated.

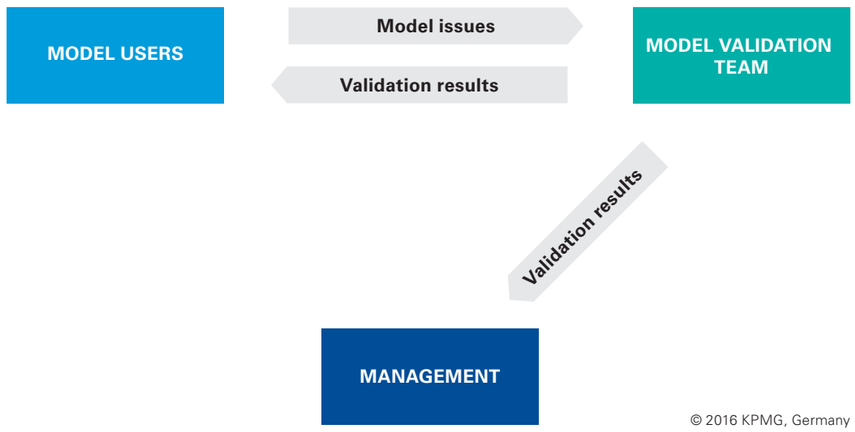
In general, there should be regular monitoring procedures in place, such as quality monitoring of the input data or the numerical stability of the model. These procedures should regularly challenge the model quality, not only when the model produces adverse results (e.g. a limit breach). Furthermore, model users should be well aware of model limitations and weaknesses and be able to interpret the model outputs within the context of these restrictions.

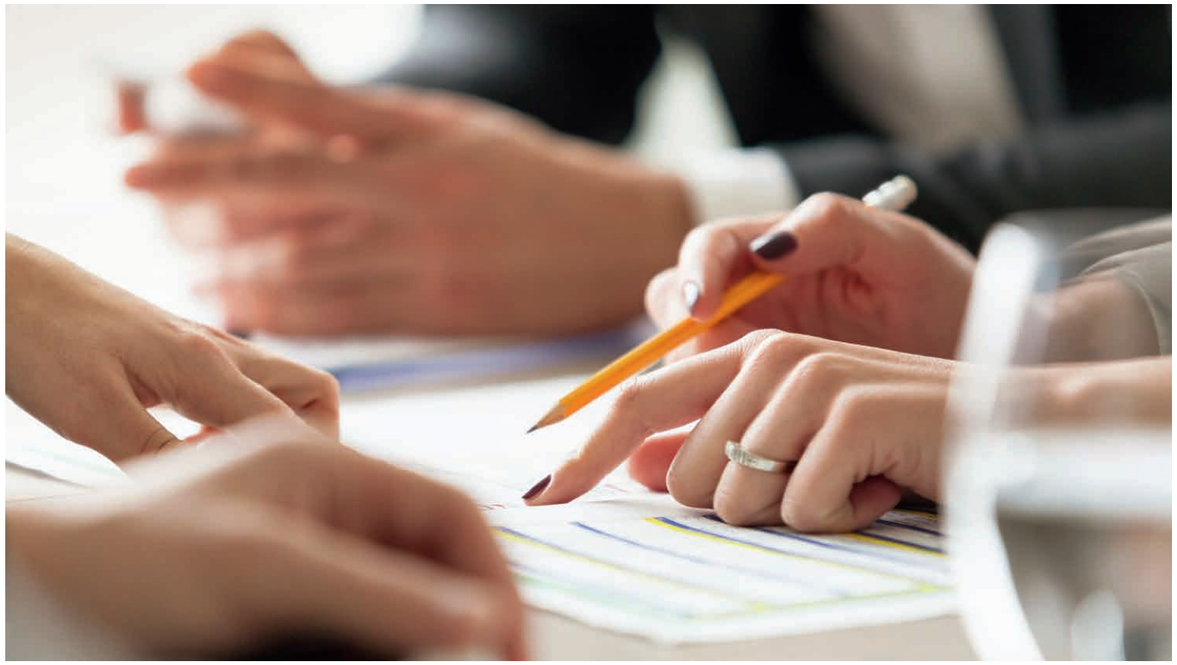
Communication and reporting

Regarding communication and reporting, the flow of information in two directions needs to be taken into account:

1. communication of known issues from model users to the model validation team
2. communication of validation results from the model validation team to model users and management

Communication and reporting





The first direction of communication is important for an effective validation process, as model issues like weaknesses and limitations are often known to model users or other stakeholders (i.e. model development), but in most cases they are not transparent to all relevant stakeholders, and especially not to the model validation team. This leads to an inefficient and ineffective validation process. One way to collect all model issues in a structured way is the "self-assessment process", as mentioned in the section "model validation".

The second direction of communication is important for a proper and prudent use of models, when validation results, in particular model weaknesses, restrictions in uses and factors to be considered in the interpretation of model outputs, are made transparent to model users. Moreover, the validation results should also be communicated to management shortly after model issues are detected. In this context, the manner in which model issues are presented to management is crucial. Deficiencies experienced here are e.g. that the validation report is overloaded with statistical tests, contains many formulas and is not understandable for non-technical experts. Furthermore, we have also observed that some model validation reports do not contain an assessment of the model appropriateness, clear conclusions or recommendations for corrective action. In this case, the validation report does not support management decisions or follow-up actions.

Ideally, the validation report should be composed in "management language", i.e. language that is understandable for senior management and third parties. It should present the model weaknesses and limitations in a transparent way, including materiality assessment as well as recommendations for rectification.

Follow-up management actions

Shortly after weaknesses, limitations and findings of the model validation have been presented to the senior management, a risk mitigation plan should be defined, which lays out short-term actions such as restrictions in model use, model reserves, risk capital add-ons etc. and long-term actions such as model weakness rectification, alternative quantification etc. Model reserves should be calculated by quantifying model risk using quantitative or qualitative measures on a model-specific and aggregate level. Qualitative measures are usually experts' estimates regarding model attributes such as severity of model weaknesses, number of model validations completed etc. Furthermore, when quantifying model risk, a risk appetite limit should be established to limit the model risk that the bank is ready to take.

In order to enable a transparent and traceable management of model weaknesses, it is crucial to regularly maintain a list of the model weaknesses already rectified and those still remaining, including materiality assessment and clear priorities. Equally important, model users should follow the decisions of the senior management on restrictions in model use.

3. KPMG solution – real world case studies

The KPMG solution for model risk management is presented in the form of sample case studies that are based on KPMG project experiences from German and international financial institutions.

CASE 1:
Principles of model governance, establishment of model risk committee

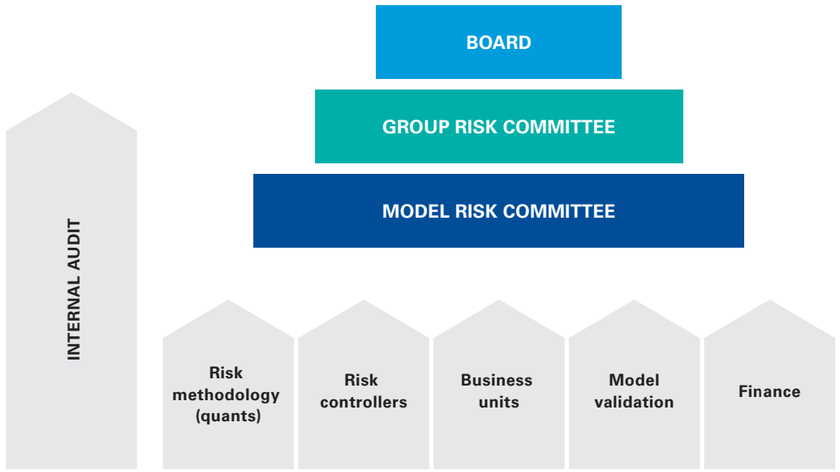
RESULT:
- Effective senior management oversight
- Cross-functional communication
- Involvement of key stakeholders

As stated before, regulators appreciate the centralized governance of model risk activities through the establishment of an interdepartmental model risk committee at mid-management level. The model risk committee serves as the highest instance of quality assurance, and its members meet regularly to discuss noticeable issues, interpret them in a consistent way, approve model risk documents and define measures for model weaknesses.

Furthermore, not only mid-management, but also senior management is regularly involved in the model risk management process. Involvement of the latter is achieved by regular reporting, for example on a quarterly basis. The report is approved in the model risk committee and contains the most relevant results, including clear conclusions and measures adopted.

Our KPMG solution of sound model governance is illustrated in the following figure:

Model governance

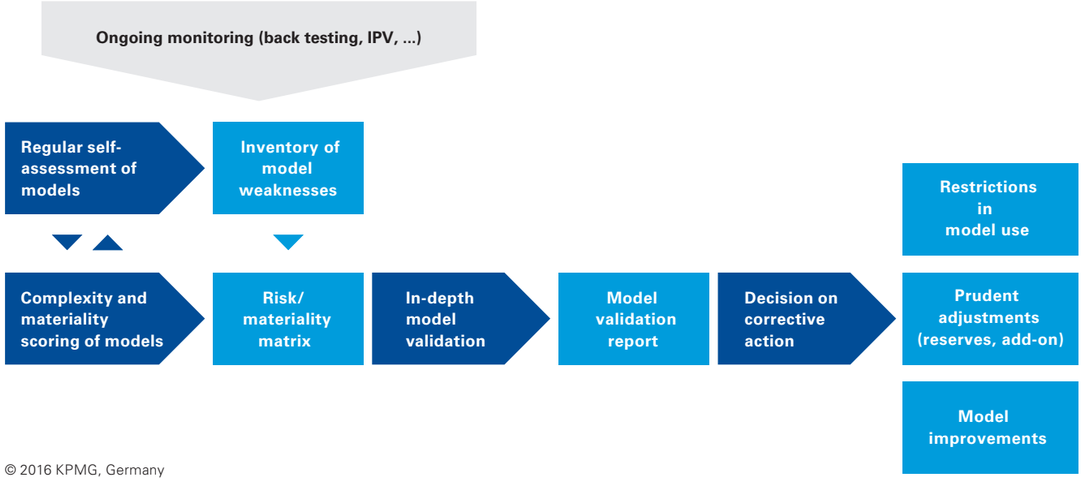


CASE 2:
Comprehensive model validation process

RESULT:
- End-to-end structured model validation process
- Model validation supporting management decisions

A comprehensive model validation process is illustrated in the following figure and described in detail in the case studies 4–7.

Model validation process



With help of a regular self-assessment of models (case 4), a model weakness inventory is carried out. Together with a complexity and materiality scoring of portfolios, a risk/materiality matrix is defined that enables the identification of portfolios for subsequent in-depth validation (case 5). All relevant model issues and validation results are then described in a validation report (case 7), which is presented in the model risk committee. In this committee, all model stakeholders come to decisions on corrective actions for model weaknesses. A weakness management process subsequently takes place, with definition of follow-up actions such as restrictions in model use or prudent adjustments (case 6).

CASE 3:
Introduction of a model inventory

RESULT:
- Comprehensive overview of all models in use as a central tool for model risk management

Model inventory serves as a central tool for model risk management and is updated at least once a year. It provides mid and senior management with a comprehensive overview of all models in use, including model owners, restrictions in use, required reserves/capital add-ons as well as key model weaknesses and their rectification status. It is important that not only internally developed models but also models purchased from third party vendors are taken into account.

A solid model inventory helps to ensure that all models are considered in the institution's internal risk steering. It also helps to give a clearer view of interdependencies between the models in use.

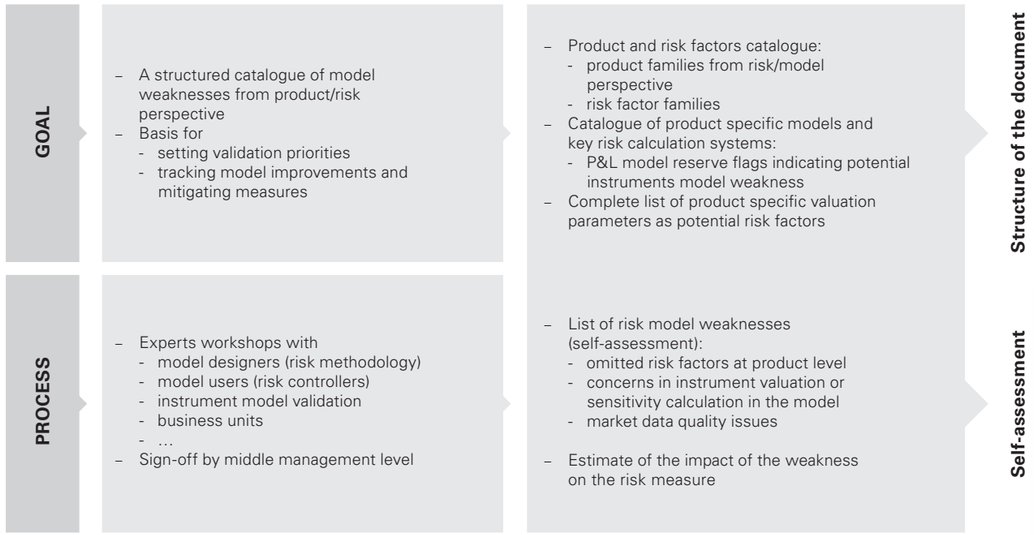
CASE 4:
Model risk self-assessment process

RESULT:
– Structured, cost efficient and documented process revealing about 90 % of key model weaknesses

The key weaknesses of a model are often already known in the institution, but in most cases they are not transparent to everyone, as they are typically not known to all stakeholders, not documented, not classified in terms of their severity or not followed up on. Thus, a well-documented and well-explained model weaknesses catalogue has clear advantages. For example, when considering a market risk model, it helps to detect discrepancies between valuation differences of instruments and their hedges. If the instrument itself is evaluated with volatility smile but its hedge is not, there will be a risk mismatch.

With help of a self-assessment process, the existing model weaknesses are documented in a well-structured way. This lays the basis for setting validation priorities, tracking model improvements and mitigating measures:

Self-assessment process



A structured self-assessment

– extends through all (material) portfolios
– extends through all (material) product types
– involves all model stakeholders e.g. by holding workshops

Results of the self-assessment are then discussed and approved in the model risk committee.

The self-assessment process is repeated regularly, i.e. annually, as well as on an adhoc basis. Triggers for adhoc self-assessment could be indications of model weaknesses from other validation activities, new product classes, changes of portfolio structure or dramatic developments in the market such as the basis spread explosion.

CASE 5:
Risk-based, business-driven model validation approach

RESULT:
– Fulfilment of model validation requirements with limited resources
– Bringing model validation closer to business

As limited expert resources are often an issue in financial institutions, it is important to handle existing resources in the most cost-efficient way. In order to achieve cost efficiency, model risk activities are prioritized and conducted for portfolios that are of higher importance, i.e. that contain strategically relevant positions with substantial position size, significant risk contribution or complex risk profiles.

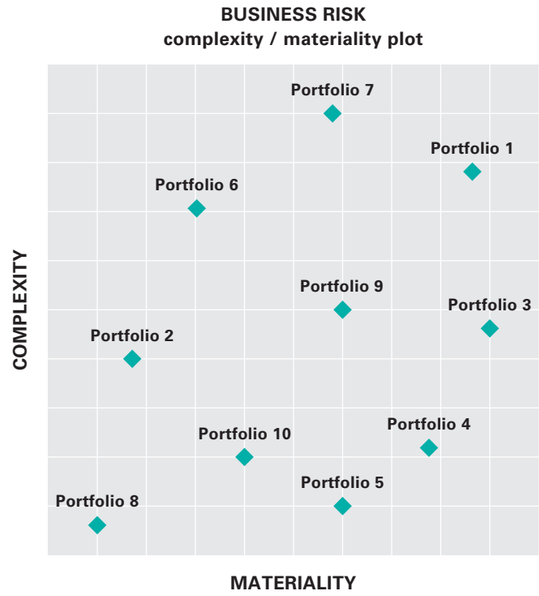
Portfolio scan

A risk-oriented prioritization of large P&L contribution, material positions and complex risk profiles helps to detect issues that really matter. A portfolio scan is a quick and cheap way to identify the most relevant portfolios for a detailed validation. It is a systematic approach that helps to identify risky areas needing further validation analysis and to prioritize validation activities based on the following dimensions:

– Qualitative assessment: What are the key risk drivers in the portfolio?
– Quantitative assessment: How much is the contribution to the bank's risk position?
– Complexity: How complex is the measurement of the risk in the portfolio?

The picture below contains an example of what the result of a portfolio scan looks like.

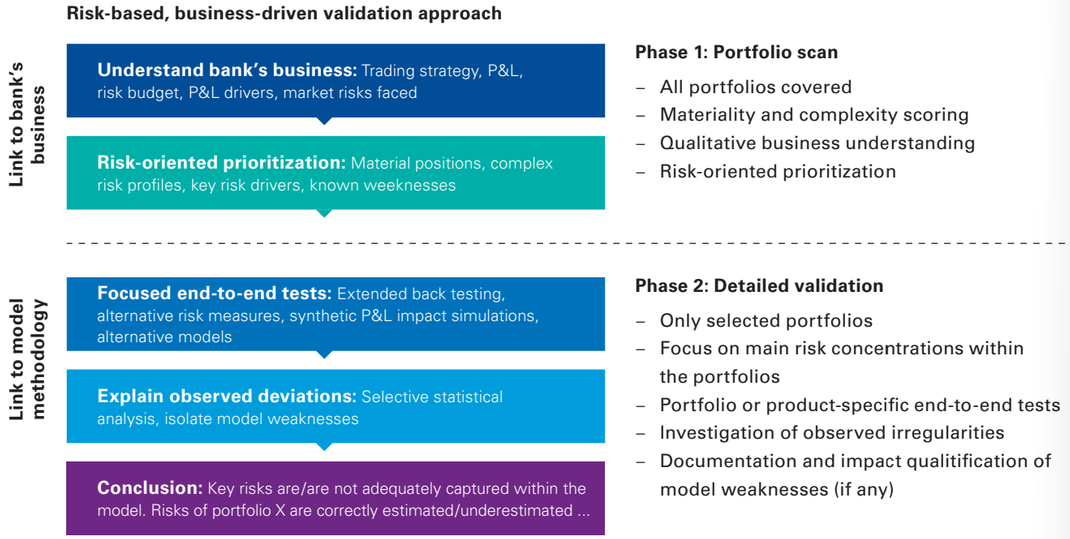
Example of a portfolio scan



Detailed validation

A detailed validation focuses on suitable end-to-end validation tests performed only for the most risky portfolios, selected within the portfolio scan. Its procedure is shown in the following figure.

Procedure of a risk-based, business-driven validation



Phase 1: Portfolio scan

- All portfolios covered
- Materiality and complexity scoring
- Qualitative business understanding
- Risk-oriented prioritization

Phase 2: Detailed validation

- Only selected portfolios
- Focus on main risk concentrations within the portfolios
- Portfolio or product-specific end-to-end tests
- Investigation of observed irregularities
- Documentation and impact qualitification of model weaknesses (if any)

Some examples of portfolio or product-specific end-to-end validation tests are:

- Extended back-testing: Perform back testing on lower portfolio levels, for a longer period of time, for different percentiles and based on dirty P&L in addition to clean P&L; split back testing result into risk drivers for a better risk and P&L analysis.
- Risk measure consistency tests: Investigate the relationship between stress tests and VaR as well as stressed VaR and VaR; compare different VaR percentiles.
- Consistency tests of VaR and P&L: Implement P&L explain; understand the relevant instrument pricing model weaknesses and their implication for VaR; verify consistency of P&L and VaR calculation processes and analyze inconsistencies.
- Model independent plausibility checks: Conduct alternative VaR calculation based on a different pricing model/sensitivity approximation etc.; compare alternative VaR methods, for example covariance matrix vs. historical simulation.
- Market data quality checks: Focus on top 10 risk factors relevant for the portfolio, plot covariance matrices based on risk market data shifts, check historic volatility and correlations and compare risk market data time series with front office's/IPV market data etc.

Further investigation is only necessary if discrepancies have been detected in the end-to-end validation tests. In this case, all possible causes of the discrepancies, for example model assumptions, system inconsistencies, market data quality etc., are isolated to decide whether they indicate a market risk model weakness. If no or only well explainable discrepancies have been observed, no further analysis needs to be performed.

It is obvious that the more complex a portfolio is, the more frequently it is validated. Generally, a risk-oriented prioritization is carried out at least once a year, indicating the five to ten most risky portfolios that deserve the most validation resources.

CASE 6:
Stepwise model weakness management

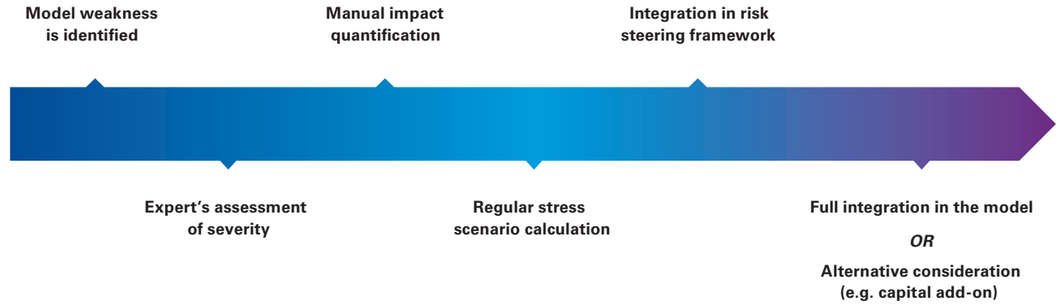
RESULT:
- Timely and transparent rectification of model weaknesses

After model weaknesses have been identified, an elaborate weakness management is the basis for setting validation priorities and monitoring model improvements. The following figure shows the different steps of a successful weakness management.

Weakness management

Stepwise progress positivly acknowledged by regulators and the bank's management

Key instrument:
Model weakness inventory
- Regular updates including materiality assessment
- Tracking of corrective actions
- Transparent to all stakeholders
- Basis for regular management reporting



First, criteria for impact assessment of the weaknesses are defined and agreed on. According to these criteria, initial classification of the severity is carried out based on (qualitative) expert judgment, which is supported by quantitative analysis at a later point. After that, a regular stress scenario is calculated and follow-up actions are defined, for example restrictions of model use, reduction of risk limit, model reserve, risk capital add-on or model correction, alternative quantification. Such a stepwise weakness management progress is positively acknowledged by regulators and the bank's management.

CASE 7:
Validation report as key communication tool

RESULT:
– Model validation results made transparent to management and other model stakeholders

Due to cross-departmental model validation activities it is important to gather all relevant validation results in a validation report that presented to both middle and senior management within the model risk committee.

The following table shows what contents a validation report should contain and what should not be part of the report.

Contents of validation report

	Do	Don't
Goal	Management's understanding of the weaknesses and limitations of the market risk model and its consideration of appropriate actions	Another contribution to the academic discussion of the VaR concept
Conclusions	Validation conclusions with transparent explanation of consequences for the bank's business and necessary action	Results of statistical tests, e.g. "distribution of risk factor XY is not stationary..."
Follow-up	Recommendation for follow-up actions, model improvements, mitigating measures etc.	No follow-up or practicable recommendations
Addressees	Bank's management, model users (controllers, front office), auditors	Academics
Form	Management presentation understandable also for non-quant	Scientific paper or audit report
Distribution	Active presentation to the management	For-your-interest email

4. Current Status and Outlook

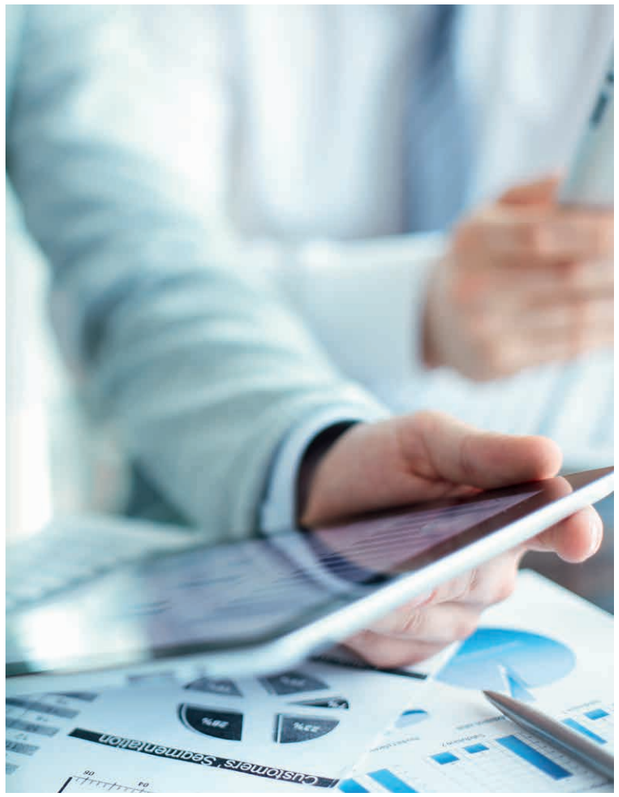
In continental Europe, there is not yet an established industry practice regarding a model risk management framework, as there is no industry consensus with respect to the best practice treatment of model risks. Most banks are now aware of model risk and are actively preparing for increasing regulatory pressure in this area, but their approaches vary depending on the bank's model risk governance, model validation framework, priorities for internal capital management, availability of economic capital, availability of relevant resources (methodology, IT, experts) etc.

Most banks are now aiming to demonstrate an adequate consideration of model risk in their economic capital. They use different measures/methods to tackle model uncertainties and to demonstrate why they ensure a sufficient capital coverage of model risk. Some of the measures are:

– conservative market data proxy concept
– conservative model calibration
– conservative risk aggregation
– stress scenarios for risk factors that are not incorporated in value-at-risk
– model-specific capital cushion, e.g. value-at-risk add-on
– overall capital cushion to cover all model risk uncertainties

The ultimate goal of progressive banks is to build models based on the best possible estimates, to control model performance and to take prompt management action in case of failure, and last but not least to calculate an overall capital cushion for model risk.

When looking to the future of model risk management, we believe that a market practice of model governance and model oversight will evolve in Europe over the next years. In this context, we have identified some developing areas. First, model risk might be defined as its own type of risk, for which capital cushion is calculated. Quantification methods of model risk have to be developed and optimized. Furthermore, banks might define early warning indicators to highlight potential increases in model risk, e.g. when market parameters are approaching stressed conditions. As concentration risk is managed in other risk types, managing model concentration risk by highlighting concentrations of model risk, by a business entity for example, could also become an issue in the future. Lastly, in order to incorporate model risk in the bank's overall risk management process, existing IT infrastructure could be extended, and it might become necessary to better manage key resources to avoid an over-reliance on key developers or validators.



Contacts

KPMG AG
Wirtschaftsprüfungsgesellschaft
THE SQUAIRE/Am Flughafen
60549 Frankfurt am Main

Matthias Peter
Partner, Financial Services
T +49 69 9587-1649
matthiaspeter@kpmg.com

Petr Paidar
Senior Manager, Financial Services
T +49 69 9587-4398
ppaidar@kpmg.com

Author

Anke Ni
Financial Services
T +49 69 9587-1268
ankeni@kpmg.com

www.kpmg.de

Picture credits:
cover © Stokkete/Shutterstock; p. 7 © zoranm/iStockphoto; p. 15 © shironosov/iStockphoto