EIOPA’s report on the results of the last full quantitative impact study (QIS5) has already indicated that the use of partial models led to an average 13% reduction in insurers’ solvency capital requirement (SCR). In 2011, only 10% of the participating companies intended to use an internal model, and almost half of those (42%) will be using a partial internal model. We expect that the importance of internal modelling will grow in the coming years. In this Knowledge Series, we will take a look at the regulatory and methodological aspects of partial models, defining the requirements a partial model has to meet and the theoretical principles applicable. We will also consider various mathematical techniques for integrating a partial model into the standard formula, using a specimen company to provide practical examples.

**Definition of a partial model under Solvency II**

The Solvency II Directive provides for two ways of measuring risk. Insurance companies can use either the standard formula or their own internal model, which must first be approved by the local supervisory authority. Developing and obtaining certification of their own internal model is, for example, attractive for well-diversified insurance companies and groups, specialist insurers and any other insurer with a risk situation that cannot be appropriately depicted by the standard formula. By using their own calculation methodology, insurers can represent their portfolio more accurately than with the Europe-wide standard formula. Solvency II allows companies the alternative of developing internally their own mathematical risk model covering all of their risks – known as a “full internal model”.

However, the hurdles to be cleared by an internal model to obtain approval are high. One of the key criteria is evidence that a company is using the internal model for internal management purposes (the “use test”). It has to be demonstrated that the internal model is an integral part of the company’s key management processes and is taken into account in making decisions. In addition to the certification process, which ties up significant resources and hence generates costs – with an uncertain outcome – an internal model is very expensive to develop and operate, which is an obstacle especially for smaller companies. But what alternatives are there to a “full internal model” if a company wishes to depict its actual risk profile more accurately?

A combination of the two approaches is also permitted whereby only certain risks are measured using a company’s own quantitative model, the remaining risks being quantified using the standard formula. This approach is known as a partial internal model (PIM) or “partial model” for short.
If a partial model is used, a distinction must be made between the parts of the risk model covered by the partial model (modelled area) and the rest of the risk model, in which calculation is based on the standard formula (non-modelled area). Insurance companies may use partial models to calculate one or more of the following components:

- Risk modules and/or sub-modules of the BSCR\(^1\) (e.g. NL-UW risk or cat risk)
- Operational risk
- Adjustments (deferred taxes, technical provisions)

The scope of the partial model may be confined to main risk drivers or main lines of business. The classification of lines of business as “main” must be justified to the supervisory authorities to prevent cherry-picking by the insurer.

**Requirements to be met by a partial model**

A partial model will only be approved if all of the requirements for a full internal model are consistently met in the following areas (adapted to the partial model’s limited area of application)\(^2\):

- Use test
- Statistical quality standards
- Calibration standards
- Integration of partial internal models
- Profit and loss attribution
- Validation standards
- Documentation standards

To obtain approval, an insurance company must also:

- justify the model’s limited area of application;
- demonstrate the appropriateness of the solvency capital requirement produced for the risk profile;
- demonstrate that the model can be fully integrated into the standard formula;
- describe and justify the technique used for integrating the model into the standard formula.

The loss distributions used in a partial model should be calculated at the highest possible level of aggregation, i.e. if necessary, the aggregation must also be part of the partial model. If possible, therefore, risk capital requirements should not be calculated for two components and then aggregated (Figure 1.1), but instead a joint risk distribution determined and the risk capital requirement derived from that (Figure 1.2).\(^3\)

Sometimes a partial model comprises several separately calculated components that cannot be aggregated within the partial model (because, for example, additional information on the non-modelled area is needed for the aggregation but is not available in the form of a distribution). If that is the case, the relevant forecast distributions should be calculated for each component and the risk figures (99.5% VaR) then applied within the aggregation in the standard formula (Figure 1.3).

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\(^1\) BSCR: Basic Solvency Capital Requirement is the risk capital including Market Risk, Life Risk, Health Risk, Non-Life Risk, Default Risk and Intangible Assets, SCR: Solvency Capital Requirement includes BSCR, operational risk and adjustments.


Techniques for integrating a partial model into the standard formula

We will use a specimen company to demonstrate various integration techniques and perform a quantitative analysis. The specimen company has the following classes of business:

- Motor liability
- Motor own damage
- Property insurance
- Personal accident

The standard formula results shown below are based on the current draft of the Level 2 text, which explains the minor changes in the figures from the publication mentioned, where the figures were based on the QIS5 calibrations and methodology.

The diagram below shows the specimen company’s risk capital for each risk category and the allocation of the lines of business under the standard formula.

Figure 2 shows that the underwriting risk is clearly the largest risk driver at the specimen company, and that the natural hazard risk is the major factor in the underwriting risk. It is therefore logical for us to concentrate initially on that risk category when creating the partial model.

The next step, therefore, is to extend the modelled area of the partial model to the entire underwriting risk. We will consider three variations:

A. Only natural catastrophe risk modelled stochastically
B. Entire underwriting risk modelled stochastically assuming that the personal accident business (PA) is calculated separately
C. Entire underwriting risk stochastically modelled as a whole

On the basis of these figures, we will now analyse all of the integration techniques listed in the current draft of the annexes to the Solvency II Delegated Acts by the European Commission and highlight the advantages and drawbacks.

Five different techniques are proposed in the annex to the current draft of the Solvency II Delegated Acts:

- Integration technique 1 ("two-world approach")
- Integration technique 2 ("extended SF aggregation")
- Integration technique 3 ("extended PIM aggregation")
- Integration technique 4 ("hybrid aggregation with SF correlations")
- Integration technique 5 ("hybrid aggregation with averaged correlations")

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4 Knowledge Series “Effect of reinsurance on risk capital – a practical example under QIS5”, online at www.munichre.com
Fig. 3: Variations of integration technique 1 ("two-world approach") in €m
Integration technique 1
(“two-world approach”)

With integration technique 1, the standard formula is used to calculate the SCR for the non-modelled area, the items to be calculated in the partial model being set at zero for this first stage. The SCR (or SCRs if the partial model comprises separate components) is then calculated from the distribution of the modelled units of the partial model. The SCRs are added together.

What are the advantages and drawbacks of integration technique 1 (“two-world approach”) and how can the results be interpreted?

Advantages:
- Integration technique 1 is a single-step integration.
- No new correlations are needed and almost no calculations.
- Simple to implement and explain.

Drawbacks:
- Not risk-sensitive as diversification effects are disregarded.
- It should produce a higher SCR than all of the other integration techniques, including the integration technique of the standard formula (see case A).
- Depending on the partial model’s area of application, of limited use for management purposes (use test).

Integration technique 1 is suitable for a model that is “mainly a partial internal model” or “mainly a standard formula model”, i.e. either the SCR produced by the PIM or the SCR produced by the standard formula is considerably smaller than the other. In our example, this means that integration technique 1 would not be very suitable for case A as the non-linear dependencies between the modelled and non-modelled areas of the portfolio are disregarded. In cases B and C however, integration technique 1 is perfectly practicable because the underwriting risk accounts for a large proportion of the total risk.
Integration technique 2
("extended SF aggregation")

The basic idea behind the next four approaches is to replicate the dependencies included in the standard formula in such a way that they can be applied across the modelled and non-modelled areas. This enables diversification, which is disregarded in integration technique 1 ("two-world approach"), to be taken into account. Technique 2 cannot be used for case B as it works only if a single module of the standard formula is modelled.

In variation C for example, an attempt is made to aggregate underwriting as a whole into the standard formula in a single block. This occurs at the level of the health and non-life modules in the standard formula. Since this technique involves changing both the content and the number of the modules to be aggregated, a new correlation matrix must be defined to enable the BSCR to be calculated. The insurance company has to select an appropriate lower and upper limit for correlation parameters.

In our example, these limits are 0% and 50%. The insurer then chooses the correlation parameters in such a way that no other set of correlation parameters results in a higher SCR.6

What are the advantages and drawbacks of integration technique 2 ("extended SF aggregation") and how can the results be interpreted?

Advantages:
- Integration technique 2 is a staged integration that in principle uses the structure of the standard formula.
- Suitable for any modelled part of the portfolio.
- Diversification effects can be better recognised than with integration technique 1.

Drawbacks:
- Integration technique 2 cannot be used if the PIM uses a non-SF aggregation methodology.
- New correlations are needed within the PIM and between PIM and SF.
- The new correlations have to maximise the SCR, which is the most conservative approach.
- Partly-replaced SF modules have to be broken up and treated as separate items. In practice, the necessary correlations between SF sub-modules and PIM units will not be defined. The structure of the standard formula is not preserved for that purpose.

Integration technique 2 is likely to suit a model that is “mainly a standard formula model”, i.e. either the SCR produced by the PIM is considerably smaller than that produced by the standard formula, or the partial internal model covers only a few of the risks.

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Fig. 4: Calculation of solvency capital requirement using integration technique 2 (€m)
Integration technique 3 ("extended PIM aggregation")

The approach of integration technique 3 is to replicate the dependencies included in the standard formula with two new correlations, which are implied by the SF aggregation and the PIM aggregation. The first correlation should model the dependency between the risks of the SF and the risks that are within the scope of both the PIM and the SF. The second correlation is for the dependency between the risks of the SF and the risks that are in the scope of the PIM and not in the scope of the SF.

Advantages:
- Integration technique 3 is a single-step integration.
- Diversification effects can be better recognised than with integration technique 2.
- The larger the modelled area, the more accurate the results.

Drawbacks:
- New correlations are needed between PIM and SF.
- The aggregation formula is only applied at BSCR level.
- The formula for the second correlation uses a "prior" value of 50%. This seems high when compared to SF correlations, which are almost all 25% or 0%.

Integration technique 3 is likely to suit a model that is "mainly a standard formula model", i.e. the SCR of the PIM is considerably smaller than that of the SF.

Fig. 5: Calculation of solvency capital requirement using integration technique 3 (€m)

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Fig. 6: Calculation of solvency capital requirement using integration technique 4 where distributions obtained directly from partial model (€m)

Fig. 7: Calculation of solvency capital requirement using integration technique 4 with derivation of SCRs (€m)
Integration technique 4 (“hybrid aggregation with SF correlations”)

In contrast to integration techniques 2 and 3 (“extended aggregation”), the aim of the next two integration techniques is to replace one or more (sub-)modules of the standard formula completely with distributions, which can then be used to derive the applicable SCR. This is a staged integration which uses parts of the standard formula structure, depending on how much of the standard formula is replaced by the partial internal model. Correlations of the standard formula are used for aggregation and no new correlations are needed.

There are also two possible approaches in variation C to the evaluation of the capital requirement for the modules of the standard formula calculated with the partial internal model.

**Required distributions obtainable directly from the partial model**

In this case, no further calculations are necessary and the results for all components can be used in the standard-formula aggregation.

**No individual distributions, SCRs derived using standard-formula methodology**

If the individual distributions required cannot be obtained directly from the partial model; the standard formula is used to re-engineer the SCRs for the relevant (sub-)modules. To do this, the SCR for the modelled area is (re-)calculated using the standard formula, and the relevant sub-SCRs are determined in such a way that the standard formula reproduces the SCR derived from the partial model. The challenge is to allocate a given partial SCR appropriately to the various components.

What are the advantages and drawbacks of the integration technique 4 (“hybrid aggregation with SF correlations”).

**Advantages:**
- Application of standard formula to the modelled area not normally required.
- All information from the partial model fed into the SCR calculation.
- No infringement of mathematical restrictions as only correlation coefficients from standard formula used.

**Drawbacks:**
- Cannot be used for individual lines of business.
- The standard formula must be used for the second approach: integration technique 4 may not be appropriate if the PIM uses an non-SF aggregation method (as it uses SF correlations for separate (sub-)modules).
- May not be appropriate if the risk profile differs significantly from the assumptions in the standard formula because the breakdown of the SCR depends on them (discussion with regulator advisable).
Fig. 8: Calculation of solvency capital requirement using integration technique 5 where distributions obtained directly from partial model (€m)

Fig. 9: Calculation of solvency capital requirement using integration technique 5 with derivation of SCRs (€m)
Integration technique 5 ("hybrid aggregation with averaged correlations")

Integration technique 5 is a staged integration that uses parts of the standard formula structure, depending on how much of the standard formula is replaced by the partial internal model. At each stage, new correlations between risks modelled in the standard formula and risks modelled in the partial internal model are implied by the standard correlations between the SF and PIM, using a weighted average. These implied correlations are applied to all risks of the partial internal model.

There are also two possible approaches in variation C to determining the capital requirement for the modules of the standard formula calculated with the partial internal model:

- Required distributions obtainable directly from the partial model.
- No individual distributions, SCRs derived using standard-formula methodology.
- The advantages and drawbacks of integration technique 5 ("hybrid aggregation with averaged correlations") and the interpretation of the results are similar to those of integration technique 4, which were described in the previous section.

Conclusion

With a partial model, individual risk categories or lines of business can be modelled more accurately than under the standard formula; for example, stochastic gross and net modelling can be performed in a separate model. The results of the risk capital calculation for the separately modelled risk categories or classes of business are then incorporated into the standard formula and integrated into the capital requirements for the other risk categories. The five integration techniques proposed by European Commission have been presented in this Knowledge Series and the advantages and drawbacks of each method set out in detail.

As can be seen in Figure 10, for case C (entire underwriting risk stochastically modelled as a whole) the various integration techniques produce different results depending on a company’s risk situation, so that no one method can be singled out as the best.
Where an insurance company is able to demonstrate to the supervisory authorities that it would not be appropriate to use the default integration technique, it will use the most appropriate integration technique. Insurance companies have to demonstrate the appropriateness of the integration technique proposed. Where an insurance company further demonstrates to the supervisory authorities that it would not be appropriate to use any of the integration techniques described in the Knowledge Series, it may use an alternative integration technique. It would then have to demonstrate the appropriateness of the integration technique proposed. This will be a part of the approval process for the partial model. An integration technique will not be considered appropriate where any of the following apply:

a) The resulting solvency capital requirement would not comply with the fundamental principles for calculating the SCR.

b) The resulting solvency capital requirement would not appropriately reflect the risk profile of the insurance company.

c) The design of the partial internal model is consistent with the fundamental principles for calculating the SCR, but would not enable it to be integrated into the solvency capital requirement produced by the standard formula.

In the ORSA process, an insurance company has to demonstrate that the standard formula would not reflect its risk profile appropriately. It can then use the partial internal model for a forward-looking calculation of its solvency capital requirement.

Solvency Consulting for your company

Provided by Munich Re, PODRA is a service based on a holistic analysis of the underwriting risk. Our specialists hold detailed discussions with clients to enable them to generate a tailor-made stochastic model that enables risk drivers to be identified and their impact on the overall risk determined. Based on that, the capital efficiency of entire reinsurance programmes is analysed and optimisation proposals produced. The client benefits from both Munich Re’s competence in modelling and calibration, and its market knowledge accumulated over many years in virtually all classes and countries.

Munich Re also assists its clients in all areas of Solvency II and risk management. In addition to developing and using internal stochastic risk models and linking them to value-based portfolio management, Solvency Consulting has a wealth of experience in dealing with the standard formula. We also play an active role in industry committees looking at regulation and specialist issues and ensure that knowledge and expertise are transferred and translated into practical recommendations for action on the ground. We are thus able to offer our clients real and effective help in preparing for Solvency II.

NOT IF, BUT HOW