

Aspects on calculating the Solvency Capital Requirement with the use of internal models

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The main reasons for giving insurance companies the option to apply internal models for calculating the solvency requirement within the Solvency II framework is to enhance better risk management and to allow a more accurate risk oriented capital requirement than the standard Solvency Capital Requirement (SCR) would provide. The possibility to use internal models within Pillar I basically means freedom to calculate the solvency requirement using some other formulae and even principles than those given by the standard formula.

In our view within Pillar I, contrary to Pillar II, there is a clear need both for insurance supervisors and for those developing internal models in practise to have a common guideline among EU member states on how to validate and approve internal models. The tentative advice from The Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) to the European Commission roughly follows the same approach. However, we believe that a broader scope of models and a more detailed approach to the validation will be needed for the final standard. This standard should give principles for the design of internal models and highlight areas that will be of greatest importance in the process of using internal models for calculating the SCR.

This paper gives a brief background review of the Solvency II project, deals with different aspects on internal models within Pillar I, and finally illustrates a rather detailed guideline that could be included in the standard for approving internal models. The main focus is on life insurance, but several issues concern equally well non-life insurance.

Keywords: Solvency II, Internal models, SCR, Stochastic modelling, Solvency measure

¹ The opinions given are those of the authors and do not necessarily reflect the position of the Insurance Supervisory Authority of Finland.

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1. INTRODUCTION

As the name indicates, Solvency II is a continuation of the Solvency I project. Solvency I focused on revising and updating the current EU solvency regime whereas the scope of Solvency II is considerable wider (see e.g. LINDER AND RONKAINEN [2004]). It strives for a fundamental and wide-ranging review of the current EU solvency regime in the light of recent developments in insurance, risk management, finance techniques, financial reporting, etc. One of the key objectives of Solvency II is to establish a solvency system that encourage and give incentive to insurance companies to measure and manage their risks (EUROPEAN COMMISSION [2003a]).

In order to ensure consistency across financial sectors the new solvency regime should to the extent necessary be compatible with the approach and rules used in the banking field. Therefore a three pillar approach similar to that implemented for banks in Basel II is also recommended for the insurance sector (EUROPEAN COMMISSION [2003a]).

It is suggested that the first pillar should concern quantitative aspects of, for instance, prudence level in technical provision, investment rules issues and especially regulatory capital requirement issues. The capital requirements are divided into two categories where the first one is more of a target like standard capital requirement (SCR) and the second one a strict minimum capital requirement (MCR), which also acts as a floor for the SCR. It is also suggested that the new system should allow insurance companies to use internal models for calculating the SCR. This should however be conditional upon the internal model having been validated and approved by the supervisory authority. The commission has further stated that validation criteria should be developed and harmonised at EU level. This goal of more harmonised quantitative as well as qualitative rules of insurance supervision is a key issue in Solvency II. The second pillar concerns qualitative aspects. This should for instance include internal control, risk management and the supervisory review process. It should be noted that internal models is also used under the second pillar, especially concerning risk management. The third pillar concerns market discipline and disclosure requirements.

In order to establish a more efficient regulatory and supervisory structure, conducive to the successful implementation of the proposals that will emerge from the Solvency II project, a so-called “Lamfalussy” approach has been adopted for the insurance sector. The approach consists of four levels and the core features for the different levels are as follows (EUROPEAN COMMISSION [2002a, 2003d]):

1. Essential or key principles are given in a framework directive (level 1 regulation) that is adopted by the Commission and proposed to the European Parliament and the Council. Once an agreement has been obtained, the detailed implementing measures are developed in level 2 regulation;
2. After consulting the Insurance Regulatory (or level 2) Committee (European Insurance and Occupational Pensions Committee, EIOPC), the Commission requests advice from the Insurance Supervisory (or level 3) Committee (CEIOPS) on technical implementing measures. The European Commission examines the advice and makes a proposal to the Insurance Regulatory Committee. If accepted, the Commission adopts the measure;
3. Insurance Supervisory Committee works on joint interpretation recommendations, consistent guidelines and common standards in areas not covered by EU legislation, conducts peer reviews and compares regulatory practise to ensure consistent implementation and application; and

4. It is the responsibility of the European Commission to check Member State compliance with EU legislation.

Concerning the Solvency II project the Commission has stated (EUROPEAN COMMISSION [2004a]) the following principles:

- i. Supervisory reporting should be compatible with accounting rules elaborated by the International Accounting Standards Board (IASB). This particularly concerns the methods used to estimate technical provisions. Any additions and adjustments to the IASB accounting rules may be proposed, provided specific reasons for such exceptions are present;
- ii. The risks addressed by the standard approach to the SCR should be based on the risk classification given by the International Association of Actuaries (IAA [2004]) and include: underwriting, credit, market operational and liquidity risk. Any additions and adjustments to the IAA risk classification can be made provided there is a specific reason for that; and
- iii. Internal models should be allowed to replace the standard approach to the SCR if the internal model has been validated for this purpose. The validation criteria and the validation process should be developed and harmonized.

Two cases have been identified where there should be a possibility to substitute the standard approach for the SCR by an internal model (EUROPEAN COMMISSION [2003c]).

- i. A company applies for the use of its internal models and provides evidence that their internal model reflects more accurately its risk profile; and
- ii. The supervisory authority requires the use of an internal model because there are indications that the standard formula will not give a result that reflects the true risk profile of the company.

Commission remarks (EUROPEAN COMMISSION [2003c]) that the European legislation must specify precise criteria for granting derogation of capital requirement with the use of internal models to ensure consistency of supervisory practise and to prevent the risk of companies “gaming” supervisors.

Furthermore, the article on internal models will have to be complemented by significant level 2 implementing measures. In order to encourage companies to develop internal models a certain freedom as regards to the methods used must be safeguarded. A standard for the validation of internal models should be designed at EU level. Flexibility is needed when internal models are required by the supervisory authority but certain common criteria could be set on EU level. Level 3 guidance for supervision may furthermore be necessary.

Requirements concerning internal models, e.g. the integration of internal models into management and control processes, validation criteria etc, should be appropriate and proportional to the role of internal models (EUROPEAN COMMISSION [2004c]). If an internal model is used in Pillar I, special rules concerning internal models should be applied. The regulation should depend on the sophistication of the internal model and how much it differs from the standard approach (this idea will be developed further in forthcoming chapters.)

Therefore the compliance criteria for the use of internal models should be set in such a way that the complexity of the internal model is reflected. On the other hand, if an internal model is used only in Pillar II, more general guidelines might be adequate.

Related to the framework for consultation on Solvency II (EUROPEAN COMMISSION [2004a]), the Commission has so far issued 23 calls for advice requests in three different waves (EUROPEAN COMMISSION [2004a, 2004d, 2005]). Request no. 11 concerns internal models and the main issues can be summarized as follows:

- i. Before the option of applying internal models can be taken into practise it is of utmost importance that sound European standards for internal models and their validation and approval processes are first in place;
- ii. The overall protection of the policyholders in terms of confidence level and time horizon must always fulfil the agreed harmonized criteria given in the EU regulations, irrespectively of the calculation method;
- iii. The answer from the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) should include technical advice on appropriate EU standards for calculating the SCR by internal model and on the compliance criteria for model validation and approval by the supervisor;
- iv. The advice should also involve more detailed aspects of internal models; and
- v. Approval procedures should be to the extent possible in the EU while also taking into account national specific features and resource issues. In particular supervisory aspects concerning the transition from the standard formula to the internal model approach should be considered.

The request should be examined in conjunction with topics related to solvency capital requirements, technical provisions, asset-liability management, supervisory review, internal controls, risk management, and group and cross-sectorial issues. Concerning internal models for calculating the solvency capital requirement there is a need to coordinate the issues in the first and the second pillar since they cannot be treated in isolation from each other.

In our view the tentative advice from CEIOPS does not fully cover the request given by the Commission. Especially the advice does not include detailed and wide enough technical advice on appropriate EU standards for calculating the SCR by internal model and on the compliance criteria for model validation and approval by the competent supervisory authority. Furthermore some advices seem to be in a contradiction with suggestions made by the EU Commission (e.g. the complexity of internal models relative to the standard approach should be reflected and partial internal models should be allowed for practicality reasons).

The approach taken by CEIOPS is that a full internal approach has to produce the whole profit and loss (P&L) distribution and any partial internal model should be considered as an internal model in the same conceptual way as a full internal approach. Hence the main focus is on internal models (both full and partial) that are based on comprehensive stochastic simulation of the P&L distribution. This excludes many practical and valuable alternatives and approaches that could equally well represent the business of a company more closely and result in a capital requirement that is better aligned to the risk profile.

The aim of this paper is both to broaden the perspective and to discuss more concretely the issue of applying internal models for solvency calculations. Section 2 reviews the main issues of the advice from CEIOPS. Section 3 concerns classification of internal models and section 4 elaborates on

some general aspects of internal models. Section 5 suggests issues for a level 3 guideline for approving internal models. Group issues will not be dealt with.

2. THE PROPOSAL FROM CEIOPS

The advice from CEIOPS has been released for public consultation (CEIOPS [2005]). The main issues of the advice are the following:

CEIOPS supports the inclusion of a specific article in the Framework Directive that sets out how the SCR might be calculated using an internal model. CEIOPS also supports the creation of a framework for the regulatory recognition of internal models, since the development of internal models can potentially deliver a wide range of benefits to supervisors, undertakings and, ultimately, policyholders.

The conceptual framework of internal models is divided into three categories, which are

- i. Modelling aspects - the system that transforms input data into forecast P&L distributions;
- ii. Risk management aspects; and
- iii. Capital requirement aspects – defined by the P&L distribution and chosen risk metric, confidence level and horizon.

The following criteria are proposed for modelling aspects:

- i. Subject to meeting validation and approval constraints, there should, in principle, be no limitation on the range of model approaches an undertaking might adopt. An undertaking must however be able to justify its selection to the supervisor, explaining why the chosen approach will deliver a better reflection of its risk profile than the standard formula; and
- ii. If an undertaking uses a 'deterministic' formula for the computation of the SCR estimate, then this formula should be justified by reference to stochastic models and distributions.

Respectively, the following criteria are proposed for risk management aspects:

- i. General aspects of risk management and internal control need to be amplified by specific criteria;
- ii. The internal model must be part of a comprehensive risk management system, which include adequate resources and structures to ensure properly functioning processes;
- iii. The Board of Directors and Senior Management should be actively involved in the internal control and establishing risk management processes associated with the internal model;
- iv. There must be appropriate documentation and sign-off of the internal model process at Board of Directors and senior management level. These parties must have a general understanding of the internal model. Senior management must have a good understanding of the operation of the internal model and has responsibility for ensuring that risk management processes are followed. The approval of the supervisor to use the model for the SCR calculation does not diminish this responsibility;

- v. Models should be allowed to evolve over time in line with risk management developments in individual undertakings, but failure to meet the compliance criteria on an ongoing basis may prompt withdrawal of supervisory approval. The Board of Directors and Senior Management should design and implement a model change policy; and
- vi. There should be appropriate audit procedures of risk management processes relating to internal models, conducted at least once a year. This should extend to appropriate internal audit procedures. The results of such reviews must be documented.

The approval of an internal model for calculating the SCR should be subject to a statistical quality test, a calibration test and a use test.

- i. The statistical test is to ensure that the model has sufficient accuracy and reliability to support internal risk management and computation of the SCR. The test will be based on an evaluation of the quality of the distributional forecasts, the output of the model;
- ii. The aim of the calibration test is to assess whether the SCR derived from the model has appropriate level of prudence; and
- iii. The overall aim of the use test is to assess whether the control loops associated with risk management function properly.

A partial internal model, i.e. a model that calculates the SCR partly by the standard formula and partly by an internal model, is to be considered as an internal model in the same sense as the above conceptual framework. The approval of partial models should be governed by the same principles as any other internal model. The same set of compliance and validation criteria – statistical quality test, use test and calibration test should be required, enhanced by tests for cherry-picking, which should not be allowed.

Insurance undertakings should present a clear rationale for proposing any enhancements to the standard formula. Enhancements should provide both an undertaking and its supervisor with a better understanding of the risks to which the undertaking is exposed. Use of data specific to the undertaking is not in itself sufficient for this purpose.

In principle, there should be no restrictions or descriptive rules for IT systems. The systems should be apt to support the review processes of internal models.

3. CLASSIFICATION OF INTERNAL MODELS

Currently a standard formula for calculating the Solvency Capital Requirement under Solvency II has not yet been agreed upon. Thus a discussion of the use of internal models is, insofar as that should be a discussion of the extent to which internal models might diverge from the standard model, a difficult task.

In order to make the discussion more transparent and easier to follow, we assume that we have adopted a fully specified standard model structure that takes account of the IAA classification of risks (IAA [2004]) and is suitably risk-sensitive within a Solvency II framework.

Concerning full internal models the advice from CEIOPS focuses on a full scale simulation of the total P&L account and the advice suggests further that partial models should be considered in the same conceptual manner. Furthermore it is stated that gaming the supervisor on the parameters of

the standard approach is neither beneficial for the companies nor for the supervisor. There should be clear distinction between adjustments to the standard approach and partial internal models.

In our view the conceptual split of internal models into full and partial model will not create much extra value. A full internal model will substitute the whole standard approach whereas partial internal model substitutes only some part of the standard approach.

Furthermore, neither a full internal model nor a partial model should be restricted to one single approach. Instead of first defining a suitable approach for a full internal model and then to accept similar sub-models as partial internal models a more practical and sensible allowance would be to divide the internal model approaches (both full and partial) into two categories depending on how much they fundamentally differ from the standard approach (reflection of complexity relative to the standard approach).

In a fully specified standard model structure there are a number of changes that can be considered as internal models and that do not significantly differ from the standard approach. We call such internal models specification-based internal models and they represent a more sophisticated standard approach. Other internal models may be based on changing more fundamental elements of the standard approach and are referred to as principle-based internal models. Thus, any specification-based or principle-based internal model can in principle be a full or partial internal model.

One remarkable advantage of a specification-based internal model (and a partial model in particular) is that companies can already after a relative short time-horizon, in line with the objectives of the Solvency II project, model more accurately their risk profile and solvency capital requirement. Principle-based comprehensive internal models will presumably take several years to develop.

3.1 Specification-based internal models

Examples of company specific changes to a fully specified standard model structure that do not significantly differ from the standard approach could be:

Correlation between different risks

When aggregating the different risk factors into one single risk measure, there is a need to have a sound system to combine the different risk factors. In the standard approach this will presumably be based on linear correlation. Since there is a need to have a simple, understandable and practical formula, the correlations might merely be based on high or low correlation as approximated by a correlation of one or zero.

There might be a need for insurance companies to apply more accurate correlations as indicated in their empirical data and risk analysis. This would result in a company specific approach to combine the different risk factors that only slightly differ from the standard approach.

Classification of risks

Since there is no unique classification system of insurance company risks, there might be a need for insurance companies to apply an own internal risk classification (typically a more detailed one) if it gives a more accurate picture of their risk profile. As an example for a reinsurance company in run-off underwriting risk related to loss ratios does not make any sense, when the largest underwriting risk for such a company is the adequacy of the liabilities. Thus some formulas in the standard

approach cannot be applied and there might be a need to “drop” certain risk factors, consider new ones or put more emphasis on other risk factors to achieve a better fit to the true risk profile of the company.

Parameters

The standard approach will presumably contain three different kinds of parameters, which are figures that are related to the audited annual financial statement, figures that are included in internal accounting and that are un-audited, and parameters that are fixed by the standard model. In order to create reliability there is a clear need to have a standard approach that is as much as possible based on audited figures.

On the other hand, there will always be a need for figures based on internal accounting. Often these figures do not possess the same reliability as audited figures. In some circumstances figures from the audited annual financial statement might not necessarily reflect the true underlying insurance risk. In such cases there might be need to use figures based on internal accounting principles instead of audited financial statement figures creating thus an internal approach that do not significantly differ from the standard approach.

The standard approach will probably contain a number of parameters that are fixed at EU-level. Some fixed parameters might be such that they can not be changed whereas some of them can be changed (at least to a certain extent). Take for instance the correlations between different asset categories. These correlations will almost surely not fit every asset/liability portfolio and therefore there might be need for insurance companies to apply their own correlation matrix creating thus an internal model that only slightly differs from the standard approach.

Internal fully specified model structure

Another way to create an internal approach that only slightly differs from the standard approach is that a fully specified model for a certain risk factor is replaced by an internal fully specified model. Such an internal approach can be more or less considered as an alternative approach that more accurately captures the true underlying risk for the insurance company, but nevertheless in the same fundamental way as does the standard approach.

Specification-based internal models in Pillar I requires that some degree of supervisory control is maintained over key variables, coefficients, aggregation of components and model structure. The appropriate level of this control depends on the scope of the changes made.

3.2 Principle-based internal models

More advanced internal models or internal changes to a fully specified standard model structure that replace an individual risk factor with an internal model or that might replace the entire standard approach with internal models and that to a significant amount is different from the standard approach (principle-based) could for instance be following:

Stochastic simulation of a single risk

The most likely internal model that may differ significantly from the standard approach would replace the standard approach of some risk factor with stochastic simulation model. Stochastic simulation could be performed to assess almost any risk, but most likely it would be market risk (the variability of assets and liabilities) and insurance risk (the uncertainty of the insurance technical result).

At the heart of the simulation there would probably be some kind of stochastic economic model that projects economic variables to the future. Based on the outcomes of the simulations and a given confidence level, the amount at risk is estimated. This approach requires a rather extensive model building.

Stochastic and integrated P&L account projection

The most advanced internal approach would be to stochastically project the total balance sheet and the income statement in absolute amounts to the future and to calculate an aggregated risk measure based on the variability of the future P&L account. In this kind of integrated stochastic simulation one tries to capture the unknown distribution of the future P&L account. It is assumed that the distribution of the future P&L account contains all relevant information of the underlying company risks. The overall P&L account is divided into sub P&L accounts (business lines for instance). Different sub-units may (will) contribute differently to overall risk, thus different sub units may have different distributions. All P&L sub-units are affected by risk factors (S&P 500, interest rate, inflation etc).

The risk factors are simulated and there is a specification of how they will affect different P&L sub units thus creating random outcomes. The dependence among risk factors is usually complex (partial dependency, tail dependency etc.) and it needs to be modelled. Linear correlation is sometimes not applicable and thus more advanced methods such as copulas might be applied. It should be noted that dependencies between different P&L sub units is implied by dependencies on common risk factors. From the distribution of the P&L account and given a desired confidence level the total amount at risk is estimated. If correctly applied the stochastic total balance sheet projection approach captures non-normal distribution behaviour in a more accurate way.

Variance-covariance modelling of indices

Another well-known approach that would probably differ significantly from the standard approach would be the variance-covariance modelling of indices. In this approach different risk categories and sub-risk categories are firstly identified. They might for instance be insurance risk with subcategories such as loss ratio and reserve strength indices per country and line of business etc. As another example interest rate risk with sub-risk categories with indices based on duration, currency, type (corporate or government) etc. could be mentioned.

As a next step the correlations between the different sub-risk categories are determined. These might take the form of linear correlation (variance-covariance matrix), but could also include more complex approach such as the use of copulas. Lastly the risk exposure to each sub-risk category is determined and with use of the variance-covariance matrix the amount at risk is calculated and calibrated to desired confidence level.

Historical simulation of indices

In historical simulation of indices a set of indices (or statistical samples) is chosen and for a given time horizon the interaction between the indices are historically simulated and reflected as variability of the true underlying exposure. From the simulation results the point that represents the amount at risk at a given confidence level is chosen.

Scenario- based approach

In a single scenario approach an event for some certain risk is defined. The event is commonly derived from a set of historical information and calibrated to some desired confidence level. The approach resembles closely so-called stress tests, but it should be noted that whereas stress tests commonly focus on extreme events with low probability to occur and high severity, single scenario-

based approach tries to capture the amount at risk at some more normally considered confidence level with one single scenario. In a full internal model, scenarios for each risk category are derived and then aggregated to get the final result. In a partial model only some risk classes of the SCR are replaced by scenario-based approach.

Obviously principle-based internal models in Pillar I require extensive supervisory control as their validation is complex.

3.3 Pros and Cons

Specification-based model

The standard approach should be easy to understand and have wide range of applicability. It should also be based on a limited number of data that is predefined. However, the standard approach will almost surely be conservative and therefore not reflect in all cases the true underlying risk accurately enough. The standard approach might also not cope very well with volatility clusters, non-stationary phenomena etc., since it will probably be calibrated to a long-term average. The standard approach will probably assume the different risk factors to be normally distributed, which might be misleading since many risk factors clearly have a distribution that goes beyond normality.

The choice of the parameters is crucial and finding one set that would suit all insurance companies in the EU area will almost surely be impossible. The parameters in the standard approach will almost surely be based on long-term historical averages that will inadequately capture the future or the current location on the financial market cycle creating thus a risk that the solvency regime pushes companies to sub-optimal management. So with no doubt there is a need for and will among insurance companies to apply for specification-based internal models.

Principle-based model

When moving towards principle-based internal models the complexity naturally increases. The benefits of stochastic simulation are unquestionable. If properly done it possesses an accuracy and information that is hard to achieve by other approaches. Complex relations, distributions, correlations and scenarios can be addressed.

It will be possible to depart from historical patterns, take better into account the location on the current financial market cycle, include management actions and above all it is a prospective, forward-looking approach. It however requires special skills and resources to master and to implement. Since there is obviously variability in the output, special attention should be set on calibration and validation and interpretation of results. Thus, these kind of internal models require an extensive internal control and some kind of compliance criteria should be set by the regulators.

The benefits of historical simulation are mainly that it is a non-parametric and distribution assumption free (in fact a specific empirical distribution is assumed) approach with in-built correlations. It is relative easy to understand and to implement and it has a wide range of applicability. However, since historical simulation is not based on a probability model it often provides biased results due to tail-estimating problems. This is of crucial importance since setting solvency requirements is basically about tail estimation. It also requires a huge amount of historical statistical data and assumes that the past is a prologue to the future.

Both the variance-covariance modelling of indices, historical simulation and single event scenario approach are based on a set of historical statistical samples and to some extent have similar tail-estimating problems and dependency on the statistical history. To some extent the tail-estimating

problem can be dealt with by making separate assumptions for the tail behaviour. The variance-covariance modelling approach is also relatively easy to understand and to implement and it has a wide range of applicability. The most crucial part of the approach is to adequately address the dependencies (variance-covariance matrix) among the different risk factors. In some cases linear dependency might not be the best possible approach, but it might nevertheless give more accurate results than the standard approach.

In order not to suffocate innovation regulators should also be prepared to accept other approaches than a full-blown stochastic simulation. Thus, the compliance criteria should not be restricted to one possible approach.

3.4 The Finnish experience of internal models

Finnish non-life insurance companies have for many decades applied a national solvency regime, which is today considered as a risk sensitive extension of the current EU solvency regime (PENTIKÄINEN and RANTALA [1982] and BERGLUND [2001]). A fully specified standard approach is stipulated by the Ministry of Social Affairs and Health (MINISTRY OF SOCIAL AFFAIRS AND HEALTH [1999]). Any changes to the standard approach should be approved by the Insurance Supervisory Authority. The regulation defines a list of possible parameters that can upon approval be changed to achieve a better fit to the company's risk profile. If a model in the standard approach is for some reason not suitable for a company it can be replaced by an internal approach as long as it is not fundamentally different from the standard approach. Any application of applying an internal approach should contain a description of the suggested approach and a proper justification for the change. Furthermore, internal approaches should not be subject to frequent changes and any changes made should be approved by the supervisor.

At EU-level a similar kind of approach could be possible. Any specification-based internal models to the EU standard approach could be applied for and approved by the competent supervisory authority of the company. However, requiring that all changes must be justified by reference to stochastic models of the P&L probability distribution would not fit well into this framework. The requirement to always justify changes with a full P&L-distribution would be a heavy burden for companies and could actually create an incentive for them to decrease their focus on the true risk profile and accept the weaknesses of the standard approach for practical reasons.

Internal models within Solvency II will however go beyond the Finnish approach since it will focus on internal models that are fundamentally different than the standard approach (comprehensive stochastic simulation models). One could anticipate that larger companies would strive for comprehensive principles-based internal models whereas many smaller and mid sized companies could be more satisfied from cost-benefit point of view, if allowed, with specification-based internal models.

The main reason for any company that wants to apply internal models for solvency calculations will be the focus on a better risk oriented solvency capital requirement commensurately with the company's ability to manage the overall risk of applying internal models. As stated earlier, specification-based internal models can be supervised with a rather small effort and guidance whereas principle-based internal models require a rather extensive supervisory control and guidance supplemented possibly with external expert reviews. Based on the Finnish experience there is no reason to focus only on extensive internal models based on comprehensive stochastic simulation and not to allow internal models based on other approaches.

4. GENERAL ASPECTS ON INTERNAL MODELS

The area where we could expect internal models be used is broad. It does neither seem desirable, nor possible, that the design of internal models is set down thoroughly in regulation. The supervisory authority should always encourage companies to focus on risk management and the compliance criteria for internal models should be such that it promotes better risk management. However, the use of principle-based internal models in Pillar I can not be an easy task for insurance companies.

Questions to be raised include the following:

- How are the exposure and the measure of the exposure and the company-specific selected coefficients developed and controlled?
- How is it assured that the internal model reflects and continues to reflect the circumstances of the company?
- How is the robustness of the model assured?
- What is the role of the internal model within the internal control and risk management environment of the company?

A crucial issue for a successful validation and approval process is to find appropriate and efficient roles and responsibilities for the different key persons involved: responsible actuary, chief risk officer, auditor, internal audit, top management, and supervisory authorities. Moreover, it seems that without appropriate benchmarking possibilities (within the same market and cross-border), the approval process will be very difficult to conduct.

Principle-based internal models will most probable be based on complex IT-solutions. Any IT routines for internal models should naturally be included in the overall IT risk management.

The two cornerstones in a general framework for compliance criteria in Pillar I are that the supervisory authority must be confident with the appropriateness and the accuracy of the selected internal approaches and the ability of the company to manage the risk inherited in applying internal models.

Applying internal models in Pillar II can be seen as a pre-phase to Pillar I. However, some internal models are used for different reasons (business planning, product design, pricing, shareholder's value etc.) and they should be viewed as normal risk management routines. It does not look sensible to in any way restrict the use of such models, since that might affect for instance the compatibility between companies and lead to sub-optimal solutions both in respect of insurance customers' interest and the insurance market.

A holistic approach to internal models in Pillar I is needed which places significant emphasis on the responsibilities of the Board of Directors and the top management. Principles for adequate internal control and risk management should be set. The supervisory authority should have the power to assess and reject the quality of internal models and its processes. One major factor is that the supervisory authority should in Pillar I have the power to in advance approve internal models and related processes.

The basic theme for validating internal models is that the applied model and the risk management principles are sound. Practices that may be theoretically unsound or insufficient should be identified and the supervisory authority should be able to determine the correct or more preferable approach.

However, the utmost responsibility for creating and justifying internal models and to set up appropriate risk management routines lies within the Board of Directors as part of their business and capital planning and management. Moreover, the Board must ascertain the company's compliance with regulation as part of appropriate corporate governance. The fact that an internal model has been approved does not diminish these responsibilities in any way.

The requirement of having sound theoretical principles is ambiguous. What is meant by sound and acceptable will evolve over time, but it also has other problems. Theoretical (economic) literature offers conflicting opinions (e.g. market is/is not efficient) and oversimplifications (all investors are alike and rational) that might create unrealistic approaches. Furthermore, the non-existence of a functioning insurance liability market, and the incompleteness of a theoretically modelled market, causes problems in a market consistent valuation of liabilities. It is clear that in Solvency II we are facing huge challenges when changing both the accounting and solvency regime fundamentally at once while even some major theoretical questions require further work.

A good internal model should both match the values of known exogenous variables and realistically represent the range of future outcomes. In the econometric literature the following criteria for a good model have been proposed (HARVEY [1989]): Parsimony, data coherence, consistency with prior knowledge, data admissibility, structural stability and encompassing.

Model building is as much art as engineering and science. Neither there exist a standard process for modelling. An iterative approach for building stochastic model is illustrated in Figure 1. The five phases can be iterated several times. Feedback from statistical inference to theory is needed because of the lack of unambiguous theory.

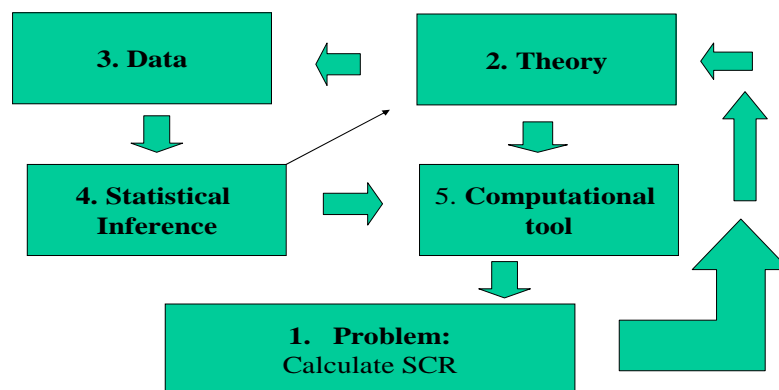


Figure 1 – Phases of modelling process: Stages in an iterative approach to internal model building. Modelling process starts from the problem formulation. Arrows indicates the direction of propagation.

There will obviously be a need to have some kind of calibration criteria for internal models. One could think of an approach where the supervisory authority has its own internal supervisory models to produce distributions of different risks and which forms a reference base for model calibration and validation. This approach however raises some questions: Can one model be superior to any

other? If anything goes wrong in the superior reference model, who is responsible for the calibration? Clearly the Board of Directors should at all time and from any perspective be responsible for the use of internal models. Therefore such a calibration criteria requirement does not seem plausible. A natural approach would be to require companies to calibrate the parameters of internal models with market observable information to the extent possible as this would reduce subjectivity and increase transparency.

Supervision should be forward looking. Clearly, setting solvency requirements is mainly about forecasting the future based on passed experience and available information by using a model. Internal models showing correlation or causation between variables could also serve as an early warning system. However, modelling is always fraught with dangers. A model, which heretofore was valid, may lose validity due to changing conditions, thus becoming an inaccurate representation of reality and adversely affecting the ability to form a good base for decision making.

In order to properly analyse the data and to construct a satisfactory model, it is essential to understand the environment in which the data has been collected and in particular how the environment has changed in the past. The assumption of constant and time invariant processes rules out evolution of the economy brought about by structural changes and regime shifts (for more detailed study, see Clements and Hendry [1998]). Models tend to have worse error variances than they should when used in outside the period of fit. There are various reasons why (CHATFIELD [2001]):

- i. Model parameters have to be estimated;
- ii. Exogenous variables may have to be forecasted;
- iii. The innovations may not be normally distributed, but could, for example be asymmetric or heavy-tailed;
- iv. The wrong model may be identified; and
- v. Underlying model may change.

It should be noted that more complicated models, while often give a better historical fit, do not necessarily produce better out-of-sample forecasts. Therefore most forecasters seem to believe that parsimony is very important.

Using findings from empirical comparisons the following nine advices to improve forecast accuracy has been proposed (ARMSTRONG [2005]): 1) Match the forecasting method to the situation; 2) Use domain knowledge; 3) Structure the problem; 4) Model experts forecasts; 5) Represent the problem realistically; 6) Use causal models when you have good information; 7) Use simple quantitative methods; 8) Be conservative when uncertain; 9) Combine forecasts. This seems to support a manner where several different approaches, all of which are not necessarily stochastic Monte-Carlo simulations, could be used.

Insurance industry tends to use extensively statistical methods and probabilistic (stochastic) models, which is of course quite natural as the insurance is based on the laws of large numbers. Other areas where useful experience and approaches in mathematical modelling is found are finance and physics (in fact many of the financial models have their origin in physics). On the question how should a mathematical model be evaluated, the following suggestions have been mentioned (ARIS [1994]): 1) Effective presentation of a model; 2) Extending the range of the parameters; 3) Using observable quantities; and 4) Comparison of models and prototypes and of models among themselves.

The Solvency II project is often compared with Basel II. Even if a consistency between the banking and the insurance sector is sought after, the spirit of the Solvency II project has been to look at Basel II, not copy it, but any deviation or adjustment from it should be given careful considerations. Concerning internal modelling of solvency capital requirement in Pillar I there seems to be a fundamental difference. Under Basel II the credit risk can be estimated with an internal model, which is based on a prescribed formula where parameters such as probability of default, loss given default etc. are to be estimated by reference to the bank's own portfolio (specification-based internal model). CEIOPS considers this to be an inappropriate approach within the Solvency II project. Therefore there is a fear that the Solvency II project is aiming at a too high complexity of internal models, without giving proper considerations to simpler approaches that could be of equal importance since increased model complexity does not always imply increased accuracy of forecasts.

When choosing modelling approaches in insurance and validating them the availability of data is a major problem in many situations and should be given special attention. This means that subjective expert opinions will play a remarkable role (i.e. we try to address a 1 in 200 years event of ruin but we may not have long enough data series, and even if we had it, the regime may have changed in the time series). This situation, which also applies to the valuation of technical provisions, is different from the short-term VaR modelling, based on day-to-day market prices, which is used in the banking sector.

5. VALIDATION AND COMPLIANCE CRITERIA

This section sets up validation issues and equally well compliance issues for the use of internal models in calculating the solvency capital requirement. The requirements noted are intended to highlight areas that should be of greatest importance to the competent supervisory authority when assessing an application to use internal models for calculating the solvency capital requirement.

There are some very valuable papers written that either directly or indirectly concern validation and compliance issues of internal models. Of special importance are the UK actuarial technical guidance notes 46 and 47 (MANUAL OF ACTUARIAL PRACTISE [2004a, 2004b]), papers issued by the Canadian institute of actuaries (COMMITTEE ON SOLVENCY STANDARDS FOR FINANCIAL INSTITUTIONS [1998, 1999] and CIA TASK FORCE ON SEGREGATED FUND INVESTMENT GUARANTEES [2002]) and the guidance on internal models given by the Canadian Supervisory Authority (OFFICE OF THE SUPERINTENDENT OF FINANCIAL INSTITUTIONS [2002]). The aggregation of ideas given in these papers increased with additional other aspects and some extensions should give a concrete and sufficiently detailed illustration of a possible future guideline for internal models.

The standard approach for calculating the SCR will probably be rather conservative, as it is intended to be applied by all companies. Since internal models will produce a more risk profile oriented capital requirement, the built-in extra-prudence of the standard approach would no longer be present. Therefore, internal models (both specification- and principle-based as either full or partial) should be appropriate for capital requirement purposes only when the overall risk management is adequate. The interaction between risk management and risk profile of a company will thus be of importance, but might be more related to the normal supervisory review process than linked to the specific validation of internal models. Most of the more general internal control and risk management principles apply equally well to internal models and will not be extensively reviewed.

As in section 3 internal models are divided into specification-based models and principle-based internal models. The validation and compliance issues focus mainly on principle-based internal models, in other words internal models that fundamentally differ from the standard approach. Therefore only selective validation and compliance criteria should be applied to specification-based internal models and of special importance are application, documentation, derivation of parameters and risk management issues.

5.1 Application

As stated by the European Commission (EUROPEAN COMMISSION [2004d]) internal models and partial internal models should be allowed to replace the standard capital requirement if the internal model have been validated and approved for this purpose by the supervisory authority.

The application should contain information of how the company is complying with given compliance criteria. The application should also include, as appropriate, information on the frequency of audits and model reviews, documentation and sample reporting. Of special importance for principle-based internal models is that the calculations and the risk management given any compliance criteria should for some years be observable as internal models under Pillar II. This will give time for the company to implement proper internal control and risk management routines and also sufficient time to run the models parallel with the standard approach to observe any model behaviour differences.

If there are material changes in the model usage, assumptions, organizational structure or other such aspects of the risk management process, the company should notify the supervisory authority in writing and explain the rationale for the changes and the resulting implications. Depending on the nature of the changes, a new approval could be required.

Obviously, the risk measure, time horizon, confidence level and the scope of the risk classification cannot be in contradiction with the standard approach. They might however be more prudent and detailed than the standard approach.

5.2 Documentation

Proper documentation of the internal models will be of great importance. Internal models and directly related risk management processes (valuation, calibration, testing, sign-off, IT etc.) should be well documented and it should be done in such a way that internal models and related risk management processes can be revised. Special care should be taken that a detailed outline of the theory, assumptions, data and mathematical basis for the models are included in the documentation. The soundness of the theoretical principles should also be justified and any weakness explained (note the limitations presented in section 4). Furthermore the documentation should indicate where the standard model fails to capture adequately the true risk profile of the company. Other policies, controls and procedures integrated to the overall internal control and risk management process or function should also be documented if related to internal models.

5.3 Risk management

The Board of Directors should unambiguously be responsible for the use of internal models. The internal models used for solvency capital requirement calculation should be integrated to the principles of how a company's risk profile is planned, monitored and controlled. Written responsibilities and accountabilities for each position in the risk management system concerning

internal models should be in place and also clearly understood. A compliance program should be in place in order to ensure that:

- i. Documented policies and procedures are being adhered to;
- ii. Internal models are reviewed by people not engaged in the development or regular use of the internal models and that the results of such reviews are documented;
- iii. Proper management controls are in place to analyse the need for model changes and to ensure that any changes are identified, documented, audited and informed to the supervisory authority;
- iv. The results generated by internal models reflect the risk profile of the company; and
- v. The management information reports are adequate and accurate.

The board of directors should at least annually validate the appropriateness of internal models, which could include:

- i. Identification of the company's risk profile;
- ii. Identification of risks to be measured and their interaction;
- iii. Selection of approaches, tools and risk measurements;
- iv. Uncertainty of data;
- v. Calibration and testing; and
- vi. Adequacy of the control functions and the reporting systems.

5.5 General risk factor specific issues

This section outlines some general risk factor specific issues that could be taken into account in a list of compliance and validation criteria (see Figure 2).

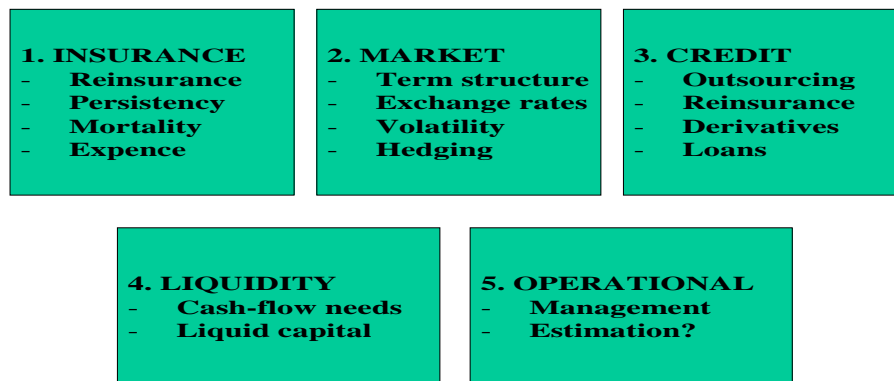


Figure 2 – Risk factors: The main risk factors considered in life assurance internal models.

5.5.1 Insurance risk

Expense risk

The expense risk is mostly linked to increased price or wage inflation, that is, expenses increase at a more rapid rate than income to mitigate it. The impact and possibility of a significantly higher inflation difference between expenses and income should be observed. The possibility is clearly linked to the time horizon, but if it is considered to be unhedged material risk it should be taken into

account. Correlations between investment return and inflation could be taken into account if historically so justified.

For companies (or business lines) in run-off the number of policies in force will reduce over time. The effect of increasing diseconomies of scale should be brought into account if it is considered to be a material factor.

If an outsourcing agreement is in place on guaranteed terms, one could assume that those terms will continue to apply for the remaining time. However, allowance should be made under credit risk or elsewhere for the possibility and impact of default by the outsourcer. Depending on materiality and time horizon, appropriate allowance should be made for a reversion to a full internal cost or a market-benchmarked outsourcing cost basis at the end of the guaranteed terms period.

Mortality and morbidity risk

Care should be taken to ensure that future mortality and morbidity expectations are stressed to produce extreme outcomes. This could include large-scale events that for a very limited time period significantly increase claims globally, nationally or only for the company, reasonable worsening of historically observed long-term trends and year-on-year volatility of non-homogeneous blocks of business. Careful considerations should be given to the necessity to assume different rates or directions for different populations.

Persistency

Rates of early termination and option take-up are affected both by a general deterioration and by specific causative factors. Both factors should be taken into account. When modelling general deterioration, care should be taken to exclude any influence of specific causative factors. Careful considerations should be given to the necessity to assume that the expected rate of persistency varies over the lifetime of a policy, reflecting both the early experience of recently written business and the possibility of changed persistency as term remaining to maturity reduces.

When modelling the take-up rate of options or the persistency of business subject to guarantees, the experience should be assumed to be positively correlated or dynamically related to the variation (or trend) of factors which change the value of the option or guarantee.

Care should be taken to ensure that future persistency and option take up expectations are stressed and in some form taken into account.

Reinsurance

Care should be taken to appropriately allow for increase in reinsurance rates and reduction in reinsurance capacity due to an adverse event.

5.4.2 Market risk

Concerning market risk, attention should not only be made to the end value of parameters with a given confidence level but also to path followed. Due to possible non-uniformity or the impact of management actions, the cost of guarantees could be different if asset prices follow smooth as opposed to non-smooth paths.

The effect of an adverse change in implied asset volatility should also be considered. This could be done for instance by imposing the assets by a varying volatility or by determining the effects on guarantees in adverse situations.

The term structure of interest rates should be subject to adverse scenarios which allow for changes in both the shape of the curve, as well as to changes of level. Preferably several stochastic interest rate models should be used. If a company's liability extend beyond regularly traded assets and is not effectively hedged, care should be taken to allow extreme behaviour of the very long end of the term structure of interest rates.

The impact of any adverse movements in exchange rates should also be considered. Appropriate allowance should be made for the correlation between exchange rate risk and other market risk.

Cost of inefficiencies associated with dynamic hedging strategies and an adverse scenario should be allowed for. If it is assumed that a hedge is put in place when a specified price movement occurs, capital should be allowed for the loss which would result if it was reasonably foreseeable that a larger price movement could occur before the hedge could be put in place, including the additional cost of the hedge after that larger movement had occurred. Careful considerations should be given to the likely capacity and pricing spreads in the relevant markets in such extreme scenarios and any assumption in this regard should, if possible, be justified relative to recent historic experience at times of large price changes.

Mapping of funds to proxy classes of indices should be plausible, intuitive and conceptually sound. The mappings should both theoretically and empirically be representative of the risk of assets held.

5.4.3 Credit risk

The variation in market prices from corporate bonds due to bond spread and default risk could either be treated as a credit risk or as market risk.

The adverse probabilities associated with the partial or complete default of reinsurance, outsourcing or other counter parties should at least be consistent with their credit rating and/or financial strength. Cash deposits should also be assumed to be subject to credit risk.

Considerations should be given to the cost (in spread terms) of obtaining identical derivatives from another counter party. It is not "reasonable foreseeable" that the financial market as a whole has ceased to function, considerations should be given to the time which may be necessary to arrange a replacement, with the consequential unprotected period and the terms which a replacement provider may likely to demand.

5.4.4 Liquidity risk

Liquidity risk should consider whether a significant increase in persistency would lead to difficulties in making the payments to policyholders when due or whether it is reasonable foreseeable that sufficient amount of its assets could become unrealisable at prices or in quantities sufficient to meet its cash-flow needs. Liquid capital sufficient to bridge any reasonable foreseeable deficit held or mitigation by any guaranteed short-term borrowing facilities to which the company has access could be taken into account. It could be unnecessary to hold capital in respect of liquidity risks, provided that the rectification measures intended are adequate. Considerations should also be given to the necessary capital while the rectification measures are implemented.

5.4.5 Operational risk

If credible historical data on any relevant operational risk is available, either within the company or from relevant industry or non-industry sources, the data should be regarded as an important input to the assessment of the potential adverse exposure to the risk of the type to which the data applies. In the absence of credible data more subjective methods could be allowed.

5.5 Aggregation of risks

Special attention and careful justification should be given to the choice of appropriate correlations between variables in more extreme scenarios. In some cases, it could be appropriate to assume a higher correlation than that historically observed to reflect relationships, which only come to play in more extreme stresses.

Where statistical distributions are fitted to different risks forming the joint distribution either in closed form or by simulation the joint distribution approach should always be an appropriate method of aggregation. Correlations, positive or negative, or dynamic deterministic relationships should be allowed for between variables, however, justified by historical observations or in accordance with any underlying economic or demographic model.

If statistical distributions are not fitted, or if the determination of a joint distribution is not possible, then more approximate methods of aggregation could be allowed. Where risks are considered to be materially correlated or linked this should be taken into account. The methods used should ensure that adequate weight is given to the capital requirement calculated for each individual risk. The methods should be theoretically sound and not inappropriately dilute or average out the capital requirements resulting from impact of high severity and low probability risks.

5.6 Principles for internal models based on stochastic simulation

If internal models are based on finding predictive distributions by stochastic simulation the following modelling principles should also be taken into account (see Figure 3).

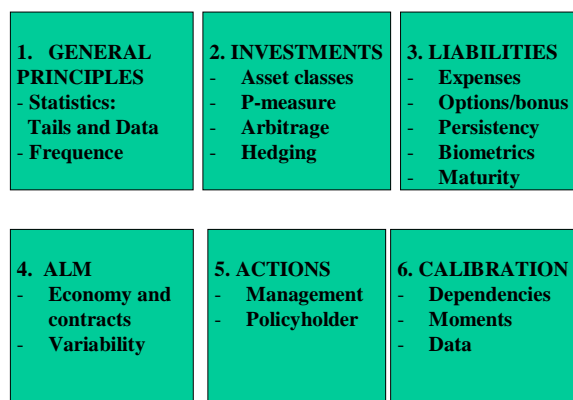


Figure 3 – Stochastic simulation: The principles for stochastic internal models.

5.6.1 General principles

Even if it is nowadays common to use given pre-programmed random number generators, they should be tested to display sufficient randomness. At least the following issues should be observed:

- i. It should be confirmed that the pseudo-random number generator does not exhibit any bias;
- ii. Pseudo-random number generators that produces simulations with a very low periodicity for certain seeds should be emphasised; and
- iii. Results from stochastic modelling should be reproducible.

The sampling errors involved in simulation should be estimated and a sufficient number of simulations should be used in the valuation so that the confidence interval is within acceptable levels of materiality. The probability distribution used should properly reproduce relevant behaviour that is the more extreme historically observed behaviour of the variable being modelled. Due to the limited amount of historical observations (even for the most common economic variables) special attention should however be given to the uncertainty in the behaviour of the tails of distributions.

The projection frequency of the asset models should be appropriately linked to the projection period in the liability model. If shorter projection periods lead to materially different results than a longer projection period (e.g. for options and guarantees) a more frequent iterations should be performed.

5.6.2 Modelling investments

The results of the model should be based on a P-measure (real world experience based valuation) as opposed to a Q-measure (risk-neutral capital market valuation). Since most published interest rate models are designed to calculate market-consistent financial instrument prices under risk-neutral assumptions, care should be taken to ensure that they are used in an appropriate way in a “real-world” projection. For all asset classes the models should reflect real world parameters and be arbitrage free. Models, which may introduce a minor theoretical arbitrage opportunities as a result of interpolation between points derived from an arbitrage-free model, should nevertheless be permitted, provided that no aspect of the modelling takes advantage of these assumptions. Investment returns should normally be generated before the application of any fees or consideration of specific product features. However, for some specific products care should be taken to assess if this is an appropriate objective. The model should not generate negative asset prices or negative interest rates.

Corporate bonds

For fixed-interest corporate bonds the necessity to model variation in prices and default rates/recoveries separately should be analysed. Where possible, models should be calibrated to historic spread variation, rerating, default and recovery experiences. The additional risk of a poor diversification should also be observed. Both market and credit risk could be incorporated in the same model if non-governmental bonds form a material part of the assets of the company.

Volatility

Assets and liabilities subject to stochastic valuation will change in value as option-implied volatility changes. Allowance for this risk should be made and an appropriate amount of capital to hold against this risk should be established.

Inflation

Inflation should be modelled stochastically if a significant exposure exists to administration expenses recovered from charges, which are not price index linked. Inflation risk should also be modelled stochastically if a material quantity of price index linked policy liabilities exist and adequate close matching assets are not held.

Hedging

Unless the hedging can be demonstrated to be robust across a wide range of scenarios, apart from immaterial differences, hedging assets should be stochastically projected consistently with the liabilities. In particular, the modelling should highlight any material imperfections of hedging (asset/liability mismatch). When calculating the price of hedging assets in stressed scenarios, care should be taken to ensure consistency between the assumptions underlying the asset-pricing model and the liability model, including consistency of shape of the long end of the yield curve.

Dynamic hedging strategies (e.g. delta hedging of guaranteed liabilities) should be taken into account in stochastic models if they form part of the ongoing management of the company. Imperfections in dynamic hedging particular for rapid, large changes (“jumps”) should be allowed for and it should take into account any readily available public or internal knowledge of market capacities and spreads in recent times of rapid change.

Any strategies which involves the purchase of hedging assets in the future, either to replace existing assets on expiry or if certain scenarios arise, should adequately allow for the purchase prices of the hedging assets at those times or in those scenarios.

5.6.3 Modelling liabilities

Within materiality considerations, the liability models should reflect the characteristics of the actual portfolio on the valuation date. A contract-by-contract assessment should be preferred while taking into account that certain risk margins over the best estimate liabilities may need to be derived collectively. Furthermore, some approximations and a certain amount of grouping could be necessary for practical reasons.

Expenses

Total expenses should vary by fund according to the terms of the contract and recent company experience. A change should not be assumed in total expenses in the future unless there is a clear and justifiable reason for doing so, taking into account past practises, competitive pressure and reasonable policyholder reactions.

Scenarios such as severe inflation, low sales, and high termination of business, should at least be assumed to examine if the tail skewness and/or fattiness of the distribution are adequately taken into account.

Maturity date

Contracts should be projected to at least the earliest possible maturity date. If policyholders have the option to renew in the future, the effect of allowing a proportion of such customers to “rollover” their contracts should be tested. If the policyholders have the option to change their maturity dates after contract issue, it should be assumed that some proportion of policyholders will elect a different maturity.

Contract guarantees

Investment guarantees should be modelled according to the terms of the contract. The level of the guarantees at the valuation date should reflect the actual guaranteed amounts in effect at that date.

Embedded options

The model should reflect embedded options according the terms of the contracts. It should be assumed that a proportion of contract holders will elect to exercise the options when it is in their financial best interest to do so (irrational behaviour). The model should allow the frequency to vary according to the current and/or historical economic environment and past policyholder behaviour.

Fund transfer

The model should allow contract holders to transfer money between investment options to the extent that such transfers increase the policy liabilities and can reasonably be justified. 'Irrational behaviour' and the ability to test varying assumptions should be included in the model as with embedded options.

Persistency

The model should allow policyholders to surrender their contracts to the extent that surrenders can reasonable be anticipated. 'Irrational behaviour' and the ability to test varying assumptions should be included in the model as with embedded options. If relevant and credible experience data to support the determination of lapse rates do not exist, lapse rates should not be assumed that materially differ from industry experience.

In a similar fashion the model should also allow policyholders to withdraw money without surrendering their contracts to the extent that such withdrawals can reasonable be anticipated and justifiable be treated differently from surrenders. Care should be taken in setting the withdrawal assumptions so that they interact with surrenders in a reasonable manner and that the overall level of fund depletion is appropriate.

Relevant scenarios on premium increases, bonus reductions and market environment (competitive pressure) should at least be assumed to examine if the tail skewness and/or fatness of the distribution are adequately taken into account.

Bonus

Emerging surplus should be recognized in an appropriate way and regulatory requirements such as the duty to treat insurance customers fairly should be taken into account. The level of future bonus to be declared should be consistent with the reasonable expectations of policyholders and the company's bonus distribution policy. The model should allow the frequency (timing) and/or amount of bonus to vary according to the current and/or historical economic environment and past experience.

Scenarios such as increased losses from defaults on debt securities, poor asset returns (decline in market value) and fluctuations in currency values, should at least be assumed to examine if the tail skewness and/or fattiness of the distribution are adequately taken into account.

Future premiums

The model should allow policyholders to make additional deposits to their contracts to the extent that such deposits increase the policy liabilities and can reasonable be expected. It should be assumed that some proportion of the contract holders would elect to contribute additional premiums to their contracts in a financial sensible way and in manner consistent with their most recent

instructions. It should not be assumed that all policyholders deposit additional amounts. The model should allow the frequency (timing) and/or amount of deposits to vary according to the current and/or historical economic environment and past policyholder behaviour.

Surrender charges & transaction fees

The model should take into account surrender charges and transaction fees only to the extent that such charges can reasonable be anticipated to affect the costs of guarantees.

Mortality

For small portfolios with large risks, simulation of extreme mortality outcomes could be appropriate. Considerations should also be given to large-scale events and long-term adverse trends.

Scenarios such as increased mortality (due to an epidemic or other catastrophe), decreased mortality (due to anti-selective lapse experience, weakening of underwriting, improvement in medical treatment or changes in lifestyles) and a potential miss-estimation of expected experience (due to incomplete data), should at least be assumed to examine if the tail skewness and/or fatness of the distribution are adequately taken into account.

Morbidity

If stochastic modelling is used for critical illness or income protection morbidity the model should allow not just for the randomness in the number of claims recoveries, but also for the risk of adverse trends (particularly in critical illness diagnosis). Considerations should also be given to the possibility of positive correlation between claims and adverse economic scenarios.

Scenarios such as a prolonged high unemployment recessionary environment (increased incidence rates combined with low termination rates), an epidemic that cause increased incidence rates without increased death rates, improved treatment for dread diseases and escalation in dental and medical costs, should at least be assumed to examine if the tail skewness and/or fatness of the distribution are adequately taken into account.

5.6.4 Modelling asset and liability interaction

Asset and liabilities should be consistently modelled with respect of economic variables where there is a clear dependence. This especially concerns embedded options, contract guarantees, bonuses and persistency rates. The adverse variability of the mismatch between assets and liabilities as financial variables changes should be taken into account.

5.6.5 Modelling management and policyholder actions

The projection of assets and liabilities stochastically could assume that the Board of Directors will react to future adverse or favourable investment or other scenarios by making changes to its practises for factors such as asset mix, bonus rates, surrender values, charges etc. If assumed a time interval should be allowed for practical and regulatory constraints on the timing of changes. Allowance should be made for the cost of any such changes.

It should be assumed that some policyholder behaviours will change, especially in more extreme scenarios. In particular, lapse rates and option take-up rates could change as options and guarantees become more or less valuable.

5.6.6 Calibration

In order to ensure that the internal models are able to generate scenarios that take into account the tail skewness and/or fatness observed in historical data, calibration tests should be performed. The emphasis of the tests should be placed on the tail of the distribution as opposed to the entire data set or some other measure such as the mean.

The calibration of the internal models and in particular the asset model should be done against market observable information and with respect of various time-horizons (at least one-, five and ten-year periods) and percentiles (at least 2.5, 5.0 and 10 percentile).

The length of historical data could be limited by availability in which case, all available data should be used. In other cases, data could be available going back much longer. An assessment should be made of the data available and the effect that different length of observation period would have. The selected parameters should also be consistent with the company's underlying future economic expectations.

Similarly, correlations between variables should be estimated over longer and shorter periods and the results compared. To the extent that there have been material changes in level between different time periods, correlations should be selected consistent with the company's underlying future economic expectations.

5.7 Data integrity and verification

Concerning data integrity and verification the following principles should be taken into account:

- i. All current and historical market price data should be derived from reputable and verifiable sources;
- ii. Used data must be subject to regular and rigorous reviews;
- iii. Responsibilities for the accuracy of insurance and market data should be clearly defined;
- iv. An audit trail should be maintained for subsequent validation and replication of results; and
- v. The statistical process for estimating parameters using historical data should be robust.

5.8 Testing

The following principles should be taken into account in order to test internal models:

- i. Internal models should be subject to rigorous testing and the results of testing should be adequately documented;
- ii. Both the implementation of the internal models and the theoretical soundness of the models and the assumptions used should be tested;
- iii. Tests should ensure that the model captures all relevant and material risk factors affecting the required calculation;
- iv. Situations, events or market characteristics that the internal models fail to capture or capture it insufficiently or inadequately should be disclosed;
- v. Modelled results should be routinely reviewed and analysed to ascertain their validity;
- vi. Models should reflect the company's actual operating practices and product features;

- vii. The results generated by internal models should be justified in a transparent way and if possible the internal models should be validated periodically against actual market performance; and
- viii. The results from internal models should be compared to the capital requirement resulting from applying the standard approach. Other benchmark models should also be used and in particular when the model for a certain risk involves high level of uncertainty.

6. CONCLUDING REMARKS

The utilisation of internal models for calculating solvency requirement is a new and developing area among EU member states. Therefore we should ask:

What can we learn from the supervision of other sectors and other modelling applications?

For solvency assessment forward looking approach is needed. Econometric modelling, for instance, has taught that *an accurate description of the past does not guarantee accurate forecast.*

The reliance on models to handle risks carries its own risks. *The most fundamental risk is incorrect model* that is not applicable. A critical consequence of an incorrect model is that the probability of a significantly adverse event is often substantially greater than one would expect based on model predictions. There is no single strategy for avoiding model risk, but applying general principles based on experience may help.

In order to manage model risk there will probably be a need for an *internal model team*, with expertise for instance in investment, insurance mathematics, statistics, economics, IT, internal control, and risk management. Team is also needed for the effective supervision of internal models. However, very often the supervisors are under-resourced, both financially and in terms of experienced personnel. Therefore *outside expert reviews on validation should be possible.*

Procedural, administrative and operational risks seem to be crucial. Practices that may be unsound or insufficient should be identified and supervisors should be able to determine the correct or more preferable approach. However, the *utmost responsibility* for creating and justifying internal models and to set up appropriate risk management routines lies within *the Board of Directors.*

Looking back in time the Finnish specification-based system is generally considered to be a success. It has given companies the necessary freedom to adjust the standard formula to an approach that better reflects the true risk profile without requiring, because of the internal approach, the implementation of extensive risk management routines. It has also been possible to keep the supervisory burden on a satisfactory level. The Finnish experience is in a strong contradiction with the tentative proposal from CEIOPS. *Specification-based internal models have been and are beneficial both for the companies and for the supervisor. Therefore they should have their place in the future Solvency II regime.*

There might be a need to have something that goes beyond the compliance criteria - *a map of best practise* for instance - both for insurance companies developing internal models and for the supervisors to be able to assess the appropriateness of the routines.

There is a need to *share the knowledge* of internal model practices among practitioners and supervisors. However, this does not include specific strategies for managing the exposure or company confidential information and in-depth technical solutions.

Supervisory arbitrage among EU member states should be avoided. This can only be achieved by *harmonized compliance and validation criteria*. We firmly believe that too general validation guidelines, even if supplemented by Peer Reviews and other forms of supervisory co-operation, cannot bring the level of harmonisation that is sought by the European Commission for the benefit of the internal market in insurance.

The compliance and validation criteria for internal models should however *not produce unnecessary costs* for companies if they do not add significant value to the supervision. Therefore careful considerations should be given to *relevancy and materiality* when modelling the SCR by internal models. The competitiveness within the insurance sector not just among companies in EU but also on a global perspective should also be safeguarded.

The management of the different aspects that directly or indirectly concern internal models or their use will be a very *demanding task*, which is furthermore a key strategy issue for the industry, and will require *further considerations* and work by CEIOPS and other market participants before any final principles can be successfully adopted in the EU area.

Acknowledgements. *We like to thank Antero Ranne for his helpful comments.*

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