

The Use and Approval of Internal Models for Regulatory Capital Purposes in Insurance

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1. Introduction

1.1 Scope

This guidance paper is the first of a series of papers with the aim of highlighting and explaining key elements of the Solvency II regime, in order to stimulate and help insurance undertakings in their preparations for the Solvency II implementation. The paper draws primarily from the “Directive of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) (recast)” (the Solvency II Directive)¹ adopted by the European Parliament on 22 April 2009 and by the Council of the European Union on 10 November 2009.

Solvency II is a fundamental review of the capital adequacy regime for European insurers and reinsurers, which will take effect from October 2012. It aims to establish a revised set of EU-wide capital requirements, valuation techniques and risk management standards that will replace the current Solvency I requirements.

Under Solvency II, the Solvency Capital Requirement (SCR) may be calculated either by using a standard formula or through a full or partial internal model. Partial internal models can be used to calculate the SCR for one or more risk modules or sub-modules and for one or more major business units. Solvency II will require undertakings to apply for supervisory approval if they want to use a full or partial internal model to calculate their regulatory capital. Unless an undertaking gains approval with effect from implementation of Solvency II, the 31 October 2012, then from that date it must follow the standard formula approach for calculation of regulatory capital.

To ensure that the approval process for both the undertaking and the Malta Financial Services Authority (MFSA) is conducted in an efficient, coordinated and effective manner, the MFSA will require significant amount of time to review the internal models against the requirements in the Level 1 text of the Solvency II Directive, as well as reviewing the undertaking’s risk management framework.

The Solvency II Directive imposes a tight framework of six months after receipt of a complete application during which the MFSA shall reach a decision on the application for approval of an undertaking’s internal model for use in calculating the SCR² (Article 112 (4) refers). In this respect, the MFSA is introducing a pre-application stage and would welcome a period of informal engagement with

¹ The Solvency II Directive is available at <http://register.consilium.europa.eu/pdf/en/09/st03/st03643-re01.en09.pdf>

² Consultation paper No. 37 Draft Level 2 Advice on the Procedure to be followed for the approval of an Internal Model available at <http://www.ceiops.eu>

undertakings prior to submission of their formal application. The aim of the pre-application would be for the Authority to understand the extent and nature of the intended use, scope of the application and the time schedule for the submission of the formal application, as well as the coverage of the internal model (for example, which risks, business units, and exposures are to be covered, how internal model components are being rolled out across the undertaking, governance and risk management arrangements, data collection and management, and testing).

The pre-application stage will also give the undertaking the opportunity to familiarise itself with the approval framework and the requirements and standards concerning the information that it will need to submit. The undertaking shall also be able to come to a view about the likely success of its application and review any elements of the internal model that may require further work before making a formal application.

The content of the pre-application shall include as a minimum the following information:

- (a) An indication that the undertaking **intends to apply** for approval to use its internal model or partial internal model to calculate the SCR and when it plans to apply.
- (b) The **scope of the internal model** application, including which risks, entities, lines of business and/or major business units are covered by the model.
- (c) An initial view from the undertaking on how the internal model meets the requirements for approval in the Solvency II Directive (i.e. a **self-assessment of internal model readiness**). The self-assessment of internal model readiness shall not be a substitute for the internal model requirements in the Solvency II Directive. The format of the self-assessment might develop over time and could vary according to the nature, scale and complexity of risks borne by the undertaking and how the undertaking is managed.
- (d) The undertaking shall also be able to explain their concrete project **plan for meeting the internal model requirements** by the date of the application.
- (e) Any information the undertaking deems necessary and relevant to understand the model at the provisional stage of pre-application (e.g. a draft of the information to be submitted later for the internal model approval application). An undertaking indicating that they intend to apply for internal model approval should be expected to be well on the way to preparing the documentation for the application.
- (f) Access to any draft documentation of the internal model as set out by Article 125 of the Solvency II Directive.

The MFSA would like to initiate the pre-application stage by requesting all undertakings to complete the attached questionnaire (see Annex 2). This will enable the Authority to get an initial indication about the number of undertakings planning

to develop a full or partial internal model in order to be better able to plan resources for assessing internal models. Consequently, the Authority would expect undertakings, which in the questionnaire express their willingness of developing a full or partial internal model, to eventually submit a pre-application with details of the content outlined above. The completed questionnaire should reach the MFSA by **3 March 2010**, addressed to the Director, Insurance Business Unit. The Authority expects that the responses received would be the result of considerations and possible decisions taken after internal model usage has been discussed within the internal structures of the company, including the Board of the company.

In addition to answering the questionnaire, undertakings are invited to comment on issues that might be prioritised by the MFSA within the process of communicating further information as Solvency II implementation approaches.

As part of the ongoing Solvency II project, the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) will be running the fifth Quantitative Impact Study (QIS5) in the second half of 2010. Whilst the MFSA expects all undertakings to participate in QIS5, participation is being set as a requirement by the Authority for those undertakings that intend to apply for a full or partial internal model approval with effect from implementation of Solvency II.

1.2 Background

It is likely to be advantageous for many undertakings to secure internal model approval if they can, as it provides a way of combining the required standard of consumer protection with efficiency in the use of capital. However, the standards which are required to be met before model recognition can be granted are rightly demanding. This document provides an overview of the expected requirements under each of these standards. It sets out the areas that undertakings should consider when planning the development and implementation of their own internal model ahead of their application for approval.

For an internal model to be approved for deriving the SCR, the undertaking will need to satisfy the tests in Articles 120 to 125 of the Solvency II Directive, as well as other requirements related to internal models³. Integration into the undertaking's risk management activity will be a key requirement. The internal model is owned by an undertaking's risk management function, such that there is a strong link between an internal model used for Pillar 1 (calculating the SCR) and Pillar 2 (the ORSA, the supervisory review process and the SFC report).

It is clear that developing, implementing and maintaining an internal model will require a cross-functional team within an undertaking. This would be expected to

³ Consultation paper No. 56 Draft Level 2 Advice on Tests and Standards for Internal Model Approval, available at <http://www.ceiops.eu>

comprise finance, actuarial, risk and IT functions as a core team, plus subject matter experts in investment, tax and reinsurance. Alongside this, it is important that undertakings' senior management and Board members ensure that they can demonstrate an understanding of the development of the internal model, its processes and outputs, and a commitment to embed the internal model into business decision-making.

1.3 Internal model definition

An undertaking's internal model should be integrated within its overall risk management and decision-making activities. Most importantly, an internal model should be used to quantify risks and assess an undertaking's economic capital. The Directive does not define an internal model, however, those undertakings that follow the International Association of Insurance Supervisors⁴ (IAIS) definition of an internal model are unlikely to find their work incompatible with the future Solvency II requirement. The IAIS definition reads:

'... internal model refers to "a risk management system developed by an insurer to analyse the overall risk position, to quantify risks and to determine the economic capital required to meet those risks. An internal model may also be used to determine the insurer's regulatory capital requirements on the basis of the insurer's specific risk profile and the defined level of safety of the solvency regime.'

The IAIS guidance paper on internal models suggests that undertakings should develop internal models for their own risk and capital management purposes, to derive their required economic capital position. The paper continues to say that they should be able to use the same model to determine their own regulatory capital (ie, to the 99.5% confidence level proposed under Solvency II). The IAIS guidance defines economic capital as 'the capital which results from an economic assessment of the insurer's risks given the insurer's risk tolerance and business plans'.

This IAIS guidance material takes the concept of an internal model away from the narrow focus of assigning capital purely to meet regulatory requirements and defines it instead as a wider risk and capital management tool, relevant for the needs of the insurer based upon its individual risk profile. The Directive specifically acknowledges this wider application in Article 118, which requires undertakings to demonstrate that the internal model is 'widely used' in their economic capital assessment.

⁴ Guidance Paper on the Use of Internal Models for Regulatory Capital Purposes, October 2008, http://www.iaisweb.org/_temp/15_Guidance_paper_No_2_2_6_on_the_use_of_Internal_Models_for_regulatory_capital_purposes.pdf

Undertakings' economic capital might differ from their regulatory capital as a result of a different calibration of the regulatory capital requirement compared with the undertaking's risk appetite. For example:

- the risk metric may be different, eg, Tail Value at Risk (TVaR), or more exacting Value at Risk (VaR) standards than the implied BBB rating, of a 99.5% one year VaR metric;
- the time period considered may be more than one year, particularly for technical provisions (which may be considered to run-off);
- margins in their provisions may be different to the regulatory level;
- the risk appetite may include, for example, external ratings or profit volatility at a different confidence level or assessed over a different time period.

For internal model approval, where undertakings develop their economic capital models to assess required capital at the level of their own risk appetite, they would then need to recalibrate to different levels, including the regulatory level of 99.5% over one year (SCR). This could form part of normal validation of the internal model, as well as highlighting some of the scenarios that management may have to deal with. By way of example, the use of the internal model to inform wider areas of financial management – such as management of earnings volatility – is not a regulatory requirement, but would be useful evidence of model embeddedness.

Undertakings do not need supervisory approval for the use of their internal models when determining their own economic capital needs or management. Differences, if any, between economic capital and regulatory capital requirements should be explicit and capable of being explained by the insurer to the Board and its supervisor. It would be useful if the internal model included reconciliation between the modelling criteria used by the undertaking for its own economic capital and the modelling criteria used for regulatory capital.

As stated in the CEIOPS advice on the principle of proportionality, undertakings are not bound by a single modelling approach. Overall, a balance has to be struck between the avoidance of unnecessary complexity of the internal model and demonstrating that undertakings' obligations will be met as they are due. Irrespective of the internal modelling approach chosen, the 99.5% VaR confidence level over one year is the common requirement to be met through regulatory capital. This level of safety represents one of the core components of the new regime, which will help to establish a level playing-field among insurers within the EU for the purposes of policyholder protection.

1.4 Partial Internal Models

As stated in Article 112 of the Level 1 text, partial use of internal models is permitted for the calculation of the SCR. Undertakings may use partial internal models for the calculation of one or more of the following:

- (a) one or more risk modules, or sub-modules, of the Basic Solvency Capital Requirement, as set out in Articles 104 and 105;
- (b) the capital requirement for operational risk as laid down in Article 107;
- (c) the adjustment referred to in Article 108.

In addition, partial modeling may be applied to the whole business of insurance and reinsurance undertakings, or only to one or more major business units.

The aims and benefits of partial internal models are:

- to ease transition from the standard formula to 'full' internal models;
- to encourage innovation and specialization to certain business areas;
- to deal with exceptional cases, like the merger of two undertakings (one with an approved model, the other using the standard formula) in a pragmatic way.

The approval of partial models is 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 – are required.

Undertakings should present a clear rationale for proposing any enhancements to the standard formula. Enhancements should provide both the undertaking and its supervisor with a better understanding of the risks to which the undertaking is exposed.

The partial use of an internal model has as an essential pre-requisite the necessity of consistency with the SCR standard formula. This means that an application for the partial use of an internal model should identify:

- which components of the SCR standard formula are affected by the use of the internal model;
- how their replacement by internal SCR estimates impacts on the rest of the standard formula; and
- how the general consistency and confidence level is maintained.

2. Characteristics of the model

2.1 Structure and assumptions of the model

Generally, the structure of the full internal model should cover the following risks

- Market risk
- Credit risk (*or counterparty default risk*)
- Life underwriting risk
- Non-life underwriting risk
- Operational risk
- Other risks

The way in which these risks are grouped or defined may differ slightly between the undertakings. For undertakings that intend to adopt a partial internal model, the definition of some risks may have to be more similar to the standard formula.

Assumptions will be required for all aspects of the undertaking's business, including the following:

- basic structure of the model
- products
- in-force business
- economic assumptions
- management actions/policies and practices
- current assets
- future experience

Some assumptions will be responsive to or a function of other model variables or results.

Undertakings should base assumptions on their own experience. If this is not reliable, the undertaking should use similar internal or external experience. In some cases "sound judgment" may be the only available basis.

Uncertainty about model inputs can also be captured by modelling the variability of the output based on accepted industry practice.

(a) Market risk

Market risk is defined as the risk of losses in on and off-balance-sheet positions arising from movements in market prices.

Insurers may be at risk to movements in market prices due to changes in equity prices, interest rates, property prices, inflation rates, exchange rates or commodity prices. Insurers largely try to mitigate this risk by adopting investment strategies where the movement in assets are offset by the movement in liabilities.

Market risk can be particularly onerous where there are options or guarantees embedded in the policy contracts, which may result in the liabilities moving differently to the assets. In practice, in these circumstances an insurer can hedge some of the market risk by using hedging strategies or taking advantage of the mitigation effects provided by the profit sharing mechanisms.

Market risk arises from the level of volatility of the market price of assets. Market risk involves the exposure to movements in the level of financial variables such as equity prices, interest rates, property, inflation rates, exchange rates or commodity prices. It includes the exposure of options to movements in the underlying asset price.

Economic Scenario Generators (ESG) can be used to model a range of economic risk factors. Typical risk factors that are modelled are the risk-free interest rate, the credit spread, equity prices, property prices, inflation and mortgage loans.

(b) Credit risk

Credit risk is the risk of default and change in the credit quality of the issuers of the security, counterparties, intermediaries and customers to whom the undertaking has an exposure. Credit risk also includes the change in value of assets due to a change in the credit spread which is available over the risk free rate.

Modelling assumptions for credit risk are split into those for individual default, such as probability of default (PD), loss given default (LGD) and exposure at default (EAD) and those for portfolio effects, such as dependencies between defaults.

(c) Underwriting risk

Specific insurance risks that are covered by the company through the insurance contracts it sells are specifically identified as underwriting risks. The risks within the underwriting risk are associated with both the perils covered by the specific line of insurance and with the specific process associated with the conduct of the insurance business.

(i) Life underwriting risk

Life underwriting risk is defined to include risks arising from changes in mortality, longevity, morbidity, lapse rates and expenses. The most common approach to assessing these risks is by using a series of scenarios/stresses and combining these with the market and other risk elements using a correlation matrix.

- Mortality stresses are often based on general data or industry data, possibly adjusted for an undertaking's own experience.
- Longevity stresses may be based on industry data, if available, or on general data.
- Lapse rates tend to be based on historical rates;

Life insurance business may be modelled by adopting a hypothetical policy often referred to as a 'model point' which reproduces the cash flows of the portfolio. Then, when the model is run, the assumed rates of decrements such as mortality and lapse will reduce the number of hypothetical policies relating to each model point.

There might be a combination of the following items, resulting in anything up to a few tens of thousands of model points to represent the most complicated portfolios of policies:

- class of policy
- whether future premiums are payable
- duration in force
- outstanding term to go
- current age and/or age at maturity
- how close guarantees in the policy are to being 'in the money' (if duration in force is not an adequate proxy for this)
- types of options (i.e., guaranteed annuity rate) in the policy.

(ii) Non-life underwriting risk

The two main sources of non-life underwriting risk are premium and reserve risk. Undertakings may structure their non-life models into premium risk from attritional claims (such as normal sized auto or household claims), large claims (such as aviation or marine claims) and catastrophe claims (such as a large amount of claims resulting from a hurricane), and reserving risk.

Undertakings may use different approaches to model the variability of attritional claims, although methods are mainly based on own data. Methods include modelling frequency and severity of claims, modelling claims ratios and modelling the overall cost of attritional claims based on the undertaking's business plan.

Large claims can be modelled with attritional claims or modelled separately, using a curve fitting approach to past data to determine a claim severity distribution.

Catastrophe claims are generally modelled using external software, usually provided by specialized companies.

(d) Operational risk

Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. Non-underwriting losses internal to the insurer may be events over which the insurer might have significant control, whereas external non-underwriting risk events may be risks over which the insurer has little or no control.

The methods used to assess operational risk vary widely, from simple approaches such as a factor based approach, based on premiums and reserves, to more complex approaches, where the frequency and severity of events are modelled based on an internal risk register.

(e) Liquidity risk

Although liquidity risk may not explicitly be modelled by insurers, undertakings might consider the effect of short term borrowing costs in their modelling.

Liquidity risk is frequently associated with the sale of assets when the asset prices are depressed, although the underlying cause of a liquidity event may not be due solely to market risk.

2.2 Risk aggregation

There are several ways of allowing for risk aggregation. In general, however, undertakings may model different risk types separately, implicitly or explicitly allowing for diversification within the risk type. The different risk type models would then be aggregated, explicitly allowing for co-dependencies between the risk models. The methodologies vary, and there is invariably a large reliance on expert judgement to assess the extent of co-dependency or independence between risk types.

Allowing for diversification effects can reduce required capital substantially. An undertaking may measure diversification benefits by running the whole model or on a marginal basis by adding one risk at a time to the model.

(a) Assets

In terms of modelling co-dependencies on the asset side, undertakings may rely on externally developed economic scenario generators that include an allowance for dependencies in the modelling of assets. This allowance should generally be based on observed data.

(b) Liabilities

The co-dependencies in liabilities for life insurance are typically modelled by the use of a correlation matrix. In non-life insurance, co-dependencies in liabilities are generally discussed in the context of co-dependencies between premium and reserve risk, and for co-dependencies between different natural catastrophes.

In terms of co-dependencies between natural catastrophes, historically observed loss experience may be insufficient to derive the structure of the spatial correlation of risk. Externally developed scientific (e.g. geological, meteorological, hydrological, seismologic) models may be necessary to understand the generation process and impact of such risks.

(c) Assets and liabilities

Co-dependencies between assets and liabilities would need to be identified and modelled as well.

(d) Aggregation between risk types

In terms of approaches to modelling co-dependencies between risk types, undertakings can model at different levels of granularity, depending on their model structure. For example, undertakings might model co-dependencies between risk types or between individual contracts.

Examples of co-dependencies between risk types include:

- Reserve variability between classes
- Rate movements between classes
- Attritional loss variability between classes
- Large loss frequency between classes
- Natural catastrophe losses between classes
- Reserve variability and attritional variability
- Inflationary link between reserves and loss volatility
- Default risk between reinsurers
- Overall default risk of reinsurers and natural catastrophe losses
- All asset returns, inflation and exchange rates
- Market risks and other risks
- Credit risks and other risks
- Underwriting risks and other risks
- Operational risk and other risks

When it comes to parameterising co-dependencies, it may be possible to use historical time series data, possibly using maximum likelihood estimation. When the use of historical time series data is not possible, particularly in the tail of distributions, parameterisation may be done using expert judgement. Expert judgement can be based on the analysis of stress scenarios that affect an undertaking's whole balance sheet.

Undertakings should devise methods for reviewing and updating co-dependencies. This could include an annual validation check/update against possible new internal/market experience and/or external benchmarking followed by an assessment of the impact of the change in dependency assumptions. Dependency structures might also be subject to independent review and challenge.

3. Use test (Article 120)

3.1 General remarks

The use test requires undertakings to demonstrate that its internal model is integrated within its risk management function (Article 44) and capital management function (Article 45), and system of governance processes and procedures (Article 41). As part of the use test, an undertaking should examine how the internal model is used for operational management purposes, how the results are used to influence the risk management strategy and business plan of the undertaking, and how senior management are involved in applying the internal model in running the business. An undertaking should demonstrate to the supervisor that an internal model used for regulatory capital purposes remains useful and is applied consistently over time, and that it has the full support of, and ownership by, the board and senior management.

If the internal model were used only for regulatory purposes, undertakings would have fewer internal incentives to keep the model and its parameters accurate and up-to-date. In contrast, the use of internal models in internal decision-making creates a need to ensure sufficient quality of the internal model and of the data fed into it. Undertakings are responsible for complying with the use test and, in accordance with Article 125, they must document how they demonstrate this compliance.

Both the risk management system and capital management activities are central to the efficient working of the internal model and embedding it in business. Both the inputs to and outputs from the internal model should link to key decisions made in these functions. Risks identified by the risk management function are also a key input into the capital model in order to reflect the nature of the business and the environment in which the undertaking operates. The internal model should include

an assessment of all the material risks highlighted on the risk register, or other risk assessment/risk monitoring tool.

To satisfy the use test, the internal model must reflect the realities of the business and the operational processes of the undertaking, hence the integration of the undertaking's risk management processes. To embed the model into the business, it is first necessary to embed the business into the model.

An important part of the risk management function is to allocate economic capital at an appropriate level of granularity (eg, by business unit, line of business, homogeneous risk group) to enable management to use this within internal reporting (eg, return on risk-adjusted/allocated capital). This process ensures that the capital allocation reflects the risks inherent in each area of the business.

3.2 Uses of Internal Models

Undertakings that are in the process of developing their internal model should start with the uses they wish to make of the internal model and design the structure of the internal model based on these. This could mean that the undertaking will decide to use a partial model, rather than model all risks.

Examples of internal model use are suggested below:

- Link to their risk management framework;
- Estimate economic capital requirements;
- Set profit targets;
- Assess return on economic capital;
- Business planning;
- Capital allocation to entities, lines of business and risks;
- Efficient use of capital;
- Use the internal model as part of their overall governance;
- Reinsurance programme design;
- Investment decision making;
- Assess customer benefits;
- Assess regulatory capital requirements;
- To price transfers of portfolios of business;
- Exposure management;
- Balancing of risks;

- Risk reporting;
- Financial reporting;
- Assess the effect / price of mergers and acquisitions;
- Production of management information; and
- Product development.

Given that each insurer writes different business, has a different risk profile, a different corporate structure, different operational processes and a different risk management framework, each internal model will be different and used in a different way.

Each function within the organisation should be expected to understand how its decisions affect the risk and capital profile of the undertaking, just as they might be expected to contribute to the scope, design, operation and development of the internal model itself. Each relevant part of the organisation is then involved in feedback loops to ensure that the internal model remains applicable for the business. Alongside this, each function retains responsibility for relevant elements of the validation process.

Where operational functions are outsourced (Article 49) the undertaking retains full responsibility for the identification, assessment and remediation of the risks in the outsourced function(s). An undertaking will wish to consider the extent to which it may be able to rely upon the outsource provider for assistance in these endeavours.

4. Statistical quality standards (Article 121)

The Directive sets out high-level requirements for the statistical quality standards underlying an internal model. This requirement aims to ensure that the methodology underlying the model is sound. The standards apply to:

- the methodology used to select, fit and, where appropriate, combine statistical distributions (probability distribution forecasts);
- data quality;
- model dependencies and diversification effects;
- risk mitigation techniques;
- the treatment of financial guarantees and options; and
- future management actions.

Undertakings seeking internal model approval will need to have accurate and complete data, as well as be able to justify assumptions and judgment. There are three data-related issues which undertakings should consider, i.e. availability,

quality and appropriateness, in order to achieve this. These three issues are also a key part of the model review process (from a supervisory perspective).

4.1 Availability of data

The availability and characteristics of data determine the quality of the model realisations and impose restrictions on the modelling approach followed by the undertaking. Due to lack of data, undertakings may be forced to apply less data-intensive and simpler modelling approaches.

When historical time series are not complete, undertakings could apply different techniques or a combination of techniques to attempt to remedy this problem. Where possible, undertakings can complement their internal data by secondary data (either from public sources or from external data suppliers). Before being captured by the undertaking's systems, external data should be checked for quality and appropriateness.

Another approach could be to enrich historical data by simulating or generating data that is not (easily) observable. This synthetic data itself is the output of a model which is subject to parameterisation⁵. For example, fixed income instruments are often liquidly traded only for short maturities. To extrapolate the yield curve, long-term forward rates are created by modelling the interest rate term structure consistent with the observable short rates and the assumptions about the key drivers of long term rates. Another example is natural catastrophes in non-life insurance. Here, historical experience on its own is rarely sufficient to allow for the complexity, geography and spatial correlation of catastrophe risks. Geophysical models for natural catastrophes (e.g. windstorm, flood, etc.) can be used to synthetically enlarge the limited set of historical events. If the models for these synthetic events are appropriate, the resulting data set are likely to be rich enough to allow for the statistical validation of the loss and severity distributions.

Whenever available data do not provide the basis for a sound risk modelling, undertakings should rely on expert judgement. Undertakings should highlight the extent of reliance on expert judgment in internal models, both for models developed completely in-house or for those with elements relying on external data or software. This should be done especially in the case for those extreme events that are most relevant to determine the required risk capital (at the targeted confidence level)⁶. However, to a certain extent, expert judgement will almost always come into play in risk modelling. Even when data samples are large, experts will necessarily have to

⁵ Parameterisation in this case, however, is possibly less challenging as the data is available and the underlying assumptions are made with a higher degree of confidence.

⁶ It is subject to expert opinion whether or not a heavy-tailed distribution is to be used for the random variable in question.

resort to data selection techniques to forecast future events. The less extensive the empirical basis, the higher will be the degree of subjectivity and the need for expert judgement.

4.2 Data Quality

High quality data is essential for modelling. Undertakings should pay particular attention to this requirement as their current quality of data may fall short of the Solvency II requirements.

Data quality issues generally fall into three categories:

- Consistency – i.e. whether data is consistent and collected in a standard format;
- Completeness – i.e. an assessment of data thoroughness, taking into consideration the importance of missing data (e.g. is data missing for large limit/high hazard locations); and
- Accuracy – i.e. an assessment of data correctness.

Inaccurate data may have similar effects to those of incomplete data. Depending on the reasons for the inaccuracies, significant bias may be introduced.

To assess the quality of the data, undertakings should perform data quality reviews comparing the available data to those required by their model, as well as performing data cleansing and validation checks.

A common starting point is to check whether the series contains outliers and try to understand the reasons for their occurrence⁷. This typically determines the way outliers are treated.

If the insurer thinks the outlier reflects an anomaly which may repeat itself in the future, it should retain the observation to estimate the volatility of the series. However, if the outlier depicts an event that is unlikely to crystallise again, or will not be relevant in the future, the insurer may decide to remove it from the dataset. In this case, it is regarded as good practice to record all adjustments that are made to the data.

Quality checks should ensure consistency between the data used for different purposes. For example, data used for accounting purposes must be consistent with that used by actuarial models.

⁷ A data outlier is an observation that is numerically distant from the rest of the data. There are several reasons for their occurrence: data errors and anomalies are the most common source for outliers.

4.3 Appropriateness

Historical data may not always be appropriate and the degree of appropriateness of data usually tends to decline with ageing.

If data is deemed as inappropriate, undertakings should apply adjustments, such as discounting the weight of historical observations, modelling selectivity (e.g. censoring, truncation, etc.). Another approach could be to use a fixed length moving window. This approach is known to be sensitive to the inclusion and exclusion of rare and extreme events. A third approach could be to resort to adjust the historical data to reflect current conditions by complementing it with expert judgement.

Whenever history is viewed to be a good guide for the future, this will last until evidence proves the contrary. It is generally considered that, for risk management purposes, data series should be long enough to cover cycles, clusters and atypical observations. The evidence against historical data would then be assessed by expert judgement and prudence.

4.4 Assessing the data, assumptions and statistical quality

The internal model provides a projection into the future of the undertaking's finances, and even an undertaking with complete historical data will need to consider what adjustments may be required to reflect current and future conditions. The undertaking also needs to make assumptions about future conditions, anticipated volumes and pricing of new business, based on past experience and own judgment.

There are various techniques in current use for assessing the data, assumptions and statistical quality of the internal model. These include:

- identifying the most financially significant variables;
- ensuring the parameters used are up-to-date at the time of the valuation;
- maintaining a record of changes to the parameter estimation;
- maintaining adequate records in a form easily accessible for use within the internal model;
- using goodness-of-fit tests to assess whether an internal model is appropriate; and
- where possible, use of back-testing⁸ and its link to validation.

The Directive refers to a 'probability distribution forecast' underlying the model and defines this as a mathematical function, which assigns to an exhaustive set of mutually exclusive events, a probability of realisation. This could be interpreted as a

⁸ See section 7.4

requirement for the internal model to produce an estimate of the capital requirement, or other appropriate metric, at different levels of probability. This assists in deriving the economic capital, and the regulatory SCR would be a further key output of the internal model.

The Directive does not prescribe methods for assessment of the probability distribution forecast. However, there is a requirement to use adequate actuarial and statistical techniques. 'Adequate' is taken to mean mathematically sound and reflective of the potential severity of the risks being examined. The methods used by the undertaking to calculate the probability distribution forecast must also be consistent with those used to calculate technical provisions, demonstrating the importance of linking reserving activities with the capital measurement function.

Undertakings may choose from a variety of approaches to assess capital requirements. These can range from a fully stochastic capital model (where each assumption is modeled using a simulation approach based on a statistical distribution) to a scenario-based approach (where the assessment of economic capital requirements is based on a series of extreme scenarios). Such approaches may be focused on the key drivers of the undertaking's risks, with a more simplistic approach applied for other, less risky elements, in line with the proportionality principle.

CEIOPS have issued advice on applying the proportionality principle to internal models⁹. An undertaking's chosen modelling approach must be considered in relation to the nature, scale and complexity of the risks it faces. This principle should also be understood to apply within an undertaking's internal model, such that an undertaking might model significant, complex risks in more detail than smaller, less complex risks.

An undertaking's modelling should be supplemented by scenario analysis¹⁰ in order to assess the impacts of extreme events, including the combined effects of such events on the insurance book, reinsurer creditworthiness, financial market conditions and the undertaking's physical and human resources. The extreme events should be based on historical and hypothetical events and should include 'ripple effects' where an event can have impacts in unexpected areas under extreme conditions. The use of scenario tests for extreme events is well developed and an important element of the validation of model output.

Many undertakings already identify the major methods (such as reinsurance, hedging of market and credit risks, securitisation) that they use to manage and mitigate risk and the threats to the effectiveness of that risk mitigation. The effects of such risk mitigants should be allowed for in capital modelling.

⁹ http://www.ceiops.eu/media/docman/public_files/consultations/consultationpapers/AdviceonProportionality.pdf

¹⁰ See Section 7.3

5. Calibration standards (Article 122)

Undertakings using an internal model to calculate their SCR may derive the SCR using a different time period or risk measure to that set out in the Directive as long as they can demonstrate to the supervisory authorities that policyholders and beneficiaries are provided with an equivalent level of protection. In this respect, the calibration standards aim to assess whether the SCR derived from the internal model has the appropriate level of prudence.

Undertakings may use a different accounting basis for their own internal purposes than that used for external reporting. This basis could be used in the internal model design and reporting. In such a case, an insurer may need to provide an analysis of the differences and demonstrate that their calculation of the SCR was equivalent to that required by the Directive, noting in particular the need for a market-consistent basis.

The Directive allows supervisors to require undertakings to run benchmark portfolios through their internal model. As an alternative, it may be more practical to use a sensitivity testing approach, which would consider the impact of changing certain key assumptions and/or variables within the internal model.

In addition, as per Article 110, undertakings may be required to estimate and report the standard formula SCR after having received internal model approval from the Authority; undertakings should be able to explain how the SCR from standard formula differs from that produced by their internal model.

6. Profit and loss attribution (Article 123)

Article 123 requires undertakings to review their causes and sources of profit and loss for each major business unit. Undertakings must do this analysis at least annually and show how the risk categorisation in the internal model explains the sources and causes of profit and loss. Furthermore the profit and loss attribution has to be a tool for validating the internal model (Article 124) and for managing the business (Article 120).

The Article 123 provisions relate to the need for models to be back-tested¹¹ (Article 124). We understand that the aim of the provision is to assess whether a model is adequately predictive in the light of the undertaking's experience, which means the model should be sufficiently granular to have flagged sources of profit and loss at an early stage and the risk of an undertaking not meeting its own targets, whether absolute or in terms of volatility.

¹¹ See Section 7.4.

The internal model should have a control cycle that ensures actual experience is applied to review the structure of the model and the assumptions underlying it, such as underlying forecasts.

Undertakings using an internal model will need to demonstrate that the internal model generates output figures that are consistent with actual experience. The undertaking will need to be able to explain the changes it has made to the internal model as a result of its analysis of experience.

7. Validation standards (Article 124)

7.1 Introduction

Undertakings should review and validate their internal model, demonstrating that appropriate risk and capital management processes are in place. Validation is an iterative process, by which an undertaking using an internal model demonstrates how it arrived at its risk estimates and confirms that its processes for assigning risk estimates are likely to work as intended. For the model to be used by management to inform its decision-making, it must first be understood to be a robust representation of prospective risk, not just at undertaking level but at component and sub-component level. Securing that outcome is likely to involve a range of people within an undertaking, including some not traditionally involved in capital management and modelling activities.

The validation standard links to the use test, in particular the requirement for the undertaking's senior management to be responsible for the continued appropriateness of the model (Article 120). The validation standard also links to Article 116, which requires the undertaking's senior management to have systems that ensure the model operates properly on a continuous basis.

The validation cycle will include the use of various tools, some of which are described in Sections 7.2 to 7.5. Once these validation tools are run, the results of the validation tools shall be analysed by the undertaking. This shall include a qualitative analysis of the outputs of the quantitative validation tools.

To achieve an effective validation, objective challenge is essential. Proper independence of the validation function will therefore be important, whether internal or external. Individuals performing the validation must possess the necessary skills, knowledge, expertise and experience. For some undertakings, use of external validation, at least in part, may be a suitable approach.

Responsibility for the design and continued operation of the internal model is the responsibility of the Board (Article 116) and is linked to the risk management

function. The Board needs to consider the nature of the validation process adopted and how their responsibilities might be delegated and reported back, including:

- responsibility for the validation process;
- regular management information on the validation of the internal model being presented to the Board and challenged by it;
- model documentation being adequate to allow independent validation of the internal model.

As part of the internal model design, the undertaking must include a regular cycle of validation and necessary updates of the internal model. However, undertakings may need to update their internal models more frequently than they had planned in some circumstances, for example, as an undertaking's situation changes (new management, new strategy, new lines of business, new competitor action, unexpected loss emergence, etc).

7.2 Sensitivity analysis and stability of the model

Sensitivity analysis is closely linked to, and to a certain extent difficult to isolate from, the statistical quality testing, back testing and stress testing analyses.

Sensitivity and stability analysis of an internal model consists of assessing the extent its outputs and valuations (e.g. regulatory capital requirements, economic capital, assets valuations, etc.) are sensitive to the underlying assumptions, structure and formulation. Issues related to the stability of the models used include reproducibility and change test.

The change test explains the differences in model outputs between two different runs. By performing this test, potential stability issues may be identified. This test should be performed on an ongoing basis.

It is important to be able to run a model several times with the same assumptions and verify that the same results are obtained each time, for instance, re-running a model with a different set of random numbers and assessing the stability of the results (i.e. reproducibility). This approach may also help to validate changes made to the model.

7.3 Stress and scenario testing

Stress testing is defined to be a risk management technique used to evaluate the potential effects on an institution's financial condition of a specific event and/or movement in a set of financial variables. It should focus on exceptional but plausible events.

A stress test typically aims to assess the impact of a single event, whereas, a scenario assesses the impact of a combination of events. Stress and scenario testing take many forms and are typically used as a validation tool (e.g. validating model assumptions) as well as in risk management and capital planning decisions (e.g. to identify key risk factors and allocate capital accordingly).

According to the IAIS¹², stress and scenario testing can be used by insurers to assess the impact of events. The IAIS¹³ recommends using regular stress tests for a range of:

- adverse scenarios - to assess the adequacy of capital resources when technical provisions have to be increased, and
- market scenarios and changing investment and operating conditions - to assess the appropriateness of asset allocation limits.

7.4 Backtesting

Backtesting is a validation technique that allows the assessment of the discrepancies between model forecasts and actual realisations. It is a method that allows an undertaking to improve the quality of its internal model by identifying and analysing the reasons behind deviations between actual and predicted values. This would help to shed light on the shortcomings of model assumptions, the calculation process, calibration, implementation etc.

The causes of such deviations can be various. In some cases, they may be due to some rare, unfavourable event and benchmarking with entities with a similar risk profile can be helpful.

Difficulties to carry out backtesting of insurance internal models may arise because of a long time horizon under consideration (i.e. one year), lack of data and homogeneity.

7.5 Benchmarking

Benchmarking is another validation tool, often recommended when the quality of data is not good enough to carry out the backtesting.

Benchmarking enables an undertaking to test whether the model results for a particular portfolio are equivalent to those of a similar portfolio or to those of

¹² “Guidance paper on enterprise risk management for capital adequacy and solvency purposes”, IAIS October 2008, and “Guidance paper on the use of internal models for regulatory capital purposes”, IAIS, October 2008.

¹³ “Insurance core principles and methodology”, IAIS, October 2003.

available public data. An example is the assessment of an internal rating system against an agency rating. The access to external data is a necessary condition for a benchmarking approach.

Similarly to backtesting, all sources of differences obtained by the benchmarking exercise should be carefully investigated, taking into account the model assumptions, methodology etc.

An insurance group can also perform benchmarking by comparing data from its subsidiaries and/or related undertakings or by using some external data.

8. Documentation Standards (Article 125)

Documentation of all internal models (both partial and full) should be thorough, sufficiently detailed and sufficiently complete enough to allow knowledgeable third parties to understand the internal model. Documentation is the principal way to communicate about an internal model with the supervisor.

Documentation should set out the current and historical situation of the model and enable new staff to understand and effectively use the model. It should also record the rationale for decisions on assumptions and parameters. The supervisor needs to understand that the undertaking has adequate documentation, but it is not yet established whether the supervisor will be required to review every part of the internal documentation as a matter of course. However, the supervisor will have the right to ask for more details as part of the approval process.

The Solvency II Directive requires undertakings to set out a detailed account of the theory, assumptions and the mathematical and empirical basis underlying the internal model, though it does not prescribe the media. Undertakings might consider innovative ways of documenting, using electronic media in addition to paper-based documentation. It would be useful to include reference to papers and other research that have informed the model design, as this would give further evidence of the technical standard of the model. Version control of documentation is an important consideration.

Undertakings are required to document the drawbacks and weaknesses of the model, including a description of the circumstances under which the model does not work effectively. This will show that the undertaking really understands the limitations of its model; there may be circumstances that the model cannot reflect, for example, extreme market circumstances beyond quantifiable levels, or future (unknown) changes in legislation affecting claims payments.

Undertakings are required to keep a record of version control of the internal model. Changes made, whether major or minor, to the design or operational details of the internal model shall be documented, including the rationale for the changes. All relevant testing and validation done in relation to model changes shall also be documented.

9. External models and data (Article 126)

The use of a 'model or data obtained from a third-party' is as acceptable as the development of in-house tools and this is recognised by the Directive. However, the use of a model or data obtained from a third-party does not exempt undertakings from complying with the internal models requirements described above.

Use of external models and data underlines the importance of management, control, documentation and operational transparency – all of which can be more difficult when using external data or an external model. Integration of external models and/or outsourced modelling activity into the undertaking's own capital model will be a key area of interest for supervisors, especially with regard to appropriateness to their business, transparency, correlation with other risks and associated sensitivity and scenario testing.

External data usage (eg mortality tables, operational risk databases, market knowledge of size of major losses) reflects existing industry practice and contributes to many aspects of risk management. As outlined in Section 4.1, the use of external data to supplement an undertaking's own data may be useful, especially where this provides additional data points for referencing.

For instance, in life assurance, an undertaking may use external mortality tables to give the shape of the mortality curve, but use its own experience to provide the overall mortality. Alternatively, undertakings might use a credibility adjustment to interpolate between its experience and the standard table. The standard table may be adjusted to reflect expected changes in mortality.

In non-life insurance, adjustments may be needed to reflect a changing business profile, undertaking-specific terms, conditions and limits as well as the nature of the insured risks.

It should be noted that most packages/systems/databases include an element of expert judgement, applied in adjusting the data, classifying the data or providing a usable piece of information. Examples of the application of expert judgement include:

Type of external data	Element of judgement
Mortality data	Development of the mortality table, projection of future mortality.
Economic scenario generator	Underlying distributions, calibration to past data, relevance to own business.
Catastrophe model	Probability of extreme events, vulnerability assessments, model scope and application.

A model obtained from a third-party could take one of several forms, such as:

- licensing a commercial capital management platform from a software supplier where the undertaking has to scope, design and programme its tailored version before populating the internal model with data;
- licensing a commercial capital management platform from a software supplier where the undertaking outsources the scoping, design and programming of its tailored version before taking over to populate the internal model with own data; and
- licensing specialist software to model specific types of risk (eg, asset risk, credit risk, non-life catastrophe risk, reinsurance optimisation) and/or the outsourcing of such modelling activities.

External model usage can have several advantages, such as:

- access to expert modelling techniques and experience, which might apply to any element of an undertaking's business or risks (eg, asset models, natural hazard catastrophe models) and provide an enhanced understanding of risk;
- outsourcing of the modelling of specific risks, enabling an undertaking to concentrate internal resource on the development of critical risk modelling activities; and
- outsourcing of the modelling of minor risks, where an undertaking does not have the expertise or resource to develop such models itself and where it is preferred not to use the standard approach to setting the SCR.

Outsourcing creates an additional interface for the undertaking to manage and it will retain responsibility for the standard of modelling and compliance with all requirements in that context. In particular, the undertaking retains the responsibility for any deficiencies of the internal model or data introduced by the use of external models or data. Additionally, undertakings shall demonstrate a thorough understanding of external models and data used in their internal model processes. In particular they shall be aware of model and data limitations.

10. Governance of the internal model

Article 120 also touches briefly on the governance of the internal model. The Board of the undertaking is required to be responsible for the design and operation of the internal model. This body is also responsible for ensuring that the internal model continues to reflect the risk profile of the undertaking. The Board should have within it a good working knowledge of the internal model, including which parts of the business it covers and which decisions it is used in.

The undertaking's internal audit function (Article 47) will review control procedures applying to the internal model to ensure that it is up to date, uses reliable data, is developed and operated by competent persons and has appropriate controls, etc, as part of their duty to evaluate the internal controls of the undertaking. The internal audit function should also review any external elements of the internal model to make sure they are fit for the purpose and are being used properly. The internal audit function should also check that an appropriate segregation of duties and challenge process routinely operates for all areas of the internal model.

The undertaking's actuarial function (Article 48) must contribute to the effective implementation of the risk management system (Article 44) in particular with respect to the design, calibration and build of the internal model, with a feedback loop being used to improve the model. The actuarial function should use the outputs of the internal model, for example in providing an improved understanding of its reserve volatility and may well use the internal model to assess the undertaking's technical provisions.

Where elements of the internal model are outsourced (Article 126) the undertaking will need to ensure that the quality of any outsourced work meets its requirements (as if it were not outsourced) and is appropriate to the nature of their business.

Undertakings using economic capital models should assess their economic capital regularly, both in terms of what is required and what is available (own funds) reflecting changes in risks, asset values, liability values and changes in their business and the external environment. An undertaking with a complex internal model may run the capital model element in full infrequently and update parts of it where necessary more frequently. Nonetheless, the assessment of the SCR should be run in full at least once a year, as detailed in Article 102. More frequent runs are generally appropriate where outcomes might be expected to differ to a statistically significant extent from the previous mean forecast of the model, or where an undertaking's own funds are close to regulatory capital requirements. The cycle of re-runs should fit with the undertaking's own risk reporting processes and systems.

Designing, building and maintaining an internal model requires expertise in risk management, capital management, regulatory requirements, finance and actuarial

knowledge. This may be found entirely within the undertaking or, in part, externally. The undertaking should decide on the appropriate balance, given the nature, scale and complexity of the risks it bears (Article 41 (2) refers).

Annex 1 - Glossary of abbreviations

CEIOPS – Committee of European Insurance & Occupational Pensions Supervisors

IAIS – International Association of Insurance Supervisors

MFSA – Malta Financial Services Authority

ORSA – Own Risk & Solvency Assessment

QIS5 – Fifth Quantitative Impact Study

SCR – Solvency Capital Requirement

SFC – Solvency & Financial Condition Report

TVaR – Tail Value at Risk

VaR – Value at Risk

Annex 2 – Internal Models Questionnaire

Q1. How do you plan to calculate the SCR with effect from implementation of Solvency II, (currently planned for October 2012)?

- (Tick one box only)
- | | | |
|------------------------|----------------------------|------|
| Standard Formula | <input type="checkbox"/> 1 | → Q5 |
| Full Internal Model | <input type="checkbox"/> 2 | → Q2 |
| Partial Internal Model | <input type="checkbox"/> 3 | → Q2 |

Q2. Have you actively started developing the internal model for use in your business?

- (Tick one box only)
- | | | |
|-----|----------------------------|------|
| Yes | <input type="checkbox"/> 1 | → Q4 |
| No | <input type="checkbox"/> 2 | → Q3 |

Q3. When do you intend to start developing the model? (please indicate month and year)

→ Q4

Q4. Please specify when you intend to complete the model development and submit the full application to the Authority for internal model approval. (Please indicate month and year)

→ Q8

Q5. Do you have plans to eventually use a full or partial internal model in the future for calculating the SCR?

- (Tick one box only)
- | | | |
|--------------------------|----------------------------|-------|
| Yes, full internal model | <input type="checkbox"/> 1 | → Q6 |
| Yes, partial internal | <input type="checkbox"/> 2 | → Q6 |
| No | <input type="checkbox"/> 3 | → Q17 |

Q6. Please give an indication of the year in which you intend to start developing a full or partial internal model.

→ Q7

Q7. How long do you expect it will take to have the envisaged model at the point where Solvency II approval standards might be met? (Please indicate number of years)

→ Q8

Q8. If you plan to seek partial internal model approval, for which risk modules, sub-modules or business lines in the SCR do you plan to substitute internal models for the standard model?

(You may tick more than one box)

- | | |
|--|-----------------------------|
| SCR non-life risk | <input type="checkbox"/> 1 |
| - non-life premium risk | <input type="checkbox"/> 2 |
| - non-life cat risk | <input type="checkbox"/> 3 |
| SCR market risk | <input type="checkbox"/> 4 |
| -currency risk | <input type="checkbox"/> 5 |
| - property risk | <input type="checkbox"/> 6 |
| - interest rate risk | <input type="checkbox"/> 7 |
| - equity risk | <input type="checkbox"/> 8 |
| - spread risk | <input type="checkbox"/> 9 |
| - concentration risk | <input type="checkbox"/> 10 |
| SCR health risk | <input type="checkbox"/> 11 |
| - long term | <input type="checkbox"/> 12 |
| - short term | <input type="checkbox"/> 13 |
| - workers compensation | <input type="checkbox"/> 14 |
| SCR default risk | <input type="checkbox"/> 15 |
| SCR life risk | <input type="checkbox"/> 16 |
| - mortality risk | <input type="checkbox"/> 17 |
| - longevity risk | <input type="checkbox"/> 18 |
| - disability risk | <input type="checkbox"/> 19 |
| - expense risk | <input type="checkbox"/> 20 |
| - lapse risk | <input type="checkbox"/> 21 |
| - revision risk | <input type="checkbox"/> 22 |
| - life cat risk | <input type="checkbox"/> 23 |
| SCR operational risk | <input type="checkbox"/> 24 |
| Business lines <i>(please describe below)</i> | <input type="checkbox"/> 25 |

→ Q9

Q9. What are your main reasons for planning to seek full or partial internal model approval?

(You may tick more than one box)

- Better risk management 1
- Better capital management 2
- Lower regulatory capital 3
- More transparent decision-making 4
- Other reason/s (please specify) 5

→ Q10

Q10. Do you plan to make use of external models and/or data obtained from a third-party?

(You may tick more than one box)

- Yes, external models 1 → Q11
- Yes, external data 2 → Q11
- No 3 → Q14

Q11. Why are you planning to make use of external models and/or data?

→ Q12

Q12. How do you plan to verify the adequacy of the external models and/or data to ensure that they are consistent with the standards and requirements set out for the use of an internal model to calculate the SCR?

→ Q13

Q13. Have you identified the third parties with whom you plan to engage with to provide your undertaking with external models and/or data? (If already identified, please give name of service providers)

→ Q14

Q14. Who is/will be the person responsible for the development of a full or partial internal model in your undertaking? (Please give name of contact person)

*(Questions 15 & 16 are to be answered **only by those undertakings which are part of an insurance group**)*

Q15. Will your undertaking make use of a group internal model to calculate the solo SCR?

Yes 1 (Tick one box only) → Q16
No 2

Q16. Briefly explain what measures you will take to ensure that the risk profile of your undertaking does not deviate from the assumptions underlying the group internal model.

Q17. If you are going to use the standard formula with effect from implementation of Solvency II, why is that the case?

(You may tick more than one box)

- Standard Formula is adequate 1
- Too expensive to develop and maintain an internal model 2
- Too demanding to develop and use an internal model 3
- An internal model brings about a too large administrative burden 4
- Other reason/s (please specify) 5

→ Q18

Q18. Please provide reasons why you believe that the assumptions underlying the standard formula work well to describe your company's risk profile.
