Article:
Auditing estimates: what will the future bring?

EY Global Financial Services Institute

March 2015 | Volume 3 - Issue 1
Abstract
Under Solvency II, national competent authorities are requesting audit procedures to be performed on all supervisory reporting. Reports will contain more information based on projections of future cash flows. The level of assurance from the Solvency II external audit is expected to be similar to the opinion provided by auditors on financial statements, i.e., reasonable assurance. Current guidelines represent only minimum requirements. So, when is good, “good enough” for the external auditor? In this article, we suggest to analyze the (audit) findings on model outputs against a reasonable range. And in specific situations, this range can exceed the traditional “tolerable error” (TE). We translate the qualitative assessment of a reasonable range and make it quantifiable and objective. We will do so by defining a tolerable range based on sensitivities of inherent variability of underlying key risk drivers. This is needed because audit materiality and TE measures are mainly focusing on “errors” (or misstatements), and are often based on less substantiated and sophisticated approaches. However, when using model outputs in which key model design and parameter choices have to be made, and cash flows are projected long into the future, it is quite often not a question of simply being “right or wrong.”
1. Introduction
In June 2013, the European Insurance and Occupational Pensions Authority (EIOPA) issued its second “unofficial” pre-consultation paper concerning “Proposals on Guidelines on External Audit.” The proposed guidelines require the statutory auditor to perform an audit on quantitative and qualitative elements of the Solvency Financial Condition Report (SFCR) of insurance companies. In particular, the Solvency II balance sheet, own funds (including the eligibility and tiering of fund items), and minimum – and solvency capital requirements (MCR and SCR).

Not awaiting EIOPA final guidelines, the PRA in the U.K. released their Solvency II audit instructions to the market on 16 October 2014. Likewise, the National Bank of Belgium (NBB) is requesting audit procedures to be performed by the insurance company’s statutory auditors on all supervisory reporting within the scope of the Solvency II interim measures.

Reporting for internal and external purposes will contain more information about projections of future cash flows. The level of assurance from the Solvency II external audit is expected to be similar to the opinion provided by auditors on financial statements, i.e., reasonable assurance. The (proposed) guidelines represent only minimum requirements. So, when is good, “good enough” for the external auditor?

2. Solvency II audit
In the audit of a Solvency II economic balance sheet and risk-based capital requirements, the auditor evaluates the outcome of complex models and complicated processes. The model outputs are often the result of various model choices, (risk) data vendor selection and significant assumptions (such as scenarios of future events or stochastic model specifications), among others. Auditors will need to involve actuarial experts in the audit.¹

¹ International Standards on Auditing (ISA) 620, ‘Using the work of an auditor’s expert.’
A model outcome, or in audit terminology “the accounting estimate,” is highly sensitive to assumptions used and, therefore, subject to high estimation uncertainty. As a consequence, the range of possible reasonable outcomes can be quite wide. This range could be much wider than the reporting materiality threshold applied for auditing the Solvency II balance sheet, taken questions should be answered:

- Is it acceptable to apply a range of reasonable outcomes that is broader than the traditional audit materiality?
- Can we develop a method to define reasonable ranges in case of high estimation uncertainty?

In this article, we aim to instigate a wider discussion on this topic in the insurance sector, and to advocate for a closer working relationship between auditors and actuaries. We will develop an audit approach for quantifiable and justifiable derivation of reasonable ranges for model estimations in balance sheet items, where a simple “right” or “wrong” cannot be determined with classical audit methods. But first we start by providing some background on the concept of audit materiality.
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Box 1: Audit guidelines
The “Proposals on Guidelines on External Audit” issued by EIOPA require that auditors will place reliance on the model validation process, since it is part of the supervisory approval. Such reliance is subject to the auditor's assessment of the effectiveness of the internal controls related to the internal model validation process. The Solvency II model validation standards, however, do not give materiality guidance for the evaluation of the model validation findings and results, nor does it focus on the Solvency II balance sheet and application of the “standard formula.” The guidance provided is more from a technical and governance model validation perspective; for example, requirements around processes, controls and calibration. Validation reports often conclude with sensitivity analyses or an extrapolation of a sample test outcome. But when are these results within an acceptable range?

The scope in the PRA (U.K.) guidelines\(^2\) includes all “internal model” firms plus the larger firms that apply the so-called “standard formula” under Solvency II. They require a “reasonable assurance” opinion on the balance sheet, technical provisions (excluding risk margin) and own funds as at 31 December 2014. This opinion needs to be from an external audit firm – not necessarily from the external auditor. To prepare for this audit, firms are first requested to provide a “review and recommend” report on their preparedness to implement the Solvency II regulatory framework.

NBB is also requesting audit procedures to be performed by the insurance company’s statutory auditors on all supervisory reporting within the scope of the interim measures. Aware that entities are still preparing for Solvency II, the NBB does not request a standard audit opinion on this quantitative and qualitative information, but a detailed report of findings. This should provide the regulator with a comprehensive overview of the level of readiness for Solvency II in the entire industry, as well as differences in practices and interpretation of the rules.

\(^2\) http://www.bankofengland.co.uk/pru/Documents/solvency2/balancesheetreview.pdf.
3. Background on audit materiality
With regard to the question of whether it is acceptable to apply a range of reasonable outcomes, which is greater than the traditional audit materiality, consideration should also be given to what is written in the current auditing standards (ISAs: International Standards on Auditing). We discuss two standards: ISA 320 and ISA 540.

ISA 320,\textsuperscript{3} which provides a general guidance, stipulates that in auditing financial statements, the overall objective of the auditor is to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement. Misstatements are considered to be material if they, individually or in aggregate, could reasonably be expected to influence the economic decisions of users taken on the basis of the financial statements. In addition, ISA 320 indicates that to determine the audit materiality, a percentage is often applied to a chosen benchmark. Examples include a percentage of “profit before tax” and a percentage of “equity.”

When applying this concept to a Solvency II balance sheet, we expect to see the audit materiality set at a percentage of “own funds.” Based on this threshold, a TE is defined. The TE is the maximum misstatement amount(s); set by the auditor at less than audit materiality for the financial statements as a whole. This is done to mitigate the probability that the aggregate of uncorrected and undetected misstatements exceeds audit materiality.

ISA 540\textsuperscript{4} more specifically discusses the issue described above. It recognizes that developing “a range” to evaluate management’s estimates may be an appropriate audit response. It requires that range to encompass all “reasonable outcomes” rather than all possible outcomes (the latter would be too wide to be effective for purposes of the audit). Also, ordinarily, a range that has been set to be equal to or less than TE is adequate for the purpose of evaluating the reasonableness of management’s estimate.

\textsuperscript{3} ISA 320, “Materiality in planning and performing an audit”.
\textsuperscript{4} ISA 540, “Auditing accounting estimates, including fair value accounting estimates, and related disclosures”.
However, the standard continues to say that, particularly in certain industries, it may not be possible to narrow down the range to below the TE amount, and that this does not necessarily preclude recognition of the accounting estimate. It may indicate, however, that the estimation uncertainty associated with the accounting estimate is such that it gives rise to a significant risk. In such cases, the auditor’s further substantive procedures are focused on evaluating how management has assessed the effect of estimation uncertainty and the adequacy of the related disclosures.

In this regard, the standard describes that management may evaluate alternative assumptions or outcomes of the accounting estimates through a number of methods, such as undertaking a sensitivity analysis. Please note that, in addition to business and risk management purposes, certain accounting frameworks require disclosure of this information, such as IFRS4 and IFRS7.

Based on the above guidance, it can be concluded that it would be necessary to analyze the (audit) findings on model outputs against a reasonable range. And in specific situations, like for the financial services industry, this range can exceed the traditional TE. The challenge we face now is: how to translate the qualitative assessment of a reasonable range, and make it quantifiable and objective? We believe that we can take a step toward such an assessment by defining what we refer to as a “tolerable range” based on sensitivities of inherent variability of underlying risk drivers. We believe we need to add this concept because audit materiality and TE measures are mainly focusing on “errors” (or misstatements). Thresholds for acceptable ranges are often based on less substantiated and sophisticated approaches (e.g., a certain percentage of the booked reserve). However, when using model outputs in which key model design and parameter choices have to be made, and cash flows are projected long into the future, it is quite often not a question of simply being “right or wrong.”

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4. Assessing models
When assessing (the output from) a valuation or risk model, the auditor should, among others, evaluate the model's theoretical soundness, mathematical integrity and appropriateness of the model parameters (ISA 540). These are common elements as part of a model validation process, and are also referred to as follows:

- **Theoretical soundness**: representativeness or fit for purpose
- **Mathematical integrity**: arithmetical correctness
- **Appropriateness of the model parameters**: objective measurability of parameters

We will initially focus on these elements in order to be able to define a tolerable range in a quantifiable and objective measure. As will be described later in this article, just doing this is not sufficient to form the auditor’s opinion — similar to model validation being much more comprehensive than merely looking at these three elements.

In assessing the representativeness of input and methodology the verification focuses on whether the model and input used are “fit for purpose” (e.g., interest curve used, basis spread correction) and whether the methodology is widely used and is a market (leading) practice. The arithmetical correctness can be tested, for example, by parallel modeling using the same input as that used for the assessment value or even parallel modeling using underlying contractual input and market information obtained independently. The objective measurability of input parameters can be determined by reconciliation of static input data with underlying contracts and/or systems and reconciliation of market input data with objective systems (data providers, such as Bloomberg and Reuters). By assessing model outputs using these criteria, assessing one of these criteria often implicitly contains a (partial) assessment of the other elements.

To determine the arithmetical correctness and representativeness of a valuation or risk model, the analysis could be based on the difference between the model output under a parallel replicated model, alternative method(s) and the assessment value.
We appreciate that parallel modeling is not always feasible in full, but model points and/or benchmark portfolios and/or parameters can provide sufficient insight for audit purposes. A conclusion can be drawn based on objective measures, such as:

- The absolute difference
- The relative difference
- The absolute difference expressed as a percentage of the sensitivity of the assessment value to changes in key assumptions/parameters

The objective assessment measure selected depends on the goal of the audit procedures performed. For example, in validation procedures for financial derivatives valuation, we generally use the third method described above. This provides a sufficient level of comfort on the arithmetical correctness and, to a certain extent and as a bonus, also the representativeness and even objective measurability of the derivative valuation method.

5. **DV01: dollar value of 1 basis point**

The objective measure based on the absolute difference expressed as a percentage of the sensitivity of the assessment value to changes in key assumptions/parameters is generally referred to as the DV01 method. A DV01 is the sensitivity of the value of a financial instrument, like a derivative, to a 1 basis point (bp) change (parallel shift) in the underlying interest curve. Mathematically, DV01 estimates the “first derivative” to the interest rate of the valuation function.

Looking at a DV01 for interest rate derivatives makes sense. Many derivatives are based on a fictive notional, meaning that the notional is not transferred but used as reference to base the coupon payments on, and are structured on large (implicit or explicit) long and short positions. For example, an interest rate swap (IRS) has a value of nil at issue date because the (large) notional/value of the floating and fixed leg are equal. After the issue date, the fair values of the floating and fixed leg change due to remaining maturity and changes in underlying market interest rates.
The fair value of the IRS is the net value of both legs. This net value is, therefore, very sensitive to the underlying interest rate curve. Hence, differences with other models and/or parameters can easily occur, but are not necessarily an error, and the auditor wants to know when “good is good enough” for audit considerations.

Differences can be explained by varying definitions and/or interpretations and/or choices of day-count conventions, inter- and extrapolation, choice of data vendors to extract interest rate curves from etc. When auditing the value of interest rate derivatives, 3 times DV01 could be an acceptable range, the tolerable range, for the setting of a materiality threshold. This “3” is the inherent variability and chosen for European IRS based on the following rationales:

- Movements of 3 bps to 5 bps during a business day are normal for euro IRS rates.
- Differences of 2 bps to 4 bps at a point in time is seen for euro IRS rate between different data vendors.

This inherent variability is the objective range in which the risk driver lies “as a fact of life” and can be seen as the intuitively reasonable range that is not neither right nor wrong by definition. Hence, a tolerable range based on valuations from 3 bps change to interest rates could be reasonable to audit the assessment value. This means that when the difference between the assessment value and the output of the parallel model is below 3 times the DV01 of the parallel model, this difference would not be considered as being material.

With this in mind, we are able to set a materiality threshold objectively for the purpose of mathematical correctness. Note that this measure will be proportional to the underlying assessment value. Indeed, in the New World where many reports are based on model output, we believe that materiality is an important consideration in model risk management, and a proportionate risk-based approach is practically sensible.

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6 In this example, we assume euro denominated derivatives; for other currencies and/or other complex derivatives with, for example, Steeper features, the DV01 and/or TR might not be appropriate.
This means that when the auditor determines the materiality for the object on which assurance is expressed, the tolerable range should be based on different materiality considerations per model, per risk driver, per usage and per disclosure; like the case for TE to reduce the probability to an appropriately low level that the aggregate exceeds materiality.

To illustrate the concept of DV01, let us consider an IRS example by assessing the value of a €100 million notional receiving 2.5% fixed/pay floating swap. The assessment value equals €1,492,594.

We determined a value using a parallel model of €1,255,579, resulting in a difference of €237,015.

The auditor has a tolerable error threshold of €150,000. Remember, this is the “traditional” threshold in terms of error for reporting purposes. Is the difference material?

In this example, we probably would not conclude so. The DV01 is determined as €81,405, and 3 times DV01 at €244,215 (TR), which is higher than the difference between the assessment value and the value determined using a parallel model.

By looking at the inherent variability of the risk driver, we also need to look at the objective measurability of the underlying risk driver. And the parallel model used to assess the audit estimate is not necessarily the exact same model as that used for the assessment value. One could have used a stochastic model to value a European equity option whereas this parallel model could be built on, for example, a binomial tree or closed form Black-Scholes formulas when these are also market practice for the valuation of the option. So, when determining the arithmetic correctness and the representativeness (fit for purpose), the model outcomes are only “as good as the input” - the parameters (or risk drivers) needed in the valuation function or in the risk function. Inherently, there is uncertainty around the parameters chosen. In setting a parameter, there is often expert judgment involved. As long as the parameter is within a reasonable range defined by the expert, there might not be a misstatement issue.
As part of the audit procedures, it should be determined whether the expert uses all relevant data and should be able to substantiate their choice. This is a governance discussion that continues to be crucial in audits. To what extent are policies set, controls on assumption setting available and effective, model choices documented and approved etc. We will elaborate on this further in the section describing “the audit of the estimation process.”

Can we apply this concept to assess acceptable ranges for the valuation and risk measurement of insurers businesses as well?

6. DVOC method
As previously mentioned, a DV01 model where interest rate is the key parameter is defined as the difference in value from the model as a result of a 1 bp change in the yield curve. A DV01 model where volatility is the key parameter could be defined as the difference in value from the model by changing the volatility by 1% (i.e., estimating the “Vega”). Next, we can determine the inherent variability of (implied) volatilities to set the multiplier for that “DV01.” The same could be generalized for some noneconomic parameters (risk drivers) like lapses, mortality, etc.; hence, looking at the (estimated) set of (mathematically spoken) “first partial derivatives” of the valuation (or risk metric) function.” We have defined these sensitivities based on (inherent) variability as Delta Value of Change (DVOC).

Insight in the DVOC has clear advantages. One advantage is that it allows us to determine the key parameters driving the majority of the model output. Experience has shown that more than 95% of the results, in terms of an economic value like “solvency own funds” or a risk metric like “solvency capital requirement,” can be explained by only a limited number of input parameters – these are the function's key risk drivers.

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7 In mathematics, a partial derivative of a function (in this article the function is the model used to estimate the economic value or risk metric) of several variables is its derivative with respect to one of those variables, with the others held constant. Partial differentiation is the act of choosing one of the lines to every point on this surface and finding its slope. The slope of this line is a measure of the sensitivity of the functions outcome around the input parameter.

8 This has already been acknowledged in the evolution of embedded value principles for life insurers over the years where sensitivities have to be disclosed.
Another advantage is to continue the analysis by using these key risk drivers to determine and analyze their (inherent) variability. This can and should be used to determine the acceptable range of resulting outcomes —the tolerable range for audit purposes by setting objectively a multiplier of DVOC as that range (like the “3” for DVO1).

We believe there are other advantages to using DVOC — one being for ‘analyses of changes’ (or ‘movement analyses’). We will describe this later in the article.

Like for swaps, the value of an insurance liability is often also at net value: the difference between the discounted value of future premiums and the discounted value of future benefits. Likewise for risk metrics.⁹ Therefore, we see the benefit of generalizing the concept of DVO1 to DVOC.

We will use two case studies in the remainder of this article to elaborate on the concept of DVOC and to show some remaining challenges. We will cover both assets and liabilities, as well as the solvency capital requirement (based on Solvency II standard formulae). In the first case study we will look at a stylized life insurance company and its capital position. Based on Solvency II principles, we will determine a market value balance sheet and its solvency capital requirement. Because we know upfront that the figures are dependent on choices (preferences?) in parameter setting and inherent variability of various risk drivers, we will apply the DVOC concept to this particular audit example.

This means that we want to gain insights into the key parameters (those that matter the most), the objective range of parameter possibilities (for example, based on the inherent variability of these parameters) and hence a measure of model materiality, the tolerable range.

The second case study covers a non-life insurer for which the estimation process seems to have a much wider range of sensitivities; hence, additional audit procedures need to be performed. For this case study we limit the example to the economic values of the insurer’s liabilities.

⁹ Like the solvency capital requirement as a surplus-at-risk measure, the surplus is the net difference between all market valued assets and liabilities.
7. Case study 1: life insurance

We consider the insurance company Solve & See Life, that has an insurance book consisting of the following two products:

- Annuities: insurance contracts consisting of annual payments to the policyholder for as long as the policyholder is alive; the annuities are financed by a single premium payment by the policyholder at the start of the insurance contract.
- Term insurance: life insurance contracts that pay out in case of death (whole life coverage); the whole life insurance contracts at Solve & See Life are financed by a single premium payment by the policyholder at the start of the contract as well.

Table 1 presents the base assumptions used for valuation of the life insurance liabilities by Solve & See. Please note that in this example, for simplification purposes, the risk margin has been set to zero and annual expenses are not included in the best estimate calculation.

For discounting the future payments, we used the yield curve as published by the Dutch National Bank. This yield curve is based on European swap rates for maturities up till 20 years. For maturities above 20 years, the yield curve is extrapolated by converging the one-year ultimate forward rate to 4.2% over a 40-year period.

Table 1: Valuation assumptions of the life insurance liabilities of Solve & See

<table>
<thead>
<tr>
<th></th>
<th>Annuity</th>
<th>Term insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality forecast</td>
<td>A5 2012-62</td>
<td>A5 2012-62</td>
</tr>
<tr>
<td>Mortality experience factor</td>
<td>ES-L2 10</td>
<td>100%</td>
</tr>
<tr>
<td>Life expectancy at 67 male/female</td>
<td>21.4 / 22.5 years</td>
<td>18.6 / 21.1 years</td>
</tr>
<tr>
<td>Yield curve</td>
<td>EUR Swap curve w/ UFR 31 Dec 2013</td>
<td></td>
</tr>
</tbody>
</table>

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10 Mortality experience based on observations in Dutch insurance market for annuities during 2007-09. ES-L2 (Ervaringssterfte Lijfrente 2) Mortality experience Annuities 2. The mortality assumptions (and acronyms used in the table) will be discussed further.

11 DNB curve including UFR
Method yield curve: http://www.toezicht.dnb.nl/5/19/10/50-205324.jsp
Yield curve: http://www.statistics.dnb.nl/usr/statistics/excel/t1.3nm.xls
7.1 Mortality assumptions
For the chosen products, it seems clear that mortality rates and interest rates are the key risk drivers in the valuation of these products. So we start by identifying the inherent variability of mortality range in particular (for interest rate we refer to the DV01 section), as the first step to determining the tolerable range. In recent years, there have been initiatives to securitize longevity and mortality risk through, for example, the construction of longevity bonds, mortality swaps or “qx forward/future” contracts.\(^\text{12}\)

However, currently the market volume of these mortality-related investment products is not yet sufficient to derive (local) market prices for mortality rates. Objective measurability of used mortality assumptions by reconciliation to quoted market data is therefore not possible, contrary to, for example, swap rates.

Within an audit where the focus is on mortality assumptions, an actuary would typically use the base table mortality rates and future mortality improvements available. The base table is derived from general population data adjusted to reflect the portfolio’s current mortality experience, while future mortality improvements are obtained from industry or countrywide forecasts.

After analyzing “equally valid” mortality tables and approaches for mortality improvement factors, we conclude that the inherent variability is equivalent to a change of 5% mortality rate improvement and equivalent to the difference between two mortality tables under inspection.

So, let us have a look at some numbers. In our example, we assume, after testing, that the following model points are representative of the total life insurance portfolio of Solve & See:

- Male and female age 67, with annual annuity payments of 105
- Male and female age 67, with a term insurance coverage of 1,000

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The assets on the balance sheet are listed equities, government bonds (coupon 3% and remaining maturity 10 years), and an existing 15-year 3% fixed/Euribor floating swap with a notional of 1,650 (all free from default, spread and concentration risk). Table 2 presents a (simplified) Solvency II balance sheet of the firm. The Solvency Capital Requirement based on Solvency II standard formula amounts to 562, resulting in a solvency ratio of 150%.

Figure 1 and 2 show the impact of the sensitivity of the different risk drivers on the balance sheet, as well as the Solvency II capital requirements.

**Figure 1:**
*Impact of change of risk driver on balance sheet compared to best estimate scenario*
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Figure 2:
Impact of change of risk driver on capital requirements compared to best estimate scenario

Table 2: Market value balance sheet of Solve & See, year-end 2013

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>Own funds</td>
</tr>
<tr>
<td>Bonds</td>
<td>Life insurance liabilities</td>
</tr>
<tr>
<td>Swap</td>
<td>Annuity</td>
</tr>
<tr>
<td></td>
<td>Term insurance</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>1,000</td>
<td>842</td>
</tr>
<tr>
<td>4,431</td>
<td>4,683</td>
</tr>
<tr>
<td>94</td>
<td>3,517</td>
</tr>
<tr>
<td>1,166</td>
<td></td>
</tr>
<tr>
<td>5,525</td>
<td>5,525</td>
</tr>
</tbody>
</table>
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Table 3: Solvency capital requirement Solve & See, year-end 2013

<table>
<thead>
<tr>
<th>SCR</th>
<th>Market risk</th>
<th>Life risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equity risk</td>
<td>Longevity</td>
</tr>
<tr>
<td></td>
<td>Interest rate risk</td>
<td>Mortality</td>
</tr>
<tr>
<td></td>
<td>Diversification</td>
<td>Catastrophe</td>
</tr>
<tr>
<td>Total market risk</td>
<td></td>
<td>Diversification</td>
</tr>
<tr>
<td>SCR</td>
<td>Market risk</td>
<td>Life risk</td>
</tr>
</tbody>
</table>

The reference point is the risk dashboard in table 3, for which the base assumptions (BE = best estimate based on the mortality table from the Dutch Actuarial Society - AS 2012-62) are used as described at the start of this case study.
Box 2: Inherent variability of mortality rates

Base table mortality rates
The base table represents the current mortality rates for the insurance portfolio. Starting point for this base table is general population data for the country in which the insurer operates, as these general population mortality rates are based on the largest sample possible for that region. The population in the insurance portfolio is a subset of the general population and can have different mortality characteristics than the average person. Consumers who buy immediate annuities are often healthier than the general population (and therefore have lower mortality rates). The difference in mortality rate is expressed in a mortality experience factor, based on experience in the portfolio. An experience factor of, for example, 80% means that the mortality rates of the policyholder is 20% below general population.

Mortality experience factors are estimated based on an experience analysis of the observed deaths in a portfolio relative to expected deaths according to the general population table. The uncertainty in these experience factors depends on a number of factors including the size of the portfolio, the observation period chosen and the extent of detail of the experience rates (one factor, or gender, and/or age dependent).

As an indication of the sensitivity of the market value of life insurance liabilities, we have analyzed a parallel relative shock of experience rates by 1% (i.e., where a mortality factor of 80% on general population mortality rates is applied, this is shocked to 80.8%) and the relative impact on the market value. The difference, or DVOC, is shown in Figure B1. The result can then be used for setting a tolerable range depending on portfolio specific uncertainty of experience rates - the inherent variability.

For life annuities, the difference, or DVOC, of the parallel shock on the market value of the liabilities increases with age; while for term insurance, the difference decreases by age.
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Figure B1: DVOC for the market value of liabilities as a function of age in case of 1% relative shock (decrease) on mortality experience factors
Future mortality improvements

So, what is the inherent variability for mortality experience factors? There is a wide variety of methods to forecast future mortality improvements.\textsuperscript{13} These methods can be divided into three general approaches:

1. Expectation of mortality development
2. Extrapolation of historical mortality development
3. Explanatory approach by using causes of death

Given the wide variety of methods and approaches available, there are multiple (equally acceptable) mortality forecasts for the same population that all have a valid rationale but generate different results. Analysis shows that these methods lead to differences in mortality improvement assumption over 1%. Differences in the base assumed mortality rates (different mortality tables that are available to the insurer) should also be investigated. The knowledge of both analyses can then be used to determine the inherent variability of the underlying risk driver (i.e., mortality assumptions), and hence the factor to multiply the DVOC with to determine the tolerable range for the value of the liability.

In several countries, the local society of actuaries have set up mortality forecast models; some with variable parameters and variable output (for example, CMI in the U.K.)\textsuperscript{14} and others with fixed parameters and output (for example, the Dutch Actuarial Society).\textsuperscript{15} In addition to these forecasts, other projections are available from government institutes like the Bureau of Statistics (CBS).

\textsuperscript{14} http://www.actuaries.org.uk/research-and-resources/pages/continuous-mortality-investigation.
\textsuperscript{15} Antonio et al., 2012, Prognosetafel 2012-2062, Actuarieel Genootschap.
As previously mentioned, inherent variability could, therefore, be seen as variability among the different mortality rate forecasts and subsequently the tolerable range as the relative spread of the liability value results using these different (generally accepted) population mortality forecasts. For example, we have analyzed the following mortality forecasts available in the Netherlands:

- CBS forecast 2012–60: projected mortality rates taking into account smoking related deceases and convergence to Western European mortality trend.

Both forecasts are updated every two years. As the Actuarial Society forecast is directly derived from observed mortality, we have also created forecast 2013–62 by extending the used observation period for the short- and long-term average to 2012.

Figure B2 shows the variability of the present value of the annuity and term insurance product for the different equally accepted mortality projections. The update of the Actuarial Society model with an extra observation year led to a slight increase in future mortality rates compared to the 2012–62 forecast. The impact has, therefore, been to decrease the present value of the annuity and increase the term insurance product. Further analysis showed that using an alternative forecast, the CBS 2012–60 forecast, led to a further decrease/increase in present value for the annuity/term insurance.

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Figure B2: Cumulative DVOC for annuities (left) and term insurance (below), for impact of Actuarial Society model by new observations (yellow) and further change as a result of using a different accepted model/forecast (CBS forecast)
The following risk drivers are concluded to be key and hence, taken into account:

- **Mortality forecast:** the assumption for future mortality improvements is adjusted to other equally accepted forecasts, in this case CBS 2012–60; this should reflect the inherent variability on mortality forecast.
- **Mortality experience rates:** to reflect current mortality rates observed in the portfolio, general population rates are adjusted with experience factors. The uncertainty of these experience factors depends on a number of factors, like the number of observations used in the experience study. We analyze the impact of a relative 5% increase of all mortality rates and a 5% decrease of all mortality rates; this reflects the inherent variability on mortality experience rate assumptions.
- **Interest rate:** the yield curve is increased and decreased with three basis points; this should reflect the inherent variability of the use of the interest rates (instead of 1bp sensitivity shock and multiplying with 3 afterwards to show differences in this stylized example easier).

### 7.2 Analyzing the results

Graphically it is easy to see that SCR is relatively stable whereas the own funds are more sensitive. Hence the Solvency II ratio is sensitive. The impact of the mortality forecast on the market value of the liabilities amounts to -2% on the annuities and +2% on the term insurance, which is in line with analysis performed (see Box 2). As the annuities are the biggest part of the liabilities, the total liabilities decrease and the own funds increase by 5%. In the calculation of the required solvency capital however, the decrease in interest rate risk is offset by an increase in longevity risk, resulting in a relatively stable SCR (+0.5%). Still, the solvency ratio increases by 6% point.

The impact of a permanent increase or decrease in mortality rates, indicating possible inherent uncertainty in the current level of mortality rates, is similar to a change in mortality forecast, in this case of a 5% shock of mortality rates. This demonstrates the importance of statistical analysis on the experience factors used by an insurance company. The impact on liabilities is about 1% for both the annuity and term insurance portfolio (and in line with the analysis shown in Figure B1 in Box 2 for a 1% shock - 0.2%).
The 3 bp shock shows the interest rate sensitivity of both assets and liabilities. Note that the swap is, as expected, most sensitive to the interest rate shock (6% for the swap but only 0.3% for the insurance liability). Furthermore, we see that both mortality forecasts, using BE or CBS rates, are similarly sensitive to the interest rate shocks. This is not too surprising as the sensitivity is just the delta (the difference between assessment value and shocked value).

The main risk drivers in this example, per the balance sheet item, seems clearly to be mortality and interest rates. The mortality forecast available produces a solvency ratio range of 150%-156%, while the level of mortality leads in this case to a range of 144% -156%. The solvency ratio itself seems quite stable based on the DVOC for interest rate (or in this case DV01) - the swap seems to do its work quite well. These ranges could, therefore, be used to set the total tolerable range for the life insurance portfolio; the range could potentially be set to 144%-156% or even larger when combined with the DVOC for mortality forecast. However, like setting the tolerable error as part of total materiality, the tolerable range could and should also be translated using underlying key components of the total balance sheet to reduce to an appropriately low level the probability that the aggregate of uncorrected and undetected misstatements exceeds materiality.

Concluding that DVOC for SCR for interest rate is close to zero, should also trigger the question of whether the swap position is correct in the first place. The model tells us that if no swap was entered into, or the existing swap was agreed against less favorable conditions (e.g., at a time the fixed interest rate was, say 2.5% instead the current 3%) the SCR ratio would be much worse. In the base scenario, the SCR would be 130% when interest was agreed at 2.5% and even only 113% if no swap was entered into at all.
That is why it is important to also look carefully at the constituents of the balance sheet and the quality of data used (exposure and risk data assessed for completeness, accuracy and reliability). This might even have a larger impact on the ratio than the validity of the model itself. And this is not an inherent variability.

8. Case study 2: general insurance

In this case study we will evaluate the model materiality of claims reserves in property and casualty insurance. General insurance liabilities are known for their wide variety of underlying insurance risk types, ranging from medical expenses to environmental liability and natural catastrophe losses. The actuarial techniques used to estimate the claims reserves are also known for their extensive use of expert judgment. We will show why model assessment here has to focus on theoretical soundness and objective measurement of parameters, given the large material impact of model selection.

Let us analyze the company Solve & See P&C, with a book of business consisting of:

- Motor/truck liability commercial lines
- General third party liability (GTPL)
- Motor liability private lines
- Product liability
- Workers compensation

A general characteristic of liability claims is possible delays in the claims reporting, as well as long duration of claims handling.

Consequently, the claims reserves per event year can have a run-off lasting more than 20 years. The actuarial department of Solve & See uses a structured way to select the valuation model in three steps:

1. Optimized paid chain ladder: a run-off analysis on the cumulative payment data; for the two most recent event years, if they have developed less than 75% of the estimated ultimate claim size, the method switches to a loss ratio calculation derived from the older event years, applied to the earned premium of the current event year.
2. **Optimized incurred chain ladder**: the same analysis on the cumulative incurred claims data (paid plus outstanding case reserves), with the same switching regime.

3. **Final average**: the best estimate reserve is chosen as the nominal average of both results.

The approach here is just one example of widely used approaches. In practice, the model selection depends heavily on the reliability of the available data. Note that payment data are “exact,” but outstanding case reserves are estimates made by claims handlers that apply their expert knowledge combined with standardized methods. It is very common that these reserves are overestimated. Typically, actuaries take into account additional information from the claims department to interpret the data. For parameter setting, more expert judgment is applied, for instance, in smoothing the outliers, trend fitting and other selections. In addition, more detailed data can be used to estimate the claim numbers and the claim amounts separately, or more statistically validated regression techniques can be applied.

As stated previously, there is no common opinion on the best practice methodology choice. To illustrate the large volatility of model results, we have tested the theoretical soundness of this valuation approach on a large market dataset from the U.S.\(^\text{17}\) This is a dataset of the National Association of Insurance Commissioners, made available to the Casualty Actuarial Society for public use. It consists of over a thousand sets of 10-year run-off statistics (both payments and incurred data) for six different lines-of-business\(^\text{18}\) from 376 U.S.-based property and casualty insurance companies. This dataset can be used for back testing valuation models over a 10-year run-off period.

Figure 3 provides a comparison of the best estimate reserve method with the reserve realization after 10 years.\(^\text{19}\) It shows the nominal deviation between the actuarial estimate and the “true” value, compared to the premiums received the previous year.


\(^{18}\) The number of datasets used in our calculation for each business line is given in brackets: Motor/truck liability commercial lines (95), GTPL (160), motor liability private lines (94), product liability (33), workers compensation (69).

\(^{19}\) Note that after 10 years the runoff was not finalized, so the realization still bears an element of estimation.
Without this scaling, the results are far more erratic. We see here, for example, that in General third party liability (160 datasets) the median estimate is 10% higher than the scaled true value, and the 30th to the 70th percentile would deviate in a range of -11% to +56% from the scaled true value.

**Figure 3: Relative spread of reserve estimates per branch**

This boxplot provides the 10th, 30th, 50th, 70th and 90th percentile of the deviation of the branches relative to last year's earned premium.
These results provide insight into the large volatility of the results of a methodology that seems at first sight to be a sound approach. We derived similar results for other structured model selection methods. This proves that the model selection has a very large impact on the results, and justifies the common practice of the use of detailed expert judgment in model selection and parameter selection.

Table B1: Implicit considerations and residual risks when using DV01 for assessing interest rate derivatives

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Implicit</th>
<th>Example</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic correctness</td>
<td>Objective measurability</td>
<td>Assessing valuation of IRS by parallel modeling using own market data</td>
<td>Errors due to wrong market input are not detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(result &lt; 3DV01)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objective measurability</td>
<td>Assessing valuation of IRS by using client data from systems (result &lt; 3DV01)</td>
<td>Errors due to wrong input (wrongly fed into system) are not detected; for example, errors in static data or incorrect assumptions</td>
</tr>
<tr>
<td></td>
<td>Representativeness</td>
<td>Assessing valuation of IRS by parallel modeling using own market data</td>
<td>Wrongfully concluding representativeness of valuation methodology used by clients; for example, from difference DV01 not visible that client did not use OIS*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(result &lt; 3DV01)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Representativeness</td>
<td>Input data used can be reconciled with objective sources (e.g., credit spreads and static data)</td>
<td>Underlying market data is not representative to be used for valuation or static data not fit for purpose (wrong entries/links)</td>
</tr>
<tr>
<td></td>
<td>Arithmetical correctness</td>
<td>Input data used can be reconciled with objective sources (interest curve)</td>
<td>Calculation errors in (enriched) data not detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Representativeness</td>
<td>Arithmetical correctness</td>
<td>Use of discounted cash flows methodology based on OIS, construction of curve</td>
<td>Agreeing upon an interpolation method that is wrongly implemented</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arithmetical correctness</td>
<td>Use of certain source (DNB curve, Barclays index) is market practice</td>
<td>Errors in information that is used widely and generally accepted for the purpose</td>
</tr>
<tr>
<td></td>
<td>Objective measurability</td>
<td>Use of basis spread correction in the valuation (according to client's valuation manual)</td>
<td>Basis spread wrongly taken from data provider/wrongly implemented</td>
</tr>
</tbody>
</table>
8.1 Audit approach
Given the justified use of detailed expert judgment, how can we derive audit materiality ranges for claims reserves? The ranges derived from the analysis could be applied as ranges for reasonable estimates around an independent model choice of the auditing actuary. A remark here is that the auditing actuary who performs an independent recalculation will have the same deviation distribution. The materiality interval will, therefore, become very large, making this approach less useful in practice to set a tolerable range (at this stage) although it still provides a lot of insight in the key items driving the value.

In the audit practice, the soundness of model selection and of assumption and parameter setting for claims reserves is usually audited by testing the results against experience; benchmarking the method against market practice and testing the estimates for sensitivity to parameter choices. Since expert judgment needs thorough independent review, checks on the documentation and internal review assessments will help to evaluate the reasonability and justification of the model selection and parameter choices.

Having gained insight into the key sensitivities and the key parameters driving these, the auditor can use this information to assess the objective measurability of these parameters. And users of the information often want to understand these key risk drivers and their impact on the value and/or risk drivers. By using a sensitivity or DVOC approach the company does have this type of information available. It should also be clear that simply setting a tolerable range alone is not sufficient for drawing conclusions. Actuaries and auditors should look at the underlying process of why certain choices have been made. This is because some audit risk will remain when one would only look at DVOC’s and model materiality (see Box 3). To mitigate the remaining audit risk, additional control procedures need to be performed. And by looking at those elements that really do matter, by using DVOC information, the overall audit on modeled reported results can be made more efficient, effective and much more transparent. For this part, let us continue considering the audit approaches for estimates.
Auditing estimates: what will the future bring?

**Box 3: Remaining audit risks when using DVOC**

There will remain some audit risk when one only looks at the DVOC’s and model materiality. Models can never predict the future or describe the real world exactly, so model risk will remain. We should also recognize that audit risks remain in our suggested DVOC approach for assessment purposes. As the experience in the asset management industry (by applying DV01’s to IRS, for example) is more mature than applying DVOC’s for insurance firms, we have listed in Table B1 some implicit considerations and risks that remain for applying DV01. These could also be extended to DVOC.

Hence, in the case of DVOC, the use of wrong static data input in the model might not be detected when the difference between the assessment value and parallel model value is within the DVOC range. Reason could, for example, be incorrect use of day count convention, wrong coupon rate, wrong interest rate curve, wrong lapse rate used, wrong experience assumption factor used, wrong interpolation/extrapolation methods have been used, etc. However, the impact is limited on the assessment value. Note that ‘wrong’ here could mean ‘different from market (leading) practice or different from the own company’s policy’. Even if these errors could be detected during the qualitative assessment within the audit procedures, traditional audit reporting materiality considerations will be applied to conclude whether corrections have to be made or not, even when differences stay within the tolerable range applicable for the modelled reported figures.
9. The audit of the estimation process
Economic values and risk measures are the result of an estimation process that can be summarized as in Figure 4. In general, each element in the estimation process should be supported by sufficient governance and internal controls addressing the risk of what could go wrong in the (sub)process, substantiated by sufficient documentation supporting the design and operating effectiveness of the controls. In this regard, the following key procedures and/or controls are relevant for the auditor to consider in its audit of the estimation process.

Figure 4: The estimation process
9.1 Data and data processes
The data that are used as input for the valuation and risk models need to derived from the (routine and nonroutine) data processes, such as premiums, claims and policy master file maintenance. The insurance company should demonstrate accuracy and completeness of such data in a systematic manner. A useful data quality framework that can be used by insurance companies to demonstrate their ongoing quality of data is based on a continuous process monitoring approach, which is illustrated in Figure 5.

**Figure 5: Generic data quality framework**
In addition, where model points are extracted from databases, procedures should be in place to assess whether they are representative of the total portfolio.

9.2 Parameters
The selection of parameters by the insurance company involves procedures for calibration to market observables (e.g., benchmarking), selection of sources of data, rationale for assumption changes against experience and documentation of management best estimates for the parameters where no external data is available, and final review and approval of management.

9.3 Model
With respect to the models used in the estimation process, the following procedures need to be considered:

- **The model validation process:** in its “Proposals on Guidelines on External Audit,” EIPOA stipulates that insurance companies should ensure that the contract of engagement states that the Solvency II external audit will place reliance, where possible, on relevant internal controls and internal validation processes, including internal audit, as explicitly required by Solvency II for the purpose of the design and implementation of their audit procedures, subject to conditions set out in the international auditing standards or in nationally accepted auditing standards. This means that to be able to ensure compliance, the auditor should perform the following procedures (refer to ISA 610, “Using the work of internal auditors” and ISA 620, “Using the work of an auditor’s expert,” including the use of managements’ expert):
  1. Evaluate the competence, capabilities and objectivity of that expert
  2. Obtain an understanding of the work of that expert
  3. Evaluate the appropriateness of that expert’s work

- Monitoring of model risk by continuously analyzing model results against actual experience.
- **The change management procedures:** are checks on plausibility of the model results and analysis of experience against model outcome performed to provide a continuous impulse to model enhancements? Are adjustments and enhancements of the models as a result of changes in the environment or new products, distribution methods, etc. monitored?
Auditing estimates: what will the future bring?

- **IT policies and procedures:** is version control applied and monitored by appropriate personnel? Are proper access controls implemented? Are changes to the model independently verified, tested and approved by appropriate personnel?

9.4 Output: analyses and selection
The output (e.g., analysis of change, plausibility checks, analytics on results, exception reporting, etc.) should be monitored and analyzed by management. The quality and documentation of this analysis are important factors for the auditability of the information.

9.5 Monitoring experience and management action
The documentation of management’s response to the model output in relation to monitoring the progress of the strategic planning and of the risk budgets is important to ensure that the measure is used by management to manage sensitivity to the relevant risks. The rationale and signoff of any management action should be documented.

10. Analysis of change
As mentioned above, in the audit of the estimation process, an analysis of change is an important tool in getting better insight into the “why” question and also in becoming comfortable with the reliability of the actual estimates. Let us consider the following example for a specific product and align to our DVOC approach.

On 1 January 2014, the portfolio “value” included 50,000 death benefit contracts with the following characteristics:

- Maturity: 31 December 2023
- Annual premium, payable 1 January per contract: €1,250
- Acquisition costs per contract, paid 1 January 2014: €1,000
- Death benefit (on occurrence of death), payable 31 December, per contract: €100,000
- Required capital for risk margin purposes: €12,500,000 (the risk margin is calculated by determining the cost of providing an amount of eligible own funds equal to the solvency capital requirement necessary to support the insurance obligations over their lifetime).
Furthermore, assume cost of capital rate of 6% a (flat) risk-free rate (curve) of 3% and best estimate mortality rate of 1% for all future years.

At t=0, the basic own funds (BOF * €1,000) for this portfolio equals €61,219.

After one year, the BOF equals €58,498. We want to analyze the change between year t=0 and t=1.

We can undertake an “analysis of change” by using the information about the portfolio at t=0:

1. In the market consistent risk neutral world, the BOF will generate a return, in the best estimate assumption, equal to the risk-free return
2. Similarly, the BOF will increase with the release of the risk margin (+risk-free interest)

Variance in period (0,1)
3. The BOF will change due to difference between best estimate mortality and realized mortality.
4. The BOF will change due to delta in actual investment return (under- or outperformance relative to risk-free return).

Assumption changes after t=1
5. The BOF will change due to a change in mortality assumption.
6. The BOF will also change due to a change in interest rate curve.

Items 1 and 2 are fixed, and items 3 to 6 can be estimated by using DVOCs calculated on t=0 and actual parameter changes known on t=1. No additional “full balance sheet and/or P&L” calculations are needed.
10.1 Results (* €1,000)
1. BOF will make a return in the best estimate assumption equal to the risk free return; hence a euro return of €1,837
2. BOF will increase with the release of the risk margin for the period between t=0 and t=1 (+risk free interest): €773
3. DVOC death benefits: €100,00 per individual
4. DVOC investment return: €1.25 per bp increase in return (over risk free)
5. DVOC mortality assumption: −€3,747.52 per basis point increase in mortality rate
6. DVOC interest rate: −€0.60 per basis point increase in interest rate

After one year, the changes (variances and assumption changes) are also known. In the case of this example:

- 20 more individuals died in the past year (period between t=0 and t=1)
- Investment return turned out to be 3% above risk free
- Mortality assumption increased by 1bp (hence: 1.01% per year instead of 1.00%)
- Interest rate (curve) increased by 50bp (hence: 3.5% flat rate as of year 1 onwards)

Table 4 presents the analysis of change using the above information.

Table 4: Analysis of change

<table>
<thead>
<tr>
<th></th>
<th>t=0 calculated BOF</th>
<th>€ 61,219</th>
<th>% delta BOF&lt;sup&gt;20&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 additional deaths</td>
<td>€ 2,000</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>0.50% change in interest rate</td>
<td>€ 30</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>3% additional investment return</td>
<td>€ 375</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>1 bp increase in mortality rates</td>
<td>€ 3,748</td>
<td>134%</td>
<td></td>
</tr>
<tr>
<td>Risk-free change BOF</td>
<td>€ 1,837</td>
<td>66%</td>
<td></td>
</tr>
<tr>
<td>Release risk margin Y1</td>
<td>€ 773</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>t=1 estimated BOF</td>
<td>€ 58,426</td>
<td>Estimated using the DVOCs</td>
<td></td>
</tr>
<tr>
<td>Calculated BOF</td>
<td>€ 58,498</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unexplained</td>
<td>€ 72</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

At t=0, the BOF for this portfolio equals €61,219. At t=1, BOF equals €58,498

<sup>20</sup> Delta BOF equals €2.721 (€61,219−€58,498).
The unexplained amount seems, in this simplified example, relatively small compared to the key risk drivers. Unexplained contains not only the estimation error for using DVOCs, it also contains a harder-to-split nonlinear impact due to changes in parameters that occur simultaneously during a year (the DVOC concepts could be further enhanced by looking at the (estimated) first partial derivative to two risk drivers). Furthermore, it contains the interest rate convexity (which could be estimated at t=0 as well by using convexity - not done here yet). Having insight in the DVOCs should also help risk management to focus on those key risk drivers that really do matter. As long as the “unexplained” is reasonably small, this approach saves a lot of calculation time.

11. Summary
Solvency II audit will certainly happen. With it, comes a number of questions, such as how does one assess “right or wrong” when reported results are based on modeled/projected future cash flows? And, what does model materiality mean in this New World? Different methods and assumptions could be equally valid, and as such there is a need to evaluate the (expert) judgment applied, and define an acceptable or tolerable range to be able to assess whether projections can be considered acceptable. In contrast, an error (when found) in the model itself, the source data, the model parameters (key risk drivers) or underlying process is a “hard” error (factual misstatement) and should be evaluated by the “traditional” materiality considerations. Using the concept of DVOC in audit processes helps making the tolerable range objective, based on those key risk drivers that really do matter.

DVOC describes the sensitivity of the (key) parameters to which an assessment value is (most) sensitive. Mathematically speaking, DVOCs are the first partial derivative of the valuation or risk function. A tolerable range as model materiality measure for audit considerations can be defined by multiplying the DVOC with a factor that is determined on the inherent variability of that specific risk driver.

We believe that the concept of using DVOC is a concrete and objective solution, in line with Solvency II standards. Technical Provision 6.34 sets out that the assessment of an error may be carried out by expert judgment or by more sophisticated approaches, for example:

---

Sensitivity analysis in the framework of the applied model: varying the parameters and/or the data to observe the range at which a best estimate might be located.

Compare with results of other methods: applying different methods gives insight into potential model errors. These methods would not necessarily need to be more complex.

Descriptive statistics: in certain cases, the applied model allows for the derivation of descriptive statistics on the estimation error contained in the estimation (of course, this would not include the uncertainty arising from a misspecification of the model itself). Such information may help to quantitatively describe the sources of uncertainty.

Back-testing: comparing the results of the estimation against experience may help to identify systemic deviations that are due to deficiencies in modeling.

Quantitative assessment scenario as benchmark.

When assessing economic values or risk metrics, one should use various components to align with the overall model risk appetite. Assessment for a stand-alone model should be made with consideration to materiality per legal entity versus group consolidation. One should distinguish between avoidable risk (e.g., model risk stemming from not modeling known risks such as credit spread implied volatility risk) and unavoidable risk (e.g., insufficient data available in order to get a clear picture of how fat the tail of a probability distribution function is). In conclusion, tolerable range boundaries should be defined based on inherent variability, risk appetite for model risk and approval from senior management.

We see an increased need by many stakeholders to look beyond realized (ex-post) cash flows and to become comfortable with forward-looking (ex-ante) figures such as economic values and risk metrics. These figures are nothing more than an estimate within a range of possible outcomes. To assess reasonableness, auditors and actuaries need to work side by side to translate the qualitative considerations and make it quantifiable and objective as part of the overall process of accepting the figures used to manage the business.

With this article we hope to having taken a step in this direction.
## Editorial

### Editor

Shahin Shojaei  
EY, U.A.E.

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ISSN 2049-8640