Scenario Analysis

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1 Summary and outline

Summary

Scenario analysis and stress testing techniques have been widely used in the financial industry for many years. Their application ranges from capital management, risk budgeting and liquidity planning to regulatory capital models as well as financial reporting. The significant variety of applications has created a large set of commonly used stress tests and scenarios. This has also given rise to a major challenge on companies' resources and infrastructures, on how both stress test and scenario analysis results are communicated and defined.

The definition of appropriate scenarios and stress tests depends on the purpose of the exercise and the available resources (e.g.: data, people and information technology). The definition requires decisions on the appropriate severity and persistency of the shock and the risk factors to be incorporated. We provide principles that can be used by practitioners to develop an appropriate set of scenarios and stress tests.

Today, regulatory requirements drive a substantial part of companies' internal stress test and scenario analysis programmes. This is particularly true for companies operating in multiple jurisdictions. Besides regulatory requirements, leading practice stress test and scenario analysis frameworks cover various other valuation frameworks. It is observed that internal economic metrics have higher priority in most companies. Other relevant frameworks are local GAAP, international accounting standards (IAS) and market-consistent or European embedded value (MCEV, EEV).

Severity, persistency, the number of risk categories or risk factors, and the valuation lenses represent relevant dimensions for scenario and stress testing. These can easily create a significant variety of individual stresses and scenarios, which are of potential interest. Given the operational challenges of proper data preparation, calculation, analysis and communication processes, it is of paramount importance to carefully select those stresses and scenarios, which are relevant and vital to the company.

Recent developments in insurance accounting and the efforts to modernize and harmonize regulatory regimes around the world provide some hope that different valuation models will converge or at least move closer together. This would enable companies to substantially restructure and simplify their stress test and scenario analysis programmes. Under current conditions, it is essential to consider different valuation models for strategic decisions (e.g. because asset-liability-matching strategies will have different consequences in a book-value regime and a market-value regime).

Overall, we believe that stress tests and scenario analysis represent valuable risk management and communication tools. The scope of their application is company specific. It depends on the risk profile and the set of alternative tools at hand for an individual purpose (e.g. whether the company operates based on an internal capital model or not).

Outline

In the context of this paper, we will use the stress test and scenario analysis concepts. Stress test means the analysis of the impact of a single adverse risk factor or event, such as the assessment of capital requirements per risk factor. It includes sensitivity testing where the focus is typically on how a smaller risk factor (the independent variable) impacts a value function (the dependent variable)

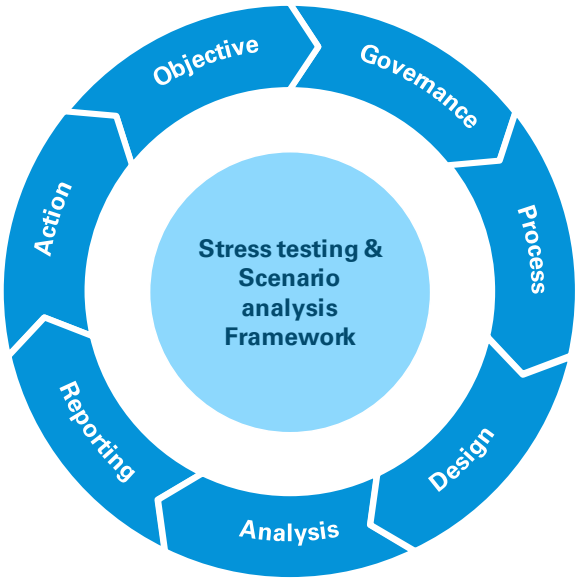
such as own funds. Reverse stress testing asks for the risk factor change leading to a prescribed change in the dependent variable, but may also encompass a full real-life type scenario.

Scenario analysis means the analysis of the impact of a combination of (adverse) movements in risk factors. For our purposes it is not necessary to draw a strict line between these individual concepts. However, stress testing in its various characteristics generally is of a mathematical nature (99.5% shock, basis point sensitivity, goal seek stress on breaching a financial target), whereas scenario analysis generally includes expert judgement and practice experience with real-life events. Throughout the paper, we will use stress testing & scenario analysis (ST&SA) to cover the full range.

In the following section, we begin by suggesting a list of objectives and principles that we deem useful for setting up an appropriate ST&SA framework (see figure 1). The objectives and principles represent, in essence, a summary of the rest of the paper. They include important aspects of governance and process set-up regarding ST&SA.

The remaining sections of the paper intend to provide guidance on the individual elements of a ST&SA framework. This includes the analysis and the design as well as reporting and actions. We will provide examples of current practices along with the general considerations. Several examples are taken from a survey held among all CRO Forum members that also provided views on various aspects of ST&SA.

Figure 1 ST&SA framework



The paper will close with a summary of how scenario analysis and stress testing is currently used in regulatory practice and public disclosure in section 5.

2 Objectives and principles

Objectives

ST&SA can achieve multiple objectives depending on the context in which it is used. An obvious objective of ST&SA is to fulfil regulatory requirements. However, the emphasis of this paper is on ST&SA used by insurers for internal purposes outside of the regulatory requirements, which may be inappropriate for the insurer at hand. ST&SA carried out for own risk and solvency assessment (ORSA - a continuous and forward looking assessment of the overall solvency needs performed by the insurer) is an example of ST&SA with an internal focus, which is nonetheless also carried out for regulatory purposes.

Internally, ST&SA is performed to help the organisation to better understand and manage risk and return. However, there are various uses for ST&SA, which go beyond classical risk control. It can be a key component of the planning process, or could be used to help management make decisions on large transactions and acquisitions. Key objectives of ST&SA include, but are not limited to, the support of:

- *Better understanding and communication of risks that a business faces* – As a scenario analysis involves a clear cause and effect relationship, it can provide valuable transparency of the impact of a particular factor or event. As such, results of scenario analysis are communicated in a relatively straightforward manner, adding to their appeal as components of management reports or external disclosure.
- *Discussion at senior level on existing, emerging and potential future risks*, and actions that can be taken under various scenarios, thus supporting the development of management's action and contingency plans – The first component of this objective involves developing a forward-looking view of risks in addition to considering which risks the entity faces today. The future risk profile of an entity is a function of its existing risk profile, its strategic plan and the external environment, each of which should be considered when carrying out multi-year scenario analyses.
- *Management of earnings, liquidity and capital in an integrated way, including supporting the setting of target operating levels for key metrics within the business* – In particular, this typically concerns multi-year scenario analysis, where concrete scenarios are considered, often of a less extreme variety compared to that in a classic stress test. As part of the planning, liquidity and capital management processes, insurers can take into consideration multiple alternative scenarios, typically an expected case, worst case and best case. This has the advantage of allowing management to consider, which strategic courses of action they should follow for a range of future states of the world, as opposed to only a single base case.
- *Preparation of risk tolerance, appetite and strategy* – Stress tests provide a possible basis for defining risk tolerance[1]. An insurer may define its risk tolerance in such a way that it may continue to accept risk only if it can remain a going concern given a particular stress event. Further, stress tests provide insights into the possible impact of a risk appetite and strategy.
- *Risk steering in a crisis situation* – In a crisis situation, stress testing provides for a fast and flexible way to respond to the fast changing market conditions. Especially in situations, when standard risk monitoring turns out inadequate, stress testing represents an alternative. In the middle of a crisis many decisions depend on the mid-term perspective. How fast is the

[1] For example, the FSB consultation paper from 17 July on risk appetite states that "stressed conditions" need to be taken into consideration when defining risk appetite (see: http://www.financialstabilityboard.org/publications/r_130717.pdf).

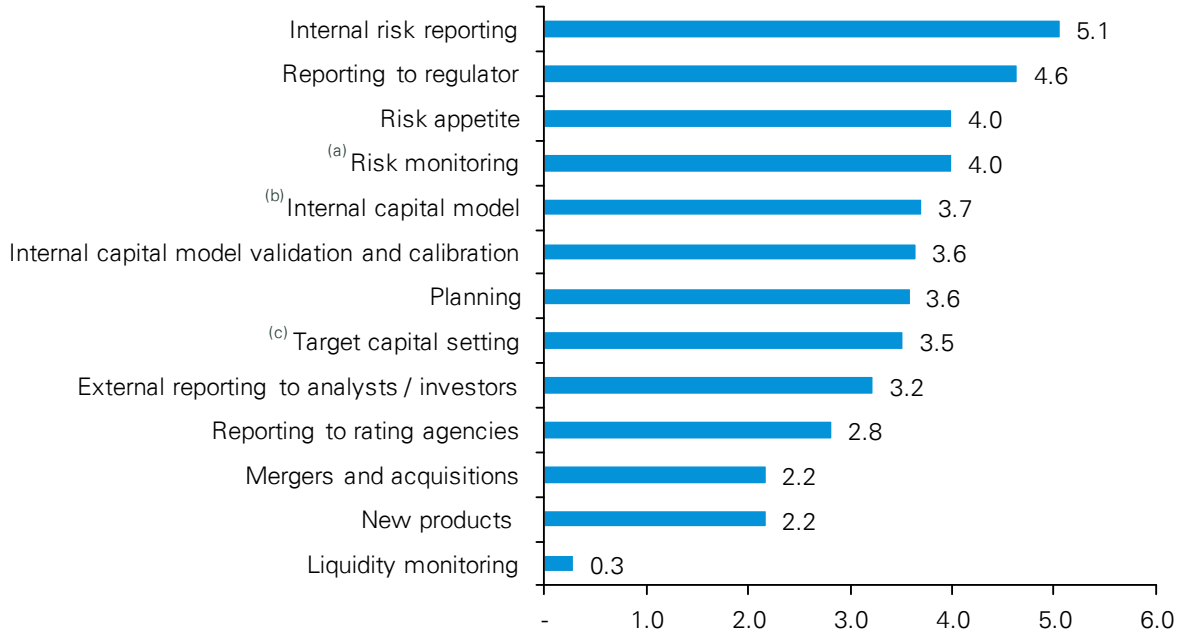
recovery? Is a certain market change persistent or temporary? The analysis of mid-term scenarios shows the consequences of short-term and strategic decisions and may help to find a better alternative.

ST&SA may indeed be one of the several approaches used to achieve the stated objectives. In most cases, it is not carried out as a standalone exercise, but rather in combination with other approaches, in some cases either verifying or refuting the outcomes of the accompanying ST&SA. ST&SA is an analytic approach of higher complexity. Time and experience is needed to help enable the results to be properly interpreted and acted upon by management.

Prior to using ST&SA, organisations should carefully consider whether ST&SA is the most effective approach to achieve the objectives at hand. In any case, the objectives should be of sufficient importance so that the necessary time commitment for all involved parties — for preparation as well as interpretation and challenging — is justified. If this is the case, specific principles should be considered when performing ST&SA. The relative importance of these principles in turn depends partly on the specific objective of the ST&SA exercise. In this paper, we set out some principles as guide to help the designer of an ST&SA exercise consider the objectives combined with the various principles and decide to the degree the objectives warrant a particular focus on any given principle.

In a survey held amongst CRO Forum member companies, members confirmed that internal risk reporting and regulatory requirements are the key initiators of ST&SA. The survey also identified that establishing risk limits is currently one of the prominent objectives of ST&SA and that ST&SA plays an important role in internal capital model design and validation.

Figure 2, primary purposes of scenario analysis and stress testing, scale 0 (low priority)–6 (high priority), based on CRO Forum survey



Note:

(a) Defined limits on individual stresses / scenarios

(b) Modules are based on single stresses / scenarios

(c) Holding x m. EUR above internal / regulatory / rating agency capital requirements

Principles

Any ST&SA framework should be embedded in the insurer's processes. For the purpose of this paper, three major categories of principles are identified (these link with the framework as reflected in figure 1):

- the first category relates to Governance and Processes (principles denoted by 'G'), how should the framework be embedded within the organisation, who is responsible, etc.;
- the second category is Design and Analysis (denoted by 'D'), what is to be part of the scenario analysis, what severity is needed, how many scenarios are envisaged, etc.; and
- the third category is Reporting and Action (denoted by 'R'), how should the result of the scenario analysis be used.

Governance and Processes ('G')

Any scenario analysis framework should be embedded in the risk management system of the insurer. To this end the following governance principles are identified:

Principle G1: Senior management should be involved in the overall scenario analysis programme.

The extent of engagement of senior management in ST&SA plays an important role in the effectiveness and ability of ST&SA to deliver results that can facilitate the understanding of the impact of stress events. The openness and flexibility of an organisation and the time available for consideration of ST&SA are factors that can help improving the experience and usefulness of the results.

Principle G2: The assumptions, parameters and model limitations in the ST&SA should be clearly set out.

A comprehensive understanding of the assumptions and limitations beyond the analysis of the final results is imperative for the success of ST&SA.

Principle G3: Data and indicators used in scenario setting should be relevant and representative — picking up past and emerging risks/trends.

Principle G4: The scenario analysis programme should be embedded in the risk management framework and supported by an effective infrastructure to ensure appropriate timing and complexity.

A comprehensive ST&SA programme typically demands the involvement of multiple units within an organisation, often from risk, finance and strategy, underwriting, operations or claims management. Therefore, process descriptions should be kept up to date and avoid being overly prescriptive while at the same time ensuring that roles and responsibilities are clear and well understood.

In order to run a ST&SA, the insurer should have an appropriate infrastructure in place. This includes:

- solid, reliable and secure IT systems;
- appropriate process controls;
- knowledgeable professionals;
- adequate processing times of systems and processes.

The scenario analysis infrastructure should also be able to run ad hoc analyses. These ad hoc analyses will be necessary to answer emerging issues and therefore need to have a short processing time (week, maximum month).

Principle G5: The ST&SA programme should be reviewed regularly and the insurer should assess its effectiveness and fitness for its intended purpose.

Comprehensive scenario analysis exercises are typically run once a year, only, due to the overall effort required. Often this forms an integral part of the business planning cycle, and planning tools are often used as the primary generator of available and required capital projections. Occasionally, for instance in times of a market crisis, situations may emerge where increased frequency and/or ad-hoc scenario analysis must be adopted. Ad-hoc scenario analysis will likely be carried out as a more pragmatic and focused exercise, with more flexibility of the process.

Roles and responsibilities are usually highly dependent on the existing infrastructure landscape within an organisation. The infrastructure used to carry out stress tests is often present in multiple functional areas and used for various objectives beyond stress testing (often for processes which had been in place long before the stress-testing programme was implemented). It is important to ensure sufficient resources are available and responsibility is taken by the right people and departments. A clear planning with timing, roles and responsibilities is likely to make ST&SA processes run more smoothly with timely and high-quality reporting so that proper action can be taken based on ST&SA results.

Principle G6: Scenario analysis outcomes should be encompassed in feedback loops within the insurer (bottom-up and top down).

The conclusions and actions, which are drawn following the scenario analysis can be used in various components of the risk management and governance systems (e.g.: the outcomes assessing risk taking in line with the risk appetite; scrutinising the business planning and the sustainability of the strategy in the longer run; monitoring important metrics and triggers to be prepared for adverse developments).

As the outcomes of the ST&SA are used in various ways, the validity of the chosen stress tests and scenarios is restricted to only one period (mostly a year), subsequent to which the insurer should analyse whether the set of scenarios is still usable. It has to be verified that the assumptions and parameters are still valid, that the severity used is still appropriate, and that the major identified risks are encompassed. Thus, feedback loops are necessary.

Bottom-up analysis will identify whether the ST&SA was actually accomplishable and sufficiently sensible, by verifying whether all scenario descriptions could be used, and whether this would lead to management actions to counter any adverse impacts. Top-down analysis will identify whether the stress tests and scenarios did actually manage to *scare* the senior management. A severe stress test could hurt an insurer unless the risks are properly mitigated, and leads to the design of appropriate management actions.

Design and Analysis ('D')

Designing a ST&SA at the right level of detail presents many challenges. High level analyses will not provide proper results. An overly detailed analysis will not give enough room for the business. Overly severe scenarios will not be believed and too moderate stress tests will be deemed a waste of resources. But what is the correct level? The following principles are identified to support the design process.

Principle D1: A scenario analysis framework should include a consideration of all material risks and all relevant valuation frameworks.

Principle D2: The scenario analysis should be executed at several levels of the organisation. Thus, along with the group-wide scenarios, business scenarios are also expected to reflect the major business units.

The risks considered should primarily be based on the assessment of the insurer rather than a regulatory framework. The scenario analysis should encompass all the material risks. As an example, it can be beneficial to align the definition of materiality with the calculation of the (economic) balance sheet.

The scenario analysis framework could comprise focussed scenarios on single variables/sensitivity/parts of an entity and integral scenarios covering the entire group or entity. But the total of all scenarios should include all the material risks.

If a scenario analysis is focussed on a specific part of the group or the entity, this does not necessarily imply that one should not assess its outcomes on the level of the group. For example, a scenario may be defined for a specific business line. However, depending on the size of this business line, this scenario can have a material impact on group level as well. In addition to this, a representative set of scenarios should be developed at group level for the major risk drivers of the group.

Principle D3: Scenario analysis should reflect the scale and complexity of the insurer/portfolio.

Similar to the other parts of the risk management system the proportionality principle applies when designing a scenario analysis framework. The application of the proportionality principle should be consistent with the use elsewhere. Prescription of scenarios is only necessary in case companies do not use any scenarios on their own, or need support in developing those. For ORSA purposes and other regulatory requirements, regulators should rely on company-specific analysis and not be too prescriptive. The one size fits all approach will not be sufficient to cover the variety of business models and to reflect upon individual risk mitigation methods in place.

Principle D4: Scenario analysis should be based on exceptional but still plausible events. The scenario analysis programme should cover a range of scenarios with different severities.

Principle D5: Scenario analysis should consider the impact dynamics: the time scale of the impact (a sudden short effect or a long-term effect) and the potential impact over multiple time horizons.

One of the most important parts of the ST&SA is the setting of the appropriate severity. For example, Solvency II is set at a severity of 1 in 200 years. If the severity is too high nobody in the organisation will accept the scenario as credible. This will not lead to conclusions and actions. However, the scenarios should be such that it is sufficiently material, despite the existence of risk mitigation measures. Actions are needed to counter the 'pain (stress)'. For each insurer this will be different depending on the actual and future risk profile.

The scenario analysis should not only focus on the impact on the current financial position of an insurer but should also assess the impact of the distinct scenario on the outcomes of the business planning (e.g. the situation over a number of years). The analysis should reveal whether the business planning results in more or less sensitivity to the scenario.

Reporting and Action

Scenario analysis is a tool, which should be used by the insurer in its daily operations and processes. But scenario analysis should not be deemed to be the objective (goal); the outcomes should be used as inputs. The following remaining principles are identified for designing, maintaining and using the framework.

Principle R1: Scenario analysis should not be just a mechanical process, flexibility in approach and process is required.

Stress tests and scenarios will differ from period to period. New risks can emerge, for instance, by introducing a new product, others can disappear, such as through divestiture of a particular business line. New departments can be called upon and the organisation can be changed. Therefore, the whole process of stress testing should be flexible and not carved into stone. The stress test framework should not become too mechanical as this will keep people from having a fresh view on the matter.

Principle R2: Scenario analysis is an organisational endeavour to gain insights and foster debates.

Principle R3: Analysis of results should encompass both quantitative and qualitative (e.g. reputation) information.

The outcome of the scenario analysis should not be a mere collection of quantitative figures. It should also include qualitative descriptions of the outcomes in terms of policyholders' behaviour, reputation, financial strength rating and attractiveness of the insurer to do business with customers, suppliers, investors and employees.

Principle R4: Effectiveness of risk mitigation (hedging, reinsurance, operational controls) should be assessed and challenged.

Principle R5: Scenario analysis should be actionable and linked to strategy — risk appetite, new products, liquidity requirements and growth targets.

The scenario analysis will identify events or combination of events which could — if becoming reality — substantially impact the going concern status of the insurer. Therefore, the insurer should use the outcomes in establishing measures, ready to be taken by the insurer. Several of the actions could already be implemented if the result of the scenario analysis is going beyond the risk appetite and the expectations of management and/or stakeholders. Several of the actions could be called upon if the events actually do occur. To this end, the scenario analysis will also guide the insurer in setting appropriate triggers. These triggers will have to be monitored. For example, if the organisation is sensitive to a certain level of lapse of policyholders, the insurer could establish policyholder satisfaction surveys to assess their behaviour and loyalty. The insurer could also assess each lapse and categorise the reason for these.

3 Design and analysis

For ST&SA to be effective there should be a clearly defined purpose. In other words, it should be clear "what insights are needed and being sought?" Within the Enterprise Risk Management (ERM) framework of insurers there are several different purposes that may need to be addressed. This makes the possible scope quite large and it will be difficult to cover everything perfectly, but it can encompass elements such as assessing impact of various asset-liability management (ALM) strategies, impact of new products, or the scale of operational risk.

As a general rule, stress events should be developed for likely and credible events, which can impact an organisation (Principle D4).[2] To make ST&SA as effective, efficient and insightful as possible, impact generally should be assessed via a multi-dimensional approach. That means accounting for all relevant and material risks, shocks at various levels of severity (including multi-year events) and with impact assessed using a range of loss metrics. It is very difficult to assess and to compare the likelihood of individual scenarios without sufficient context.

Since every organisation clearly has to deal with a limited amount of resources and other constraints, it is nearly impossible to build a single integral ST&SA framework that covers everything. Further, the use of ST&SA often needs to be conducted in parallel with other processes using the same systems and resources. Therefore, companies need to make choices about the extent of ST&SA to be used, how elaborate it should be and the level of granularity on which the calculations should take place; e.g., full stochastic runs vs. estimations via deterministic cash flow models or duration approaches. The figure below shows what insurers in general look at when setting up or further developing their ST&SA framework. These elements will be discussed in detail in the rest of this section.

Figure 3: Developing relevant scenarios

Risk identification	Risk dependencies	Possible external events	Assessment of impact
■ Financial ■ Actuarial ■ Operational	■ PDFs ■ Diversification ■ Non-linearity	■ Nat. catastrophe ■ Cure for cancer ■ Low interest rate environment ■ Economic depression	■ Regulatory solvency ■ IFRS / GAAP ■ Economic capital ■ Ratings

Risk identification and determining risk dependencies

Stress testing and scenario analysis design begins by fully understanding how risks are identified, assessed, and how they interrelate because these aspects are inputs to the scenarios (*Principle G2)*. As the focus of this paper is specifically on ST&SA, we assume for simplicity reasons that the

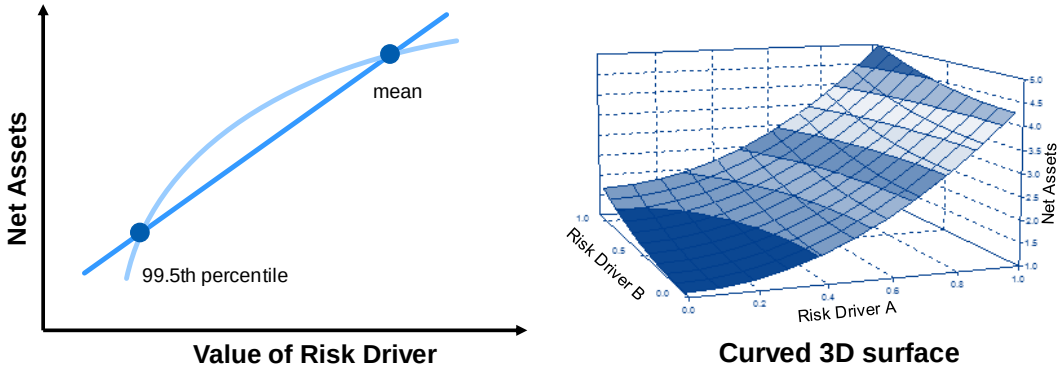
[2] Of course out of the box thinking or thinking the unthinkable type of exercises should not be ruled out, but these are additional to the general ST&SA processes that are performed and which need to be relevant.

insurer has set its risk appetite[3] by identifying all material risks, choosing appropriate metrics to calculate exposure for these risks, and defining limits that translate how much risk it is willing to accept. We also assume that exposure to material risks is calculated using for instance, probability density functions (PDF) for specific risk drivers and that these PDFs estimate impact on the insurer's balance sheet as opposed to PDFs that analyse the behaviour of the risk factor.

There are two aspects that require particular attention when performing ST&SA: dependence and non-linearity. The impact of a single risk driver is insightful, but for a full picture to emerge the interdependencies between risk drivers also must be identified. This is a key element for insurers as the insurance business model is heavily based on diversifying risk. Interdependencies can, for instance, be captured in a correlation matrix. These correlation parameters should be based on the correlations in a stressed scenario[4].

Besides diversification, non-linearity is important to capture. Non-linearity may exist within a single risk driver (e.g. in the form of convexity), but also between risk drivers (e.g. changes in both longevity assumptions and interest rates occurring at the same time). In many frameworks the combined impact of risks is determined with the use of the percentile and correlation approach via a correlation matrix as explained above. However, such an approach stresses each risk separately and assumes linearity. More sophisticated approaches are required to capture existing non-linear effects, for instance, by running events where several risk drivers move at the same time, the use of single equivalent scenarios, or dependence via copulas.

Figure 4: Non-linearity, single risk driver (left) and between risk drivers (right)



Non-linearity may have a significant positive or negative impact on the actual total impact of scenarios, especially with regard to scenarios where several risk drivers move at the same time and affect each other's impact.

The ST&SA should cover all material risks. It often needs a stress test to confirm that a specific risk is immaterial. Consequently, the ST&SA programme is typically not limited to material stress tests. It is helpful to establish a materiality concept along with the ST&SA to ensure completeness of the programme.

To conclude this initial step, identifying the risk universe and possible interactions lays the foundation for developing credible scenarios. This foundation is usually built on a systematic

[3] See also CRO Forum's and CRO Council's recent publication on Risk Appetite which can be found on the Forum's website (http://www.thecroforum.org/).

[4] See http://www.thecroforum.org/diversification-consideration-on-modelling-aspects-related-fungibility-and-transferability-2/ and the references therein.

approach for analysing historical data to identify interactions. The next step, extracting credible and likely scenarios, generally requires a higher amount of expert judgement and understanding of a company and its context.

Possible external events: Shock severity and multi-year scenarios

The construction of PDFs requires very detailed insight into how risk behaves and how it may impact an insurer. Full and perfect determination of such functions is challenging, therefore, the focus generally is on establishing a couple of key 'percentiles' (e.g.: 1/10, 1/50 and 1/200 year events) on a relevant time horizon (e.g. 1 year). For example, based on historical analysis it may be established that an equity shock of x% occurred once every 10 years on long-term average. Apart from the occurrence probability, one needs to specify a reasonable time horizon over which a stressed event occurs before a company is able to take effective measures to counter further impact.

Depending on the purpose, different choices can be made. Within Solvency II, which focuses on policyholder protection in extreme events, the calibration for capital requirement shocks is set at 1-in-200 year events (99.5th percentile) value-at-risk (VaR) over a one-year horizon. In a regulatory framework, which aims at providing a basis for some comparability between companies, such a simple and uniform approach makes sense. However, at the same time it limits the actual insight into the sensitivity of a particular insurer towards changes in its environment. Therefore within more sophisticated and tailored models such as an economic framework an insurer may make more granular decisions. The 99.5th percentile is of course a rather arbitrary level, but there is simply no real best level that can be identified; it remains a matter of preference. However, the choice for VaR does ignore extreme impacts further in the tail that would be captured using a tail-VaR approach. For a regulatory framework it may be sufficient to draw a hard line somewhere, but senior management generally would be interested to understand possible extreme impact tail events even if it is not directly impacting actions taken (Principle G2). In addition, extreme values of VaR are increasingly considered. This would favour, decreasing the percentile to support day-to-day decisions on model outputs that are more reliable. ST&SA can help fill that gap.

Whatever choice is made in this respect, it is not easy for every risk to establish what an event should look like at specific percentiles. This is not just due to lack of available historical data, but also due to constantly changing environments making historical data obsolete for predicting future events. An extreme focus on specific percentiles is therefore also not advisable. It is important that stresses/scenarios are sufficiently sensible and simple to communicate.

The time horizon at one year chosen in Solvency II is likely to be too general to be relevant for each risk factor. Market shocks can develop quite fast, but many markets (e.g.: equity, interest rates) also give the opportunity for companies to act swiftly and take counter measures. Especially dynamic hedging programmes have shown more recently to stay quite effective during very volatile markets in 2008. A shorter time horizon may therefore be justified. For longevity risk the one-year horizon on the other hand may be too short. Not only do changes in mortality generally develop over longer periods of time (e.g. development of medical advances) but it is also more difficult to offload longevity risk due to markets still being relatively limited and underdeveloped. Within Solvency II the development of internal models can help to address such elements by bridging between regulatory and economic frameworks.

In general, the above assessment of risk factors and distributions is still very much a clinical exercise primarily based around simple time-zero shocks. Since Life insurance is a long-term business, companies need not only be aware of such simple single events (e.g. a world-wide epidemic causing an increase in mortality rates), but also of events that happen over time. This can be, for instance, in the form of multi-year events based on observations from the past, such as the development of a cure for cancer (Principle D5, Principle G3). In such events, the gradual impact (e.g. due to persistency) can be measured, but also the actions an insurance company can employ to mitigate impact or to increase its impact absorbing capability (e.g. attracting new capital).

The developments of such events and available counter measures should be as realistic as possible. Risks may behave very differently in the tail, and in times of stress the insurance company may be faced with fewer options available to take counter measures. This analysis has become increasingly relevant given the focus on recovery and resolution plans[5]. The scenarios developed for this purpose have the character of a reverse stress test, need to be built around possible real life situations and should therefore also reflect practice as much as possible in the range of follow up actions available in case such an scenario would unfold. In order to address a wide range of scenarios that could trigger recovery actions, several scenarios can be considered: short versus long term, idiosyncratic versus system-wide. Depending on the scenario different counter-measures are effective. For example, in an idiosyncratic scenario financial markets would still work as normal, but these same markets are likely disrupted during a system wide scenario that involves the wider financial system possibly limiting access to capital or derivatives markets.

The survey of CRO Forum members indicated that it is helpful to consider complex scenarios (e.g. deepening of EU crisis with all implications) in addition to simple stress tests (e.g. interest rates +100bp). Moreover, it was deemed to be helpful to consider scenarios under several valuation lenses.

The table shows what an ST&SA universe may look like including areas where it generally is used.

Table 1: Overview of the 'scenario' universe

		Shock		
		Instantaneous	Stepped shock	Multi -year
Severity	Worst case (1/50 or more)	*Economic capital, Regulatory capital, Capital planning*	*Economic capital*	*Business planning*
	Stress (1/10 - 1/50)	*Reverse stress testing, Model validation*		*Business planning, Risk mitigation, Accounting*
	Regular (1/5 – 1/10)	*Risk mitigation, Model validation*	*Risk mitigation*	*Accounting, Capital planning*
Goal		Use to set target capital levels and sensitivity analysis		Short-to medium term risk and capital management
Management actions		Management actions generally excluded, unless automatic		Management actions generally accounted for
Single vs. multiple factor		Single or multiple		Multiple

[5] See http://www.thecroforum.org/recovery-and-resolution-2/ and the references therein.

The two main dimensions are the severity of the shock and how a scenario may come about. Regulatory capital frameworks such as Solvency II or SST focus primarily on instantaneous, high severity shocks to determine baseline capital requirements to secure a high degree of solvency. Operational activities such as hedging processes, on the other hand, focus more on less severe shocks (as small as basis point sensitivities) and may also include so-called steps shocks. For instance, in a dynamic hedge, where the hedge is constantly rebalanced due to market movements, it is not just important to know how big changes can be in a risk factor over say a one-year period, but also how this change comes about because the effectiveness of such a hedge is partly determined by path dependency.

Within accounting frameworks the focus is more on testing the impact of multi-year events. As such frameworks are based on amortising approaches (total impact is spread out over duration) instead of market values (total impact fully reflected immediately). Therefore, to get a good view on potential impacts a multi-year approach should be used. The severity of the shocks is not as extreme as in capital frameworks, but more focused on what is likely to happen in the short and medium term closer to the level of 1-in-10 year events. Particularly for the life insurance business, such an approach is better able to account for the long-term nature of the business.

For capital management planning purposes the focus is more on scenarios that evolve over time. Such planning is cash flow based and therefore is not always as much served by knowing the impact of instantaneous shocks on market value, but also needs information on the timing of cash flows (considering the different accounting regimes) and therefore accounting for how developments may unfold over the long term. Such information is vital in making decisions on the issuance of bond-type capital, which requires coupon and bond repayments at pre-determined dates. Also, the timing of attracting new capital is important to make capital management as effective as possible. It is not cost efficient to attract expensive extra capital if stress testing points out that capital availability is sufficient for the next 2-3 years. On the other hand, if a capital need somewhere in the future is identified, a company may also not want to wait until the moment this need has to be addressed, perhaps in the middle of a crisis, when capital may be less widely available and/or much more expensive.

When actually running the shocks, it is important to decide how to account for possible management actions. In the case of instantaneous or rapidly evolving shocks it is difficult to account for management actions, unless they are defined ex ante and rather automatic. For shocks that evolve over time, however, management actions should be accounted for as much as possible in line with how management is expected to react in the tested situation. For uses such as business planning this is essential and shows the difference between taking a short- versus long-term view.

Finally, reverse stress testing receives increasing attention. As mentioned, it is essentially used in recovery and resolution planning, but also is a requirement within the Solvency II framework and can help with business and capital planning.

Impact analysis is required to determine relevant action. The next paragraph will shed some more light on how insurance companies measure impacts.

Assessment of impact

Insurers have to comply with a diverse set of frameworks each employing a different metric (refer to Table 2 below). This need for compliance demands that ST&SA is designed and performed keeping in mind the diverse usages of insights gained.

Table 2: Various metrics assessed in stress testing and scenario analysis

Framework	Metric	Primary audience	Primary purpose
IFRS	IFRS earnings and equity	Shareholders and analysts	■ Basis for comparing to other companies ■ Focus on IFRS balance sheet and earnings ■ No concept of risk capital
Regulatory reporting	Regulatory solvency ratio	Regulators	■ Basis for assessing ability of insurer to satisfy policyholder obligations ■ Focused on regulatory balance sheet and regulatory capital
EEV	Embedded value	Shareholders and analysts	■ Basis for assessing value of a company based on projection under regulatory reporting rules ■ Focus on future ability to pay dividends, given regulatory constraints
Rating agency	Excess capital	Rating agencies and (indirectly) policyholders	■ Similar to regulatory reporting ■ Adjust regulatory capital to assess insurer's ability to make good on policyholder's promises ■ Focus is to pay back bondholders (after of course paying the policyholders)
Economic framework	Economic capital and P&L	Management	■ Common 'risk language' across business lines/jurisdictions ■ Guiding business decisions ■ Performance measurement
Capital management	Cash flow information	Management	■ Focus on ability to service capital providers (e.g. shareholders and bondholders) ■ Based on information on timing of real, expected cash flows

The analysis of results requires recognition of the strategy and the risk appetite of a company and all management actions that it has at its disposal (Principle R5). Due to the variety in frameworks that an insurance company needs to adhere to, managing across the various metrics becomes a

balancing act as it will be challenging in every event to show the desired results in all frameworks (Principle D1). Together the complete set of different metrics gives clear insight into how a business performs from a wide set of angles. However, currently many frameworks differ substantially from each other so that analysing the outcomes of a stress test or scenario may provide conflicting indications on how well risks are managed. For instance, if a company hedges on an accounting basis to keep P&L volatility to a minimum, stress testing the market value balance sheet in its Economic framework may show extreme volatility. Changing the accounting hedge to an economic one simply reverses this with the accounting balance sheet suddenly becoming less controllable. Interpreting the results therefore requires careful consideration of choices an organisation has made in its business model and on the targeted weight for each metric.

Looking at the various metrics, especially market value approaches have gained significant ground in insurance risk management models in recent times. Such frameworks make it possible to install effective economic risk mitigation programmes and also introduce a common currency within a company[6] to make risk-return comparisons across business units. The downside is that information is collapsed into one figure showing the total impact over time, but losing information on the timing of the impact. Also, there are difficulties in establishing proper market values as markets do not always yield the information required or are distorted for some periods, which may lead to short-termism if not interpreted correctly. Especially for life insurance companies that have long-dated, highly illiquid liabilities on their balance sheets such short-termism is extremely dangerous. Although very insightful and if done properly a good basis to make risk management decisions, a sole focus on market-value based frameworks, only, is therefore not recommended. Due to the long-term nature of many insurance businesses, cash flow analysis should also get some deserved attention to stay informed on the timing of cash flows, which is important for liquidity impacts and efficient capital planning. Accounting frameworks, although generally lacking a concept of capital, continue to remain important for external stakeholders such as investors and therefore also provide valuable information. It will be important that the approaches adopted in such frameworks align with insurance business practice and should not deviate too much from other frameworks, but the value of such frameworks continues to exist for specific purposes. When designing stress tests the different set ups of the frameworks have to be kept in mind to draw meaningful results from all of them. Running market value stresses in a framework that works on a book value or amortised cost basis is not very insightful.

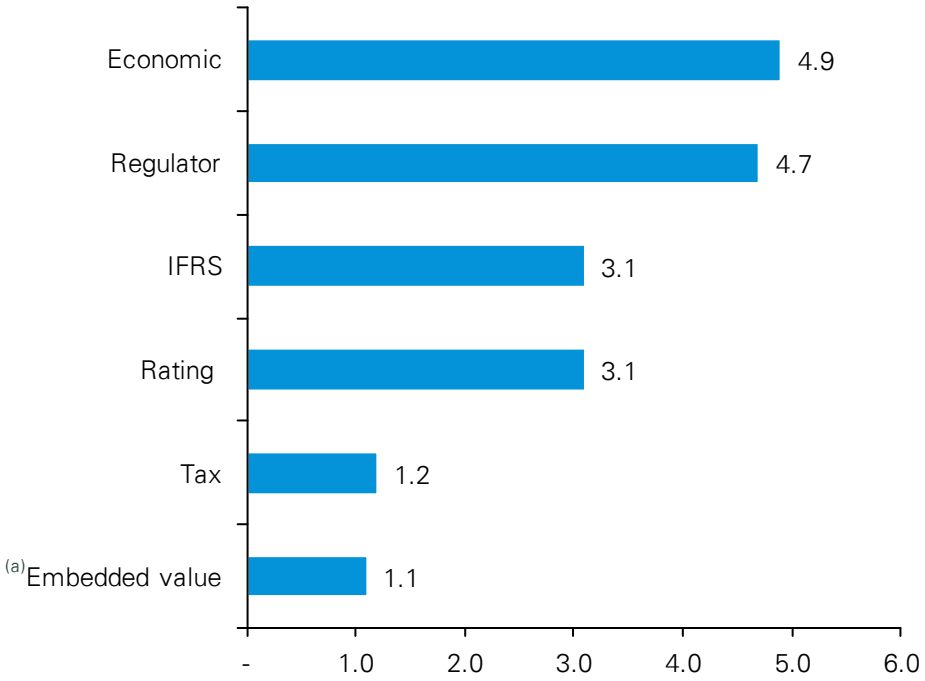
It should be acknowledged that exact measurement of impacts can be extremely difficult for certain insurance liabilities that require stochastic modelling or in case of multi-year scenarios that require a lot of professional judgment about possible future developments (e.g. the reliability of projected values will dissipate quickly with the length of the projection).

[6] Perceived market value such as equity prices is actually nothing more than a market average. The market value attached to assets and liabilities may differ per company. Therefore market value frameworks can act to provide a common denominator within a company, but comparison across companies can be deceiving.

Survey results — main valuation framework

The figure below illustrates the most common valuation frameworks used for scenario analysis/stress testing (scale 0–6).

Figure 5, main valuation framework, based on CRO Forum survey



Note:
(a) Including European Embedded Value and Market-Consistent Embedded Value

Companies set a focus on internal economic metrics and have to satisfy regulatory requirements. Even with the focus on economic metrics, it is important to monitor other valuation frameworks. In particular, this is necessary when ST&SA results can potentially be contrary under different valuation frameworks.

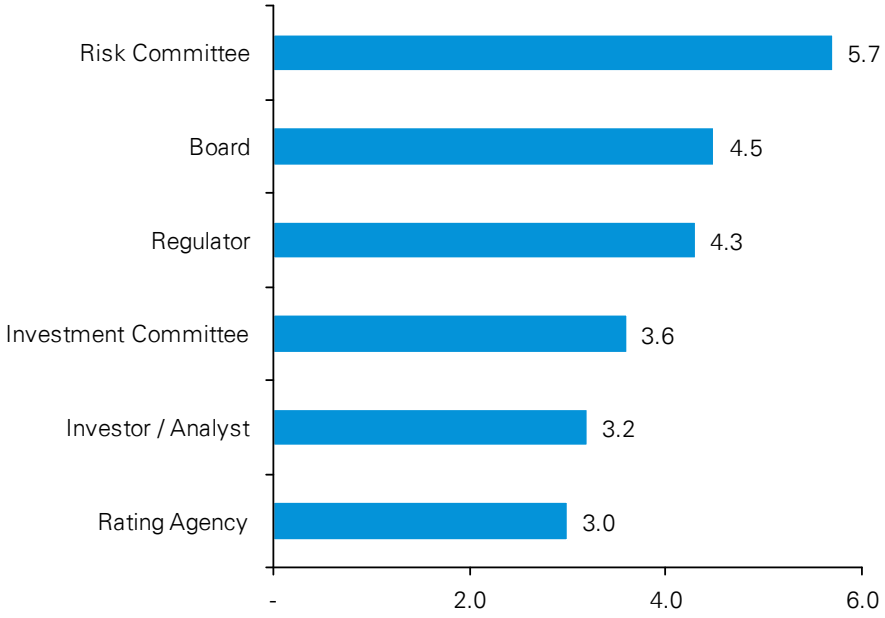
However, it is also acknowledged to monitor accounting and regulatory constraints, in particular, when ST&SA results under different valuation frameworks may be contrary.

4 Reporting and action

This section discusses how results of an ST&SA exercise can be used and turned into decisions.

Reporting is the first ingredient to this process. It should be tailored according to the audience, i.e., adjusted to internal or external stakeholders and existing expertise in the specific topic. Our survey confirmed that the audience of ST&SA is widespread with different levels of understanding of companies' exposures and available options to respond to real stress events (see figure 6). In particular, ST&SA results reported externally should be embedded into sufficient context including past reference events and the set of mitigation measures available.

Figure 6, primary audience of result



The survey also confirms that senior management is the key company internal audience. This indicates that ST&SA has strong potential to create action or is considered to have the potential.

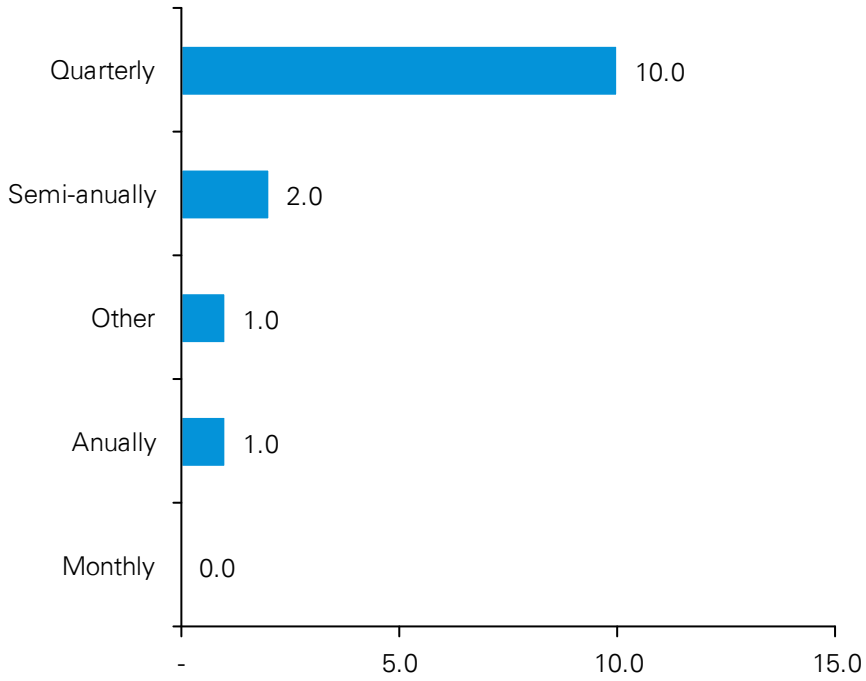
To ensure management can actually use the outcomes in its decision making, the tests and results must be relatively easy to understand. A way to achieve this is by attributing the responsibility to define or approve the scenarios to the risk committee. This way they can be incorporated into business planning and can help management to decide on risk appetite and risk limits. Results should also provide enough insight into operational preparedness (Principle G2).

Reporting should provide sufficient transparency of the design of the ST&SA (principle G2). The primary assumptions and parameters defining scenarios and/or stress tests should be clearly stated. This should include an assessment of materiality and sensitivity regarding these assumptions and parameters. It is helpful, if not necessary, to provide an estimate of the occurrence probability of the scenario and/or stress test, too. The occurrence probability provides a reference point and makes comparison of results and actions to previous ST&SAs easier.

The key element of the reporting is the impact of the scenario or stress test under the relevant valuation frameworks. This should encounter own funds and profit&loss (P&L). The impact assessment could take possible actions into account. However, typically in the first step the description of possible actions may be less detailed (e.g. as general as reducing credit exposure, leaving out the details of the action plan). On that basis senior management can decide, which options to explore in more detail.

Regarding the frequency of the reporting, the survey showed that circa 70 percent of the companies report on a quarterly basis on ST&SA.

Figure 7, frequency if on a regular basis...

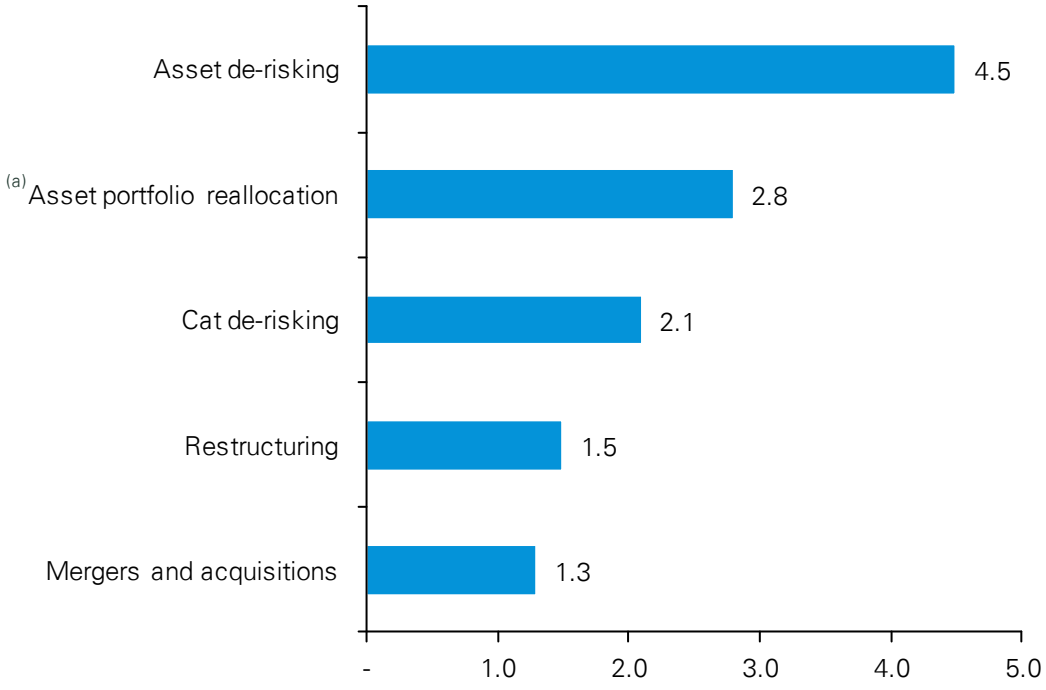


Whereas when looking at the asset side, only, ST&SA are conducted more often. About 20 percent of the companies report on a weekly basis.

Potential actions that could evolve from an ST&SA are the de-risking of the asset portfolio, additional risk mitigation such as reinsurance or hedging programmes, raising capital, the adjustment of profit participation strategies, the adjustment of the business and/or marketing strategy as well as the adjustment of the internal capital model or other internal valuation models (e.g. pricing models). ST&SA will more often result in de-risking actions, simply driven by the fact that the objectives of ST&SA are more often driven by intentions to mitigate risk. However, it is not unlikely that the purpose of ST&SA is to explore additional risk budget available to create additional return.

When asking our members about the typical applications of ST&SA, we received confirmation that it is a mix of de-risking and return-oriented business decisions (see figure 8).

Figure 8, actions triggered by ST&SA



Note:
(a) Without significant de-risking

An initial ST&SA report should at least list and assess various possible actions. The assessment can be done on a qualitative basis. When the objective of the ST&SA is strategic or mid- to long-term, senior management will typically decide on a number of actions to be explored in detail. Just as the overall selection of stress tests and scenarios to be investigated, also the selection of action for closer evaluation must consider available resources and time constraints. The implementation of a new hedging programme may require the involvement of several external parties, such as investment banks, and a significant time to negotiate final conditions. A simple 'explore all options in detail' is typically not feasible.

In a crisis situation, reporting and action will be different. ST&SA will have to be performed in a more flexible manner neglecting less material details and it needs to be performed more frequently. The reporting must focus on the most material elements of the ST&SA. This may for instance mean turning the focus from a general consideration of credit exposure to individual names or groups of names. The availability of mitigation measures in a crisis situation may be limited. As an example the capacity of reinsurance markets may shrink due to the capital pressure on the entire market; reinsurance prices may rise as a consequence. Therefore, evaluation of measures must be aligned to availability and time constrains for making measures operative.

We do not believe that an ST&SA programme should necessarily result in a single, for instance, annual homogeneous report. Different risks have different maturities. Mitigation measures have different time scales. The features of newly issued (re-)insurance or existing policies can often be adjusted annually (if at all); asset reallocation can be operated (almost) daily. The ST&SA programme

should align to these differences such that different risks may have different reporting frequency and focus.

However, if an annual homogeneous report is considered, the reporting of results of the internal capital model can form a starting point. As an example the Solvency II standard formula can be considered as a combination of stress tests or scenarios. It may become a viable option to turn the standard formula calculation into a full ST&SA programme. The credibility of full stochastic internal models may benefit from parallel reporting of stress tests too.

5 Insurance supervision and public disclosures

ST&SA is a tool commonly used in national and supranational regulation. An internationally active (re-)insurer is exposed to various stress test regimes. The latest developments around ComFrame and G-SII may result in increasing the metrics even further, which is a strong concern for the industry.

Quite often, in addition to regulatory capital regimes, especially where Solvency I is the prevailing measure, simple stress tests are applied by the regulators. Table 3 provides examples including public disclosures, but does not intend to be comprehensive.

Table 3: Examples of current usage of stress tests and scenarios in regulatory frameworks and public disclosure

Regime	Valuation framework	Persistency	Example
Solvency I	Local stat	Instantaneous shock	National regulators use different prescribed scenarios (e.g.: equity, interest shocks, technical life and non-life shocks).
Solvency II – standard formula	Market-consistent	Instantaneous and one-year shock	Interest rate stress, stress on specific asset investments such as equity and real estate, scenario specification for man-made catastrophic events such as tanker collision.
Solvency II and alike – ORSA/ ICAAP	Market-consistent/ local stat	Multi-year scenarios	ORSA requires forward-looking capital management that includes capital forecasts under different scenarios.
EIOPA stress test	Market-consistent/ IAS	Instantaneous shock	Multi-risk factor economic scenarios, including long-term impact.
Market consistent embedded value	Market-consistent	Instantaneous shock	Stresses on biometric and economic risk factors (e.g. a decrease in mortality rates).
IAS	IAS	Not prescribed	Stress tests are not prescribed but should provide information on the risk sensitivity of the portfolio.

Setting the target capital level is a typical and central application of ST&SA. As an example, to a large extent the draft Solvency II standard formula can be seen as a combination of stress tests; which are calibrated and aggregated to a 99.5% VaR level. Similar approaches are applied in the regulatory standard models in Switzerland, Australia, the US and many other countries. However, the process of calibration of the individual stresses may be quite different as in the case of the UK ICA, the Swiss and the Australian regulatory regime and in certain cases it is outsourced to the (re-) insurance companies as well. Rating agencies typically follow a similar approach as well (e.g. by performing their capital assessment on various stress tests and scenarios).

Apart from the stress magnitude and the considered confidence level, the individual models also differ in terms of the level of detail in prescribing the scenarios or stresses. The prescription ranges

from a simple stress (risk factor times volume measure) to a comprehensive scenario definition (e.g. historical scenarios as considered in the Swiss solvency test).

Table 4: SST historical scenarios[7]

Scenario	Risk factors
Stock Market Crash 1987	Interest rates, credit spreads, FX rates, equity investment returns (listed and private), real estate investment returns, hedge fund returns, participation values, option implied volatilities, in multiple currencies
Nikkei Crash 1989	
European Currency Crisis 1992	
US Interest Rates 1994	
Russia / LTCM 1998	
Stock Market Crash 2008	

For setting the target capital level, the focus is on absolute magnitudes (e.g. stress impact in EUR). This requires careful calibration of stress tests and an appropriate definition of aggregation methods for several individual stress test impacts. A typical starting point for a stress test definition is a prescribed confidence level or occurrence probability and the chief decision point is the stress magnitude at the prescribed level. This leads to different results, if occurrence probabilities from two or more individual time series are used, rather than using one comprehensive scenario definition and analysis. The difference in the magnitude will grow with the level of dependency between the considered risk factors and the number of (dependent) risk factors under consideration. Some leverage is available via the choice of an appropriate aggregation method. The Quantitative Impact Study 5 defines a single equivalent scenario to partially address this difficulty.

As an additional layer of security, the stress testing of capital adequacy has gained importance in some regulatory regimes. The target is to assess the capital adequacy subsequent to an adverse scenario. Typically, capital adequacy levels are defined based on scenarios with an occurrence probability ranging from 1% to 0.5%. By adding another (severe) stress test layer, the question "How certain is the promise to policy holders?" turns into the question "How likely is a violation of the regulatory capital levels." We observe this change of perspective, for instance, as a part of the forward-looking assessment of the Solvency II ORSA and as part of the Australian Individual Capital Adequacy Assesment Process (ICAAP).[8]

While we deem it sensible for an insurer to monitor the frequency or occurrence probability of not meeting regulatory requirements, we question the calibration of the stress of the capital adequacy in the range of probability of ruin levels. In the case of Solvency II, such an approach adds an additional (inconsistent) intervention level above the existing levels Minimum Capital Requirements (MCR) and Solvency Capital Requirements (SCR).

Stress testing the capital adequacy requires a post-stress estimate of (regulatory) capital requirements. For complex scenarios, it will be challenging to assess the overall impact on own funds. Typically, it will be far more complex to estimate the impact on required capital, say SCR. If

[7] See section 5 of Technical Document on SST

[8] "APRA expects that the Board will satisfy itself that the capital targets are in line with the risk appetite. This will include consideration of the Board's appetite for potential breaches of regulatory capital requirements." See item 20 APRA Prudential Practice Guide CPG 110

the SCR is derived from an internal model than the stress event may lead to recalibration of particular internal model parameters. Beyond this significant level of complexity to rerun an internal model under approximate post stress calibrations, we believe that reporting of post-stress SCR estimates creates disproportionate certainty around the quality of the estimate, even if reported carefully under disclosure of all assumptions. On the other hand, an oversimplified SCR estimate will not be able to inform the decision makers appropriately. Overall, we believe that multi-year, post-stress SCR estimates should — if at all — be used very carefully and restricted to few, selective applications, only.

Apart from setting capital levels and stress testing capital adequacy, ST&SA is often used to compare financial institutions. The focus of such a comparison is on relative magnitudes and on the sensitivity of financial balances to individual or groups of risk factors. The calibration of the occurrence probability of stress test is less relevant, as the focus of the process is on an appropriate balance between generality — to allow for appropriate applications to different portfolios and of existing risk mitigation techniques – and granularity – to avoid widespread interpretation and implementation between different institutions. As an example, International Accounting Standards (IAS) requires stress tests, but leaves the definition up to financial institutions and the development of common market practice. In contrast, MCEV reporting has a fixed list of simple stress tests or sensitivities (see table 5).[9] The reporting aims to reveal the portfolio sensitivity and also the efficiency of risk mitigation instruments (Principle R4). The reported figures are, in general, not directly linked to a solvency assessment.

Table 5: Sensitivities as per MCEV principles

Risk factor	Change
Interest rates	Parallel shift, +/- 100bp
Equity/Property	10% decrease
Equity/Property, implied volatility	25% increase
Swaptions, implied volatility	25% increase
Maintenance expenses	10% increase
Lapse rates	10% decrease
Morbidity/Mortality rates	5% decrease

In the past, regulatory stress testing frameworks were often missing a dynamical element, which prevents pro-cyclical behaviour. Only lately, countercyclical measures were introduced. As an example, the German regulator changed its regular equity stress test method in 2008 following the start of the financial crisis. Regulatory frameworks such as ORSA do not prescribe a list of stress tests to be conducted but rather apply similar principles as described in section 3 to define a stress test framework, which is aligned to the individual company's situation and needs.

A theme that more recently has received some attention, partly due to the systemic risk debate is the usefulness of idiosyncratic versus system-wide type of scenarios (see also above on recovery and resolution plans). Insurers, in general, do not pose a systemic risk and therefore focus on developing scenarios that have specific relevance for their particular business model. This makes sense as the (financial) strength of a single company is best tested by stress events that are geared towards the risks an insurance company actually has on its own balance sheet. However, due to the

[9] See http://www.cfoforum.eu/embedded_value.html and the references therein.

recent financial crises that impacted financial markets worldwide, there is an increased interest from supervisory institutions to include the impact of system-wide scenarios. These system-wide scenarios required by regulators may change priorities: an insurance company focusing on economic survival in a catastrophic event (say Avian flu scenario) prioritises scenarios differently than if there is a regulatory requirement to "uphold certain critical services to the society as a whole" (such as upholding the claims handling services) that are not strictly necessary for its economic survival.

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