Stress Testing and Scenario Analysis in Life Insurance… …and Beyond

A paper by the Stress and Scenario Testing Working Party of the Institute & Faculty of Actuaries

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1. Introduction

Synopsis

1.1. The profile of stress testing and scenario analysis (also referred to in this paper as stress and scenario testing, or SST) has risen in recent years, not least as a consequence of the Global Financial Crisis of 2007/8. Central banks and regulators have turned increasingly to stress and scenario testing as a tool to assist in the promotion of their objectives, including maintaining financial stability. Current examples are the 2014 European-wide insurance stress tests (EIOPA, 2014) and enhanced SST requirements for Global Systemically Important Insurers (IAIS, 2013).

1.2. For the UK life insurance industry, SST has been an important part of the regulatory landscape for more than 30 years. Its use as a tool to inform decision-making in insurance has a far longer heritage. However, stress testing and scenario analysis still presents a range of challenges to insurers, both technically and operationally.

1.3. This paper explores a selection of these more challenging areas, providing perspectives on current practice and highlighting areas for further development. Whilst the paper focuses on practices in life insurance, it also considers several examples of recent developments concerning stress and scenario testing in other industries.

1.4. This paper is principally aimed at SST practitioners, and users of SST results, in the life insurance industry. However, it is not a particularly technical paper, and many of the concepts are not unique to life insurance. It is hoped that the paper will be useful to those with an interest in SST, whether in life insurance or in other fields.

1.5. The authors are members of the Stress and Scenario Testing Working Party of the Institute & Faculty of Actuaries (hereafter referred to as the "Working Party"). The Working Party was established by the Life Research Committee of the Institute & Faculty of Actuaries.

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Definitions

1.6. In this paper, consistency is retained with the current UK regulatory definition of stress testing and scenario analysis from the financial services handbook of the Prudential Regulation Authority[1]:

- **Stress testing** typically refers to shifting the values of individual parameters that affect the financial position of a firm and determining the effect on the firm's financial position
- **Scenario analysis** typically refers to a wider range of parameters being varied at the same time. Scenario analyses often examine the impact of adverse events on the firm's financial position, for example, simultaneous movements in a number of risk categories affecting all of a firm's business operations, such as business volumes, investment values and interest rate movements.

1.7. Both stress testing and scenario analyses are forward-looking analysis techniques, which seek to anticipate possible losses that might occur if identified risks crystallise.

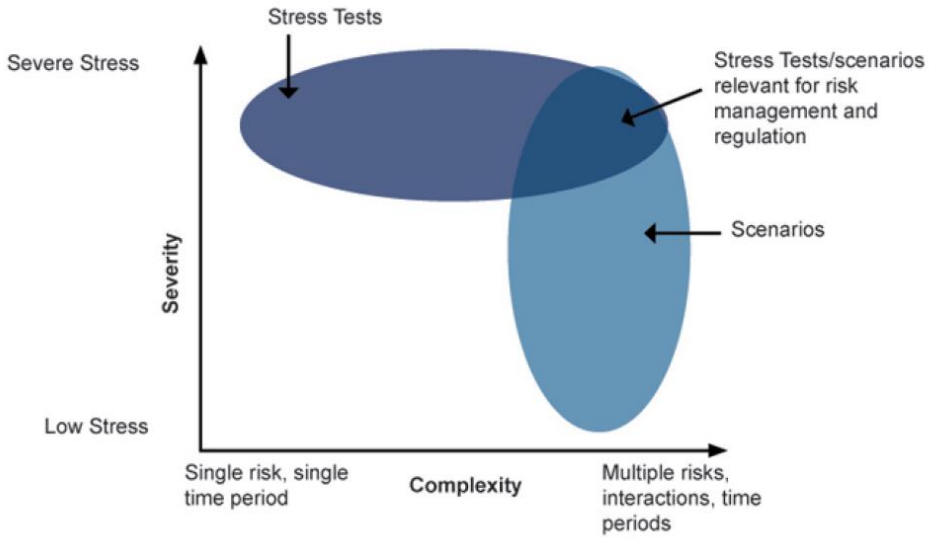
1.8. Another concept referred to in this paper is reverse stress testing, where again this paper uses the current UK regulatory definition[2], namely:

- **Reverse stress testing** refers to stress tests and scenario analyses that test a firm's business plan to failure.

1.9. It is acknowledged that other distinctions might be made between stress tests and scenario tests, for instance a recent IAA paper on stress and scenario testing (IAA, 2013) distinguished between severity as well as complexity:

[1] http://fshandbook.info/FS/html/handbook/GENPRU/1/2

[2] http://fshandbook.info/FS/html/handbook/SYSC/20/2



1.10. As this diagram highlights, it can be the use that defines the appropriate severity and complexity of the test and, in some senses, this is more important than the semantics.

The structure of this paper

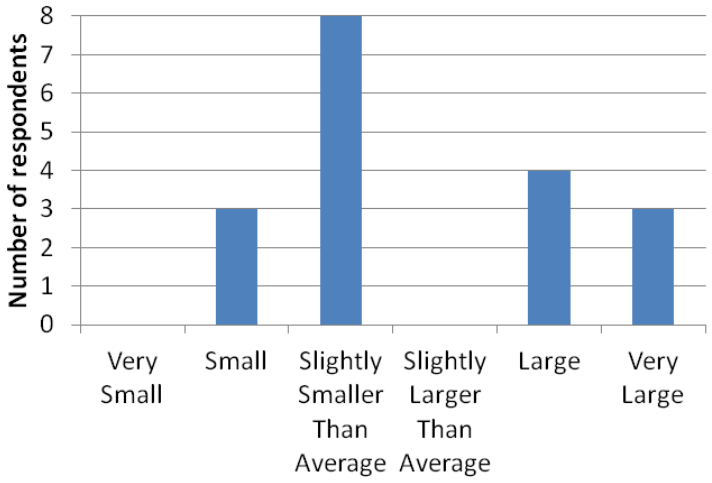
1.11. This paper is structured as follows:

Chapter	Summary
Executive summary	Captures the paper's key points
Use and embedding	Discusses the uses to which SST is put, challenges to successful embedding and how SST design might develop in future to enhance effectiveness
Communication	Discusses good SST communications practices
Scenario selection	Looks at the tools and techniques for devising and specifying stresses and scenarios that are focussed, useful and provide insight
Management actions	Analyses current practice in life insurance stress and scenario testing and considers areas for improvement
Insights from other industries	Considers recent developments in stress and scenario testing in selected industries
Final remarks	Some final thoughts to conclude the paper
Appendix	High level summary of a PESTEL analysis
Bibliography	References and selected additional texts concerning stress and scenario testing

Survey data used in this paper

1.12. In order to shed light on current SST practices in the UK life industry, the Working Party ran an SST Survey[3] in autumn 2013 (hereafter referred to as the "Survey"). Eighteen UK life insurers participated and the results of the Survey are central to this paper.

1.13. The Survey questionnaire was sent to Chief Risk Officers and Chief Actuaries, and included a question asking respondents to self-assess the size of their firm. It can be seen from the following graph that Survey responses were received from firms of different scale.



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- the 18 insurers participating in the Survey, and especially for the extent of their qualitative responses
- our employers for giving us the freedom and flexibility to contribute to the Working Party
- James Tufts, for kindly agreeing to Chair the SIAS meeting at which this paper is presented.

[3] http://www.actuaries.org.uk/research-and-resources/documents/life-insurance-stress-scenario-testing-survey-2013-0

Views expressed

1.15. The views expressed in this paper are those of the authors and do not necessarily represent the views of our employers or clients. The authors are responsible for any errors or omissions in this document; responsibility for referenced books or websites remains with their authors.

1.16. The authors are happy for reasonable use to be made of any of the content of this paper, with appropriate acknowledgement.

1.17. The authors very much welcome feedback on this paper; the best point of contact is shown on the Working Party's pages on the website of the Institute & Faculty of Actuaries[4].

[4] http://www.actuaries.org.uk/life-insurance/pages/stress-and-scenario-testing

2. Executive summary

Introduction

2.1. The UK insurance industry is seeing a significant increase in the use of stress and scenario testing, by firms and their regulators. There are various underlying reasons - the most important ones being the global financial crisis of 2007/8 (hereafter the "Global Financial Crisis") and Solvency II, the forthcoming new regulatory regime for insurance.

2.2. The Global Financial Crisis brought into clear view the interconnectedness of financial markets and the threats posed by systemic risk. This has prompted increasing use of SST by regulators on an international scale, as well as enhanced SST requirements for firms deemed to be of global systemic importance. The Global Financial Crisis also exposed vulnerabilities in the business models of certain financial firms, which has led to greater regulatory focus on reverse stress testing for insurers as well as banks.

2.3. Furthermore, SST is seen as a key validation tool with respect to internal capital models, which can be highly complex. Stress and scenario testing is a means of enabling stakeholders to engage more effectively with the modelling, and to challenge outputs. Many insurers have invested heavily in technology and process improvement in the run-up to Solvency II implementation. For some, this has brought increased capacity to carry out stress and scenario testing. On the other hand, the complexity of establishing the base capital position has materially increased for many firms, meaning that evaluating the impact of stresses and scenarios to this base position is now far more challenging.

2.4. Stress and scenario testing increasingly involves a broader dialogue with different functional areas within insurers. Multi-disciplinary input is of particular value when formulating stresses and scenarios, including reverse stress tests, and when considering how the firm would respond to the stress. Recovery planning for systemically important insurers requires them to consider even more carefully the availability and effectiveness of management actions in stressed conditions, and operational readiness more generally. Roughly one third of firms participating in the Survey make use of "war gaming" approaches, which test a firm's response to a simulated crisis situation, as part of their stress and scenario testing.

2.5. Another important trend is for stress and scenario testing to be subject to more formal governance. Involvement of Boards and Risk Committees in stress and scenario testing is increasing. Proximity of the Board and Risk Committees to the scenario setting process at key stages is required in order for governance to be sufficiently robust. Key touch-points include scenario selection, the definition of business model failure for reverse stress testing, approval of key assumptions including management actions (such as risk mitigation) under stress, as well as approval of results.

Use and embedding

2.6. Stress and scenario testing is a critical tool for an insurance firm. It is used for a wide range of purposes, including defining risk appetite and limits, setting capital buffers, risk reporting, as well as informing strategy, capital management, risk acceptance and risk mitigation decisions. As discussed above, it can also be a powerful tool for validating results obtained from probabilistic models. Further, it can be useful when the probabilities of alternative scenarios are unclear and not reflected in probabilistic models, e.g. change in government policy.

2.7. More generally, stress and scenario testing is a useful means of communicating risk and uncertainty. No business decision is completely absent of risk, and better appreciation of risk should enhance the quality of decision-making.

2.8. Notwithstanding its history of use in the insurance industry, stress and scenario testing continues to challenge insurers. Lack of time and / or resources is a common challenge, as is appropriate stress and scenario selection. Interestingly, many firms, particularly larger ones, struggle to make stress and scenario testing relevant to business decisions. Arguably, regulatory-driven exercises, where the derivation of the stresses and the use of results can be opaque from the perspective of firms, have contributed to this. Such exercises are set to continue, as stress and scenario testing is also an important tool in the toolkit of regulators, working to meet their statutory objectives.

2.9. A well designed stress and scenario testing framework can provide much needed clarity by promoting common understanding, defining roles, responsibilities and accountabilities, and providing a structure around which more detailed plans can be built. The key ingredient when developing such a framework is engagement of those with responsibilities and accountabilities for stress and scenario testing. Only with broad engagement will the framework best reflect the overall needs and priorities of the business.

2.10. Stress and scenario testing frameworks should be regularly reviewed by insurers to ensure their continued appropriateness, given the changing needs of the business and the external environment.

Communication

2.11. An effective communication strategy is essential to ensure that a range of information is presented such that individual target audiences all receive the right message in a way that supports effective decision-making.

2.12. Communication should be tailored to each audience and presented in a way that suits it, adjusting for its requirements.

2.13. The timing of exercises should be planned appropriately so that results, communicated in a format that supports their use, can inform the business and strategic planning process with the most up to date information. In

doing so, this should limit the requirement for significant additional effort to ensure timeliness of data. The Own Risk and Solvency Assessment ("ORSA") is a means of linking the process and the outputs together on a continuous basis.

2.14. Recommendations should be clearly presented while acknowledging the degree of uncertainty and judgement applied. Findings should be clearly backed by analysis and data but presented in a way that ties in with the purpose of the exercise. This will help avoid uncertainty and misunderstanding.

Scenario selection

2.15. Good techniques for identifying interesting scenarios, specifying their features and assessing their impact are at the core of a successful stress testing and scenario analysis exercise.

2.16. Time spent in deriving relevant stresses, taking account of the risk profile of the business, helps improve the insights that can be gained and drives engagement in stress testing and scenario analysis, making it easier to turn analysis and insight into action. Engagement of colleagues throughout the firm in a focussed and productive exercise to identify stresses not only grounds stresses and scenarios in the business reality but may also of itself produce benefits in furthering interest in stress testing results and embedding best practice in consideration and management of risk.

2.17. There is also a close relationship between the objectives of the stress and scenario testing exercise and those of the economic capital model. By acknowledging the latter, the former can focus effort efficiently and provide powerful insight into one of the most complex areas of the business.

Management actions

2.18. This paper uses the term "management actions" to encompass the range of actions available to the management of an insurer to mitigate or respond to adverse events; in other words, the set of possible contingency actions.

2.19. The use of management actions to mitigate adverse events is a key component of stress testing and scenario analysis and the ability of a firm to take actions in response to an event can have a significant financial impact. Firms need to be able to calculate the impacts of management actions consistent with other financial metrics, and in order to take credit for management actions in modelling a firm will need to be confident that they can be applied in practice. An insurer's governing body will need to understand and agree that the actions will be taken, if required, and monitoring processes are needed to ensure that the actions can respond to events in a timely manner.

2.20. Firms need to link management actions to the specific stresses and scenarios being considered. Whilst some actions can be universally applied, some actions will only be appropriate in certain circumstances and the actions should not be applied outside those circumstances.

2.21. Considering how a scenario or stress test evolves will also help a firm understand the steps it is likely to need to take and where any weaknesses might exist in its processes. This also allows firms to use stress and scenario testing to assist with effective risk management and recovery planning.

Insights from other industries

2.22. Stress and scenario testing is used in a wide range of industries, and time has permitted only a short analysis in a handful of sectors. There may be merit in a deeper cross-sector analysis in the interests of sharing best practices and learning points.

2.23. With respect to the sectors considered in this paper, namely banking, social housing and nuclear energy, there are many similarities to be found in stress and scenario testing practices, as compared with insurance. Key themes are:

- Increasing prominence of reverse stress testing
- Stress testing and scenario analysis outputs including a clear action plan for mitigating risks identified
- Focus on the availability and effectiveness of contingency actions in stress conditions
- Consideration of combination events with non-linear outcomes
- Use of benchmarking and peer review (e.g. in banking the UK regulator has developed a number of internal modelling tools, and recent European stress tests of the nuclear industry involved peer review of national reports).

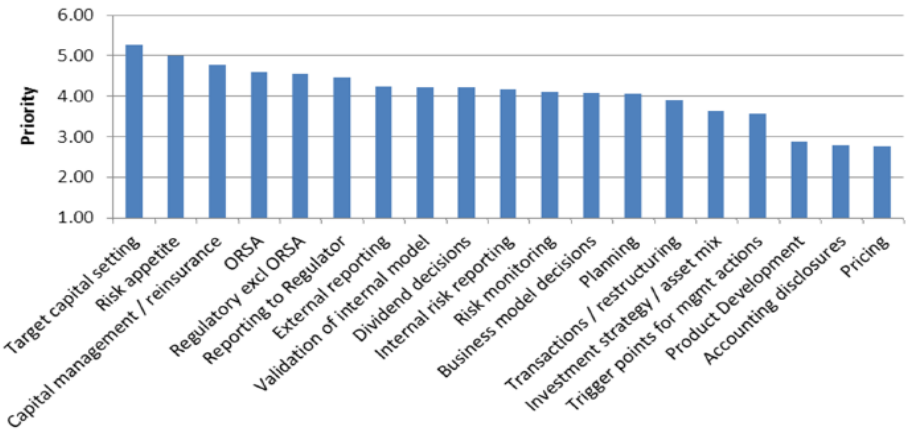
2.24. Of general relevance across all corporate sectors are the recent changes to the UK Corporate Governance Code (the "Code"). The 2014 version of the Code includes the requirement for a "viability statement" in the strategic report to investors, providing an improved and broader assessment of longer-term solvency and liquidity. It is expected that this statement will look forward significantly further than 12 months, and will be supported by stress and scenario testing.

2.25. For UK insurers, it is expected that the underlying stress testing and scenario analysis will already be available from a well-functioning ORSA process. For some corporates, though, the expectations of the new Code may require significant further investment to address in full. Indeed, the new Code may generate interest in the experience of insurers, particularly in relation to ORSA.

3. Use and embedding

Overview of current usage

3.1. Stress testing and scenario analysis is used for a wide range of purposes in life insurance. Most of these are business uses, and some are to meet regulatory requirements. The following table shows the uses referenced by Survey participants in order of the priority assigned to each use (high priority = 6, low priority = 1):



(Life Insurance Stress and Scenario Testing Survey 2013 – by Stress and Scenario Testing Working Party of the Institute and Faculty of Actuaries)

3.2. Stress and scenario testing is a key tool used by insurers when defining their risk appetite (i.e. the level of risk a firm is prepared to accept in pursuit of its strategic objectives). For example, stress testing the assumptions underpinning a business plan might highlight that the amount of risk associated with the plan is outside the firm's risk appetite. Thus, either the articulation of risk appetite needs to be updated, or action needs to be taken to bring the risk-reward trade-off back within risk appetite.

3.3. Stress and scenario testing is also used in the identification, assessment, management, monitoring and reporting of risk in the business on a regular basis. Uses such as ORSA, internal risk reporting and risk monitoring all fall into this category. Internal risk reporting was cited as the highest priority use of SST in a recent CRO Forum study (CRO Forum, 2013).

3.4. Closely related to risk and risk appetite is the process of setting target capital. Insurers typically have a policy to maintain capital in excess of minimum or economic capital requirements, and this "capital buffer" is often set using stress and scenario testing. For example, regulation might require the firm to hold capital sufficient to withstand a 1-in-200 year event. Insurers seek to hold additional capital such that, following a moderate shock, they still have sufficient capital to withstand a 1-in-200 year event. Stress and scenario testing is commonly used to derive buffer capital, and/or to articulate in real life terms, the severity of shock that the buffer capital covers.

3.5. It follows that stress and scenario testing is also important for firms in formulating dividend plans and making dividend decisions, these being key to the maintenance of the target capital position. Indeed, these could be seen as tools within a broader capital management toolkit - also including tools such as capital raising, reinsurance and asset-liability management.

3.6. **It is clear that stress and scenario testing is key to some of the most fundamental aspects of operating an insurer**. Indeed, the challenge of balancing risk and return is certainly not unique to life insurance. The use of SST in a selection of other financial and non-financial sectors is explored in Chapter 7.

Looking ahead

3.7. Stakeholder needs evolve over time. Respondents to the Survey expected to see greater use of stress and scenario testing over the next two years in the following areas:

- Risk monitoring, planning and capital management
- Reverse stress testing
- Internal model validation
- Regulatory-driven exercises.

3.8. Stress and scenario testing may also be increasingly used to facilitate understanding and communication of existing, emerging and potential future risks, and to identify risk concentrations across multiple business lines.

3.9. However, the focus for many Survey respondents related to the need to improve communication of stress and scenario testing, a topic discussed in the next chapter. For other firms, the priority is to further develop modelling capabilities to increase the number of scenarios and to improve the timeliness of results production, to support decision-making across a broad range of uses.

3.10. Whilst Survey participants did not comment on recovery planning, it seems that this will become increasingly important. Global systemically important insurers have already faced enhanced stress and scenario testing requirements[5], which consider in some detail how management would be expected to respond at various points in an unfolding scenario. Whilst a long list of management actions may be available in theory, the availability and effectiveness of these actions will vary according to the particular scenario in question. This area is considered further in Chapter 6.

3.11. Simulation exercises, for instance whereby a firm's management is required to make decisions in response to an unfolding scenario, may also see greater take-up over time. Around one third of Survey respondents already use "war gaming" techniques, described by the Survey as "testing the firm's response in a simulated crisis situation, including dimensions

[5] http://www.iaisweb.org/G-SIIs-988

such as information flow, speed, organisation, leadership and communication". War gaming often takes a "red team / blue team" format, whereby the red team challenges the decision-making of the blue team.

3.12. Such simulation activities also highlight the value of early warning indicators; as the name suggests, these provide an early indication of trouble ahead, potentially giving management more time to respond. There is a wide range of possible early warning indicators, including implied volatility indices, spread betting quotes and regulatory announcements, to name just a few.

3.13. Timely and relevant management information, including risk metrics, is needed to enable management to respond appropriately. Trigger points defined at pre-agreed levels of key metrics (e.g. capital, liquidity, performance, risk) help to ensure that management discussions regarding the appropriate course of action happen in a proactive and timely fashion.

3.14. While some might see this as straying beyond the boundaries of conventional stress and scenario testing, requirements are already moving in this direction i.e. towards demonstrating a position of "readiness" to deal with unfolding adverse scenarios. This represents a significantly higher bar than the stress testing and scenario analyses that insurers have typically conducted.

3.15. Stress testing and scenario analysis is expected to become more widely used and supply further insights to assist with risk and capital management. There is increasing focus on the readiness of firms to respond to adverse conditions, and stress and scenario testing tools continue to develop to support evolving requirements.

Challenges to successful embedding

3.16. Successful embedding of stress and scenario testing remains elusive for many firms.

3.17. On a scale of 1 to 6, where 1 is not challenging and 6 is very challenging, the Survey asked participants to rate each of the following areas:

	Overall	Smaller firms	Larger firms
a) Lack of time / resources	4.3	4.3	4.4
b) Appropriate stress and scenario selection	4.0	4.4	3.4
c) Making SST relevant to business decisions	3.8	3.5	4.1
d) Recalibration of scenario generator under stressed conditions	3.5	3.7	3.2
e) Assessment of impact of selected stresses / scenarios	3.3	3.1	3.6
f) Presenting results / insights from SST in an effective way	3.3	3.3	3.4

a) Lack of time/ resources

3.18. Survey respondents gave an average score of 4.3 to the issue of "lack of time / resources". On average, this was seen as the most challenging area.

b) Appropriate stress and scenario selection

3.19. The next highest score, of 4.0, was in respect of appropriate stress and scenario selection, a topic that is discussed in more detail in Chapter 5. Smaller firms appear to find this area more challenging than larger firms, with scores of 4.4 and 3.4 respectively.

3.20. A particular barrier to engagement is the perception that scenarios are either irrelevant or inappropriately calibrated.

3.21. The appropriate strength of calibration depends very much on use. For example, whilst a firm's management will be interested in low probability, high impact events, typically management also attributes high value to mild or moderate strength scenarios, particularly those within or at the limit of risk appetite. Such scenarios are very useful to ensure that risk appetite is appropriately defined and consistently understood across the business. Prudential regulators focussed on testing individual firms' vulnerabilities or the vulnerabilities of the financial system as a whole may be less concerned with moderate shocks.

3.22. Qualitative survey comments relating to inappropriate calibration of stresses may be a symptom of poorly targeted communications rather than genuine evidence of poor calibration. Clarifying the use to which the results of a stress test will be put is therefore key to promoting engagement – an observation that applies equally to internally and externally driven SST exercises.

c) Making stress and scenario testing relevant to business decisions

3.23. Interestingly, the next highest score, of 3.8, was in respect of "making stress and scenario testing relevant to business decisions". It is not entirely clear why this is problematic, but some potential explanations are considered below.

3.24. Given the wide range of uses, demands for SST in a business can become difficult to manage. There is the risk that SST becomes an increasingly time-consuming, labour and capital intensive process. To keep the process manageable, short-cuts are often taken, for instance trying to meet different requests with a single set of outputs. What can result is a process that does not actually address the questions posed and is neither timely, nor relevant nor effective. Stress and scenario testing can become a process divorced from the needs of end users.

3.25. This issue may be more prevalent for larger firms than smaller ones. The average score for larger firms was 4.1 compared with an average score of 3.5 for smaller firms. It is also the case that larger insurers have been more impacted by regulatory-driven exercises, some of which are targeted only at insurers of a certain scale or significance, and some of which are

targeted only at insurers intending to apply for internal model approval for Solvency II (larger insurers being overweight in this category). Arguably, regulatory-driven exercises, where the derivation of the stresses and the use of results can be opaque from the perspective of firms, can obscure the link between the stress and scenario testing process and the end use.

3.26. Successful embedding relies on strong engagement across the business. Engagement with a process is likely to be highest when stakeholders feel that the process is helping them to meet their objectives. From the discussion above, it can be seen that this is not always the case.

d) Recalibration of scenario generator under stressed conditions

3.27. The average scores shown are based on the 12 responses received, suggesting that only a subset of firms participating in the Survey make use of economic scenario generator outputs. This paper is non-technical and does not consider this topic further.

e) Assessment of impact of selected stresses/scenarios

3.28. Survey respondents cited that "users" of SST want more realistic scenarios, recommendations and scenarios and meaningful actions. Users value involvement across business units and with a variety of scenarios, risk sensitivities and projections and "what-if" analysis of results. Timely reporting is a key requirement.

3.29. Stakeholders are most likely to be engaged when stress and scenario testing is of an appropriate quality. Not only must the calculations be fit for purpose, and at an appropriate level of granularity, but the key assumptions should be articulated succinctly along with key limitations. Data must be of sufficient quality, meeting standards for accuracy, appropriateness and completeness, including traceability.

f) Presenting results/ insights from SST in an effective way

3.30. Another significant bugbear of Survey participants, particularly in their qualitative responses, and arguably the biggest obstacle to engagement with the SST process and its results, is poor communication and reporting, a topic discussed in the next chapter.

3.31. **The survey showed that many firms continue to face challenges with the stress testing and scenario analysis process from the derivation of the scenarios through to the presentation of results.**

Examples of good embedding practices

3.32. As discussed above, ever-increasing demands for stress and scenario testing can lead to a situation where stress and scenario testing becomes ineffective. A stress and scenario testing framework can help to provide much-needed focus. Stakeholder engagement around the development of the framework helps bring to the fore the real needs of the business, helping to prioritise and plan the cycle of stress and scenario testing. An

annual process can be set out around the key business processes, including business planning, financial reporting and ORSA. Good SST frameworks set out governance arrangements, including key accountabilities and responsibilities and the role of senior management and the Board, enabling better planning and engagement. Consideration should also be given to the triggers for ad hoc stress testing, for instance material changes in risk profile, or planned future changes (arising from transactions, for example).

3.33. An SST framework also enables good disciplines to be formally articulated. For example, stresses need to be regularly reviewed for relevance. It is easy to add another stress to an ever-growing list, but more difficult to deliver with the accuracy and timeliness required. Stresses that are less relevant should either be removed or run on a less frequent basis. Stress and scenario testing needs to address risks that are not included in a firm's model used to calculate capital requirements, for instance because capital is not an appropriate mitigant. Examples might include liquidity risks and strategic risks, and the framework can usefully set out how stresses might be assessed qualitatively as well as quantitatively.

3.34. The stress and scenario framework should be subject to formal approval processes and subsequently subject to periodic review.

3.35. **A stress and scenario testing framework, developed in conjunction with the business, can be of great value on the path to successful use and embedding of stress and scenario testing**. Given the forthcoming implementation of Solvency II, this would need to integrate appropriately with the ORSA policy.

3.36. Another important trend is for stress and scenario testing to be subject to more formal governance. Involvement of Boards and Risk Committees in stress and scenario testing is increasing. Proximity of the Board and Risk Committees to the SST process at key stages is required in order for governance to be sufficiently robust. Key aspects to discuss and agree with stakeholders include scenario selection, the definition of business model failure for reverse stress testing, approval of key assumptions including management actions, such as risk mitigation under stress, as well as approval of results.

4. Communication

4.1. Responses to the Survey indicated that effective communication of the results of stress and scenario testing would address aspects such as the following:

- Scenarios "made real"
- Sufficient granularity of scenarios
- Risk percentiles and answers to "what if" questions
- How this informs what management actions should be taken in practice
- Targeted and relevant concise reports
- Clear recommendations and analysis
- Greater integration of Key Risk Indicators (KRIs).

4.2. An enormous amount of work goes into stress and scenario testing. Unless results are communicated in a way which helps stakeholders to make better decisions, this effort can be wasted.

4.3. That said, following a small number of simple communication principles will help to ensure that a greater benefit is obtained from the stress and scenario testing performed – a positive for companies, regulators and ultimately for the customer.

4.4. The principles considered here are:

- Tailor to the audience
- Relate to the decisions which need to be made
- Provide a summary but allow for drill down into results
- Perform communication "housekeeping" checks.

Tailor to the audience

4.5. The results of stress and scenario testing need to be communicated to a range of potential audiences, from modelling or risk specialists to business leaders (execs and non-execs) to external parties such as regulators, rating agencies, auditors and investors. To make decisions using the stress and scenario testing results, users need the information to be presented in a way that suits them. The communication strategy should be tailored to the circumstances and purpose of the tests. It should convey the key messages but be presented to individual audiences in a way that adjusts for their time, level of expertise and their responsibilities within the process.

4.6. It is probably most challenging for modelling teams to write material for senior business leaders. While business leaders may well be familiar with the metrics, they cannot be experts in all the detail of the underlying modelling. On the other hand, they need to have the right information to take the appropriate strategic decisions to steer the enterprise. The author must present the relevant information and conclusions in a way to support

this without assuming that the reader will be able to interpret a glut of results and reach their own conclusions in a limited timeframe. In practice, this means clearly articulating findings and proposals, along with the key underlying assumptions and areas of judgement and uncertainty.

4.7. A clear communication strategy will include a summary of relevant background information and sufficient detail (based on the circumstances and purpose of the tests) for the reader to frame the information presented and form their own opinion on the information provided. Information included should be fact-based and precise, avoiding ambiguity that might lead to misunderstanding but clarifying areas where reliance is placed on tentative assumptions or simplifications.

4.8. It is important to avoid reporting too much detail – reports should clarify the conclusions reached together with the options available. Thus, there should be a close link to management actions. Supporting information should be referenced, included in appendices or otherwise set out so as not to obscure the key outputs of the exercise results, conclusions and recommendations.

4.9. Tailoring write-ups to the audience can take significant time and skill but, without it, conclusions can be easily misinterpreted and recommendations ignored. The time and effort required to do this is typically small in comparison to the effort involved in the setting-up, running and interpreting stress and scenario testing. However, it is essential to provide sufficient time in the SST process to provide scope for high quality reporting.

Relate the stress testing and scenario analysis to decisions

4.10. As mentioned earlier, there is little point to stress and scenario testing unless it can ultimately be used to inform decision-making.

4.11. This means that when communicating stress and scenario testing, the options and recommendations need to be clearly related to the decisions to be taken. This principle applies equally to the process of agreeing which stress and scenario tests are conducted as to discussing the results.

4.12. Another consequence is that stress and scenario testing results need to be up to date and, often, forward-looking. In some cases it is better to sacrifice precision for speed of results ("back of the envelope" assessments do have a legitimate place in stress and scenario testing). However it is also important for businesses to continue to look for ways to run robust stress and scenario testing results as quickly and efficiently as possible.

4.13. It can be easy to fall into a trap of ever-expanding management information, as topical new stresses are added and pre-existing stresses are retained. Due consideration needs to be given as to whether all the information continues to be useful, having regard to current conditions, changes in the firm's risk profile or risk appetite.

4.14. Lastly, in order to be relevant to decision-making, it is important that stress and scenario testing should try to cover all relevant measures where possible. This is particularly the case for internal decision-making where organisations generally need to consider the impact of potential actions on multiple measures, such as earnings, profit, capital and liquidity positions, and, potentially on multiple bases for certain measures. Stress and scenario testing results are much more likely to influence decisions if they are able to consider the impacts across the relevant measures and bases. Further discussion of metrics to consider in SST can be found in Chapter 5 under the heading "Measure to be assessed".

4.15. For practicality, it is not unreasonable to model some measures in more detail than others. However, the level of detail needed should be driven by the type of decisions being made rather than the available model. For example, there might be no value gained from running a full economic capital model if the particular decision turns on a profit impact which can only be modelled approximately.

Summarise results but also provide a drill-down

4.16. It is often useful to provide a summary section or report, but also to make available more detailed findings, which users can drill-down into later if needed.

4.17. It is good practice - but also increasingly important for internal and regulatory purposes - that there is a comprehensive record of stress and scenario testing conducted. This means it can be revisited and investigated at a later date.

4.18. For example, internally, an organisation may wish to investigate the conclusions at a later date (e.g. if circumstances change) or if they need to explain a movement in results from one period to the next. It is important to maintain an audit trail of the decisions made and the conclusions. External stakeholders such as regulators or auditors may also wish to investigate conclusions at a later date for example as part of their checks on the robustness of a firm's stress and scenario testing framework.

Perform communication "housekeeping" checks

4.19. Before finalising the write-up of stress and scenario testing results it is worth performing a small number of "housekeeping" checks to ensure that the documentation is well received.

4.20. For example:

- Provide sufficient context and background
- Make sure recommendations are clear
- Make sure results work as a standalone document
- Remove unnecessary jargon
- Highlight the key limitations succinctly
- Occasionally, test that write-ups make sense to someone new.

4.21. It is important to explain up front the context for the work performed and the process followed – for example for reverse stress testing it will be necessary to explain the definition of business model failure. It is also important, for example, to communicate the key assumptions for extreme stresses which are likely to be very material to the actions required.

4.22. As mentioned above, a key check is to ensure that recommendations are clear. Linking recommendations to the supporting results and analysis will enable the reader to drill down and follow the steps in the analysis to reach their own conclusion.

4.23. Ideally, a results document should work as a "standalone" paper. Whilst it is sometimes helpful to provide references to other underlying documentation, in most circumstances readers shouldn't need to also read the underlying documents in order to use the results document in their decision-making. (An exception might be audit or regulatory review of the wider stress and scenario testing process.)

4.24. A useful housekeeping check is to remove unnecessary jargon (i.e. words or acronyms that do not appear in a standard dictionary). It is good practice to include a glossary where use of jargon is unavoidable.

4.25. Authors must exercise an appropriate degree of judgement in order to determine the appropriate level of caveats in communicating to senior management. It is important to communicate the materiality levels assumed, which affect the accuracy of the results. They must acknowledge the degree of uncertainty but also be able to communicate what this means in practice to a reader of the results to help them to deal with any limitations that remain. It is often helpful, where possible, to frame caveats by providing a range describing the impact of the uncertainties they cover.

4.26. It can be useful to periodically test the results write-up with someone from a different area of the business (or new to the team) to make sure that a generalist can easily follow the conclusions.

5. Scenario selection

Chapter overview

Background

5.1. In the FSA's[6] Policy Statement 09/20 of December 2009, firms' own stress testing was listed as one of the three main elements of the FSA's approach to stress testing[7], stating "We expect firms to develop, implement and action a robust and effective stress testing programme which assesses their ability to meet capital and liquidity requirements in stressed conditions, as a key component of effective risk management."

5.2. In line with GENPRU 1.2.73B, the PRA publishes a supervisory recommended scenario for the UK, as a complement to firms' own scenarios. This scenario takes the form of specified movements in parameters, such as GDP and housing price index, which need to be considered when setting scenarios for Individual Capital Assessment ("ICA"). Notably, this positions the supervisory scenario more as an input for consideration into the scenario selection process than a prescribed scenario. It can be useful as a benchmark of strength for scenario selection, although how the parameters specified by the supervisory scenario are interpreted as inputs to insurers' models is a matter of judgement.

5.3. The Survey provided some insight into the effect of regulation on stress and scenario testing. The results of the Survey showed that while emerging regulatory requirements had influenced stress and scenario testing, the majority of respondents indicated that the requirements were not significantly limiting the stress and scenario testing they would like to perform.

5.4. So whilst some of the motivation behind stress and scenario testing exercises may be driven by regulation, it is recognised that this is not the only driving factor. Firms are looking to these exercises to answer their own internal questions as well as to demonstrate resilience to stresses and scenarios tailored to their individual circumstances. Furthermore, regulation is not seeking to prescribe scenarios so much as encourage firms to construct appropriate scenarios for themselves, in keeping with the direction of travel implied by the introduction of the ORSA with Solvency II.

5.5. It is clear that there is the desire and the need for firms to design their own stresses and scenarios.

Objectives

5.6. This chapter focuses on stress and scenario testing exercises for which a firm intends or is required to specify scenarios, and discusses the

[6] The Financial Services Authority as it was at the time, the relevant function now being under the remit of the Prudential Regulation Authority.
[7] The other two elements being supervisory stress testing and system-wide stress testing.

selection of these scenarios. Although not strictly a necessary concern in scenario selection, some consideration is included of the challenges faced in the assessment of the impact of selected scenarios.

5.7. The following elements are discussed:

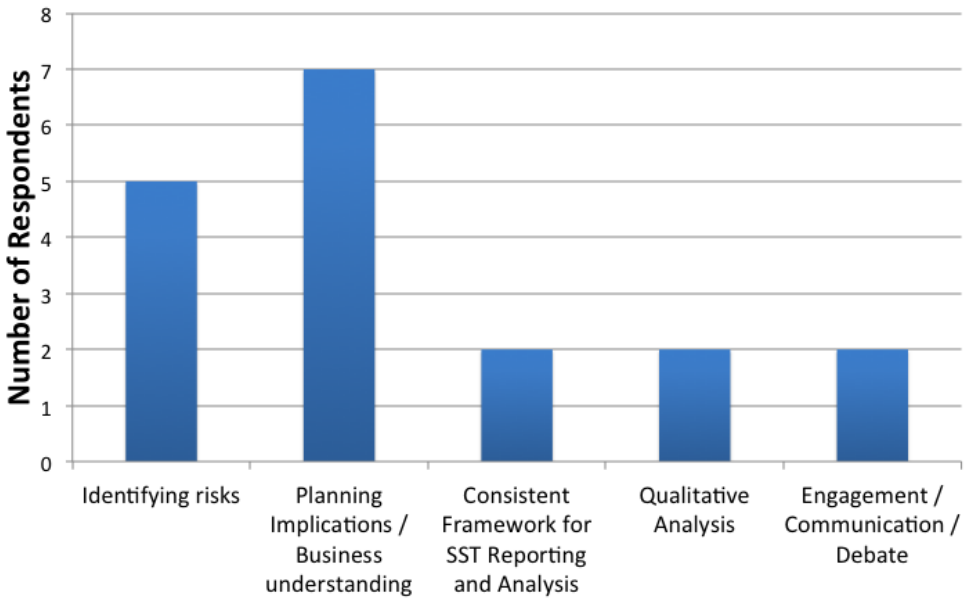
- Identification of risks
- The form of stresses and scenarios
- Setting the strength of scenarios
- Scenario selection by reverse stress test
- Benefits of governance in scenario selection
- Metrics to be assessed in the scenario
- The relationship of stress and scenario selection and testing with economic capital
- Evaluating the impact of scenarios on an economic capital basis
- The value in repeating previous stress and scenario tests
- Features of one possible framework for identifying risks - the PESTEL analysis.

5.8. This paper aims to be forward-looking such that the propositions remain equally valid under the Solvency II regime.

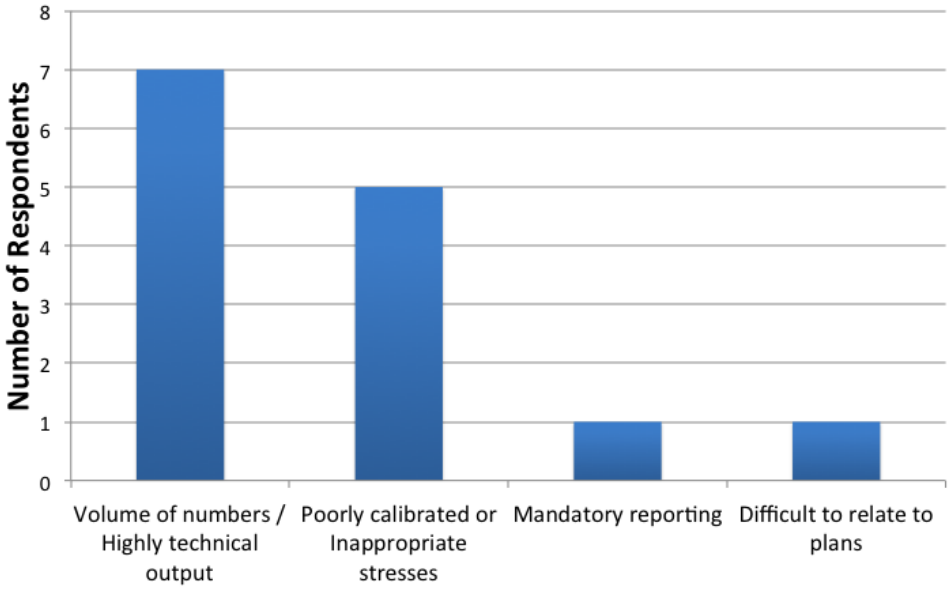
Preamble

5.9. A common remark in the Survey results was that users of SST processes found the identification of risks one of the most useful aspects. Conversely, poorly calibrated or inappropriate stresses were commonly cited as being the least useful elements in an SST process.

What Did Users Find Most Useful?



What Did Users Find Least Useful?



5.10. Therefore, the identification of scenarios that pose a risk to the firm is an important area, which requires particular focus.

5.11. Reasons for stresses being considered inappropriate included: those that take no account of the risk profile of the business, scenarios that are poorly reasoned and very extreme scenarios. Some respondents noted that they found scenarios prescribed by an external entity less useful.

5.12. Certainly where inappropriate scenarios are selected there will be far less benefit from analysing them, and senior management will be less likely to engage in the exercise. Furthermore, a robust collaborative approach to identifying the risks can also promote risk awareness within the business.

5.13. Practices should be implemented that make the relevance of the stress and scenario testing exercise evident and easy to communicate. In selecting stresses and scenarios, the identification of relevant risks should go hand-in-hand with a clear understanding of why the risk is relevant. Staying up-to-date with emerging risks and current mitigation procedures is essential. Risk identification should link to (and be consistent with) the most recent analysis or advice provided elsewhere, be that in the formal reporting process, the sign-off of models or the setting of strategy.

5.14. Time spent identifying scenarios and ensuring that it is easy to communicate their relevance adds considerable value to the SST process.

Risk identification

Tools for identifying potential risks

5.15. The probable starting point in a stress and scenario selection process is the generic insurance firm single factor risk exposures relating to categories such as markets, mortality, morbidity and persistency. Operational risk might also be thought of under this list, although approaches to identifying, assessing and managing the components of operational risk could vary more between insurers than the other risk exposures noted.

5.16. The likely more interesting, and arguably harder to identify (and to calibrate, evaluate and analyse), scenarios (i.e. combinations of individual risk exposures) are those that relate more directly to the particular circumstances of the firm. These will typically involve numerous risk factors moving at the same time, or could relate to changes in conditions that are less often considered, such as a change in the regulatory environment.

5.17. There are a number of ways to approach the scenario identification process. The challenge is often to ensure a sufficiently broad range of scenarios is identified, but there are tools and frameworks that can assist identifying scenarios across a range of scenario types. An example is the PESTEL analysis, which provides a framework for identifying scenario risks against Political, Economic, Social, Technological, Environment and Legal factors (see Appendix).

5.18. Engagement of senior management in the scenario selection process is a key component to achieving buy-in to the process, building confidence in the process and raising the profile of the output. Various functions of the business should be involved in the identification and initial assessment of scenarios.

5.19. It is important that the range of functions included in the scenario identification process is wide enough; for example HR, Legal, Investments, Operations, IT and so on. This will ensure a good breadth of scenarios is considered. During this engagement the SST practitioner should aim to keep discussions productive and focused. Preparation of an agenda of areas to explore will assist with this aim.

5.20. In the scenario identification process it can be useful to raise a number of questions, for example:

- What drives the profitability of the firm and what are the under-pinning assumptions in the overall strategy?
  - Can a plausible scenario be envisaged that would make the assumptions unrealistic?

- What were the big drivers for analysis of change in any of the recent metrics of interest?
  - Big losses driven by a particular factor may build momentum
  - Big gains driven by a factor could swing the other way
  - Were any unexpected results satisfactorily explained in a way that brings into focus uncertainties in factors that were

previously considered stable?

- Which models are relied upon for providing analysis and information? Model weakness or limitation lists may provide opportunities for a scenario analysis to examine the materiality of aspects that are not quantified by the model. For example:
  - If a model is known to omit the full effects of a certain risk or of interacting risks, a scenario may consider these
  - A full consideration of model weaknesses and limitations may shed light on ways to bolster risk mitigation, provide comfort that a limitation is not material or prompt further action.

- What do market or investment reports tell the SST practitioner?
  - Is there significant hedging activity being undertaken currently?
  - Are any indicators at an all-time minimum or maximum and what would happen if they progressed further or snapped back?
  - Ideally any scenarios based on a movement in market indices should be mapped back to plausible, easily understood, and not too remote, causes.

- What information is available from the product development area?
  - Have new product lines been launched recently?
  - New features in products and new markets may increase sources of risk for the firm
  - Is profitability on existing products being squeezed?
  - Are profits being made on new sales sustainable?
  - Are sales limits in place for risky products and how well are the factors determining the exposure to the risks understood?

- Peer analysis and analysis across industries to understand scenarios that have caused challenges for other insurers and other businesses:
  - How does the firm compare to its peers in terms of its performance, products, strategy or other areas?
  - There may be unique elements in the firm's strategy that expose it to more esoteric risks
  - The firm may be more sensitive to certain types of risk than its peers
  - Are there lessons that can be learnt from risks faced by other industries?

5.21. There are numerous avenues to explore in selecting scenarios and effective communication and focussed discussion is key to good scenario selection.

Form of stresses and scenarios

5.22. The original resilience test that the Government Actuary's Department applied in 1985 looked at a 25% fall in equity prices and a 3% change in interest rates. Since then, scenarios have become more sophisticated. As stresses or scenarios become more complex, it is increasingly important that consideration is given to the form they take and that their specification minimises ambiguity.

Specification of the stresses and scenarios

5.23. As the selection process unfolds, stresses and scenarios that have been identified must be captured and defined in as clear and unambiguous a manner as possible. Where the stress or scenario is similar to one that has been analysed in a previous exercise, it is worth giving some consideration as to whether retaining consistency with the previous exercise is useful (for example to highlight trends or measure the effect of management actions).

5.24. When defining a stress or scenario where there are several possible interpretations as to how the event might be realised, this should be noted, the preferred interpretation captured and, if practical, justified. Potential criteria for determining a preferred interpretation might include relevance to the firm's strategy or plausibility of the stress or scenario occurring in one manner rather than another.

The definition of stresses should be as clear and unambiguous as possible.

5.25. When defining the stresses and scenarios the following features should be considered:

- Whether the risk event involves multiple risk factors
- Time horizon over which the stress occurs
- Whether the stress or scenario definition should capture a specific event driving further consequent risks being realised. Examples of specific event-driven scenarios might be:
  - Collapse of a bank or re-insurer
  - Break-up of the Euro
  - Change in competitive or regulatory conditions
  - A re-play of a historical scenario such as the oil price crisis of 1974.

5.26. Each of the above events would have consequential impacts on the calculation of metrics for the insurer.

5.27. It should be recognised that the form of the stress or scenario can affect the effort required to evaluate and analyse its impact and the management actions that would be appropriate. However, these need not necessarily be key considerations in defining the form of the stress or scenario where there is compelling evidence to indicate that a more complex form would provide more useful insight.

Aspects of time horizon

5.28. In this paper, the time horizon for a stress or scenario refers to all of the following:

- The point in time at which the risk event is assumed to be initiated (in practice, life insurers might typically assume the latest valuation date or the next upcoming valuation date).
- The amount of time the event persists, takes to fully unfold or be recognised (for example a market fall may occur in the space of a few days, or over weeks and months).
- The amount of time for which the stress or scenario continues to cause measurable effect on the business, taking into account the amount of time the business takes to fully implement any actions prompted by the stress or scenario.

5.29. The following sections consider these aspects in more detail.

Point in time at which the stress or scenario initiates

5.30. The utility of a forward-starting stress will be driven by the extent to which the risk profile of the business is changing. For example, a mature book where stable new business volumes are expected might be relatively insensitive to the timing of the start of the stress. However this would not be the case if the current strategy is changing - for example, if the product mix or target market is being re-considered.

5.31. Consideration ought to be given to whether the impact of the stress would be more onerous if it followed benign conditions - for example, if the management style suggests changes in equity-backing ratios would be made assuming a market stress does not happen immediately.

5.32. It is considered unlikely that a stress or scenario that starts significantly later than the next SST exercise would be useful because at that point the on-going strategy ought to be informed by more up-to-date stress and scenario testing information. Furthermore, for stresses and scenarios initiating too far in the future, the perceived relevance and immediacy of the need to mitigate impacts will be diluted.

The amount of time taken for the stress to unfold

5.33. For market-related risks where an active hedging or management strategy is relevant, the time the stress takes to unfold will impact the extent to which the hedging strategy can cope with the stress or scenario. Stretching such hedging strategies to their limits may be more illuminating than applying movements with which the strategy is designed to cope, so an extreme stress is likely to be appropriate. However the stress or scenario should remain plausible enough to believe that it might actually occur. There will most likely be plenty of data available to assess the maximum daily change that could reasonably be anticipated to happen, helping inform the strength of the stress. Furthermore, it should be remembered that increasing the speed of market movements is not the only method of testing the effectiveness of a hedging strategy (for example basis risks and the term structure of market movements also play a part).

5.34. Demographic stresses entail different considerations, as there can often be a lag of a few years between a fundamental change occurring in a demographic rate and this being picked up in experience analysis: the result may be that new business continues to be written on inappropriate terms. However, the demographic assumptions used will not solely be informed by reference to experience analysis; for example the impact of a medical advance or the ultimate effect of an emerging new disease may be anticipated to some degree in current base assumptions.

Persistence of stress effect

5.35. The scenario may be a point in time scenario that is measured, or a multi-year scenario.

5.36. Depending on the measure(s) being assessed, some thought should be given to the persistence of the effect of the stress. For example if the effect of a stress on profits arising is analysed, consideration should be given to how long from the start of the stress the cashflows are affected. For other measures of profitability, it should be considered how long it might be before new business is re-priced. In the case of an analysis of present values, an effect that persists for only the first year's cashflow might be easily quantified without the need for a projection, if the short-term nature of the stress effect is recognised.

5.37. The different aspects of the time horizon of the stress should be considered carefully as these can alter the plausibility, impact and ease of assessment of a stress.

Specifying scenarios driven by macro-economic events

5.38. In the following sections, consideration is given to the expected scenario following a specified external event, such as the break-up of the Euro.

5.39. A couple of ways in which such a scenario might be conceived are:

- As a result of formal or informal reverse stress testing, where a set of risk events occurring together would cause problems for the business. Following this analysis a common cause for the elements of the scenario may be sought
- Inspiration from an external source of a specific potential event that would be expected to have a significant impact on the firm. Inspiration for the scenario might arise from taking note of speculation of this event in the wider environment, historical instances of similar events, an event of a comparable nature in another industry or anything else that might come to mind.

Cause-driven scenarios from reverse stress tests

5.40. Inclusion of a plausible event that results in the scenario under investigation can be useful in helping make the scenario analysis more real for managers of the business.

5.41. By their nature, specific events are very difficult to predict and it is no trivial matter to specify one that actually comes to pass. However, where vulnerability in the business would be exposed by a combination of risks that are not normally linked, there is clearly some benefit to

considering possible common causes. Further, it is worth noting that although the specific predicted cause may not actually come to pass, there may be potential causes that could not be reasonably foreseen that actually link the risks.

Cause-driven scenarios from external inspiration

5.42. Identifying a plausible but unusual event with material consequences (such as Scottish independence), and thinking through those consequences for the business, can help to identify combinations of risks that would not otherwise be expected to occur together; in the case of Scottish independence, market effects may have been coupled with operational effects.

5.43. When assessing scenarios driven by a specified event it is worth noting that it is generally unlikely that the scenario will occur exactly as predicted and so approximations, which cover some different sensitivities around the movements in the risk parameters, may be appropriate.

5.44. Scenarios linked to specific causes are often interesting and bring stress testing to life; the power of setting out a plausible chain of events should not be overlooked.

Scenario calibration (translation to model parameters)

5.45. Assessment of the impact of the stresses and scenarios that have been identified will be enabled by translation into model parameters. Even where approximations or proxy models are used to assess the impact, the translation will exist, albeit in an implicit and likely more vague form.

5.46. Careful consideration should be given to this translation. A balance should be struck between a detailed specification of parameter movements - this will probably take the most time for an impact to be produced - versus re-using mappings created for other purposes – where there is the risk of losing the nuance which made the original scenario definitions interesting and useful.

5.47. The biggest challenges are likely to arise in scenarios where interacting risks are realised together, that is where the impact of two or more risks that occur at once is not equal to the sum of the impacts of the risks when they occur separately. One example of this is the impact of a combined interest rate and longevity scenario on the value of an annuity.

5.48. The nuance of the scenario may also be important in situations such as where hedging is employed, or where there is a term structure to the shock, exposing a mismatch in assets and liabilities that would otherwise go unnoticed.

5.49. In the context of a Group structure, some or all of the scenarios in the exercise may be specified at Group level with calculation of impacts left to business units. In this case, there is a balance to be struck between achieving consistency in the interpretation of the scenario across the entities within the Group and allowing local specialists to calibrate the scenario in a way that makes sense for the business unit. Too

prescriptive a calibration is likely to result in long turn-around times and less opportunity for business units to provide insight. At the other end of the scale, where a high degree of flexibility is provided, understanding the calibrations that have been used and how these might lead to inconsistencies between business units is very important.

5.50. The definition of the stresses and scenarios should not ignore how these are to be quantified through models or proxy models. Where the limitations mean that the definition of the stress is not adhered to, this should be communicated effectively.

Prioritising scenarios

5.51. In the practical implementation of a stress testing and scenario analysis exercise there will need to be consideration of the cost of carrying out the exercise and resource constraints. This may lead to a restriction on the number of stress or scenarios that can be evaluated. So, once a broad range of potential scenarios has been identified, a prioritisation exercise should be performed to select which scenarios to analyse in detail in the current cycle of stress and scenario testing.

5.52. By its nature, the prioritisation of scenarios will be performed before detailed analyses of the scenarios are available and will most likely be dependent on judgement. It is therefore desirable to adopt a framework for prioritisation to increase objectivity and consistency in priority assessments.

5.53. Criteria for comparing scenarios might include relevance, materiality, extent of reliance on mitigating actions, timescale over which the scenario would unfold, the potential for the analysis to provide useful lessons or the extent to which the scenario contributes to the fulfilment of a regulatory requirement. Firms might want to prioritise the criteria and then perform a relatively simple analysis against the criteria to assist the scenario selection.

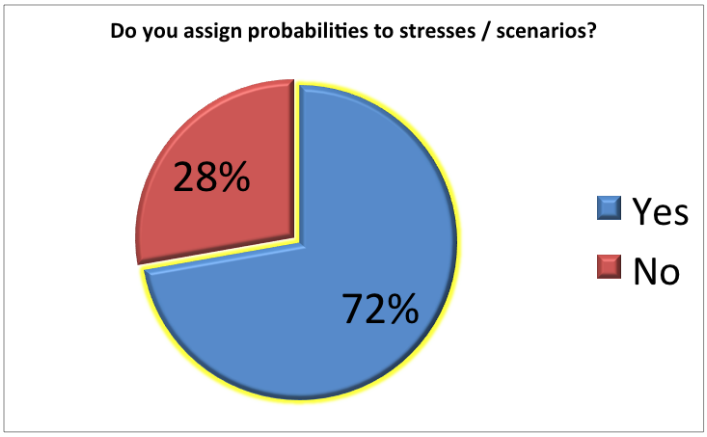
5.54. Outcomes of the prioritisation and the scenarios that are selected to be analysed in detail should be agreed with stakeholders.

Considerations in setting the strength of stresses and scenarios

Assigning probabilities

5.55. The Survey examined assignment of probability to stresses and scenarios.

5.56. Although the majority assigned probabilities to stresses and scenarios, a number of respondents commented that not every stress or scenario was assigned a probability.



5.57. It is useful, wherever possible, to assign probabilities to the stress and scenario tests considered. This provides a number of benefits:

- Stresses and scenarios can be ranked against each other if probabilities are available, aiding prioritisation for further focus
- A clearer view of the strength of the stress helps put the impact in context. This can inform decisions about the extent of effort to expend on further analysis or mitigating actions
- Consistency with stochastic models can be checked, bearing in mind that there is not necessarily an ultimately correct probability assignment.

5.58. However, where a probability assignment would be pure judgement, spurious or likely to lead focus to unproductive speculation, the SST report may be better to omit such assignment. In this case, it would be important to provide commentary or a description that communicates a sense of the plausibility of the stress or scenario to the end user.

5.59. An alternative to assigning probabilities is to rank scenarios in order of likelihood; this provides useful information in that stresses and scenarios can then be compared effectively. Highlighting scenarios with a high likelihood rank and proportionately large impact can be a powerful argument for prioritising mitigating actions.

5.60. Assignment of probabilities has clear benefits but can be subjective and is not necessarily essential to a successful scenario analysis.

Using probability assignments in scenario selection

5.61. At the scenario selection stage, the probability of various scenarios can be helpful in determining a cut-off point for how extreme the scenarios to be considered are. Conversely, high probability scenarios may be of less interest in some exercises (assuming there is confidence that such scenarios will have low impact on the metrics considered).

5.62. Setting the strength of stresses and scenarios to test will depend on the output to be produced - its use and intended audience. For output that is intended to comprehensively investigate risks, the inclusion of a number of extreme events may well be appropriate. For a report intended to aid in setting strategy, including scenarios that are reasonably plausible but have meaningful impact would be desirable (perhaps around a 1 in 10 year probability).

5.63. Reverse stress testing will aid with finding the most plausible stresses or scenarios that have a particular impact, and can provide useful insights to help find scenarios and stresses that will be most interesting to report. For example, a simple proxy model with a small number of related risk factors can be used to get a feel for the shape of the impacts as strength of scenarios increase and may help to highlight where the impact is most sensitive to each of the factors. However, some caution should be exercised if coupling this output to a stress where probabilities are assigned, because choosing a parameterisation that maximises sensitivity of the impact can make the stress less likely than it might seem based on the strength of the individual factors used; for example, a change in slope in the yield curve at the terms where the insurer is most exposed is less likely than a more general change in shape of the same magnitude.

Scenario selection by reverse stress test

5.64. The starting point for defining a reverse stress test is the identification of a business result that is considered a failure. This could be a measure based on liquidity, solvency or some other breakdown in the business model such as a loss of confidence amongst customers. A less extreme form of reverse stress testing might consider a restriction of the firm's ability to pursue the preferred strategy - in respect of risk appetite for example.

5.65. It is important that senior managers and the board agree on the definition(s) of failure to be investigated, and input is required early in the process to avoid a lack of engagement later on. This is particularly true where the reverse stress testing is focussed on a more esoteric measure of failure.

Non-technical approach

5.66. Consider the situation where there is no available model to derive stresses or scenarios from the desired mode of failure or where scenarios outside of the domain of such a model are sought. In this case, tools to be used in the generation of reverse stress scenarios would be similar to those discussed in paragraph 5.20 or a framework such as PESTEL (see Appendix). The key difference in using these tools for a reverse stress test would be a focus on more extreme events.

Technical approach

5.67. Discussion of the relationship between stress and scenario testing and the economic capital model, with a focus on validation of the model and evaluation of the impact of stresses and scenarios, can be found later in this chapter (see "Relationship with Economic Capital"). First, consideration is given to how the economic capital model might aid in selecting scenarios.

5.68. Allocation of capital back to risk factors provides a method by which the most onerous scenarios implied by the model at various levels of probability may be determined. So the allocation of the capital required at a 1-in-10 level might provide an interesting combination of fairly plausible risks to examine. Note that where every risk is assumed to be

normally distributed, the relative strength of the risks will not vary with the probability. Therefore it is important when doing this to take care to capture non-linearity and interactions appropriately.

5.69. It should be borne in mind that scenarios selected in this manner will be the most onerous for the probability level under consideration (assuming the model used is accurate). It can therefore be useful to give some thought as to whether similar impacts would be seen across a range of scenarios bearing reasonable resemblance to the one under consideration or if the reverse stress test leads to a narrow hotspot. It may also be useful to consider whether there are local maxima elsewhere in impacts for combinations of risks that are less similar to that determined in the reverse stress test.

5.70. Potential avenues to explore that might aid investigations using the reverse stress test include: looking at the change in the results if the exposures are adjusted in the economic capital model, and using loss functions or interpolation of losses to approximate the results of scenarios which have different composition but comparable probability of occurrence.

Benefits of governance in scenario selection

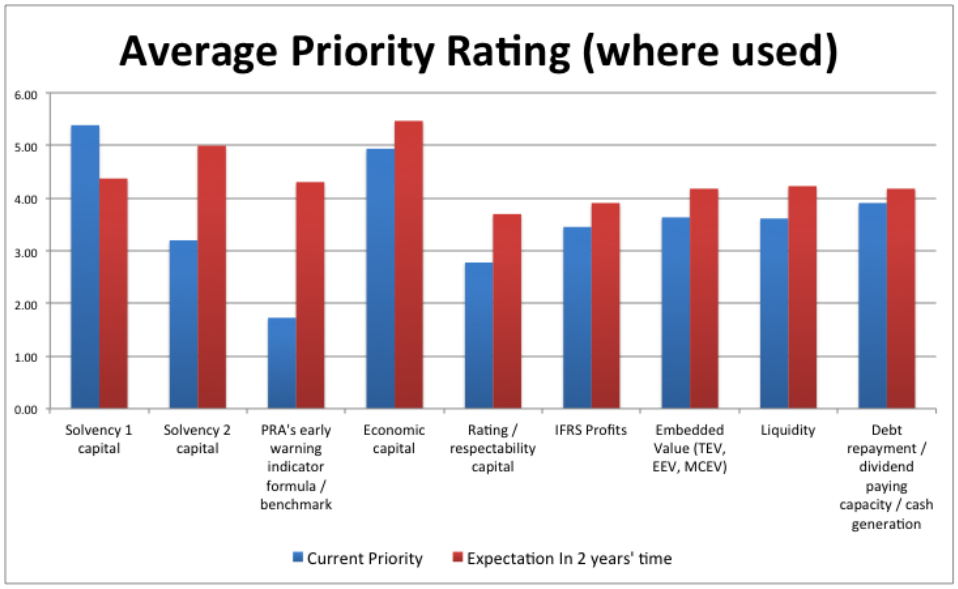
5.71. Achieving agreement from stakeholders and leaders has been noted previously. However, the importance of including appropriate governance in the stress and scenario selection process should not be underestimated.

5.72. Governance in the scenario selection process should not only help demonstrate a credible approach to scenario setting but also achieve leadership buy-in. Leadership acknowledgement of the selected and prioritised scenarios as interesting and relevant at the start of the process should stimulate desire to engage with results. This may facilitate application of resources to the analysis of stresses and scenarios but should also help focus discussion when the final results are available on impacts and mitigation options rather than the range of scenarios included.

5.73. Benefits of governance in the selection process extend to the entire stress and scenario testing exercise, not least the final communication of the results.

Measures to be assessed

5.74. The Survey (conducted in autumn 2013) indicated that the most common metric prioritised in SST exercises was Solvency 1 capital, closely followed by economic capital.



5.75. The Survey results also indicated that this is set to change over the next two years with economic capital being top priority followed by Solvency II capital.

5.76. The consideration of which metric or metrics to prioritise in the analysis of stresses and scenarios should depend on the key metrics used by the business and should pay regard to the intended use and time horizon of the stress and scenario testing exercise. Where a stress and scenario testing exercise is intended to provide analysis for a single pre-defined use, a single metric may be sufficient to illustrate the results. The more likely situation of a stress and scenario testing exercise that will be referenced for numerous decisions will probably need to consider impacts on a number of different metrics. Consideration may, however, be given as to whether to focus on a single metric for accurate assessment and provide more approximate assessments for other metrics.

5.77. The measures to be analysed in detail should be linked to the management of the firm and the use for which the exercise is intended.

Relationship with economic capital

5.78. Stress and scenario testing exercises share common features with required economic capital calculations (i.e. the ICA in the current regime and the SCR under Solvency II)[8]. This leads naturally to consideration of consistency between them and approaches to maximise efficiency.

[8] For those unfamiliar with these metrics – they are a measure of the capital an insurer would require to withstand a 1 in 200 year stress event, they can also be thought of as the Value at Risk (or VaR) at a probability of 1/200.

Validation of the economic capital model

5.79. Where probabilities have been assigned to stresses and scenarios in the stress testing and scenario analysis exercise, comparison against probabilities assigned to equivalent scenarios in the economic capital model can be a useful validation. It can also be useful to compare the losses under the stresses and scenarios with losses calculated under the economic capital model at a similar probability level. In doing this comparison, it is worth noting that the assignment of probabilities is often subjective in nature, however differences may highlight inconsistencies in the approaches to assigning probabilities.

5.80. Even where probabilities have not been assigned, impacts of stresses and scenarios for which losses can be calculated in the economic capital model (but which have not been used as inputs) can be useful for validation. Note, however, that there may be stresses or scenarios which do not map to scenarios that can be identified in the economic capital model (one example might be where there is a particular focus on new business), and the nature/objectives of the SST exercise may mean that none of the stresses and scenarios are comparable to derived losses from the economic capital calculation (for example if the aim of the exercise is to determine effects on a metric such as liquidity rather than overall capital).

5.81. Where they are comparable, the losses under the scenario as assessed in the SST exercise should be close to those produced for comparable scenarios in the economic capital model. Differences can highlight deficiencies in proxy models if these are used or in non-linearity adjustments, and in the case of scenarios it will also help to validate allowances for interactions.

5.82. Validation will be particularly relevant for scenarios derived from reverse stress tests based on economic capital output, i.e. where the scenario has been constructed for a given level of loss at the least extreme probability.

Use of the economic capital model framework

5.83. If validation of the economic capital model is not an expected outcome of the stress testing and scenario analysis exercise then some consideration can be given to using the existing economic capital framework in the exercise. Use of the framework will be at the cost of independence from the economic capital model.

5.84. Clearly using impacts that have been assessed as part of the economic capital calculation will speed up evaluation of stresses and scenarios. The extent to which this is possible will depend on the similarity of the stress and scenarios to those that have previously been evaluated.

5.85. Probabilities and impacts of stresses and scenarios can be a useful check on the required economic capital model (if they are independent of it). Where independence is less of a concern, stresses used in the VaR calculation may assist in analysing stress identified in the SST exercise.

Influence of the economic capital model on scenario selection

5.86. The most direct influence the economic capital model is likely to have on stress and scenario testing is in the evaluation of reverse stress tests as these may well be identified from the economic capital model itself. This is discussed in more detail above (see "Scenario Selection by Reverse Stress Test").

5.87. Stress testing and scenario analysis can also be considered as a method for exploring scenarios the economic capital model is not suited for. In this context consideration should be given to areas where the economic capital model is known to be approximate, or in potential "blind spots" such as scenarios composed of risks with complex interactions. Areas of approximation in the economic capital model are likely to be of interest in either demonstrating that the approximations or omissions are not material or providing quantification of the approximations. The exercise can also provide an opportunity to explore different forms of stress, such as different term structures.

5.88. Stress testing and scenario analysis should complement the economic capital model. Stress testing and scenario analysis can be used to cover the areas the model does not or it can be an exercise in examining the scenarios driving the economic capital results in more detail.

Repetition of tests

5.89. Results from the Survey showed that half of the respondents produced SST reports annually, the other half being fairly evenly spread between reporting 2, 3, 4 and 12 times per year. Commonly cited triggers for ad-hoc reports were regulator requests and changes in risk profile.

5.90. When the exercise has been run twice or a few times, it may be that some familiarity with results has built up. At this point the stress testing and scenario analysis framework might be considered fairly mature and consideration may be given to the value that repeating stresses/scenarios assessed in previous exercises add to the current exercise.

5.91. Some stresses may be understood well enough that their relationship to some indicators of exposure (such as duration and reserves of current policies) can be used to give a good estimate of the results of the next exercise.

5.92. However, in such circumstances, it is important to guard against complacency and periodically challenge assumed relationships, which may not hold under different conditions (see further below).

5.93. Where there are stresses and scenarios that have been successfully mitigated, or which generally have a small impact, some brief commentary on why these would not now be expected to be more significant may be sufficient.

5.94. Senior managers can often have a preference for a suite of scenarios that remains relatively stable from year-to-year, assisting with

comparability of results between periods. This can also help evaluate how effective risk management or mitigation techniques that have been introduced are.

5.95. For certain stresses or scenarios it may be that on-going monitoring on a more formal basis is desirable to provide confidence in managing the business.

5.96. Where the business has undergone significant changes, it may be the case that the results of previous exercises no longer provide relevant insights into the current risk profile. Examples might be:

- Following a merger or acquisition
- Following a change in the mix of policies, or the emergence of contracts written with significantly different terms
- Where there is a change in the tax position of the fund
- Where base assumptions have changed significantly (particularly where these might alter the expected duration of the business, or relative importance of different blocks of business)
- Where the management style has changed (for example the risk appetite).

5.97. The stress and scenario testing exercise should not fall into a formulaic procedure of running a prescribed set of tests, neither should repetition of tests be ruled out completely.

6. Management actions within stress testing and scenario analysis

Introduction

6.1. This paper uses the term "management actions" to encompass the range of actions available to the management of an insurer to mitigate or respond to adverse events; in other words, the set of possible contingency actions. An event occurs and the firm reacts by taking action under the control of governing bodies. The aim of the management actions is to initiate a desired response to change the situation to a more acceptable one. The use of management actions is a key part of any stress testing and scenario analysis framework to assess how a firm will react to events, and often significant credit is taken for these actions in quantification of impacts. Understanding the use of management actions within stress testing and scenario analysis also assists with risk management of the business.

6.2. This chapter focuses on the derivation and use of management actions within stress testing and scenario analysis with consideration of the consistency between the actions taken and the scenario being considered. Solvency II Pillar 1 reporting has specific requirements in order to take credit for management actions within solvency calculations. This paper considers actions which may require less justification and be used within a wider risk management framework, for example stress testing business plans.

6.3. Management actions, and considering whether to take management actions, are an integrated part of running a successful business. In many day-to-day, moderate situations the firm may not take any actions at all, but in severe situations very extreme actions may be taken. As such when considering how management might react in stress and scenario situations, it is important to understand:

- The range of options that might be available;
- The ability to react and offset the effects of a particular scenario;
- For risk management purposes, to recognise that pre-emptive action might be required now to withstand a future scenario, and particularly so in the case that management actions following the stress are not sufficient.

6.4. The most common reason for taking management actions is to reduce the adverse financial impacts of a scenario. The assumption is made that the action will mitigate the effects of a particular event. An example is sale of an asset class in response to a falling market, thereby preventing additional losses.

6.5. Understanding the application of management actions is a key part of any stress and scenario testing framework and will provide a useful feedback loop to understand how the business will perform in the stressed situations. Understanding the situations where a firm is unable to respond are potentially more important than those situations where a firm can respond

as this might guide strategic thinking in running the business. The importance of understanding how a firm will react is arguably as important as calculation of the capital impacts and may potentially result in pre-emptive management actions to mitigate against future events.

6.6. Allowance for management actions is a key consideration within stress testing and scenario analysis.

Scenario specific management actions

6.7. The selection of the stress tests and scenario analyses is outlined in Chapter 5. The management actions used in stress testing and scenario analyses can be derived under the same framework, or can come from different sources such as the ICA, realistic balance sheet or other exercise. The management actions used should be similar regardless of whether they were derived when setting the scenarios as part of a stress testing exercise or for another purpose. For each purpose it is important to establish that the management actions will be available in each scenario.

6.8. Not all firms specifically relate the management actions to the scenario being considered. There is, however, a need to make this link - to test that the action would actually be available in a particular situation. An example would be to consider the set of actions and order taken for a fall in markets, where certain actions such as outsourcing or reinsurance might conflict with other aims of the business. The actions themselves may impact subsequent actions that can be taken.

6.9. It is often straightforward to write down management actions that a firm may take, but it is also important to ascertain how the scenario evolves and interacts with the action being taken. This is discussed later in this section. In some cases the action may not be available at all – for example, raising debt or equity may be difficult to cover solvency issues, and obtaining additional mortality reinsurance during a pandemic may be difficult at a reasonable price. Where firms assume that they will take actions such as these, the justification of the assumptions is important to ensure actions will actually be available.

6.10. It is important that, when considering the evolution of a stress, the actions taken do not pre-empt the future trajectory of that stress. To an extent, a firm may naturally over-react to prevent further losses from a particular risk, but it is not reasonable to assume that actions are taken in advance of events that will not be known for certain at the time.

6.11. At the same time, a firm will not want to unnecessarily restrict the actions it may wish to take in a particular scenario. Some practitioners advocate formulaic application of actions a firm will take in response to every scenario; however, this is not necessarily realistic, as the exact scenario modelled never occurs and the firm will look to a range of options in response to a developing scenario. Some automation of actions may be required to ensure that the full benefit is obtained from an action.

6.12. The capacity of a management action may also vary by a particular scenario. This should also be considered for each particular scenario tested as it could have a significant effect on the impact of the management action. To an extent this might be mechanical, or a modelling exercise; for example, a with-profits contract where the ability to reduce asset share enhancements might decrease with a declining solvency position. For other management actions, such as increasing policy charges, in practice the extent that this will be possible may well depend on how a firm performs relative to its peers in a particular scenario. Assumptions will be required for these situations and, to the extent they are material, they should be explicit.

6.13. More sophisticated approaches might include modelling that specifically includes coded management actions with a specific hierarchy. This, however, can be computationally difficult to define, especially where a range of options is employed. Also, conversely, firms that build very complex models with management actions may struggle to explain easily the results of the model, due to the interaction between the scenario and the management actions that are automatically being applied. If a model has this functionality then it should output the appropriate information to understand the results. To the extent that insights are to be gained from the modelling, it may encourage model development and ensuring output is fully understood.

6.14. Additional insight might be obtained from stressing the value of management actions. This might be considered as part of providing a range to the available management actions, but is also an interesting development in its own right.

6.15. Stress testing the management actions will help understand the impact of reducing either the range of available management actions, or the capacity of management actions. The presentation of results which draws out the impact of stress testing the management actions will help to show resilience to a particular scenario. Calculations performed with and without management actions will show the very worst outcome and value of the management action to help understand the importance and materiality of non-availability.

6.16. An approximate probability might be assigned to each action to put the likelihood that the actions will be available in the given context. A probability weighted application of the actions might give a more realistic assessment of the value of the actions. However, determining probabilities would come with its own challenges. An alternative might be to group the management actions into bands depending on the severity of a particular situation. Examples might be, business as usual, moderate and extreme.

6.17. It may also provide insight to perform stress and scenario testing which utilises all the management actions available. This will show the total capacity of the firm to withstand a set of events. The firm may gain confidence from this exercise that it has the capacity to withstand very severe events with the range of actions available or, if not, it may need to reconsider the actions it might be forced to take in response to events, or more general strategy.

6.18. When applying management actions, consideration should be given to the specifics of the scenario to ensure the actions are valid.

Consistency with other models

6.19. A firm's stress and scenario testing framework will determine how the stress and scenario tests are derived and defined. Often, as shown in the Survey, the scenarios were defined though a brainstorming process, or in consultation with various experts around the business.

6.20. The process used for setting the stress and scenario tests and management actions may be detached from that used to calibrate the internal model stresses and management actions. This creates a risk that there is an inconsistency between the management actions within the internal model and those in the stress and scenario testing. There is a wider point (covered elsewhere in this paper) that the stresses themselves might be inconsistent as the primary purpose of the internal model is not necessarily to create intuitive or plausible scenarios.

6.21. For management actions that might be a firm's response to a very wide range of situations, these need to be applied consistently (e.g. in the scope and order of actions) when determining impacts on solvency. However, the actions taken for the two exercises need to be consistent both for business understanding and consistency of results.

6.22. Stress tests to business plans, or balance sheet projections, may have different management actions to those applied in an internal model balance sheet calculation which considers stresses instantaneously (often referred to as "time zero") or over one year. A check should be performed that the management actions for projections are consistent with the internal model where the underlying risk drivers are similar – e.g. based on a market shock a change in investment strategy can be performed for a time zero or business plan stress.

6.23. Firms may also have a set of unmodelled actions "in-reserve" to demonstrate some flexibility and general resilience. These may not be used in the internal model, but should be consistent with the modelled actions. Some of the additional actions might be extensions of those actions already agreed, for example further reductions in equity backing ratio.

6.24. A firm should consider the consistency between the management actions for stress testing and scenario analysis and those used for other reporting to ensure differences are understood and are acceptable.

Commonly used management actions

6.25. The Survey requested participants to outline management actions that were used within their firms. The most popular actions are discussed below, along with some of the challenges that might be considered when applying them in particular scenarios. This could provide a useful checklist for firms.

6.26. For all these actions the firm will need to consider the particular severity level at which the action is applied.

6.27. This section has been divided into two parts: those which impact policyholder benefits – primarily, but not exclusively, in with-profits funds, and those which relate to shareholder or firm assets. The considerations of Treating Customers Fairly (TCF) creates a higher threshold for justification of those actions which relate to policyholder benefits. In practice, where firm solvency is threatened the distinction becomes blurred.

a) Actions impacting policyholder benefits

6.28. It is important that these action can actually be taken in practice under the contractual terms of the policies involved and that TCF requirements are met. For many with-profits actions, the Principles and Practices of Financial Management (PFFM) of the with-profits fund in question will provide justification for the actions. For other non-profit business, past practice, and the need to ensure that the actions are fair, will need careful consideration.

6.29. There may also be additional governance for these actions involving for instance a With-Profits Committee, Customer Committee or With-Profits Actuary. These additional steps will be required to take credit for the action in the scenario testing, and will also potentially slow down implementation in the actual event.

6.30. The reaction to actions which impact policyholder benefits may also need to be considered in the scenario. For example, an increase in charges or reduction in policy values may increase lapses, which could worsen the scenario.

6.31. Some of these actions may be considered features of the policy and effectively "business as usual", and others more extreme. The level of justification for the actions used will need to be commensurate with the level agreed.

6.32. The regulator may also influence these actions. To the extent that the regulator considers them inappropriate, their value may be limited. The actions may also interact with those taken by the regulator on an industry wide basis – for example to change rules around how the funds are run. There will be occasions when the management action required will be forced upon the firm, for example closure to new business.

Management Action Assumed	**Potential Challenges**
Change in asset mix – e.g. reduction in equity backing ratio	Are these consistent with PPFM? Have they been used previously?
Reduction in bonus rates	Will this be available in the particular scenario?
Reduction in policy values – e.g. enhancements	Will there be any reputational issues with additional impacts?
Introduction of or increase to charges on with-profits / unit-linked / Protection business	Will this have subsequent effects such as increased lapses or reputational issues? PPFM and TCF considerations Potential fall in value of action following stress
Hedging / Asset-Liability Management	How quickly can this be implemented to mitigate the effect of market changes?
Demutualisation	May not happen quickly enough to mitigate impact
Closure to new business	Potentially results in higher lapses (which may be beneficial), and additional closure costs Likely to have impact on the business plan rather than immediate effect – due to redundancy costs, and expense management strategy

b) Actions impacting shareholder funds

6.33. The following actions primarily impact shareholder resources. There is less need to consider TCF to justify these actions, but as mentioned elsewhere in this section, the firm's executives will need to be committed to applying these in practice to take credit for them when assessing the scenarios.

Management Action Assumed	**Potential Challenges**
Reinsurance	Will this be available in the particular scenario? At what price?
Dividend reductions	Will there be any reputational issues with additional impacts?
De-risking staff pension scheme	How quickly can this be achieved?
Review margins in basis	Margin capacity expected to be limited on realistic bases?
Closure to new business	Subsequent impact on retention, costs and business value will need to be considered
Cost reduction	What can be realistically achieved?
Hedging / Asset-Liability Management	How quickly can this be implemented to mitigate the effect of market changes?
Raise capital / call on funding arrangements	Timing challenges
New business strategy changes / business volume changes	How quickly can these be implemented?

Management Action Assumed	Potential Challenges
Injection of capital into subsidiaries / transfer of capital within a group	May be restricted by regulatory constraints, especially for different countries
Sale of subsidiaries	Potentially could take significant amount of time and value might be limited for sale at distressed times

Evolution of stresses

6.34. Consideration of how a scenario evolves over time and the incremental management actions taken as a scenario develops can be very insightful. This will provide as much information and understanding as to the operational decisions that a firm will need to take, as to the ability to react with, and capacity of, the management actions in those situations.

6.35. Many stress tests and scenario analyses are simplistic in the way they are modelled for ease of application. Often calculations will apply the stress or scenario at time zero, or if in a projection, e.g. business plan, or indeed any model, then the stress and the reaction to it will be applied approximately.

6.36. In practice, the event will unfold over time and so will the management action. Considering the actual sequence of events can provide insight to how the firm will react and may well highlight areas where the firm thought it could react, but in practice the development of events may actually prohibit action from being taken. For example, if a firm considers that assets can be sold to change equity backing ratios, or hedging will be enacted, then, depending on the speed of change in the markets and the ability of the firm to react, the value of the action may be limited or non-existent.

6.37. The approach of looking at the development of the management actions in a particular scenario can sometimes be referred to as "war gaming". The majority of firms participating in the Survey did not use war gaming techniques.

6.38. Whilst considering the development of a particular scenario and the management actions that might be available is theoretically insightful, it is potentially very time consuming and including senior members of the firm in the work may not always be seen as the best use of resources. Therefore, it is key to ensure that, where these specific scenarios are considered, they are chosen to obtain the greatest value from the work performed. However, as mentioned above, it is important to document the assumptions made around how the management actions are applied, to ensure that users of the information are aware of them, and can challenge as necessary.

6.39. The method by which the firm responds to a particular event can provide valuable insight as to what might happen and how the firm will need to prepare for that event were it to occur.

6.40. The exercise of understanding how the firm reacts to a scenario is important to get management buy-in for that particular action. Until the link is made clear that a certain action has been taken in a certain scenario, then governing bodies may not fully understand the basis on which the impact of scenarios has been calculated. Management will need to contemplate taking the action in reality – consequences are potentially dangerous if, in practice, the firm decides not to take the assumed actions. The outcome of the scenario is likely to be worse than predicted, with the business less resilient than expected.

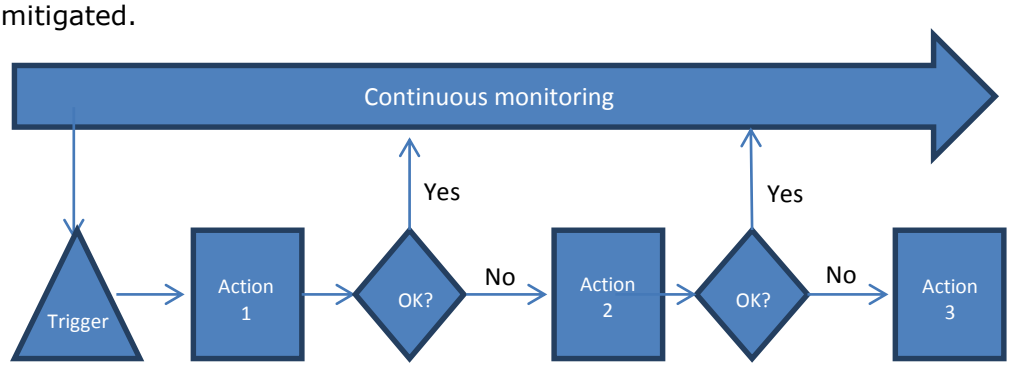
6.41. Defining trigger points can be helpful to determine when a firm plans to take action. Pre-defining these before applying the stress will help with the modelling process and understand what will be happening when the actions are taken in practice. It is preferable to link triggers to other risk management metrics, for example solvency risk appetite. A firm may take a limited sub-set of actions when solvency coverage is marginally below appetite but, as solvency coverage declines, there may be trigger points where significant additional actions are taken. In these situations, firms are likely to be "behind the curve" in terms of the information they have on the current position, and some allowance for this will be needed as actions are taken.

6.42. It might be useful to categorise management actions with an order for application:

a) **Strategic static actions** which are taken in advance to change something where the results of stress testing and scenario analysis reveal a breach of the insurer's risk appetite.
b) **Dynamic actions** which can be taken concurrently with or in quick response to the scenario. In practice this will always be imperfect, so allowance will need to be made for reduced effectiveness.
c) **Static actions** which attempt to improve the situation post-event.
d) **Strategic static actions** post event which may put the firm on a strategic new direction.

6.43. Most management actions are, in practice, static and need a clear link to the scenario to avoid them having limited effect. For example, if de-risking a firm pension scheme would be advantageous, then it might be equally worthwhile to do it before an event.

6.44. The following diagram shows a very simple example of how management actions may evolve following a trigger event. Actions will be taken until metrics have returned within their desired criteria. It can be the case that a firm may exhaust available actions and further adverse events cannot be mitigated.



6.45. Considering the evolution of a scenario can give insights into the actions used, their availability in stress, and assist with potential strategies to mitigate risks before events occur.

Data and monitoring requirements

6.46. The evolution of stresses and the management response described above rely on the firm having information to monitor relevant metrics so it can react. A firm should consider what information is required to trigger the use of management actions and determine if this will be available on a timely basis so that management actions can be taken in practice.

6.47. A firm might have a set of actions to take in response to a weakening solvency position, but this will rely on solvency monitoring ability and accuracy. If solvency monitoring techniques are approximate and only performed infrequently the firm may miss the trigger point when management actions are to be taken, with a consequential reduction in the value of the management actions.

6.48. When taking credit for the management actions in stress testing and scenario analysis the availability and accuracy of information will be an important consideration, particularly if the management action requires a rapid response to a trigger.

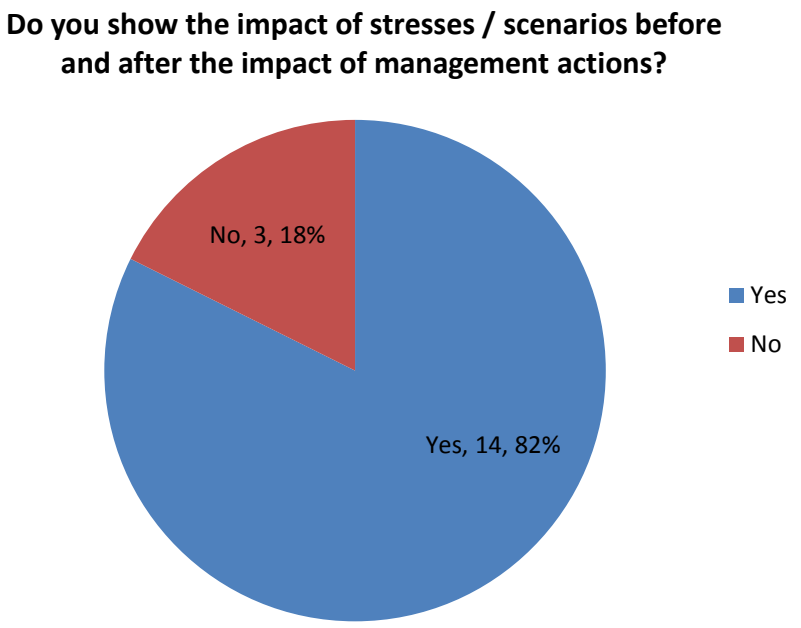
6.49. Solvency will be a key piece of information as many management actions are triggered as a result of deteriorating solvency. There are likely to be a number of other areas where timely information might be required such as assets, claims or volumes of new business.

6.50. The feedback from this exercise might suggest improvements in the accuracy and speed of some of the monitoring tools to ensure that information allows management time to react.

6.51. Credit for management actions should consider a firm's ability to monitor its position and obtain timely information.

Impact assessment

6.52. In the Survey, 82% of respondents stated that they showed the impact of stress testing and scenario analysis before and after management actions, thereby assessing the amount and availability of those actions within the stresses. Firms clearly see the benefit of applying management actions as part of their stress and scenario testing process. Given the significant credit taken for management actions, firms should perform these assessments to show the impact of management actions and the credit taken. Regulation may also require firms to do this. If not quantifying the impact of actions, this should be an active decision made clear to the users of the information, with qualitative assessment of effectiveness or a range of possible outcomes.



6.53. The Survey showed that a number of participants did not quantify the impact of management actions. It might be considered that lack of quantification renders consideration of the management action less useful though it is not necessarily the case.

6.54. The lack of quantification may have been because it was not possible to quantify the value of the management action due to the vast number of assumptions and expert judgement involved, for example closure to new business can have many effects on a business. Alternatively, the management actions described were not essential and these actions may have been held "in reserve" to provide additional capacity which was not needed in the particular scenario considered. These actions might be classified as "contingency" actions and considered separately to those actions which are quantified.

6.55. If possible the value of actions should be quantified; if difficult an approximate range may help guide the users of the information to understand materiality. Management will find this useful, to understand what additional capacity might be available, although to an extent it is speculative.

6.56. The quantification of management action capacity will also give useful insight. The firm can then assess how much of the total available actions have been used in the scenario, helping to identify how near to the limit of availability of actions it is.

6.57. Where possible the impact of management actions should be quantified; however, this may not always be possible and firms may have to provide a qualitative assessment or range of outcomes to help inform the users of the stress testing and scenario analysis.

Governance and documentation

6.58. In many cases, the management actions assumed will significantly impact the effect of a particular scenario. An example is the removal of asset share enhancements – in a strong with-profits fund this can effectively absorb a wide range of scenarios potentially reducing the net impact to near zero.

6.59. As the management actions can have such a significant effect, documenting the actions and giving them suitable prominence through governance processes is clearly important. To the extent that a firm is relying on particular actions to mitigate the scenario, then the actions should be brought to the attention of the governing body that is relying on them to reduce the effect of the stress. If the governing body is not actually willing to take the actions in practice then the results of the stress test are meaningless and there will be false confidence in the results. Commitment to the management actions should be highlighted both at the point of setting the scenarios and when reviewing the results.

6.60. When providing this documentation, it is important to be clear about which actions might be used when. This links into the section above where actions should be linked to the scenario in question. For relatively minor events, a firm might not increase policyholder charges, yet for severe events they may well do. The documentation will need to be clear for what scenarios it is appropriate to apply the action.

6.61. The Survey highlighted that the governance that particular management actions went through differed between firms. Some actions were only included if approved by the Board, others by senior management, and some received no formal governance. The governance should reflect the amount of credit taken for the management actions, and the prominence of the stress testing exercise. As significant credit is often taken for management actions, best practice should be that approval to include a Board or committee of the Board with appropriate expertise.

6.62. Clear documentation and governance of the rationale for the application of management actions is required to ensure common understanding.

Integration into the risk management framework

6.63. Significant value can be gained by linking the use of management actions within stress and scenario testing to the risk management framework to understand the risks a firm is willing to take before action is taken. Chapter 3 discusses the use of stress testing and scenario analysis within a firm. Here, specific consideration is given to management actions within this framework.

6.64. Risk management best practice usually requires setting of risk appetite, often for policyholders and shareholders. Risk appetite defines how much risk a firm is willing to take. Looking at this another way, it could be considered a means of defining how and when a firm should take action to

control its risks in response to a situation. This use of management actions in stress testing and scenario analysis can provide significant insight.

6.65. The Survey showed that many firms were interested in low severity events, such as 1-in-10 year, as well as the more traditional 1-in-200 year events. The actions and response taken in these less severe events will help determine and influence the setting of risk appetite and how the firm reacts to these more frequent events. The firm will need to be comfortable with the level of risk being taken and the response. For example, if a particular scenario at a given confidence level requires that the firm take significant actions such as cutting dividends or major changes in investment strategy, then the firm may consider that outside appetite, and make changes accordingly.

6.66. The management actions taken in the stress testing and scenario analysis can therefore be seen as a feedback loop to ensure that the risk appetite is appropriately set and understood, and that the actions taken are commensurate with that appetite.

6.67. Strategy is similar to risk appetite, and should also be linked into this process. The strategy, risk appetite and the management actions in response to particular events should all be consistent. A firm might explore a small number of scenarios to understand how these develop, the risks considered and how the firm adapts.

6.68. For more severe scenarios the firm can link the management actions with recovery and resolution planning. The response to a severe situation will inform a firm's view on recovery and resolution planning and assist with documenting the plans and options that may be taken. Again consistency across all exercises is important. Joining up the two processes can also potentially be more efficient than running separate processes.

6.69. Good practice is to integrate stress and scenario testing into the broader risk management framework.

7. Insights from other industries

Introduction

7.1. This chapter considers a selection of other industries with a view to identifying themes and learning points with relevance to insurance.

7.2. Stress and scenario testing of various forms is used in a wide range of industries, which presents the significant challenge of selecting those for further analysis. The principal criteria used in this selection process have been:

- Industries that have recently seen developments in stress and scenario testing – perhaps in response to a crisis or a changing risk landscape – on the grounds that this is likely to reflect latest thinking and emerging best practice
- Regulated sectors – more likely to be relevant to insurance
- Variety – e.g. selecting industries facing different challenges to provide a broader perspective.

7.3. However, before delving into specific industries, some recent changes to the UK Corporate Governance Code are considered.

UK Corporate Governance Code

7.4. The UK Corporate Governance Code (the "Code") applies to all companies with a Premium listing of equity shares on the London Stock Exchange, regardless of whether they are incorporated in the UK or elsewhere.

7.5. The Code has been the subject of a series of enhancements in recent years, with the most recent changes in the area of risk management reflecting the findings of the 2012 Sharman Inquiry (Sharman, 2012). The 2014 version of the Code (FRC, 2014b) includes the requirement for a "viability statement" in the strategic report to investors, providing an improved and broader assessment of longer-term solvency and liquidity. It is expected that this statement will look forward significantly further than 12 months, and will be supported by stress and scenario testing.

7.6. Focussing on requirements C.2.1 and C.2.2 of the Code, which pertain to risk management, rather than the provisions of the Code more generally:

C.2.1. The directors should confirm in the annual report that they have carried out a robust assessment of the principal risks facing the company, including those that would threaten its business model, future performance, solvency or liquidity. The directors should describe those risks and explain how they are being managed or mitigated.

C.2.2. Taking account of the company's current position and principal risks, the directors should explain in the annual report how they have assessed the prospects of the company, over what period they have done so and why they consider that period to be appropriate. The directors should state whether they have a reasonable expectation that the company will be able

to continue in operation and meet its liabilities as they fall due over the period of their assessment, drawing attention to any qualifications or assumptions as necessary.

7.7. Updated guidance accompanying the Code was released by the Financial Reporting Council in September 2014 (including FRC, 2014c).

7.8. This guidance explains that the statement required by C.2.2 is intended to express the directors' view about the longer term viability of the company over an appropriate period of time selected by them, and goes on to say that:

This should be based on a robust assessment of those risks that would threaten the business model, future performance, solvency or liquidity of the company, including its resilience to the threats to its viability posed by those risks in severe but plausible scenarios. Such an assessment should include sufficient qualitative and quantitative analysis, and be as thorough as is judged necessary to make a soundly based statement. Stress and sensitivity analysis will often assist the directors in making their statement. These simulation techniques may help in assessing both the company's overall resilience to stress and its adaptability and the significance of particular variables to the projected outcome.

The directors should consider the individual circumstances of the company in tailoring appropriate analysis best suited to its position and performance, business model, strategy and principal risks. These should be undertaken with an appropriate level of prudence, i.e. weighting downside risks more heavily than upside opportunities. This may include analysis of reverse stress, starting from a presumption of failure and seeking to identify the circumstances in which this could occur.

7.9. For UK insurers, it is expected that the underlying stress testing and scenario analysis will already be available from a well-functioning ORSA process. The ORSA is a forward-looking risk assessment, including multi-year projections under base and stressed conditions, including reverse stress testing. Analysis of mitigating actions and assessment of the risks being run against risk appetite are important elements of the ORSA. Nonetheless, it will be important for insurers to ensure that the appropriate disclosures are made in the annual report, in accordance with the new guidance.

7.10. For some corporates, though, the expectations of the new Code may require significant further investment to address in full. Indeed, the new Code may generate interest in the experience of insurers, particularly in relation to ORSA.

Banking

7.11. In terms of regulatory developments, banking is increasingly becoming a bellwether for insurance, notwithstanding the significant differences in risk profiles of the two industries.

7.12. Banking regulation and supervisory approaches have been overhauled in the wake of the Global Financial Crisis. The profile of stress and scenario testing has materially increased, with regular national and international stress testing exercises for larger banks and building societies now established (e.g. PRA, April 2014, EBA, January 2014). The insurance industry is following in the footsteps of banking, with a regular cycle of European and national insurance stress tests for larger insurers becoming established.

7.13. A variety of themes come through the PRA's discussion paper on a framework for stress testing the UK banking system (PRA, 2013). Key themes with relevance to insurance are:

- Use of bespoke and standard stress tests
- Expectations of further developments, for instance to capture the effects of various feedback and amplification mechanisms
- Use of a suite of proprietary models to estimate the impact of stress scenarios
- A forward-looking emphasis.

7.14. Bespoke stresses are often favoured by firms as they represent stresses that are more appropriate to a firm's risk profile. However, standard stress tests can also be useful for regulators to compare risk profiles between firms and formulate a better picture of systemic risks.

7.15. Further developments around feedback and amplification mechanisms, for example to better reflect the interconnectedness of firms, are expected to further improve this picture of systemic issues. The stress testing approach is thus a step on a journey of increasing rigour, towards a framework that not only captures individual bank risks but also reflects the dependencies and contagion risks between banks.

7.16. Of particular interest is the use by the regulator of proprietary models to estimate the impact of stress scenarios. The PRA's intentions were reinforced in the key elements of the 2014 UK banking stress tests (PRA, April 2014). This is reflective of regulatory scepticism around the internal models in banking, as described in the PRA's approach to banking supervision (PRA, June 2014) which includes explicit reference to "the potential for firms to use models to game regulatory requirements by masking inherent riskiness of activities".

7.17. The development of Basic Capital Requirements for Global Systemically Important Insurers is an example of the significance of regulatory models, which trump insurers' own internal capital models when the latter give a lower capital requirement. Individual Capital Guidance, which has existed in the UK's Pillar 2 regime for insurers for some years, could also be seen in this light.

7.18. A forward-looking perspective is critical for firms and regulators seeking to proactively manage risks and prepare effectively for adverse conditions. In August 2013, the US Fed put out a paper on capital planning in US large bank holding companies, highlighting regulatory expectations and indicating a range of current practices. Areas relevant to insurance include encouraging firms:

- To use stress scenarios that reflect macroeconomic and financial conditions tailored specifically to stress a firm's key vulnerabilities and idiosyncratic risks, based on factors such as its particular business model, mix of assets and liabilities, geographic footprint, portfolio characteristics and revenue drivers
- To ensure that the Board gives sufficient scrutiny to the scenarios selected, and ensures that a sufficiently wide range of scenarios is considered
- To consider in more detail the feasibility or effectiveness of contingency actions in periods of stress
- To allow for harder-to-quantify risks such as reputational, strategic and compliance risk in the capital planning process
- To consider the appropriateness of models designed to reflect ongoing business activities in times of severe stress
- To articulate the key assumptions underpinning stress tests, and to provide sensitivity analysis on those assumptions
- To use backtesting and alternative models to validate models used for stress testing
- To develop triggers across a range of different metrics and events that measure or affect the financial condition or perceived financial condition of the firm, e.g. liquidity, earnings, debt and credit default swap spreads, ratings downgrades, stock performance, supervisory actions, or general market stress.

7.19. It is also noted that, in the context of the UK Corporate Governance Code, specific additional guidance in relation to the Code was published for directors of banks (FRC, 2014d). This banking-specific guidance contains more extensive references to stress and scenario testing than the general guidance.

Social housing

7.20. Social housing is a sector that has seen significant change in the UK in recent years (HCA, 2014a). Whilst demand has been increasing, the traditional supply side model has been severely disrupted in the wake of the Global Financial Crisis. This model relied on a combination of cheap long-term debt bank finance, housing benefit providing security of rental income, and substantial government grants to fund new development. In response, the sector has sought new development opportunities and sources of finance. Indeed, some insurers have been active in providing long-term investment in this market.

7.21. The social housing regulator, the Homes and Communities Agency (HCA), has recently consulted on changes to the regulation of the sector, driven by the perceived changing risk profile of the sector with the introduction of new providers and new commercial activities (HCA, 2014a). This consultation addressed proposals to:

- Ensure that social housing assets are not put at risk
- Protect the public value in those assets.

7.22. The proposals included changing the Governance and Financial Viability Standard – specifically including a requirement for stress testing – and introducing a code of practice to give registered providers a better understanding of what is required by the Standard.

7.23. The requirement for stress testing is for registered providers to carry out "detailed and robust stress testing against identified risks and combinations of risks across a range of scenarios" and to put in place "appropriate mitigation strategies". The emphasis is on multi-variate analysis that considers downside economic and business risks across significant and realistic scenarios. More specifically,

It is intended that this stress testing be a key business tool that registered providers use in order to test whether their current and future business strategy is appropriate and the necessary risk mitigations are in place. Registered providers should be testing under a range of different scenarios and therefore have a full understanding of what would happen to the business in each case and how they could mitigate those effects. It should include answering the question "what could bring the business down or significantly weaken it and what would the mitigating action be"?

7.24. Further, "the Regulator wants to ensure that boards are thinking seriously about how the results of stress and scenario testing inform how they structure business decisions and risk mitigations they put in place" and "business plans should be reviewed and revised to ensure that the business remains within acceptable levels of risk."

7.25. This bears strong resemblance to reverse stress testing in insurance. Social housing has a particularly long-term horizon and perhaps it is unsurprising that the regulatory framework for stress and scenario testing of the two sectors have significant commonality.

7.26. The proposed code of practice contains two examples of stress tests by way of illustration (HCA, 2014c), although the registered providers are expected to consider what stress testing is appropriate given the size, type and structure of the organisation:

The board of a developing association with a shared ownership and outright sale programme that is raising external debt will need to think about how key variables in the business plan would move during a housing market slowdown or crash. This would include for example, not only what is happening to sale prices and volumes, but also how lenders would be operating in that market, the potential for impairment, what might be happening to variable rate debt and the costs of working capital, other costs of holding the asset such as increased security costs and the movements in nominal and real inflation rates.

The board of an organisation with significant supported housing business, but little new development, will need to think about what might happen if the registered provider lost key contracts or saw unsustainable price inflation or wage growth that removed margin from the business. The organisation should consider the impact on corporate overheads as well as contract-specific costs.

Nuclear power

7.27. Licensing processes for nuclear installations are lengthy and rigorous, as one might expect (e.g. ONR, 2014). Licensing processes include the demonstration, to the satisfaction of the regulatory authorities, of the validity of the design, safety case and security of the installation. Prudent margins are included to demonstrate capacity to withstand very extreme shocks. Periodic assessments post licensing are carried out to ensure that design bases remain sufficient in light of emerging information.

7.28. The Fukushima Daiichi accident in March 2011 prompted an internationally orchestrated response to reassess the resilience of nuclear installations via a series of stress tests.

7.29. In Europe, the stress test specifications were issued by the European Nuclear Safety Regulators Group (ENSREG, 2011) taking into account advice from Western European Nuclear Regulators Association ("WENRA"). The stress tests comprised three key steps as follows:

- Operator assessment and proposals for safety improvements, following the ENSREG specifications
- Independent review by national regulators of the operators' assessments and the issuing of requirements, when appropriate
- European peer review of the national reports submitted by regulators, including questioning of each national regulator on their report and site visits.

7.30. The stress tests focussed on the root causes of the Fukushima accident - namely the combination of initiating events (e.g. earthquake, flooding) and the loss of safety functions (e.g. loss of electrical power, loss of ultimate heat sink) – along with the effectiveness of severe accident management procedures. The operator submissions were also required to include an assessment of the robustness of each installation beyond its design basis and identification of any "cliff edge" effects – an example of the latter being a breach of flooding defences.

7.31. Notwithstanding the very different nature of the nuclear industry to life insurance, the similarities in the design of these stress tests to those used in life insurance are striking. Points of particular note include:

- The potential for risk interactions to cause non-linear outcomes e.g. in life insurance the potential for simultaneous longevity and interest rate stresses to have a bigger impact on liabilities than the sum of the two impacts occurring separately
- "Cliff edge effects" can be experienced in life insurance e.g. when a counterparty fails
- Assessment of robustness beyond design basis is similar to the idea of reverse stress tests

- Loss of safety functions could, in a life insurance context, include circumstances such as the drying up of liquidity or reinsurer failure
- The focus on severe accident management processes is akin to probing the availability and effectiveness of contingency actions in stressed conditions, and probing the operational readiness of an insurer to respond effectively to severe stress
- The nuclear stress tests were action-oriented, key outputs being coordinated action plans to further enhance safety (in an insurance context this might equate to proactive de-risking to enhance the security of policyholder benefits)
- The regulatory peer review process, and the extent to which this might be of relevance to national insurance regulators in the context of maintaining a "level-playing field" across Europe.

8. Final remarks

8.1. Stress and scenario testing is receiving unprecedented attention, not just as a technical risk management tool but also as a key communication tool that can be engaging for Boards and other stakeholders.

8.2. Stress and scenario testing is a powerful validation tool, helping to cut through complexity in firms' internal models. It is hoped that a result of robust validation will be a higher level of comfort among all stakeholders in the models that are important to effective, risk-based decision making.

8.3. Recent changes to the UK Corporate Governance code are of broad applicability, and some of the material in this paper will be of interest for sectors outside of insurance. There remains significant scope for the insurance sector to further share its experiences in areas such as scenario selection, multi-year projections under stressed conditions, reverse stress testing and analysis of contingency actions.

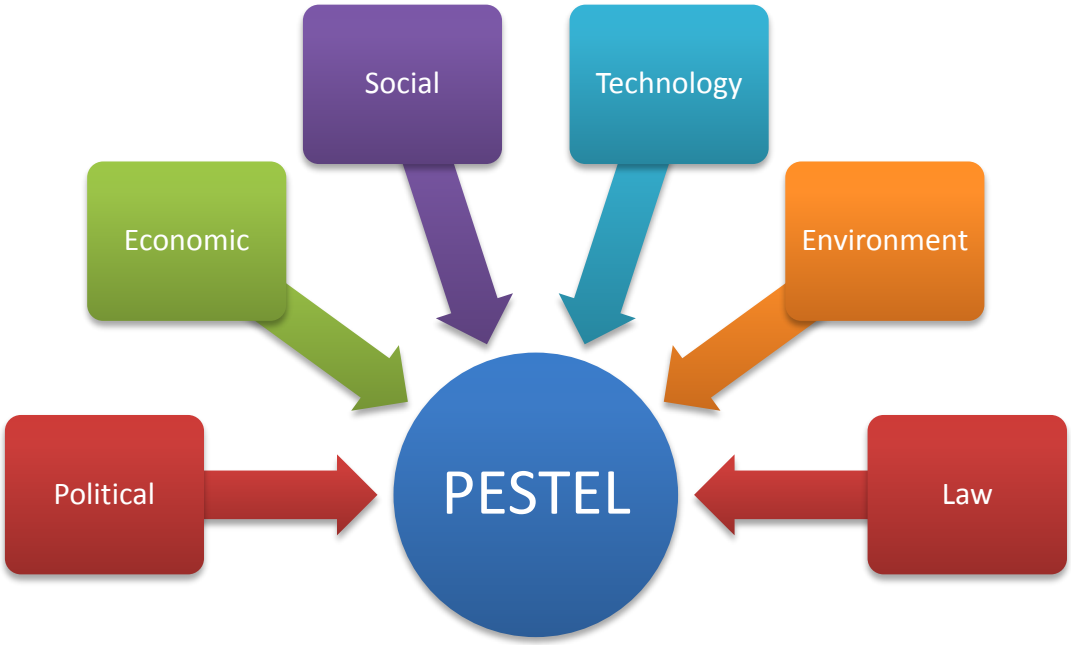
8.4. It is expected that developments will continue apace, particularly in areas such as:

- The identification and monitoring of early warning indicators
- The definition of trigger points for management actions
- The analysis of risk interactions and non-linearities
- The analysis of contingency actions, their availability and effectiveness in stressed conditions
- Capturing effectively, in macro level stress and scenario testing, the key interdependencies that exist between firms, economies and financial systems.

8.5. Whilst a small contribution to the broader debate, hopefully this paper provides useful pointers to firms to help them enhance the value that they obtain from their substantial investments in stress and scenario testing.

8.6. Finally, the authors would be very grateful for comments on this paper; the relevant contact details are provided in Chapter 1.

Appendix A: PESTEL analysis



PESTEL analysis gives a bird's eye view of potential risks that may affect the firm from the whole environment. The analysis starts by compiling a list of factors relating to 6 headings – Political, Economic, Social, Technological, Environmental and Law – that affect the firm.

The next step of the PESTEL analysis is to consider how each factor (or combination of factors) will/may affect the firm or the industry.

The third step is to consider which of these factors amount to real and significant opportunities or threats to the firm and what actions the firm can take in response.

SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis or other analysis tools can be used to identify and narrow down the significant factors, and to think about action plans to take advantage of opportunity or to mitigate threats.

Based on the analysis, the firm can then devise an action plan to maximize opportunities; and minimize threats to the firm.

Bibliography

September 2014

a) Financial Reporting Council, "FRC Updates UK Corporate Governance Code: PN 58/14"
https://www.frc.org.uk/News-and-Events/FRC-Press/Press/2014/September/FRC-updates-UK-Corporate-Governance-Code.aspx

b) Financial Reporting Council, "The UK Corporate Governance Code"
https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/UK-Corporate-Governance-Code-2014.pdf

c) Financial Reporting Council, "Guidance on Risk Management, Internal Control and Related Financial and Business Reporting"
https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/Guidance-on-Risk-Management,-Internal-Control-and.pdf

d) Financial Reporting Council, "Guidance for Directors of Banks on Solvency and Liquidity Risk Management and the Going Concern Basis of Accounting"
https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/Guidance-for-Directors-of-Banks-on-Solvency-and-Li.pdf

June 2014

Bank Of England | PRA, "The Prudential Regulation Authority's Approach to Insurance Supervision"
http://www.bankofengland.co.uk/publications/Documents/praapproach/insuranceappr1406.pdf

Bank Of England | PRA, "The Prudential Regulation Authority's Approach to Banking Supervision"
http://www.bankofengland.co.uk/publications/Documents/praapproach/bankingappr1406.pdf

Anand, K, Bédard-Pagé, G and Traclet, V, "Stress Testing the Canadian Banking System: A System-Wide Approach, Bank of Canada | Financial System Review
http://www.bankofcanada.ca/wp-content/uploads/2014/06/fsr-june2014-anand.pdf

Office for Nuclear Regulation, "Licensing Nuclear Installations, 3rd edition"
http://www.onr.org.uk/licensing-nuclear-installations.pdf

May 2014

a) Homes and Communities Agency, "Consultation on changes to the regulatory framework"
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/313834/Consultation_document_on_changes_to_the_reg_fwk_full.pdf

b) Homes and Communities Agency, "Consultation on changes to the regulatory framework Annex 1: Existing Governance and Financial Viability Standard with proposed changes"
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321043/ccrfa1_-_track_changes.pdf

c) Homes and Communities Agency, "Consultation on changes to the regulatory framework Annex 2: Governance and Financial Viability Standard Code of Practice"
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/313990/ccrfa2_fullc.pdf

April 2014

Bank Of England | PRA, "Stress testing the UK banking system: key elements of the 2014 stress test"
http://www.bankofengland.co.uk/publications/Documents/praapproach/insuranceappr1406.pdf

EIOPA, "Press Release: EIOPA launches EU-wide Insurance Stress Test"
https://eiopa.europa.eu/fileadmin/tx_dam/files/activities/financial_stability/insurance_stress_test_2014/2014-04-30_Stress_Test_2014.pdf

January 2014

European Banking Authority, "Main features of the 2014 EU-wide stress test"
https://www.eba.europa.eu/documents/10180/563711/Communication+on+the+2014+EU-wide+stress+test.pdf

December 2013

Bank Of England | PRA, "SS6/13: Stress Testing, Scenario Analysis and Capital Planning"
http://www.bankofengland.co.uk/pra/Documents/publications/policy/2013/stresstestingss613.pdf

CRO Forum, "Scenario Analysis"
http://www.thecroforum.org/stress-test-and-scenario-setting-3/

October 2013

Bank Of England | PRA, "A framework for stress testing the UK banking system – A discussion paper"
http://www.bankofengland.co.uk/financialstability/fsc/Documents/discussionpaper1013.pdf

August 2013

US Federal Reserve, "Capital Planning at Large Bank Holding Companies: Supervisory Expectations and Range of Current Practice"
http://www.federalreserve.gov/bankinforeg/bcreg20130819a1.pdf

July 2013

International Association of Insurance Supervisors, "Global Systemically Important Insurers: Policy Measures"
http://www.iaisweb.org/G-SIIs-988

International Actuarial Association | Association Actuarielle Internationale, "Stress Testing and Scenario Analysis"
http://www.actuaries.org/CTTEES_SOLV/Documents/StressTestingPaper.pdf

Financial Stability Board, "Recovery and Resolution Planning for Systemically Important Financial Institutions – Guidance on Recovery Triggers and Stress Scenarios"
http://www.financialstabilityboard.org/publications/r_130716c.pdf

January 2013

UK Financial Services Authority, "Supervisory recommended scenarios, Pillar 2 "anchor scenario""
http://www.fsa.gov.uk/about/what/international/stress_testing/firm_s/pillar_2_stress_testing/supervisory_recommended_scenarios
http://www.fsa.gov.uk/about/what/international/stress_testing/firm_s/pillar_2_stress_testing/supervisory_recommended_scenarios/faqs

November 2012

Financial Stability Board, "Recovery and Resolution Planning: Making the Key Attributes Requirements Operational (Consultative Document)"
http://www.financialstabilityboard.org/wp-content/uploads/r_121102.pdf?page_moved=1

June 2012

Sharman, Lord, "Going Concern and Liquidity Risks: Lessons for Companies and Auditors, Final Report and Recommendations of the Panel of Inquiry"
https://www.frc.org.uk/getattachment/591a5e2a-35d7-4470-a46c-30c0d8ca2a14/Sharman-Inquiry-Final-Report.aspx

April 2012

Schuermann, T, "Stress Testing Banks"
http://fic.wharton.upenn.edu/fic/papers/12/12-08.pdf

March 2012

Board of Governors of the Federal Reserve System, "Comprehensive Capital Analysis and Review 2012: Methodology and Results for Stress Scenario Projections"
http://www.federalreserve.gov/newsevents/press/bcreg/bcreg20120313a1.pdf

May 2011

European Nuclear Safety Regulators Group, "EU 'Stress Tests' Specifications"
http://www.ensreg.eu/sites/default/files/EU%20Stress%20tests%20specifications_1.pdf

June 2010

Rebonato, R, "Coherent Stress Testing: A Bayesian Approach to the Analysis of Financial Stress", The Wiley Finance Series

Tattersall, P, "Stress-testing for authorised deposit-taking institutions", APRA Insight
http://www.apra.gov.au/Insight/Documents/10-Insight-Issue-2.pdf

2010

O'Brien, C "Insurance regulation and the Global Financial Crisis: a problem of low probability events", The Geneva Papers on Risk and Insurance-Issues and Practice 35(1): 35-52

December 2009

Office of the Superintendent of Financial Institutions Canada, "Guideline - Stress Testing"
http://www.osfi-bsif.gc.ca/Eng/Docs/e18.pdf

UK Financial Services Authority, "Policy Statement 09/20: Stress and Scenario Testing"
http://www.fsa.gov.uk/pubs/policy/ps09_20.pdf

October 2009

Financial Reporting Council, "Going Concern and Liquidity Risk: Guidance for Directors of UK Companies 2009"
https://www.frc.org.uk/FRC-Documents/FRC/Going-Concern-and-Liquidity-Risk-Guidance-for-Dire.aspx

April 2009

Board of Governors of the Federal Reserve System, "The Supervisory Capital Assessment Program: Design and Implementation"
http://www.federalreserve.gov/bankinforeg/bcreg20090424a1.pdf

May 2009

Board of Governors of the Federal Reserve System, "The Supervisory Capital Assessment Program: Overview of Results"
http://www.federalreserve.gov/newsevents/press/bcreg/bcreg20090507a1.pdf

February 2009

Haldane, A.G., "Why banks failed the stress test" (Haldane speech at Marcus-Evans Conference on stress testing)
http://www.bis.org/review/r090219d.pdf

January 2009

Bank for International Settlements, "Principles for sound stress testing practices and supervision" (Consultative Document)
http://www.bis.org/publ/bcbs147.pdf

April 2008

Society of Actuaries, "Effective Stress Testing in Enterprise Risk Management"
https://www.soa.org/News-and-Publications/Publications-Browse/Monographs/2008/2008-04-Effective-Stress-Testing-in-Enterprise-Risk-Management.aspx

October 2003

International Association of Insurance Supervisors, "Stress Testing by Insurers – Guidance Paper",
http://www.iaisweb.org/__temp/stress_testing_by_insurers_guidance_paper.pdf