

Stress and Scenario Analysis – Risk Assessment and Quantification and use in the determination of Capital

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Summary

In this paper we provide an overview of the considerations needed in the assessment and quantification of risk for the purposes of determining capital requirements for UK non-life insurers. The focus here is on the use of stress and scenario analysis rather than the use of a fully integrated Dynamic Financial Analysis (“DFA”) Model.

Keywords

Capital requirements, stress test, scenario analysis, DFA, ICA

The views expressed in this paper are those of the working party and do not necessarily represent the views of every member or of any organisation with which any member of the group is, or has been, associated.

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Background

1 Introduction

The objective of this paper is to provide an overview for the actuary of the considerations needed in the assessment and quantification of risk for the purposes of determining capital requirements for UK non-life insurers. The focus here is on the use of stress and scenario analysis rather than the use of a fully integrated Dynamic Financial Analysis (“DFA”) Model. This paper is very much descriptive and is not a mathematical treatise on the subject.

The paper covers a number of different topics which are outlined below:

Background - Section 2 provides the necessary background to the paper, namely a discussion of the various regulatory environments both within the UK (Company and Lloyd’s markets) and overseas (e.g. Canada). The comments on regulation are based on those in the public domain as at 12 July 2004. CP190 has been used as the main reference point for the company market, with updates as far as has been practical with the PS04/16 revision. Section 3 involves a discussion of the main risk categories and sub-risks facing a typical insurer.

Stress Testing and Scenario Analysis – This section is the backbone of the paper with a discussion of Stress Testing and Scenario Analysis (Section 4), Why do it (Section 5) and the Design of these tests (Section 6). Attention is then drawn to the Modelling of Risks (Section 7) and their Validation (Section 8).

Reporting and Disclosure – The assessment and quantification of risk will usually be embedded within a company’s risk management framework. Given this, we discuss Risk Management Frameworks (Section 9) and Disclosure (Section 10).

Case Study – To bring it all together we have included a case study which focuses on MANIC (a primary insurance company). Additional considerations when looking at a Lloyd’s syndicate are brought out in Section 12.

2 Regulatory Frameworks

2.1 UK Regulatory Framework - PS04/16 (CP190)

In April 2003, the FSA issued a consultation paper, CP181, which set out the changes in the solvency requirements under the EU Solvency I Non-life Directive. In this new requirement, the level of Minimum Capital Requirement (MCR) for non-life insurers was raised modestly. A more thorough review of insurers' capital requirements in line with the international banking capital discussion (the Basel 2 accord) is planned. This will lead to the EU Solvency II Directive. However, this review is unlikely to become effective regulations until at least 2007. As an interim measure, the FSA proposes in PS04/16 (CP190) a new regulatory regime on capital requirement for non-life insurers.

The new capital requirement comes in two forms, the Enhanced Capital Requirements (ECR) and the Individual Capital Guidance (ICG). The purpose of this new regulation is to:

- Promote a more transparent regulatory regime.
- Provide earlier regulatory intervention when financial problems develop.
- Align capital requirements with risks.

Enhanced Capital Requirement (ECR)

The regulation on ECR is expected to apply to all non-life insurers, including reinsurers and non-EEA insurers operating a UK branch, with the following exemptions:

- Mutual insurers not subject to the insurance directive, eg. small friendly societies.
- Swiss general insurers operating a UK branch and EEA deposit insurers (ie. non-EEA insurers operating a UK branch, but supervised by another EU member state).
- Insurers in run-off, whose Part IV permission has been varied before the implementation of ECR to remove the regulated activity of effecting contracts of insurance.
- Lloyd's of London will be subject to similar requirements under a separate regulation (see section 2.2).

The FSA commissioned Watson Wyatt to conduct a study on the insurance industry to derive a set of risk based capital charge factors that are applicable to different classes of business. This analysis forms the basis of the ECR calculation.

ECR Calculation				
Net written premiums	x	relevant premium factors	=	X
Insurance related values	x	relevant claims factors	=	Y
Asset related values	x	relevant asset factors	=	Z
Total ECR			=	X+Y+Z

Definitions of the financial items are as follows:

Net written premiums – These are defined as written premiums net of reinsurance but before deduction of commission. Factors vary by class of business.

Insurance related values – These include outstanding claims reserves, IBNR and IBNER (all net of reinsurance recoveries), unearned premium reserves (net of deferred acquisition costs) and unexpired risks reserves. Factors vary by class of business.

Asset related values – These are calculated after applying the relevant rules on admissibility and valuation. However, derivative contracts will be treated differently. If the derivative contract forms part of an exposure to a certain asset class and value by holding cash or other cover with the derivative, then the relevant capital charge factor will be applied according to the asset class and value of the synthetic or equivalent asset type. Under the new Policy Statement, PS04/16, the FSA has revised the capital charge on money market funds to 0%.

Also, in arriving at the ECR calculation above, discounting of technical reserves is disallowed, but the ECR can be reduced by the level of the equalisation reserves.

The new rules will be issued in the Integrated Prudential Sourcebook (PRU). Under the new requirement, insurers will be required to hold capital of certain quality sufficient to meet the higher of the following:

- Minimum Capital Requirement (MCR) as proposed under the EU Solvency I Directive.
- Enhanced Capital Requirement (ECR) as set out in PS 04/16.

This is likely to be introduced in two stages. During the first stage, insurers are required to calculate the ECR. The second stage will require insurers to hold sufficient capital resources to meet the ECR at a later date. Under PS04/16, the ECR is a soft target and the requirement to disclose the ECR calculation publicly in the annual return is removed. There are rules in defining different types of capital and their admissibility limits and in classifying them into different tiers for solvency purposes.

The rationale behind the ECR calculation is to apply differential capital charge factors to reflect the underwriting profitability by class of business, the volatility and adequacy of technical provisions by class of business and the volatility, liquidity and security of different asset classes. This capital requirement calculation is expected to be broadly equivalent to a BBB credit rating with a 99.5% confidence level of survival over one year. Also, it is calibrated to be more suitable for larger insurers.

The FSA would generally expect smaller insurers to hold on average 20% to 80% more capital than proposed under the ECR calculation. The ECR will be used as a benchmark by the FSA in providing individual capital guidance.

The ECR calculation attempts to introduce a simple measure in capital requirement relating more specifically to risks. However, it has its limitations. For instance, the ECR calculation tends to penalise those insurers who are holding a stronger level of claims reserves. Similarly, an insurer charging higher premiums than its competitor with the same risks exposure will end up with a higher ECR calculation. In view of these limitations, the FSA is taking the risk based capital approach further by introducing the concept of Individual Capital Assessment (ICA) and Individual Capital Guidance (ICG). This will help to mitigate the problems highlighted above.

Individual Capital Assessment and Individual Capital Guidance

Before the introduction of the EU Solvency II Directive, the FSA envisages that insurers should carry out their own individual capital assessment. This assessment will be specific to its business and operation. It will apply to all insurers covered under the ECR regulation, but it will also apply to non-directive mutuals and insurers in run-off as well.

For this purpose, the FSA has issued guidelines on Individual Capital Adequacy Standards (ICAS) on how insurers should assess their own capital needs. The objectives in providing ICAS are:

- For insurers to hold capital more appropriate to their business needs and risks.
- For senior management to accept responsibility in ensuring the insurer has adequate financial resources to meet its liabilities.
- To provide incentives for better risk management.
- To enhance consumer protection and market confidence by reducing the risk of financial failure.

Individual Capital Adequacy Standards

Under the ICAS framework, the FSA requires insurers to comply with these requirements with effect from 1 January 2005. Generally, insurers are expected to maintain sufficient financial resources to meet their liabilities as they fall due. In doing so, insurers must have systems and procedures in place to assess the financial resources necessary to meet this requirement. Insurers are expected to identify and deal with the major sources of risk threatening their business. For each of the major risks identified, the insurer should carry out stress and scenario tests, appropriate to its size and nature of business. This should cover an appropriate range of realistically worst case events. It should then quantify the amount of financial resources it needs to meet its liabilities if these events occur.

In summary, in order to assess the insurer's capital adequacy, the insurer needs to:

- Identify the major risks it faces.
- Assess whether capital is appropriate to mitigate these risks.
- Quantify the level and type of capital required.

The FSA has identified a number of risk factors in the Integrated Prudential Sourcebook that insurers should consider in detail in their analysis. These include the following broad headings:

- Insurance risks
 - Underwriting risks
 - Reserving and claims risks
- Credit risks
- Market risks
- Liquidity risks
- Operational risks

There are many other risks that an insurer faces which may fall within or outside these broad headings. Further discussion on major risks faced by insurers can be found in section 3. The FSA has deliberately tried not to be prescriptive in its approach. Instead, it expects insurers to carry out their own detailed stress and scenario analyses to determine the range and quality of capital required in order to reduce the risk of insolvency to an acceptable minimum over a predetermined time horizon.

Furthermore, it may be helpful for the insurer to consider the extent its own business diverges from the underlying assumptions of the ECR calculation. For instance, the ECR calculation is based on a stable, well managed diversified business, with assets matching its liabilities and no exposure to large, unusual or high risk transactions. In particular, the FSA has highlighted the following risk areas for consideration: interest rate risk, asset securitisation risk, residual risk, concentration risk, high impact and low probability events, business cycle and capital needs, and systems and control risk.

The FSA has also raised a number of issues on evaluating capital resources and requirements. For instance, in considering worse case scenarios under adverse economic conditions, asset values may be depressed. This should be taken into account if the assets need to be liquidated by adopting their realisable values under the scenario concerned. On the other hand, insurers can diverge from the admissibility rules if appropriate in considering available capital resources.

Also, technical provisions can be valued on a discounted basis if not paid immediately and equalisation reserves can be removed. The underlying principle is to treat assets and liabilities on a realistic and consistent basis under the scenario in consideration. Special consideration may be given to insurers within a group. However, the FSA may not necessarily treat an insurer more favourably if its parent is financially stronger. As quite often, the parent company itself may be under financial stress when its subsidiary's solvency position is threatened.

In the consultation paper, the FSA provides an illustrative example on how a small insurer could undertake the stress and scenario analysis. The issues discussed are not exhaustive but it provides a qualitative approach going forward. Generally, insurers are not only expected to consider the current trading and economic conditions, but also on possible conditions that could occur in the next three to five years. The FSA expects insurers to consider a combination of realistic worst case scenarios and decide that it would require capital of between £A and £B to absorb these risks with reasonable justification.

Use of Capital Models

In their example, the FSA has used a simple approach to illustrate the principle on which small insurers can apply to assess their capital needs. However, many bigger insurers may adopt a more sophisticated approach by building dynamic financial analysis (DFA) or capital models for this purpose. In this case, the FSA has provided some further guidelines on the issues that it would consider in evaluating the results.

Generally, the model should as far as possible cover all risks and all areas of business, with each element of the projection based on a statistical distribution. Its outcome should also be based on a pre-determined probability of insolvency over an appropriate horizon with suitable justification.

The consultation paper has set out a list of assumptions the FSA expects to be allowed for in the financial model. This includes the following over a period of 5 years:

- Future investment returns (eg. interest rates and implication on bond yields, equity and property prices, dividend and rental income and inflation).
- Premium rates by class of business and effect of underwriting cycles.
- Claims exposure by class of business.
- Premium volume and growth in business plan.
- Expenses and commission.
- Frequency and severity of claims by category, incorporating social, legal, medical, price and earnings inflationary effects.
- Catastrophic events and aggregation of claims.

- Claims settlement pattern and reinsurance recoveries by class of business.
- Inflationary effect on claims, expenses, reinsurance costs and investment returns.
- Changes in reinsurance programmes, terms, reinstatements and loss experience.
- Non-recovery of reinsurance and other debtors.
- Foreign exchange movements.
- Unintended risk coverage.
- Correlation between risks.

In general, the FSA would need to be satisfied the extent of use of the capital model in setting the insurer's capital management policy. Also, the insurer has put in place sound and appropriate risk management procedures in operation, with all material risks adequately allowed for either qualitatively or quantitatively. Historical data should be used to back test and validate the model with sufficient checks to ensure its accuracy. Finally, in order to complete the picture, the insurer would also consider any other risks not covered adequately by the financial model. However, if an insurer is applying for a waiver for an ICA less than the ECR on the basis of the results of the capital model, then the FSA will most likely expect the model to be independently validated and reviewed.

Individual Capital Guidance ("ICG")

ICA and ICG are intended to be private information exchanged between the insurer and the FSA. It is not intended for public information. The FSA plans to provide their initial ICG to insurers over the next 2 to 3 years in the form of arrow visits. During these reviews, the FSA will assess the individual capital adequacy position of the insurer, using the ECR as a benchmark. ICG will be provided at or above the ECR level. This can be in the form of a fixed percentage or a multiple of ECR or MCR under Solvency I. Alternatively, it can be a fixed monetary amount or an additional factor applied to a particular type of asset, liability or income measures, or some other modification of the capital rules as seen fit by the FSA.

As mentioned above it is possible that the insurer's ICA may fall below the ECR. In this case, the insurer can apply for a waiver. This can arise if the ECR is inappropriate due to the unique nature of the insurer's business. Another possibility is that the insurer has developed financial models, which suggest its degree of diversification is greater than that allowed for in the ECR. Therefore, its risks are lower overall. In this situation, the FSA is likely to require some independent analysis to confirm the insurer's assessment. In any case, insurers are expected to demonstrate their case to the FSA to the FSA's satisfaction. Subsequent reviews of ICG will form part of the regular supervisory process.

Under PS04/16, insurers are expected to be in a position to explain to the FSA how they have assessed their ICAs with effect from 1st January 2005. However, the FSA recognises that the ICA process will take time to evolve and implement, so they may be reviewing work in progress initially rather than the final assessment. Also, the FSA recognises that insurers may want to maintain a capital buffer above the ICG, although the size of this buffer is left to the discretion of the insurer. This leaves the interesting question open as to how much a buffer should insurers retain on top of the ICG buffer.

In order to facilitate the FSA to carry out ICG efficiently and consistently across the industry, the FSA has proposed a standardised format for ICA. This will include the following information:

- Summary of financial position of insurer and the risks it faces.
- Insurer's proposal for ICG (ie. ICA) as a percentage of ECR.
- Any historical factors which may have future implications.
- The Business profile, its operating environment, projected business plans, projected financial position and future sources of capital.
- Detailed review of capital adequacy and comparison between ICA and appropriateness of ECR. Commentary of historical solvency levels, future outlook and future capital requirement.
- Identification of major risks by risk factors and associated capital requirements.
- Quantitative results of stress and scenario analysis, with key assumptions and confidence levels.
- Any risks not adequately covered by ECR, their assessments and capital implications.
- Parameters and confidence level assumed in financial modelling.

Insurers are expected to document the assessment on these risks and retain its records for 3 years.

In the FSA's opinion, the more thorough, objective and prudent an insurer's ICA is, the more reliance the FSA will be able to place on it as a reasonable capital requirement. The FSA will be looking at the breadth as well as the depth of the analysis with appropriate justification. The level of details and the degree of sophistication expected will depend on the size of the insurer and the complexity of its business. Generally, the FSA expects ICA to become part of the risk management process, it will also recognise and give credit to good risk management practices.

It is still early days before the EU finalises its proposal on Solvency II. However, early discussion seems to indicate that other member countries are generally in favour with the approach proposed by the FSA going forward.

List of Relevant Consultative Papers:

PS04/16	Policy statement: Integrated Prudential Sourcebook for Insurers	July 2004
CP04/7	Lloyd's: Integrated prudential requirements and changes to auditing and actuarial requirements	Apr 2004
CP190	Enhanced capital requirements and individual capital assessments for non-life Insurers	July 2003
CP181	The Interim Prudential Sourcebooks for Insurers and Friendly Societies: Implementation of the Solvency I Directives	Apr 2003
CP178	Review of prudential regulation of the Lloyd's market	Apr 2003
CP143	Integrated Prudential Sourcebooks – Feedback on CP97	July 2002
CP142	Operational risks systems and controls	July 2002
CP136	Individual Capital Adequacy Standards	May 2003
CP128	Liquidity risk in the Integrated Prudential Sourcebooks – Systems and Controls	Mar 2003
CP116	The Interim Prudential Sourcebooks for Insurers and Friendly Societies: Guidance on insurance group solvency	Nov 2001
CP115	Integrated Prudential Sourcebooks – Timetable for implementation	Nov 2001
CP97	Integrated Prudential Sourcebook	June 2001

2.2 Lloyd's Framework - CP04/7 (CP178)

In April 2003 the FSA published consultation paper CP178 “Review of prudential regulation of the Lloyd's market”. This stated that the FSA's approach to the regulation of Lloyd's would follow the policy developed for general insurers unless there are justifiable reasons why the policy should not apply to Lloyd's.

The FSA considered that between them, the Society of Lloyd's (“The Society”) and Managing Agents manage all the prudential risks that affect policyholders. Therefore, the FSA proposed to develop appropriate rules and guidance to apply directly to each of them.

CP190 confirmed that the FSA aimed to ensure that Lloyd's operates to capital standards equivalent to those that the FSA set for other UK insurers that they regulate. However, it acknowledged that the structure of Lloyd's means that direct application of all the rules in the integrated prudential sourcebook would not be practical or appropriate.

Therefore the FSA intended to develop rules for Lloyd's that are consistent with those proposed in CP190, but taking into account the unique features of Lloyd's.

Proposals for the application of capital requirements to Lloyd's were set out in consultation paper CP04/7 – "Lloyd's: Integrated prudential requirements and changes to auditing and actuarial requirements", which was published in April 2004.

Modifications of the application of the rules to Lloyd's compared to that for other UK insurers include:

- Managing Agents will be required to calculate the ECR and ICA for individual Syndicates.
- The capital requirements will have to be assessed separately for each Syndicate Period (effectively each open year where the proportionate membership of a Syndicate changes).
- Syndicates do not hold all the capital that is available to support the underwriting activities of the Syndicate, as capital is also held as Funds at Lloyd's ("FAL") and as central assets. Therefore the Managing Agent will notify the Society of the amount of capital needed to support the risks of the Syndicate, but which is not held by the Syndicate – this is termed the "Balancing Amount".
- The Society will allocate the ECR's to members and adjust these for the charges relating to FAL to calculate member level ECR.
- The Society will compare the Syndicate ICA with the Risk Based Capital ("RBC") that it calculates using its central model and modify the ICA figures appropriately. The Society will then allocate the modified ICA figures to members adjusting them for charges on FAL and for diversification benefits, to arrive at member level ICA.
- Letters of Credit will continue to be admissible as capital resources, although the FSA is consulting on whether their use should be restricted in future.

The capital raising cycle and coming-into-line process at Lloyd's has implications for the timing of the introduction of the new requirements. The FSA recognise this and therefore decided to consult on two options for Lloyd's:

- Apply all requirements from 1 Jan 2005

Due to the Lloyd's capital raising cycle, this would mean that the Society would need to work with managing agents as soon as possible to identify instances where managing agents' syndicate ICAs are likely to be higher than the Society's assessment for the syndicate.

- Managing Agents to ensure the adequacy of syndicate financial resources from 1 Jan 2006

If this option were used, the FSA propose to defer the use of profits as capital to support new business but would nevertheless expect managing agents to assess syndicate ICAs from 1 January 2005.

The first option was stated as the FSA's preferred approach, but they recognise that it would allow a very short lead time. Initial feedback has suggested that the second option may be more practical.

2.3 Canada - Dynamic Capital Adequacy Testing (DCAT)

Dynamic Capital Adequacy Testing ("DCAT") has been a regulatory requirement since 1999, where the appointed actuary for Life and P&C companies has to perform annually a DCAT analysis, sign an opinion and provide a report.

Scope

- DCAT is the process of analysing and projecting the trends of a company's capital position given its current circumstances, its recent past, and its intended business plan under a variety of future scenarios.
- The DCAT report informs company management of the likely implications of the business plan on capital and surplus and provides guidance on the significant risks to which the company may be exposed, and the relative effectiveness of alternative corrective actions. Furthermore, knowing the sources of threat, the company can strengthen the monitoring systems of the vulnerable areas, thus providing continuous and timely information to management.

Process

- The DCAT process involves development of a base scenario, which includes forecasts of revenue statements and balance sheets over several future years and modeling of several adverse scenarios.
- The CIA guidance lists risk categories that the actuary should examine for possible threats to capital adequacy. The risk areas posing the most significant threats should be examined in detail and allowance made for any "ripple effects" and possible management responses.

- The following risk categories are identified and those that are relevant to company circumstances are modelled and stress-tested:
 - Frequency and severity (of claims)
 - Pricing
 - Misestimation of policy liabilities
 - Inflation
 - Interest rate
 - Premium volume
 - Expense
 - Reinsurance risks
 - Deterioration of asset values
 - Government and political action
 - Off-balance sheet risks
- This list is not exhaustive. Other risk categories relevant to the operations of the company must also be examined.
- When stochastic models with reasonable predictability are available, an adverse scenario would be considered plausible if all remaining probability in the tail beyond this scenario is in the range of 1% to 5%. For risks where no stochastic models with predictive capabilities are available, judgment should be used in selecting plausible, severe adverse scenarios.
- Selection of those scenarios requiring further analysis – At least the three risk categories showing the greatest surplus sensitivity should be examined in further detail, including more detailed reflection of the associated ripple effects. Any risk category under which a plausible scenario causes the insurer to fall below the minimum regulatory capital during the forecast period should be subject to further examination and reporting. Again, the stress-testing approach, but now taking fuller account of ripple effects, can be used to assess plausibility.

Reporting

Reporting is required on the base scenario, and then on all risk categories, but at different levels of detail:

- Irrelevant categories - a short explanation of why
- Relevant but less sensitive categories - a brief description of the approach taken and results
- Most sensitive categories - a more detailed description of the risk category, circumstances in which a negative scenario could arise, what kinds of ripple effects could take place and how they have been taken into account, what management action if any has been assumed, and the plausibility of the results.
 - For the more sensitive categories a determination of whether or not any integrated scenarios are required. To do this the actuary needs to determine if any adverse scenarios are “more probable.” Examples of “more probable” adverse scenarios are (i) scenarios involving default on a large or strategic asset where the probability of default is high; (ii) status quo scenarios where the base scenario assumes aggressive cost reduction, sales targets or other initiatives and the insurer does not have a good track record in achieving these objectives; (iii) status quo scenarios where the base scenario assumes a favourable event outside management control.
 - For the more sensitive categories, the results without the effect of any extraordinary management actions or regulatory action. An example of extraordinary management action would be discontinuing the sale of a line of business where such discontinuance is not part of the business plan. On the other hand, changing a dividend scale or increasing property and casualty rate levels could not normally be considered to be extraordinary management actions.

Detailed discussion of Risk Categories

The actuary is expected to develop an understanding of the sensitivity of the insurer’s financial condition under each major risk category which is material to the company. Detailed guidance is given on plausible adverse scenarios for each category. Ripple effects and possible management responses are listed where relevant.

The suggested adverse scenarios generally consist of shock changes to experience, which take place in the fiscal year following the period under examination. For each risk category, the actuary should determine and test the most adverse plausible event.

Ripple effects are effects following shock changes, often with some delay. Post-event inflation may follow a catastrophic loss, for example. A change in inflation unrelated to the catastrophe would not be considered a ripple effect, but would be considered under a separate risk category.

Other issues

The CIA guidance also discusses:

- Preparation and Signing of the Opinion
- Level of Detail
- Assumed Capital Enhancements
- Assumed Management Action
- Assumed Regulatory Action
- Assumed Rating Agency Action

2.4 Australia - APRA

The Australian equivalent of the FSA is the Australian Prudential Regulatory Authority (APRA). APRA was incepted in 1998 and tasked amongst other things to initiate prudential reform of Australian general insurance.

After several years of policy development and industry consultation, APRA's reform proposals were approved by the Government in November 2000, and legislated by the Parliament in August 2001. The final standards took effect on 1 July 2002.

There are three key aspects of the general insurance reform to improve public confidence in industry soundness. These are:

- The shift to upgraded, risk-based capital adequacy requirements;
- The checks and balances created by stronger governance standards; and
- The universal 'health check' on all companies under the re-authorisation process.

In Australia every company had to gain re-authorisation. To do this each company had to meet capital standards calculated via a formula or by an internal model.

Internal Model

In order to use a model the model has to be approved by APRA and the Treasury. APRA is looking for a model to operate within a risk management environment that is conceptually sound and supported by adequate resources. There is guidance on what a model should cover.

To gain APRA's approval for use of the model the insurer will also have to carry out stress testing, and there is a review process in the form of a detailed questionnaire and one or more visits from APRA . We understand the vast majority of Australian insurers use the formula approach.

Formula

The formula is risk based and has 3 elements:

- Insurance risk capital charge
- Investment risk capital charge
- Concentration risk capital charge

Insurance risk capital charge

This is made up of an outstanding claims risk and a premium liability risk. Factors are given separately by line of business, for direct insurance and inwards reinsurance.

Insurance risk charge is:

Net O/S claims x claims factor (by line of business) + NWP x premium factor (by line of business)

Investment risk capital charge

For each asset there is an Investment Capital Factor that is applied to their value according to their riskiness. The factor varies with the type of investment. For debt the factor also depends on the term to redemption and counterparty credit rating. Similarly for reinsurance recoveries the counterparty credit rating is used.

Concentration risk capital charge

Each insurer must calculate its Maximum Event Retention (MER), the largest loss to which an insurer will be exposed due to a concentration of policies, after netting out reinsurance recoveries. The published guidance note takes a return period of 1 in 250 years.

An insurer must inform APRA when its MER changes.

2.5 USA

The National Association of Insurance Commissioners (NAIC) in the US introduced the present regime of risk based capital requirements in 1994. The risk based capital calculation is based on a standard formula, taking into account elements of risks broken down into six categories as follows:

Risk Category	Risk Charges Applicable
R ₀ - Off balance sheet risk	<i>Investments in insurance affiliates, non-controlled assets, guarantees for affiliates and contingent liabilities.</i>
R ₁ - Fixed income securities	<i>Cash, bonds, bond size adjustment factor and mortgage loans, short term investments, collateral loans and asset concentration adjustment for fixed income securities.</i>
R ₂ - Equity securities	<i>Common stock, preferred stock, real estate, other invested assets, aggregate write-ins for invested assets and asset concentration adjustment.</i>
R ₃ - Credit risk	<i>Reinsurance recoverables and other receivables.</i>
R ₄ - Loss reserves risk	<i>Basic reserving risk charge, offset for loss-sensitive business, adjustment for claims-made business, loss concentration factor and growth charge for reserving risk.</i>
R ₅ - Net written premium	<i>Basic premium risk charge, offset for loss-sensitive business, adjustment for claims-made business, premium concentration factor and growth charge for premium risk.</i>

There is a separate risk charge applied to each of the individual items above. It is interesting to note that there is a separate factor for bond size to reflect the degree of diversification in terms of number of holdings, and an asset concentration factor for both bonds and equities as a further incentive for diversification. Similarly, there is a separate factor for concentration and growth, for both reserving and premium risks, to reflect the level of risks associated with rapid growth in business.

The total amount of capital required is calculated by the formula below:

$$R_0 + \{ R_1^2 + R_2^2 + (R_3/2)^2 + (R_3/2 + R_4)^2 + R_5^2 \}^{1/2}$$

The rationale for singling out R₀ in the formula above is to ensure the insurance company's capital requirement is independent of its organisation structure. The reason for grouping the results of R₁ to R₅ squared and then taking the square-root is to allow for the degree of interdependence between risks.

The inclusion of half of R_3 with R_4 in the formula is to reflect the potential correlation between the risk of adverse claims development and the credit risk associated with reinsurance recoveries.

The measure of capital adequacy is used to determine the level of attention attracted from the insurance regulators. These are broken down into 4 levels in order of increasing severity:

- Company Action Level – The insurer submits a plan of action to meet the capital requirement, with no further action by the state insurance department.
- Regulatory Action Level – The insurer submits a plan of action as above and the insurance commissioner may take discretionary corrective action, eg. to restrict new business.
- Authorised Control Level – The insurance commissioner is “authorised” to take control of the company.
- Mandatory Control Level – The insurance commissioner “must” rehabilitate or liquidate the company.

In brief, this forms the basis of the regulatory framework in terms of capital requirements in the US.

2.6 Sarbanes / Oxley

The Sarbanes-Oxley Act of 2002 came into being as a result of financial failures such as Enron and Worldcom. The scale of losses being exaggerated by misrepresentation of financial accounts for a prolonged period of time. The legislation affects US listed companies, the key sections of the act being Sections 302 and 404 which are listed:

Section 302: Corporate Responsibility For Financial Reports

The CEO and CFO of each issuer shall prepare a statement to accompany the audit report to certify the "appropriateness of the financial statements and disclosures contained in the periodic report, and that those financial statements and disclosures fairly present, in all material respects, the operations and financial condition of the issuer." A violation of this section must be intentional to give rise to liability.

Section 404: Management Assessment Of Internal Controls

Requires each annual report of an issuer to contain an "internal control report", which shall:

- State the responsibility of management for establishing and maintaining an adequate internal control structure and procedures for financial reporting
- Contain an assessment, as of the end of the issuer's fiscal year, of the effectiveness of the internal control structure and procedures of the issuer for financial reporting.

Each issuer's auditor shall attest to, and report on, the assessment made by the management of the issuer. An attestation made under this section shall be in accordance with standards for attestation engagements issued or adopted by the Board. An attestation engagement shall not be the subject of a separate engagement.

The language in the report of the Committee which accompanies the bill to explain the legislative intent states, "--- the Committee does not intend that the auditor's evaluation be the subject of a separate engagement or the basis for increased charges or fees."

Directs the SEC to require each issuer to disclose whether it has adopted a code of ethics for its senior financial officers and the contents of that code.

Directs the SEC to revise its regulations concerning prompt disclosure on Form 8-K to require immediate disclosure "of any change in, or waiver of," an issuer's code of ethics.

A valuable insight

Those companies affected will have to go through a process of looking at their own internal control structures and procedures for financial reporting. This will provide valuable input for the assessment and quantification of risk, in particular, for operational risk.

3 Major Risks faced by Insurance Companies

3.1 General Comments

Insurance companies face a multitude of risks which come in the form of different guises. The main categories of risk are as follows:

- Insurance Risk – Underwriting Risk and Reserving Risk
- Credit Risk
- Market Risk
- Liquidity Risk
- Operational Risk
- Group Risk

Within each of these risk headings we have provided a definition and listed examples of risk factors that need to be considered. Some of these risk factors are either explicit (e.g. Underwriting Risk - Catastrophe losses) or implicit (e.g. Underwriting Risk - Underwriter writing risks outside of guidelines).

Insurance Risk

Definition

"The inherent uncertainties as to the occurrence, amount and timing of insurance liabilities."

Insurance risk consists of two aspects, namely the risks associated with the writing of new business (Underwriting Risk) and the risks inherent from writing past business (Reserving Risk).

Underwriting Risk

"Risk associated with the uncertainty of business underwritten in the future, both new business and renewals of existing policies. This would also include catastrophe risks."

Reserving Risk

"Risk associated with the uncertainty of the adequacy of claims reserves (including case reserves, IBNR and ALAE) and provisions for unearned premiums and unexpired risks."

Examples of Risk Factors:

Underwriting Risk

- Claims experience - uncertainty of future claims experience for both attritional and large / catastrophe claims; and length of claims development
- Pricing - incorrect pricing due to data, methodology etc.
- Premiums - effects of rapid growth (underpricing) or decline in premium volume (excessive pricing)
- Underwriting Controls - Inappropriate underwriting strategy; failure to apply underwriting guidelines; policy wordings
- Market - Lack of innovation; exposure to market forces (underpricing)
- Portfolio - Change in business mix, lack of diversification
- Brokers - dependence on Intermediaries for a large share of premium
- Reinsurance - inappropriate reinsurance programme; large reinsurance price rise; unavailability of reinsurance; exhaustion of reinsurance arrangements
- Geographical - geographical mix and geographical or jurisdictional concentrations

- Expenses - variation in expenses (including indirect costs)
- Modelling - reliability of internal and external models and assumptions
- Catastrophes - Aggregation of claims

Reserving Risk

- Claims reserves - adequacy of claims reserves, including case reserves, IBNR and ALAE
- Underwriting provisions - adequacy of provisions for unearned premiums and unexpired risks.
- Latent claims
- Large claims – frequency and severity of large claims
- Unexpected exposures
- Legal / Legislative - change in legal systems, changes in court awards, policy wording interpretation
- Inflation - the effects of inflation on claims reserves and expenses
- Social - social changes resulting in an increase in the propensity to claim or to sue; and other social, economic and technological changes.

3.2 Credit Risk

Definition

"The risk of loss if another party fails to perform its obligations or fails to perform them in a timely manner."

Examples of Risk Factors:

- Adequacy of reinsurance programme for the risks selected
- Reinsurance failure of the company's reinsurance programme and the impact on claim recoveries
- Credit deterioration of the company's reinsurers, intermediaries or other counterparties
- Credit concentration to a single counterparty or group
- Credit concentration to reinsurers of particular rating grades
- Reinsurance rates increasing
- Bad Debts greater than expected.

3.3 Market Risk

Definition

"Market risk is the risk of an adverse movement in the values of assets as a result of market movements such as interest rates, foreign exchange rates, asset prices etc which is not matched by a corresponding movement in the value of liabilities."

Examples of Risk Factors:

- Asset price moves
- Adverse interest rate movement
- Inadequate valuation of assets
- Unexpected losses and defaults of issuers
- Asset and liability mismatch
- Currency devaluation

3.4 Liquidity Risk

Definition

"The risk that a company does not have sufficient financial resources that enable it to meet its obligations as they fall due, or can secure them only at excessive cost."

Examples of Risk Factors:

- Mismatch between expected asset and liability cashflows
- Inability to sell assets quickly
- General cash-flow position and the ability to withstand sharp, unexpected fund outflows via claims, or an unexpected drop in the inflow of premiums

3.5 Operational Risk

Definition

"The risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events."

Examples of Risk Factors:

- Fraud - likelihood of fraudulent activity occurring
- Pension - company's obligation to fund a pension scheme for its employees

- Technology - technological risks a company may be exposed to regarding its systems
- Reputation - reputational risk exposure, e.g. a company's brand
- Marketing - marketing and distribution risks that a company is exposed to
- Legal - impact of legal risk
- Outsourcing - impact of possible outsourcing difficulties
- Management - management of employees
- Risk Management resourcing – resourcing of staff with appropriate skills
- Procedures – adequacy of policies and procedures manual
- Management Information – adequacy and timeliness of management information
- Internal Audit – appropriateness of the internal audit function structure
- Business Continuity – adequacy of company's business continuity management plans
- Disaster Recovery – adequacy of a company's disaster recovery plan
- Political – likelihood of political interference

3.6 Group Risk

Definition:

"The risk associated with being part of a group, particularly as a result of contagion. Risks would include no longer having a guarantee of financial support given by the parent, or the risk for the insurer of an impaired parent or affiliate within the group."

Examples of Risk Factors:

- Insolvency of Parent
- Rating downgrade of Parent
- Impairment of an affiliated company

Stress Testing and Scenario Analysis

4 Stress Testing and Scenario Analysis

There are many definitions of (i) Stress testing and (ii) Scenario analysis that vary according to what source you read e.g. PS04/16 (CP190) or the International Association of Insurance Supervisors (IAIS). Despite the differences they each have common themes which are outlined below:

Stress Testing

- Stress testing typically refers to shifting the values of individual parameters that affect the financial position of a firm, and then determining the effect on the firm's business.
- The stress testing should address significant adverse threats to the future financial condition of the insurer, rather than just mildly uncomfortable possibilities, so as to truly test the insurer's exposure and the sufficiency of its technical provisions and capital.
- A stress test isolates the impact on a portfolio's value of one or more predefined moves in a particular market risk factor or a small number of closely linked market risk factors.

Scenario Analysis

- Scenario analysis typically refers to varying a wider range of parameters at the same time. Scenario analyses often examine the impact of catastrophic 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.
- Scenarios can also be generally considered under three broad headings. Changes to the business plan, changes in business cycles and those relating to extreme events. The scenarios can be derived in a variety of ways including stochastic models or a repetition of an historical event. Scenarios can be developed with varying degrees of precision and depth.
- Often scenarios contain symmetric shocks (up and down), unlike a stress test scenario which typically shocks a given market risk factor in only one direction (up or down).

5 Why do Stress Testing and Scenario Analysis

5.1 Best Practice

Stress tests and scenario analyses can be undertaken by firms to gain a better understanding of the vulnerabilities that they face under extreme conditions. They are based on the analysis of the impact of unlikely, but not impossible, events. These events can be financial, operational, legal or relate to any other risk that might have an economic impact on the firm.

To better inform the board and management of the insurer's exposure to risks, it is useful to determine how adverse a risk must be for it to impair the insurer's financial position. The insurer should use stress testing for strategic planning and for contingency planning.

A large part of an insurer's financial management is based on an understanding of expected outcomes and the normal variation around these expected outcomes. An analysis of the financial effects of atypical or extreme scenarios is needed to gain a comprehensive view of the risk assumed, e.g., measuring the potential impact of a stock market collapse on the insurer's equity portfolio.

A more relevant question in the current context is therefore what are the merits of a stress and scenario testing approach as opposed to stochastic modelling? To a large extent the relative merits of the two approaches will depend upon the purpose of the risk analysis.

In many cases, a risk analysis is undertaken in order to assess the resilience of a business to an extreme event. For instance the FSA requirements are that capital be sufficient to absorb losses in 99.5% of cases over 12 months.

A *Stochastic approach* will produce a distribution of outcomes which will permit the 99.5th percentile to be read off and the capital set accordingly. This point in the distribution of outcomes will generally be reached where a number of adverse factors coincide. Such a coincidence of factors is very difficult to model reliably using a parametric approach. The results from stochastic modelling need to be treated with a great deal of care in the tails of the distribution.

In performing a *Stress or Scenario test*, however, consideration of the likely coincidence of certain features of the experience will be a part of the analysis. The downside of such an approach is that there is no specific probability associated with the outcome and so subjectivity becomes more significant. Arguably, however, this may be more appropriate than the possibly spurious accuracy implied by a stochastic approach.

Reasons for using a Stress & Scenario testing approach may include the following:

- **Stress and Scenario Analysis tends to be more focused**

A stochastic approach tends to involve a full analysis even where the full output is not required. As an illustration, where the focus is on the extreme outcomes, a stochastic analysis will often involve giving consideration to full distributions of the constituent risk factors, even when only the real extreme outcomes will have any bearing on the result. On the contrary a stress or scenario test can be very much more focused on the specific question being asked.

- **Stress and Scenario Analysis produces reliable results more quickly**

Because there is generally more focus on the specific question, stress and scenario tests can generally be constructed and get to the point of producing reliable results much more quickly than in the case for stochastic models.

- **Stress and Scenario Analysis results are easier to communicate**

Communication of the results of stress & scenario tests in principle is easier than stochastic models, as there is a greater degree of transparency. The actual scenarios used will be comprehensible to management of the business, and the subjectivity in the assessment of relative likelihood will clear for all to see. This would not normally be the case in stochastic modelling where a greater understanding of the mechanics of the model and the detailed assumptions would be required before full confidence could be gained.

5.2 Regulatory

Aside from the reasons given under best practice in section 5.1, a key driving force behind change is the regulatory influences, in particular PS 04/16 (CP190) in the UK. Regulation is not the be all and end all of why companies should do this analysis but regulation has certainly accelerated what would normally have taken place during the course of time.

PS 04/16 (CP190) goes on to further state that for each of the major sources of risk identified, the firm must carry out stress tests and scenario analyses that are appropriate to the nature of the major sources of risk, as part of which the firm must:

- take reasonable steps to identify an appropriate range of realistic adverse circumstances and events in which the risk identified crystallises; and
- estimate the financial resources the firm would need in each of the circumstances and events considered in order to be able to meet its liabilities as they fall due.

6 Design of Stress Tests and Scenarios

6.1 Required Expertise

The stress and scenario tests that a company will wish to carry out are intended to help quantify the financial effects on the company of the risks that it is running. The company will therefore want to consider the risks that it faces and design tests to capture the effect of plausible adverse scenarios. The company may also wish to test the effects of plausible favourable scenarios to prepare responses to capitalise on such events should they occur.

A description of some generic risks that the company may face is given in Section 3. Risks covering all aspects of the company's business should be considered. Therefore, developing a thorough understanding of the risks in order to design stress and scenario tests will involve enterprise wide input. However, it may also be useful for there to be a review of the overall adequacy of coverage of the tests that is independent of the operational units.

The team developing stress tests will need extensive knowledge of the business and the ability to extract and assimilate information from all areas of company. They will need to have a good understanding of the risks being faced, knowledge of plausible events (for example, the external environment, catastrophe models etc), how the risks can be translated into a quantifiable form, the way risks interact, and technical / statistical knowledge to understand the quantification of risk parameters and correlations. Perfect data will often not be available so they will need to be able to understand and interpret the uncertainties in the quantification process and may need to make significant subjective input and incorporate qualitative information.

Clear communication, and documentation, of the key assumptions, results and uncertainties will also be very important.

6.2 Stress Test design steps

The steps involved in designing stress tests might be:

- Establish the base against which to stress test. Typically this would be the current business plan.
- Identify the risks faced by the company
 - The company should have a risk map which it uses to manage its risks. This should give a comprehensive view of the risks the company faces. This is a good starting point for the design of stress and scenario tests.

- Select key risks for analysis
 - It is unlikely that all the individual items on the risk map will be tested separately. A risk matrix analysing the impact and likelihood of risks is a useful way to prioritise key risks. The capital requirements for others may be grouped. Some of the key risks may also be analysed as a group if their effects are similar, for example different risks affecting future loss ratios. Further, some of the risks may be better mitigated through systems and controls rather than by holding capital.
 - The company might, say, look to stress test the top 15-20 risks and capture other risks in a broader way
- Consider the causes and effects of the risks being analysed. This may help to identify which risks are correlated and hence give a means for deciding how to aggregate the results of the stress tests, and also ripple effects.
- Decide on the risk measure to be used for the tests (eg ruin probability)
- Identify plausible adverse scenarios based on the chosen risk measure
- This might be done by quantifying ranges for parameters within a stress test, or by selecting events (eg windstorms) that are consistent with the chosen risk measure.
- Calculate the resulting capital requirement should the plausible adverse scenarios materialise.
- Aggregate the results of the stress tests making allowance for correlations between the risks and ripple effects

6.3 Considerations

- Correlations - Are stress tests designed independently
- Risk Measure – What risk measure should be used e.g. TailVAR of X or Ruin Probability of y%. What does this mean in terms of setting up the parameterisation of individual stress tests
- Loss drivers - To what extent to look at the drivers of large or attritional losses to derive scenarios or look at the effects i.e. variation in ultimate loss ratios directly. The latter approach means a need to use judgement to adjust past experience as consider appropriate for current conditions.
- Deterministic stress or scenario test v stochastic approach – Do you test a few specified catastrophes or determine a distribution for “all” catastrophes from which to sample stochastically
- Frequency of stress testing
- Time horizon
- Data – internal and external data available

- Consistency of Stress test design - Calibration of return period of hurricane vs assessment of potential deterioration in reserves vs operational risks. Should each risk be analysed at similar risk appetite levels, or could a strategy be to run some risks at different appetites (e.g. insurance risks at one level and more averse operational risks at another say higher level)

6.4 Areas for Stress Testing

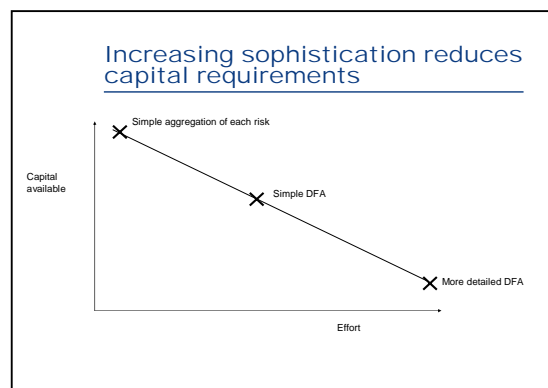
- Major individual contracts written - i.e. check can meet each in isolation, consider combinations. Test can cover any individual risk written.
- Single catastrophe - RDS scenarios
- Multiple Catastrophes
- Multiple "Large" losses - consider possibility of random events, possible common causes (eg economic downturn / financial institution issues) causing a series of losses hitting significant part of syndicate retention / potentially exhausting lower layers of programmes.
- Poor attritional claims experience - General impact on ULR, or look at variation in frequency / severity
- Market premium rate falls – e.g. new capacity
- In-accurate pricing models or overall level or relativities
- Premium volume decrease - driven by cutting book in down cycle, withdrawal of key broker business, loss of major individual contracts
- Premium volume increases (and altering balance of book)
- Deficits emerging in reserves - general underestimation, latent claims
- Reinsurance bad debt / other credit risk
- Reinsurance slow payment - gross cashflows, liquidity issues
- Economic conditions
 - Interest rate shifts
 - Inflation
 - Asset values – equities, property and liquidity issues
 - Exchange rates
- Expenses and inflation
- Tax changes
- Operational risks - IT failures, Key man risks, Fraud etc.
- Group risks

7 Modelling Approach

7.1 An Overview

Risk quantification can be made simple or very complex. We all use our instinct to assess risk within micro seconds both in every day life and in our businesses. This is a simple procedure but can be very effective. If we wish to be more rigorous, we might carry out some stress tests or scenario tests. And we could go the whole way and build a DFA model to help us quantify risk. But which is the right approach from the point of view of the FSA and from the point of view of internal modelling for management purposes.

This is a very simple graph which can hardly be described as actuarially precise.



Satisfying the FSA

The amount of work that will be required to satisfy the FSA is likely to depend on the capital available to the company. If there is plenty of capital, a simple stress test aggregating the risks is all that is required and the amount of effort will be small. If a large company has a relatively low level of capital, a detailed DFA model is likely to be necessary to convince the FSA that the company is sound. This is likely to take rather more effort. So the message is that if you have plenty of capital you probably only need to do a little work to convince the FSA that your company is sound whereas if you have relatively little capital, you will have to undertake rather more work. Of course the building of models is not just relevant to the FSA. It can be very useful for internal purposes and it may be that, even if you have plenty of capital, there is reason to build sophisticated models to help you in the running of your business.

Financial Model

A financial model can indeed be complicated but it can also be very simple. For example, a clear understanding of one's own insurance company might allow a couple of very simple, but nevertheless helpful, stress tests to be carried out. What happens if my equities fall 20% and my loss ratio increases by 10%?

This is a very simple model but can give a powerful result in conjunction with an understanding of the portfolio. Simple models can be more appropriate than very complicated ones. The very complicated models are often difficult to parameterise and it is difficult to produce results from them that are credible in practice.

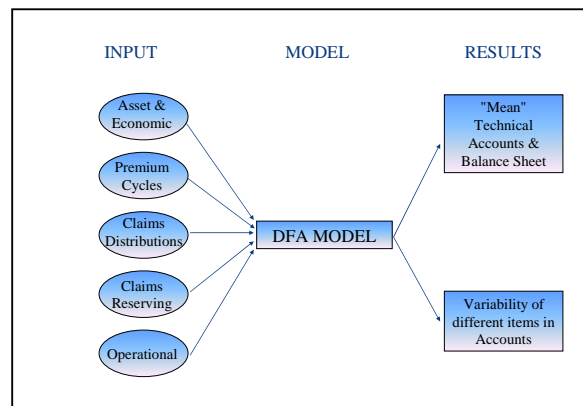
Whether we are talking about a simple model or a complicated one we are effectively trying to simulate the results of a real insurance company. The more complicated models will use stochastic simulations to produce a series of technical accounts and balance sheets for each future year. The variability in these results is particularly important for understanding the risks inherent within the insurance company. The model will typically allow comparison of various different options.

The type of questions that stress and scenario tests or a DFA model can answer are as follows:

- Will I remain solvent for the foreseeable future?
- How much capital do I need?
- Should I buy more reinsurance?
- What is the optimal investment strategy?
- What is the real profitability of each class?
- Should I sell equities if the solvency margin drops below 40%?

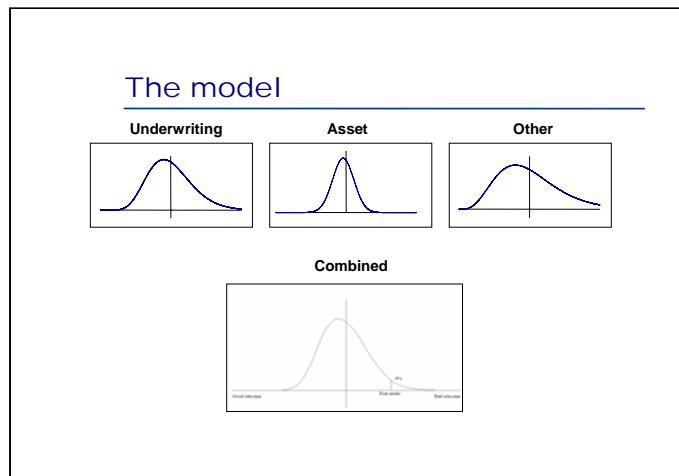
Such questions are of relevance to the FSA but, more importantly, they are vital questions in the day-to-day management of any insurance company. While a lot of the recent impetus to use stress and scenario tests or DFA models has come from the FSA, it is important not to lose sight of the fact that such techniques are vital to the running of an insurance company and need to be implemented even without the FSA impetus.

A DFA model might look something like this.



There are a number of inputs the most important of which are shown in the prior exhibit. These inputs feed the DFA model which produces many simulations of the future. A stochastic simulation not only produces the mean result, but perhaps more importantly, it produces a number of possible future results for the company and hence the variability of the result in that year can be estimated. A similar process will happen for all future years.

In statistical terms, one might think of the various inputs such as underwriting risk, asset risk and other risks being represented as statistical distributions. All of the statistical distributions are then combined to determine the overall distribution for the profitability or the free assets of the company.



Correlations

In undertaking this process, it is necessary to consider the correlations between the different risks within the model. For example, it is very likely that if a motor account turns sour because of increasing bodily injury claims, there will be a similar problem in the liability account. On the other hand, problems of falling asset values are unlikely to be correlated with any over-run in costs associated with the introduction of a new computer system. Thus, when modelling it is important to allow appropriately for the correlations between the different classes of business but not to assume that there are material correlations between assets and many operational risks.

There are a number of ways to allow for such correlations. Theoretically, you can build them up from scratch but practically this is very difficult. A simpler and often more useful method is to assume that the correlations that happened in the past will happen again in the future, perhaps with some modification as appropriate. One might also use correlation drivers. So for example, the inflation rate from the asset model may be used to drive both loss ratios and asset values.

The loss ratio might be used to predict the loss of a scheme in that, when the loss ratio is low, schemes are more likely to go self-insured resulting in a subsequent higher level of expenses for the remaining accounts. Bad gross results might be used to drive reinsurance failure.

What-ifs

Any model must be capable of undertaking "what ifs" so that the results of different future strategies can be compared. It will also be necessary to have a model, which allows for the use of decision rules. Examples of such decision rules are to:

- Sell equities if the market value drops 20%
- Buy reinsurance if the solvency margin falls to 30%
- Stop writing a class of business if the results are poor
- Cut your marketing budget if the loss ratio rises
- Outsource IT if the current systems fail.

7.2 A Possible Process

A structured Approach

- Keep the process simple and then build upon the level of complexity
- If possible, use both deterministic and stochastic approaches. They are complementary techniques and the results of one can be used to develop the other
- Understand the strengths and weaknesses of the different modelling

A possible approach is outlined below:

Scenario Modelling over 12 months

- Select a limited number of individual scenarios, say 20-25 in total covering each of the major risk categories and each of which represents a realistic adverse scenario. These will be predominantly insurance risk exposures. Other key risk categories would be credit and market risk. Operational risk scenarios should be no more than 3 or 4 of this total at this stage.
- For each scenario show the gross and net loss impacts, e.g. for underwriting risk both gross and net losses after application of reinsurance. Also, it is useful to show results at both the 1 in 100 and 1 in 200 year levels of ruin probability, given the subjective nature of many scenarios.
- Scenarios can be added to or subtracted from as appropriate based upon the results from the initial analysis.

Stochastic Modelling over 12 months

- Here the focus is on the use of distributions and simulation techniques. This is more of an integrated approach with the convolution of the separate distributions for each risk. The models will need to reflect some form of dependency structure, e.g. large natural catastrophe loss followed by increased risk of reinsurance failure (credit risk).
- An alternative to this approach would be to calculate the various capital numbers for each risk category (based on distributions) in isolation and then convolute via a correlation matrix between risk categories.

Scenario Modelling over 3 to 5 years

- The medium term view is important to reflect the ripple effects that are often associated with individual scenarios. An example being an increase in premium rates in the year following a large insurance loss. There are some scenarios that may not be captured in the current environment, e.g. a large insurance loss at the bottom of the 'Soft' market or the management of the trade-off between market share and profitability over the insurance cycle.
- Also, it is no good being able to demonstrate solvency over 12 months if there is an unacceptable high risk of insolvency in 3 to 5 years time.

Stochastic Modelling for 3 to 5 years

- The same comments apply as above for scenario modeling. This approach can be used to demonstrate the affect of many scenarios, where each simulated run over the time period is in effect a scenario e.g. 5,000 simulations being equal to 5,000 scenarios.
- A distribution is obtained at the end of each year of the time period, which in theory can be used to assess ruin probabilities at these points in time.

7.3 Modelling Issues

Scenario Modelling

- How to convolute the individual scenarios within a risk category, e.g. underwriting risk there may be 4 scenarios for property losses each of which has a separate loss size for the same ruin probability.
- How to convolute risk categories – a correlation matrix a possible solution
- The integration of asset and liability modelling

Stochastic Modelling

- **Parameter Risk** – There is uncertainty associated with estimating the parameters for modeling purposes as there is a ‘best’ estimate with an associated standard error. The results from these models over longer time periods will exhibit ever increasing uncertainty due to the interaction of many variables, each of which has a potential source of uncertainty.
- **Model Risk** - The risk associated with not capturing fully the dynamics of the insurance process when making projections, especially the dependency structures which are so crucial when extreme events occur, as the continuation of a plan without management intervention often produces unrealistic extreme results.
- These issues need to be recognized when setting business objectives. An objective of having enough capital now to have a 97.5% confidence level of being above a certain solvency hurdle in 5 years time is inherently more uncertain than one based on a shorter time horizon. The modelling work is still very useful to demonstrate the potential variability of results, but careful thought is needed if business decisions are predicated on it.

8 Validation

8.1 Validation of Scenarios

The general issues surrounding the stress and scenario test design have been covered in section 6. This part of the paper elaborates on some of the points discussed there. One of the key areas in validation is the validation of scenarios.

In general, the risk identification and selection process should reflect the following:

- An in-depth understanding of the industry it operates in, e.g. the competition it faces and the likely impact of future potential changes.
- A good understanding of the external factors in the market that can influence its future, e.g. the investment and reinsurance markets.
- An extensive understanding of the internal operational processes, its strengths and weaknesses, and any loopholes etc.

This should form an integral part of the risk management framework, which is discussed in section 9. If a sound, efficient and up-to-date risk management process is in place, then the task of risk identification should be relatively straight forward.

Risk quantification tends to work with a much fewer number of risks than will be found in the qualitative assessment. A key task is to validate (i) risks for quantification with (ii) risks based on a qualitative assessment. This can be done by a mapping from one to the other. There will be both explicit and implicit links between the two approaches.

Example – Underwriting Risk

If in the quantification of capital for insurance losses from new business one was working with a projected net loss ratio and a distribution, then this approach could be linked to a few qualitative risk factors e.g.

- External losses (random element of large losses)
- Underwriters charging rates less than technical price - implicitly captured in historical data; which has been used for setting future assumptions
- Underwriters writing business outside of guidelines – implicit (as above)

8.2 Validation of Assumptions

As with any scientific modelling, the results of the analysis will depend on the validity of the underlying assumptions. Therefore, it is important to validate the assumptions; to ensure their appropriateness for its purpose and that they are consistent with one another.

Internal vs External Data

Although appropriate external data may not always be easily available, there is value in validating the assumptions against both internal and external data sources if they are available, to test for consistency. For instance, in analysing the financial impact of large claims on the basis of a 1 in 200 year event, it is useful to carry out an extreme value analysis to validate the assumption on the size of claim of this extreme event against the insurer's own experience. Also, it is useful to validate the assumption against some external industry data, if available. In both cases, it may be appropriate to adjust the data to make an allowance for claims inflation.

For other analyses, there are some useful sources of information from credit rating agencies, for instance, on the credit rating of reinsurers and on default rates for bonds with different investment grades. Other sources of information may include the ABI and Lloyd's of London.

Time period

Also, consideration should be given to the period from which historical data is collected for validation purposes. In general, the empirical data set should cover a reasonably representative period under investigation. For example, UK bond yields have risen consistently throughout the 1970s, before stabilising during the 1980s and then falling throughout the 1990s.

Therefore, the assumptions on the volatility of bond yields should be validated against the data collected throughout the whole of this period in order to provide a representative sample.

Otherwise, the assumptions may be biased towards the upswing or downswing phase of a cycle. This is particularly pertinent in considering economic assumptions under cyclical market conditions. Similarly, on analysing underwriting results, the data collected during the review period should cover the whole of the underwriting cycle.

8.3 Analysis and Interpretation of Results

The results of the scenario tests and capital requirement can be validated in a number of ways:

- Peer group comparison.
- Comparison with the insurer's historical experience.
- Comparison of results between independent stress tests.
- Comparison of results between deterministic and stochastic analysis.
- Comparison with the ECR calculation.
- Comparison with results of capital models from credit rating agencies.

There is no single standardised approach to ICA both in terms of methodology and calculation. Therefore, it is particularly useful to obtain peer group review to check for rationality and reasonableness.

A long established insurer would have gone through peaks and troughs in its underwriting and claims experience. A good starting point to validate the results of the ICA calculation is to compare it against the financial impact of a similar experience in the past, if it is available.

There is also value in comparing the results of independent stress tests with the combined effects, especially for a complicated scenario. This will also help in understanding the interaction and correlation between risk factors.

If the insurer is carrying out both deterministic stress and scenario tests and stochastic analyses, the results of the stress tests can be useful in setting parameters for further stochastic analyses. Also, the results of the deterministic analyses can be used to validate the results of stochastic modelling. It can also help in understanding and interpreting the results, as well as explaining the results of the analyses to management and non-technical people.

As the FSA is using the ECR calculation as a benchmark in evaluating capital requirements, it is sensible to compare the ICA with ECR as a test for consistency. One needs to bear in mind that the ECR is calibrated according to the industry average by class of business, with a bias towards the larger insurers and equivalent to a BBB rating.

It would be useful to understand how the insurer differs from the average. For instance, if the insurance operation can demonstrate that historically it has been holding a very strong level of claims reserves, then it would be reasonable to expect the capital requirement for claims reserving to be lower than the ECR calculation. The reverse would also be true if the insurance operation is under reserved consistently.

Many rating agencies have developed risk based capital models to assess the credit ratings of insurers based on their capital strength. Although each model has its own characteristics and biases, it would be useful to compare the ICA calculations with these models as a further test of consistency if they are available.

8.4 Board / Senior Management Approval

The FSA has highlighted that the risk management framework should be embedded in the management thinking and culture. Also, the responsibility in ensuring the insurer has sufficient capital to meet its liabilities rests with the senior management. Therefore, it is important for the senior management to be closely involved in the ICA process and agree on its assumptions and results.

The following are key areas that the senior management should be involved in:

- Compilation and subsequent review of the risk log.
- Assessment of the risk appetite in relation to the business plan and needs.
- Specification of stress and scenario tests.
- Review of the results of the stress and scenario tests and the output from financial models.
- Agreement on the ICA calculation.

This would enable the senior management to have a good understanding of the risks associated with the business, its risk appetite and the level of capital required to safeguard the financial security of its policyholders as well as satisfying its business objectives.

Reporting and Disclosure

9 Risk Management Framework

9.1 Introduction

Stress testing and scenario analysis can be viewed as a key component of a company's risk management framework. This section considers risk management in general without any specific focus on the insurance industry and considers how such analyses may fit into an overall risk management framework.

9.2 Risk, Risk Management and Risk Management Policy

Risk

Risk can be defined as the combination of the probability of an event and its consequences. In all types of undertaking, there is the potential for events and consequences that constitute opportunities for benefit or threats to success.

Risk Management

Risk management is a central part of any organisation's strategic management and, to be effective, must be integral to the culture of the organisation. It is the process whereby organisations methodically address the risks attaching to activities with the goal of achieving benefits both within each activity and across the portfolio of all activities.

Risk Management Policy

An organisation's risk management policy should set out its approach to and appetite for risk and its approach to risk management. The policy should also set out responsibilities for risk management throughout the organisation.

Attaching to the risk management process is an integrated set of tools and techniques for use in the various stages of the business process.

9.3 Risk Management Process

The Risk Management Process can be viewed as follows:

- Strategic Objectives
- Risk Assessment
 - Risk Analysis – Identification / Description / Estimation
 - Risk Evaluation

- Risk Reportng
 - Opportunities
 - Threats
- Decision
- Risk Treatment
- Residual Risk Reporting
- Monitoring

9.4 Risk Analysis – Risk Identification / Description / Estimation / Profile

Risk Identification

Risk identification sets out to identify an organisation's exposure to uncertainty. This requires a detailed knowledge of the organisation, the market in which it operates, the legal, social, political and cultural environment in which it exists, as well as the development of a sound understanding of its strategic and operational objectives.

Risk Description

The objective of risk description is to display the identified risks in a structured format, for example, by using a table. The risk description table described below enables one to describe and assess the risks. The use of a well-designed structure is necessary to ensure a comprehensive risk identification, description and assessment process.

By considering the consequence and probability of each of the risks set out in the table, it is possible to prioritise the key risks that need to be analysed in more detail.

- Name of Risk
- Scope of Risk
- Nature of Risk
- Stakeholders
- Quantification of Risk
- Risk Tolerance / Appetite
- Risk Treatment & Control Mechanisms
- Potential Action for Improvement
- Strategy and Policy Developments

Risk Estimation

Risk estimation can be Quantitative, Semi-quantitative or Qualitative in terms of the probability of occurrence and the possible consequence. For example, consequences both in terms of threats (downside risks) and opportunities (upside risks) may be high, medium or low. Probabilities may be high, medium or low but requires different definitions in respect of threats and opportunities.

Different organisations will find that different measures of consequence and probability will suit their needs best. For example many organisations find that assessing consequence and probability as high, medium or low is quite adequate for their needs and can be presented as a 3 x 3 matrix. Other organisations find that assessing consequence and probability using a 5 x 5 matrix gives them a better evaluation.

Risk Profile

The result of the risk analysis process can be used to produce a risk profile which gives a significance rating to each risk and provides a tool for prioritising risk treatment efforts. This ranks each identified risk so as to give a view of the relative importance.

This process allows the risk to be mapped to the business area affected, describes the primary control procedures in place and indicates areas where the level of risk control investment might be increased, decreased or reapportioned. Accountability helps to ensure that 'ownership' of the risk is recognised and the appropriate management resource allocated.

9.5 Ranking of Risks through a Qualitative Risk Assessment process

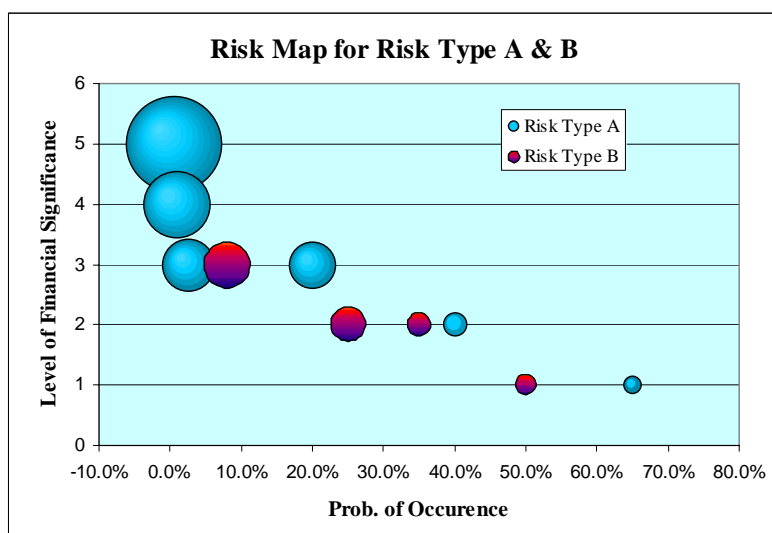
If one can easily attach a probability to each risk and quantify its likely impact, then all is fine and well. But in practice, this may not be easy. In this case, each risk can be ranked according to a simple matrix. For instance, the likelihood of occurrence can be ranked according to the following:

	Likelihood	Probability of occurrence
1.	Improbable	Less than 0.1%
2.	Unlikely	From 0.1% to 1%
3.	Possible	From 1% to 5% %
4.	Likely	From 5% to 20% %
5.	Very likely	Greater than 20%

In terms of financial impact, it may be sensible to relate the financial significance of a risk to its likely impact on solvency. The likely financial impact can be ranked as follows:

	Financial Significance	Likely Impact on Solvency
1.	Minor	Financial effect is trivial or insignificant
2.	Moderate	Can deplete up to say 20% of free reserves
3.	Significant	Can deplete between 20% to 50% of free reserves
4.	Substantial	Can deplete more than 50% of free reserves
5.	Catastrophe	Can lead the insurance operation close to or into insolvency

To some extent, it is subjective how to define each category of financial impact precisely. For instance, an impact of 30% of free reserves to a weakly capitalised insurer could be significant or even threaten its solvency position. While the same impact to a strongly capitalised insurer may only be moderate.



The outcome of this exercise can be summarised in a risk map similar to the following. When using heat maps one has to be very specific with the risk description, as a risk can have many different combinations of Likelihood and Impact.

Example – Movement in interest rates (Risk Factor)

There may be a probability < 1% of a bond market value loss of £ 50m due to interest rate movements but a probability of 50% of a loss < £ 10m. So the question is where on the heat map due you put the risk factor of a loss due to movement in interest rates.

10 Disclosure

10.1 What to Present Internally – Who, Why and What

Who

The Board and Senior Management are obvious recipients of information relating to the capital assessment process. There are also lesser interested parties who are probably closer to the process and detail; namely - Underwriting, Risk Management, Actuarial, Finance and Claims.

Why

PS 04/16 (CP190) emphasised that it is the responsibility of senior management to ensure firms have adequate financial resources. For example the ICAS framework is designed to promote the concept that senior management should take responsibility for assessing the appropriate level of regulatory capital to hold.

It is therefore crucial to keep the senior management informed as the ICA is ultimately their responsibility. They need to understand the results of any modelling exercises and their sensitivities. Senior management are well placed to form part of the challenge process

It will be the senior management that need to take action if they feel the firm has insufficient capital. They will also need to be aware if resource is diverted from other business needs.

What

- At the project outset
 - What is needed to comply with regulations
 - Benefits of suggested approach
 - Timescales
 - Resource required; and internal/software/consultancy costs
 - Next steps
- After modelling work is completed:
 - ICA number
 - Stress and scenario test outputs
 - Links to risk register
 - Assumptions used
 - Sensitivities to assumptions
 - Methodology for stress and scenario testing

- How methodology / risks compare with market best practice
- Shortcomings of methodology
- Risk Appetite
- Next steps – process for updating

10.2 What to Present Externally – Who, Why and What

Who

- Shareholders
- Credit Rating Agencies
- The FSA

Why

- Shareholders
 - It is important to keep shareholders accurately informed as they are providing capital for the running of the business
- Credit Rating Agencies
 - Very influential as they provide an independent assessment of the company and as such will influence market sentiment
- The FSA
 - They are the regulators

What

- Shareholders
 - Results of “What if” scenarios
 - Risk and Return on investment
- Credit Rating Agencies
 - How solvency and scenarios fit into Credit Rating criteria
- The FSA
 - Items satisfying PS04/16 (CP190) and equivalent CP requirements

10.3 Formal Reporting – Stress and Scenario Testing Report

The format of any formal report, either internally or externally to the FSA is at the discretion of the company.

Significant time and effort will be required to develop the capabilities to perform and to execute the projection and analysis. The preparation of a clear and complete report on the results and implications of this work is an important component in the entire process. The audience for this report is company management as well as the board of directors and the regulator.

A sample report outline follows:

- Executive Summary
 - Summary of the base and adverse scenario results (regulatory capital adequacy ratios, earnings, assets, liabilities, surplus)
 - Summary of the recent and current financial position, highlighting the most significant solvency risks
- Introduction to Process
 - Purpose, Scope, Process, Method
- Capital Adequacy Measurement
 - Description and summary of the current financial position (e.g. Solvency ratio)
 - Definition of minimum regulatory capital requirement – MCR, ECR
 - Definition of satisfactory financial condition used in the analysis
 - ICA as a percentage of the ECR
- Base Scenario
 - Description of scenario, assumptions, results, discussion of consistency with business plan
- Adverse Scenarios
 - Description of scenarios, assumptions, assumed management action, results
 - Description of results without extraordinary management, if applicable
 - Recommendations on what actions management could take to mitigate adversity
 - Additional comments regarding any adverse scenarios causing the company to fall below any minimum regulatory capital requirement

- Analysis of Risks by Line of Business
 - Discussion of risks and scenario results
- Link to Qualitative Assessment
 - Heat Map
 - Risk Ownership
 - Risk Appetite
- Conclusions and Recommendations
 - Summary and future developments
- Appendices
 - Key corporate objectives/initiatives
 - Capital enhancement activities
 - Key assumptions and other considerations (rating agencies, taxation, valuation/accounting issues)

10.4 Stress and Scenario Test Template

Outlined below is a possible way of summarising each Stress and Scenario Test:

Descriptive

- Company / Syndicate Name
- As at Date
- Risk Reference
- Risk Description
- Stress / Scenario Test Owner
- Scope - Does it apply to whole business or certain classes? Gross or Net ?
- Reason for Scenario - Why it is a risk for entity
- Risk Category - Part of reference, could be more than one category
- Test Description - Description of test - or cover under methodology
- Causes - Helps to identify related risks
- Effects - Helps to identify related risks
- Related Risks - Identify related stress test codes – correlations

Financial Impact

- Capital Requirement
- Risk Measure used
- Conclusions

Methodology / Assumptions

- Modelling Complexity – L / M / H
- Degree of Judgement required – L / M / H
- Outline of Methodology
- Key Assumptions
- Data Sources
- Related Actions / Ripple Effects
- Issues for further investigation
- Attachments

Case Studies

11 Case Study – Primary Insurance Company

11.1 Background

This section considers how stress and scenario testing can be usefully employed in practice. Such techniques are compared with the approach of using a full DFA model. A case study of the Midlands and Northern Insurance Company ("MANIC") illustrates the methodology.

Section 11.2 describes MANIC and the particular case study. Section 11.3 considers various stress tests which might be applied to MANIC. Section 11.4 then looks at the use of a DFA model to undertake rather more sophisticated modelling of MANIC.

11.2 MANIC

Description

The case study of the Midlands and Northern Insurance Company ("MANIC") will be considered. Inevitably it is not possible here to provide all the details of the case study but nevertheless it is hoped the description in this report will be helpful.

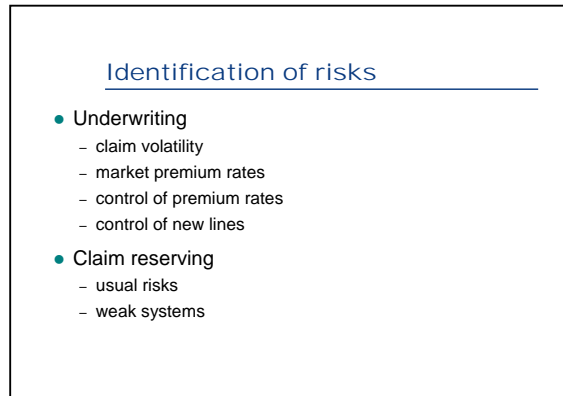
MANIC is of course purely hypothetical but it does have many of the characteristics of real insurers.

MANIC is primarily a motor insurer writing both direct and through brokers. It has recently allowed brokers to discount premiums by up to 15% because they were upset at being undercut by the insurer's new direct channel. In addition to motor, it writes a little motor-related business including residual value insurance, extended warranty and creditor; this business has results that are highly dependent on the economic conditions. Some of the company's computer systems are relatively frail and because of this it has some unnecessary claims leakage. It holds its free assets in equities with its technical reserves being split between corporate bonds and cash. The guidelines given to its investment managers are rather weak.

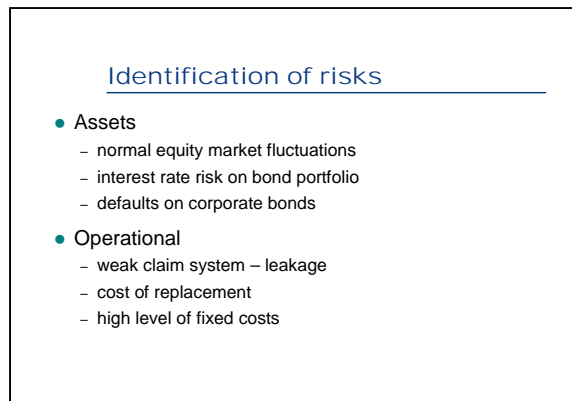
In terms of numbers, its premium income is £300 million. It made a small insurance profit in 2002. It has claim reserves of £345 million. The company has an actual solvency capital of £140 million, and its enhanced capital requirement is £107 million with its minimum capital requirement being £47 million.

Identification of risks

The key risks of MANIC need to be identified and included in any model. As well as the normal risks of any insurer, the risk from allowing brokers to discount the company's rates by up to 15% will be considered. Currently the average discount given is believed to be around 8% but, without any proper controls, this figure may increase or decrease.



As well as underwriting and claim reserving risks, there will be asset and operational risks:



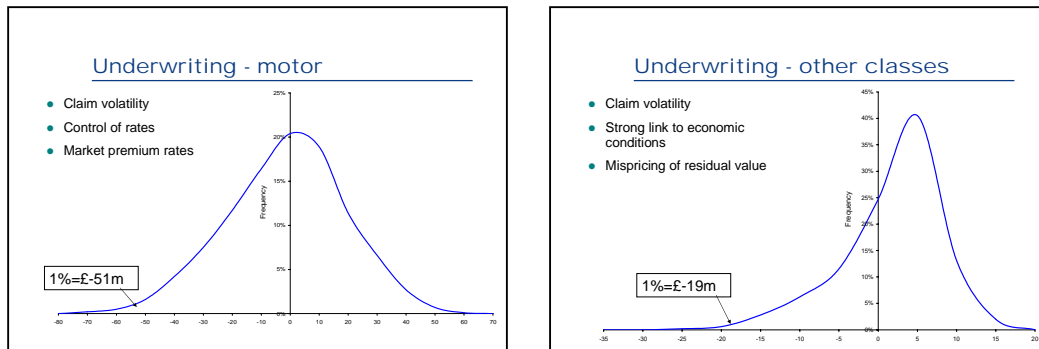
It is not sensible to include all possible minor risks as this will unnecessarily complicate the model and make it difficult to parameterise without providing any additional insights in the results obtained.

Parameterisation of the model

The model needs to be parameterised in a number of different areas.

Underwriting

In terms of underwriting, a typical graph would appear as follows:

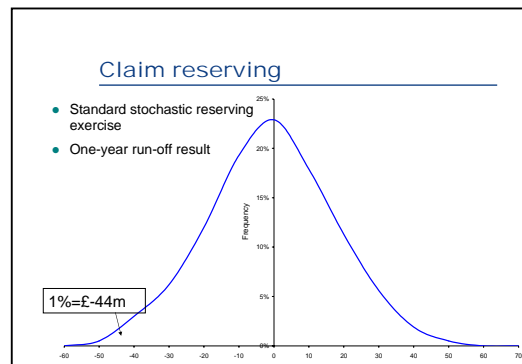


It can be seen that there is a 1% chance that our underwriting profit will be worse than minus £51 million. The insurance cycle will need to be superimposed on to this distribution, which in a DFA model; will need to be projected stochastically like all the other assumptions.

Similar considerations will apply to the underwriting of the other classes of residual value insurance and creditor. These classes have results that are closely linked to economic conditions and thus will be driven by the output from the asset model.

Reserves

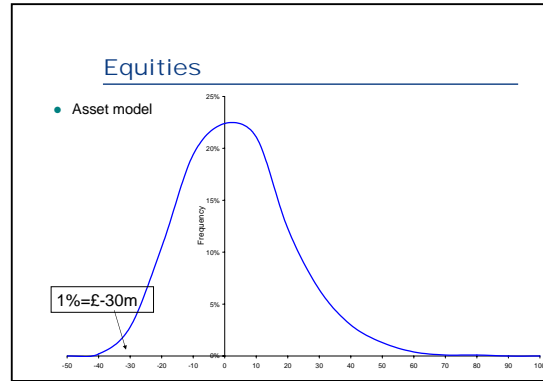
The risk that MANIC's claim reserves are not calculated correctly is an important one. For many companies in the market this risk represents up to 40 per cent of their overall risk and is often the most important risk they are running. The distribution for MANIC's adequacy of reserves is shown below.



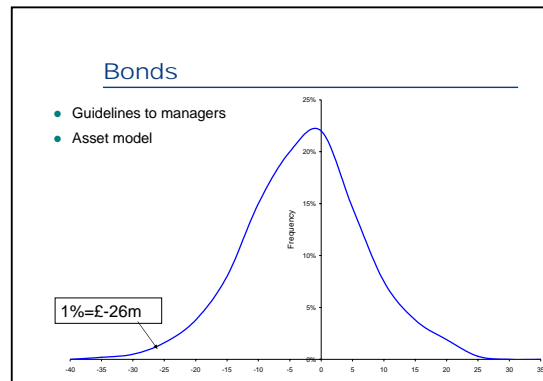
There is a 1% chance that the reserves will be underestimated by over £44 million.

Assets

Distributions are also required for the asset classes. These will come from the asset model. Typical results for equities are shown in the graph below where there is a 1% chance of a fall in MANIC's equities of £30 million or more.



For bonds there is a 1% chance that the market value will fall by £26 million.



In terms of operational risk the claims leakage is assumed to continue until the new computer system is in place. It is also assumed that the new computer system may over-run by £10 million; in such circumstances, it will be delayed and hence claim leakage will continue for the period of the delay.

11.3 Stress and Scenario Testing

This section considers how stress and scenario tests might be applied.

The table below simply summarises the chance that in each of the different areas there will be a loss at the 1% level.

Summary of key risks and capital required	
	£m
Underwriting - motor	51
- other	19
Reserves	44
Equities	30
Corporate bonds	26
Operational	10
Capital growth	(7)

These figures are taken from the graphs in section 11.2. The figure of £7 million for capital growth is the expected level of investment return on the free assets. The expected return on the technical reserves is included in the underwriting category. The risk of investment return is included in the equity and bond risks. This leaves the expected level of investment return on the free assets to be accounted for separately.

If all the risks are assumed to be dependent on each other, all the various figures could be added together to give a capital requirement of £173 million.

Stress tests	
Capital required:	
Assuming dependence	
$(51 + 19 + 44 + 30 + 26 + 10) - 7$	$= 173$
Assuming independence	
$(51^2 + 19^2 + 44^2 + 30^2 + 26^2 + 10^2)^{1/2} - 7$	$= 74$

However, this is clearly too high as not all the various risks will go wrong at the same time. If there was independence between risks the capital requirement would be

£74 million. This is too optimistic because, for example, worsening inflation and economic conditions is likely to affect both MANIC's assets and liabilities, particularly for the classes whose claims are dependent on the state of the economy.

If all the risks go wrong at the same time it will cost £173 million. However this is an unlikely scenario. We might have sufficient knowledge of MANIC's account to say that there is a likelihood that three of those risks could go wrong at once in which case the required solvency margin would be £144 million.

Stress tests

- Simple deterministic projections
- All risks go wrong at same time: £173 million
- Say, three worst risks all go wrong at same time (assume all underwriting classes as one risk as strong correlation)

	£m
Underwriting	70
Reserves	44
Equities	30
	144

Alternatively if it is assumed that only two risks reached the 99th percentile the capital requirement would be £114 million.

Stress tests

- Two risks go to 99th percentile

	£m
Underwriting	70
Reserves	44
	114

- Other possibilities eg two risks go to 99th percentile, third to 95th

Other possibilities such as two risks at the 99th percentile and a further risk at the 95th percentile are also possible. While such stress tests are relatively unsophisticated, they can nevertheless be powerful tools in the hands of those who understand their business. Stress tests of this type from someone who understood the business is likely to be more useful than a complicated DFA model produced by someone who did not understand the risks the business was running.

The various stress tests can be summarised and compared with MANIC's actual capital requirements as follows:

Capital requirements over one year for 99% confidence	
	£m
Stress test assuming independence	74
Largest two risks	114
Largest three risks	144
Stress test assuming dependence	173
Minimum capital requirement	47
Enhanced capital requirement ("ECR")	107
Actual free assets	140

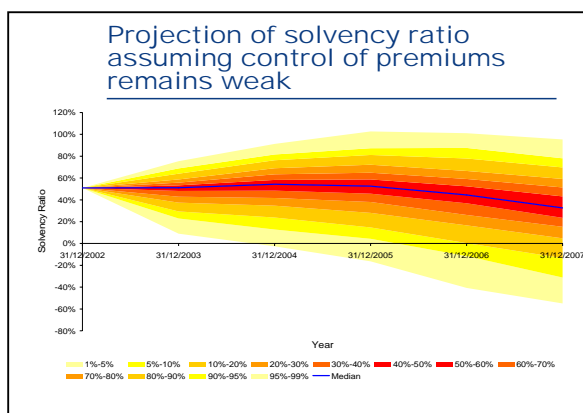
The question arises as to whether two risks at the 99th percentile is the equivalent to ½% chance of insolvency over 12-months. The latter is what the FSA has specified in PS 04/16 (and earlier CP190). To investigate fully what two risks at the 99th percentile means requires the use of a full DFA model.

11.4 DFA Modelling

This section looks at the results of a full DFA model.

To produce a full DFA model, the individual risk distributions need to be combined into one overall model. To do this the correlations between risks need to be taken into account. There are a number of these but the most important are the correlation drivers for the economic risks, the linking of the premium cycles for each class, the correlation between the claims for the current accident period and prior years, and the IT over-run and delay.

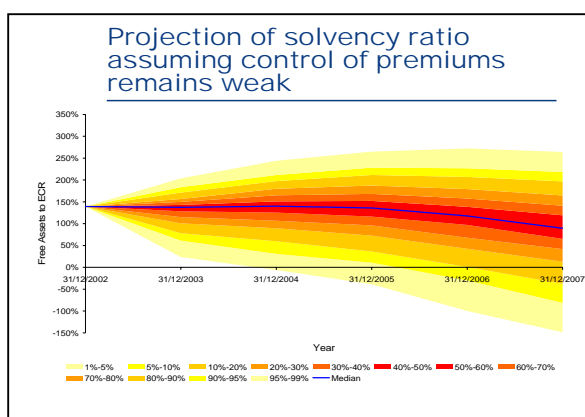
An example of the output from MANIC's DFA model is shown here.



The solvency ratio starts at 50% and then fans out depending on the particular results being generated in the stochastic simulations from the model. The blue line shows the median result with the flame coloured blocks showing the probability of different results.

The lightest block at the bottom of the fan represents the 95th to 99th percentile of outcomes. That is to say that there is about a 5% chance of the company's solvency ratio falling to minus 30% by the year 2007. Or perhaps more realistically there is about a 3% chance of MANIC being insolvent by the end of 2004 if our model is correct and no other remedial action is taken.

The FSA has indicated in PS 04/16 (and CP190) that it would like insurers to compare net assets with ECR. So rather than having solvency ratio on the y-axis it might be better to have net assets as a percentage of ECR.



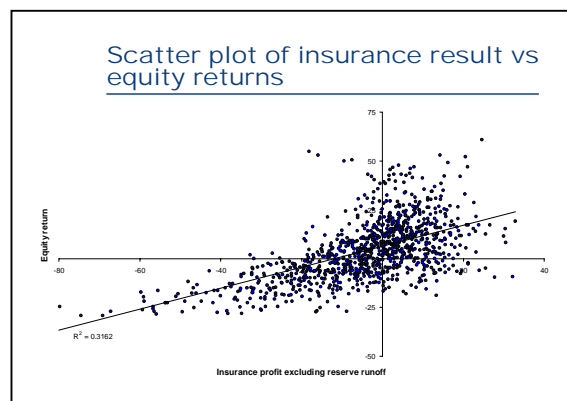
The critical point might be when the net assets as a proportion of the ECR falls below 100%.

The results from the DFA model together with the results of the simple stress tests are shown in the table below.

Capital requirements over one year for 99% confidence	
	£m
Stress test assuming independence	74
Largest two risks	114
DFA model	121
Largest three risks	144
Stress test assuming dependence	173
Minimum capital requirement	47
Enhanced capital requirement ("ECR")	107
Actual free assets	140

The capital requirement shown is that which would be required to ensure with 99% confidence that the company was not insolvent within one year. At the bottom of the slide are the various statutory and actual solvency margins. Compared with the actual free assets it can be seen that the more pessimistic stress tests imply there are insufficient free assets whereas the more sophisticated DFA model, allowing appropriately for correlations, implies there are sufficient free assets.

There are a number of ways to analyse the results of the DFA model. Scatter plots can be used either to demonstrate a correlation between two different risks or to show how much one risk contributes to the total risk of our company. In the graph below the correlation between equity returns and insurance profit excluding reserve run-off is shown.



It can be seen that the two are correlated. This is not a surprise, as we know that both the equity return and the insurance profit are affected by the economic conditions.

From the results of the DFA model, we can determine the risks of falling below the various hurdle levels. It can be seen in the table below that, over a five-year period, we have a 54% chance of falling below the ECR and a 17% chance of becoming insolvent.

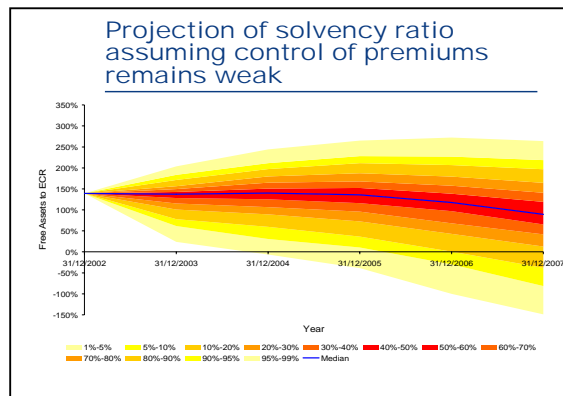
Results assuming control of premiums remains weak

	Risk over	
	3 years	5 years
Falling below ECR	31%	54%
Falling below MCR	11%	31%
Zero net assets	4%	17%

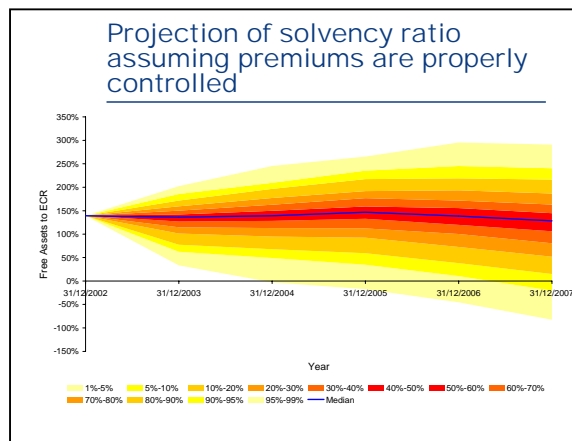
The relatively high probabilities of failure arise because MANIC has only just a break-even insurance profit in 2002. This is a particular problem when the market is at the top of the underwriting cycle with a downturn in rates a real possibility. A company requires a larger solvency margin at the top of the cycle than at the bottom. The control weaknesses on claims and premiums only exacerbates the position. The effect of putting proper underwriting controls in place needs to be examined.

To make a DFA model useful, it is essential to look over a time period greater than one year. In doing so, it is assumed that management will take appropriate action to ensure the solvency of the company. In the example below, it is assumed that there will be no growth during a downturn and that the discounts given by brokers will be controlled.

This was the funnel graph under the assumption that the control of premiums remained weak.



Assuming that premiums are now properly controlled, the results improve as shown below.



The risks of falling below the various hurdle levels have improved as can be seen in the table below.

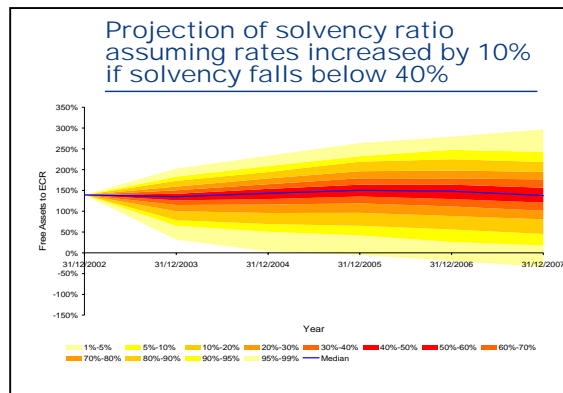
Results assuming premium controls put in place

	Risk over 3 years	
	No premium controls	Premium controls
Falling below ECR	31%	24%
Falling below MCR	11%	6%
Zero net assets	4%	2%

MANIC can hardly be described yet as being healthy although the putting in place of premium controls certainly helps the position.

Typically MANIC's management would also plan other actions. It has been assumed that management would reduce risks in the event of solvency being threatened. They would limit the volumes of business and increase premium rates. This is, of course easy to say but the FSA will be asking whether there are systems and controls in place to ensure that the appropriate actions are taken.

Assuming that the rates were increased by 10% if the solvency margin falls below 40% the funnel plot narrows as shown here.



It can be seen that the probability of insolvency has decreased further.

Showing the results of this modelling as numbers we can see that in the right hand column the risk of falling below the various hurdle rates has been significantly reduced further.

Results assuming rates increased by 10% if solvency falls below 40%

	Risk over 3 years		
	No premium controls	Premium controls	Premium controls & rate increases
Falling below ECR	31%	24%	21%
Falling below MCR	11%	6%	5%
Zero net assets	4%	2%	1%

The risks of failing in one year are minimal although there remains a risk over three or five years. Clearly premium controls are critical for MANIC and the results are significantly improved if action is taken to reduce risk if solvency is threatened.

This analysis of MANIC can only give a flavour of the applications of stress tests and DFA models.

12 Case Study – London Market (Lloyd’s Syndicate)

This example relates to the estimation of Syndicate level ICA and does not consider the additional steps required to translate this to member level ICA.

12.1 Background

The syndicate writes a wide variety of classes including a significant property catastrophe book. It was established in 1990, but 1992 & prior liabilities were reinsured into Equitas. The ICA relates only to 1993 and post.

	Stamp £M	Gross Premium £M
2003	100	80
2004	150	130
2005 (expected)	150	120

Years of account have closed as normal, so current open years are 2002 & prior, 2003 and 2004. Calculations are being done in October 2004 as at 31 December 2004 in preparation for 2005 Year of Account. 2002 is expected to close into 2003.

The syndicate is supported by a mix of private names and corporate capital, so the proportionate membership changes year on year. The managing agent is therefore estimating the ICA for syndicate periods 2003&prior, 2004 and the prospective 2005.

The split of business is approximately US\$ 60%, £ (&conv) 30%, Can\$ 5%, other 5%. This has been fairly constant since 1993.

The syndicate cedes approx 30% of its gross premium income in reinsurance, including a 10% quota share and a variety of excess of loss protections. The property catastrophe account is protected \$80M xs \$5M for two losses, and \$40M xs \$5M for a third loss. The Syndicate holds cash and fixed interest assets, but no equities or property. It had a significant WTC loss affecting the 2000 and 2001 underwriting years.

The largest realistic disaster scenario exposures are on a gross of reinsurance basis 40% of capacity from US windstorm and on a net of reinsurance basis 20% of capacity from Turkish earthquake.

12.2 Key risks and analysis, and how these differ to MANIC

- Reserving risk

As for MANIC, reserving risk is a large part of the ICA. However, given the nature of the business written, the syndicate needs to consider the uncertainty in inwards and outwards premiums and in reinsurance recoveries as part of the reserves.

- Underwriting risk

- Catastrophes

When modelling its underwriting exposure to future catastrophes, the syndicate considers the gross loss profile and how the reinsurance will respond to various perils and losses in different territories. The impact on future reinsurance costs and inwards catastrophe premiums is also considered

- Other attritional

- Credit risk

- to quota share reinsurance
- other reinsurance when catastrophes occur

The heaviest usage of the syndicate's outwards reinsurance would be if a catastrophe were to occur. The syndicate therefore models the reinsurance bad debt that might arise corresponding to the recoveries assumed under the catastrophes considered as part of the underwriting risk.

- Coverholder / broker balances

The syndicate has procedures in place to agree an approved list of coverholders and brokers that can be used. The syndicate reviews the security of these third parties on a regular basis.

- Asset risk

- Fluctuation in interest rates
- Exchange rate risk

Much of the syndicate's business is written in currencies other than sterling. The syndicate considers the risks associated with any mismatched positions and the impact of exchange rates set within reinsurance policies.

- Operational risks

- Disaster recovery

In line with others in the Lloyd's market, much of the transaction processing is carried out by third parties. The syndicate has reviewed the backup facilities necessary to protect against failure of IT likes, and has reviewed the additional expenses that would arise should these facilities be needed to be activated.

12.3 Modelling Approach

The syndicate estimates its ICA by stress testing each of the risk areas described above to events that could arise at a 1/200 level. In order to allow for the possibility of correlation between risks, the syndicate considers how specific events, such as a catastrophe loss, could trigger more than one risk simultaneously.

13 Conclusions

This paper has covered a number of different topics related to stress testing and scenario analysis. There are many challenges over the coming months in the assessment of capital and what constitutes best practice. Stress and scenario testing has an important role to play in this process but as we have seen there are many practical considerations. Some of the more important ones being the number of scenarios, their composition amongst the different risk categories, the time horizon, the convolution of scenarios and the modelling of causes and effect. One also needs to factor in some of the more subjective and important elements like attaching likelihoods to scenarios and model / parameter risk in some of the more mathematical type modelling like DFA.

Risk quantification is an important part of the overall risk assessment process together with the qualitative assessment of the risks. The linking of the two is a key step in demonstrating that all material risks have been captured in the capital assessment process. Recognising the implicit and explicit links between the qualitatively assessed risks and their quantification is an important step.

Further work is needed in this area, work of which could follow up on some of the points raised in the first paragraph. During the course of time it is anticipated that best practices will begin to emerge in an area where actuaries have an important role to play.

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