Using Models In Decision Making

ACTUARIAL ANALYSIS - FOR THE PUBLIC SECTOR - FROM THE PUBLIC SECTOR

GOVERNMENT ACTUARY'S DEPARTMENT

Introduction

Section 1

1.1 Purpose of this document

This document discusses risk in the context of using models to help make decisions, with a view to identifying and mitigating those risks and maximising the value gained from modelling within government. It is aimed at any individual involved with this process, from those developing models to those using a model's output to inform decisions or those providing model assurance.

This guide is based on GAD's experience of modelling and providing assurance on models, but is not intended to be a step-by-step instructional guide to either of those activities. Rather it is intended to stimulate thought and discussion and to raise awareness of the issues and risks involved.

In March 2013 the final report by Sir Nicholas Macpherson (Permanent Secretary to the Treasury) into the quality assurance of analytical models that inform government policy was published. This made recommendations on the steps departments and their Arm's Length Bodies should take going forwards to extend best practice across government. Although this guide does not aim to provide advice about how the review's recommendations should be implemented, it may provide some useful thoughts about what should be considered as part of a quality assurance process.

1.2 Structure of this document

Section 1 of this document provides an introduction to models and the risks that arise from their use.

Section 2 relates to modelling in general, and outlines some of the considerations which are relevant to different parties involved in a modelling exercise.

Section 3 discusses some additional considerations for those parties using long term financial models.

The appendices contain additional information which may be useful when carrying out modelling exercises.

The majority of GAD's modelling experience and expertise is financial in nature. However, the discussion in Section 2 shows that there is a great deal of transferable knowledge and skills that can be applied to modelling more generally.

1.3 Background

Models are increasingly used to help guide decisions and are growing in complexity.

As a result there are increasing risks that inappropriate decisions may be made following the use of a model. These may be caused by:

> people not adequately understanding the underlying model so that it is used inappropriately where it is not fit for purpose

> inputs, calculations or outputs containing errors or omissions which are not detected

> model results not being clearly communicated to the relevant individuals

> an over reliance on the model, and insufficient appreciation of the uncertainty and risk inherent in the model results and in the real world

An awareness of the risks and uncertainties which are inherent in any modelling is therefore of increasing importance to a range of stakeholders.

1.4 What is a model?

A model is a mechanism for demonstrating some aspect of the real word.

It may be very simple – for example, a world map which is a two dimensional representation of a three dimensional surface – or it may be extremely complex – for example, some meteorological models used in weather forecasting.

Models are typically used to make predictions about how the real world will behave under a particular set of circumstances and therefore allow more informed decisions.

There are typically three parts to a model:

> inputs (assumptions and data)

> calculations

> output (numbers, words and pictures)

These individual components are likely to be the focus of model developers themselves. However, the risks arising from models are not confined to a narrow definitions of these components. Indeed, the most significant risks may not be captured at all by such a restrictive view.

1.5 The extent of risk in modelling

Model risk is not limited to the process of designing and building a model but can occur in many stages of the model lifecycle.

Quality assurance should therefore not be limited to verification that a model accurately reflects its specification but should also include consideration of whether the model is fit for purpose and how model outputs are communicated and used.

1.6 Different groups of individuals may tend to focus on risks at different stages in the process (as illustrated in the diagram below):

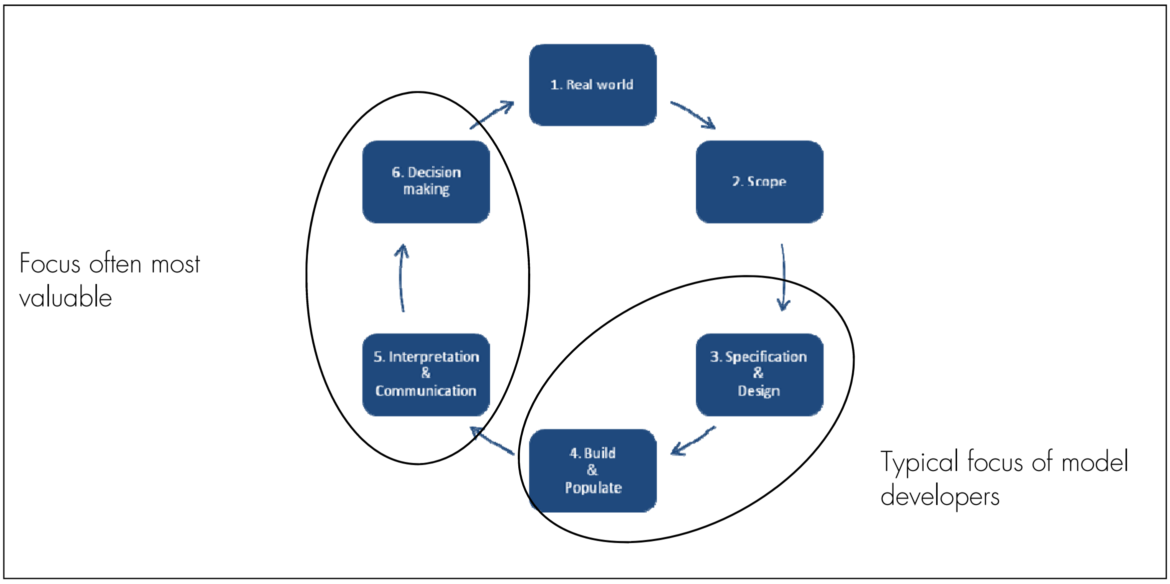
> model developers might focus on the risks involved in model implementation (stages 3-4), such as technical coding concerns

> model users might focus on using appropriate inputs, and interpreting and communicating the results to decision makers (stages 5)

> decision makers (or 'model customers') will need to consider the limitations of the model when selecting an appropriate course of action in the real world (stage 6)

However, this partitioning between groups should not be absolute – the aggregate model risk is reduced if individuals are aware of, and act upon, the risks facing one another.

Diagram illustrating a model's lifecycle



1.7 Considering risk in the modelling process as a whole, rather than through the components of the model, also highlights those risks to decision makers which might otherwise be understated or overlooked entirely.

For example:

> how can the results be communicated in a manner which can be interpreted by the appropriate individuals, perhaps without a detailed technical knowledge of the model and/or issues?

> how do the limitations and uncertainties in the model results affect our proposed course of action?

One of the recommendations from Sir Nicholas Macpherson's review of quality assurance of government models was that a single Senior Responsible Owner (SRO) should be appointed for each model. This SRO should take responsibility for the model throughout its life cycle and sign off that it is fit for purpose.

This section presents some general considerations for the different groups involved in a modelling exercise, with a view to minimising model risk and maximising model value. There may well be overlap between the groups, and in any event, members of each group should be aware of the considerations for one another.

2.1 Senior Responsible Owners

Those responsible for overseeing models throughout their lifecycle, from the commissioning stages though to the interpretation of model results so that decisions can be made using them.

Preliminary considerations - scope and specification

2.1.1 Objectives should be clearly defined and understood before beginning any modelling exercise. For example, the aim may be to determine the optimal configuration of a particular set of traffic lights. In this context, optimal could mean a configuration which provides the greatest traffic flow per hour, minimises the number of road accidents, maximises the ratio of the two, or optimises some other measure. In some cases the modelling itself might reveal where the tradeoffs lie, but in any event the purpose of the exercise should first be well understood.

2.1.2 The suitability of a modelling approach should be assessed once the objectives have been identified. Not all questions are suited to a purely mathematical, equation-driven framework which may then take precedent over more human elements. Objectives such as 'improving customer satisfaction' may require more of the latter. There can sometimes be a tendency for more complex, mathematical models to be considered as more realistic, more reliable, or more trustworthy. In fact the converse may be true since there is perhaps a larger chance of errors (in development, use and interpretation) from more complex models.

2.1.3 Models built for one purpose can be inappropriate for other purposes and this is perhaps more likely with models which are more complex and heavily refined. Further, since complex models may (perhaps incorrectly) be viewed with more confidence, and typically have a higher development cost associated with them, it may be precisely those models which are applied to circumstances other than those for which they were intended.

2.1.4 Consideration should be given to the expertise and time required; if the required expertise is not available in-house then external assistance may be necessary. An organisation which is staffed with experts in one field may not readily have access to staff with the same degree of competency in modelling a new area. Thought should be given to amount of time that will be required for the quality assurance of the model so that it is not skipped over when there is insufficient time at the end of the project.

"Objectives should be clearly defined and understood
before beginning any modelling exercise"

Modelling governance

2.1.5 Once a decision has been taken to commission, make use of, or update a model, consideration should be given to formalising a framework to address such issues as the:

- ownership of the model, lines of responsibility and how issues will be escalated
- extent of quality assurance and documentation which should be carried out
- source, validity and suitability of data and assumptions
- detail and timing of results and communications between different parties
- production of an audit trail of results and discussions to justify resulting decisions
- scope for feedback and challenge of the model by management and stakeholders
- dependency on key individuals or resources (such as IT infrastructure)
- extent to which the modelling will be made publicly available
- compliance with any relevant professional standards
- ensuring any internal systems add value without becoming too onerous

Interpreting results

2.1.6 When presented with the model output, Senior Responsible Owners should consider:

- the suitability of the model for the current purpose
- the limitations which are inevitably inherent in the modelling approach, the impacts of those limitations, and the materiality of those impacts
- in general terms there is a cost to uncertainty, a value in flexibility and (if relevant) a price for removing risk. If these features are not modelled explicitly they may have a significant impact on the value of any decisions taken
- any legal implications, such as age/gender discrimination legislation, which may require changes to a model methodology or inputs

2.1.7 Model outputs depend critically on the validity and suitability of the inputs used. Specific considerations relating to assumptions and input data are discussed in the section for model users, though the Senior Responsible Owner will invariably be involved in determining the appropriate model configuration to some extent (and perhaps entirely). In any event, the set of inputs and outputs should be considered together when making decisions and so the points raised there apply equally here.

2.1.8 Insights from the modelling exercise itself can help decision makers understand uncertainty and manage risk. The complexities of reality are unlikely to be illustrated by a single number. To help understand the uncertainty, models can be interrogated using alternative inputs and assumptions.

"Insights from the modelling exercise itself can help decision makers understand uncertainty and manage risk"

Communication

2.1.9 The results of a modelling exercise must be communicated in a language and manner which are suitable for the intended audience. Poor communication risks not only failing to add value but (worse) inferior decisions may be made as a result of being misinformed. Such concerns are often confounded when communicating with more removed parties such as the press, or over time as the quality or quantity of documentation degrades.

2.1.10 Communicating the uncertainty of the modelling may involve presenting a full range of sensitivities and scenarios covering:

- different variables (sensitivities)
- wide ranges for any key individual variable
- key combinations of variables (scenarios)

The use of too narrow a range of scenarios can give the impression that all outcomes will appear in just a narrow band. However, decision makers should be made aware that any set of results is unlikely to show the full extent of the risks in pursuing a particular course of action.

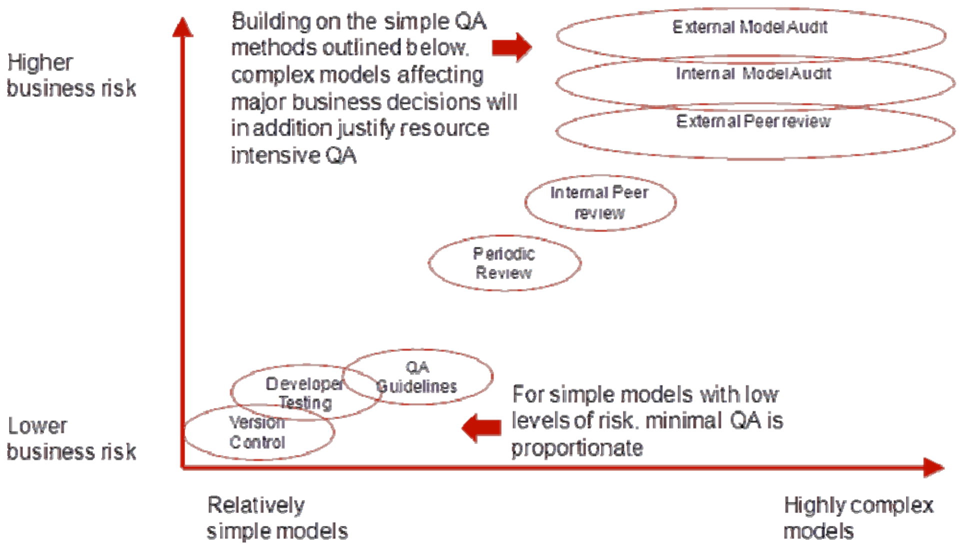
2.1.11 The communication should be clear about what each scenario represents. For example, whether the base/central scenario is a best estimate or if it includes margins for prudence and the likelihood of alternative scenarios shown.

2.1.12 It may be helpful to communicate the results in terms of:

- absolute numbers and percentages
- differences through time, or allowing for any changes
- any affected groups in isolation as well as total populations

Assurance

2.1.13 The schematic below illustrates how the level of quality assurance is likely to vary depending on the impact and complexity of the model. Obtaining suitable external assurance may increase confidence in the model, and identify avenues for further investigation and improvement.



Source: HM Treasury
Review of quality assurance of Government analytical models

2.2 Model users

Those individuals who configure and use an existing model to produce results to aid decision makers.

Overview

2.2.1 Users should understand all the model limitations and approximations, consider their applicability to the case in hand, and ensure that decision makers are aware of them.

Model inputs

2.2.2 **Initial data can be critical.** In some models small changes in initial conditions can quickly magnify into major changes in model results – the sensitivity to any initial data (or assumed ranges for that data) depends critically on this level of 'chaos' within the model together with the modelling time horizon.

2.2.3 **Assumptions are also critical.** Important considerations include:

- the presence of any bias in the assumptions, how it might be detected, and whether that is appropriate for the current purpose
- in particular, optimism bias may develop as assumptions are adjusted to support existing prejudices or the preferred prior views of decision makers
- implicit assumptions in the model methodology
- the applicability of any standard assumptions, and the time since they were last reviewed
- determining appropriate key variables and ranges for comparing different scenarios
- the feasibility and appropriateness of repeated model simulations with assumptions varying according to some probabilistic assumption (a stochastic model)

2.2.4 **There is likely to be a need for judgment** in configuring a model. For example, a model requiring assumptions about the average rate and age at which women give birth might require judgements concerning future cultural changes and medical developments.

2.2.5 **It is easy to arrive at 'wrong' assumptions.** For example, by how much should it be assumed that increases in earnings will exceed inflation? Historical differences over the10 years to 2009 might suggest 1% but over 20 years might suggest 2%. However, more recently inflation has actually exceeded earnings. Empirical evidence is by no means clear and any attempt to use a theoretical model requires assumptions such as those about the rise of India/China. It is important to be very careful with assumptions like this and to show scenarios.

"There is likely to be a need for judgement in configuring a model"

2.2.6 **Behavioural impacts can have a strong effect** which should be modelled. When a change is introduced at least a proportion of individuals will almost inevitably act to improve their position; however, the size of this change may not be easy to estimate in advance.

2.4.7 **Inconsistencies between various elements of the model could invalidate outputs**, and may be compounded over time (for example, different measures of price inflation). It is important to consider the suitability of the set of assumptions overall as well as individually.

2.2.8 **Care should be taken with extremes**. Full historical information is unlikely to be available for 1 in 200 year events. This should not stop assumptions being made, in good faith, based on what does exist but it means the user should be aware of the real limitations on which the model is based.

2.2.9 **Dependencies in extreme environments may not be the same** as in more normal conditions. For example, in the investment world, although assets such as property and corporate bonds may provide some diversification in 'normal' times, the returns on these assets can become highly correlated in extreme scenarios. Calibrating a model based on an extreme environment may therefore suggest correlations which are not 'usually' appropriate.

Outputs and communication

2.2.10 **Results should be compared** with any previous sets of outputs and external data sources if available. Model users should understand why the model produces the outputs that it does and why these may differ from other models.

2.2.11 **Communication of outputs is important** as this is ultimately what decision makers will rely on to make decisions. Achieving an appropriate level of detail and volume to inform but not overwhelm can be difficult to achieve in practice. The outputs should allow the user to understand:

- what the answer(s) is/are
- the range of answers under different scenarios
- the level of uncertainty in the answer(s)
- any critical points within that range (such as maxima/minima or tipping points)
- any limitations to the modelling

2.3 Model developers

Those individuals responsible for building or updating a model. These can often be the same individuals as the model users.

Specification

2.3.1 The specification of a model should (already) be well defined and developers should ensure it is clear and well documented. This may be particularly relevant if a model has been adapted from its original purpose, or combined with another new or existing model.

2.3.2 Additional assumptions often come to light over time, in the process of implementing a model, as parties become more familiar with the subject under consideration. An effort should be made to identify them early and in any event to adjust the specification to document these.

Design

2.3.3 Time spent considering how to best design a model is usually well spent. A good design can speed up calculations, reduce the risk of mistakes and make the model easier to understand aiding those checking the model and any future users and developers. Considerations should include what appropriate software or code is the most appropriate to use, how the data will flow through the model and hence what is the most appropriate layout.

Verification

2.3.4 Developers will often be responsible for the verification of the model, ensuring that it meets the stated specification. It is often difficult for the original model developer to be sufficiently critical of their own work to successfully check it themselves and therefore model testing should usually be carried out by another analyst.

Documentation

2.3.5 Good documentation allows others to understand the model even when the original developer has left. It also allow the model to be more easily checked if it is clear what and why the model is built as it is. As well as the specification, documentation may include a user guide on how to operate the model and technical documentation explaining how the specification is implemented. Documentation may include both separate written documents and comments in the code/spreadsheet. A version control, logging what changes have been made and by whom, will avoid old models being used by mistake and will allow others to know what changes have been incorporated.

2.4 Providers of model assurance

Those who provide peer reviews or model audits as part of a quality assurance process. Below we highlight those issues which are particularly relevant to those carrying out such reviews but considerations elsewhere in the document will also apply.

Clarity and scope

2.4.1 **There should be clarity** regarding what it is required to give assurance on, to whom and for what purpose. It is easier to provide assurance on a set of outputs where the use of the model is clear than on the accuracy of a complex model in all circumstances.

2.4.2 **Significant gaps in the model specification make it more difficult** to give assurance. The bigger the gaps, the greater the qualifications needed. Over-complexity also has dangers though, so any gaps and their materiality should be reviewed in order to understand the balance being struck.

2.4.3 **If discretions are built into the matter being modelled it is easier** to give assurance, for example, if there is a model of benefit costs which would normally increase with inflation but with an automatic provision not to increase in times of deficits, a stronger assurance can be provided over longer term viability than might otherwise be the case. Even so, any assurance must take into account the inherent uncertainty of any projections.

2.4.4 **Care is needed when models are used for a different purpose** to that originally intended. Implicit assumptions that may have been originally made should be reviewed to ensure that they are still valid. In addition, care should be taken to avoid complacency when using existing models with new data or assumptions.

2.4.6 **Consider what actions have been taken to reduce model errors** and what other reviews have taken place. It may not be possible given the scope of the assurance to cover all areas of the model development (such as a full review of a model's code) but any gaps should be highlighted.

2.4.7 **Thought should be given to actual or perceived conflicts of interest.** There can often be internal pressures to support the stated aims of the senior personnel. Any reviewer or provider of assurance should ideally be free from actual and perceived conflicts that can otherwise arise by being sufficiently independent. Exceptions reduce the (perceived) credibility of any assurance offered.

Validation

2.4.8 Optimism bias may be present, and can apply to the style of presentation of results as well as the assumptions and data input. The source of ownership of assumptions should be clear, empirical evidence should be valid and appropriate, and decision makers should be aware of any modelling approximations.

2.4.9 A range of outputs should be seen which show the sensitivity to changes in individual variables as well as to alternative scenarios where several variables are changed simultaneously. Without these it may not be possible to gain a proper understanding of the issues and consideration should be given to how these outputs are presented to decision makers. Extreme scenarios merit additional care, since they tend to have the largest effects and have the least data to support judgements.

2.4.10 Caution should be used if outputs are expressed in terms of just differences or changes from an implied base or status quo. Outputs of just differences are often confusing and more liable to error and misunderstandings. Ensure that the absolutes (i.e. the base and the changed figures) are both also shown.

"Extreme scenarios merit additional care, since they tend to have the largest effects"

The remainder of this note is about some of the specific issues and risks that affect long-term financial modelling.[1]

Actuaries are specialists in modelling over longer time periods where correspondingly long-term relationships between different variables become significant. This area therefore forms a major part of GAD's experience and expertise.

Economic and investment models

3.1 The results of economic models are typically highly dependent on the assumptions used, and are often used to guide investment policy or decisions. Risks concerning appropriate assumption setting and detecting bias are therefore especially relevant. Similarly, the behaviour of dependencies between variables in extreme scenarios may require careful consideration (e.g. between equities and bonds).

Very long term models

3.2 Small changes in the model configuration can lead to major changes in long-term results. For example, a 0.5% lower investment return each year can knock over 20% off the expected value after 50 years. Initial data, or assumed ranges for that data, are therefore especially important for long-term projections and this highlights the need to appreciate the uncertainty in the model results. Expert judgement may therefore be required to choose appropriate assumptions which combine current financial or market conditions in the short term with long-term expectations.

3.3 In long-term government projections there will invariably be policy changes over the period and it is not possible to fully allow for these. Conversely, some policy issues such as benefits are notoriously difficult to change in terms of accrued rights and small changes now may take many years before being noticed.

3.4 The real benefit of long-term projections is therefore to assist current decision makers by showing the impact of proposed changes on the direction of travel and the effects in the long term of making changes now. The long-term results are only reliable to the extent that continual adjustment is possible in order to maintain the desired direction.

Policy models

3.5 Behavioural changes are especially relevant for policy models and can have a significant effect, for example, most individuals will act to reduce their tax burden.

3.6 It is important to consider the results on distinct groups in isolation who may hit the headlines. The popular 80/20 rule of thumb (also referred to as the Pareto principle) suggests that 80% of the opposition may come from just 20% of the population.

3.7 Big bang changes in particular have the opportunity to cause headlines due to the creation of distinct winners/losers, whereas relative losers may be less identifiable in a gradual transition.

3.8 Models need to be run over a sufficiently long period to allow for any generational impacts which may not be evident initially (for example, retirements of the baby boomers). Such effects may require more than one generational shift (of 25-30 years) to materialise.

[1] The long term might be considered as 15 years and over

Capital adequacy models

3.9 Capital adequacy models are used as an approach to assessing the minimum level of capital required by an institution to protect against rare events with particular relevance in the regulation of banks and insurance companies.

3.10 The rare events are often expressed as 1 in 200 year events. As there is not adequate data to know what an event like this really is, care is needed in terms of explaining to users and management what is really being delivered.

3.11 Recipient boards, investors and other users may have little or no understanding of these very complex models. This causes the risk that such recipients treat the results as absolutely correct and do not understand the limitations.

3.12 Solvency II, the proposed regulatory approach to insurance companies, incorporates several features to ensure good practice and which other models should aspire to. These include standards relating to:

> model governance

> statistical quality of data and assumptions

> calibration

> validation

> Documentation

> Comparison of actual outcomes over time with model outputs and assumptions

Appendix A
modelling tools and techniques

Some tools and techniques which may aid the use of models in decision making.

Assumptions log - A document which clearly sets out the assumptions adopted in the model and the impact of these.

Backtesting - Comparing the results of the models to historical experience.

Delphi method - Use of a structured approach to combine expert opinions in assumptions setting.

Formula maps - A way of identifying unique or inconsistent formulae within Excel spreadsheets.

Monte Carlo analysis - Attaching probability distributions to parameters and then using (pseudo)random numbers to analyse the probability of different outcomes occurring.

Numeric testing - Tests which concentrate on the resulting numbers rather than logical flow of the model. These can range from simple checks that subtotals sum correctly to reproducing the results in an independent model.

Peer review - Evaluation of the modelling work by an independent reviewer who may be either internal or external to the organisation.

Relationship/bubble diagram - An approach to show the logical flow of the model to help design and document the model.

Reverse stress testing - What are the inputs (assumptions or initial data) needed to cause failure?

Scenario analysis - What are the outcomes under other alternative plausible scenarios?

Sensitivity testing - What impact does each of the assumptions in the model have?

Specification - A document which specifies, ideally in a complete sense, the behaviour of the model.

Stress testing - What is the consequence (in terms of success or failure) of applying certain extreme assumptions?

Unique formulae list - Listing all the unique formulae within an Excel model to check that these are correct.

Usability testing - Checking that the model is useable by someone who is unfamiliar with it.

Validation - Checking that the model is fit for purpose including the appropriateness of the chosen methodology.

Verification - Checking that the calculations in the model are correct and that the model complies with its specification.

Some tools and techniques which may be used in more general risk analysis.

Bayesian networks* – An approach to identify distributions of risk outcomes by considering conditional probabilities and often using a diagrammatical approach.

Cognitive mapping* – An organised set of ideas to help guide thoughts, identify uncertain areas and make clear any assumptions taken for granted in the mental process.

Concept mapping* – Considers links between cause and effect through a single-page diagram of boxes and arrows to assist focus on where to manage/control.

Deep dive – The selection of key issues to discuss, and thoroughly challenge, at a risk committee.

Evolution/cladistics* – Use of DNA/biometric techniques along with information theory to identify which risks to monitor and assign linkages to.

Enterprise risk management (ERM) – A framework for risk management which looks at the activities of an organisation holistically.

Heat maps – One or two-dimensional charts (likelihood or impact v likelihood) to assist prioritisation and action.

Horizon scanning – Systematic mechanism to become aware of potential known and unknown unknowns which may start to create risks or hidden pressures.

'Lessons learned' – To ensure that potential failure events are fed back into risk analysis to ensure better future management and control.

Pattern recognition – Systematic tracking of events to pinpoint emerging risks using pattern recognition techniques (including fuzzy pattern identification).

Risk dashboard – A way to clearly communicate key risks and enable important information to be quickly discerned.

Risk optimisation models – To help decide which risks deliver acceptable value and which do not.

Value at Risk (VAR) – A common technique in financial entities to look at losses at the unlikely end of the spectrum.

*All of these may help with the proper development of risk dashboards – what should be shown and what combinations cause danger, relative to a tipping position.

Appendix C
15 tips when using spreadsheets

Spreadsheets are not always the most appropriate software for all modelling tasks; however, their flexibility, availability and ease of use make them extremely popular. Below we highlight some tips which should help reduce the risk of errors in spreadsheet models and make them easier to use, update and check.

1. Include a documentation sheet including the version number, name of developer and date of development. You may also wish to include further information such as a description of the model, assumptions and instructions, an explanation of the model layout or a list of changes made to the model.
2. Keep the layout clear. Structure your spreadsheet calculations from top left to bottom right to make it easier to follow and read. Try to use each column for the same purpose throughout the model eg always use column X for Jan 2013.
3. Clearly separate data, assumptions, calculations and results. Consider using separate worksheets for each of these, especially for complex models.
4. Avoid hard coding numbers, such as inflation rates, into formulae. Parameters should be recorded in separate cells and formulae should be linked to them.
5. Clearly document the spreadsheet. Cells and sheets should have meaningful headings and consideration should be given to writing formulae in words (either at the head of a column or row, or on a separate sheet) to help with checking the spreadsheet.
6. Keep formulae consistent down a column or across a row. Where formulae vary down a column or across a row clearly document this, both at the column or row heading and at the point of change.
7. Keep formulae as short and efficient as possible. Consider splitting longer formulae (and nested functions) over a number of columns – this aids checking and is less likely to lead to errors.
8. Where certain calculated items are used regularly in the calculations it is best practice to calculate them once in the workbook and then call upon them elsewhere. This is less memory intensive, simplifies formulae and means that any changes need only be made once.
9. Consider using named ranges, especially for key assumptions or parameters. These can help make formulae easier to read and understand.
10. Circular references should be avoided as these are difficult to check and are prone to errors.
11. Checks are a vital part of spreadsheet development – consideration should be given to devoting sufficient space within the workbook to documenting various checks (such as sums, minimum and maximum functions), including cross-checks within the spreadsheet.
12. Format cells appropriately (eg with the appropriate number of decimal places) and clearly identify the units (eg whether they are thousands or millions). Colour can be used to aid clarity about cell contents or to highlight particular tabs.
13. External links should be used with caution and only where necessary, particularly in workbooks that are likely to evolve over time or where the linked files are prone to significant updates.
14. Macros should be written in a way that is easy to follow, with clear documentation within the code. They should only be used where it is believed they will add value to the workbook.
15. Include the filename and the date on printed versions of spreadsheets – this can be included as default within the headers/footers of a standard template.

ABOUT GAD

GAD provides actuarial analysis to the public sector from the public sector. As a 'shared service' supplier to the UK government and the devolved administrations, our aim is to deliver top notch service, actuarial analysis and policy advice.

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