



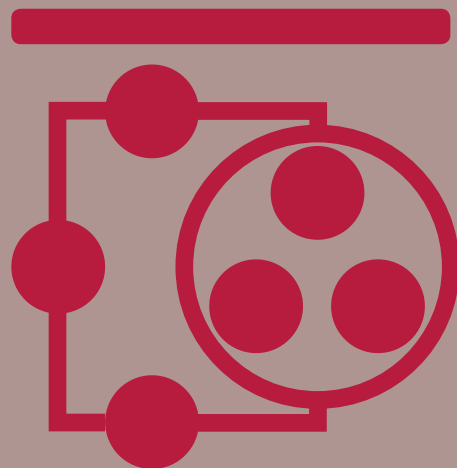
National Audit Office

National Audit Office

Framework to review models



Interactive





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Introduction

Government Departments and Agencies routinely develop and use models to generate insight into business problems and business decisions. These models can vary in complexity from relatively simple spreadsheets, to detailed forecasts using specialist software. The outputs of these models and associated decisions can involve large amounts of money and resources.

Our report on forecasting in government to achieve value for money, identified weaknesses associated with forecasting in 71 NAO reports reviewed between 2010 and 2013. These weaknesses included:

- limited or poor quality data;
- unrealistic assumptions and optimism bias;
- a lack of forecasting or modelling; and
- inadequate sensitivity and scenario analysis.

This framework provides a structured approach to review models, which organisations can use to determine whether the modelling outputs they produce, are reasonable.

Evidence base

The framework to review models builds on the evidence and guidance available from:

- HM Treasury's 'review of quality assurance of government analytical models' (2013);
- HM Treasury's 'Aqua Book' (2015);
- The Department for Energy and Climate Change (DECC) 'Quality Assurance: Guidance for Models' (2014); and
- International Standard on Auditing 540 'auditing accounting estimates, including fair value accounting estimates, and related disclosures'.



And our experience of reviewing government models, for example:

- The Work Programme – review of a spreadsheet model projecting cost of welfare to work programme over lifetime of the contract.
- Long term public finance report projections – review of a non-transferable, internal, specialist actuarial model projecting public sector pensions over the next 50 years.
- Training new teachers – review of the published Teacher Supply Model, which estimates how many initial teacher training places are needed each year.

How to use the framework

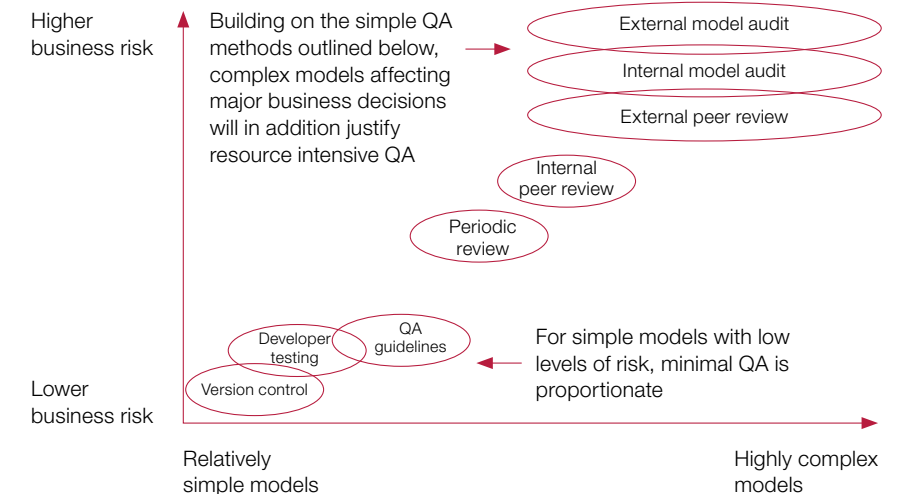
This framework is aimed at people who commission analysis, provide analytical assurance and deliver the analysis itself.

It is not intended to be a checklist, instead it is a flexible approach which can be tailored, based on:

- the amount of time and resource available;
- the complexity and risk associated with the model; and
- the level of assurance needed to reach an overall judgement.

This concept is in line with HM Treasury's 'review of quality assurance of government analytical models' (see diagram).

Schematic showing indicative types of quality assurance that might be expected given different levels of risk¹

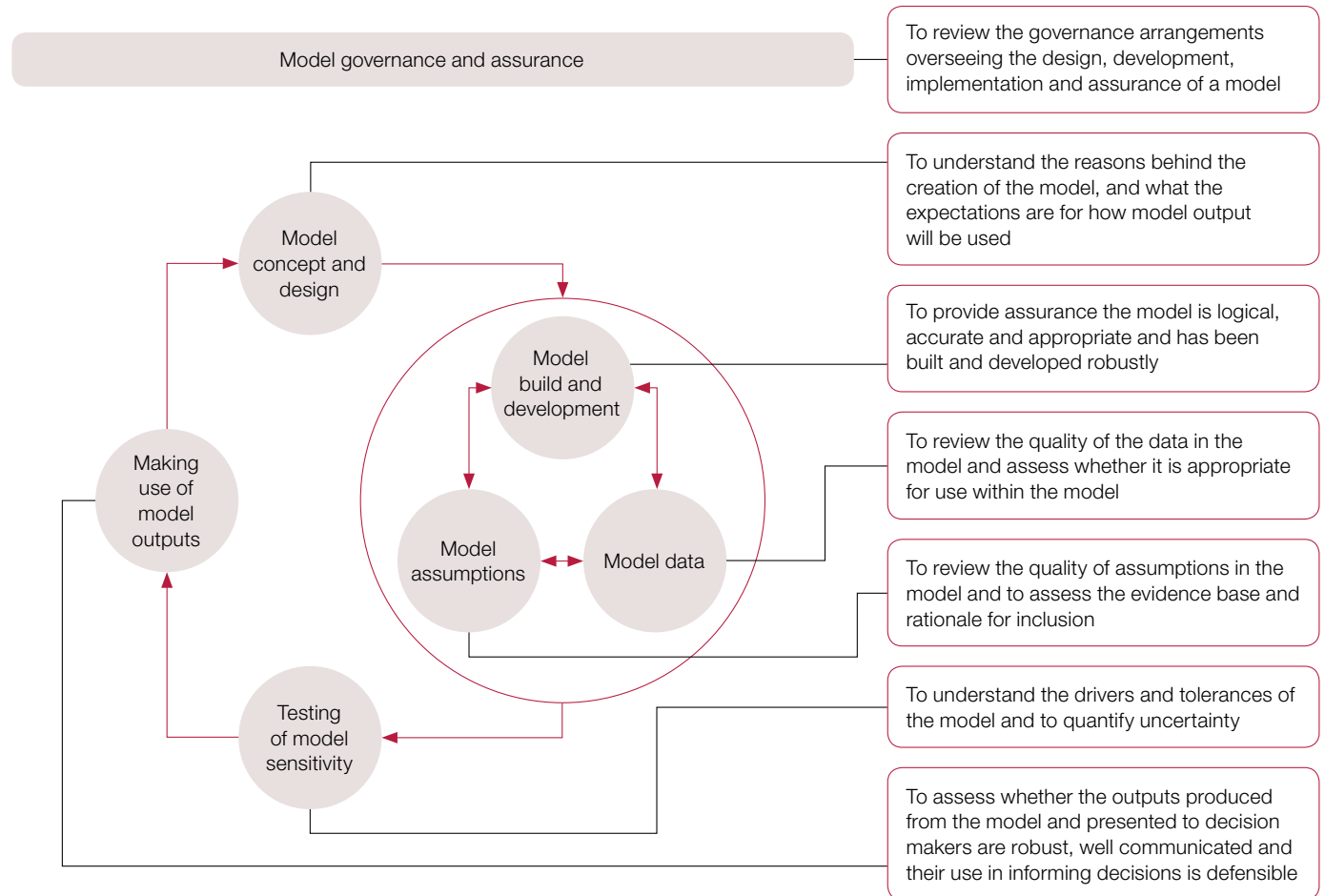


¹ Chart 2.C, page 22, Review of quality assurance of Government analytical models: final report, HM Treasury (2013).



The framework is split into seven stages starting with the model concept and design, ending with making use of model outputs and all overseen by a governance and assurance structure² (see diagram).

Areas to consider when reviewing models



² The questions in the framework are not exhaustive, meaning there will be other checks that can be applied.

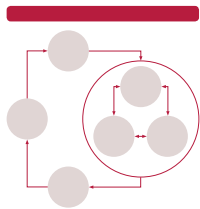


Deciding on whether a model is robust and used appropriately to support business decisions requires a proportionate, evidence-based judgement. It will often be the case that a review will identify issues and weaknesses in some aspect of how the model was designed, built and used. Crucially, the objective of a model review is to identify, in your opinion, whether those issues had an impact on the quality of the model. And whether there is a risk it could materially impact on the outputs, how they are interpreted and used in decision making and risk management processes.

How the NAO can help

If you have any queries about this framework or suggestions for how it can be improved, please use the [contact form](#) and select Value for Money methodology.

The model



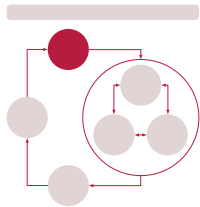
Model Governance and Assurance

To review the governance arrangements overseeing the design, development, implementation and assurance of a model.

Questions to consider	Examples of checks to make or evidence to look for
Who is the single Senior Responsible Owner (SRO) for the model?	Documentation of roles and responsibilities throughout the model development and use process.
Is the model 'business critical'?	<p>Define what makes a model 'business critical'. Test this definition with definitions from other organisations.</p> <p>Evidence the Accounting Officer's governance statement (typically within the annual report) includes an appropriate quality assurance framework for business critical models.</p> <p>Evidence the Accounting Officer maintains an up to date list of business critical models and that this is publicly available.</p>

Questions to consider	Examples of checks to make or evidence to look for
Does the model have good documentation on governance and assurance?	<p>Are roles and responsibilities (i.e. commissioner, lead analyst, lead analytical assurer) documented?</p> <p>What processes are in place for succession planning/handover, i.e. when a key person leaves the modelling project?</p> <p>Has the model been developed in collaboration with customers and/or stakeholders? For example:</p> <ul style="list-style-type: none"> Are requirements captured and documented into a specification? Are assumptions listed and agreed? <p>Is there an agreed quality assurance plan throughout the model development process?</p> <p>Is there evidence the customer of a model has influenced it to meet expectations?</p>
How are model outputs challenged and used?	<p>Is there a forum available for people outside the model development process to challenge the development and use of model outputs?</p> <p>How do model customers develop an understanding of the caveats of the model?</p> <p>Are model limitations and caveats reported alongside the main outputs of the model?</p>

Introduction 	The model 	Contact 
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Model concept and design

To understand the reasons behind the creation of the model, and what the expectations are for how model output will be used.

Questions to consider

Examples of checks to make or evidence to look for

What is the decision the model is designed to support?

Identify who the stakeholders of the decision are.
 Consideration given to alternative solutions to support the decision.
 Was the model designed specifically to support this decision, or is an existing model being re-used? [If so, is this appropriate?]

Is there evidence of the rationale and the scoping of the model concept?

Documentation detailing the rationale, concept and structure of the model, such as:

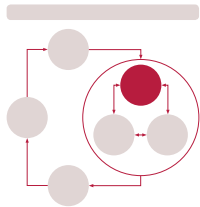
- what the model aims to replicate;
- the input, output and model logic;
- the model type (including options for alternative approaches which have been rejected);
- the stakeholders responsible for policy and delivery;
- the required precision (offset against complexity); and
- identification of the limitations of the model.

Questions to consider

Examples of checks to make or evidence to look for

Is there a technical guide that demonstrates the logical flow of the model?

Compare the data flow, logic and structure in the model with the description in the technical guide.
 Are you able to understand the model?

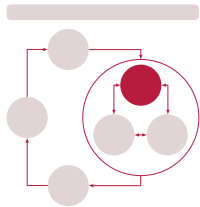


Model build and development

To provide assurance the model is logical, accurate and appropriate and has been built and developed robustly.

Questions to consider	Examples of checks to make or evidence to look for
Has the model been published?	If the model has not been published, identify the rationale for why not.
Do you understand the model?	Are you able to draw a simple picture representing the model or can you describe it in lay terms? Are inputs, calculations and outputs separate?
Does the model respond logically to basic changes being made to the model inputs?	Review how changing basic model inputs impact the model outputs, for example by: <ul style="list-style-type: none"> ● simplifying settings to the most basic scenario; ● examining the initial (starting) conditions for the model; ● sensitivity analysis with realistic input variations; and ● sensitivity analysis with extreme or implausible inputs variations.

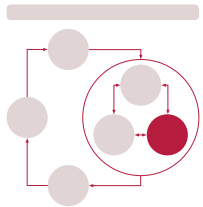
Questions to consider	Examples of checks to make or evidence to look for
How accurate is the detail of the model?	Take sample checks to assess whether the model is doing what it should, for example by re-performing calculations on sections of the model. Consistency of accuracy and aggregation of the data. For Excel based models identify areas that might expose weaknesses in the model, such as: <ul style="list-style-type: none"> ● circular reference warnings; ● hard coding of values; ● linking of data from other files; and ● complexity of formulae. For syntax based models, review whether comments or notes explain what the element of the model is doing and whether it is understandable to someone unfamiliar with the model.



Model build and development *continued*

To provide assurance the model is logical, accurate and appropriate and has been built and developed robustly.

Questions to consider	Examples of checks to make or evidence to look for
How accurately does the model perform against historical data?	<p>Review (or perform) checks assessing how the model predicts known history, both on data available during development and since implementation.</p> <p>For older models, use back casting to determine its 'forecasting' record.</p>
Has the model been subject to external review during or after development?	<p>Identify who has reviewed the model, and why.</p> <p>Review documentation produced by bodies reviewing the model. This is not limited to the building of the model and could cover any of the areas outlined in this framework.</p> <p>Identify whether there is an external assurance statement.</p>
What documentation and processes are in place to ensure a corporate memory for the model exists?	<p>Review how changes to the model, for example, detail of change, rationale and impact, are recorded.</p> <p>Review the adequacy of any model documentation (technical and non-technical) provided for new users, for details of what the model does and how to operate it.</p>



Model data

To review the quality of the data in the model and assess whether it is appropriate for use within the model.

Questions to consider

Examples of checks to make or evidence to look for

Is the data in the model of good quality?

Review the quality of data and sources, such as the extent to which data:

- are up-to-date;
- source is documented;
- is based on a robust sample;
- is consistent with other sources; and
- meets the requirements it is being used for.

Check data (as much as is practically feasible) in the model to the source data for accuracy.

Does model documentation outline the limitations of the data?

Where good quality data is lacking, what steps have been taken to work around this, for example making use of experts to provide estimates.

Is the data the model using, coming from other models?

Review whether separate models also need to be part of the scope of the model review.

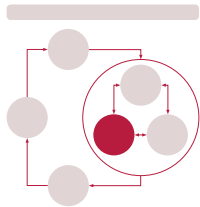
Questions to consider

Examples of checks to make or evidence to look for

What processes does the model use to handle input data?

Review how input data is included in the model, this could include considerations such as how data is cleaned or transformed from the original source, and how easily this is repeated when the model is refreshed.

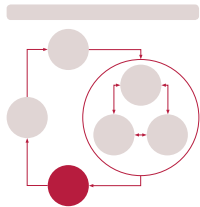
Check that data is applied consistently throughout the model.



Model assumptions

To review the quality of assumptions in the model and to assess the evidence base and rationale for inclusion.

Questions to consider	Examples of checks to make or evidence to look for	Questions to consider	Examples of checks to make or evidence to look for
<p>Are the details of assumptions recorded and justified?</p>	<p>Identify and review list of assumptions, for example:</p> <ul style="list-style-type: none"> ● Suitability of selection based on the purpose of the model. ● Underlying evidence – source and quality. ● Level of simplification/complexity. ● Rationale for level of accuracy and aggregation. ● Distinction between data and structural assumptions. <p>What are the main assumptions in the model?</p>	<p>Have the status of the assumptions been critically compared to third party sources, or benchmarked against industry norms?</p>	<p>Check to similar models. Check to published standard assumptions.</p>
<p>What process is used to change/update assumptions?</p>	<p>Review the process for managing how assumptions are changed within the model.</p> <p>Review whether assumptions should have been updated in light of any changes to circumstances.</p>		



Testing of model sensitivity

To understand the drivers and tolerances of the model and to quantify uncertainty.

Questions to consider

Examples of checks to make or evidence to look for

What are the uncertainties of the model?

Review whether uncertainty has been quantified in the model (i.e. are high and low estimates provided alongside a point estimate?).

Review whether the model estimates the level of confidence in the output.

In the context of materiality, consider developing:

- a list of modelling uncertainties;
- a list of input data, evidence and intelligence used in the analysis and consider each type of uncertainty that could affect it; and
- a diagram representing key parts of the model with consideration for what additional factors might act at that point and affect the analysis outcome.

Has sensitivity analysis been performed to calculate ranges or the likelihood of outcomes occurring?

Review whether levels used in sensitivity analysis are realistic and conservative based on the source data.

Review or perform analysis such as Monte Carlo simulation or scenario analysis.

Questions to consider

Examples of checks to make or evidence to look for

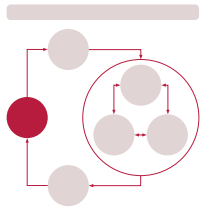
Do changes in the inputs/assumptions have a material or significant impact on outputs?

Review or perform additional runs of the model to test sensitivities on outputs when the assumptions are changed.

Review or perform additional runs of the model to test sensitivities on outputs when inputs are changed.

Have issues over poor quality data and assumptions and other identified risks been addressed?

Test for the impact of weak information in the model.



Making use of the output

To assess whether forecasts receive sufficient challenge, are integrated in to decision making and risk management systems and are compared with actual outcomes in order to inform future development.

Questions to consider

Examples of checks to make or evidence to look for

Are you able to validate model outputs?

Review appropriateness of model output by comparing to:

- previous runs of the model;
- other models such as parallel systems; and
- independent sources.

What is the process for the routine review of outputs?

Review process for circulating outputs internally and externally, checks could involve different roles, for example:

- Technical staff not directly involved with the model.
- Senior staff responsible for the model.
- External expertise.

Are the limitations and uncertainty of the model output communicated to decision makers?

Review how model outputs are presented to decision makers, for example how findings are presented in a business case.

Questions to consider

Examples of checks to make or evidence to look for

Are decisions based on the model output proportionate to the robustness of the model?

Review whether decisions are appropriate and proportionate to the robustness of the model, for example considering monetary impact of decision given constraints of the model.

Are the outputs from the model responsive to the ongoing needs of the organisation?

Review whether the model is being used to track on-going performance as a monitoring tool.

Is the output from the model adjusted outside of the model?

Review whether any additional procedures or adjustments that are made to the model output are justified and how they impact on the robustness of decisions made.

Does the model output meet the requirements and aims of the model as outlined in the model concept?

Compare the actual outputs of the model with the aims of the concept model.

Are forecasts compared with actual outputs in order to validate the results and inform future development?

Compare the actual outputs with reality to check accuracy and check if this is used to update future iterations.

Introduction



The model



Contact



Contact

How the NAO can help

If you have any queries about this framework or suggestions for how it can be improved, please use the [contact form](#) and select Value for Money methodology.

The National Audit Office scrutinises public spending for Parliament and is independent of government. The Comptroller and Auditor General (C&AG), Sir Amyas Morse KCB, is an Officer of the House of Commons and leads the NAO, which employs some 810 people. The C&AG certifies the accounts of all government departments and many other public sector bodies. He has statutory authority to examine and report to Parliament on whether departments and the bodies they fund have used their resources efficiently, effectively, and with economy. Our studies evaluate the value for money of public spending, nationally and locally. Our recommendations and reports on good practice help government improve public services, and our work led to audited savings of £1.15 billion in 2014.

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