INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2017

Subject CA2 – Model Documentation, Analysis and Reporting

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

Possible models with an audit trail or summary are posted on the website. It should be noted that these include more detail than would ordinarily be possible within the time allowed for the examination.

The specimen solutions are based on one possible approach to modelling the assignment set but the examiners gave credit for any alternative approach or interpretation which they considered to be reasonable.

Luke Hatter
Chair of the Board of Examiners
July 2017

A. General comments on the *aims of this subject and how it is marked*

1. The aim of this subject is to ensure that the successful candidate can model data, document the work (including maintaining an audit trail for a fellow student and senior actuary), analyse the methods used and outputs generated and communicate to a senior actuary the approach, results and conclusions.

2. The subject is split into two papers, the first covers the objectives:

   - analysis of data.
   - development of a model with clear documentation.

   The second paper covers:

   - ability to analyse the methods used and the model's outputs.
   - ability to apply and interpret the results.
   - communication of the approach, results and conclusions to a senior actuary.

3. As the focus of the subject is on communication the majority of the marks are for the documentation and outputs generated rather than for technical modelling skills. For example, a technical mistake only loses marks once and students can still earn marks for accurate and clear communication of what was done.

4. Candidates who give well-reasoned points, not in the marking schedule, are awarded marks for doing so.

B. Comments on *student performance in this diet of the examination*

PAPER ONE

Modelling

In this section the candidates could gain 30 marks by using the data provided and carrying out the required modelling steps. To ensure the accuracy of the results, as with any data supplied, the candidates are expected to perform an analysis of the data. This analysis should include some checks, which would have confirmed that the data supplied is reasonable and free of obvious errors. Most candidates did not include reasonableness checks in their audit trail and lost marks.

Most candidates made a good attempt at the first part of the model and projected the relevant items for both course A and course B. The most common errors here, among candidates who had problems, was not stopping repayments when the loan was paid off or not allowing for a lower balancing payment in the final year. Most candidates also made a reasonable attempt at calculating the present value of net income, however some candidates misinterpreted cumulative discounted net income (CDI), often attempting to calculate a net present value of income at the start of the course instead.

The stronger candidates went on to correctly calculate the cumulative discounted value of repayments (CDR) under the current and alternative scenarios and the strongest could correctly interpret the requirements for goal seeking the required percentage of salary to equate the CDR of the alternative method with the CDR of the original method. A common error here was to equate the CDI of the two methods instead.

Most candidates set up a reasonable graph for the CDI.

Only the stronger candidates could set up the correct CDR on all three scenarios, mainly because only the strongest had performed all the required calculations.

There was quite a wide interpretation of timings of income and repayments, both regarding timing within each year and using an incorrect number of years in the projection, particularly not stopping the repayments at age 40 for the alternative method. For most errors regarding timing the loss of marks was minimal as long as the general method was reasonable. Candidates are reminded that it is important to make sure that the audit trail assumptions stated agree with their modelling approach.

The presence of clear auto checks in the model was weak in this sitting. Candidates should be aware that to gain full marks for auto checks in the model they needed to have an automatic formula indicating "OK" or similar and ideally a description of what is being checked and why, rather than just a calculation.

Candidates need to be aware of the importance of the relevant reasonable tests in ensuring that the results make sense and the model is robust in producing reasonable results.

Most candidates demonstrated reasonable modelling techniques and gained most of the available marks in this area.

Audit trail

Most candidates offered a well-structured audit trail with sections following the order in which the modelling stages were carried out. The audit trails mostly started with an overview of the model, describing the data available and the assumptions relating to the calculations in the model.

Some audit trails lacked sufficient detail in the methodology section, for example just stating what was carried out and not how. There were some very good audit trails describing the method and also the reason for carrying out the various steps.

To score well in the method part, candidates need to describe the modelling steps as well as signpost where in the worksheet the calculation has been carried out. Signposting may be provided by reference to the worksheet, tables or row and columns of the worksheet. Almost all candidates provided some description of the method and signposted the calculations by reference to the relevant worksheet. However the candidates who provided a detailed description of the methodology with sufficient technical detail and adequate signposting scored the highest marks in this section.

There was a maximum of eight marks available for discussing the reasonableness of the results obtained and the graphs constructed. Many candidates failed to gain any of these marks. Descriptions of the differences in the pattern of results between courses, the changes between scenarios and explanations of why these are reasonable were provided by strong candidates.

PAPER TWO

Modelling

In this section 15 marks were available for accurate completion of the additional modelling and production of the required charts. The majority of the candidates carried out the required modelling and produced the relevant charts well. Some candidates misinterpreted the format of the required contributions for Mr Potter to target the GMA at retirement, usually by calculating a fixed defined contribution fund to be held throughout the rest of his working life, rather than an annual contribution. They often then stated it was an annual contribution in their Summary report.

The chart projecting 2016 and 2018, high and low projected pensions compared to the GMA was completed well by fair to stronger candidates with common errors among weaker candidates being to split the graph into three or four separate ones which made drawing reasonable comparisons harder, or not including the GMA levels.

Some candidates missed out the graph of pension value versus service. This highlights the need to properly read the question for all required steps.

Nearly all candidates could graph Mr Potters projected pension versus GMA on both the original and target GMA scenarios clearly.

Summary

The structure of the summary was generally completed to a high standard. The vast majority of the candidates offered a summary that followed the same order of the items that they had been requested to include in the summary.

Most candidates did well in producing a list of assumptions although it is important to add extra assumptions which were not included in the audit trail to gain full marks for this section.

The majority of candidates produced most of the required charts but some did not state all of the possible numerical results, particularly Mr Potter's projected pension fund at retirement.

Stronger candidates were able to provide a balanced method at a level of detail suitable for a senior actuary. Weaker candidates gave very brief methods with no accurate formulae or descriptions or alternatively provided too much detail with excel references and signposting which is not necessary, nor is it appropriate for the audience of the document.

The description of the modelling approach in the summary needs to be of a different style and depth to that needed in the audit trail as the two documents serve different purposes. While selective use of parts of the audit trail (such as formulae) is acceptable, large scale reproduction of the method from the audit trail in the summary is inappropriate in general.

A minority of the candidates reproduced sections of the audit trail in the overview and methodology part of the summary. For this sitting this did not lose marks, providing the resulting summary method was of an appropriate style and content, because the candidates were not explicitly instructed not to copy the examination question audit trail. Where inappropriate elements were included (such as excel references) this has been reflected in the marking.

In future sittings a clear warning will be made not to reproduce large sections from the Examination Question (including the audit trail) and that no credit will be awarded for doing so.

Having produced the results, candidates are expected to comment on the results and explore interactions within individual scenarios and the comparison between the results of the scenarios. Often inadequate commentary on the results is due to shortage of time. Candidates are advised to allow sufficient time to analyse the results, comment on the observed pattern and then try and explain what this pattern shows or why it has occurred. Such commentary indicates the extent to which the purpose of the model and the results it has produced, have been understood.

Often candidates did not include overall conclusions or repeated their comments on the results. Weaker candidates lacked commentary on the results. Candidates who passed tended to offer some explanation of the results and provided some overall conclusions.

In the next steps section of the summary, candidates are required to include their recommendation on the next steps to take on the basis of their model and how it works, the results and the analysis of the results. The next steps, therefore, need to be relevant and specific to the particular model and include specific descriptions linking them to the particular model and an explanation of what they would achieve. Most candidates were able to produce a list of next steps, but only the strongest gained the full marks available for each step by providing adequate explanation. Generic or irrelevant lists of next steps, sometimes reproduced from previous exams, did not gain many marks as they are adding very little, if any, relevant information.

C.   Pass Mark

The Pass Mark for this exam was 60.

PAPER 1 (Simulation of Investment Product)

Marking Guide

Q2   (i) – (viii)

Calculations performed

Student loan repayment schedule:

Correct calculation of student's expected salary for next 40 years based on course A attendance	[2]
Correct calculation of the increase in loan while the student is undertaking course A	[1]
Correct calculation of the loan repayments due under course A's schedule	[2]
Correct calculation of the interest on the outstanding loan under course A's schedule	[1]
Correct calculation of the loan outstanding at the end of each year	[1]
Correct calculation of the student's expected salary for course B	[1]
Correct calculation of the increase in loan while the student is undertaking course B	[1]
Correct calculation of the remainder of the loan schedule for course B	[2]
Correct calculation of the present value of each year's income net of fees (one mark for net income, one for discounting)	[2]
Correct calculation of the accumulation of discounted net income	[2]
Chart comparing cumulative discounted net income	[3]
Correct calculation of the discounted value of the repayments under the current structure	[1]
Correct calculation of the cumulative discounted value of repayments under the current structure	[1]
Correct calculation of the payments due under the alternative structure	[2]
Correct calculation of the discounted and cumulative discounted value of these payments	[2]
Correct calculation of the percentage salary required to be repaid (2 marks for set up; 1 for goal seek)	[3]
Chart comparing cumulative discounted repayments under the 3 scenarios	[3]

[Maximum 30]

Other marks

Good spreadsheet practice

Use of cell references rather than copy & paste	[1]
Use of parameters rather than hard-coding in formula	[1]
Flagging rows/columns that don't copy down	[1]
Use of simple techniques	[2]
Clear and accurate labelling within the spreadsheet	[2]

[Maximum 7]

Other Checks

Auto checks

Suitable auto check on loan schedule A and/or B	[1]
Suitable auto check on discounted income calculations	[1]
Check on Goal seek	[1]

[Maximum 3]

Reasonableness checks on student loan repayment schedules under current structure

Loan outstanding from course A increases while at university and
decreases once repayments start [1]
Loan outstanding from course B doesn't start decreasing until a few
years after repayments start [1]
Loan from course B takes longer to repay than loan from course A due
to: [1]
- higher fees [1]
- longer course [1]
- not outweighed by higher starting salary, due to structure of
  repayments [1]
Total net income (discounted and undiscounted) is higher for course B –
higher salary outweighs higher fees and longer course [1]
Net income on a year on year basis is higher in B as soon as course is
completed (justify by comparing salaries and repayment amounts) [1]
Graph: lines cross at 30 years, matching comparison of cumulative
discounted net income [1]
Graph: shape while on the courses (flat for B and shallow upward slope
for A) [1]
Any other sensible reasonableness check [1]

[Maximum 5]

Reasonableness checks on student loan repayment schedules under alternative structure

Alterative structure target percentage is higher than 8% as we are
wanting the students to pay back more money that they would under the
alterative structure   [2]

Setting the target percentage to 8% gives rise to the same result as under
the alternative structure   [1]

Graph: The line for the current structure doesn't reach its maximum
level until later than either of the alternative structures as repayments
continue beyond age 40.   [1]

Graph: The line for the goal seeked scenario is steeper than the original
alternative as the percentage is higher   [1]

Graph: All three lines commence at year 5 which is when the students
leave university   [1]

Graph: The lines for the goal seeked scenario and the original scenario
reach the same level.   [1]

Graph: The lines for the percentage salary scenarios are linear whereas
the original scenario is curved   [1]

This is because the payments grow faster than the salary growth (due to
the minimum level of salary before payments start)   [1]

Any other sensible reasonableness check   [1]

[Maximum 5]

[Overall Maximum for Other Checks 8]

[Total 45]

Q3 Audit Approach

Fellow student can review & check the methods used in model

For a newcomer, the audit trail is easy to follow i.e. the marker does not
have to look at the model directly to understand what has been done   [2]

All the steps are correctly and clearly described   [1]

There is sufficient technical detail   [1]

The workbook is well labelled and is easy to navigate through   [2]

Where there are, or could be errors, the audit trail would enable the student
to identify and correct errors   [1]

Danger areas in the spreadsheet are appropriately flagged (e.g. goal seek) [1]

[Maximum 8]

Senior actuary can scrutinise & understand what has been done

A reasonable overview of the model is included   [1]

There are clear statements of the assumptions made, and justification of the
values chosen   [2]

There is sufficient technical detail and does not include excessive use of Excel
formulae to describe steps [1]
Data sources are clearly described [1]
It is easy for a senior actuary to pick up the high level detail of the modelling [1]
Reasonableness checks are clearly stated and their results explained [2]

[Maximum 8]

Written in clear English

The audit trail is written in clear, crisp and flowing English [2]
Accurate spelling [1]
The audit trail is laid out well, with good formatting to aid
clarity [1]

[Maximum 4]

Logical order

Data is introduced before referring to it [1]
Assumptions are stated before using them [1]
The methodology is described in a logical order i.e. nothing is
introduced which would require that the reader has read ahead [1]

[Maximum 3]

Audit Content

All steps CLEARLY explained

The level of detail in the audit trail is appropriate for a newcomer to
understand what has been done [1]
All the methodology steps are set out clearly [2]
Data provided and any necessary adjustments made are described
and justified clearly. [1]
All reasonableness checks applied are adequately documented [1]
Areas where manual intervention or caution is required are well
flagged (e.g. goalseeks or non-standard model areas) [1]
The marker does not need to look directly at the model to understand
what has been performed [1]

[Maximum 7]

Signposting / labelling CLEAR

The audit trail allows the user to follow the model through [1]
The audit trail allows the user to understand each calculation easily [1]
There is adequate signposting in the audit trail to describe the purpose
of each tab [1]
There is adequate signposting in the audit trail to describe the general [1]

direction of the model
Model labelling is consistent with the audit trail (data, parameters,
scenarios, outputs, charts) [1]

[Maximum 5]

Steps CORRECTLY described

Overview [1]
Data used, including source [1]
Calculation of student's salary [1]
Calculation of annual increase in loan [1]
Calculation of loan repayment due [1]
Calculation of the interest on the loan [1]
Calculation of the loan outstanding at the end of each year [1]
Update to loan repayment schedule for course B [2]
Calculation of discounted net income [1]
Accumulation of the discounted net income [1]
Calculation of the discounted repayments under the current structure [1]
Calculation of the repayments under the proposed alternative structure [2]
Calculation of the discounted repayments under the alternative structure [1]
Determining the percentage salary required to meet the specified
conditions [1]
Construction of charts [1]
Any other distinct, valid step… [1]

[Maximum 15]

[Total 55]

PAPER 2 (Analysis and Summary)

Marking Guide

Q3   Techniques – Additional Scenario

Update of member projection (2 for inflation; 1 for investment returns)	[3]
Amendment to Mr Potter's DC contributions for target pension value	[1]
Solving of level DC contributions for target pension value	[1]
Check on goal seek	[1]

[Maximum 6]

Q4   Charts

Construction of chart showing 2016 positions and "high" and "low" projected members' pension value at 31 Dec 2018 versus GMA	[3]
Construction of chart showing 'low' projected members' pension value versus service	[2]
Construction of chart showing Mr Potter's projected benefits versus GMA	[2]
Construction of chart showing Mr Potter's projection reflecting flat level contributions	[2]

[Maximum 9]

Q6   Summary Methodology

Purpose, Data, Approach, Assumptions

Statement of purpose	[1]
Data used	[1]
Source of data	[1]
Data validation / review	[1]
Assumptions – up to 5 marks for a good list of "added value" assumptions	[5]

[Maximum of 1 mark for restating any assumptions from the Audit Trail, 1 mark each for new valid ones]

Calculation of director's projections

Calculation of CARE pension	[2]
Calculation of DC fund	[2]
Value of benefits	[1]
Projection of GMA	[1]

Calculation of Mr Potter's projections

Calculation of CARE pension	[1]
Calculation of DC fund	[1]
Total value compared to the GMA	[1]
Update to director projections	[2]
Explanation of target scenario (target GMA at retirement age)	[2]

[Maximum 20]

Senior actuary can understand what has been done

The level of detail included is appropriate for a senior actuary	[2]
All methodology steps are set out clearly	[2]
The senior actuary would be able to understand the approach taken without having to refer to other documentation	[1]

[Maximum 5]

[Overall Maximum for Summary Methodology 25]

Summary Drafting

Clear & concise drafting to give a senior actuary a good understanding

Clear / concise drafting of the objective, and data summary/description	[1]
Clear / concise drafting of the assumptions and methodology	[1]
Clear / concise drafting of the results and conclusions	[2]
The summary report is written in clear, crisp and flowing English.	[2]
Accurate spelling	[2]
The summary is well laid out, in a reasonable order, with good formatting to aid clarity	[2]

[Maximum 10]

Results

Appropriate chart showing 2016 position and both 2018 positions	[1]
Statement of how many of the members exceed the GMA at 2016	[1]
Statement of how many of the members exceed the GMA at 2018	[1]
Appropriate chart showing pension values versus pensionable service	[1]
Appropriate chart showing Mr Potter's projected benefits over time	[1]
Statement of the value of Mr Potter's projected pension at his retirement	[2]
Statement of level contributions required to meet GMA at retirement	[2]

Appropriate chart showing Mr Potter's projected benefits allowing
for level DC contributions [1]

[Maximum 10]

Conclusions

Observation that updating the assumptions doesn't affect those
who are projected to be over the GMA [2]
Explanation of the impact of amending the assumptions: Reduce
GMA (due to lower inflation than expected) [1]
Explanation of the impact of amending the assumptions: All
members' projected value down but the extent of which depends
more on the size of the DC funds (as investment ret falls more
than inflation) [2]
Observation that longer service leads to higher pension value on
average [1]
Explanation of the relationship between service and pension
value: longer to contribute/accrue, more interest [2]
Explanation of why there are exceptions to the rule: higher
salaries mean accrue value quicker [2]
Observation that Mr Potter is projected to exceed the GMA by his
retirement [1]
Observation that Mr Potter's pension value is expected to exceed
the GMA from 2036 onwards. [1]
Observation that Mr Potter's pension is expected to have a value
of more than $300k over the GMA [1]
Observation that the value of Mr Potter's pension is expected to
increase smoothly of his working lifetime. [1]
Explanation of why the value increases smoothly: salary increases
smoothly, accrual is smooth. But steeper in later years as
proportionate increase grows over time. [2]
Observation that the level contributions are lower than the current
contributions [1]
Explanation of why the contributions are lower: need to reduce
value by c.$300k. [2]
Observation that the updated graph shows that Mr Potter's
pension value is equal to the GMA at his retirement age. [1]
Commentary that pension values will depend on actual inflation,
actual contributions, actual investment returns etc. [2]
Any other valid conclusions [3]

[Maximum 20]

Next steps

Validate the information provided	[2]
….when Mr Potter is assumed to retire	[1]
….current accrual (DC and CARE)	[1]
Consider historic salary increases for the directors and consider if the assumption is reasonable	[2]
Independently verify the possible future economic outlook and hence the lower assumptions	[2]
Understand how the directors' DC funds are invested and reflect it in the assumed investment returns	[2]
Undertake projections for all members of the GP PS as other members may be affected, not just the directors	[2]
Project the directors' pensions to retirement rather than just 2018	[2]
Allow for the assumed inflation assumption to vary over time (i.e. inflation curve)	[1]
Allow for the assumed investment return assumption to vary over time	[1]
Model future inflation stochastically to give a likelihood of the pension value exceeding the GMA at retirement	[2]
Model future investment returns stochastically to give a likelihood of the pension value exceeding the GMA at retirement	[2]
Calculate the penalties that would be imposed on members who exceed the GMA	[2]
Calculate the premiums required to target GMA at retirement for the directors	[1]
Confirm timings of contributions to more accurately reflect the investment returns	[1]
Calculate the contribution rate Mr Potter could make to meet the GMA on retirement instead of a fixed level contribution.	[2]
Allow Mr Potter's pension contributions to vary more considerably by age/allow for additional voluntary contributions	[1]
Allow for investment returns to be age dependent e.g. de-risk as approach retirement	[2]
Update Mr Potter's projections for the lower assumptions	[1]
Sensitivity test the contribution rates	[1]
If appropriate, enhance the model to allow for monthly cash flows.	[2]
Shock event – stop accruing benefits; sudden drop in value of DC funds	[2]
Back test the model using real life data	[2]
Update the model as time progresses to allow for actual experience	[2]
Obtain a peer review of the work performed	[1]
Any other valid next steps	[3]

[Maximum 20]

[Total 85]

END OF EXAMINERS' REPORT