INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2018

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 2018

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 is only penalised 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 carrying out the required modelling steps.

Most candidates made a good attempt at the model, calculating the Required Capital, Own Funds and Solvency Ratio. Most candidates were also able to update the model for the reinsurance scenario and complete a goal seek to find the motor reinsurance proportion to achieve the target solvency level. The most common issues, among candidates who had problems in this section, were not correctly allowing for the counterparty risk capital and not resetting the property reinsurance proportion to zero for the target solvency level scenario.

One issue that arose for a number of candidates was the interpretation of the examination instructions. The examination instructions stated that Premium Risk Capital/Reserve Risk Capital should be calculated by summing, over all lines of

business, the expected premium/year end reserves multiplied by the solvency capital premium/reserve percentage for that line of business.
The correct approach was that the multiplication should occur separately for each line of business before summing the results over all lines of business. Where candidates had completed the summation and then multiplied by one of the premium/reserve percentages, marks were lost at this stage. However, no further deductions were applied for subsequent steps in the model if the correct approach was adopted.

Candidates were also asked to produce a chart to illustrate the proportional contributions to the total Required Capital. Most candidates had produced the figures for this chart but some candidates produced a chart that did not fully illustrate the overall proportions in a suitable manner.

Most candidates were able to complete the solvency projections until 2021. Those candidates that had produced a simple model for the base scenario performed better for this part of the model as it was easy to copy calculations across each year of the projection period.

In relation to the required calculations, most candidates were able to project the premiums and reserves for both lines of business and subsequently correctly calculate the projected Required Capital. However, a significant number of candidates did not project Excess Assets and Own Funds correctly. While candidates did correctly calculate the expected profit and the retained profit, errors arose with the timing of how the retained profit impacted the Excess Funds. This error resulted in incorrect solvency levels being calculated for future years.

Where candidates had completed the solvency projections, candidates subsequently produced an appropriate chart to illustrate the projection of Required Capital, Own Funds and Solvency levels. Charts on the whole were well presented.

The final scenario to calculate the target dividend payout ratio was not completed by all candidates. Again it was those candidates who had kept the model simple that were able to update the model to complete this aspect. A number of candidates also produced an incorrect result due to errors in the original solvency projection modelling.

Given the limited amount of data in this examination, auto checks could only be completed on the calculations performed e.g. checks on the goal seek and resetting subsequent scenarios to the original scenarios. While the number of available marks for automatic checks was relatively low, most candidates struggled to include any auto checks.

Most candidates demonstrated reasonable modelling techniques and gained most of the available marks in this area. As mentioned above, candidates who kept the model simple were able to complete most aspects of the model accurately. This demonstrates the importance of planning the structure of the model.

Audit trail

Most candidates provided 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.

The list of assumptions provided by candidates did not always provide added value assumptions. Assumptions should not simply restate information that has been provided in the examination instructions.

Some candidates explained what parameters were included in the parameters worksheet. If the data has already been described in the data section, then candidates could save time by simply stating that the parameters can be found in the parameters tab.

Some audit trails lacked sufficient detail in the methodology section, for example just stating what was carried out and not how. While some steps of the model were relatively simply, it is still important to explain how the calculations were completed within the model.

Most candidates did provide a good description of how the Required Capital, Own Funds and Solvency Ratio were calculated. However for later stages, additional information could have been provided. For example, in the first reinsurance scenario, many candidates did not explain how the counterparty risk capital was calculated.

The more complete audit trails did cover this as well as clearly and logically explaining how the model was updated in order to calculate the projected solvency ratios.

To score well in the audit trail, 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 rows and columns of the worksheet. Almost all candidates signposted the calculations by reference to the relevant worksheet and a significant proportion of candidates provided further detail by signposting the relevant cells.

While there was less potential to provide auto checks within the model, there was significant opportunity to pick up marks for reasonableness checks. Many candidates failed to gain any of these marks, and over two thirds of candidates earned less than half of the available marks for checks. Candidates could have provided good reasonableness checks on the results of the base scenario and how the results change as a result of reinsurance. Furthermore, candidates could have provided justification of how the Required Capital and Solvency Ratio changes in the projections.

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

results. This is a recurring point in Examiners' Reports for this subject: including reasonableness checks not only provides a check on your own work; it also proves to the examiners that you understand what you are doing, and can communicate this effectively.

PAPER TWO

Modelling

The majority of the candidates carried out most of the required modelling. A number of candidates lost marks by not including goal seek checks on the two additional scenarios. Another very common error occurred when candidates did not remove contributions after ten years for the '10 year target' scenario. While candidates had correctly calculated the required contribution level, the projection of the assets after ten years was incorrect because contributions continued to be allowed for.

Some candidates also assumed that the additional return on assets was a fixed nominal amount but the correct approach was to assume an additional yield.

Charts were generally well produced, with only an occasional candidate choosing an unusual chart type. A more common issue was encountered with the chart showing projected assets and liabilities for the three scenarios. To provide more meaningful analysis, all three scenarios should be included on the one chart but a number of candidates produced three individual charts.

Summary

The structure of the summary was generally of 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.

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 included most of the required charts in the summary but some did not state all of the results, particularly the key financial results e.g. the deficit at the end of the 15 years, the additional annual return on assets and the level of donations required.

The quality of the methodology section varied between candidates. Stronger candidates were able to summarise the methodology adopted for all steps. Weaker candidates either gave very brief descriptions of the methodology adopted, only described some of the steps or provided a similar level of detail as provided in the audit trail, including 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.

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 to explain what this pattern shows or why it has occurred. Explanation of why is the key to performing well in this section – merely observing the change in results earns minimum marks, but showing understanding of the reason for the change is what is required. Such commentary indicates the extent to which the purpose of the model and the results it has produced, have been understood. Candidates who passed tended to offer some explanation of the results and provided some overall conclusions.

In this examination, there were many opportunities to analyse the results produced. Marks were available for valid observations e.g. in all scenarios the deficit would reduce to zero by the end of the projection period. Additional marks are then available for explaining why the results are as they are e.g for the '10 year target' scenario:

- the deficit reaches zero at 10 years and remains at zero thereafter;
- as the assets and liabilities are matched because;
- there are no further donations, outgo impacts both assets and liabilities and interest on both assets and liabilities is assumed to be the same.

In the next steps section of the summary, candidates are required to include next steps, which are 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 marks available for each next step by ensuring that it was specific to the model and explaining the relevance of the next step to the problem being considered. Generic or irrelevant lists of next steps, sometimes reproduced from previous exams, did not gain many marks as they add very little, if any, relevant information.

C. Pass Mark

The Pass Mark for this exam was 62.

PAPER 1

Marking Guide

Q2 (i)-(vii)

(i) Correct calculation of the Required Capital under the base scenario (two marks each for Premium and Reserve capital) [4]

(i) Correct calculation of the Own Funds under the base scenario [4]

(i) Correct calculation of the Solvency Ratio under the base scenario [1]

(ii) Appropriate chart showing the proportional contributions to the total Required Capital [3]

(iii) Correct calculation of the reduced 2018 premiums under the first reinsurance scenario [2]

(iii) Correct calculation of the Solvency Ratio under the first reinsurance scenario (one mark for the counterparty risk capital and one mark for the total) [2]

(iv) Correct calculation of the percentage of the Motor business to reinsure to target a solvency ratio of 140% (2 marks for set up; 1 for goal seek) [3]

(v) Correct projection of the premiums and reserves to 2021 (one mark each) [2]

(v) Correct projection of the Required Capital to 2021 [1]

(v) Correct projection of the Excess Assets and Own Funds to 2021 [2]

(vi) Suitable chart of the projected capital position [3]

(vii) Calculation of target dividend payout ratio (Set up 2 marks, goal seek 1 mark) [3]

[Maximum 30]

Other Marks

Good spreadsheet practice (up to 7 marks)

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

Setting reinsurance percentage to zero should get base result [1]

Check projections are increasing as expected [1]

Check on Goal seek [1]

Reasonableness checks on the base and reinsurance scenarios (max 5):

Reserve risk for Motor contributes the highest amount to the total Required Capital [1]

Reinsurance reduces premiums so reasonable that both Required Capital and Expected Profit reduce [1]

Reinsurance increases the Solvency Ratio as the reduction in Required Capital is greater than the reduction in Expected Profit [2]

Portion of Motor business to be ceded should be more than 50% to achieve a similar solvency ratio as under the first reinsurance scenario [2]

Reasonableness checks on the projection and dividend payout calculation (max 5):

Required capital increases over time as the volume is projected to increase [1]
Annual increase of 5.5% is reasonable considering the average growth rates for premiums and reserves [1]
Excess Assets increases each year as dividend payout ratio is less than 1. [2]
Expected Profit increases each year as premiums volumes are projected to increase. [1]
Solvency Ratio increases each year GIL should be writing profitable business. [2]
Dividend payout ratio less in the scenario to achieve the target solvency ratio [2]
Any other sensible reasonableness check [1]

[Maximum 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 (eg 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 (max 5 marks):

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

[Maximum 5]

Assumptions

Up to 5 marks for including assumptions (1 for each distinct, reasonable "added value" one listed) [5]

[Maximum 5]

Steps CORRECTLY described (max of 15)

Overview [1]
Data used, including source [1]
Calculation of Required Capital [2]
Calculation of Expected Profit [1]
Calculation of total Own Funds and Solvency Ratio [1]
Update for the first reinsurance scenario [2]
Calculation of the reinsurance percentage under the second reinsurance scenario [1]
Calculation of the projected Required Capital [1]
Calculation of the projected Excess Assets [2]
Calculation of the projected Own Funds and Solvency Ratio [1]
Update required for the dividend payout scenario [1]
Calculation of the dividend payout, by Goal seek or otherwise [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

Correct donations reflected	[1]
Correct allowance for additional yield (correct calculation & incl. in year-end assets)	[2]
Correct additional yield found using goal seek (or other suitable approach)	[1]
Check on goal seek	[1]
10 year target:	
Correct donations found	[2]
Correct allowance for (zero) donations post 10 years	[2]
Check on goal seek	[1]

[Maximum 10]

Q4 Charts

Construction of chart showing campaign's projected assets and liabilities	[2]
Construction of chart showing projected assets and liabilities for three scenarios (15 year target, allowance for additional returns, 10 year target)	[2]
Construction of chart showing annual items which positively affect the assets under the additional returns scenario	[3]

[Maximum 7]

Q5 Summary methodology
Purpose, Data, Approach, Assumptions

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

Award a total of 1 mark for restating assumptions from the Audit, 1 mark for each new valid one

Calculations

Liabilities:	
Calculation of interest	[1]
Calculation of year end liabilities (liabilities - outgo + interest)	[1]
Assets:	
Calculation of annual donations (allowing for inflation)	[1]
Calculation of asset returns	[1]
Calculation of year end position (assets - outgo + donations + interest)	[1]
Calculation of deficit	[1]
Scenarios:	
15 year donation target (solve for donation so deficit is zero after 15 years)	[1]

additional returns (add in additional returns in line with interest (1); donations in line with campaign (1); solve so deficit is zero after 15 years(1)) [3]

10 year target (update donations so zero after year 10 (1);
solve for donation so deficit is zero after 10 years (1)) [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]

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 [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

Statement of the deficit at the end of 15 years based on the campaign [2]
Appropriate chart showing the campaign's projected assets and liabilities [1]
Statement of the donations required to be in balance at the end of 15 years [1]
Statement of the additional annual return required to be in balance assuming campaign donations [1]
Appropriate chart showing the elements which act to increase the assets [1]
Statement of the donations required to be in balance at the end of 10 years [1]
Appropriate chart showing the projected assets and liabilities (showing 3 scenarios) [1]

[Maximum 8]

Conclusions

Observation that the charity's liabilities > assets and therefore there is a deficit at the end of the 15 years [1]
Observation that the charity has a deficit for the duration of the projections [1]
Gap between liabilities and assets reduces (0.5) - because campaign donations are off-setting the outgo on the asset side (1); which is further added to by the interest on these donations (0.5) [2]
Observation that 'deficit target' donations need to be higher than the 'campaign' donations. [1]
Explanation of why the deficit target donations are higher - deficit at end of campaign projections needs to be paid off [2]
Explanation of why the deficit target donations are <$56k/15 - inflationary increases (2) and additional yield (1) [3]

Observation that the largest factor causing the assets to increase is the original investment returns [1]
Explanation that the investment returns varies year on year as the NBI forward yields vary (and the shape of the return follows the shape of the forward yields i.e. higher yield = higher interest) [2]
Observation that additional return is only a small contributor & is fixed [1]
Observation that the donations increase smoothly over time (1) (+ explain why inflationary increases (1)) [2]
Explanation that main contributor is investment returns (original + additional) which means heavy reliance on investment strategy [2]
Observation that '10 year target' donations are the highest [1]
Explanation why 10 year target donations are high - less time to meet the deficit [2]
Observation that all scenarios have zero deficit at the end of 15 years [1]
Explanation of graph under '10 year target' scenario - zero deficit at 10 years (0.5); assets and liabilities match after that point (0.5) because no further donations (1) and interest on both is assumed to be the same (1) [3]
Explanation that the assets under the '10 year target' scenario diminish more slowly than under the other scenarios (0.5 observation) as the donations assumed to be received are greater (1.5) [2]
Explanation why 'investment risk' and 'donation target' asset lines are roughly equal (0.5 observation) - additional donations ~ additional returns (1.5) [2]
Explanation as to why assets and liability lines slope down (0.5 observation) – outgo is larger than interest and donations (1.5) [2]
Explanation as to why assets reduce more slowly than liabilities (0.5 observation) – donations don't affect the liabilities (1.5) [2]
Observation that the liabilities over time are the same in all three scenarios. [1]
Act results will depend on investment returns achieved (1) and actual donations received (1) [2]
Any other valid conclusion [3]

[Maximum 20]

Next Steps
Validate the information provided particularly: [1]
….Confirm with the asset managers whether achieving returns in line with the NBI is reasonable. [1]
….Verify the starting balance sheet position of the charity [1]
Confirm that the trustees would accept the additional risk required under the 'Additional Return' scenario. [1]
Confirm whether any material changes have taken place between 1 January 2018 and the time of the projections being undertaken e.g. are the NBI yields being used still appropriate of have markets moved substantially? [2]
Independently verify whether targeting higher investment returns is achievable. [2]
Make the additional yield vary over time [1]
Make an allowance for additional credit risk as a result of investing in higher risk assets to achieve the additional yield. [2]
Model future investment returns stochastically so that a range of deficit values can be provided, giving Peter an idea of the likelihood of a deficit at the end of 15 years. [2]

Allow for the assumed inflation to vary over time i.e. reflect an inflation curve rather than a single assumption. [2]
Find out about the anticipated timings of donations and outgo so that investment returns can be more accurately calculated. E.g. are donations more likely to be received over the Christmas period. [2]
If appropriate, enhance the model to allow for monthly cashflows. [1]
Sensitivity test the result to changes in outgoing cashflows. [2]
Consider the change to investment returns and/or donations for the deficit to be met one year earlier or one year later. [2]
Allow for the charity to grow over the course of the projections, resulting in different income (be it from donations or other sources) and higher levels of outgo. [2]
Determine the additional margin required over the NBI yield for the deficit to be removed by the end of 10 years, rather than varying the assumed donations. [2]
Undertake a "shock" scenario test – for example: what would happen if the charity were to require more substantial outgoes in any one particular year, if the assets were to drop substantially [2]
Undertake a "shock" scenario test – for example: what would happen if the market value of assets were to drop substantially [2]
Update the projections monthly as time passes. This will enable Peter to determine whether Hilltop needs to try and obtain higher levels of donations in future years or whether there is less pressure to campaign for donations. [2]
Consider tax implications, e.g. gift aid, on donations or reclaims of tax allowed on outgoing cashflows for charities if not already allowed for in Peter's figures. [2]
Confirm that any costs of the campaign are included in the outgoing cashflow figures, or if not obtain and include them if they are to be met from charity funds. [2]
Check that new donations can be used to remove the deficit and are not ring-fenced. [2]
Allow for a combination of increased donations and increased investment returns [2]
Obtain a peer review of the work performed. [1]
Any other valid next steps [3]

[Maximum 20]

END OF EXAMINERS' REPORT