

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

April 2020 Examinations

### **Subject CP2 – Modelling Practice Core Practices**

#### **Introduction**

The Examiners' Report is written by the Chief 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.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

Mike Hammer  
Chair of the Board of Examiners  
July 2020

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

1. The aim of the Modelling Practice 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:

- preparation and exploratory 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 candidates can still earn marks for accurate and clear communication of what was done.

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

**B. Comments on candidate 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 and completing automatic checks on the data and results

Data checks were generally completed well, although only the better candidates carried out a Chi squared test of the random numbers and included automatic checks against the key features of a uniform distribution. Many candidates copy and pasted raw data to correct rather than linking formulae to it.

It is noted that on page 7 of the question paper, there is a typo in the statement {Score (out of 100) for card  $i$  for competitor  $n$  (where  $1 \leq i \leq 100$ )}. The range should be around parameter  $n$ , rather than  $i$ . All marks were available for a reasonable attempt or interpretation of the data. For example a candidate could have used the data vertically or horizontally for their analysis.

Most candidates used the provided random numbers and calculate the simulated scores at 50m and 100m correctly. Where errors were made, it was usually in the execution of one or more component parts of the score formula, with candidate able to gain method marks for the other components. Some candidates rounded the simulated scores to the nearest whole score which was considered acceptable.

The calculation of summary statistics of the 25m scores and averages for 50m and 100m were generally handled well, although a significant number of candidates only calculated the minimum and maximum score, and not the average score.

Only the better candidates managed to calculate the junior MQS for equal numbers of junior and senior scholarships and complete the chart of average scores correctly.

Most candidates managed to complete the modelling exercise, but not many completed all the steps and produced all the results that were asked for. Candidates should read the paper carefully to ensure that they understand exactly what they are being asked for.

### **Audit trail**

Most audit trails were formatted clearly and were easy to follow.

A number of candidates put a lot of effort into elaborate introductions and commentary on the data provided, and then ran out of time to describe the workings of the model.

Some candidates included as assumptions a lot of information provided in the background information, which didn't earn them any marks. Assumptions need to add value, and not just repeat what has been given.

Most candidates did not include any reasonableness checks. Where these were included they were on the whole only very basic reasonableness checks, with little attempt to check that the final output was reasonable or that the scenario calculations were working properly. A lot of 'checks' produced were essentially just confirming that Excel is working correctly, such as doing exactly the same calculation in two different ways. A reasonableness check should be an explanation of *why* a result makes sense.

In general, audit trails were fairly well written, but often there was not enough detail for full marks. Descriptions of steps taken should cover both *what* is being done and *how* it is done. A number of candidates used screen shots of the various score simulation formula, which while acceptable, needs to be backed up by description of where and how the calculations were carried out and how they were linked together.

## **PAPER TWO**

### **Modelling**

The majority of candidates made a reasonable attempt at the additional scenario, gaining some of the marks available. There were a large number who did not introduce the overall guarantee fee or final year guarantee comparison correctly (for example applying

the guarantee on an annual basis). This often resulted in a very favourable mean investment level after 10 years which should have flagged up the error.

Most candidates produced good charts, and scored highly in this section.

### **Summary**

The methodology was generally set out well by better candidates, with clear explanations but sometimes lacking detail.

Two common errors of either copying the audit trail provided into the summary, or writing the summary in the style of an audit trail, with numerous references to the spreadsheet were less common than in previous sittings, although there were a small number of candidates who did one or other of these. The Summary should be a standalone document that doesn't make any reference to the spreadsheet. Similarly, inserting 'reasonableness checks' which belong in the audit trail should be replaced by explaining results.

Most candidates managed to pick out the most obvious conclusions from the results. These were often however observations and not supported with an explanation. Many conclusions were often rather brief and basic, focussing on the 'what' but not the 'why'. This area remains the clearest distinction between good candidates and the rest, as it shows an understanding of the assignment and an ability to communicate this.

Most candidates produced plenty of next steps, but only the better candidates linked these clearly to the scenario in the question and explained how each step would help. In addition, some candidates produced lists which were repetitive in nature, rather than considering a range of different ideas. Those who produced a 'scattergun' list of short one-liners earned very limited credit. In particular, the use of a template list of next steps can often be noticed, either by not making these relevant to the assignment, or including steps which are patently out of place.

### **C. Pass Mark**

The Pass Mark for this exam was 60.

1097 candidates presented themselves and 724 passed.

## Subject CP2

### Paper 1

#### Q1

##### (Spreadsheet Model)

- (i) Validation of data on scores and relevant adjustments (1 mark each):
- Age band is either S or J
  - No scores are greater than 100 or less than 90
  - Appropriate adjustments made on age band
  - Appropriate adjustments made on scores
- [Max 3]
- (ii) Calculation of average of the 25 metre scores for each competitor. [1]
- (iii) Calculation of summary statistics, each for seniors, juniors and overall: [2]  
Count and average score per card across all competitors  
Highest and lowest individual average
- (iv) Calculation of the “points dropped” figures for each competitor [2]
- (v) Calculation of the individual mean and standard deviations of the “points dropped” figures [2]
- (vi) Validation of  $U[0,1]$  data (1 mark each unless otherwise stated): [4]
- Count 2,000
  - Minimum 0 and maximum 1
  - Checks automatically show OK/Error (or similar) (give mark if only one of them is done this way)
  - Mean close to 0.5
  - Variance close to 0.083
  - Above checks are automated using a tolerance (give mark if only one of them is done this way)
  - Graphical demonstration of uniformity [2]
  - Chi-squared test [2]
- (vii) Simulation of scores for each competitor at 50 metres and 100 metres: [4]
- Calculation of exponential parameter [1]
  - Simulation of exponential random variables [1.5]
  - Calculation of scores out of 100 [1.5]
- (viii) Calculation of averages at each of: [2]
  - 50 metres; and [1]

- 100 metres [1]
  - (ix) Calculation of trial score for each competitor. [2]
  - (x) Determination of number of competitors for each of the teams: [2]
    - Senior team [1]
    - Junior team [1]
  - (xi) Determination of the overall sponsorship budget required for base run. [1]
  - (xii) Determination of the MQS for equal number of seniors and juniors receiving scholarships. [2]
  - (xiii) Suitable chart of the average scores [3]
- [Total 30]**

## Q2

- (i) Good spreadsheet practice: [7]
- No hard-coding (use of parameters and no copy and paste values) [1]
  - Flagging rows/columns that don't copy down [1]
  - Easy to follow (inputs, checks and outputs easy to find) [1]
  - Logical order (left to right, top to bottom, within and between sheets) [1]
  - Clear and accurate labelling within the spreadsheet - rows, columns, worksheets [1]
  - Use of simple techniques (but not oversimplified) - formulae not overly complex/steps split out and calcs built up [2]
- [Total 7]**

- (ii) Other checks (1 mark each):

- The overall highest individual average is equal to the higher of the senior and junior highest averages
- The overall lowest individual average is equal to the higher of the senior and junior lowest averages
- Overall average at 50 metres is less than at 25 metres
- Overall average at 100 metres is less than 50 metres
- All total Trial Scores are <2,000
- Verification that that equality run gives the required number of seniors (same as number of seniors in the base scenario)
- Verification that the equality run gives the required number of juniors (same as number of seniors in the equality scenario)
- Resetting the MQS in the equality run gives the base run team numbers
- Any other distinct, valid check

**[Total 5]**

**Total for spreadsheet model [42]**

### Q3

#### Audit trail

##### Audit approach

(i) Communication skills:

- HOW the steps have been executed is clear, rather than just WHAT has been done being stated [2]
- There is sufficient technical detail and does not include excessive use of Excel formulae to describe steps [1]
- Sufficient detail is providing in the audit trail as a self alone document - does not refer references in the model [1]

**[Total 4]**

(ii) Fellow student can review and check the methods used in the 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]
- The workbook is well labelled and is easy to navigate through [1]
- Where there are, or could be errors, the audit trail would enable the student to identify and correct errors [2]
- Danger areas in the spreadsheet are appropriately flagged (e.g. goal seek) [1]

**[Total 7]**

(iii) Senior actuary can scrutinise and understand what has been done

- A reasonable overview of the model is included [1]
- There are clear statements of the assumptions made i.e. concise list of value added assumptions, not long list with many not adding value [1]
- Data sources and changes are clearly described [1]
- It is easy for a senior actuary to pick up the high level detail of the modelling - can pick up the high level without having to read all the detail [2]
- The level of detail is appropriate for a senior actuary - explanations are clear and concise [1]
- Reasonableness checks are clearly stated and explained [1]

**[Total 7]**

(iv) 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]

**[Total 4]**

(v) Written in a 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]

**[Total 3]**

Audit content

- (vi) 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 [2]
- [Total 8]**
- (vii) Clear signposting included throughout
- 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]
  - Model labelling is consistent with the audit trail (data, parameters, scenarios, outputs, charts) [1]
- [Total 4]**
- (viii) Statement of assumptions made (1 for each distinct, reasonable “added value” assumption listed) [5]
- (ix) All model steps accurately covered [1 mark each]
- Overview
  - Data used – nature
  - Data used – source
  - Data validation (scores)
  - Data adjustments (scores)
  - Verification of data (random numbers)
  - Determination of summary statistics at 25 metres
  - Calculation of “points dropped”, including average and standard deviations
  - Determination of exponential parameters
  - Simulation of scores
  - Calculation of straight averages at 50 and 100 metres
  - Calculation of trial score
  - Calculation of number of places to be offered for each squad (base run)
  - Calculation of budget (base run)
  - Calculation of MQS required to get same numbers of juniors as seniors (equality run)
  - Clear description of all modelled (auto) checks
  - Construction of chart

**[Total 16]**

**Total marks for audit**

**[58]**



**Total marks for paper 1**

**[100]**

## **PAPER 2**

### **Q1**

#### Spreadsheet Additional Scenario

- (i) Calculations for 'overall guarantee' option [5]
- Calculation of new initial investment under the overall guarantee option. [1]
  - Calculation of annual fund values under the overall guarantee option. [1]
  - Calculation of the correct fund value under the overall guarantee option. [3]
- (ii) Calculate the guarantee charge under the stress test for the annual guarantee option. [2]
- (iii) Calculate the guarantee level under the stress test for the overall guarantee option. [2]
- [Total 9]**

### **Q2**

#### Chart Production

- Construction of chart showing the mean, minimum and maximum outcomes under the three options. [2]
- Construction of chart showing the guarantee charges under the original annual guarantee option and the stress test. [2]
- Construction of chart showing the guarantee levels under the original overall guarantee option and the stress test. [2]
- [Total 6]**

### **Q3**

#### Summary

- (i) Methodology (including purpose, data, approach and assumptions)
- Statement of purpose. [1]
  - Data used, including 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. Award 1 mark for any valid assumption not included in the audit.
  - Calculation of annual investment returns for each scenario and year. [1]
  - Annual fund projection correct with annual management charge. [1]
  - Calculation of the summary statistics for the no guarantee option. [1]

- Calculation of the fund value under the annual guarantee options (additional management charge (1) and the maximum fund calculation (years to include (1); guarantee level (1))). [3]
  - Correct new initial fund under the overall guarantee option. [1]
  - Calculation of the fund values under the overall guarantee option (same annual projections as base case (1), final fund value allowance for guarantee (years to include (1); guarantee level (1))). [3]
  - Stress test for the annual guarantee option. [2]
  - Stress test for the overall guarantee option. [2]
  - Senior actuary can understand what has been done (max 5 marks).
  - 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]
- [Total 27]**

(ii) Results, including charts

- Inclusion of chart of the comparison of expected performance. [1]
  - Inclusion of the table of summary statistics. [2]
  - Inclusion of chart showing comparison of the annual guarantee charges. [1]
  - Inclusion of chart showing comparison of the overall guarantee level. [1]
- [Total 5]**

(iii) Conclusions

*Where results are observed but not explained only ½ mark should be awarded, unless the mark is specifically stated to be for an observation.*

- Observation that the mean is higher under the no guarantee option. [1]
- ...because the charges are less under the no guarantee option [1]
- Explanation of why the mean return should be lower under the guarantee options (expected profit for the investment company). [2]
- Observation of higher volatility under the no guarantee option. [1]
- Explanation of why minimum levels are significantly higher under the guarantee options (the guarantees provide a floor). [2]
- Explanation of why the minimum under the overall guarantee option is \$85,000 (as this is initial value so has to be the minimum overall). [2]
- Observe that the maximum is highest under the base scenario. [1]
- ...because the higher costs of the options mean that the maximum funds available are less than the no guarantee option. [1]
- Comparison of the standard deviations under the no guarantee option and the two guarantee options and why they differ [2]
- Observation that minimums and maximums are similar, consistent with the standard deviations..... [1]

- ...which means that that the protection is similar despite the different structures. [1]
  - Comparison on the expected result under the overall guarantee option as a percent of the no guarantee option and the 15% initial charge. [2]
  - Explanation that the annual charge in the stress test is lower than under the base scenario because the fund value needs to increase. [2]
  - Explanation of the annual charge in the annual stress test (that 1.09% reflects the theoretical value of the guarantee).... [2]
  - ...and the expected profit for the investment company is 0.41%. [1]
  - Explanation of guarantee level in the overall stress test (it increases above 100% because the average was originally lower than the no guarantee option).... [2]
  - ...and the comparison to the 3% lower expected return. [1]
  - Explanation of the impact of the guarantee and therefore what the choice will depend upon [2]
  - A valid conclusion with the reason why. [3]
  - Conclusion that the actual outcome will depend on experience. [1]
- [Total 23]**

(iv) Next steps

- Validate the investment mean and standard deviation provided [1]
  - ...against another source [1]
  - ...and is up to date [1]
- Validate the appropriateness of the use of the normal distribution for investment returns [1]
  - ...a distribution with “fatter tails” may be more appropriate [1]
- Extend the analysis to other time periods than 10 years. [1]
- Adjust the model to additional investments or withdrawals over time. [1]
- Adjust the model to allow for a more sophisticated model of investment returns, for example with dependencies between annual returns. [2]
- Enhance the model to test the implications of any changes in the investment strategy. [2]
- Solve for annual guarantee level to give the same expected fund value. [1]
- Solve for the initial overall guarantee charge to give the same expected fund value. [1]
- Sensitivity test the results by using different investment performance parameters. [1]
- Check if other guarantee options are available, for example with other investment companies. [2]
- Check the implications if Mr White needs to withdraw his investment early, in particular under the overall guarantee option if the fund value is currently under the maximum value up to that point. [2]

Model the market returns stochastically so that a probability distribution of results can be produced. [2]

Test the model against experience going forward and update the investment guarantee levels. [2]

Obtain a peer review of the work performed. [1]

Any other valid next steps.

**[Total 20]**

**(v) Drafting**

- 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]

**[Total 10]**

**Total marks for paper 2**

**[100]**

**END OF EXAMINERS' REPORT**