INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2019

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.

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.

Mike Hammer
Chair of the Board of Examiners
September 2019

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 analyse data, develop a model, and document the work (including maintaining an audit trail for a fellow student and senior actuary). They should be able to 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 and completing automatic checks on the data and results

Most students managed to use the provided random numbers and calculate the profit for the first vineyard correctly. Where errors were made, it was usually in making the link between the 100 random numbers per simulation, and the 100 days of the grape growing period. However marks were awarded for any reasonable approach.

The calculation of summary statistics and drawing out the components of profit for the median simulation were also handled well, although a significant number of students did not realise that they were expected to do this.

Only the better students managed to correctly calculate the cost of overtime for the second vineyard.

Most students managed to complete the modelling exercise, but not many completed all the steps and produced all the results that were asked for. Students 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 students 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.

Most students 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 students included 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 are 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.

PAPER TWO

Modelling

There was an error in the model provided regarding the application of the minimum parcels that could be delivered by each driver. Most students did not pick up on this, and no marks were deducted from any submission that replicated the error.

As the exam paper advises **'You should assume that your colleague's calculations have been checked and are correct.'**

However, it is possible that the incorrect approach in the model provided caused some candidates some confusion. The criteria for reviewing borderline cases was expanded to capture additional scripts for review. In undertaking these reviews examiners were generous in awarding marks so as to compensate for any potential lost time this issue may have caused.

The majority of students handled the additional scenario correctly, but there were a large number who did not set up the goal seek correctly. This resulted in a single price which ensures all scenarios result in a profit, but not necessarily the maximum price. Students

needed to set the goal seek so that the minimum profit was equal to the target profit, rather than finding a price which set the number of scenarios returning target profit to 100, as this condition was met by any price lower than $2.36.

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

Summary

The methodology was generally set out well by better students, 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 papers. 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 students managed to pick out the most obvious conclusions from the results. However, they were still 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 students produced plenty of next steps, but only the better students linked these clearly to the scenario in the question and explained how each step would help. 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.

Marking Schedule
PAPER 1

Marking Guide
Q2 (i)-(ix)

i.	Data checks - count random numbers and check in minimum/maximum	[1]
	Data checks - mean and standard deviation including sufficient tolerance level	[2]
	Data checks - suitable statistical check on distribution - graphical or chi squared test	[2]
ii.	Correct calculation of the total number of sunshine hours for each simulation	[2]
	Auto check on the base case	[1]
	Correct calculation of the total number of wine bottles produced for each simulation	[1]
	Correct calculation of expected profit/(loss)	[2]
ii.	Calculation of key statistics - minimum, maximum and mean (0.5 for one or two, 1 mark for all three)	[1]
	Calculation of theoretical profit and comparison to average simulated profit	[1]
	Correct calculation of the probability of making a loss	[1]
v.	Ranking of data to produce chart	[1]
	Construct chart showing variability of profit	[1]
v.	Correct identification of median simulation (taken as 50th simulation)	[1]
	Correct identification of the components of profit for the median simulation	[1]
ʼi.	Correct calculation of minimum price per bottle to ensure no loss: (1 for setting up goal seek; 1 for solving)	[2]
	Check on Goal seek for minimum price per bottle for no loss (or check on result)	[1]

ii.	Correct update to model for alternative investment opportunity (0.5 mark - updating mean from Uniform Distribution, 0.5 mark - using correct number of days, 2 marks - correct calculation of overtime costs)	[3]

	Calculation of summary statistics for alternative investment opportunity	[1]

	Correct identification of components of profit for median simulation under the alternative investment opportunity	[1]

ii.	Appropriate chart or charts to illustrate the key statistic(s) for the outcomes under both investment opportunities	[1]

x.	Appropriate chart to illustrate the components of expected profit for the median outcome under both investment opportunities	[2]

[Maximum 30]

Other Marks
Good spreadsheet practice

- 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 calculations built up [2]

[Maximum 7]

Other Checks

Reasonableness checks:
- Probability of making a loss is quite low which is reasonable given values for maximum profit and maximum loss. [1]

- For the chart showing distribution of profit, around 90% of simulations show a profit greater than zero – our calculated value of making a loss (12%) is therefore reasonable. [1]

- Target price per bottle is higher than base price as the initial scenario showed that the vineyard could make a loss therefore it is expected that the price per bottle would need to increase. [1]

- Reset goal seek scenario to $10 price per bottle to get same results as initial scenario [1]

- Average expected profit is higher for the alternative vineyard opportunity as mean expected of number of hours will increase as mean daily number of hours increases by 25% and number of days only falls by 10% [1]

- Wider range of expected outcomes under the alternative vineyard opportunity due to more sunshine hours but also higher vineyard rental cost. [1]

- Average profit has more than doubled in alternative scenario due to 50% increase in revenue but lower increase in total costs [1]

- The increase in costs is more heavily weighted by the fixed costs which have only increased by 25% [1]

- Check that profit from components equals total profit for the 50th simulation [1]

- Any other sensible reasonableness check - 1 per valid reasonable check subject to a maximum of 3 [3]

[Maximum 5]
[Total 42]

Q3 Audit Approach

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 standalone document - does not refer references in the model [1]

[Maximum 4]

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]

- 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]

[Maximum 7]

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 i.e. concise list of value added assumptions, not long list with many not adding value [1]

- Data sources 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 their results explained [1]

[Maximum 7]

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]
[Maximum 25]

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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 [2]

[Maximum 8]

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]

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

[Maximum 4]

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

[Maximum 5]

Steps CORRECTLY described (max of 15)

- Overview [1]

- Data used, including source [1]

- Check on data statistics [1]

- Graphical or Chi Squared check on data [1]

- Calculation of total number of hours of sun [1]

- Calculation of grapes produced [1]

- Conversion of grapes produced into bottles of wine (including impact of spoilage) [1]

- Calculation of production costs, total costs, total revenue and expected profit [1]

- Calculation of theoretical profit and compare to simulated answer [1]

- Calculation of summary statistics [1]

- Calculation of probability of making a loss [1]

- Determining the median expected profit and its components [1]

- Determining the target price per bottle so that no loss is expected [1]

- Update worksheet for alternative vineyard opportunity to pick up new parameters [1]

- Construction of charts [1]

- Any other distinct, valid step… [1]

[Maximum 16]
[Total 33]

PAPER 2 (Analysis and Summary)

Marking Guide
Q3 Techniques - Additional Scenario

- Update allocation of parcels to 650 for the cheapest driver first [2]

- Update allocation of parcels to 650 for the maximum delivery driver first [2]

- Set-up for target pricing for all drivers (1 for starting from correct scenario, 2 for changing to single parameter) [3]

- Run of goalseek for target pricing [1]

- Check on goal seek for target pricing or on solution [1]

[Maximum 9]

Q4 Charts

- Construction of chart for scenario 1 - cheapest driver first   [2]

- Construction of chart for scenario 1 - maximum delivery driver first   [2]

- Construction of chart comparing charging structure for all drivers   [4]

                                                                        [Maximum 8]

Q6 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 trail, 1 mark for new
  valid ones

Projections

- Calculation of the number of parcels from random numbers   [1]

- Order of the allocation to cheapest driver   [1.5]

- Allocation of parcels to driver with most capacity   [1.5]

- Calculation of income / outgo / profit (0.5 if don't have all three)   [1]

- Calculation of summary information for each scenario   [2]

- Changes made for scenario 2   [2]

Alternative scenarios

- Explanation of the changes made when number of parcels increases to 650   [1]

- Explanation of changes made for the target pricing structure   [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]
[Total 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

- Scenario 1 (a) and (b) - statement of minimum, maximum and average profit, or prop. scenarios meeting target profit [1]

- Chart showing the variation of profit for cheapest driver first [0.5]

- Chart showing the variation of profit for maximum delivery driver first [0.5]

- Scenario 2 - results stated as per scenario 1 [0.5]

- Scenario 3 increased number of parcels - results presented as per scenario 1 [0.5]

- Statement of target pricing under scenario 4 [1]

- Chart showing the charges per driver [1]

[Maximum 5]

Conclusions
 (where Results are observed but not explained, only award 1/2 mark)

Three key observations:

- Allocating to cheapest driver first generates better profits [1]

- Scenario 2 results in a reduction in potential to earn profits [1]

- ABC are more likely to make better profits if deliver more parcels [1]

- (for all other conclusions, where results are observed but not explained, only award 1/2 mark)

- Driver V has cheap pricing but also delivers a large potential number of parcels, so makes sense that cheapest driver first generates most profits [2]

- Driver II has potential to earn ABC a large amount of profit if they get their maximum allocation of parcels [2]

- Allocation to maximum number of parcels driver first (i.e. Driver IV) who has the highest charging - will reduce profits [2]

- Explanation of why maximum delivery scenario results in much lower profits [2]

- Explanation of why reduction seen in scenario 2 [2]

- Sense check of level of reduction in scenario 2 [2]

- Little difference in the minimum profits for scenario 2, plus explanation of why [2]

- ABC very likely to have a chance to meet target profit if more parcels delivered under the cheapest driver allocation [2]

- Explanation of why the target pricing is sensible [2]

- Comment on impact per driver of the target pricing [2]

- Final results are dependent on: availability of drivers, number of parcels [2]

- Comment that there is no guarantee that target profit could be achieved per day [2]

- Any other valid conclusion (max 3) [3]

[Maximum 23]

Next Steps

- Validate the information provided particularly: [1]

- Number of parcels per driver [1]

- Costing per driver [1]

- Compare parcel delivery costs to other companies in the market [2]

- Compare charges per driver to other companies in the market [2]

- Consider pricing of parcels based on size and weight [2]

- Consider pricing of parcels based on delivery distance [2]

- Consider price paid to driver based on delivery distance [2]

- Increase number of drivers to increase potential number of parcel deliveries [1]

- Increase the simulations to get a more stable distribution of results of profits for ABC parcel delivery company [2]

- Other expenses – include costings of holding areas for parcels, and potential refunds to customers if parcels not delivered in tack [2]

- Combine an increase in parcel deliveries with the equal costings [2]

- If equality pricing for drivers is not mandatory, consider drivers who are cheaper to maximize profit [2]

- ...But consider potential reputation issues if drivers are not as good as the more expensive drivers [1]

- Maximum number of parcels need to reach target profit 100% of time [2]

- Take tax into account [1]

- Do market research on acceptability of target pricing per driver [2]

- Consider scenario of shock event e.g. all drivers unwell and can't deliver, market crash of parcel delivery firms [2]

- Update the model as time passes to allow for actual experience, especially the no. of parcel deliveries achieved [1]

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

- Any other valid next steps (max 5) [5]

[Maximum 20]

END OF MARKING SCHEDULE