Institute and Faculty of Actuaries

EXAMINERS' REPORT

CP2 Modelling Practice

Core Practices

Paper One

April 2023

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.

For some candidates, this may be their first attempt at answering an examination using open books and online. The Examiners expect all candidates to have a good level of knowledge and understanding of the topics and therefore candidates should not be overly dependent on open book materials. In our experience, candidates that spend too long researching answers in their materials will not be successful either because of time management issues or because they do not properly answer the questions.

Many candidates rely on past exam papers and examiner reports. Great caution must be exercised in doing so because each exam question is unique. As with all professional examinations, it is insufficient to repeat points of principle, formula or other text book works. The examinations are designed to test "higher order" thinking including candidates' ability to apply their knowledge to the facts presented in detail, synthesise and analyse their findings, and present conclusions or advice. Successful candidates concentrate on answering the questions asked rather than repeating their knowledge without application.

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.

Sarah Hutchinson
Chair of the Board of Examiners
July 2023

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

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.

The subject is split into two papers. The first, dealt with in this report, covers the objectives:

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

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.*

The overall difficulty of the paper was in line with the average CP2 diet.

Modelling
The more straightforward elements of the modelling were well handled, with the data analysis particularly well covered. Averaging costs over the year was only managed by the stronger candidates, while later elements of the modelling were only completed correctly by the stronger candidates.

We were pleased to see candidates attempt the modelling even where challenges were faced. By taking this approach candidates had a good model off which to base their audit trail. The descriptions in the audit trail are awarded credit where they reflect the modelling completed therefore even where the modelling did not achieve all of the technical marks, the audit trail would gain credit for the description.

Prospective candidates should be reminded that there is an expectation that any element of the Core Principles can be drawn on in the CP2 exam. It is therefore recommended that CP2 is best approached after being familiar with the content of these earlier subjects.

Audit Trail
Most candidates get the main elements of an audit trail. The quality of methodology descriptions continues to improve over time, as more candidates cover both the what and how of what the model is doing. Reasonableness checks continue to be a weak area for most candidates.

C. Pass Mark

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The Pass Mark for this exam was 60
1107 presented themselves and 708 passed.

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Solutions for Subject CP2-1 - April 2023

Q1

Validation of data:

(i)

The status at the start of the year is in one of the four states (H, S, I, D)	[½]
The status at the end of the year is in one of the four states	[½]
No resurrection	[1]
Adequate automated checks to identify the incorrect entries (one resurrection and two unknown statuses)	[1]
Reasonable correction of the three entries (e.g. deletion of the incorrect entries)	[2]
Any other valid data checks (e.g. check no missing data, check counts etc)	[1]

(ii)

Calculation of the number of movements in each of these 16 states	[3]

(iii)

Conversion of the movements into transition probabilities	[2]

(iv)

For each year in the projection period:

Calculation of the number of people in each of the four states	[2]

Calculation of the present value of the total costs:

Allowance for inflation	[1]
Allowance for the timing of the costs	[2½]
Allowance for discounting	[1]
Calculation of present value of cost per life alive (calculation of number of lives alive and correct division using the number of lives alive at t-1)	[1½]

(v)

For the alternative scenario:

Adjustment to the transition probabilities	[1]
Adjustment to the drug costs	[1]
Correct calculation	[1]

(vi)

For the drug cost in the alternative scenario:

Adjustment to the set-up of the drug costs in the S and I states	[1]
Correct set up of a goal seek	[1]
Calculation of the drug costs	[1]

(vii)

Production of a suitable chart for the number of lives alive under the base and alternative scenario	[2]

(viii)

Production of a suitable chart to illustrate the real cost per individual alive under each of these three scenarios	[2]

[Sub-total 29]

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The technical modelling for this paper was reasonably simple throughout, but had enough complexity to allow better candidates the opportunity to display a more thorough understanding of the assignment.

The initial data analysis was very well handled by nearly all candidates. The errors in the data were found, and a variety of corrections were made, which were all acceptable provided a rationale was given.

The majority of candidates managed the simpler elements of the calculations well, with most managing to project the number of people in each state, and calculating the costs each year. However, only the stronger candidates managed to apply some approach to averaging the costs over the course of a year. This was despite many candidates including assumptions about transitions between states taking place half-way through the year. There was scope within the assignment to allow for a number of approaches to this issue, but it is expected that candidates present a coherent solution, where the assumptions made tie in to the modelling performed.

Better candidates managed to complete the modelling, and managed to adjust the transition probabilities correctly, and perform the goal seek for the altered drug costs. For weaker candidates, common errors were to not fully account for the transitions from the three live states into all four states, or to not apply the additional transitions correctly.

When it comes to the final results and the creation of graphs, this was less well handled. Many candidates misunderstood the concept of the present value of costs per life alive, and there were a large variety of approaches here. A notable proportion didn't understand that this result needed to be calculated for each year of the projection, and thus only produced a single figure based on the total discounted cost. Candidates are expected to consider the rationale behind what is being asked for and use this understanding of the assignment to inform their modelling, and the reasonableness checks on their work. In this case, the impact of the different drug was cumulative, with the transition probabilities to healthy improving and to sick and very sick reducing over time. Stronger candidates were able to pick this up and present the results appropriately as graphs over time showing the difference between scenarios. They were also able to provide reasonableness checks which displayed their grasp of the assignment. It should be kept in mind that the ability to produce reasonableness checks that show an understanding of what the model is supposed to do is one of the best indicators of a pass.

Q2

(i)

Auto checks on the modelling completed in Q1:

Check the system is closed (i.e. all transitions are accounted for/all statuses

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always add up to 1,000,000) [1]
Check the probabilities of each of the four transitions sum to 1 [1]
By setting the parameters in Scenario 2 to the same as scenario 1, the model gives the NPV results of scenario 1 [1]
Check that the sum of those dead and alive at the end of the 30-year projection period equals to 1,000,000 i.e. no. of lives we started out with [1]
By setting goal seeked drug costs in Alt_scenario 2 same as those in Alt_ Scenario 1, the NPV results are the same and model should show that goal seek needs to be rerun. [1]
Any other reasonable auto checks

[Marks available 5, maximum 2]

(ii)
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 calcs built up [2]

[Sub-Total 9]
[Total for spreadsheet model 38]

Most candidates obtained marks for auto checks on the transition probabilities. Spreadsheet practice continues to be well handled, with only the weaker candidates scoring poorly here.

Q3

Audit trail
(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 provided in the audit trail as a stand-alone document [1]

(ii)
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]

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

(iii)
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]

(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]

(v)
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]

(vi)
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 [2]

(vii)
Reasonableness checks:
The Dead (D) state is an absorbing state (i.e. no transitions out of this state)
(This mark can only be awarded once - if awarded as an auto check, cannot get further credit here) [1]

Comment on the reasonableness of the transition probabilities, with specific example: [1]
Expect most healthy people stay healthy [1]
Expect most of the individuals with minor illnesses (S state) to recover [1]

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Increasing probability of dying the more ill an individual becomes [1]
Probabilities of each transition state sum to 1 *(This mark can only be awarded once - if awarded as an auto check, cannot get further credit here)* [1]

The change to the transition probabilities sum to zero in the alternative scenario [1]
There are no probabilities greater than 1 or less than 0 at any time t in the alternative scenario [1]
There are more lives alive in the alternative scenario [1]
Because the transition probabilities have improved [1]
The present value of the cost of the programme came to about $8.8bn. This seems to be consistent with the NHA budget of $9bn. [1]
For Alt_Scenario_1 - cost has gone up to $10bn which is over NHA's budget. [1]
This is not unreasonable given the new drugs cost significantly more than those in the base scenario. [1]
The drug costs using goal seek is less than that in the alternative scenario 1, which is reasonable, given the total real costs in the alternative scenario 1 exceeds that of the original scenario. [1]
Any other sensible reasonableness check

[Marks available 14, maximum 6]

(viii)
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]

(ix)
Up to 3 marks for including assumptions (1 for each distinct, reasonable "added value" one listed) [3]

(x)
Steps correctly described:
Purpose [1]
Data used, including source [1]
Data checks [2]
Data adjustments (correcting errors identified and removed) [1]
Calculation of the number of movements amongst health statuses [1]
Conversion of movements into transition probabilities [1]
Calculation of the number of individuals in each of the four states in each year [1½]
Calculation of the present value of the total cost in treating these people [1½]
Calculation of the real cost per live alive [1]
Calculation of the alternative scenario [2]
Calculation of the drug costs for the counter proposal [2]
Construction of the two charts [1]
Any other distinct and valid step

[Total marks for audit trail 62]

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In general, audit trails were fairly well written, and show a heartening continuation of an improving trend over the past few years. Better candidates showed evidence of time planning and were able to focus their attentions on the key areas of the modelling and audit trail.

Once again, there was a wide range in the quality of audit trails produced, from those that clearly ran out of time, to the stronger candidates who are able to clearly explain both what was done and how it was done in the model.

Many candidates struggled with providing assumptions that add value to the audit trail. Many simply re-stated information provided in the background information, or resorted to listing items which are assumed not to change. The better candidates were able to grasp the ambiguity in the question and make assumptions that were relevant to that situation. As mentioned above, many candidates made common assumptions but then didn't perform the modelling in line with them.

Most candidates included only very basic reasonableness checks, with little attempt to check that the final outputs or graphs made sense or that the scenario calculations were working properly.

[Paper Total 100]

Issue with the exam paper

There were two sheets, which were inadvertently left 'hidden' in the 'data for candidate' spreadsheet. The names of these work sheets were 'Alt scenario_1 (alt)' and 'Alt scenario_2 (alt)'.

It could be deduced that the first of these relates to the alternative scenario examiners outlined in the exam paper, and the second relatives to the goal seek scenario. (The (alt) in brackets is a nod to this being an alternative approach - we include 3 possible approaches in the sample solution.)

Within these worksheets is a table, with column labels, that could be used to derive a high-level structure of a potential approach to solving the alternative scenario. Much of this structure, however, flows organically from the exam paper.

All formulae contain #REF!, meaning all cells within the table show #REF! as the output. No numerical elements or answers are shown. Candidates would have needed to derive a parameters sheet by taking the information from the exam paper and then use these parameters to correct the #REF!'s.

An extensive detection exercise was undertaken, combining electronic and manual searches to determine which candidates may have identified these hidden sheets during the course of the exam. It was concluded up to c.1.5% of candidates may have used these hidden sheets.

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The results of these candidates were analysed extensively, both independently of and alongside the marks achieved under paper 2. The results varied, and the pass rate of these was broadly consistent with the average for the diet overall.

It has been concluded that the presence of these sheets was only discovered by a small cohort and has not had an impact on the overall performance of candidates in this sitting.

The pass mark was determined excluding these candidates, considering the skills being examined by the paper. It was therefore not biased by this issue.

The Chief examiner and their team apologise for the stress this may have caused candidates sitting this session. Steps are being taken to sanitise materials provided to candidates in future sittings.

END OF EXAMINERS' REPORT

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