INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2021

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.

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.

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.

Paul Nicholas
Chair of the Board of Examiners
July 2021

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 candidate 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 paper 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 candidates 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 *candidates' performance in this diet of the examination.*

PAPER ONE Modelling
1. 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.

2. Most candidates managed to check the data and find six of the seven errors. Not many checked the likely validity of the solar electricity generation over the course of the day/night, hence did not spot the erroneous entry between the hours of 1am and 2am. Some candidates copied and pasted raw data to correct rather than linking formulae to them. The data set provided was intentionally big to resemble real-life modelling. Candidates were expected to use their judgement to come up with sensible checks on the data.

3. While the calculation of the saving in dollars of installing a battery was supposed to be reasonably straightforward, some candidates failed to recognise the need to take the battery storage from the previous time period.

4. Most candidates succeeded producing a suitable chart to illustrate clearly of the solar generation/electricity usage/purchased pattern. Candidates should note that the results calculated in the "Solar&usage Calculations" tab in the sample solution are in excess of those required to get the full marks. These workings are retained in the sample model as they demonstrate careful consideration of the work completed, with

additional data to check for consistency and reasonableness. However, they are not intended to reflect what is expected from most candidates under exam conditions.

5. The calculation of the NPV was generally handled better. One common error was to omit the cost of installing a battery in the calculation. The IRR calculation helped differentiate better candidates. The calculations of NPV and IRR are inherently similar and stronger candidates were able to capitalise on this. The IRR could either be solved directly using excel functions or via a goal-seek; both approaches (as well as any other sensible approach) were acceptable.

6. This paper placed more of an emphasis on data validation. In any modelling exercises it is important to make sure the data used is fit for purpose. Any data changes should be handled with care and documented in detail. The modelling itself was reasonably straightforward. Some candidates fared poorly on time management. The paper was written in such a way that marks could still be awarded for later sections, and indeed the audit trail, even if they failed to complete some of the previous section.

7. Most students managed to complete the modelling exercise, but not many completed all the steps and produced all the results required. Candidates should read the paper carefully to ensure that they understand exactly what they are being asked for and plan their time appropriately to maximise their chances of passing.

Audit trail
1. Most audit trails were well structured and easy to follow.

2. 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. Candidates should prioritise their time appropriately to ensure that their audit trails provide maximum coverage of all elements of what they've done in the model. The importance of adequately documenting the data tests should not be overlooked as it often has been in the past.

3. Some candidates included as assumptions a lot of information provided in the background information, which didn't earn them any marks. Assumptions need to be relevant and add value, and not just repeat what has been given or deal with situations that aren't used. Where candidates knew they had made an error or needed to make assumptions in order to proceed with the modelling, should be commented upon as such in the audit trail.

4. Most candidates included only very basic reasonableness checks, with little attempt to check that the final output was reasonable or that the IRR/NPV calculations were sensible. 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 is different from an auto check in Excel and should be an explanation of *why* a result makes sense.

5. In general, audit trails were reasonably 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

1. The majority of the candidates carried out most of the required modelling for the two additional products, for both the original and rumoured scenarios. A number of students lost marks by not including the outgo of the additional product in the sum calculation.

2. Another common error was not adjusting the diversification factor to 100% for the product with the largest expected net present outgo, resulting in incorrect minimum capital requirement.

3. Generally, candidates produced good charts and scored highly in this section. Labelling of the minimum capital requirement and ratios charts could have been clearer for some candidates.

Summary

1. The methodology was set out well by better candidates, with generally clear explanations covering most of the main steps, albeit lacking detail sometimes.

2. Few candidates wrote the summary in the style of an audit trail in this sitting, which is encouraging to see. The summary should be a standalone document that doesn't make any reference to the spreadsheet. A very small number of candidates still copied the audit trail into the summary paper. These submissions were heavily penalised.

3. Most candidates 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. Candidates should aim to explain what they see and find a reason for it. An example is that almost all candidates observed that applying the stresses increases the net present outgo but only the better candidates provided a justification (e.g. a heavier mortality is assumed in the stressed scenario).

4. 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. Those who produced a 'scattergun' list of short one-liners earned 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. Candidates should ensure that their suggestions are relevant to the situation and make sense as an additional area of investigation. They should also try think a bit deeper and explain the benefit one would achieve from doing this – which will ensure that they get maximum credit for each idea.

C. Pass Mark

The Pass Mark for this exam was 61.
1,021 presented themselves and 590 passed.

Solutions for Subject CP2-1 April 2021

Q1 (Spreadsheet Model)
(i)
Validation of data on scores and relevant adjustments:
- Graphing average hourly rates for usage and solar generation [2]
- Adequate automated checks to identify the outliers (five negative electricity usage, one high electricity usage, one night solar generation entry) [3]
- Reasonable correction of the 7 entries (negative set to 0 or positive, high electricity usage to 0 or appropriate average, night time solar to 0) [1]

(ii)
Calculation of the hourly amount of electricity which will be bought from the electricity provider, without a battery [1]

(iii)
Calculation of the hourly excess solar electricity generated over electricity used [1]

(iv)
Modelling the cumulative battery charge level assuming a battery is installed [4]

(v)
Calculation of the hourly amount of electricity which will be bought from the electricity provider, with a battery [2]

(vi)
Calculation of the saving in dollars ($) over 2020 of installing a battery [2]

(vii)
Appropriate tabulation of the data and production of a chart to illustrate
- monthly solar generation [½]
- electricity usage [½]
- electricity purchased without a battery and [½]
- electricity purchased with a battery [½]
- Production of suitable chart [2]

(viii)(a)
Projection of the annual savings from installing a battery for 20 years
- electricity price inflation 4% [1]
- electricity price inflation 4% increasing by 0.25% p.a. (Naomi estimate) [2]

(b)
Calculation of the NPV of the savings from installing a battery
- electricity price inflation 4% [1]
- electricity price inflation 4% increasing by 0.25% p.a. (Naomi estimate) [1]

(ix)
Calculation of the IRR of installing a battery
- Appropriate set up (Cashflows or Excel function) [1]
- Solving for electricity price inflation 4% [1]

- Solving for electricity price inflation 4% increasing by 0.25% p.a. (Naomi estimate)

[1]

[Total 28]

Q2
(i)
Auto checks on the modelling completed in 1

- Check maximum battery charge level is less than or equal to 12.5 Kwh [1]
- Check battery charge hourly increase is less than or equal to 12.5 Kwh [1]
- Check no negative electricity values [1]
- Check battery usage over all sources sums to total i.e. solar + battery + provider = total [1]
- Check total electricity generated is accounted for [1]
- Any other reasonable auto check [1]

[Marks available 6, 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]

[Total 9]

Q3 (Audit trail)
<u>Audit Approach</u>
(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]
- 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]

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 (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:

- Comment on pattern of electricity usage over 24 hours [1]
- Comment on pattern of solar electricity generation over 24 hours [1]
- Solar electricity energy shows a bell curve, peaking in summer months [1]
- Electricity usage peaks in winter months [1]
- The period between approximately 09:00 to 16:00 when average solar electricity generation is higher than average electricity usage is the period when the battery would build up storage of electricity [2]
- The period after approximately 16:00 when average electricity usage is higher than average solar electricity generation is when any electricity stored in the battery could be used to power the excess of electricity usage over solar electricity generated [2]
- Electricity purchased from the electricity provider without a battery is lower than electricity usage because some electricity usage is met by electricity generated by solar [2]
- Electricity purchased from the electricity provider with a battery is lower than electricity purchased without a battery, because more electricity usage is covered by solar electricity generated and stored in the battery [2]
- The IRR for Scenario 2 with increasing electricity price inflation is higher than Scenario 1 with fixed inflation because the $ savings increase faster in Scenario 2 which means the battery investment provides a higher return [2]
- The IRRs are in the range of 6% p.a. - 11% p.a. which seems reasonable for an investment with the expected risks and returns explained by Naomi [1]
- Any other sensible reasonableness check [1]

[Marks available 16, maximum 5]

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

(x)

Steps CORRECTLY described (max of 16)

- Overview [1]
- Data used, including source [1]
- Data checks (Graph data) [1]
- Data checks (Explain errors) [1]
- Data adjustments (Correcting errors identified) [1]
- Calculation of the electricity purchased from the energy provider for each hour, with no battery [1]

- Calculation of the excess solar electricity generated over electricity used for each hour, with no battery   [1]
- Modelling the cumulative battery charge level for each hour   [2]
- Electricity bought from provider (in excess of solar generation & battery storage)   [1]
- Calculation of savings generated by installing the battery   [1]
- Projection of Scenario 1 and NPV   [1]
- Projection of Scenario 2 including inflation adjustment and NPV   [2]
- Calculation of the IRR on each of the scenarios   [1]
- Construction of monthly totals graph   [2]
- Any other distinct and valid step   [1]

[Marks available 18, maximum 16]
[Total 63]
[Paper Total 100]

Solutions for Subject CP2-2 April 2021

Q1 Spreadsheet Additional Scenario
(i)
Calculations for total expected net present outgo and minimum capital requirement

- Calculation for option B (term assurance and annuity products)   [3]
- Calculation for option C (term assurance and critical illness products)   [3]

(ii)
Repeat the Minimum Capital Requirement calculations allowing for the updated diversification factors   [2]

[Total 8]

Q2 Chart Production
(i)
Construction of chart showing the net present outgo for each product before and after allowing for the stress   [3]

(ii)
Construction of chart showing the annual claim/benefit payments for all three products to see the cashflow profile   [3]

(iii)
Construction of chart comparing the minimum capital requirements (as amounts) between the options for both the original and rumoured scenarios   [2]
(iv)
Construction of chart comparing the calculated ratios (as percentages) under the three options for both the original and rumoured scenarios   [2]

[Total 10]

Q3 Summary

(i)

Methodology (including purpose, data, approach and assumptions)
- Statement of purpose [1]
- Data used, including source [1½]
- 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. Award 1 mark for any valid assumption not included in the audit
- Calculation of stressed mortality and morbidity rates [1]

Term Assurance calculations
- Calculation of term assurance in-force probabilities [1]
- Calculation of in-force probability x mortality rate x number of policies x benefit amount [1]
- Calculation of the stress test (including expenses) [1]
  Annuity calculations
- Calculation of the in-force probabilities [½]
- Calculation of in-force probability x number of annuities x payment (must mention age that came into payment) [1]
- Calculation of the expenses [½]
- Calculation of the stress test (including expenses) [½]

Critical illness calculations
- Calculation of the morbidity rate x number of policies x benefit amount [1]
- Calculation of expenses [½]
- Calculation of the stress test (including expenses) [½]

Minimum Capital requirement calculations
- Calculation of the Xj [½]
- Allowance for Max Xj and impact on Aj's [1]
- Application of the formula for minimum capital requirement [½]
- Calculation of the ratio [1]

Rumoured changes
- Update to minimum capital requirements calculations [1]

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]

[Marks available 26, maximum 25]

(ii)

Results, including charts
- Inclusion of chart showing the net present outgo for each product before and after allowing for the stress [½]

- Inclusion of chart showing the annual claim/benefit payments for all three products to see the cashflow profile [½]
- Inclusion of chart showing the minimum capital requirements (as amount) between the three options for both the original and rumoured scenarios [½]
- Inclusion of chart showing the calculated ratios (as percentages) between the three options for both the original and rumoured scenarios [½]
- Inclusion of minimum capital requirements under base and rumoured scenarios [1]
- Inclusion of the ratios under the base and rumoured scenarios [1]
- Inclusion of indication of the impact of the stresses [1]

(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 applying the stresses increases the net present outgo; because [½]
  - a heavier mortality is assumed in the term assurance scenario [½]
  - a lighter mortality is assumed in the annuity scenario [½]
  - a more severe incidence rate is assumed in the CI scenario [½]
- Comment that the base case reflects the average likely outgo whereas the stresses are designed to demonstrate a 'worst case' style scenario [1]
- Observation that while all NPVs increase under the stress scenario, the increase in NPVs is lower than the stress applied to the underlying tables due to: [½]
  - the interaction of the stresses with the cashflows i.e. the stresses cause payments to be brough forward for the Term Assurance and Critical Illness products or extended for the annuity products [1½]
  - and the interaction with the expense stresses [1]
- Option B reduces the Minimum Capital Requirement which is logical as the risks are negatively correlated i.e. if mortality goes up people die younger so Term Assurance payouts increase, but annuity payments will cease sooner [2]
- The ratio reduces for C despite the Minimum Capital Requirement increasing: [½]
  - Minimum Capital Requirement increases due to positive correlation i.e. expect critical illness incidence rate to increase if mortality is increasing [1½]
  - But different risks so overall the risk is spread hence ratio is lower [1]
- If the company is willing to expand, then subject to charging an appropriate premium option C would reduce the relative risks the company are exposed to even though it has increased the absolute amount of risk [2]
- Consideration of premiums and profit margins in decision of strategy [1]
- Shape of future cashflows - Term Assurance and critical illness have smooth increase as policyholders age and hence rates increase, drop off at end of term (which differs for the two products) [1]
- The critical illness claims cease 5 years earlier than the term assurance claims as we have assumed a 30 year term for term assurance products compared to a 25 year term for critical illness products [1]

- Shape of future cashflows - annuities don't start until appropriate age (step up as males and females reach set age) and then slowly decrease as the policyholders die; long tail as no fixed term [2]
- Amount of cashflows and therefore net present outgo will depend on sales volume and actual mortality and morbidity rates [1]
- The graphs comparing the Minimum Capital Requirements and the ratios demonstrate that while the magnitude of the changes are sensitive to the adjustments specified in the stress tests and the diversification factors, the conclusions would remain broadly unchanged [1]
- The ratio for option C is now higher than under option A as the diversification factor has increased which implies that the risks are more highly correlated than suggested by the current factors [2]
- Rumour reduces Minimum Capital Requirement for option B while increasing it for option C because [½]
  - although the magnitude of all of the diversification factors have increased [1]
  - negative correlation of the risks in option B mean that this is of 'benefit' whereas the positive correlation of the risks in option C mean that it increases the requirements [1½]
- Ratios act in the same way as the MCR due to change in MCR while no change is made to the net present outgoes [1]
- The change in Minimum Capital Requirement and ratios for C is greater than for B due to the scale of the stress for CI versus annuities [2]
- Any other valid conclusion with the reason why [1-2 per valid conclusion]
  [Marks available 28, maximum 22]

(iv)
Next steps
Where next steps are broadly relevant but not specific to context of the project, only ½ mark should be awarded.
- Validate the data and assumptions provided by the CEO [½]
  - e.g. decrement rates [½]
  - Validate the proposed volumes and business mix of the annuities and CI products [1]
- Specifically, investigate whether the proposals are feasible in the current market and external environment, and carry out scenario tests by varying the volumes and business mix over time [1]
- Obtain data from an alternative source [½]
  - e.g. industry with regards to volumes of policies likely to sell and update the projections to give a more accurate fit of the analysis [1]
  [Marks available 4½, maximum 3]

- Investigate the impact of writing the new products slowly over time [1]
- Expand the business mix to allow for different ages [1]
- Model mortality/incidence rates more for risk [½]

- o e.g. allow for differences due to smoker status [1]
- o Expand modelling of mortality to allow for mortality improvements over time [1]
- o Allow for critical illness deterioration over time [1]

[Marks available 5½, maximum 3]

- • Model more realistic expense assumption [½]
  - o Allow for expense inflation over time using the local inflation rates [1]
  - o Allow for increase in expenses as the portfolio diversifies [1]

[Marks available 2½, maximum 2]

- • More sophisticated modelling/offerings of products [½]
  - o Allow for different terms of the term assurance /critical illness products [1]
  - o Allow for term assurance and critical illness policies to lapse over the projection period [1]

[Marks available 2½, maximum 2]

- • Expand model to allow for discount rate to vary over time to provide more realistic outputs of the scenarios… [1]
  - o and therefore better reflect the potential risk particularly of the longer-term business [1]
- • Allow for investments within the company [1]
  - o and any potential impacts this has on claim payments [1]
  - o allow for asset risk in the Minimum Capital Requirements [1]

[Marks available 5, maximum 2]

- • Consider a mixture of scenarios B & C [1]
- • Update the model over time with experience [½]
- • No allowance has been made for premiums and how these may change over time in the projection period [1]
  - o so allowance to be made for these to see if it offsets the claim impacts [½]
  - o e.g. if premiums are possibly reviewed if experience changes [½]

[Marks available 3½, maximum 2]

- • Complete more analysis across the full projection period [1]
  - o e.g. how do the Minimum Capital Requirements change over time [1]
  - o e.g. consider the run off of reserves [1]
- • Consider the impacts of new policies being written over the projection period [1]
  - o and its impact on capital [1]
- • Investigate if any other products are available in the market that the company may wish to consider [1]
  - o e.g. do they want to remain as purely a Life insurance company [½]
- • Consider the target market that selling products to ensure that don't get selected against [1]
- • Study other factors of the product to ensure that changing the portfolio is sensible [1]

- o e.g. profitability analyses, cashflow analyses (ensuring that the company has sufficient cashflow to expand to a new line of business), and market analyses [1]
- Consider regulatory impact [½]
  - o whether the Regulator would allow the company to write a new line of business [1]
  - o whether this is in line with the risk appetite of the company [1]

[Marks available 12, maximum 2]

- Consider changes in the Minimum Capital Requirement calculations [½]
  - o e.g. what if can define own parameters rather than using prescribed amounts [1]
- Consider changes in underwriting and risk management practices, not just the impact on the Minimum Capital Requirement [1]
- Allow for tax on the cashflow calculations [1]
- Obtain a peer review of the work performed [1]
- Any other valid next steps that is relevant to the context of the project [1 each]

[Marks available 35½, maximum 20]

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

[Total 8]

[Paper Total 100]

END OF EXAMINERS' REPORT