INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2019 Examinations

Subject CP2 – Modelling Practice
Core Practices

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

Possible models with an audit trail or summary are posted on the website. It should be noted that these include more detail than would ordinarily be possible within the time allowed for the examination.

The specimen solutions are based on one possible approach to modelling the assignment set but the examiners gave credit for any alternative approach or interpretation which they considered to be reasonable.

Mike Hammer
Chair of the Board of Examiners
July 2019

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 students 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 *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 candidates made a good attempt at the model:
- reviewing and amending the data;
- calculating the required statistics; and
- calculating the grant per school.

Some candidates did not fully automate the data checks but nearly all candidates corrected the data.

Candidates used the correct functions to calculate the average mark and standard deviation for each school. Candidates were also asked to produce a chart to illustrate whether the data for all schools combined followed the normal distribution. Most candidates produced a chart to illustrate this. There were a number of alternative charts that could have been produced but a number of candidates produced charts which did not produce a suitable chart from which conclusions could have been obtained.

Most candidates were able to calculate the number of pupils who met the expected standard and the number of pupils who met the higher standard. Some candidates calculated the percentage that met the expected standard based on those students who had achieved between 50% and 75%. This approach was acceptable provided that the base grant was calculated by ranking schools based on the percentage of pupils meeting the expected standard plus the percentage of pupils meeting the higher standard.

Most candidates were able to produce the ranking by school in order to calculate the base grant for each school. And most candidates were able to calculate the additional grant from pupils attaining the higher standard in order to calculate the total grant. Marks were also awarded for those candidates who completed ranking per pupil in each school but the ranking by school was required in order to calculate the total grant.

Most candidates were able to produce the two charts requested – one showing the proportion of pupils reaching the expected and higher standard per school and the other showing the total grant, split between based grant and additional grant, for each school. For the latter graph, it was expected that a stacked chart was produced so that it would be easy to see the total grant per school.

Most students were then able to update the model to calculate the expected grant per school for the following year. This could be completed using a goal seek or by applying the proportion of the first year's total additional grant to the following year's additional grant.

The final part of the model involved completing a T-test. Many candidates did not attempt this aspect of the project. For those candidates who completed this part of the model, most students were able to identify the correct data for Schools A and E and the data for Schools B, C and D. This enabled candidates to calculate the necessary average and variance for each of these groups. Some candidates then struggled to calculate the test statistic which could then be compared to the critical t-factor. If this had been completed, it was important that candidates produced an outcome of the T-test – while best practice would be to ensure that this was dynamically programmed, marks were still awarded if this conclusion was not produced automatically.

Most candidates demonstrated reasonable modelling techniques and gained most of the available marks in this area. As mentioned above, some of the data checks were not fully automated and in many cases, the parameters within the checks were hard coded.

Candidates who kept the model simple were able to complete most aspects of the model accurately. This demonstrates the importance of planning the structure of the model.

Audit trail

Most candidates provided a well-structured audit trail with sections following the order in which the modelling stages were carried out. The audit trails mostly started with an overview of the model, description of the data used and the assumptions relating to the calculations in the model.

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

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

Some audit trails lacked sufficient detail in the methodology section, for example just stating what was carried out and not how. While many steps of the model were relatively simply, it is still important to explain how the calculations were completed within the model. For example, candidates could refer to which excel functions are used to complete calculations.

Most candidates did provide a good description of how the scores were converted to percentages, which were then used to determine the percentage of pupils meeting the expected standard and the higher standard. However for later stages, additional information could have been provided. For example, in calculating the total grant paid to each school, many candidates did not explain how each of the base grant and the additional grant were calculated before summing to give the total grant.

The more complete audit trails did cover this as well as clearly and logically explaining how the model was updated in order to calculate the total grant for next year.

To score well in the audit trail, candidates need to describe the modelling steps as well as signpost where in the worksheet the calculation has been carried out.

Signposting may be provided by reference to the worksheet, tables or row and columns of the worksheet. Almost all candidates signposted the calculations by reference to the relevant worksheet and a significant proportion of candidates provided further detail by signposting the relevant cells.

There was significant opportunity to pick up marks for reasonableness checks. For this exam, many candidates gained some of these marks but around 50% of candidates earned less than half of the available marks for reasonable checks.

Most candidates did provide commentary on whether the scores followed a normal distribution. Candidates also provided good reasonableness checks on the profile of the more successful schools.

For further reasonableness checks, candidates could have commented on the difference in the total grant amount between schools. In relation to the T-test, candidates could have provided commentary on why the test was met or otherwise.

Candidates need to be aware of the importance of the relevant reasonable tests in ensuring that the results make sense and the model is robust in producing reasonable results. This is a recurring point in Examiners' Reports for this subject: including reasonableness checks not only provides a check on your own work; it also proves to the examiners that you understand what you are doing, and can communicate this effectively.

PAPER TWO

Modelling

On the 'Model for candidate' spreadsheet provided, on the 'parameters' worksheet, alongside the cell for each parameter, the parameter name was given in red text. It was indicated that the LS proposal uptake rate cell (C13) had the parameter name 'Lump_sum_take_up_rate'. This was not however the case, in fact it had been named 'Enhanced_Transfer_Value_uptake_rate'. This parameter was not used in the 'Model for candidate' spreadsheet, however it would be reasonable to assume that students used this parameter within their work. It is possible that this misnaming may have caused some candidates some confusion. Candidates were awarded marks irrespective of which parameter name was used in their modelling. 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 the candidates carried out most of the required modelling. Some candidates did not correctly calculate the expected lump sum payable as at 1 January 2020 and this will have subsequently resulted in further incorrect values (but candidates will only have lost marks for the initial error).

Charts were generally well produced, with only an occasional candidate choosing an unusual chart type. A more common issue was encountered with the chart showing all projected cashflows from 1 January 2021 under the different scenarios. Some candidates incorrectly included the lump sum payment payable on 1 January 2020 in this chart.

Summary

The structure of the summary was generally completed to a high standard. The vast majority of the candidates offered a summary that followed the same order of the items that they had been requested to include in the summary.

Most candidates did well in producing a list of assumptions although it is important to add extra assumptions which were not included in the audit trail and which add value to the summary to gain full marks for this section.

The majority of candidates included the four required charts in the summary. Very few candidates stated the value of the lump sum payment which will be made on 1 January 2020. This was a key result and therefore should have been explicitly stated in the summary.

The quality of the methodology section varied between candidates. Stronger candidates were able to summarise the methodology adopted for all steps. Weaker candidates either gave very brief descriptions of the methodology adopted, only described some of the steps or provided a similar level of detail as provided in the audit trail, including signposting which is not necessary, nor is it appropriate for the audience of the document. No marks were awarded where a candidate simply copied the methodology from the audit trail.

The description of the modelling approach in the summary needs to be of a different style and depth to that needed in the audit trail as the two documents serve different purposes.

Having produced the results, candidates are expected to comment on the results and explore interactions within individual scenarios and the comparison between the results of the scenarios. Often inadequate commentary on the results is due to shortage of time. Candidates are advised to allow sufficient time to analyse the results, comment on the observed pattern and then try and explain what this pattern shows or why it has occurred. Explanation of why is the key to performing well in this section – merely observing the change in results earns minimum marks, but showing understanding of the reason for the change is what is required. Such commentary indicates the extent to which the purpose of the model and the results it has produced, have been understood. Candidates who passed tended to offer some explanation of the results and provided some overall conclusions.

In this examination, there were many opportunities to analyse the results produced. Marks were available for valid observations e.g. average pension per individual generally increases as age increases, the expected PV of the LS proposal is higher than the existing expected PV. Additional marks are then available to explain why the results are as they are e.g when analysing the chart showing all expected future cashflows on the existing arrangement and if all individuals accepted the PIE proposal, the following observations and explanations could have been provided:

- Existing and PIE cashflows diverge from 0 at 2021 as initially only a small proportion of pensions have begun payment;
- Existing and PIE cashflows converge towards 0 at 2055 as a small proportion of pensions remain in payment;
- The PIE cashflows increase faster than the existing cashflows due to higher starting pensions coming into payment, which are greater than the initial inflation increases received on the existing cashflows; and
- After the youngest individual's pensions are in payment (2030), PIE pensions are flat, existing pensions receive inflation increases and existing cashflows become higher than PIE cashflows (by 2035).

In the next steps section of the summary, candidates are required to include next steps, which are relevant and specific to the particular model and include specific descriptions linking them to the particular model and an explanation of what they would achieve. Most candidates were able to produce a list of next steps, but only the strongest gained the marks available for each next step by ensuring that it was specific to the model and the relevance of the next step to the problem being considered. Generic or irrelevant lists of next steps, sometimes reproduced from previous exams, did not gain many marks as they are adding very little, if any, relevant information.

C.   Pass Mark

The Pass Mark for this exam was 60.

Subject CP2

Q2

(Spreadsheet Model)

(i)   Validation of data and relevant adjustments (1 mark each unless stated):

        check max min, limit max to 60, (2 data corrections over 60 value & negative)No
        scores are greater than 100 or less than 90   [2]
        automatic check on gender   [1]
        additional check on data   [1]

(ii)   Calculation of averages and standard deviations   [2]

(iii)   Chart to show whether data combined follows a normal distribution   [3]

(iv)   a) correct calculation of percentage of pupils achieving expected standard [1]
        b) correct calculation of percentage of pupils achieving higher standard   [1]
        c) correct calculation of rank for each pupil and/or school   [1]

(v)   Chart to show percentage of pupils achieving expected and higher   [3]

(vi)   Calculation of the total grant to be awarded to each school. For each school calculate:
        the base grant amounts   [1]
        the additional amount for pupils achieving the higher standard and   [1]
        the total grant   [1]

(vii)   Chart to show the base & additional grant (one chart)   [3]

(viii) Calculate the amount to be awarded per higher score based on the revised budget of
        £75,000:
        set up new parameter   [1]
        run goal seek   [1]

(ix)   Completion of a t-test:
        Set up t-test hypothesis   [1]
        Calculate t value   [2]
        Calculate critical value   [1]
        Conclusion of t-test   [1]

        Spreadsheet checks
        Two distinct auto checks   [2]

        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]

[Max 7]

[Total for spreadsheet model 37]

Q3

(Audit trail)

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 provided in the audit trail as a self alone document - does not require reference to the model [1]

- 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]

- 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]
- 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]

- Written in a logical order
  - o Data is introduced before referring to it [1]
  - o Assumptions are stated before using them [1]
  - o 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

- Reasonableness Checks (1 mark each unless stated otherwise): **[max 5]**

  - o Comment on the shape of the data
  - o Comment on whether min/max average/st dev are as expected
  - o Zero marks - is this correct or could they have been absent?
  - o No marks over 50 for School A- why would this be, is it likely to be correct
  - o Comment on whether data follows normal distribution, (eg fixed upper bound, low outliers, roughly average 44) (Up to two marks)
  - o Setting additional amount on sensitivity run to be equal to base value gives the same results as the base run
  - o Grant awarded is higher for school with highest rank / lowest for school with lowest rank
  - o Additional grant awarded for higher standard increases gap between highest and lowest rank
      Sensitivity reduces the additional grant amount which is expected as need to reduce total spend
  - o Reducing the additional grant amount reduces the gap between rank 1 and rank 5
  - o T test is significant, suggesting there is a bias in the results as suggested by the government official (or other reasonable comment if a different result is obtained)
  - o This is to be expected because schools A and E are ranked 3rd and 5th
  - o Other sensible reasonableness checks (max three marks)

- All steps clearly explained
  - o The level of detail in the audit trail is appropriate for a newcomer to understand what has been done [1]
  - o All the methodology steps are set out clearly [2]
  - o Data provided and any necessary adjustments made are described and justified clearly. [1]
  - o All reasonableness checks applied are adequately documented [1]
  - o Areas where manual intervention or caution is required are well flagged (eg goalseeks or non-standard model areas) [1]
  - o The marker does not need to look directly at the model to understand what has been performed [2]

- Clear signposting included throughout
  - o The audit trail allows the user to follow the model through [1]
  - o The audit trail allows the user to understand each calculation easily [1]
  - o There is adequate signposting in the audit trail to describe the purpose of each tab [1]

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

- Statement of assumptions made (1 for each distinct, reasonable "added value" assumption listed) [5]

- All model steps accurately covered
  - o   Overview [1]
  - o   Data used including source [1]
  - o   Data checks - checking for errors in the data - max,min and adjustments [2]
  - o   Data checks - average and standard deviation [2]
  - o   Percentage of pupils achieving expected [1]
  - o   Percentage of pupils achieving higher [1]
  - o   Ranking of schools and/or pupils [1]
  - o   Total grant [2]
  - o   Sensitivity – reduced grant, including set up of calculations [2]
  - o   Setting up t-test [3]
  - o   Construction of charts [1]
  - o   Any other distinct, valid step [1]

[**up to max 16 marks**]

[**Total marks for audit 63**]

Total marks for paper [**100**]

PAPER 2

Spreadsheet Additional Scenario

- Correct LS cashflow at 1/1/2020 calculated [2]

- Correct future cashflows after LS proposal calculated for all relevant future years [2]

- Correct expected present value of cashflows after LS proposal [2]

[Total 6]

Chart Production

- Construction of chart showing average pension per individual per age group [2]

- Construction of chart showing all expected future cashflows on the existing arrangement and if all individuals accepted the PIE proposal. [4]

- Construction of chart showing expected PVs under the existing, PIE and LS proposals [2]

- Construction of chart showing all expected future cashflows on the existing arrangement, after PIE proposal and after LS proposal (from 2021 onwards i.e. excluding LS in 2020) [3]

[Total 11]

Summary

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]

  o Award a total of 1 mark for restating assumptions from the audit. Award 1 mark for any valid assumption not included in the audit.

Existing scenario:
- Calculation of payment indicators [1]

- Calculation of cumulative inflation increases [1]

- Calculation of existing expected cashflows using sumproduct function on starting pension at age 65 and cumulative inflation increases for each future year [1]

- Calculation of expected NPV for existing scenario [1]

PIE Proposal
- Calculation of PIE expected cashflows (1.5 marks for using sumproduct on non-increasing starting pension at age 65 and payment indicators, 0.5 marks for multiplying by expected take up rate) [2]

- Calculation of non-PIE expected cashflows (1.5 marks for sum product of inflation increasing starting pension and cumulative inflation increases, 0.5 marks for multiplying by (1-PIE take up rate)) [2]

- Calculation of expected NPV for PIE proposal scenario. [1]

- Goal seek to calculate actual PIE pension ratio [1]

LS Proposal
- Calculation of expected LS payment at 1/1/2020 [1]

- Calculation of expected cashflows for all years after LS proposal (allowing for (1 - take up rate)% to remain on existing cashflows) [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]

[Total 25]

Results, including charts

- Chart showing average pension per age group [1]

- Chart showing all expected future cashflows on the existing arrangement and if all individuals accepted the PIE proposal. [1]

- Chart showing expected PVs under existing, PIE and LS proposals [1]

- Statement of the lump sum cashflow expected to be paid at 1/1/2020 on the LS proposal [1]

- Chart showing all expected future cashflows on the existing arrangement, after the PIE proposal and after the LS proposal [1]

[Total 5]

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.
- Average pension per individual generally increases as age increases [1]

- Existing and PIE cashflows diverge from 0 at 2021 as initially only a small proportion of pensions have begun payment [1]

- Existing and PIE cashflows converge towards 0 at 2055 as a small proportion of pensions remain in payment [1]

- The PIE cashflows increase faster than the existing cashflows due to higher starting pensions coming into payment. Which are greater than the initial inflation increases received on the existing cashflows [2]

- After the youngest individual's pensions are in paymnet (2030), PIE pensions are flat, existing pensions receive inflation increases and existing cashflows become higher than PIE cashflows (by 2035) [2]

- As age groups reach their life expectancies cashflows of both existing and PIE diminish. We can see that in years when no one dies PIE cashflows remain flat while existing cashflows increase, causing small jumps. [2]

- The expected PV of PIE and existing proposals are equal. This is because the PIE starting pensions were calculated to ensure this. [1]

- The expected PV of the LS proposal is higher than the existing expected PV. This is because the lump sums offered were enhanced to 110% of the expected PV of the existing pensions. [2]

- The LS cashflows are below the existing and PIE cashflows because some individual's cashflows have been eliminated by a lump sum payment at 1/1/2020 which is not included in the graph [2]

- The LS cashflows follow a similar pattern to the existing cashflows because members who do not take up the offer receive their existing cashflows [1]

- Overall the higher (than existing) PIE cashflows in early years offset the lower (than existing) PIE cashflows in later years so that the expected PV of PIE and existing cashflows are equal. [2]

- The difference between PIE and existing cashflows appears smaller in the earlier period but this is because they contribute more to the PV as they are discounted for less time. [1]

- The PIE proposal removed some uncertainty about future inflation increases for the cashflows of individuals who take up the proposal but uncertainty over future lifetime remains [2]

- The LS proposal removes all inflation and expected future lifetime uncertainty for those who take up the offer. [2]

- Automake need to consider if the higher expected PV of the LS proposal is worth paying to remove the future cashflow uncertainty [2]

- Automake need to consider the cashflow implications of the potentially large LS payment at 1/1/2020 on the LS proposal and if this it is affordable to bring forward the cashflows in such a way. [2]

- Actual cashflows will not be known until they occur and will be particularly affected by actual inflation, actual mortality and actual take up rates [1]

- Any other valid conclusion [3]

[Total 23]

Next steps – 20 marks

- Validate the data provided [1]

- Validate the expected take up rate by comparing to other clients projects or other examples [1]

- Validate the expected lifetimes provided by Automake against publicly available mortality research or by investigating Automake's previous employees mortality if data available. [1]

- Confirm Automake's expectations of their ability and willingness to meet future cashflows as well as a potential large lump sum cashflow at 1/1/2020 [2]

- Consider a shock scenario of higher take up rates than expected for both projects and illustrate the potential maximum effect on cashflows and expected PV [2]

- Research any regulations which may restrict whether Automake can untertake the proposals or any rules they must follow when implementing them. [2]

- Check if the PIE proposal is allowed to offer a starting pension which does not result in equal expected PV to the existing pension. [2]

- Confirm if any significant changes have taken place since 1 January 2019. For example the recommended inflation or discount rate. [2]

- Update the projections if necessary before 1 January 2020 to check if the proposals are still viable (including to bring data up to date). [1]

- Consider varying the LS enhancement offered and consider the resulting effect on the LS take up rate. Plot these on a scatter chart to help Automake consider which enhancement to offer. [2]

- Model inflation increases stochastically to give a range of future cashflows under the existing scenario to give Martin an idea of the inflation uncertainty Automake faces. [2]

- Allow for the future inflation increases to vary with time, i.e. reflect an expected inflation curve rather than a single assumption. [2]

- Sensitivity test the results for different take up rates (including considering age dependent take up rates). [2]

- Sensitivity test the results to significant changes in expected lifetimes, for example if there is a cure for cancer or a flu epidemic. [2]

- Allow for more complex mortality expectations (i.e. standard current actuarial mortality tables) [1]

- Consider tax implications (for examplet if Automake pay out large lump sums at 1/1/2020) [2]

- Confirm the costs of executing the two proposals [1]

- Consider if there are other ways to manage the inflation or mortality uncertaintly, for example investing existing funds to hedge against inflation risk or buying annuities for individuals. [2]

- Consider the impact if both proposals are run at once. On costs, take up rates, cashflows. [2]

- Ask Automakes accounting advisers to report on the potential impact of the proposals to their financial accounts [1]

- Consider if a fixed PIE pension ratio at all ages is fair or appropriate. Investigate what proportion increases would give a PV equal to the existing for each individual age group. [1]

- Obtain a peer review of work already completed. [1]

- Any other valid next steps [3]

[Total Max 20]

Drafting – 10 marks
- 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 **[100]**

END OF EXAMINERS' REPORT