CAA GLOBAL

10 October 2018

Module 5: Models and Audit Trails

Time allowed: 3 hours + 15 minutes reading time

INSTRUCTIONS TO THE CANDIDATE

1. You have 15 minutes reading time at the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have 3 hours to complete the paper.

2. You must build your submission from the beginning and not use an imported e-template.

Your file names must include your ARN, the name of the document and the paper sat (e.g. 9000000-Summary) and each file should contain your ARN as a header or footer.

Please note that the content of this booklet is confidential and students are not to discuss or reveal the contents under any circumstances nor are they to be used in a further attempt at the exam.

If you encounter any issues during the examination please contact the Examinations team at online_exams@actuaries.org.uk T. 0044 (0) 1865 268 255

Background

A vintage car magazine is planning on publishing an article to help its readers understand how they can improve the reliability of their cars. They believe that if more drivers either regularly replace their car's engine oil or start to regularly change their car's tyres then they would last much longer before failing and needing expensive repairs.

Research published by the Vehicle Welfare Institute suggests that changing a car's engine oil each year will cause a 5% per annum reduction in car failure rates, and that starting to change car tyres each year will cause a 3% per annum reduction in car failure rates in the first year, reducing uniformly at the end of each year to 1% per annum from year 6 onwards. These improvements are expected to have a cumulative effect over time. For example, if the reduction in car failure rates in year t is i_t, then the adjusted car failure rate in year 3 is $(1 - i_1)(1 - i_2)(1 - i_3) \times q_x$, where q_x is the car failure rate for a car aged x.

The editor of the vintage car magazine has approached your boss and asked for her help in performing calculations to show the impact that these reductions in car failure rates might have on the life expectancy until failure of older cars. To do this separate calculations are required for the oil change scenario and the tyre change scenario and for cars which are exactly 10 and exactly 15 years old.

To assist with this work your boss has provided you with car failure rates by age from the Vehicle Welfare Institute for cars aged exactly 10 years and over. The failure rates provided are for cars that have not had regular oil or tyre changes.

PART 1

Your boss has asked you to construct a spreadsheet model for analysis of the expected impact of each of the scenarios on car failure rates. You are required to carry out checks throughout.

(i) Set up a spreadsheet to include separate worksheets for the "Data"," Parameters", "Base", "Oil Change", "Tyre Change", "Results" and any other worksheets as required. [2]

(ii) Perform a range of checks on the data provided to check the validity of the data, and comment on whether the data appears to be reasonable. For example, check that the probabilities are sensible. You are not required to make any alterations to the data. [5]

(iii) In the "Base" worksheet, calculate the probability of survival for cars at each age from 10 to 50. [1]

(iv) Determine the cumulative probability of survival for cars currently 10 years old and cars aged 15 years old. [3]

(v) Hence determine the life expectancy until failure for a 10 year old car and a 15 year old car in the Base scenario. [2]

(vi) In the "Oil Change" worksheet, determine the adjusted car failure rates for a 10 year old car after allowing for a 5% per annum reduction in car failure rates relative to the "Base" scenario. [3]

(vii) Hence determine the cumulative probability of survival and life expectancy until failure for a 10 year old car. [4]

(viii) Repeat parts (vi) – (vii) for a 15 year old car. [4]

(ix) In the "Parameters" worksheet, generate the expected reductions in car failure rates under the Tyre Change scenario for each future year. [2]

(x) In the "Tyre Change" worksheet, determine the adjusted car failure rates for a 10 year old car after allowing for the expected reductions in car failure rates calculated in part (ix). [3]

(xi) Hence determine the cumulative probability of survival and life expectancy until failure for a 10 year old car. [2]

(xii) Repeat parts (x) – (xi) for a 15 year old car. [4]

(xiii) Produce a chart in the "Results" worksheet to show the future expected failure rates under each of the three scenarios for a car currently 10 years old. [3]

(xiv) Produce a chart in the "Results" worksheet to compare the life expectancy until failure under each of the three scenarios for both 10 and 15 year old cars. [3]

Marks available for model accuracy, completeness and good modelling techniques [41]

[Sub-total 41]

PART 2

You need to document all your work in an audit trail so that a fellow Analyst student (with similar experience to yourself) could:

- peer review and check your model.
- continue to work on your model, and
- run your model on different assumptions, or extend your model to allow for extra data fields or scenarios.

Your audit trail should include the following aspects:

- the purpose of the model
- any assumptions you have made
- any limitations of your assumptions or of the model
- your methodology, i.e. a description of what you have done, and how and where in the model you have done it
- an explanation of all the checks you have performed
- a description of the charts you have produced

The audit trail can be in a separate worksheet within your Excel model or in a separate Word document.

Marks available for audit trail:

Audit approach

- **Fellow Analyst student can review, check and modify the model** **[8]**
- **Written in clear English** **[4]**
- **Written in a logical order** **[3]**

Audit content

- **All model steps accurately covered** **[24]**
- **All checks clearly recorded** **[7]**
- **All steps clearly explained** **[7]**
- **Clear signposting and labelling** **[6]**

[Sub-total 59]

[Total 100]

Additional information

Probability of Survival

The probability of survival p_x is the probability that a car aged x will survive to age $x + 1$, which may be calculated as:

$$p_x = 1 - q_x$$

Where q_x is the car failure rate, the probability that a car aged x will fail by age $x + 1$.

Life Expectancy

The life expectancy from age x can be calculated as:

$$e_x = \sum_{t=1}^{\infty} {}_tp_x$$

Where ${}_tp_x$ is the cumulative probability of survivorship from age x to age $x + t$, which can be calculated as:

$${}_tp_x = p_x \times p_{x+1} \times p_{x+2} \times \ldots \times p_{x+t-1}$$

END OF PAPER