CAA GLOBAL

9 May 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

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Background

Company X is an insurance company, and it is currently considering making changes to the design of one of its investment products.

You are an actuarial analyst working for Act Consultant inc, an actuarial consultancy firm. Company X has approached your boss, a qualified actuary, and asked him to perform some modelling in order to help Company X understand the impact on the expected total returns on the investment product following the proposed changes to the product's design.

Product description

The product that Company X is considering changing is called the "Prize Bond".

The bondholder invests a single premium at the start of the contract, with interest being added to the customer's fund value at the end of each year. The rate of interest that is added at the end of each year is determined by means of random selection.

Each Prize Bond is randomly assigned a number between 0 and 1, to 4 decimal places, at the end of each year. The random number allocated to a particular bond will then determine the level of interest that will be added to the fund value for that bond.

Current Rates of Interest

Allocated Random Number		Interest rate p.a. (% of fund)
From	*To*	
0.0000	0.1999	0%
0.2000	0.3999	1%
0.4000	0.5999	2%
0.6000	0.7999	3%
0.8000	1.0000	4%

The marketing director of Company X believes an alternative product design with higher potential prizes would be more attractive to customers and has proposed an alternative prize breakdown as follows:

Proposed Rates of Interest

Allocated Random Number		Interest rate p.a. (% of fund)
From	*To*	
0.0000	0.1999	0%
0.2000	0.3999	1%
0.4000	0.5999	2%
0.6000	0.7999	8%
0.8000	1.0000	10%

Additional information

Company X has provided the following additional information to allow you to model the proposed new rates of interest:

- Each bond holder invests £150,000 at the start of the contract.

- Each bond has a fixed term of 20 years, with no withdrawals or surrenders allowed prior to the end of this period.

- Under the current product structure, an annual management charge of 0.5% p.a. of the fund value is applied. This is deducted from the fund value of each bond at the end of each year immediately after any interest has been added.

- The only factors which impact on the value of each bond are the prize interest applied and the annual management charges deducted.

- An additional Excel model which sets out 4,000 random simulations from a uniform U[0,1] distribution. These represent the random numbers to be used to determine the prize interest for 200 simulated bonds over the next 20 years. Each row of data represents the simulations for each of the 200 bonds. Each column represents a projection year, from 1 to 20.

PART 1

(i)   Set up a spreadsheet to include separate worksheets for the data, parameters, projected fund values based on current rates of interest, projected fund values based on proposed rates of interest, charts and any other worksheets as required.   [2]

(ii)   Perform a range of checks on the simulated probability data provided and comment on whether the data appears to be sensible, given the information you have been provided. You are not required to make any alterations to the data.   [9]

(iii) In the current prize bond worksheet, use the simulated probability data and current interest rates provided to produce a table of the simulated interest rates added at the end of each of the 20 years for the 200 simulated bonds.   [3]

(iv)   In the same worksheet use the expected investment returns determined in (iii) and apply the annual management charge to produce 200 sets of projections to determine the expected value of each bond at the end of each of the 20 years.   [3]

   Hint: See the additional guidance on how to calculate the expected bond value.

(v)   Rank the 200 simulated bonds in ascending order, from 1 to 200, based on the projected fund values of each bond at the end of the 20 year period.   [2]

(vi)   Hence identify the simulations ranked 50th, 100th and 150th. In a separate worksheet, construct a suitable chart to illustrate the projected fund value at the end of each year over the term of the bond for each of these three simulations.   [4]

(vii) In the current prize bond worksheet calculate, for each of the 200 projections, the effective annualised returns after the management charges over the 20 year period.   [2]

(viii) Determine, over all 200 projections:

   (a)   the annualised maximum return, after the management charge
   (b)   the annualised minimum return, after the management charge
   (c)   the annualised mean return, after the management charge   [3]

(ix)   In the proposed prize bond worksheet repeat the calculations in steps (iii) to (viii) using the new proposed interest rates.   [8]

(x)   Using goal seek or otherwise, determine the level of annual management charge for the prize bond, using the new proposed interest rates, which produces a mean investment return equal to the mean investment return on the prize bond using the current interest rates.   [2]

(xi)   Construct a chart to illustrate the annualised maximum, minimum and mean returns for both the current and proposed prize bond projections.   [3]

Marks available for spreadsheet model:

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**   **[5]**
- **Written in a logical order**   **[3]**

Audit content

- **All model steps accurately covered**   **[20]**
- **All checks clearly recorded**   **[8]**
- **All steps clearly explained**   **[8]**
- **Clear signposting and labelling**   **[7]**

[Sub-total 59]

[Total 100]

Additional guidance

Expected Bond Value

The expected bond value f(t) at the end of year t can be calculated using the following relationship:

f(t) = f(t-1) x *(1 + i)* x *(1 – amc)*

where

f(t-1) the expected bond value at the end of year t-1
i is the interest rate p.a. (% of fund)
amc is the annual management charge p.a. (% of fund)

Useful Excel functions

The RANK() function in Excel can be used to return the ranking of a cell within an unsorted array of numbers. For example, RANK [cell, array, 0] will return the ranking that the number in the given cell would have if the (unsorted) array was sorted into descending order. And RANK[cell, array, 1] will take a similar approach but assuming it was sorted into ascending order.

The GOALSEEK utility in Excel can be used to determine the input values needed to achieve a specific goal. In the Data Tools group of the Data menu tab, GOALSEEK may be found in the What-If Analysis menu. It allows you to set a chosen cell to a specified value by altering a given input value.

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