

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

3 October 2019 (am)

Subject CP2 – Modelling Practice Core Practices

Paper One

Time allowed: Three hours and fifteen minutes

INSTRUCTIONS TO THE CANDIDATE

1. *You are given this question paper and the Excel file.*
2. *Mark allocations are shown in brackets.*
3. *Attempt all questions. Questions are to be answered as per “exam requirements”.*

If you encounter any issues during the examination, please contact the Examinations Team at
T. +44 (0) 1865 268 255

Exam requirements

- 1** Read the background document, which describes the scenarios that need to be modelled and documented for this project.
- 2** Construct a spreadsheet model that produces the following calculations and charts. You should ensure that your spreadsheet contains appropriate self-checks and that you have performed (and documented in the audit trail) reasonableness checks at each stage of your calculations.
 - (i) Verify the data provided, confirming it does come from the Uniform (0,1) distribution by calculating summary statistics and checking the overall distribution. [5]
 - (ii) For each simulation:
 - (a) calculate the expected number of hours of sunshine
 - (b) determine the expected number of bottles of wine that could be produced
 - (c) calculate the expected profit that the vineyard could generate. [6]
 - (iii) Calculate the following key statistics from the simulations produced in part (ii):
 - (a) the average expected profit (and compare against the theoretical average)
 - (b) the maximum profit
 - (c) the maximum loss
 - (d) the probability that the wine producer will incur a loss. [3]
 - (iv) Produce a chart to illustrate the variability of the potential outcomes from the simulations in part (ii), showing the amount of profit in ascending order. [2]
 - (v) Determine the components of expected profit for the median simulation. [3]
 - (vi) Calculate the minimum price for each bottle that would need to be charged so that there would be no loss incurred across all simulations. [3]
 - (vii) Repeat steps (ii), (iii) and (v) for the alternative vineyard investment opportunity. [5]
 - (viii) Produce a chart or charts to illustrate the key statistics for the outcomes under both investment opportunities. [1]
 - (ix) Produce a chart to illustrate the components of expected profit for the median outcome under both investment opportunities. [2]

Note: all scenarios outlined on page 2 should be modelled separately within your spreadsheet. The user should not need to change the parameters to see the results.

Marks available for spreadsheet model and checks:

Accurate completion of above modelling steps and associated checks. [30]

Demonstration of good modelling technique and practice. [7]

[Sub-total 37]

3 Produce an audit trail for your spreadsheet model which includes the following aspects:

- (a) purpose of the model
- (b) data and assumptions used
- (c) methodology, i.e. description of how each calculation stage in the model has been produced
- (d) explanation of the checks performed.

You should ensure that your audit trail is suitable for both a senior actuary, who has been asked to approve your work, and a fellow student, who has been asked to peer review and correct your model, or may be asked to continue to work on it or to use it again for a similar purpose in the future.

Marks available for audit trail:

Audit approach

- Communication skills [4]
- Fellow student can review and check methods used in the model [7]
- Senior actuary can scrutinise and understand what has been done [7]
- Written in clear English [4]
- Written in a logical order [3]

Audit content

- All steps clearly explained [8]
- Reasonableness checks included [5]
- Clear signposting included throughout [4]
- Statement of assumptions made [5]
- All model steps accurately covered [16]

[Sub-total 63]

[Total 100]

Background

WineCo is a producer of fine wine. The company is considering an investment under which it would rent a new vineyard. The annual rental cost of the vineyard is \$20,000 per annum.

The vineyard has 10,000 vines on which grapes grow. The number of grapes that grow on a vine is dependent on the number of hours of sunshine that the vine is exposed to during the growing period. The grapes develop on the vines for a period of 100 days.

The daily number of hours of sunshine follows the Uniform Distribution (0,12) with a mean of six hours of sunshine.

The total number of grapes that are expected to be grown in the vineyard can be calculated from the following formula, which has been provided by the Wine Association:

$$\text{Number of grapes} = \text{number of vines} \times e^{(Ax+B)}$$

Where A and B are fixed variables and x is the total number of hours of sunshine that the vine is exposed to over the growing period.

The wine producer has advised that variable A equals 0.0054 and variable B equals 2.37.

At the end of the growing period, all grapes are picked from the vines (using a team of 20 grape pickers). The harvested grapes are then used to produce bottles of wine. It is expected that while the grapes are being picked, there will be some spoilage. The wine producer has advised that 10% is a typical spoilage rate.

WineCo has also advised that:

- 750 grapes are required to produce one bottle of wine
- the expected variable costs to produce one bottle of wine is \$2 (this includes materials, machinery and employment costs)
- the bottles of wine can be sold for \$10 per bottle.

The wine producer has asked your company to determine the profitability of this potential investment by calculating expected revenue and expected costs (including the annual rental cost).

Modelling

You have been provided with an Excel file with 10,000 random numbers from the Uniform (0,1) distribution. This has been provided in the format of 100 rows by 100 columns.

Your manager would like you to use these random numbers to produce 100 simulations of the potential profit or loss that could be generated from the investment in the vineyard.

Using these projections, your manager would also like you to:

- 1 Calculate the key statistics to illustrate the potential outcomes of these projections.
- 2 Produce a chart showing the variability of the profit/loss outcomes under all the simulations completed showing the amount of profit in ascending order.
- 3 Determine the median outcome for the projections. (For the purposes of this work, the median outcome should be taken as the 50th outcome when the outcomes are ranked in ascending order.) The wine producer is interested in knowing the various components of expected profit (i.e. the components of revenue and costs) for this outcome.

To further understand the potential risk involved in this investment, the wine producer would like to know the minimum price that would need to be charged to avoid a loss across the simulations.

Alternative option

The wine producer has been contacted about another potential vineyard of a similar size in another region, which could be rented for \$25,000 per annum.

The production of grapes follows the same formula as above. However, although the number of hours of sunshine per day still follows the uniform distribution in the new region, the maximum number of hours of sunshine per day is 15 hours (minimum of zero). The higher levels of sunshine leaves the region exposed to heavy rain at the end of the summer, meaning the vines can only be grown for a period of 90 days.

The grapes can then only be harvested for a period of ten days. To ensure all the grapes are picked within this time, the grape pickers need to work for the maximum number of possible hours each day. However, workers in this region are protected by strict legislation. This legislation sets out the terms under which the grape pickers can work, namely:

- (i) Workers can only work when the sun is shining.
- (ii) While workers can work up to a maximum of 15 hours per day, if the number of hours worked exceeds 7.5 hours in any one day, they will be entitled to an overtime payment of \$5 per hour for each hour (or part thereof) over 7.5 hours. For example, if a worker works 9 hours in any one day, they will receive an overtime payment of \$7.50, being 1.5 hours multiplied by \$5.

You have been asked to complete the same analysis for this option so that comparisons can be made between the two investment opportunities.

Your manager is out of the office and cannot be contacted for the next three hours. They would like the above calculations finished and documented in an audit trail ready for their return.

END OF PAPER