

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

9 April 2024 (am)

Subject CP2 – Modelling Practice Core Practices

Paper Two

Time allowed: Three hours and twenty minutes

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator.

If you encounter any issues during the examination please contact the Assessment Team on T. 0044 (0) 1865 268 873.

Exam requirements

Read the background document, which describes the scenario that has been modelled and documented for this project and the work that remains outstanding.

Read the audit trail that has been written by your colleague, another actuarial student, for the calculations that they performed. This will assist you in following and understanding the calculations performed in the Excel model provided.

You are not required to add to or amend the audit trail.

You should assume that your colleague's calculations have been checked and are correct.

1 Spreadsheet model

Expand the spreadsheet model to:

- (i) Recalculate the net present value of profits over the 5-year period for both plants when the number of computers produced is capped to demand (wherever applicable). [3]
- (ii) Recalculate the net present value of profits over the 5-year period for both plants under the adverse economic scenario (under this scenario, if applicable, the number of computers produced is capped to demand). [5]

You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks.

[Sub-total 8]

2 Charts

Construct, for each of the following, suitable charts to illustrate:

- (i) The relationship between the historic market demand and the Interbank Interest Rate (IIR). [3]
- (ii) The projection of all future cashflow components for Plant A and Plant B under the base economic scenario after capping the number of computers produced to demand. [3]
- (iii) A comparison of net cashflows for each of the forecast years for Plant A against Plant B under:
 - (a) the base economic scenario with production capped to demand.
 - (b) the adverse economic scenario, also with production capped to demand.

[4]

[Sub-total 10]

3 Summary document

Prepare a summary document of around five to seven pages, capturing the main features and results of the work done by you and your colleague. You can assume that the summary is being prepared for your manager, a senior actuary, who will present the work to the client.

Your summary should include the following:

- The purpose of the project, data, method and assumptions used by you and your colleague
- Results, including relevant tables and charts
- Commentary on the results
- Key conclusions
- Suggested next steps.

Commentary on the results should cover, but not be limited to:

- analytical comments on each stage of the results, including explaining patterns in the results and any unusual features.
- an explanation of the differences between the results under the scenarios modelled.

Next steps need to be specific to the project, with some mention of why each is valid. The summary should cover the full scope of the project, including the current approach, which was modelled in the spreadsheet provided.

You are not required to add to or amend the audit trail.

Marks available for the summary:

(i)	Methodology (including purpose, data, method and assumptions).	[26]
(ii)	Results, including charts.	[5]
(iii)	Commentary on results and conclusions.	[22]
(iv)	Next steps.	[19]
(v)	Drafting.	[10]
		[Sub-total 82]
		[Total 100]

Background

A computer manufacturing company is considering moving one of its key manufacturing plants to a new site to enable automation of processes and improve efficiency. Your company has been approached to assess the financial impact of this change given the below details:

- The existing plant, Plant A, is old with a lot of manual processes and requires frequent repairs. As a result, the number of employees required to run Plant A is 80, with an average staff cost of \$8,000 per month per employee. In contrast, the new plant (Plant B) would be largely automated and is expected to be run by a smaller, highly technical team of 20 with an average staff cost of \$10,000 per month per employee.
- Plant A has the capacity to produce 1,020 computers per month under normal operations, compared to a potential production of 2,040 computers per month at Plant B.
- Computers produced by Plant A can be sold for \$2,000, while computers produced by Plant B will have higher specifications and can be sold for \$2,100.
- The cost of the raw materials required by the two plants is the same, at \$200 per computer.
- For both plants, salaries are expected to increase by 6% p.a.
- The cost of building Plant B is estimated to be \$100 million.

The project team believes that demand for the computers is expected to be driven by economic variables. The Interbank Interest Rate (IIR) is a suggested good measure of economic performance and the following formula could be used to estimate future demand of computers:

$$\text{Demand} = \text{intercept} + \text{slope coefficient} \times \text{IIR}$$

The project team has obtained the historical IIRs for the last 60 months from the reserve bank's website. The computer manufacturing company has also provided the monthly market demand for its computers over the same period.

The expected IIRs under normal economic conditions for the next 5 years were obtained from the annual report of a reputable econometrics consulting firm.

Your company has been asked to construct a financial model to determine:

1. the intercept and slope coefficient of the demand formula above, to establish the relationship between the demand for computers and the IIR (and test the statistical significance of the relationship found).
2. the expected demand for computers over the next 5 years.
3. the net present value of the profit for the next 5 years between the two projects, using a discount rate of 7% p.a. to determine if building a new plant would be financially viable.

Your colleague has prepared a spreadsheet to calculate the above, assuming that the plants will operate at maximum capacity. However, the computers sold are capped at demand level.

Additional considerations

The computer manufacturing company would like to consider the impact on profits if production is capped at the expected demand level to reduce production and warehousing costs.

In addition, the company would like to consider an adverse economic scenario under which the following applies:

- The IIRs over the following 5-year period are expected to reduce by 50%.
- Salary increases are expected to be 75% lower than that assumed from the base economic scenario salary increases, i.e. 25% of 6%.
- The company does not expect to have sufficient resources to carry out breakdown repairs. As a result, Plant A production capacity is expected to reduce the number of computers produced in any single year by 40%. Plant B is not expected to breakdown so often and only 10% production is expected to be lost.
- For this scenario, you should again assume that production is capped at the expected demand level.

Your manager has asked you to update the model to:

- recalculate the net present value of profits over the 5-year period for both plants when production is capped to demand (retaining the base economic conditions).
- recalculate the net present value of profits over the 5-year period for both plants under the adverse economic scenario.

Your manager has asked you to prepare a summary covering all elements of the work (both the original work that your colleague completed and the additional modelling that you have completed).

Your summary should include the following:

- Purpose of the project, data, method and assumptions used by you and your colleague
- Commentary on the regression analysis results, including charts as outlined in the exam instructions above
- Commentary on the cashflow projection results from the plants, and key conclusions
- Suggested next steps.

You are not expected to include the additional modelling you undertake in the audit trail, but all results should be included in the summary.

Audit trail

Objective

A computer manufacturing company is considering constructing a new manufacturing plant to improve the automation and efficiency of its processes. The purpose of the model is to estimate the expected revenue, costs and profits over the next 5 years under the two options:

- A. Maintaining the existing plant
- B. Building a new plant.

The demand for computers is assumed to follow a linear equation. A regression analysis will be performed to check the relationship between the demand and the Interbank Interest Rate (IIR) based on historic data.

Data

The computer manufacturing company has provided the demand of their computers for each of the last 60 months. The corresponding IIRs for the same period were obtained from the reserve bank's website. These are provided in the 'Data' worksheet.

Expected capital expenditure, material costs, staff costs and the price of each computer have also been provided by the company and are documented in the 'Parameters' worksheet. Production capacity and discount rates have also been provided by the company.

The forecasted IIRs, under a normal economic scenario, for the next 5 years were obtained from the annual report of a reputable econometrics consulting firm.

Data checks

The following data checks are completed in this worksheet:

- In cell B3 and C3, the Excel COUNT function is used across the market demand entries and IIR data points. Automatic checks for this are added in the cells to the right of this, which return true if the count is 60.
- The Excel MIN and MAX functions are used to return the smallest and largest value of each of the market demand data and the IIRs in cells B4:C5. Demand is always expected to be non-negative so an automated check is included to check that the minimum value obtained is greater than or equal to zero in cell D4.

Reasonableness check: The maximum market demand and IIR are both greater than the minimum market demand and IIR, respectively. This is consistent with the hypothesis that market demand increases when IIRs increase.

Assumptions

1. The monthly observations are independent.
2. There are no other costs associated with the manufacture of the computers.
3. Capital expense outlay occurs at the beginning of the period.
4. Raw material costs, staff costs and revenue are assumed to be spread evenly over the year.

Regression

This worksheet provides the regression analysis of the historic demand against the IIRs.

Standard Excel Linear Regression functionality was used (from the Analysis Toolpak). The 'Regression' worksheet shows the output, with some modifications made to aid understanding and interpretation of the results. This was pointed to columns B and C on the 'Data checks' worksheet. The key results included on the 'Regression' worksheet are:

- The intercept, shown in cell B3
- The slope coefficient, shown in cell B4
- The T-test values, given in cells D3:D4, and the corresponding P-values next to them in column E. Both the values are well below the 5% confidence interval so we can reject the null hypothesis that there is no relationship between IIR and Demand.

The coefficient of determination (R^2) is shown in B8. The level of R^2 of about 0.65 confirms that about 65% of the variability is explained by the linear regression equation fitted.

Cashflow Projection Plant A

This worksheet provides cashflow projections for the existing plant for 5 years.

Column B provides the forecasted IIRs for the next 5 years. The demand for each year (t) is calculated in column C using the formula:

$$\text{Predicted demand}_t = 12 \times (\text{Intercept} + \text{slope coefficient} \times \text{IIR}_t)$$

Column D calculates the potential production for the plant using an IF statement depending on which plant is being considered and using information from the 'Parameters' worksheet.

Column E calculates the computers expected to be sold each year as the minimum of the calculated demand and the potential production.

Revenue is calculated in column G as the computers sold multiplied by revenue per computer for plant A from the 'Parameters' worksheet.

The costs of operating the manufacturing factory are calculated in columns H to J:

- Any capital expense is included in column H.
- The cost of raw material is calculated in column I as the number of units produced multiplied by cost of raw material per computer for plant A from the 'Parameters' worksheet.
- Staff cost is calculated as the number of employees from the 'Parameters' worksheet multiplied by the average salary and applicable salary inflation. An IF statement is used here to pick up the correct number of employees and the correct average salary for each plant, multiplied by 12 to find the annual cost.

Net cashflow is calculated as revenue less expenses, allowing for the time value of money. The below formula is used to calculate the net cashflows for each year in column L:

$$\text{Net cashflow} = (\text{revenue} - \text{cost of raw materials} - \text{staff cost}) + \text{capital expense}$$

Discount factors are calculated in column M as:

$$\text{Discount factor}_t = (1 + i)^{-(t - 0.5)}$$

for all projection periods t .

The discounted net cashflow is calculated in L4 using the formula:

$$\begin{aligned} \text{Discounted net cashflow} = & \sum_{t=1}^{t=5} \text{net cashflow}_t \times \text{discount factor}_t \\ & + (1 - \text{discount factor}_1) \times \text{capital expenditure} \end{aligned}$$

The capital expenditure is assumed to take place at the start of the year, and so the discounting applied in the SUMPRODUCT function is added back.

Cashflow Projection Plant B

This sheet provides cashflow projections for the new plant for 5 years.

The calculations in this worksheet are similar to the 'Cashflow Projection Plant A' worksheet, but cell A6 has been updated to 'Plant B' so that the parameters for Plant B are picked up in the formulae.

END OF PAPER