

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

November 2025

CP2 - Actuarial Modelling (Paper A)

Time allowed: 3 Hours 15 Minutes

Total Marks: 100

Q. 1) Modelling steps and data checks

Read the background document, which describes the scenarios that need to be modelled and documented for this project.

Construct a spreadsheet model that produces the following calculations. 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) Carry out checks on the data provided, making any adjustments wherever necessary to confirm that the data is complete, reasonable, and fit to use. (3)
- ii) Verify that the data provided for number of faulty days in a month during the export of electricity follow Poisson distribution with mean of 4 by performing a chi-squared test.

Note:
 1. You are not expected to make any changes to the data. You will also be able to continue to complete the model using the numbers provided even if you have not completed the required verification.
 2. The chi-squared test can be performed using *CHIINV* Excel function at 85% confidence interval and expected cumulative frequency can be determined using *POISSON.DIST* Excel function. (4)
- iii) Calculate the following details pertaining to import and export of oil on monthly basis for period of 10 years:
 - a) Import of crude oil from company A (in barrels) (2)
 - b) Price of crude oil per barrel imported from company A (2)
 - c) Price of crude oil per barrel imported from company B (2)
 - d) Total value of import of crude oil (0.5)
 - e) Value of exports of refined oil to other countries (2.5)
- iv) Calculate the following details pertaining to import and export of essential and non-essential items on monthly basis for period of 10 years:
 - a) Price of import and export of essential and non-essential items per unit (4.5)
 - b) Value of import and export of essential and non-essential items (1)
- v) Calculate the following details pertaining to exports of electricity on monthly basis for period of 10 years:
 - a) Price of export of electricity per unit (2)
 - b) Value of export of electricity (after considering the penalty for faulty days) (2)
- vi) Estimate the cumulative foreign exchange reserves of the country at the end of each month for the period of 10 years. (1.5)
- vii) Calculate the following details after the sovereign credit ratings requirement on monthly basis for period of 10 years:

- a) Quantity of imports of non-essential items (in units) (2.5)
- b) Cumulative foreign exchange reserves at the end of each month (0.5)
- viii) Construct a chart that shows the cumulative foreign exchange reserves of the country at the end of each year over the period of next 10 years before and after the sovereign credit rating requirements. (3)

[Note: all scenarios outlined above should be modelled separately in your spreadsheet. The user should not need to change the parameters to see the results.]

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Q. 2) Modelling technique and practice

- i) Auto checks or reasonableness checks on the modelling completed in (Q.1). (4)
 - ii) Demonstration of good modelling techniques and practice. (6)
- [10]

Q. 3) Audit trail

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

- Purpose of the model
- Data and assumptions used
- Methodology, i.e., description of how each calculation stage in the model has been produced
- Explanation of 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, to continue work on it or to use it again for a similar purpose in the future.

Marks available for audit trail:

Audit approach

- i) Communication skills (the audit trail provides enough detail to be read as a stand-alone document). (4)
- ii) Fellow students can review and check methods used in the model. (7)
- iii) Senior actuary can scrutinize and understand what has been done. (7)
- iv) Written in clear English. (4)
- v) Written in a logical order. (3)

Audit content

- i) All steps clearly explained. (8)
 - ii) Clear signposting included throughout. (4)
 - iii) Statement of assumptions made. (5)
- (15)

- iv) All model steps accurately covered.

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Background

The government of a country wants to ensure that sufficient foreign exchange reserves are available to maintain economic stability within the country over the period of next 10 years. The government has an initial foreign exchange reserve of \$2,00,00,000.

The government has reached out to your actuarial firm, RST Actuarial Services, to assist them with this exercise.

The government has provided the following information for this exercise:

Import and export of oil

The country imports crude oil from 2 foreign companies, company A and company B.

The country has a long-term agreement with company A to import crude oil. The import of crude oil during the first month will be 12,000 barrels. This will grow every month by 0.5% of previous month's barrels till the end of fifth year. Thereafter, there will be degrowth of 1% every month. The price of crude oil from company A will be \$60 per barrel for the first year. This price will increase at the start of each year from second year onwards at an annual rate of 4%.

The monthly import of crude oil from company B has been shared in the data template. The price of crude oil from company B will be derived based on the prevailing price of crude oil imported from company A. The price of crude oil imported from country B will be available at a discount of 6% as compared to the price of crude oil imported from company A during the first year. From the start of second year, this discount will increase linearly every year by 1% till the price of crude oil imported from company A is within \$75 per barrel. The discount will not change further after the crude oil imported from company A breaches the price of \$75 per barrel.

The oil imported will be refined within the country and 60% of this refined oil will be consumed domestically. The remaining 40% of the refined oil will be exported to other countries. The price of refined oil per barrel exported to other countries will be 35% higher than the weighted average price of crude oil imported from company A and company B.

Import and export of essential and non-essential items

The quantity (in units) of import and export of essential and non-essential items of the country are shared in the data template.

The details of price of essential and non-essential items per unit that will be imported are shown below:

Particulars	Essential items	Non-essential items
Price per unit during first month	\$65	\$30
Number of years before increase in price	6	2
Percentage increase in price	25%	5%

The details of price of essential and non-essential items per unit exported are shown below:

Particulars	Essential items	Non-essential items
Price per unit during first month	\$40	\$50
Number of years before increase in price	5	3

Percentage increase in price	15%	10%
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The percentage increase in price for import and export of both essential and non-essential items will be calculated on their previous month's price.

For instance, the price of import of non-essential items per unit will increase after the end of every 2 years by 5% of the previous month's price. Similarly, the price of import of essential items and export of essential and non-essential items per item will change based on the values provided in above table.

Exports of electricity

The country exports entire surplus electricity generated from renewable sources to other countries. In case the company experiences fault during the export of electricity, such faults will last for an entire day and the company will not be able to export any electricity during such faulty days. The number of such faulty days in a month is expected to follow Poisson distribution with mean of 4. Additionally, the country will have to pay a penalty of \$20,000 per faulty day. The surplus electricity (in units) that can be exported before faulty days and number of faulty days on monthly basis have been shared in the data template. *(You can assume that there are 30 days in a month and surplus electricity per day is identical in a month).*

The price of electricity exported will be \$25 per unit during the first month. This will increase by 2% if number of faults in the previous month is less than 4, decrease by 1% if number of faults in the previous month is more than 4 and remains the same if number of faults in the previous month is 4. This change in price will be calculated on the previous month's prevailing price.

Sovereign credit rating requirements

The government wants to ensure that the sovereign credit ratings will not deteriorate over the period of next 10 years to enjoy favorable debt obligations, reduce fiscal deficit and support domestic economic growth. It has been indicated by the credit rating agencies that if the expected foreign exchange reserves fall below \$1,00,00,000, there are chances that the sovereign credit ratings might deteriorate. To avoid the deterioration of sovereign credit ratings, the government will introduce the import restriction as follows:

The import of non-essential items will be discontinued after the cumulative foreign exchange reserves fall below \$1,25,00,000. This restriction will remain active until the cumulative foreign exchange reserves reach \$1,35,00,000. The import of non-essential items will resume from the same position as it would have been without restriction after foreign exchange reserves are above \$1,35,00,000.

Additional Information:

The quantity of crude oil barrels imported from company A and company B, refined oil barrels exported to other countries and import and export of essential and non-essential items need to be rounded downwards to the next integer at each month of projection. The price of crude oil per barrel imported from company A and company B, price of refined oil per barrel exported to other countries, price of import and export of essential and non-essential items per unit and price of export of electricity per unit need to be rounded nearest to 2 decimals at each month of projection.

The few parameters and its values, as described in the background, required for the purpose of projection are provided in "Parameters" sheet in the data template. *(You are not required to carry out checks on these parameter values.)*
