

INSTITUTE OF ACTUARIES OF INDIA
EXAMINATIONS

26th March 2022

**Subject CM2B – Financial Engineering and Loss
Reserving (Paper B)**

Time allowed: 2 Hour (14.30 – 16.30 Hours)

Total Marks: 100

- Q. 1)** A newly formed toll operating company named RRR Inc. has applied for many tenders to operate national highway roads through the country. The CEO of RRR Inc. is confident that the company would certainly bag at least 3 deals from the applications.

Now, the CEO wishes to **understand various financial uncertainties in collection of toll fee** of these 3 projects. The weights to be given to projects 1, 2 & 3 are in the ratio 50:20:30 respectively.

One of the employees, who has advised to estimate the above information **using a single factor index model** from the data available from a similar company Q Inc. already operating in the industry.

The CEO is wary of such gross generalizations and agrees to the use of modified **Single factor index model**.

The company would use betas of fees from 3 already completed projects of Q Inc.

However, **the modifications** are as follows:

- Betas would be increased by 10%.
- Variance of the error terms under each project in the Model would be derived using Value of risks (which were derived from a different source) assuming that error terms follow normal distribution with Mean = 0.

The following information is given in the data:

- Historical monthly toll fee collected for 3 projects of Q Inc.
- Average historical monthly fee of all the tolls in the country.
- Monthly Value at risk at 5% confidence level to be used for each of the projects.

Notes & Instructions:

- Single factor index model is defined in the Golden book.
- Beta represents sensitivity of project's fee to country's fee.
- Standard Normal inverse value at $\alpha = 5\%$ is given in the excel template.

- i)** Estimate monthly Betas from 3 projects of Q Inc. (8)
- ii)** Estimate the monthly Systematic risk, Specific risk & Total risk under each of the projects of RRR Inc. (11)
- iii)** Estimate the monthly Systematic risk, Specific risks & Total risk of the portfolio for RRR Inc. (9)
- iv)** Check if Total risk is equal to the sum of Systematic risk and Specific risk. (5)

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- Q. 2)** A mid-sized health insurance company is selling one-month term health insurance policies. The premium is collected at the beginning of the month and all claims are reported within twelve months from the end of term of the policy. The data of the claims reported for policies written from March 2020 to March 2021 is provided.

- i) Calculate the Development Factors for each development month and calculate the reserve as at 31.03.2021 using Basic Chain Ladder method. (10)

The country in which the insurer has its operations was affected with COVID and due to that the Country went on lock-down during the months of September 2020 and October 2020. This severely affected the flow of premium and claims. After October 2020, the premium flow started increasing. Due to the pandemic, the expected loss on the portfolio also increased. The data of premium received from March 2020 to March 2021 and expected claim ratio for each month is provided.

- ii) Calculate the reserves required as at 31.03.2021 using Bornhuetter-Ferguson Method. (12)

- iii) Compare the results of (i) & (ii) and comment on the limitation of Basic Chain Ladder method. (6)

To make the model more statistically credible, it is assumed that all claims will be reported within six months. The revised data is provided.

- iv) Calculate the revised reserve as at 31.03.2021 using Basic Chain Ladder Method and comment on the results by comparing the same with the results of (i) of the corresponding period. (6)

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- Q. 3)** i) The share price of a non-dividend paying chemical company is currently trading at Rs. 435. The price of the share is modelled by a two-period recombining binomial model assuming that it will increase or decrease by 10% every month.

Given the risk-free rate of interest (continuously compounding) is at 4% per annum.

Let S1, S2, S3 denote the three possible stock prices at the end of the second month.

S1: Denotes the stock price resulting from two up-steps

S2: Denotes the result of an up then down (or down then up) step

S3: Denotes the result of two down steps.

The state price deflators for these states are:

State	Price	State Price Deflator
1	S1	0.8950
2	S2	1.1004
3	S3	1.1890

- a) Calculate the state prices for the three states. (4)
- b) Using state price deflators estimate the expected share price at the end of 2 months and calculate the monthly rate of return on the share. (5)
- c) Calculate the value of put option (using risk-neutral probability) on this chemical companies share with strike price at Rs.420. (2)
- ii) Assume the current price of put option is Rs.12 and other values same as given above, estimate implied volatility of the share (σ). (6)

- iii) Calculate “Vega” of this European put option using the results from (i)c and (ii) above and hence estimate the impact of 1% volatility change in the price. (4)
- iv) Using put-call parity or otherwise calculate the price of European call option with same put option and exercise price as given in (ii) above. (3)
- v) Calculate the current price of 2-month forward contract on this share. (2)
- vi) Show the portfolio payoff at maturity, if an investor has a long position on one call option and short position in 2-month forward on the share, if the share price varies in the range of Rs.300 to Rs.600. Prepare a suitable graph showing the total payoff at maturity of the investor’s portfolio. (7)

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