

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

20th November 2019

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

Time allowed: 1 Hour 45 Minutes (14.45 – 16.30 Hours)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

- 1. Mark allocations are shown in brackets.*
- 2. Attempt all questions, beginning your answer to each question in the template provided.*
- 3. Attempt all sub-parts of the question in the template provided only, unless otherwise instructed to do so.*
- 4. The working of each part of the question should be on a separate tab (sheet). For example, question 1(i) should be worked out within the tab (sheet) with name 1(i) of worksheet named CM2B.*
- 5. Where possible, summarize your data used & assumptions made (if any) in a separate tab.*
- 6. Do save your work in Excel files on a regular basis.*
- 7. Please check if you have received complete Question Paper and no page is missing. If so, kindly get new set of Question Paper from the Invigilator.*
- 8. Ensure that you click the “Submit” button only when you have completed the question paper and final submission has to be made.*

AT THE END OF THE EXAMINATION

Please return this question paper to the supervisor separately. You are not allowed to carry the question paper in any form with you. You are requested to save and submit the work before leaving the examination premises.

- Q. 1)** The cumulative claims paid under a certain cohort of general insurance policies for different accident years are given in the Table below:

Accident Year	Development Year						
	0	1	2	3	4	5	6
2008	3,000	3,800	4,500	5,400	5,625	6,300	6,425
2009	3,200	3,900	4,800	5,600	6,200	6,385	-
2010	3,600	4,300	5,200	5,800	6,300	-	-
2011	3,850	4,525	5,265	5,900	-	-	-
2012	4,325	5,300	6,175	-	-	-	-
2013	4,850	5,925	-	-	-	-	-
2014	5,325	-	-	-	-	-	-

Using the excel spreadsheet models,

- i) Calculate the development factors under the basic chain ladder technique and state the assumptions underlying the method. (6)
- ii) The rate of claims inflation over these years, measured over the 12 months to the middle of each year is given in the Table below:

Accident Year	Inflation rate
2009	7.50%
2010	8.60%
2011	11.20%
2012	8.00%
2013	6.00%
2014	9.00%

Calculate the development factors using the inflation adjusted chain ladder technique and state the assumptions underlying the method. (12)

- iii) Based on the development factors in (i) and (ii), calculate the fitted values under the two methods and compare the results of the Actual and fitted values for the accident year 2008 and 2009. (12)
- [30]

- Q. 2)** You are provided with the daily stock price of Nanosoft over the past 500 business days.

- i) Compute the daily log returns for the stock and the mean, median, variance and volatility for returns. (5)
- ii) Using the volatility/variance of 1-day returns, find the annual volatility and the monthly volatility, assuming 252 business days and 12 (equal) months in a year. (4)

Assume that Nanosoft's stock is valued at Rs 50 today and the distribution of the price movement over the next 1-day is the same as empirical distribution of historical returns.

- iii) Evaluate the shortfall probabilities over the next 1-day assuming the benchmark return levels of 0%, -2% and -4%. (3)

- iv) Find the 1-day value-at-risk (VaR) at the 95th and the 99th percentile levels for an investment in 100 stocks of Nanosoft today. (4)

We wish to value 6-month European call and put options with Rs 50 strike on Nanosoft's stock. No dividend is payable in the next 6 months by Nanosoft. The continuously compounded risk free rate of interest is 5% per annum.

- v) Set up a 6-step recombining binomial tree with each step equalling one month, and compute the price of the call option. (10)

[Hint: Use the monthly volatility to calibrate the up-step and down-step, u and d]

- vi) Obtain the price of the call option using the Garman-Kohlhagen formula. How do the two prices compare? (6)

- vii) Change the initial stock price in the binomial tree to Rs 50.05 and obtain the call option price again. Is the direction of change as expected? (4)

- viii) Increase the assumed level of volatility by 0.1% and obtain the call option price again. Hence obtain an estimate of vega for the call option and interpret the result. (4)

[40]

Q. 3) Postal Service of a certain country has introduced a new savings plan to its citizens. The new Savings plan is a single payment plan of 15-year term which promises to pay back the Single payment along with the accumulated interest rate. The interest rate offered is 7% p.a. compounding yearly.

- i) The redemption amount is Rs 250,000 for a customer. Find the initial Single payment made to Postal Service. (1)

- ii) An Actuary is employed to value the liability of its "new Savings plan".

The Total amount collected from the scheme is Rs 2,500 crores. The amount is to be invested in a zero-coupon Government Bond. The only zero-coupon Government Bond available is a 25-year G-sec.

The value of 25-year zero coupon Government Bond for 100 nominal is Rs 18.425

- a) Calculate the total number of bonds invested (to the nearest integer). (1)
- b) Assuming flat yield curve, estimate the spot yield as reflected by the 15-year zero coupon asset. (2)
- iii) The Actuary fears that a change in interest rate may make it difficult to pay the liability at duration 15 due to Asset liability mismatch. Therefore, he decides to use a **stochastic model** to estimate the difference.

He assumes that, each year, rate of change of short-term interest rates are independent from every other year and are identically distributed.

The rate of change of short-term interest rate follow normal $(0, 0.002^2)$ i.e. $r_t - r_{t-1} \sim \text{Normal}(0, 0.002^2)$. The interest rate is simulated using 100 simulations for the next 15 years.

(Hint: The random variable from Uniform distribution is provided in the Excel sheet. Convert it to normal using inverse function)

- a) Calculate the average short-term interest rate at the end of 15th year. (10)
- b) Assuming flat yield curve, calculate the 90th percentile Value at Risk (VaR) for 100 nominal Bond Price at the end of 15th year & the value of Asset in crores if the above VaR is taken as the Bond price. (6)
- c) Calculate the Difference between asset and liability at duration 15. (2)
- iv) Recalculate (b) & (c) of (iii) above if the yield curve is upward sloping with the below function

The nth year spot yield is calculated by $r_n = r_0 \cdot (1 + 0.01 \cdot n)$ (8)

[30]
