INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

18th June 2019

Subject CS2B – Risk Modelling and Survival Analysis (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 on a new page.*

3. *Attempt all sub-parts of the question in one document only, unless otherwise instructed to do so.*

4. *Data set file accompanying the question paper is located at: C:\Users\admin\Desktop\CS2B\filename*

5. *You need to import the same into R studio as soon as you begin the exam.*

6. *Ensure to copy and paste R codes and output at regular intervals onto the MS word file.*

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) A general insurance company has sold 5000 Accident Benefit Policies to independent lives. The number of claims follows a Poisson distribution with parameter 500. The amount of claim from individual policy is following a Gamma distribution with parameters $\alpha = 250$ and $\lambda = 0.5$. Calculate the aggregate claim amount paid by the insurer by simulating 5000 values if the insurer retains only 350 (assume the aggregate claim amount follows a compound Poisson distribution). Use seed corresponding to your birth year. **[4]**

Q. 2) ABC General Insurance Company Limited has sold total of 1000 insurance policies under 3 type of insurance, where each type of insurance gives rise to a maximum of one claim per year. The insurer hold the following portfolio:

Portfolio	Number of Policies	Claim distribution	Probability of claim
Fire Insurance	300	Exp (0.006)	0.002
Marine Cargo Insurance	500	Exp (0.007)	0.001
Marine Hull Insurance	200	Exp (0.006)	0.003

All policies and claims are independent.

i) Simulate a set of 5,000 observations from the insurer's aggregate claims size distribution. Use seed corresponding to your birth year. (12)

ii) Summarize the output, draw plot histogram of the simulated results, and comment on the results. (5)

[17]

Q. 3) The following graph shows the relationship between the first premium paid and the ratio of Maturity/Death SA to the first premium of several policies whose term is 20 years.
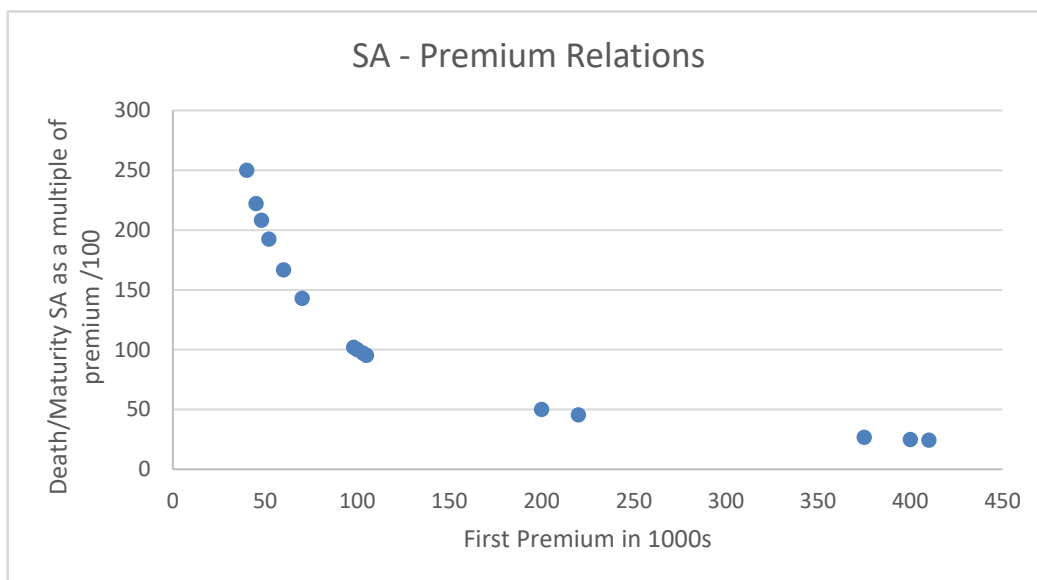
i) Devise a binary decision tree that can be used to identify the nature of a policy – Regular Premium, Regular Limited Payment and Single Premium - based only on their First Premium paid and the Death/Maturity SA (assuming that Death and Maturity SA are the same) and the policy term is 20 years. (4)

ii) Explain the reason behind the scales in the above graph. (2)

iii)   Also, write the R code for finding the nature of policy based on Binary decision tree
         method.   (4)

                                                                                              [10]

Q. 4) ABC Tech, a Speedboat manufacturing company, was established a few decades back. The
         company has shown a consistent growth in its revenue from Speedboat sales since its inception.
         However, over the years the company has struggled to keep it's inventory and production cost
         down because of variability in sales and Speedboat demand. The management at ABC Tech is
         under enormous pressure from the shareholders and board to reduce the production cost.
         Additionally, they are also interested in understanding the impact of their marketing and
         customer connect efforts towards overall sales. In the same effort, they have your employer as
         a data science and predictive analytics consultant.

         Your senior have analysed the sales data and believe that ARIMA model will fit the data. She
         has suggested you to develop an ARIMA model to forecast sale / demand for next three years.
         Additionally, she has also suggested you to investigate the impact of marketing program on
         sales by using an exogenous variable ARIMA model. You agreed on the steps to be followed
   and agree on the following steps.

         Note: You will require "Forecast" package for this assignment.

i)   Read the data (as provided in the CSV file in soft copy) in R and plot a time series chart
         with year as X axis and sales as Y axis with suitable labelling. Basis the plot thus obtain,
         comment on the type of time series.   (3)

ii)   Plot ACF and PACF to identify potential AR and MA model for this series and
         comment on the results.   (2)

iii)   You believe that differencing series is one of the ways to remove trend. Obtain the first
         order and second order difference series and plot the same. Also provide comment on
         variance of the d(1) series.   (3)

iv)   Looking at the plots of difference series, you decide to apply log transformation to the
         original series to smoothen the variance. Obtain the log-transformed (base 10) series
         and plot the same.   (2)

v)   Obtain the first order difference series of the transformed series and plot the same.   (2)

vi)   Plot ACF and PACF to identify potential AR and MA model for this series and
         comment on the results.   (3)

vii)   Use Auto arima function in forecast package in R helps us identify the best fit ARIMA
         model on the fly. Comment on the summary results of fitting this series and on Akaike
         Information Criterion (AIC) and Bayesian Information Criterion (BIC) values.   (4)

viii)   Predict speedboat sales for next 3 years i.e. for 2015, 2016, and 2017 through the above
         model and plot the results along-with one times the range of standard error from
         predicted value.   (5)

ix)   Plot ACF and PACF plot of the residuals of the best fit ARIMA model and comment
         on the results.   (3)

                                                                                              [27]

Data provided in Speedboat-Sales.csv in the system

Q. 5) A particle is moving on the graph below by starting on a randomly chosen vertex (each with the same probability) and at each time step moving along one of the adjacent edges to a neighbouring vertex, choosing the edge with equal probability and independently of all previous movements.
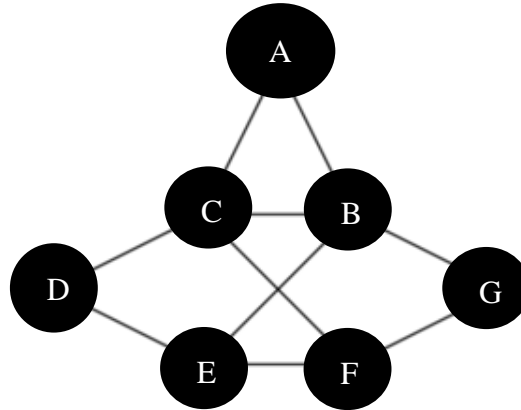
i)   Create a matrix with the transition matrix with probabilities using the state names as {A,B,C,D,E,F,G} and plot the transition matrix graph.   (6)

ii)   What is the absorbing state in the transition matrix? Find the steady state or stationary distribution.   (4)

iii)   How much time it will take to reach the steady state if the particle is starting from state A, B and C?   (7)

[17]

Q. 6) Suppose *X* has survival function defined by

$$S_0(x) = \frac{1}{10}(100 - x)^{1/2}, \quad \text{for } 0 \le x \le 100.$$

i)   Create a function for survival model in R and then find the probability of: (2)

   a) a new born surviving till age *65*.   (1.5)
   b) 10 year old surviving till 95.   (1.5)
   c) a new born die between the ages 65 and 70 years.   (2)

ii)   Create a mortality table q(x) using the survival function above for ages 1,5,10,15,20……….85,90,95,96,97,98.   (5)

iii)   Suppose Mu(x) has the following function:

$$\mu_x = \frac{1}{2(100 - x)}, \quad \text{for } 0 \le x < 100.$$

Use the approximation qx=1-exp(-Mu(x+1/2)) to identify qx of all ages in table 1,5,10,15,20……….85,90,95,96,97,98.   (5)

iv)   Plot a graph compare the qx derived from the survival function in part **(i)** (in red color) and function of Mu.x in part **(iii)** (in blue color).   (4)

v)   Please comment if the qx derived from survival function is similar with the qx derived using the Mu function. Please support your answer basis the relationship between the two functions.   (4)

[25]

Link for Data Set : http://www.actuariesindia.org/downloads/CS2B_Speedboat_Sales.csv

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