**Enterprise Risk Analytics**

**Assignment 2**

**What to submit?**

Please submit (i) a word file explaining in detail your answers to each question (you can use screenshots of the R Code to explain your answers) AND (ii) an R file for each question. For each question, make sure you develop the model and present the simulation results – the R code should be self-explanatory. **The assessment of your work will include both the accuracy and the clarity of your word file and the R Code.**

1. Answer the following two questions.

a) According to probability theory, if two random variables each follow a Normal distribution with given means and variances, their sum is also normally distributed with a mean equal to the sum of the means of two random variables and variance equal to the variances of the two random variables. Develop a simulation model and use the model to illustrate that this theory holds for any mean and variance. Use the following mean and variance parameters to set up your simulation model.

μ1 : mean of the first random variable.

μ2 : mean of the second random variable.

σ1 : standard deviation of the first random variable.

σ2 : standard deviation of the second random variable.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| μ1 | 100 | 100 | 100 | 100 | 100 | 100 |
| σ1 | 10 | 10 | 10 | 10 | 10 | 10 |
| μ2 | 200 | 200 | 300 | 300 | 400 | 400 |
| σ2 | 20 | 30 | 10 | 20 | 30 | 40 |

b) According to probability theory, if two random variables each follow an Exponential distribution with rates a and b, respectively, then their minimum is also an Exponential random variable with rate a+b. Develop a simulation model and use the model to illustrate that this theory holds for any rates a and b. Use the following a and b values to set up your simulation model. Note that Exponential distribution has a single parameter, which is given as “mean” in the lecture notes. Using “rate” is another parameterization method and rate is reciprocal of the “mean.”

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| a | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 |
| b | 0.3 | 0.7 | 0.8 | 0.9 | 1.0 | 1.5 |

1. Camer Pharmaceuticals is testing a new product in the market1. The demand for the new product is estimated to be Normally distributed with a mean 2,000,000 and standard deviation 250,000. The demand is estimated to grow at a rate of 4% per year. The R&D costs are estimated to be between $500 millions of dollars and $800 millions of dollars with a most likely value of $700 millions of dollars. Clinical trial costs are estimated to be between $135 millions of dollars and $160 millions of dollars with a most likely value of $150 millions of dollars. There are competitors in the market, and Camer Pharmaceuticals estimates that their market share in the first year will be any number between 6% and 10%, with each number being equally likely. The company estimates that their market share will grow by 20% each year. A monthly prescription is estimated to generate a revenue of $240. The variable costs are estimated to be $30. Develop a simulation model that calculates the net present value (NPV) of this project over 3 years assuming a discount rate of 10%. Run the simulation for 1000 iterations and answer the following questions.
2. What is the distribution of the NPV (mean and standard deviation)?
3. What are the first quartile, median, and third quartile of NPV?
4. What is the probability that NPV over 3 years will not be positive?
5. What NPV are we likely to observe with a probability of at least 0.9?
6. What cumulative net profit in the third year are we likely to observe with a probability of at least 0.9?
7. What is the 95% confidence interval for the mean NPV? Interpret the resulting confidence interval.
8. What is the number of iterations needed if we want to estimate the NPV within $4,000,000?
9. Interpret the sensitivity chart.

1This problem is a variation of a problem originally developed by J. R. Evans.