INTRODUCTION

We must choose one of several ideas being considered by management for this project. The benefit-cost analysis is their major tool for analyzing and selecting among the available initiatives. Both the annual benefits and the annual expenditures resulting from a project are estimated in numerous areas in this study. The benefit-cost ratio is then calculated by dividing the overall benefit by the total cost. Corporations then utilize this ratio to compare a variety of projects under consideration. A benefit-cost ratio larger than 1.0 shows that the advantages outweigh the expenses, and the higher the ratio, the more likely a project will be chosen over others with lower ratios.

The JET Corporation is now assessing the building of two dam projects, one in southwest Georgia (Dam #1) and the other in North Carolina (Dam #2). Improved navigation, hydroelectric power, fish and wildlife, recreation, flood management, and commercial development of the area are among the six areas of benefit cited by the corporation. In addition, for each type of benefit, there are three estimates available: a lowest possible value, a most probable value (i.e., a mode or peak), and a maximum possible value. The overall capital cost, annualized over 30 years (at a rate stipulated by the creditors and the government), and the yearly operations and maintenance expenses have been recognized as two categories connected with a construction project of this sort. These benefits and costs estimations for both dam projects (in millions of dollars) are as follows:

Dam #1: Benefits & Costs

	Estimate		
Benefit	*Minimum*	*Mode*	*Maximum*
Improved navigation **B1**	1	2.1	2.9
Hydroelectric power **B2**	7.9	11.5	15
Fish and wildlife **B3**	1.5	1.5	2.3
Recreation **B4**	6.3	9.9	14.9
Flood control **B5**	1.6	2.6	3.7
Commercial development **B6**	0	1.5	2.5

Cost	*Minimum*	*Mode*	*Maximum*
Annualized capital cost **C1**	13.3	13.9	18.8
Operations & Maintenance **C2**	3.6	5	7.5

Table 2: Benefits and costs for the Dam #2 construction project in millions of dollars

Dam # 2: Benefits & Costs

	Estimate		
Benefit	*Minimum*	*Mode*	*Maximum*
Improved navigation **B1**	2.3	3.1	4.7
Hydroelectric power **B2**	8.6	11.8	13.9
Fish and wildlife **B3**	2.2	2.9	2.9
Recreation **B4**	5.5	8.5	14.8
Flood control **B5**	0	3.2	3.2
Commercial development **B6**	0	1.1	1.7

Cost	*Minimum*	*Mode*	*Maximum*
Annualized capital cost **C1**	12.7	15.7	20.3
Operations & Maintenance **C2**	3.5	5.5	8

First task (Part One)

(i) Perform a simulation of 10,000 benefit-cost ratios for Dam #1 project and 10,000 such simulations for Dam #2 project. Note that the two simulations should be independent of each other. Let these two ratios be denoted by $\alpha 1$ and $\alpha 2$ for the dams 1 and 2 projects respectively.

Dam 1

Benefits:	Theoretical Mean: E(X) = (a+b+c)/3	Th. Variance
Improved navigation B1	2.000	0.152
Hydroelectric power B2	11.467	2.101
Fish and wildlife B3	1.767	0.036
Recreation B4	10.367	3.109
Flood control B5	2.633	0.184
Commercial development B6	1.333	0.264
Costs:	Theoretical E(X)	Th. Variance
Annualized capital cost C1	15.333	1.517
Operations & Maintenance C2	5.367	0.651

Because we know the basic value for the dam benefits and costs (a, b & c), we can use the Triangular distribution to calculate the theoretical mean and variation for each variable in the benefits and costs sections.

Dam 1's theoretical mean and variance were calculated, with benefits ranging from 1.33 to 11.467 and expenditures between 5.367 and 15.333. The theoretical benefit variance ranges from 0.036 to 3.109, whereas the theoretical cost variance ranges from 0.651 to 1.517.

Dam 2		
Benefits:	Theoretical Mean: E(X) = (a+b+c)/3	Th. Variance
Improved navigation B1	3.367	0.249
Hydroelectric power B2	11.433	1.187
Fish and wildlife B3	2.667	0.027
Recreation B4	9.600	3.755
Flood control B5	2.133	0.569
Commercial development B6	0.933	0.124
Costs:	Theoretical E(X)	Th. Variance
Annualized capital cost C1	16.233	2.442
Operations & Maintenance C2	5.667	0.847

Here also, we know the basic value for the dam benefits and costs (a, b & c), we can use the Triangular distribution again to calculate the theoretical mean and variation for each variable in the benefits and costs sections.

Dam 2's theoretical mean and variance were calculated, with benefits ranging from 0.933 to 11.433 and expenditures between 5.667 and 16.233. The theoretical benefit variance ranges from 0.027 to 3.755, whereas the theoretical cost variance ranges from 0.847 to 2.442.

Random value generation

After computing the theoretical values, we need some random observations to comprehend and draw any conclusions, hence the rand () function was used to create 10000 random probability values ranging from 0 to 1. Then, in order to better understand real-world scenarios, a simulation was built for these random numbers using the following circumstances:

1. if $r \le K$, $x = a + \text{sqrt}(rM)$

2. if $r > K$, $x = b - \text{sqrt}((1-r)N)$

We generated a total of 10,000 random numbers for dams 1 and 2, as well as the stimulation for benefits and costs. We needed to know the benefit-cost ratio for both dams after we created the stimulation, so we calculated the benefit-cost ratio for each dam separately and labeled them $\alpha 1$ and $\alpha 2$ correspondingly.

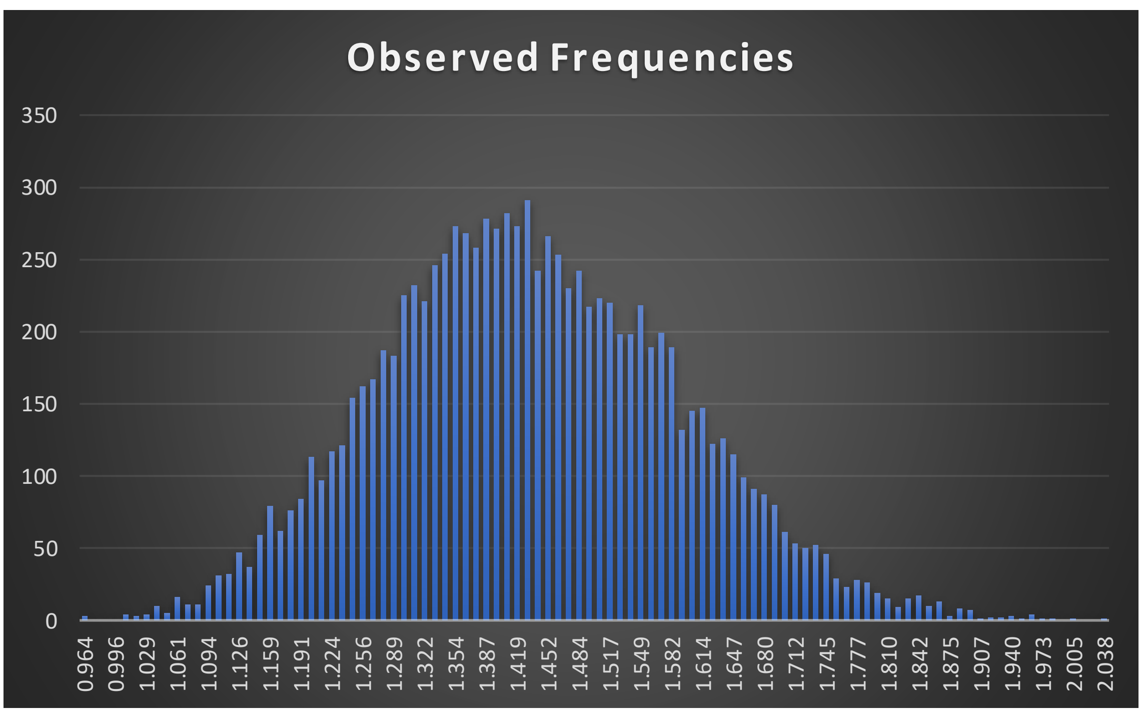
	Dam1 $\alpha 1$	Dam2 $\alpha 2$
Minimum	0.966	0.906
Maximum	2.010	2.031
Range	1.044	1.125
Classes/Bins	100	100
Class width	0.010	0.011

The table above shows the maximum and minimum benefit-cost ratios for both dams, as well as the range, classes/bins & class width which is used to generate the frequency distribution table.

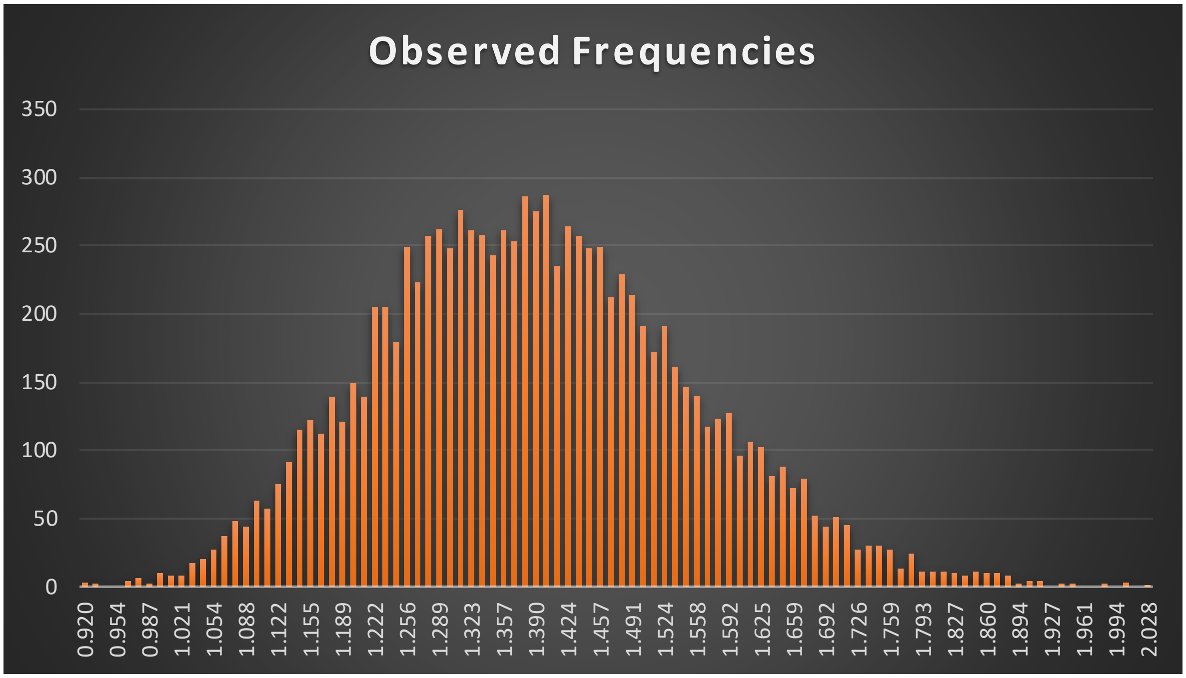
(ii) Construct both a tabular and a graphical frequency distribution for $\alpha 1$ and $\alpha 2$ separately (a tabular and a graphical distribution for $\alpha 1$, and a tabular and a graphical distribution for $\alpha 2$- a total of 4 distributions).

In this section, we'll construct a separate tabular for each dam, which we performed in Excel. Based on our tabulation, we need to figure out which distribution these data belong to. Using a graphical depiction is one of the simplest ways to understand this.

Frequency Distribution Graph for Dam 1

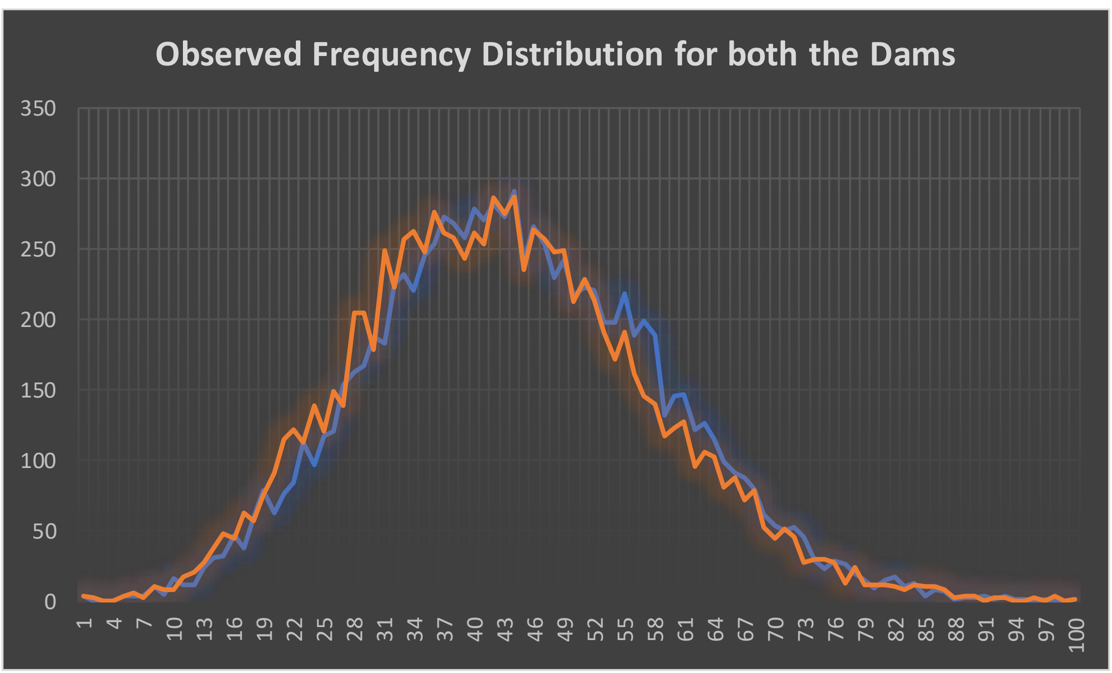


Frequency Distribution Graph for Dam 2



The significant concentration of data in the middle of both graphs indicates that our graph is normally distributed. We may say that both graphs are normally distributed, however when we repeat the simulation numerous times, they skew a bit to their right or left.

Graph which compares the Observed Frequency Distribution for the both the dams.



Looking at the graph, we can clearly notice their peaks, minimum and maximum observed frequency values which in this case is normally distributed for both the graphs.

(iii) For each of the two dam projects, perform the necessary calculations in order to complete the following table.

Dam 1	Observed	Theoretical
Mean of the Total Benefits	29.592	29.567
SD of the Total Benefits	2.434	2.418
Mean of the Total Cost	20.670	20.700
SD of the Total Cost	1.466	1.472
Mean of the Benefit-cost Ratio	1.439	X
SD of the Benefit-cost Ratio	0.156	X

Dam 2	Observed	Theoretical
Mean of the Total Benefits	30.090	30.133
SD of the Total Benefits	2.423	2.431
Mean of the Total Cost	21.877	21.900
SD of the Total Cost	1.814	1.814
Mean of the Benefit-cost Ratio	1.385	X
SD of the Benefit-cost Ratio	0.159	X

As we can see from the tables, the observed and theoretical values for Dam 1 and Dam 2 are quite similar.

Second task (Part Two)

Use your observation in (ii) of First Task to select a theoretical probability distribution that, in your judgement, is a good fit for the distribution of $\alpha 1$. Next, use the Chi-squared Goodness-of-fit test to verify whether your selected distribution was a good fit for the distribution of $\alpha 1$. Describe the rational for your choice of the probability distribution and a description of the outcomes of your Chi-squared test in your report. In particular, indicate the values of the Chi-squared test statistic and the P-value of your test in your report, and interpret those values.

The goodness-of-fit test will be applied to the frequency distribution values we generated in the previous task. For this, we'll utilize the chi-squared goodness-of-fit test on $\alpha 1$.

Chi-Square test

• Ho: The Triangular distribution is a good fit.

• Ha: The Triangular distribution is not a good fit.

We obtained the following results after performing the chi-squared goodness fit test on $\alpha 1$

Chi-squared Test Statistic:	93.451
Chi-squared P-value:	0.555

Because the P-value is significantly greater than 0.05 we don't have enough evidence to reject the null hypothesis. Therefore, the Triangular distribution is a good fit for $\alpha 1$.

Third task (Part Three)

(i) Use the results of your simulations and perform the necessary calculations in order to complete the table below.

Here the $\alpha 1$ is benefit-cost ratio for dam 1 while $\alpha 2$ is benefit-cost ratio for dam2.

	α_1	α_2
Minimum	0.932	0.930
Maximum	2.159	2.068
Mean	1.436	1.382
Median	1.432	1.374
Variance	0.024	0.026
Standard Deviation	0.156	0.160
SKEWNESS	0.155	0.306
$P(\alpha_i > 2)$	0.000	0.000
$P(\alpha_i > 1.75)$	0.024	0.017
$P(\alpha_i > 1.5)$	0.340	0.223
$P(\alpha_i > 1.25)$	0.884	0.787
$P(\alpha_i > 1)$	0.999	0.998

(ii) Use your observations of the results obtained in tasks 1-3 to recommend one of two projects to the management. Explain all your rationales for the project that you have recommended. In particular, include with the final conclusion of your report an estimate for the probability that $\alpha 1$ will be greater than $\alpha 2$.

$P(\alpha_1 > \alpha_2)$	**0.595**

When we consider the probabilities calculated above, I believe we should choose the project option $\alpha 1$. P ($\alpha 1 > \alpha 2$) is 0.595, or 59.5 per cent, indicating that dam1's benefit-cost ratio will outperform project one as the dam2's maximum value 59.5 per cent of the time. Based on the likelihood and data we collected, I would recommend dam 1.

CONCLUSION

Based on our probability distribution, I feel that dam 1 is the preferable choice for a better benefit – cost analysis. Finally, I learned more about Monte Carlo simulation and how to apply it to a real-world business situation and got a better understanding of Excel while preparing this simulation in the Excel Spreadsheet. I also learnt how to use random number generation and the triangular probability distribution to fit in the chi-squared goodness of fit test.

REFERENCES

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