Module 2 Project: Benefit-Cost Analysis

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**Introduction**

In today's business environment, corporations are constantly faced with the challenge of selecting the most profitable projects to invest in. One of the primary tools used to evaluate and select among available projects is the benefit-cost analysis. The benefit-cost analysis estimates the annual benefits and costs associated with a project in several different categories, and then calculates a benefit-cost ratio to compare the projects under consideration. In this context, the JET Corporation is evaluating two dam construction projects, Dam #1 in southwest Georgia and Dam #2 in North Carolina and is using Monte Carlo simulation to analyze the benefit-cost ratio. This method involves generating random samples of the input parameters and calculating the output distribution, which provides insights into the likelihood of the project being profitable. By evaluating the various benefits and costs associated with each project, corporations can make informed decisions about which projects to invest in, ensuring maximum profitability for their business.

**Part 1**

1. For part one, the company will simulate 10,000 benefit-cost ratios for each project independently. The resulting ratios will be denoted as 𝛼1 and 𝛼2 for Dam 1 and Dam 2, respectively. A benefit-cost ratio greater than 1.0 indicates that the benefits outweigh the costs, and the higher the ratio, the more likely a project will be selected. The independent analysis of both the dams are mentioned in the excel sheet provided along with the report. We can see that the mean of 𝛼1 is less than that of 𝛼2, hence we can say that there are chances that Dam #2 will be more beneficial to the company compared to Dam #1.
2. The tabular frequency distribution for 𝛼1 and 𝛼2 would show the frequency count of each range of values for the benefit-cost ratio. The graphical frequency distribution is given below.

**𝛼1 Graphical Frequency Distribution**:

The graphical distribution for 𝛼1 shows the frequency count of different ranges of values for the benefit-cost ratio for Dam #1. The x-axis represents the range of values for 𝛼1, while the y-axis shows the frequency count or the number of times each range of values occurs.

Based on the graphical distribution for 𝛼1, we can observe that the distribution is a **normal distribution** with a **peak** near the value **1.42** along with a **minimum** near **1.01** and **maximum** near **2.14**.

𝛼2 Graphical Frequency Distribution:

The graphical distribution for 𝛼2 shows the frequency count of different ranges of values for the benefit-cost ratio for Dam #2. The x-axis represents the range of values for 𝛼2, while the y-axis shows the frequency count or the number of times each range of values occurs.

Based on the graphical distribution for 𝛼2, we can observe that the distribution is approximately symmetric. This means that the values are evenly distributed on both sides of the graph. The **peak** near the value **1.54** along with a **minimum** near **1.12** and **maximum** near **1.99**. This suggests that the projects being evaluated for Dam #2 have a more uniform distribution of benefit-cost ratios.

In summary, the graphical frequency distribution for 𝛼1 is skewed to the right, indicating that there are fewer projects with very high benefit-cost ratios. In contrast, the graphical frequency distribution for 𝛼2 is approximately symmetric, indicating a more uniform distribution of benefit-cost ratios.

1. From the below table here are the basic insights that can be derived:
2. The mean benefit-cost ratio of Dam 1 is 1.483 in the observed data.
3. The standard deviation of the benefit-cost ratio of Dam 1 is 0.137 in the observed data.
4. The mean of the total benefits of Dam 1 is 23.657 in the observed data and 23.667 in the theoretical data.
5. The standard deviation of the total benefits of Dam 1 is 1.839 in the observed data and 1.856 in the theoretical data.
6. The mean of the total cost of Dam 1 is 15.988 in the observed data and 16.000 in the theoretical data.
7. The standard deviation of the total cost of Dam 1 is 0.785 in the observed data and 0.782 in the theoretical data.



From the below table here are the basic insights that can be derived:

1. The mean benefit-cost ratio of Dam 2 is 1.509 in the observed data.
2. The standard deviation of the benefit-cost ratio of Dam 2 is 0.123 in the observed data.
3. The mean of the total benefits of Dam 2 is 27.107 in the observed data and 27.000 in the theoretical data.
4. The standard deviation of the total benefits of Dam 2 is 1.487 in the observed data and 1.683 in the theoretical data.
5. The mean of the total cost of Dam 2 is 18.022 in the observed data and 18.000 in the theoretical data.
6. The standard deviation of the total cost of Dam 2 is 1.048 in the observed data and 1.202 in the theoretical data.



We can observe by comparing the two tables that Dams 1 and 2 have comparable mean benefit-cost ratios, but Dam 2 has a little higher ratio. Both dams have lower benefit-cost ratio standard deviations, which suggests that the benefit-cost ratio is less sensitive to changes in the input parameters. The fact that Dam 2's total benefits and costs are marginally larger than those of Dam 1 suggests that it might have a bigger economic impact. The simulation's findings indicate that both dams are feasible projects from an economic standpoint, however Dam 2 may have a little higher benefit-cost ratio and a bigger economic impact.

**Part 2**

For part 2 we are going to perform a chi-squared goodness of fit test to determine if the distribution of Dam 1 we obtained earlier is a triangular distribution or not. Following are the null and alternative hypothesis:

Null Hypothesis : The given distribution is a triangular distribution.

Alternative Hypothesis : The given distribution is not a triangular distribution.



From the above results obtained after performing chi-squared goodness of fit test, we can see that our test statistic value is very large, and the p value is 0. It denotes that the null hypothesis, that the data follow a triangular distribution, states that the observed data is an exceedingly unlikely outcome. This finding provides substantial support for an alternative hypothesis over the null hypothesis. In addition, the large test statistic shows that there is a significant difference between the observed data and the null hypothesis's expected values. This further demonstrates that the null hypothesis is unlikely to be true. Hence, We reject the null hypothesis and we can say that the distribution is not a triangular distribution.

**Part 3**

1. Based on the table obtained below, we can summarize the following insights:

According to the average benefit-cost ratio for Dam 1, which is 1.483, the project's benefits generally surpass its costs. Comparing the kurtosis for both the dams we can see that since for Dam 1 it is negative hence, we can say that it is flatter on the peak whereas for Dam 2 it is positive it is slightly peaked than a normal distribution. Dam 2 is somewhat preferable since it has a marginally higher mean and a marginally lower standard deviation than dam 1. The calculated probabilities greater than 1.8,1.6,1.4,1.2 and 1 for Dam 2 is greater than then probabilities for Dam. Additionally, the probability when the benefit-cost ratio for Dam 1 greater than Dam 2 is only 0.3506 i.e., 35.06% which states that Dam 2 would be economically more beneficial to the company.

1. In this paper, benefit-cost ratios are used to analyze the effects of two dams, Dam 1, and Dam 2. 10,000 benefit-cost ratios for each dam, labeled as 𝛼1 and 𝛼2, were produced as a result of the simulations run for each project. Our study suggests that Dam 2 has a greater economic impact than Dam 1, a somewhat higher benefit-cost ratio, and a more uniform distribution of benefit-cost ratios. Nonetheless, the benefits of Dam 1 generally outweigh its expenses, and both dams have workable benefit-cost ratios. The graphical frequency distribution for 𝛼1 is tilted to the right, indicating fewer projects with extremely high benefit-cost ratios. The graphical frequency distribution for 𝛼2, on the other hand, is almost symmetric, reflecting a more equal distribution of benefit-cost ratios. It's also important to note that the benefit-cost ratios for both dams have relatively low standard deviations, which suggests that the benefit-cost ratio is less sensitive to changes in the input parameters. While the positive kurtosis of Dam 2's distribution suggests that it is slightly more peaked than a normal distribution, the negative kurtosis of Dam 1's benefit-cost ratio distribution suggests that it is flatter on the peak.

Finally, the likelihood that Dam 1 will have a better benefit-cost ratio than Dam 2 is only 35.06%. As a result, it could be wiser to invest in Dam 2 because it will probably bring about more long-term economic gains.

**Reference**

1. Wikipidea *Triangular distribution* <https://en.wikipedia.org/wiki/Triangular_distribution>
2. Zach (January 2018) *An Introduction to the Triangular Distribution* <https://www.statology.org/triangular-distribution/>
3. Tunrey.S (May 2022) *Chi-Square Goodness of Fit Test | Formula, Guide & Examples* <https://www.scribbr.com/statistics/chi-square-goodness-of-fit/#:~:text=of%20fit%20test%3F-,A%20chi%2Dsquare%20(%CE%A72)%20goodness%20of%20fit%20test,close%20to%20the%20observed%20values>.
4. Module 2 Lab 2*- The Triangular Probability Distributions & Random Number Generation* <https://northeastern.instructure.com/courses/131431/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=8233589>
5. Zach(Apr 2020) *How to Perform a Chi-Square Goodness of Fit Test in Excel* <https://www.statology.org/chi-square-goodness-of-fit-test-excel/>

**Appendix**

An excel file named “ALY6050\_MOD2Project\_ShahD.xlsx” has been attached along with this assignment report.