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ALY6050

Module 2 - Project Report

Benefit-Cost Analysis of Dam Construction Projects

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Professor: Roy Wada

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By

Rhea Thoppil

**Introduction:**

This report will explore the feasibility of two dam construction projects by analyzing potential benefits and costs through a cost-benefit analysis. Cost-benefit analysis is a technique used to weigh the total expected costs against the total expected benefits of one or more actions to choose the best option. We'll focus on six benefit areas: hydroelectric power, navigation, recreation, fish and wildlife, commercial development, and flood control.

Using Excel, we will run 10,000 simulations to determine the benefit-cost ratio for each dam project, representing a wide range of possible outcomes. We'll visualize these outcomes to see which project might be more advantageous. To ensure our simulation is on track, we'll use the Chi-squared goodness of fit test to validate our theoretical probability distribution against the observed data from Dam 1.

Finally, we will compare various statistics like the minimum, maximum, mean, and median from the simulations to help the management decide on the better investment between the two dam projects.

**Part 1:**

We generated 10,000 random samples for each aspect of benefit and cost related to the two dams using Excel’s RAND() function. This simulation produced a comprehensive range of total costs, allowing us to calculate the benefit-cost ratios, referred to as α1 for Dam 1 and α2 for Dam 2. This process provided us with the necessary data to estimate the economic feasibility of each dam project.

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Figure 1 - The benefit-cost ratio for (α1)

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Figure 2 - The benefit-cost ratio for (α2)

For producing a random number variable for the Triangular Distribution variable, we have used the following formula;

|  |
| --- |
| **Triangular random number generation:** |
| **if r <= K, x = a + sqrt( rM )** |
| **if r > K, x = b - sqrt( (1-r) N)** |

Further, using the benefit-cost ration, we have calculated the value of mix, max, range, bin width, and count. Range is a difference between least value and the maximum. Bins was calculated using **=SQRT(COUNT(range of benefit-cost ratio))**

|  |  |
| --- | --- |
| DAM 1 | |
| min | 0.952 |
| max | 1.970 |
| range | 1.018 |
| classes/Bins | 100.000 |
| class width | 0.010 |

|  |  |
| --- | --- |
| DAM 2 | |
| min | 0.952 |
| max | 1.982 |
| range | 1.030 |
| classes | 100.000 |
| class width | 0.010 |

We then created the frequency distribution for both the scenarios:

Figure 3 - Frequency Distribution of Dam 1

The graph shows the observed frequency distribution of the benefit-cost ratio for Dam 1 based on 10,000 simulations. It appears to follow a normal distribution, with the highest frequency of observations around the central peak, and frequencies tapering off as the benefit-cost ratio values move away from the mean towards the tails.

Figure 4 - Frequency Distribution of Dam 2

The graph appears to be a histogram depicting the observed frequency distribution of benefit-cost ratios for Dam 2. The distribution looks symmetrical, suggesting a normal-like distribution, with the most frequent ratios clustered around the central peak and less frequent occurrences towards the tails.

Below is the theoretical and observed Standard Deviation and Mean for Total Benefit, Total Cost and Benefit- Cost Ratio for Dam1 and Dam 2

|  |  |  |
| --- | --- | --- |
| **Dam 1** | **Observed** | **Theoretical** |
| **Mean of the Total Benefits** | **29.470** | **29.467** |
| **SD of the Total Benefits** | **2.316** | **4.504** |
| **Mean of the Total Cost** | **20.773** | **20.767** |
| **SD of the Total Cost** | **1.519** | **5.117** |
| **Mean of the Benefit-cost Ratio** | **1.426** | X |
| **SD of the Benefit-cost Ratio** | **0.151** | X |

The benefit-cost ratio's mean has been calculated at 1.426 with a standard deviation of 0.151. The mean's observed and theoretical values are closely aligned, but there's a notable discrepancy in the standard deviation—specifically, the theoretical standard deviation of the total benefits is double that of the observed value.

|  |  |  |
| --- | --- | --- |
| **Dam 2** | **Observed** | **Theoretical** |
| **Mean of the Total Benefits** | **30.713** | **30.700** |
| **SD of the Total Benefits** | **2.411** | **4.025** |
| **Mean of the Total Cost** | **22.058** | **22.067** |
| **SD of the Total Cost** | **1.734** | **5.200** |
| **Mean of the Benefit-cost Ratio** | **1.401** | X |
| **SD of the Benefit-cost Ratio** | **0.157** | X |

The benefit-cost ratio's mean has been calculated at 1.401 with a standard deviation of 0.157. The mean's observed and theoretical values are closely aligned, but there's a notable discrepancy in the standard deviation—specifically, the theoretical standard deviation of the total benefits is double that of the observed value. It is observed that Dam1 and Dam2 follows the same pattern.

**Part 2:**

Here, a is the min value, b is the max value and c is the value is calculated using the reference of the formula as shown in the below screenshot. The formula for the mean is

Mean = a + b + c / 3 Here, the value of K, M, and N and a, b, c, a-c, a-b, b – c is calculated.

|  |  |
| --- | --- |
| DAM 1 | |
| a | 0.952 |
| b | 1.970 |
| c | 1.355 |
| **K = (c-a) / (b-a)** | 0.396 |
| **M =(b-a) (c-a)** | 0.410 |
| **N =(b-a) (b-c)** | 0.626 |

Using theoretical probabilities and observed frequencies, we'll evaluate if the triangular distribution fits well. Assuming a significance level of 0.05 and considering three parameters (a, b, c) for our degrees of freedom calculation, we'll test the following hypotheses:

Null Hypothesis (H0): Triangular distribution is a preferable fit.

Alternative Hypothesis (H1): Triangular distribution is not a preferable fit.

|  |  |
| --- | --- |
| **Chi-squared Test Statistic:** | **1173160.204** |
| **Chi-squared P-value:** | **0.000** |

The test statistic is notably high at 3244.207, and the p-value is 0.00, indicating a poor fit.

**Part 3:**

In this Part, we make some observations to choose from both the projects.

|  |  |  |
| --- | --- | --- |
|  | **𝛂1 (Dam 1)** | **𝛂2 (Dam 2)** |
| **Minimum** | 0.952 | 0.952 |
| **Maximum** | 1.970 | 1.982 |
| **Mean** | 1.426 | 1.401 |
| **Median** | 1.421 | 1.393 |
| **Variance** | 0.022901724 | 0.024620119 |
| **Standard Deviation** | 0.151333156 | 0.156907994 |
| **SKEWNESS** | 0.171312899 | 0.297662072 |
| **P(𝛂i > 2)** | 0.0000000000 | 0 |
| **P(𝛂i > 1.8)** | 0.0079000000 | 0.0105 |
| **P(𝛂i > 1.5)** | 0.3060000000 | 0.2548 |
| **P(𝛂i > 1.2)** | 0.9349000000 | 0.9055 |
| **P(𝛂i > 1)** | 0.9997000000 | 0.9987 |
| **P(𝛂1 > 𝛂2)** | **0.552** | | |

The table compares two sets of data, Dam 1 and Dam 2​. Both have the same minimum value, but Dam 1​ has a slightly lower maximum value and higher mean and median compared to Dam 2​. The variance and standard deviation are also slightly lower for Dam 1​, indicating less spread in the data. The skewness value is higher for Dam 2​, suggesting that its distribution is less symmetrical compared to Dam 1​.

The probability comparisons indicate that the chances of **𝛂** exceeding certain thresholds are generally higher for Dam 1​ than for Dam 2 except for very high thresholds where they are approximately the same.

Finally, the probability of Dam 1​ being greater than Dam 2 is 0.552, indicating that there's a slightly higher than 50% chance that the values from Dam 1 will exceed those from Dam 2​.

**Conclusion:**

Upon reviewing the 10,000 simulations for the Dam 1 and Dam 2 projects, it is observed that the benefit-cost ratio for Dam 1 generally surpasses that of Dam 2. Dam 2 shows a slightly higher skewness compared to Dam 1, suggesting a more asymmetric distribution. Consequently, Dam 1 emerges as the preferable choice, presenting a more favorable profile with a better likelihood of yielding higher benefit-cost outcomes.

**References:**

northeastern.instructure.com. ***The Triangular Probability Distributions & Random Number Generation.***

[***https://northeastern.instructure.com/courses/164919/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module\_item\_id=9743994***](https://northeastern.instructure.com/courses/164919/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=9743994)