**MODULE 2 - EXECUTIVE SUMMARY REPORT**

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ALY6050 - Introduction to Enterprise Analytics

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April 25, 2022

**INTRODUCTION**

Cost-benefit analysis or Benefit-cost analysis is a means of comparing the costs and benefits of an intervention. Costs includes those involved in fulfilling an intervention. Benefits includes all the resultants from an intervention. It analyzes the value for money of a project or investment opportunity by considering both quantitative and qualitative factors. CBA helps to determine if the decision to choose a project or an investment is sound, determining if and by how much its benefits outweigh its costs. It provides a basis for comparing investments (or decisions), comparing the total expected cost of each option with its total expected benefits. Cost–benefit analysis (CBA) and cost-effectiveness analysis (CEA) are methods used by economists to appraise educational programs, projects, or investments. CBA evaluates programs in financial terms while CEA evaluates programs against specified educational objectives.

**PROBLEM STATEMENT**

Two dam projects are given along with the various benefits and cost involved for each project. The benefit-cost analysis is evaluated for each project, and it’s used as the primary instrument for selecting the project.

The Dam project 1 is planned in southwest Georgia and project 2 planned in North Carolina. There are 6 areas of benefits and 2 areas of costs estimated for each project. The table 1 illustrates the various costs and benefits of project #1 and #2.

*Table 1: Dam #1 and #2 construction project- Benefits and costs (in millions $)*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Dam - 1** | | | **Dam - 2** | | |
| **Estimate** | | | **Estimate** | | |
| **Benefits** | ***Minimum*** | ***Mode*** | ***Maximum*** | ***Minimum*** | ***Mode*** | ***Maximum*** |
| Improved navigation - **B1** | 1.1 | 2 | 2.8 | 2.1 | 3 | 4.8 |
| Hydroelectric power - **B2** | 8 | 12 | 14.9 | 8.7 | 12.2 | 13.6 |
| Fish and wildlife - **B3** | 1.4 | 1.4 | 2.2 | 2.3 | 3 | 3 |
| Recreation - **B4** | 6.5 | 9.8 | 14.6 | 5.9 | 8.7 | 15 |
| Flood control - **B5** | 1.7 | 2.4 | 3.6 | 0 | 3.4 | 3.4 |
| Commercial development - **B6** | 0 | 1.6 | 2.4 | 0 | 1.2 | 1.8 |
| **Costs** | ***Minimum*** | ***Mode*** | ***Maximum*** | ***Minimum*** | ***Mode*** | ***Maximum*** |
| Annualized capital cost - **C1** | 13.2 | 14.2 | 19.1 | 12.8 | 15.8 | 20.1 |
| Operations & Maintenance - **C2** | 3.5 | 4.9 | 7.4 | 3.8 | 5.7 | 8 |

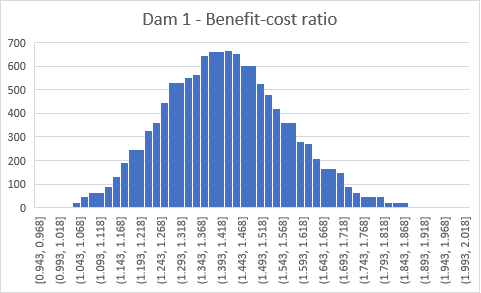
**Benefit-Cost ratio of Dam 1 and 2:**

A cost-benefit analysis is a systematic method used by organizations to determine which actions should be made and which should be averted. It is a way to compare the costs and benefits of more than one project, where both are expressed in monetary units.

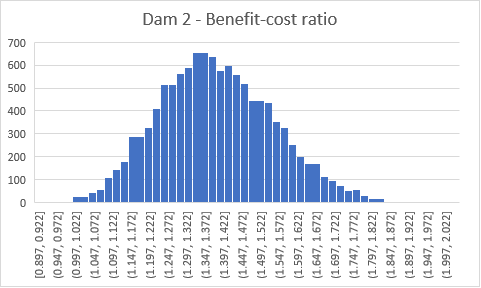
With the given benefits and costs of each project, 10000 values of benefit-cost ratios are simulated using a triangular distribution. These simulations are independent of each other. The frequency distribution of benefit-cost ratios for dam construction projects is depicted in Figures 1 and 2.

We can see the benefit-cost ratios of dam #1 follows the normal distribution bell curve (Figure 1). The benefit-cost ratios of dam #2 are similar to dam #1 with a bell curve, however, the curve is skewed to the right (Figure 2).

*Figure 1: Frequency distribution of Benefit-cost ratio - Dam #1*



*Figure 2: Frequency distribution of Benefit-cost ratio - Dam #2*



**Statistics Summary of the projects:**

To understand more about the benefits, costs, and benefits-cost ratio of each project, we are calculating the mean and standard deviation from the simulated 10000 values and comparing them with the theoretical values. Tables 2 and 3 has the details of Dam #1 and #2 respectively.

We can see that all the observed values are approaching the theoretical values when the number of simulations is 10000. Alternatively, we can say that the Law of large numbers is true in our experiment.

From tables 2 and 3, it is observed that the BCR of Dam project #1 (**1.427**) is slightly higher than that of Dam project #2 (**1.399**).

*Table 2: Dam #1 construction project- summary (in millions $)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Dam 1** | | **Observed** | **Theoretical** |
| **Total Benefits** | **Mean** | **29.463** | **29.4671** |
| **Standard Deviation** | **2.292** | **2.3070** |
| **Total Cost** | **Mean** | **20.762** | **20.7671** |
| **Standard Deviation** | **1.512** | **1.5210** |
| **Benefit-cost Ratio** | **Mean** | **1.427** | X |
| **Standard Deviation** | **0.151** | X |

*Table 3: Dam #2 construction project- summary (in millions $)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Dam 2** | | **Observed** | **Theoretical** |
| **Total Benefits** | **Mean** | **30.681** | **30.70** |
| **Standard Deviation** | **2.404** | **2.410** |
| **Total Cost** | **Mean** | **22.056** | **22.067** |
| **Standard Deviation** | **1.728** | **1.727** |
| **Benefit-cost Ratio** | **Mean** | **1.399** | X |
| **Standard Deviation** | **0.154** | X |

**Testing the good fit of the triangular distribution:**

We have chosen to use triangular distribution to solve this problem. We are testing if the chosen distribution is a good fit or not. In this experiment, the null and alternate hypotheses are stated as follows:

H0: The triangular distribution is a good fit

H1: The triangular distribution is not a good fit

We are taking the benefit-cost ratios of the project Dam #1 for this analysis. Triangular probabilities are calculated based on the simulated benefit-cost ratio values.

*Table 4: Calculating values of A,B,C,K, M and N based on simulation for Dam #1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Metrics** | **Values** |  | **Metrics** | **Values** |
| Minimum | 0.97 |  | Left end (a) | 0.97 |
| Maximum | 1.96 |  | Peak (c) | 1.34 |
| Range | 0.99 |  | Right end (b) | 1.96 |
| Count | 10000 |  | K = (c-a)/(b-a) | 0.37 |
| Bins | 100 |  | M =(b-a) (c-a) | 0.37 |
| Class width | 0.01 |  | N =(b-a) (b-c) | 0.61 |

The theoretical probability of the triangular distribution is calculated using the below cumulative density function:

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The above function can also be used to generate random values according to a specific triangular distribution. In this method, first a standard uniform random value **r** is created. This value is then used as a cumulative probability and replaces F(x) by:

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Figure 3 shows the frequency distribution of the observed values of the Benefit-cost ratios of Dam project #1 while the figure 4 shows the frequency distribution of the theoretical values of the BCR of Dam project #2 using the triangular distribution. Also, the chi-square metric is computed by summing the values given by the formula:

(Expected frequency- Observed frequency)2

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Expected frequency

The p-value is determined using the chi-square metric value. The p-value in this test is 0 which is smaller than 0.05 (0 < 0.05). We don't have enough evidence to accept the null hypothesis because the p-value is less than the alpha values. To conclude, the triangular distribution is not a good fit.

*Figure 3: Dam #1 construction project- Observed frequency of Benefit-cost ratio*

*Figure 4: Dam #1 construction project- Expected frequency of Benefit-cost ratio*

**Analyzing the BCR of two Dam projects:**

The benefit-cost ratios of Dam 1 and 2 from the 10000 simulations are denoted as **α1** and**α2** respectively.Table 5 below shows various metrics used to compare the simulations of the two projects.

We can observe that the mean of α1 is greater thanα2and the standard deviation of α1 is smaller thanα2. Additionally, the α1 has lesser skew compared to α2.

*Table 5: Comparing construction projects Dam #1 and #2*

|  |  |  |
| --- | --- | --- |
|  | **α1** | **α2** |
| **Minimum value** | 0.965 | 0.927 |
| **Maximum value** | 2.045 | 2.012 |
| **Mean value** | 1.425 | 1.398 |
| **Median** | 1.422 | 1.388 |
| **Variance** | 0.023 | 0.024 |
| **Standard Deviation** | 0.153 | 0.156 |
| **SKEWNESS** | 0.164 | 0.289 |
| **P(αi > 2)** | 0.000 | 0.000 |
| **P(αi > 1.8)** | 0.009 | 0.009 |
| **P(αi > 1.5)** | 0.309 | 0.250 |
| **P(αi > 1.2)** | 0.933 | 0.904 |
| **P(αi > 1)** | 0.999 | 0.999 |

A benefit-cost ratio greater than 1.0 indicates that the benefits are greater than the costs and the project with higher benefit-cost ratio is generally preferred. In table 5, we are also calculating the probability of αi values in different ranges between 1 and 2. We can see that P(αi > 1) is 0.999 for both the projects which means both the projects are equally good. The probability of benefit-cost ratio greater than 1.8 and 2 is 0.009 and 0 respectively, which means that benefit-cost ratio of these **projects is** **greater than 1 but less than 1.8**. Furthermore, when we compare the probability of benefit-cost ratio being **greater than 1.5**, we can see that the **α1**(0.309)**is greater thanα2**(0.25).

Finally, we also compute the probability of α1 > α2 and found it to be 0.547. To conclude, **α1 is preferred over α2.**

**CONCLUSION**

From figures 1 and 2 we can see those similarities in the BCR of these two projects. Furthermore, both the projects have BCR greater than one which is highly recommended. However, it is evident from table 5 that the construction project of Dam #1 has higher benefit-cost ratio than dam #2 as α1 is preferred over α2. To conclude, JET Corporation is recommended to choose the dam construction project in southwest Georgia over the one in North Carolina.

**REFERENCES**

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