**Module Two Project**

**Benefit-Cost Analysis of Dam Construction Projects**

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ALY - 6050: Introduction to Enterprise Analytics

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1. **Overview:**

For this assignment, I was tasked with performing a benefit-cost analysis for two proposed dam construction projects - Dam #1 in southwest Georgia and Dam #2 in North Carolina. The JET Corporation is evaluating these projects, and my role was to analyze the estimated benefits and costs associated with each dam to determine which project would be more favorable to pursue.

The analysis involved six areas of benefits: improved navigation, hydroelectric power, fish and wildlife, recreation, flood control, and commercial development of the area. For each benefit, there were three estimates available: a minimum, a most likely (mode), and a maximum value. Similarly, there were three cost categories: the total capital cost annualized over 30 years, other costs, and annual operations and maintenance costs.

1. **Set-up:**

I engaged in a comprehensive benefit-cost analysis of two dam construction projects, Dam #1 and Dam #2, for the JET Corporation. The evaluation involved simulating 10,000 benefit-cost ratios for each project, denoted as alpha 1 and alpha 2, and constructing graphical frequency distributions. The observations from this simulation informed the selection of a theoretical probability distribution for alpha 1, followed by a Chi-squared Goodness-of-fit test to validate the chosen distribution. Detailed explanations, including Chi-squared test statistics and P-values, were provided in the report.

Moving to Part 3, I utilized simulation results to create tables with key statistical measures for Dam #1 and Dam #2. Drawing on these findings, I recommended one of the projects to the management, substantiating my choice and concluding the report with an estimate for the probability that alpha 1 would be smaller than alpha 2. The entire analysis adhered to the APA format, with a well-organized Word document and an Excel workbook containing all calculations, ensuring clarity and precision throughout the assignment.

1. **Analysis:**

**Part - 1:**

**Sub-Part 1:**

* I conducted a benefit-cost analysis for JET Corporation to evaluate two dam construction projects, estimating annual benefits and costs across various categories. The total expected benefits and costs were then compared to derive the benefit-cost ratio, a crucial metric for project viability assessment.
* Conducted independent simulations for Dam #1 and Dam #2, generating 10,000 benefit-cost ratios for each project.
* Evaluated benefits and costs for Dam #1 and Dam #2 using the Triangular Distribution method, encompassing factors like improved navigation, hydroelectric power, fish and wildlife, recreation, flood control, and commercial development.
* Utilized random number generation based on specified distribution parameters to simulate the uncertainty associated with each factor, resulting in a distribution of benefit-cost ratios.

**Sub-Part 2:**

* I constructed frequency distributions, both tabular and graphical, for the benefit-cost ratios (Alpha 1 and Alpha 2) of the two dam construction projects, Dam #1 and Dam #2.
* The distributions were created by dividing the range of ratios into 100 equal-width classes and counting the observations falling into each class. The graphical distributions revealed distinct shapes for the two projects.

Frequency Distribution for Alpha 1:

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|  |

* Insights:  
  The distribution is skewed to the right, meaning there are more observations in the lower classes than in the higher classes.

Frequency Distribution for Alpha 2:

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| --- |
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* Insights:  
  Here too, the distribution is skewed to the right, meaning there are more observations in the lower classes than in the higher classes.

**Sub-Part 3:**

|  |  |  |
| --- | --- | --- |
| **Dam 1** | **Observed** | **Theoretical** |
| **Mean of the Total Benefits** | **33.303** | **33.333** |
| **SD of the Total Benefits** | **2.265** | **2.285** |
| **Mean of the Total Cost** | **13.997** | **14** |
| **SD of the Total Cost** | **1.124** | **1.13** |
| **Mean of the Benefit-cost Ratio** | **2.394** | X |
| **SD of the Benefit-cost Ratio** | **0.251** | X |

Insights:

* Dam #1 exhibited an observed mean benefit-cost ratio of 2.391, suggesting that, on average, the project generated approximately 2.391 units of benefit for every unit of cost. This implies operational efficiency in resource utilization.
* The close alignment between the observed and theoretical mean values for total benefits (33.294 vs. 33.333) and total costs (14.016 vs. 14.000) indicates stability and reliability in the project's economic estimates.
* The standard deviations for both total benefits (2.314) and total costs (1.125) demonstrated consistent variability around the mean values, signifying a reliable spread of potential outcomes.
* The standard deviation for the benefit-cost ratio (0.253) reflects the level of uncertainty and risk associated with the economic efficiency of Dam #1.
* Lower standard deviation values suggest a more stable and predictable benefit-cost ratio, crucial for informed decision-making.

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| --- | --- | --- |
| **Dam 2** | **Observed** | **Theoretical** |
| **Mean of the Total Benefits** | **34.977** | **35** |
| **SD of the Total Benefits** | **2.243** | **2.211** |
| **Mean of the Total Cost** | **14.328** | **14.333** |
| **SD of the Total Cost** | **1.287** | **1.312** |
| **Mean of the Benefit-cost Ratio** | **2.461** | X |
| **SD of the Benefit-cost Ratio** | **0.27** | X |

Insights:

* Dam #2 demonstrated an observed mean benefit-cost ratio of 2.462, suggesting a positive economic return, with approximately 2.462 units of benefit generated for every unit of cost.
* The observed means closely matched the theoretical values for both total benefits (35.002 vs. 35.000) and total costs (14.336 vs. 14.333), indicating reliability and accuracy in economic projections.
* The standard deviations for total benefits (2.188) and total costs (1.318) showcased consistent variability around the means, indicating stable and predictable economic outcomes.
* The standard deviation for the benefit-cost ratio (0.274) highlighted the level of uncertainty and risk associated with Dam #2, vital for informed decision-making.

**Part - 2:**

* Stating the Hypotheses:
  + H0 The Triangular Distribution is a good fit for the data.
  + H1 The Triangular Distribution is not a good fit for the data.

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| --- | --- | --- | --- |
| **Chi-squared Test Statistic:** | **86.74** |  |  |
| **Chi-squared P-value:** | **0.763** |  |  |
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| **Conclusion:** |  |  |  |
| **Null Hypothesis is accepted, Triangular Distribution is a Good Fit.** | | | |
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Insights:

* The Chi-squared test was employed to evaluate the fit of the Triangular Distribution, yielding a test statistic of 97.05 and a P-value of 0.479.
* Acceptance of the null hypothesis suggests that the Triangular Distribution accurately represents the data, affirming its suitability for modeling and predictive purposes.

**Part - 3:**

**Sub-Part 1:**

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| --- | --- | --- |
|  | **α1** | **α2** |
| **Minimum** | 1.539 | 1.61 |
| **Maximum** | 3.632 | 3.583 |
| **Average** | 2.394 | 2.461 |
| **Variance** | 0.063 | 0.073 |
| **Skewness** | 0.249 | 0.188 |
| **Kurtosis** | 0.022 | -0.147 |
| **P(αi > 2.75)** | 0.0838 | 0.1466 |
| **P(αi > 2.50)** | 0.328 | 0.43 |
| **P(αi > 2.25)** | 0.704 | 0.772 |
| **P(αi > 2.00)** | 0.951 | 0.963 |
| **P(αi > 1.75)** | 0.999 | 0.999 |
|  |  |  |
| **P(α1 < α2)** | 0.305 |  |

Insights:

* The values of Alpha 1 and Alpha 2 exhibit variability, with distinct minimum, maximum, average, variance, skewness, and kurtosis.
* The probabilities of Alpha exceeding specific thresholds (2.75, 2.50, 2.25, 2.00, and 1.75) are presented for both Alpha 1 and Alpha 2, indicating the likelihood of these values occurring.
* The likelihood of Alpha 1 being less than Alpha 2 is calculated as 0.305, offering insight into their relative magnitudes.
* The table revealed the probability of Alpha 1 being smaller than Alpha 2. In other words, there was a higher likelihood that the benefit-cost ratio for Dam #2 would exceed that of Dam #1.

**Sub-Part 2:**

Final Analysis:

* **Economic Return:** Dam #2 exhibited a slightly higher mean benefit-cost ratio (2.462) compared to Dam #1 (2.391), indicating a marginally better economic return for every unit of cost incurred.
* **Reliable Estimates:** Both Dam #1 and Dam #2 showed close alignment between observed and theoretical values for total benefits and costs, reflecting reliability and accuracy in economic projections. Dam #2, with its observed means closely matching theoretical values, demonstrates stability in estimates.
* **Considerations of risk:** Although both projects exhibited variability, with standard deviations serving as measures, Dam #2 presented a marginally higher standard deviation for the benefit-cost ratio (0.274) than Dam #1 (0.253).
* **Probability Analysis:** The calculated probability of Alpha 1 being smaller than Alpha 2 is 0.305. This indicates a higher likelihood that the benefit-cost ratio for Dam #2 would exceed that of Dam #1, further supporting the recommendation.
* *In conclusion,* ***Dam #2 is recommended*** *for its marginally better economic return, reliability in estimates, and the higher likelihood of its benefit-cost ratio surpassing that of Dam #1.*

1. **Conclusion:**

In evaluating Dam #1 and Dam #2 for JET Corporation, I found Dam #2 to offer a slightly superior economic return and demonstrated reliability in estimates. Despite both projects showing variability, Dam #2 presented a slightly higher risk in the benefit-cost ratio. The probability analysis reinforced the recommendation, with a 0.305 likelihood that Dam #2's ratio surpasses Dam #1's. In summary, Dam #2 is recommended for its marginally better economic return, reliability in estimates, and a higher likelihood of its benefit-cost ratio outperforming Dam #1.

1. **Citations:**

* Triangular Distribution: [*Lab 2 Video*](https://northeastern.instructure.com/courses/165163/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=9744549)
* Random Number Generation: [*Lab 2 Video*](https://northeastern.instructure.com/courses/165163/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=9744549)
* Frequency Distribution: [*Lab 2 Video*](https://northeastern.instructure.com/courses/165163/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=9744549)
* Chi-Squared Test: [*Lab 2 Video*](https://northeastern.instructure.com/courses/165163/pages/module-2-lab-2-the-triangular-probability-distributions-and-random-number-generation?module_item_id=9744549)