**Simulation Analysis of Machine Breakdown and Repair Efficiency**

University of Illinois Chicago

IDS 420 Business Model Simulation

Presented to

Business Model Simulation: IDS 420

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1. **Introduction**
2. **Problem Description**

* **Source of the problem:** The problem simulates a manufacturing system prone to breakdowns. Each machine operates for a random amount of time before breaking down, modeled as an **e**xponentially distributed random variable with a mean time of 8 hours. This showcases the uncertainty in the system's reliability and repair schedule. Furthermore, there is a cost problem in this system, if it will be beneficial to purchase more machines to improve operational efficiency.
* **Codebook**

**Variable name Description Units**

Simulation Time How long the simulation running for Hours Number of Machines How many machines are in the system

Number of repairmen How many repairmen are in the system

Mean Repair Time How long it takes to repair a broken machine Hours

Mean Time between breakdowns How long between machine breakdowns Hours

Cost Per broken machine How much it costs to repair machine Dollars

Cost per repairman How much a repairman is paid per hour Dollars

BD Breakdown

TM Time Hours

1. **Goals and Objectives**

* **Goal:** Evaluate how much it costs to keep the system running when a machine is broken down, analyze breakdowns, cost, and operational efficiency to decide whether the system should purchase more machines or not.
* **Objectives:**

1. Calculate the total cost of the system running for 800 hours.
2. Determine the cost-effectiveness of adding more machines to the system.
3. Provide recommendations based on results.
4. **Approaches/Methods/Analysis**
5. **Approach**

We used previous knowledge of simulating a single server queuing system to model our simulation. We also used the formula: **-lambda\*ln(rand())**, to generate 200 random numbers in a separate sheet replacing lambda with -8 for the mean of 8 hours for breakdowns and 2 for the mean of repair time for each machine. We did this for all three machines and then pasted the random numbers as values in the “simulation – initial” sheet. When we added more machines, we did the same thing for machines 4-6.

1. **Logic/Formulas**

* **Repair Priority:** We formed this logic that repairman 1 will prioritize fixing machine 1 when it is broken, repairman 2 will prioritize fixing machine 3 when it is broken; Repairman 2 will step in for machine 1 when repairman 1 is busy. The third machine will go into the queue if both repairmen are busy, this pattern repeats throughout the 800 simulated hours.
* **Queue Length:** Represents the number of machines waiting for repair

COUNTIF(E3:G3, "Breakdown") This will count how many breakdowns there are from machine 1 to machine 3,

Countif(W3:X3,1), counts the number of repairmen who is busy(status 1 is busy and status 0 is idle)

This ensures the tracking of waiting machines

* **Total Cost:**

This formula combined downtime and repair status and queue length: =Z3 + (Y4 \* 50) + ((W4 + X4) \* 10). Adds the cost of machine (50$/hr) in the queue, ((W3+X3) \* 10) adds the cost of repairmen at 10$/hr.

This is because every machine waiting in the queue acquires a 50-dollar charge, we use the repairman status because if they are busy then they will be paid $10/hour.

* **Next Breakdown Determination:**

We used the random breakdowns and the repair completion time to determine this column

* **Assumptions:**

Breakdown times and repair times follow exponential distributions. All machines start operational at time zero, and no queues exist initially.

1. **Software Used**

We used Microsoft Excel for our simulation because of its easy implementation, formula support, and ability to track simulations dynamically.

1. **Findings**

* **Initial (3 machines):** The total cost to run this manufacturing system for 800 hours with current breakdowns, two repairmen, and three machines totaled up to $20,770. The average queue length was 0.4725 and the total operational time was 790 hours.
* **4 Machines:** The total cost to add one more machine was $27,240, the average queue length was 0.6375, and the total operational time was 798 hours.
* **5 Machines:** The totalcost to add two more machines was $38,160, the average queue length was 0.905, and the total operational time was 798 hours.
* **6 Machines:** The total cost to add three more machines was $43,760, the average queue length was 1., and the total operational time was 800 hours.

1. **Conclusion & Recommendation:**

The simulation results reveal that increasing the number of machines enhances operational time but also leads to higher costs and longer queue lengths per machine. With 3 machines, the system achieves the lowest cost per machine and the shortest queue length and total operational time. Adding more machines improves total operational time, but at significantly higher costs per machine and increased queue lengths.

Since we do not have information on how much revenue the manufacturer generates from their machines, we cannot give an exact number of machines that would be optimal. However, we will recommend that if the Total Cost increase from 3 machines to 4 machines is less than the revenue lost from the lesser Total Operational Time for 3 machines, then the manufacturer should choose 4 machines.