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Simulating a Pharmaceutical Supply Chain to Prevent Drug Shortages

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Problem Statement

Shortages of prescription drugs have reached and maintained at a very high level for the past 10 years. This is mainly caused by pharmaceutical companies implementing a non-resilient supply chain, which is very vulnerable to disruptions. Drug shortages can lead to high costs. The median length of a shortage is 14 months.

Research Gap

There is a need to evaluate the resiliency of pharmaceutical supply chains to disruptions. In past work, we have developed a closed-form queueing model of supply chain availability. We developed a simulation model to validate the closed-form model, conduct analyses with relaxed assumptions, and produce distributional results.

Solution Approach

Inputs and Outputs

Inputs:

- Supply Chain Characteristics
  - Failure rates
  - Recovery rates
  - Number of facilities in each echelon
- Model Settings
  - Time horizon
  - Number of replications

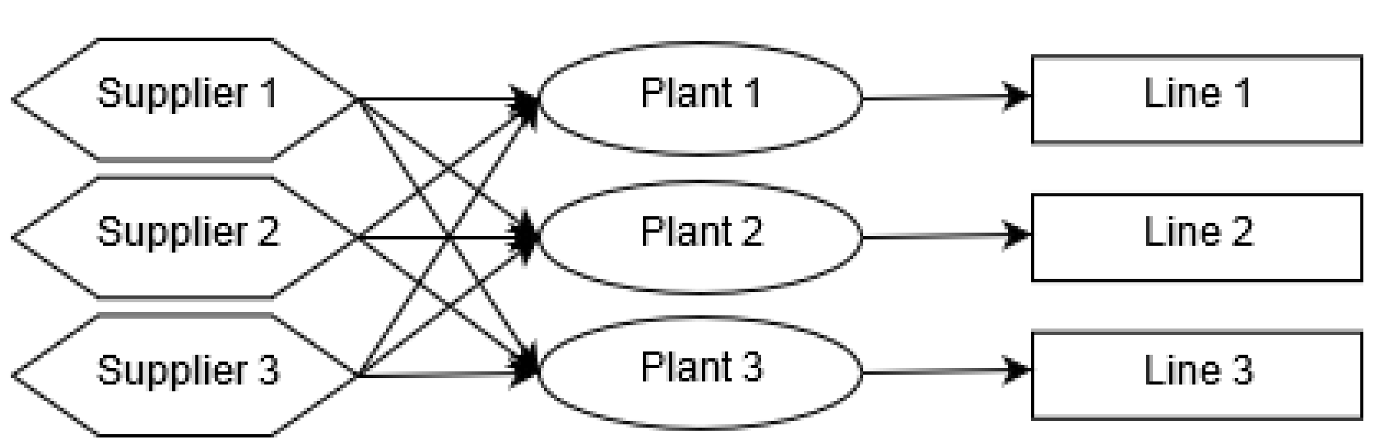


Figure 1: Supply Chain Structure Example

Outputs:

- Average Availability of the System (the percent of time demand can be met)
- Expected Shortage Time
- Average Uptime
- Average Downtime

Simulation Process

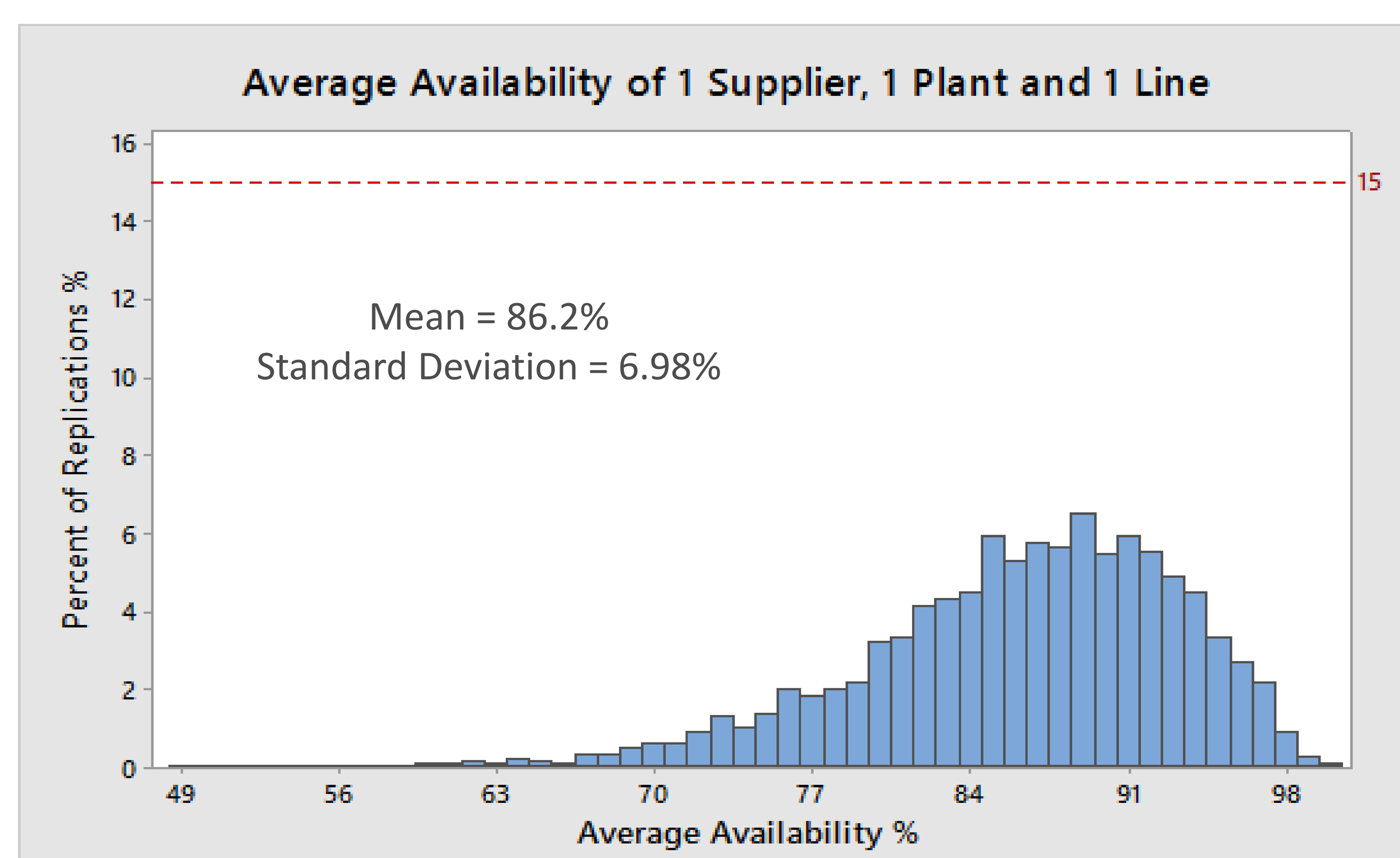
Initialize Parameters:
Depending on the user's input of number of facilities, the program creates the respective lines, plants and suppliers as entities.

Simulate Facility Statuses:
The program goes through each facility and checks if there is a change in status for them. If there is, either a failure or recovery time is randomly generated from an exponential distribution to be the facility's waiting time. If the waiting time has ended, the facility changes to its respective new statuses. We recorded the interval between status changes for each facility into an array.

Check Overall Supply Chain Status:
Based on the statuses of each facility at each time unit, the program calculates the uptime and downtime of the system as a whole.

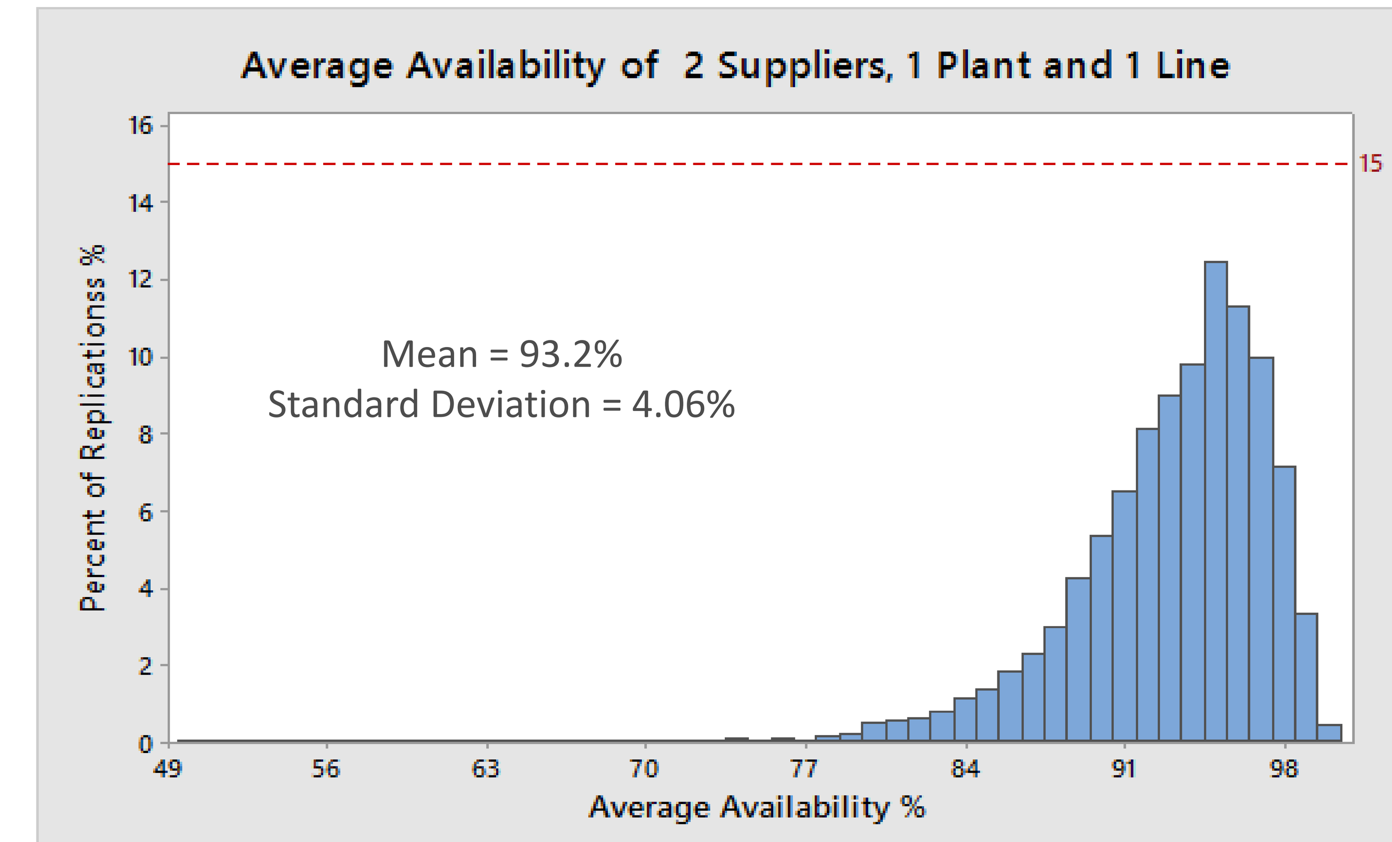
Calculate Outcomes:
Finally, given the array of uptime and downtime, the program is able to calculate the average availability, average uptime and average downtime. Then, the outputs are printed onscreen and exported in an excel file.

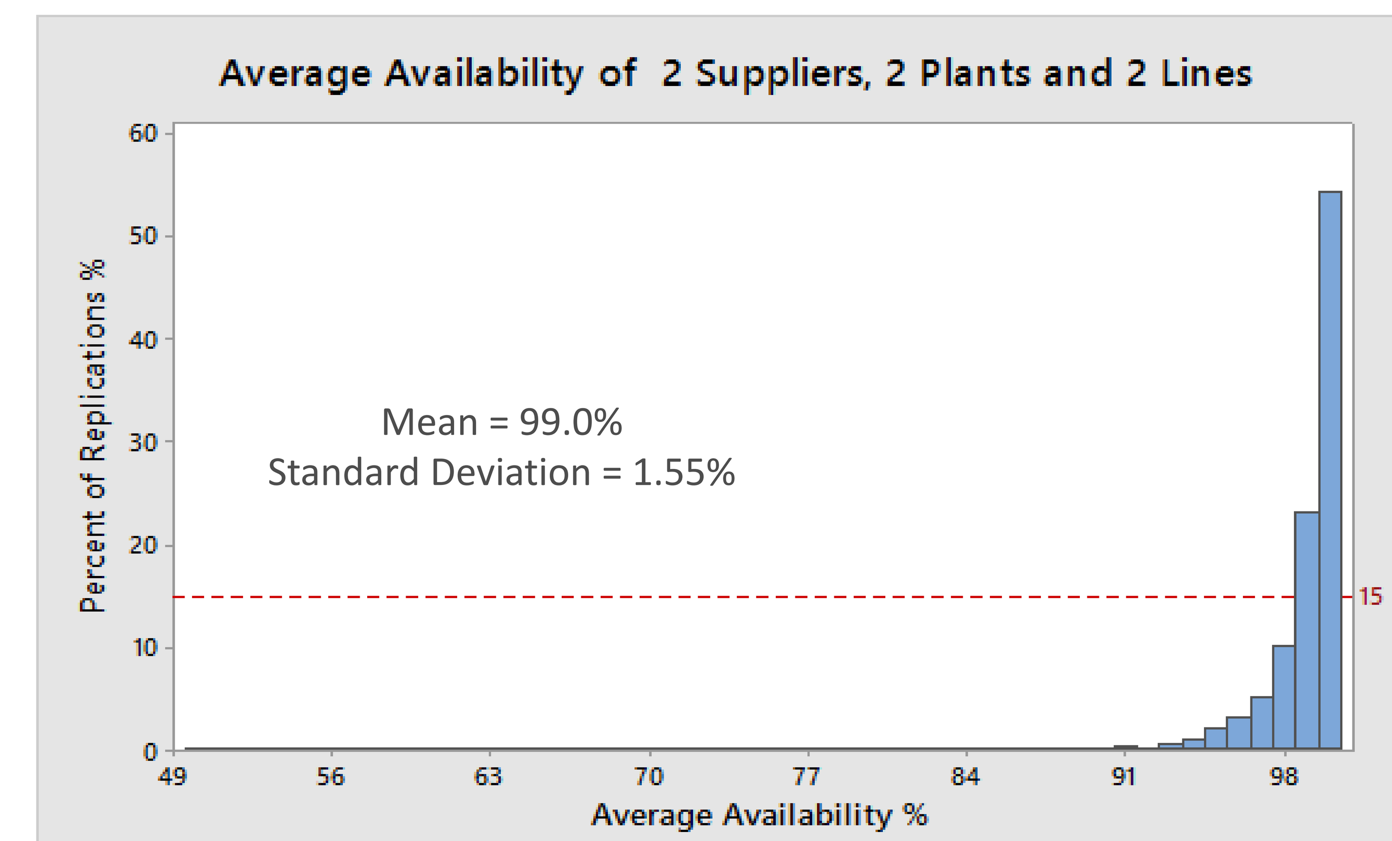
Results



With one facility at each echelon of the supply chain, the average availability is 86.2% which corresponds to a shortage of 13.8%.

With an additional supplier, the average availability is 93.2%. With redundancy at each echelon, the average availability is 99%.





Conclusions

The supply chain without redundancy is not very resilient. Substantial improvements can be seen if an extra supply is added. The supply chain with two facilities in each echelon is very resilient.

Possible extensions include: adding inventory to make the simulation more realistic and determining the most efficient configuration by considering costs.

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