

Project – Whey Protein Production

(This project is adapted from a real project. Some elements have been simplified to fit the course timeline and content.)

1 Introduction

This project focuses on a factory that makes whey protein power products. The factory runs on 2 shifts (8 hours each) for 5 days a week. Each shift begins right where the previous shift left off. In general, we can model this system using arrivals of an order, and one order is one batch of units. An order has an interarrival time distribution according to an exponential distribution with a rate of 2 per hour. The manager wants you to only focus on only a subset of products. Each order has certain attributes: weight, bag/jar, flavor, and batch size.

- Container:
 - Bag: 31.5% of all product types. Of all the bags, the following are made
 - 2 pounds: 20%
 - 5 pounds: 80%
 - Jar: 68.5% of all product types. Of all the jars, the following are made
 - 2 pounds: 74%
 - 5 pounds: 26%
- Flavor: vanilla (71%) or chocolate (29%)
- Batch size: 15 units (18%) or 20 units (82%)

An order is typically one product type. Each unit of the batch earns the following profit on average:

- 2 pound bags: \$1.20 per bag
- 2 pound jars: \$1.43 per jar
- 5 pound bags: \$4.21 per bag
- 5 pound jars: \$4.80 per jar

2 Process

All product goes through the following process:

Preparation – Weighing Station – Mixing Station – Packaging – Quality Check – Shipping

Preparation: There is only 1 workstation here with one employee dedicated to this station. The employee reads the order and prints the recipe that should be used. The recipe and order are attached to a large bin, which is big enough for one unit. The processing time **for each unit in the order** is an exponential distribution with a mean of 1.1 minutes.

Weighing Station: There are 2 weigh stations in parallel. In each one, a worker scans the order and recipe. There is an automated machine that weighs all the ingredients and pours it into the empty bin. The machine then pushes the bin out of the machine. The processing time for **each unit**, ignoring whether it is a bag or jar, follows a normal distribution with a mean of 2.6 minutes and standard deviation of 1.4 minutes. The bag/jar size (i.e. 2 pounds or 5 pounds) doesn't impact the processing time significantly.

Mixing Station: There are 3 mixing stations in parallel. The powder in the bin is dumped into the mixer by a worker. Once the mixer is done, the power is dumped back into bin. The worker removes the bin and goes to the next product. Based on an input analysis, the following processing times can be used:

- 2 pound bags and jars: Weibull Distribution, Scale = 3.5, Shape = 2
- 5 pound bags and jars: Normal Distribution, Mean = 5, Standard Deviation = 3.2

If the current unit is vanilla flavor and the next product is chocolate flavor, then the mixing station must be sanitized before starting on the next unit so that the flavors don't mix. The sanitation process was timed, and it follows a normal distribution with a mean of 7.5 minutes and standard deviation of 1 minute. There is no need for sanitization if the current flavor is chocolate and the next is vanilla. (*The company tested the flavor profiles and determined that it was not needed as it appeared the vanilla flavor overpowers the chocolate flavor. Also, the vanilla flavor tended to stick to the machine and not the chocolate flavor.*)

Packaging: Only one automated packaging machine is in the factory. The bins are loaded on the machine where the powder is poured into a funnel will then pour the product into the corresponding container, apply the label and seal the container. For 2 pound products, the processing time is from an Exponential distribution with mean of 0.85 minute. For 5 pound products, the processing time is from a Normal distribution with a mean of 1.2 minutes and standard deviation of 0.25 minutes. The bins are returned to the Preparation station from here.

Shipping: This is not in the scope of the project. Products are accumulated here and put into staging areas to be shipped out. There are no concerns here right now as they are also starved for work.

3 Current State

Currently, the factory has no mechanism that is reliably collecting data. However, using historical data and 3 weeks of observations, he was able to give you the following statistics to use to perform your current state analysis:

- Preparation Station:
 - Average Number Waiting: 30 units
- Weigh Station:
 - Average Number waiting: 25 units
- Average Throughput or a week:
 - 2 pound bags: 185
 - 2 pound jars: 1465
 - 5 pound bags: 845
 - 5 pound jars: 535

4 Objective

The manager wishes for you to investigate how to improve the system. He notices that many bins with powder are waiting in front of each station. It's taking up a lot of space. The shipping department is usually starving for product, and he knows that most of the units are WIP on the factory floor. He would like to make improvements to speed up the process and move the product through the line more quickly. He's asking you to provide some recommendations.

Some strategies to consider:

- **Resource allocation:** Managing workers and resources differently (i.e. dedicated resources to a station versus sharing resources)
- **Capital Investment:**
 - Increasing the number of resources or machines at any station
 - Personnel at the Preparation Station can be considered with negligible cost if the increase is less than 3 workers.
 - Weigh stations (\$65,000 per machine)
 - Mixing stations (\$70,000 per machine)
 - Do not consider increase to the Packaging station.
 - The investment must be advantageous to the company. If you recommend capital investment, then you must also discuss the payback period.
 - Note: When considering the profit made, only consider the units that were finished. Any WIP does not count towards profit.
- **(Required for ISYE 580 and 480 Honors only) New policy:**
 - Right now all units go to the next available machine at the Mixing and Weigh station. However, at the Mixing station, there is a sanitization process that adds additional setup time. Can you recommend any changes to this setup?
 - Perform your test in Simio and provide an explanation for why your idea does or does not work.
 - There are only 150 bins available in the factory, and he will need to throw out 50 of them because they are damaged and he thinks they are contributing to quality issues. Determine whether 100 is enough or if he should consider ordering more. If ordering more, then how many more should they purchase.
 - Bins are used at the preparation station. At the packaging station, they are gathered, cleaned (Normal Distribution of 10 minutes standard deviation of 2 minutes), and then returned to the preparation station.
- **Extra Credit**
 - (up to 10 points) Create an appealing animation for the entire simulation.
 - (up to 5 points) Create a visually appealing dashboard report showing the statistics in the simulation while it is running

5 Deadlines

5.1 Current State Analysis

Due November 14, 2025

- Build a Simio model that represents the system described
- Validate the model using the statistics provided.
- Deliverables per group:
 - Write a report (Word or PDF) providing an overview of the Simio model, and explaining your methodology for validation. It should include a statistical analysis. The model does not need to be explained in detail, but enough for any non-Simio user to understand.
 - Include a Gantt Chart showing project tasks and plan. It should include milestones (such as the due dates and any additional ones you have for your group). You can also submit this as an Excel file, but it must be mentioned and discussed in your report.
 - Simio files, as relevant

5.2 Scenario Analysis

Due December 8, 2025

- Analyze the strategies provided under “Objectives”. For each one, provide the corresponding statistical analysis.
- One submission per group:
 - Relevant Simio files/models: Please separate each strategy/scenario in a different Model or in a different Simio file
 - Final Report (Word or PDF) See the Report Guidelines section
 - Include update Gantt Chart
- One Submission per person: Peer Evaluation (this will be an electronic form. A link will be provided on Blackboard)

(Optional) Extra Credit:

- Due with final submission
- Can be submitted individually or as a group
- Must be documented within the final report with proper explanation

5.3 Report Guidelines

The audience for your report is factory manager and other floor managers, which know nothing about simulation but a bit about statistics. It is critical that your analysis is **thorough** and that you **fully justify your conclusions**. All reports are summary of analysis performed with thorough discussion of the results. Make sure to provide recommendations in your conclusions section.

The first report should contain all the sections below at minimum

- Executive Summary
- Introduction
- Model Construction
 - Include a readable screenshot of your model layout.
 - Indicate any assumptions you made when constructing the model.
 - Include a list of the distributions you used.
- Model Validation (this is your current state analysis)
- Next Steps and Project Plan

The report should contain all sections below

- Executive Summary
- Introduction
- Model Construction & Validation
 - Include a brief summary of your current state and any changes you had to make from the first report.
- Scenario Analysis
 - Have a subsection describing each scenario and the corresponding changes to the Simio model.
- Analysis of Results
- Conclusion and Recommendations

In the final report, you can make relevant changes from the first report. The final report is a cumulative of all the work for this project.

The following are other categories that you will be graded on

- Organization: Make sure your report is organized in a logical sense
- You can have appendices with detailed calculations.
 - Use alphabetic numbering (i.e. Appendix A: Detailed Calculations of 2-Sample Hypothesis Test)
- Format and Grammar
 - Font: Times New Roman
 - Allowed Font Size 11 or 12pt
 - All headings must be numbered (similar to this document)
 - Spacing can be 1.5 or 2.0
 - Margins must be 1 inch for all sides
 - Include page numbers, Cover Page, Table of Contents
 - Include correct label format for tables and figures (make sure your figures/tables are readable)
 - **All figures and tables** must be discussed. Do not include a figure or table assuming your reader will understand how to interpret it.