4 d: Experimenting

Question

Experiment with different values of the maximum production capacity and the holding costs in order to get insights for the trade-off between these in the production and inventory holding decisions for products. Justify the ranges of values you use for the experiments. Provide your interpretation of the results by discussing the impact on the objective function, different costs involved and the decisions.

4.1 Experimenting

The purpose of the experiments is to evaluate the performance of the production and inventory system under various configurations of production capacity and holding costs. Each experiment modifies the production capacity and the holding costs of three different products (18/10, 18/8, 18/0 alloys) across several suppliers. The goal is to minimize the total cost, which includes production, inventory, and purchase costs, while satisfying demand and maintaining inventory balance.

4.1.1 Steps in Each Experiment

1. Define the production capacities to be tested: 50, 100, and 150 units.
2. Vary the holding costs for each product: 5, 10, and 20 units for each of the 18/10, 18/8, and 18/0 alloys.
3. For each combination of production capacity and holding costs, run the optimization model to minimize the total cost.
4. Ensure that demand is met for each product and that inventory levels are maintained across the 12-month planning horizon.
5. Extract and save the results for total cost, production plan, inventory plan, and purchase plan for each experiment.
6. Compare the results to identify the trade-off between production capacity and holding costs and their impact on the overall system cost.

The total number of experiments is determined by the combination of different parameter values. Specifically, there are:

- 3 levels of production capacity (50, 100, 150 units),
- 3 levels of holding cost for the 18/10 alloy (5, 10, 20 units),
- 3 levels of holding cost for the 18/8 alloy (5, 10, 20 units),
- 3 levels of holding cost for the 18/0 alloy (5, 10, 20 units).

Thus, the total number of experiments is calculated as:

$$3 \times 3 \times 3 \times 3 = 81$$

4.1.2 Data Outputs

Each experiment outputs:

- Total cost for the system (production, inventory, and purchase costs).
- Production plan: the quantity of each product to produce in each month.
- Inventory plan: the stock levels for each product at the end of each month.
- Purchase plan: the quantity of each product to be purchased from each supplier.

The full output are saved in an Excel file named which you can find in the additional deliverables, with each experiment occupying separate sheets.

4.2 Results Analysis

The following section presents the analysis of the experimental results. The purpose is to identify the optimal configurations by comparing various production capacities and holding costs. The analysis is visualized using heatmaps and statistical charts, followed by a discussion of the trends observed in production, inventory, and purchase plans. Detailed results are included in the appendix.

4.2.1 Heatmap of Minimum Total Cost

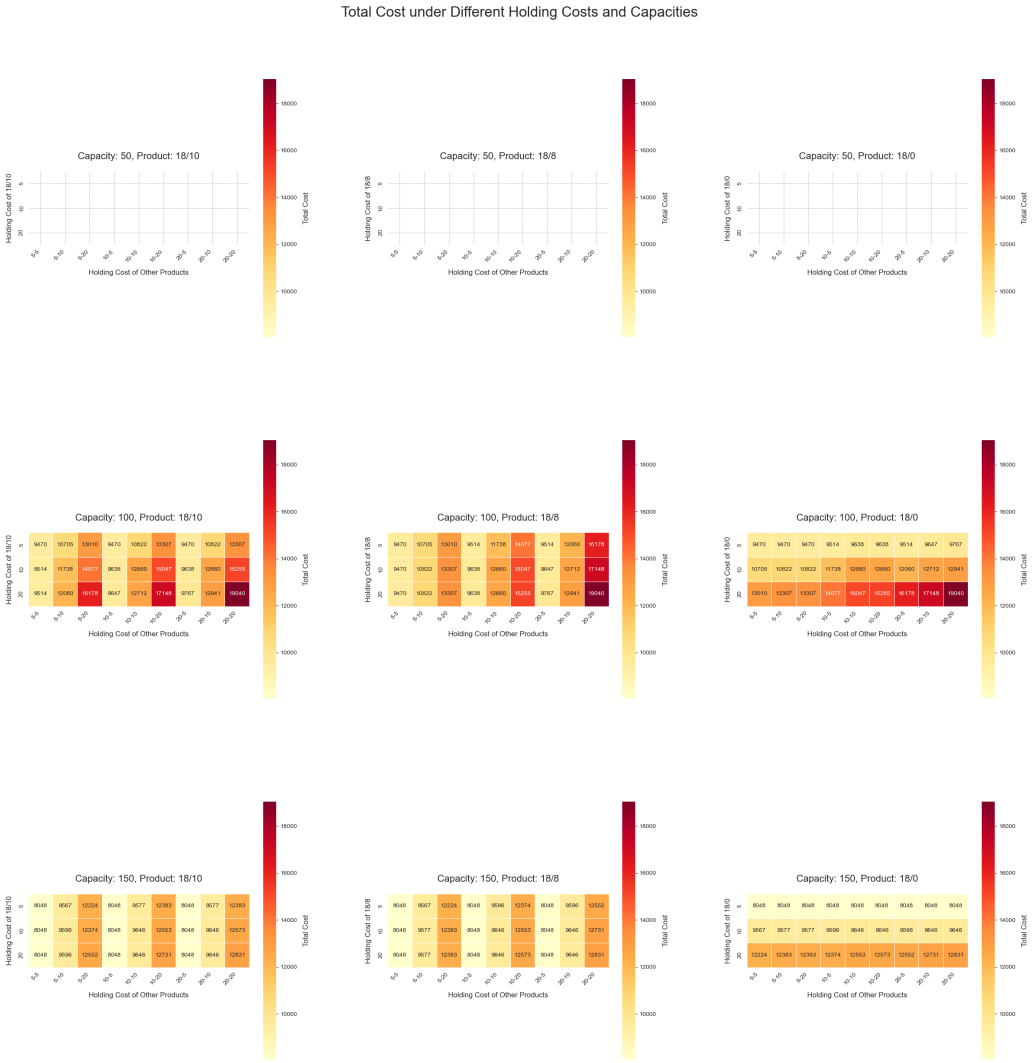

Figure 1: Heatmap showing minimum total cost across all experiments.

The heatmap (Figure 1, also can be found in additional deliverables) shows how total cost varies across different configurations of production capacity and holding costs. Specifically, the heatmaps depict three production capacities (50, 100, 150) and three alloy combinations (18/10, 18/8, 18/0), with the color gradient representing total cost (from yellow for lower costs to red for higher costs). Lower costs are concentrated in areas where holding costs are minimized for specific production capacities. For instance, production capacities of 100 or 150 units with lower holding costs for the 18/10 alloy yield the most cost-efficient results. The detailed analysis is as below.

4.2.2 Effect of Production Capacity on Cost

As production capacity increases from 50 to 150, the total cost tends to decrease for the same storage cost combination. This can be expressed as:

Total cost decreases as production capacity increases.

For example, in all product combinations, the minimum total cost with a production capacity of 150 is lower than with a capacity of 50. This suggests that increasing production capacity helps reduce total cost. This could be due to the ability of higher capacities to better manage demand fluctuations and optimize the allocation of production and storage resources.

4.2.3 Effect of Different Alloy Combinations on Cost

Each alloy combination (18/10, 18/8, 18/0) exhibits different impacts on total cost:
- For alloy 18/10, storage cost has a more significant effect on total cost. As the holding cost increases, the total cost varies more distinctly across the heatmap.
- On the other hand, for alloy 18/8 and 18/0, the total cost is more concentrated, and the effect of storage cost on total cost is less pronounced.
This suggests that different alloy combinations require different storage strategies. For example, the 18/10 alloy may require more precise storage strategies to optimize costs, while for alloys 18/8 and 18/0, changes in storage cost will not substantially affect total cost.

4.2.4 Effect of Storage Cost on Minimum Cost

The influence of storage cost on total cost becomes more evident as production capacity increases:
- In the heatmaps for a production capacity of 150, total cost significantly decreases in the regions with lower storage costs, especially for the 18/10 alloy combination.
- Overall, the optimal point for storage cost is not the same across different production capacities and alloy combinations, indicating that optimal storage strategies need to be tailored for each alloy combination.

4.3 Conclusion

Increasing production capacity can help reduce total cost, but the sensitivity of total cost to storage costs varies across different alloy combinations. For some combinations, like 18/10, optimizing storage cost is crucial to minimizing total cost, while for others, such as 18/8 and 18/0, storage costs have a less significant impact on total cost.