d Experiment

In this part, experiments with different values of the maximum production capacity and the holding costs are conducted in order to get insights for the trade-off between these in the production and inventory holding decisions for products.

Experiment description

In the experiment, the production capacity of the system and the holding costs for the three product types (18/10, 18/8, and 18/0) are modified.

The initial step is to determine the range of values to be tested, which means a "pre-test" is needed. Various random combinations of production capacity and holding costs are examined. The results show that production capacity should be at least 93 kg/month, while a capacity above 200 kg/month has minimal impact on minimizing costs and the production plan. Based on these, the production capacity is set at [95, 100, 120, 150, 200] kg/month. For holding costs, a cost multiplier set is applied to assess model performance under different conditions. The final values of the cost multiplier set are determined to be [0.1, 0.5, 1.0, 2.0, 5.0], with each value multiplying the current holding cost. This results in a total of 625 tests (5*5*5*5) to be conducted.

In short, the experiment involve the following parameter change:

- **Production capacity [kg/month]**: [95, 100, 120, 150, 200]
- **18/10 holding cost [euro/kg]**: [2, 10, 20, 40, 100]
- **18/8 holding cost [euro/kg]**: [1, 5, 10, 20, 50]
- **18/8 holding cost [euro/kg]**: [0.5, 1, 5, 10, 25]

As the number of tests increases to 625, the output is adjusted accordingly. Instead of providing detailed inventory and procurement plans for all suppliers, the model will primarily output the total cost, total storage cost, and total procurement cost for each experiment. In the subsequent analysis, plots are used to illustrate and discuss the experiment results. Complete experiment data can be found on GitHub via the link in statement if needed.

Experiment analysis

Based on the experimental data, a thorough analysis of the outcomes is conducted to gain insights into the trade-offs involved in production and inventory decisions for the products. The statistical results include key metrics such as total cost, total storage cost, and total procurement cost. In the next phase, data visualization methods including heatmap, scatter plot, and box plot are employed to clearly identify patterns and trends, illustrating how variations in parameters influence both the inventory and procurement plans. This analysis further highlights how these changes impact the overall optimization of production strategies.

Heatmap analysis

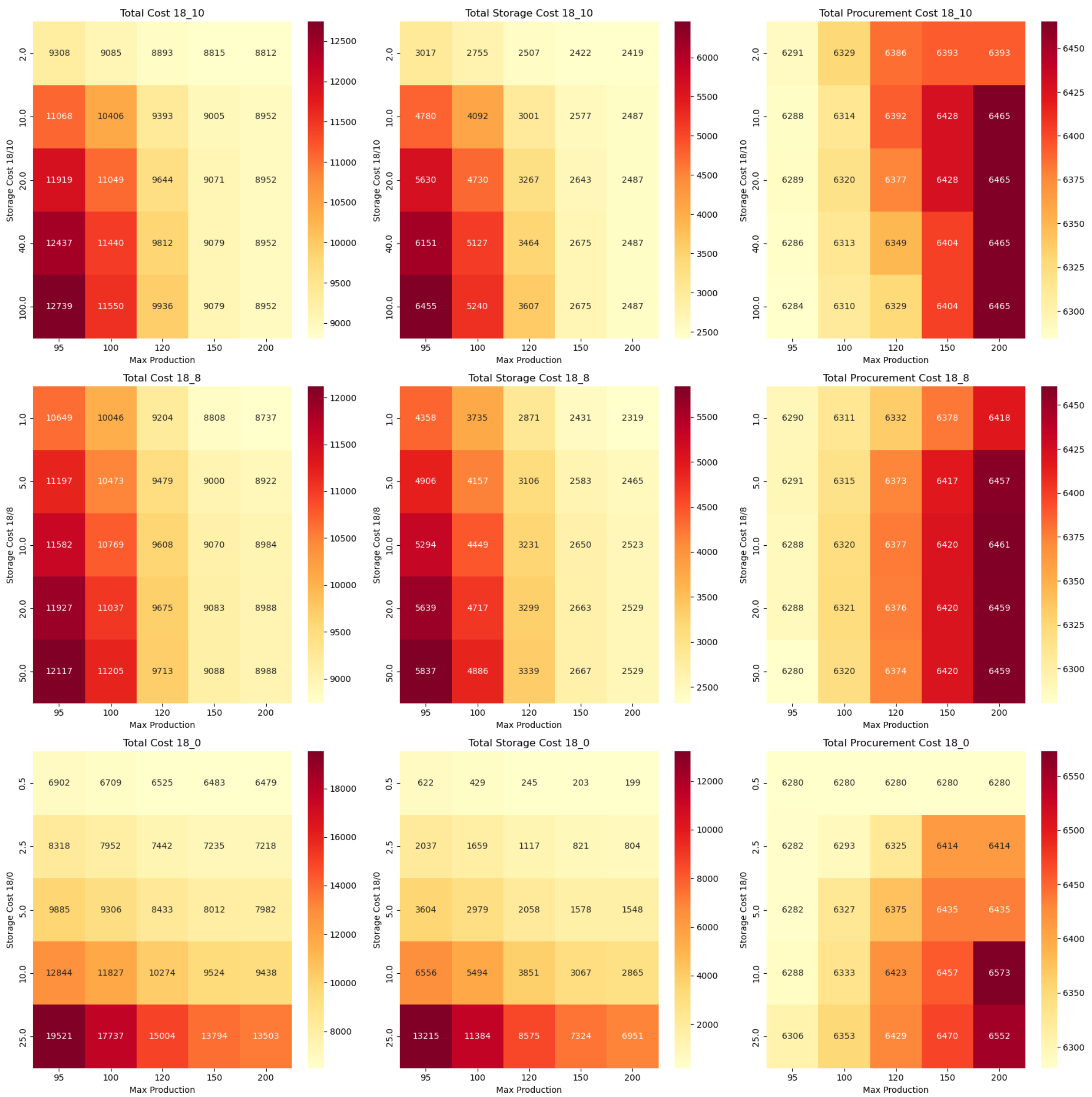

Figure 1: Heatmap of total cost, total storage cost and total procurement cost

Figure 1 shows the influence of various combinations of max production capacity and storage cost of different products on total cost, total storage cost and total procurement cost. A yellow color represents a low cost, and red and darker colors represent higher costs. In the first column, it shows that lower total costs tend to occur at higher production levels combined with lower storage costs. In the second volumn, it is shown that lower production levels and lower storage cost scenarios lead to significantly reduced storage costs. The third column shows the procurement costs, which seem to be relatively stable across different scenarios. In the whole plot, the best results in terms of minimizing costs seem to be achieved when max production is high, and storage costs are low, especially in the 18/0 scenario. To justify this assessment, further analysis is needed.

Scatter plot analysis

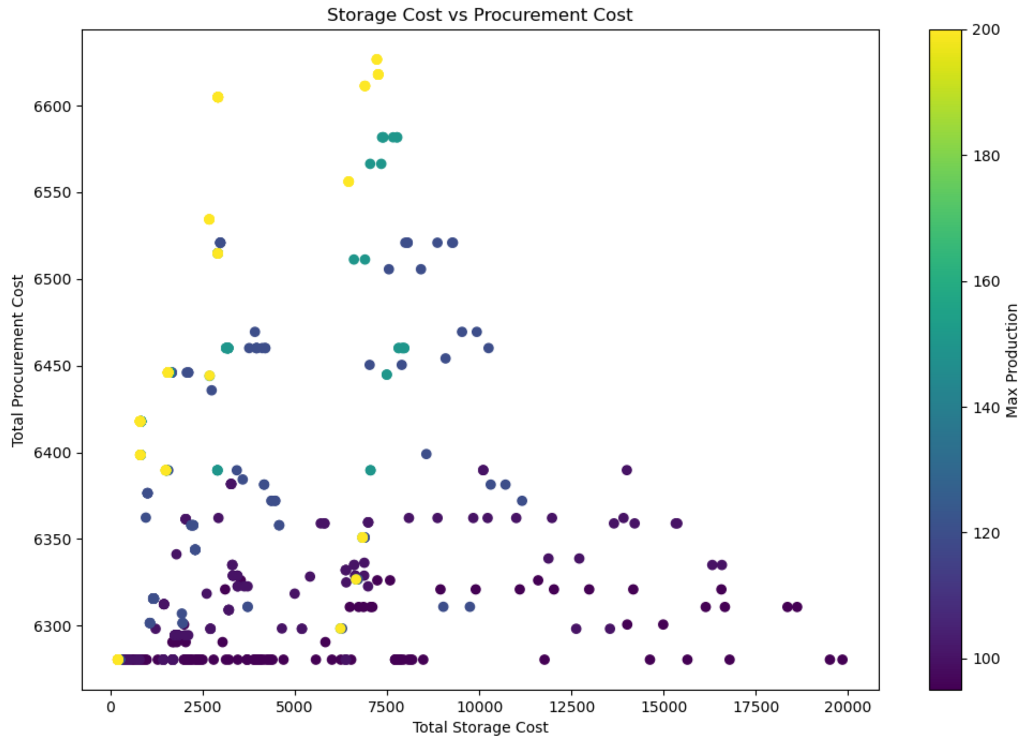

Figure 2: Scatter plot of storage cost vs procurement cost

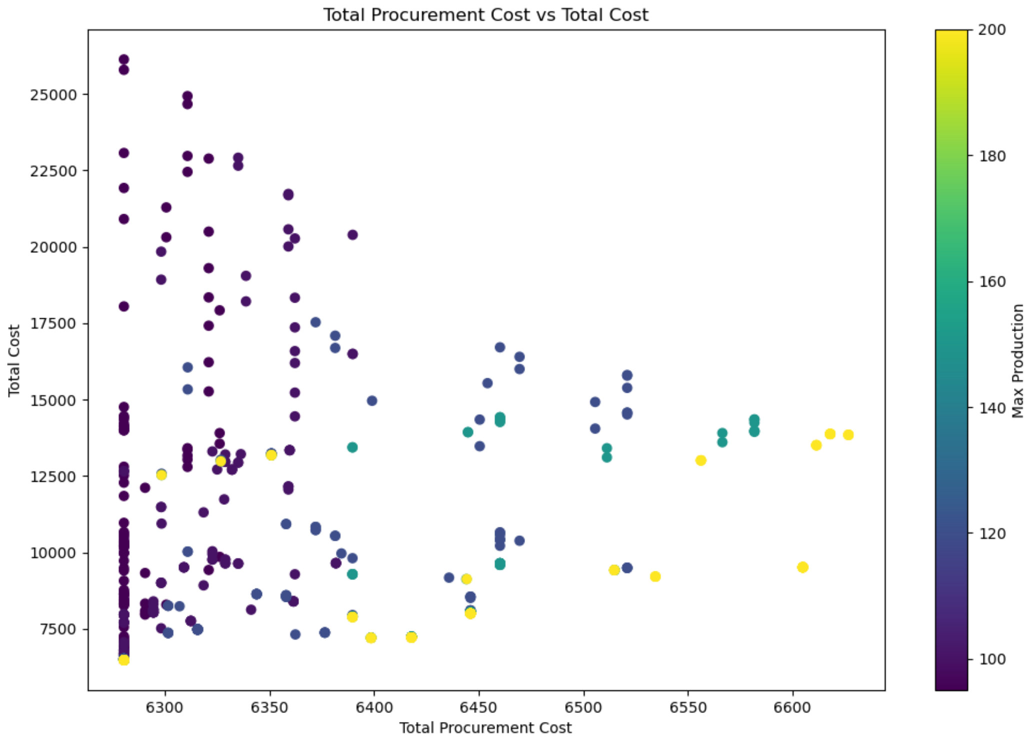

Figure 3: Scatter plot of total procurement cost vs total cost

Figure 4: Scatter plot of total storage cost vs total cost

To further analyze the direct impact of production capacity on total cost, total procurement cost, and total storage cost, scatter plots were drawn. The points in the figures are color-coded according to the maximum production capacity, with blue and darker points representing higher production capacities, and yellow and green points indicating lower production capacities.

In Figure 2 and Figure 3, it is evident that total procurement cost remains relatively stable, with no significant fluctuations as the parameters change. This suggests that procurement costs are relatively insensitive to variations in production capacity. In contrast, total storage cost shows dramatic fluctuations, particularly in scenarios with higher production capacities, where storage costs increase significantly. This trend indicates that higher production levels require more storage space to accommodate larger inventories, leading to substantial increases in storage costs. Additionally, as seen in Figure 4, there is a clear linear relationship between total storage cost and total cost. As storage costs rise, total costs increase correspondingly. This linearity supports the deductions made in the previous heatmap analysis, where storage costs were identified as a key factor driving overall cost increases.

From this scatter plot analysis, it can be concluded that while procurement costs remain relatively stable, managing storage costs is critical to controlling overall costs. Specifically, at higher production levels, the rise in storage costs can significantly drive up total costs.

Box plot analysis

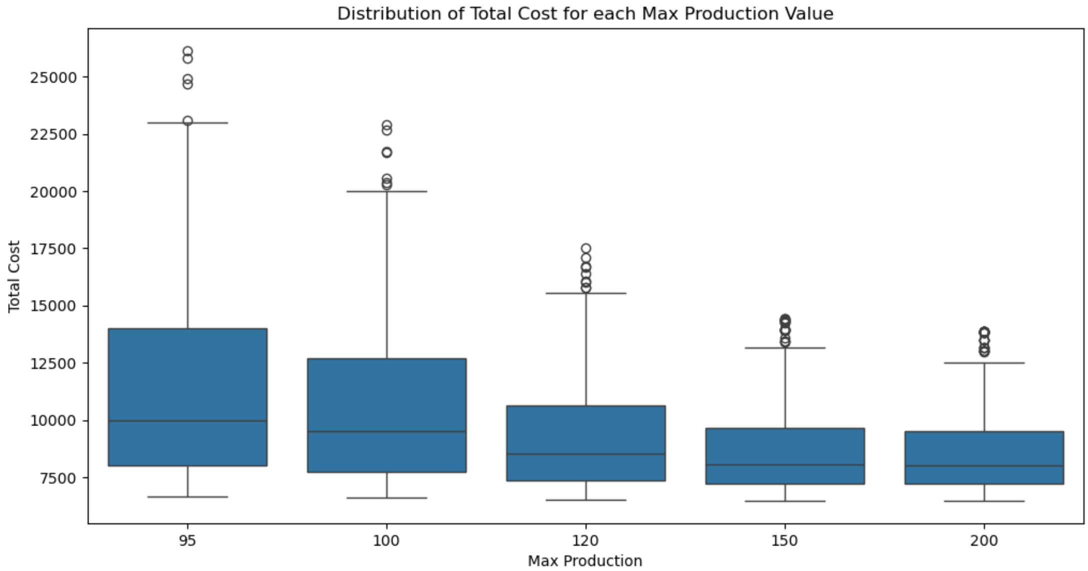

Figure 5: Total cost distribution by max production capacity

To better understand the impact of storage cost fluctuations on total cost under varying maximum production capacity scenarios, a box plot is created. Figure 5 clearly illustrates the range of total cost variations across different production capacity levels. As shown in the plot, as the maximum production capacity increases, the range of total cost variation becomes narrower. This implies that the impact of storage cost changes diminishes as production capacity increases.

The reduction in total cost variation with higher production capacities suggests that increasing production capacity can mitigate the effects of fluctuating storage costs. In other words, a larger production capacity can absorb storage cost volatility more effectively, leading to more stable overall costs. Thus, if stability in total cost is a key priority, increasing production capacity can be an effective strategy to minimize the variability introduced by changing storage costs.

Discussion

In conclusion, as max production capacity and storage cost of each product changes, the analysis highlights that storage cost is a key factor driving total cost variation, while procurement costs remain stable. Higher production capacities lead to decreased storage costs and can help reduce total cost variability. This suggests that increasing production capacity can help stabilize overall costs by mitigating the impact of fluctuating storage costs. Effective cost management should prioritize controlling storage expenses, especially in scenarios with higher production levels, to maintain a balanced and predictable total cost structure.