2 b: Implementation of the Model

Question

Implement the mathematical model in part (a) in python and solve with Gurobi. Provide the optimal solution. By the optimal solution it is meant that you need to report the optimal cost value and the production schedule. Your python model needs to also output the values of the decision variables but only those that you discuss need to be in the report.

2.1 Implementation in Python

Python code of the model and the data is in the Appendix part B.

2.2 Output of the model (optimal solution)

Following are the output of the code and provide the optimal solution (in table format with explanation).

Optimal cost Output

Optimal cost: 9646.78 EURO

Production Plan Schedule Table

Table 2 shows the monthly breakdown of the production quantities (in kilograms) for each of the three products: 18/10, 18/8, and 18/0 stainless steel.

- **Rows**: Each row corresponds to one of the three products.
- **Columns**: Each column represents a month (from Month 1 to Month 12).

Table 2: Production Plan (kg)

Product	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
18/10	25.0	25.0	0.0	0.0	0.0	50.0
18/8	10.0	10.0	10.0	14.375	5.625	10.0
18/0	8.086957	65.0	86.956522	86.956522	85.625	44.375

Product	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
18/10	12.0	0.0	10.0	10.0	45.0	99.0
18/8	10.0	10.0	10.0	19.0	1.0	0.0
18/0	78.0	80.0	62.0	80.0	36.0	0.0

Inventory Levels Schedule Table

Table 3 displays the monthly inventory levels for each product at the end of the month (in kilograms). The inventory level represents how much stock is leftover after meeting the demand.

- **Rows**: Each row corresponds to one of the three products.
- **Columns**: Each column shows the inventory at the end of each month (Month 1 to Month 12).

Table 3: Inventory Levels (kg)

Product	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
18/10	0.0	0.0	0.0	0.0	0.0	0.0
18/8	0.0	0.0	0.0	0.0	4.375	0.0
18/0	3.086957	48.086957	55.043478	117.0	152.625	72.0

Product	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
18/10	0.0	0.0	0.0	0.0	0.0	0.0
18/8	0.0	0.0	0.0	0.0	9.0	0.0
18/0	0.0	0.0	22.0	0.0	100.0	0.0

Purchase Plan Schedule Table

Table 4 5 6 shows the quantities of raw materials (in kilograms) purchased from each supplier (A, B, C, D, E) across 12 months.

- **Rows**: Each row corresponds to a supplier.
- **Columns**: Each column represents the raw material purchased from a supplier for each month (Month 1 to Month 12).

Table 4: Procurement Plan for Product 1 (kg)

Supplier	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Supplier 1	9.011628	9.011628	0.0	0.0	0.0	18.023256
Supplier 2	5.813953	5.813953	0.0	0.0	0.0	11.627907
Supplier 3	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 4	10.174419	10.174419	0.0	0.0	0.0	20.348837
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

Supplier	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Supplier 1	4.325581	0.0	3.604651	16.220930	0.0	35.686047
Supplier 2	2.790698	0.0	2.325581	10.465116	0.0	23.023256
Supplier 3	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 4	4.883721	0.0	4.069767	18.313953	0.0	40.290698
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

Table 5: Procurement Plan for Product 2 (kg)

Supplier	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Supplier 1	4.883721	4.883721	3.043478	3.043478	4.375000	2.747093
Supplier 2	1.860465	1.860465	2.086957	2.086957	3.000000	1.046512
Supplier 3	0.0	0.0	4.869565	4.869565	7.0	0.0
Supplier 4	3.255814	3.255814	0.0	0.0	0.0	1.831395
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

Supplier	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Supplier 1	4.883721	4.883721	4.883721	9.279070	0.488372	0.0
Supplier 2	1.860465	1.860465	1.860465	3.534884	0.186047	0.0
Supplier 3	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 4	3.255814	3.255814	3.255814	6.186047	0.325581	0.0
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

Table 6: Procurement Plan for Product 3 (kg)

Supplier	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Supplier 1	8.086957	65.000000	86.956522	86.956522	85.625000	44.375000
Supplier 2	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 3	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 4	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

Supplier	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Supplier 1	78.000000	80.000000	62.000000	36.000000	0.0	0.0
Supplier 2	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 3	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 4	0.0	0.0	0.0	0.0	0.0	0.0
Supplier 5	0.0	0.0	0.0	0.0	0.0	0.0

2.3 Discussion

The procurement, production, and inventory strategies outline resource management over 12 months. Product 3's production plan shows variability, with peaks in months 2 and 3, likely reflecting seasonal demand or strategic stockpiling. Product 1 has a balanced but intermittent production pattern, with increased output in the final months, aligning with year-end demand.

The inventory plan indicates Product 3's accumulation in months 4 and 5 before depleting, suggesting a push strategy to buffer against demand variability. Products 1 and 2 maintain minimal inventory, reflecting a lean production approach focused on cost efficiency.

The procurement plan shows heavy reliance on Supplier 1, especially for Product 3, with peaks in months 2, 3, and 10, posing a potential risk if disruptions occur. Suppliers 2 and 4 contribute less frequently. Product 2's procurement relies on Supplier 2 during months 4 to 6 and Supplier 1 in months 7 and 8, suggesting an adaptive strategy.

Product 3's inventory buildup between months 4 and 6 supports future production or mitigates supply chain disruptions. Lean inventory for Products 1 and 2 suggests predictable demand or a just-in-time (JIT) model to minimize carrying costs.

Overall, the organization seeks efficiency with minimal inventory while maintaining contingencies. Diversifying suppliers or increasing inventory buffers could enhance supply chain resilience.