3 c: Verification of the Implementation

Question

Verify the implementation, to convince that the code for (b) matches the mathematical formulation of (a) with a number of verification tests that cover different types of parameters used in the model. Provide a discussion on the verification experiments and their results with your justifications.

3.1 Verification Strategy

The following tests were performed by adjusting key parameters:

- **Objective Function Parameters**: Objective function verification ensures that the objective function correctly represents the actual optimization goal, such as cost minimization or profit maximization. By adjusting parameters or variables (e.g., increasing the storage cost for a specific alloy), we observe the resulting changes in the objective function. The method typically involves running small-scale experiments and manually calculating the total cost to compare it with the model's output. If the behavior matches the expected outcome (e.g., reducing storage while increasing costs), it confirms that the objective function is correctly formulated.
- **Function Parameters**: Function parameters verification aims to ensure that the model's parameters (e.g., material content, supply limits) are correctly applied in the model. By modifying specific parameters (such as increasing Supplier A's chromium content), we expect the model to adjust the material procurement to optimize production. If the model responds as expected by reducing costs, it confirms that the function parameters are appropriately influencing the model's behavior. It is also important to verify if the "unmixing" constraint (i.e., preventing the supply from being split into different products in a way that changes the composition) was correctly implemented
- **RHS parameters**: RHS (right-hand side) parameters verification checks if changes in the constraint parameters (such as demand levels or supply limits) are properly reflected in the model's decisions. By significantly altering demand or supply constraints, we observe whether the model appropriately adjusts its production or procurement plan. For example, reducing demand to zero in most months should result in a zero production plan, while reducing the availability of a key supplier should increase costs. If the model reacts as expected, it confirms that the RHS parameters are correctly applied.

3.2 Key Tests for Verification

The Table 7 below summarizes the key tests that were conducted to verify the implementation of the model. For each test, the objective is described, followed by the setup, expected results, and justifications. These tests ensure that the model behaves correctly under different scenarios and satisfies the defined constraints.

Table 7: Summary of Test Experiments for Model Verification

Test Category	Experiment Description	Expected Results	Remarks	Test Result	Passed?
Objective Function Verification	Increase storage cost of the third alloy (18/0) by 2x.	The plan will reduce monthly storage for 18/0, and overall cost will increase (cost > 9646.78).	Verifies model sensitivity to storage cost changes.	Cost=12712.02, 18/0 alloy storage reduced	Yes
Function Parameters Verification	Set chromium content requirement for first alloy to 100% and the demand for it in first month as 1, all other alloys in other months demand to 0.	Model becomes infeasible.	Suppliers can't meet demand without "unmixing" materials, which should be disallowed.	Model infeasible	Yes
RHS Parameters Verification	Demand for the first product (18/10) is 30 in month 1, with 0 for all other months.	Minimum cost will be 185.58 EUR, with 0 production/inventory in other months.	Tests how the model adjusts production with significant demand changes.	Cost=185.58 EUR, 0 production/inventory after January	Yes
RHS Parameters Verification	Reduce Supplier D's max purchase limit (high nickel content).	Overall cost increases due to reduced high-quality nickel availability.	Verifies impact of reducing key material supply on total costs.	Cost=9665.97	Yes

3.3 Conclusion

These tests demonstrate that the code correctly implements the mathematical model, with all constraints (demand, production capacity, supplier limits, and material composition) and the objective function properly adhered to. The model behaves as expected under different scenarios, verifying that the code aligns with the mathematical formulation.