***Identification of the Objective Function and Constraints***

*WGU*

*Course Number: 605*

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**B1: Demonstrate that the constraints of the optimization problem are satisfied**

The model satisfies all the constraints of the Amazon Air Optimization problem. Each of the 65 fulfillment centers receives exactly the amount of cargo required, as specified in the center demand dictionary. This was enforced using equality constraints that ensured the sum of cargo arriving at each center from either a hub or a focus city matched the center’s monthly demand.

Hub capacity constraints were also satisfied. For example, cargo shipped from the CVG hub did not exceed its maximum monthly capacity of 95,650 tons, and the AFW hub stayed within its 44,350-ton limit. Additionally, focus city flow balance constraints were enforced, requiring that the amount of cargo received from the hubs was equal to the amount shipped from the focus city to the centers. These constraints ensured that routing through focus cities remained valid and within capacity limits.

**B2: Demonstrate that the solution includes decision variables, constraints, and the objective function**

The solution is composed of three sets of decision variables:

* x[i, j]: represents the quantity of cargo shipped from hub i to focus city j
* y[i, k]: represents the quantity of cargo shipped directly from hub i to center k
* z[j, k]: represents the quantity of cargo shipped from focus city j to center k

A set of constraints governs these decision variables:

* Hub capacity constraints for CVG and AFW
* Center demand constraints that match the center input to the monthly demand
* Focus on city flow balance constraints that ensure incoming cargo from hubs equals outgoing cargo to centers

The objective function minimizes the total cost of shipping:

model += pulp.lpSum([

    cost\_x[i, j] \* x[i, j] for (i, j) in cost\_x

]) + pulp.lpSum([

    cost\_y[i, k] \* y[i, k] for (i, k) in cost\_y if cost\_y[i, k] is not None

]) + pulp.lpSum([

    cost\_z[j, k] \* z[j, k] for (j, k) in cost\_z if cost\_z[j, k] is not None

]), "Total\_Shipping\_Cost"

The PuLP solver evaluates this function to determine the most cost-efficient shipping plan.

**B3: Explain why the solution matches your expected output**

The solution matches expectations because the model successfully meets demand across all fulfillment centers while minimizing the overall shipping cost. The solver selected optimal routes that respect all constraints and leveraged cheaper shipping combinations, including routing through focus cities when cost-effective.

For example, the model chose to ship 42,588 tons from CVG to Hyderabad and then route that cargo to various centers such as C1 (Paris), C2 (Cologne), and others, demonstrating that the optimizer correctly balanced cost efficiency with operational limits. The final total cost of 22,272.5 reflects an optimal solution, confirming that the model functions correctly and the solver produced the best possible outcome under the given parameters.

**C: Reflection**

At the start of this task, I expected to develop a linear optimization model that could effectively minimize shipping costs for Amazon Air while satisfying center demand and capacity constraints. Through the development process, I realized that building the model involved more than simply defining an objective function and constraints; it required careful data mapping, accurate cost modeling, and understanding how each part of the supply chain interacts.

Initially, I encountered issues with infeasible or zero-cost solutions due to missing cost values or unconstrained variables. These challenges helped me understand the importance of filtering out invalid routes, enforcing proper flow balances, and ensuring that all routes used in the model had well-defined costs. Adding flow-balance constraints for focus cities and filtering out None values in the cost dictionaries made the model more realistic and accurate.

The final output, an optimal solution with a total cost of 22,272.5, matched my expectations of a working and efficient optimization model. It demonstrated that the solver could find cost-effective routing solutions while meeting all business rules. Reflecting on this process, I have a stronger appreciation for constraint-based modeling and how linear programming can be applied to real-world logistics optimization problems.