Assignment 13-1 – Landfill case study

Gravel Pit Corporation - Linear Optimization Analysis

Consider the problem of optimally transporting waste from two generation centers (New York and New Jersey) to six terminal landfill sites, each with a known capacity for receiving waste. Waste is generated in these two states and is transported first to transfer depots (of which there are four, each with its own throughput capacity) and then from the transfer depots to the six landfills (each with its own capacity as well). Each transfer depot can support a maximum volume of waste moving through it, and each waste-generating center generates waste with known tonnage. There are known costs associated with transporting the waste from each of the two generation centers to each of the transfer depots, as well as from transfer depot to landfills, or from generation centers directly to landfills.

Details follow.

**Supply Node Details**

The waste network has two waste-generating centers, in New York and New Jersey. Each has a maximum waste-generating volume:

|  |  |
| --- | --- |
| Supply Node Details | |
| Center | **Waste (tons)** |
| New York | 300,000 |
| New Jersey | 400,000 |

**Transshipment Node Details**

The waste can be shipped from a center to a set of four depots. Each depot has a maximum throughput:

|  |  |
| --- | --- |
| Transshipment Node Details | |
| Depot | **Throughput (tons)** |
| Bronx | 140,000 |
| Brooklyn | 100,000 |
| Queens | 200,000 |
| Staten Island | 80,000 |

**Demand Node Details**

Your network has six landfills, each with a given maximum demand.

|  |  |
| --- | --- |
| Demand Node Details | |
| Landfill | **Demand (tons)** |
| C1 | 100,000 |
| C2 | 20,000 |
| C3 | 80,000 |
| C4 | 70,000 |
| C5 | 120,000 |
| C6 | 40,000 |

**Transportation Details**

Transportation costs are given in the following table (in dollars per ton). Columns are source cities, and rows are destination cities.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Transportation Details | | | | | | |
| To | **New York** | **New Jersey** | **Bronx** | **Brooklyn** | **Queens** | **Staten Island** |
| Depots | | | | | | |
| Bronx | 0.7 |  |  |  |  |  |
| Brooklyn | 0.7 | 0.5 |  |  |  |  |
| Queens | 1.2 | 0.7 |  |  |  |  |
| Staten Island | 0.4 | 0.4 |  |  |  |  |
| Landfills | | | | | | |
| C1 | 1.2 | 2.2 |  | 1.2 |  |  |
| C2 |  |  | 1.7 | 0.7 | 1.7 |  |
| C3 | 1.7 |  | 0.7 | 0.75 | 2.2 | 0.4 |
| C4 | 2.2 |  | 1.7 | 1.2 |  | 1.7 |
| C5 |  |  |  | 0.7 | 0.7 | 0.7 |
| C6 | 1.2 |  | 1.2 |  | 1.7 | 1.7 |

**Model Formulation details used in the Colab Notebook.**

A list of numbers and symbols

AI-generated content may be incorrect.

A screenshot of a math equation

AI-generated content may be incorrect.

Your task as a data scientist is to figure out how to satisfy the demands of the end landfills while minimizing shipping costs.

Once you have formulated your optimization model, respond to the following questions:

1. **Justify the linear optimization model by explaining the objective function and constraints in your own words.**

The Gravel Pit Corporation’s goal is to minimize transportation costs of delivering topsoil from farms to project sites via intermediate warehouses. This forms a classic transshipment model. And the linear optimization model conforms to the linear equations involved.

### **Objective Function**

Minimize Z = 30 \* X14 + 20 \* X15 +  
 40 \* X24 + 30 \* X25 +  
 25 \* X34 + 35 \* X35 +  
 20 \* X46 + 10 \* X47 + 40 \* X48 +  
 30 \* X56 + 20 \* X57 + 50 \* X58

Each term represents the cost per unit transported along a path, multiplied by the amount transported.

### **Constraints**

**Supply Constraints at Farms**

X14 + X15 = 1100 (Farm A)

X24 + X25 = 1200 (Farm B)

X34 + X35 = 1200 (Farm C)

**Flow Balance at Warehouses**

X14 + X24 + X34 = X46 + X47 + X48 (Warehouse 1)

X15 + X25 + X35 = X56 + X57 + X58 (Warehouse 2)

**Demand Constraints at Projects**

X46 + X56 = 1050 (Project 1)

X47 + X57 = 1150 (Project 2)

X48 + X58 = 1300 (Project 3)

**Non-negativity Constraint**

Xij ≥ 0 for all i and j

1. **Review and run the provided Colab Notebook code which addresses this scenario.**

Reviewed and executed, the Pandas issue was discovered, debugged, and fixed. The final code ran successfully and  stored in Colab, under my account. For the sake of simplicity, the Jupyter notebook will also be loaded in the platform along with this document.

1. **Download and complete the following dashboard**

**Total Cost = 541,000.00**

|  |  |  |
| --- | --- | --- |
| From | To | Flow |
| New York | C1 | 100,000 |
| New York | C6 | 40,000 |
| New Jersey | Brooklyn | 100,000 |
| New Jersey | Queens | 110,000 |
| New Jersey | Staten Island | 80,000 |
| Brooklyn | C2 | 20,000 |
| Brooklyn | C4 | 70,000 |
| Brooklyn | C5 | 10,000 |
| Queens | C5 | 110,000 |
| Staten Island | C3 | 80,000 |

1. **Interpret the results**

The linear program was implemented in Python using Guropy. The optimal results are listed on item 3 (answers above)

The model uses lower-cost routes efficiently while meeting all demand and supply requirements.

Warehouses function as proper transshipment points, maintaining flow balance.

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