assignment_03

February 21, 2025

1 Assignment 3

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1. Transportation-Transhipment Problem

Tata operates four automobile manufacturing plants in Gujarat, one each at Naliya, Palanpur, Porbandar, and Vapi that cater to four fulfillment sites across India, one each in Delhi, Mumbai, Chennai, and Kolkata, either directly or via one warehouse located in Nagpur. Table 1 below presents supply capacities of the plants, handling volume of the warehouse, and demand requirements of the sites (in thousand automobile units). Further, Table 2 details the distance between plants, warehouses, and sites (in kms). Determine the shipping plan for the company that minimises the total operational cost while satsifying the supply, demand and volume constraints. Assume operational cost to be 25/km per thousand automobile units when transported via the warehouse and .

Table 1. Threshold quantity of automobile units

Facility	Quantity
Plant 1 (Naliya)	45
Plant 2 (Palanpur)	60
Plant 3 (Porbandar)	50
Plant 4 (Vapi)	55
Warehouse (Nagpur)	100
Site 1 (Delhi)	60
Site 2 (Mumbai)	35
Site 3 (Chennai)	40
Site 4 (Kolkata)	45

Table 2. Distance

From/To	Plant 1 (Naliya)	Plant 2 (Palanpur)	Plant 3 (Porbandar)	Plant 4 (Vapi)	Warehouse (Nagpur)	Site 1 (Delhi)	Site 2 (Mumbai)	Site 3 (Chennai)	Site 4 (Kolkata)
Plant 1 (Naliya)	0	445	470	780	1260	1200	945	2200	2440

From/To	Plant 1 (Naliya)	Plant 2 (Palanpur)	Plant 3 (Porbandar)	Plant 4 (Vapi)	Warehouse (Nagpur)	Site 1 (Delhi)	Site 2 (Mumbai)	Site 3 (Chennai)	Site 4 (Kolkata)
Plant 2 (Palanpur)	445	0	525	500	950	790	665	1915	1995
Plant 3 (Porbandar)	470	525	0	710	1235	1310	870	2170	2450
Plant 4 (Vapi)	780	500	710	0	765	1215	170	1520	1880
Warehouse (Nagpur)	1260	950	1235	765	0	1135	770	1125	1200
Site 1 (Delhi)	1200	790	1310	1215	1135	0	1380	2180	1470
Site 2 (Mumbai)	945	665	870	170	770	1380	0	1345	1885
Site 3 (Chennai)	2200	1915	2170	1520	1125	2180	1345	0	1670
Site 4 (Kolkata)	2440	1995	2450	1880	1200	1470	1885	1670	0

Use the following notations: - x_{ij} - flows from plant i to site j - y_{i0} - flows from plant i to warehouse - y_{0j} - flows from warehouse to yo site j

1. Formulate a linear optimisation model for this problem. (Begin by writing the compact mathematical form first, and thereafter express in the expanded form) (6)
2. Solve the above linear optimisation model using a spreadsheet to find the optimal solution. (10)
3. Introduce slack into each technical constraint and transform the above linear optimisation model. (3)
4. Evaluate slack at the optimal. (3)
5. Infer shadow price by relaxing each constraints for each plant supply capacity constraint, warehouse handling volume constraint, and site demand requirement constraint. (3)