JOURNAL ON COMMUNICATIONS

ISSN:1000-436X

REGISTERED

Scopus

www.jocs.review

A New Approach to Define Transportation Model in terms of Goal Programming

Dr. C. Ashok kumar[1], Dr. T. SRINIVAS[2,*]

1.Assistant Professor, Palamuru University Post Graduate Center-Kollapur , Nagar Kurnool (Dist.), Telangana.

2.Department of FME, Associate Professor, Audi Sankara Deemed to be University, Gudur, Andhra Pradesh.

*Corresponding Author email Id: Dr. T. SRINIVAS

MSC 2020 CLASSIFICATIONS: PRIMARY33C20, SECONDARY 33C65

ABSTRACT:

In this paper, we are focused to study to define one of the models proposed to demonstrate how prioritized goal programming can be used in solving the process of a transportation problem. The objective of this method is to minimize the total transportation cost. The basic assumption underlying most of the formulations of these transportation models is that management is concerned solely with one objective, namely cost minimization with using of Goal Programming Technique. Prioritized goal programming extends traditional transportation models by handling multiple conflicting objectives through a hierarchy of priorities, rather than assuming sole focus on cost minimization.

KEYWORDS: Goal Programming; Optimization; Multi-objective transportation problem.

INTRODUCTION:

The transportation problem models the efficient allocation of goods from multiple supply sources, like factories, to multiple demand points, such as warehouses or customers, to minimize total costs or maximize profits.

Core Assumptions

Supply equals total demand in balanced models, with costs varying by route due to factors like taxes and distance. Unbalanced cases adjust via dummy sources or sinks. Hitchcock formalized this in 1941 as a linear programming problem solvable without full simplex methods.

Solution Methods

Common algorithms include Northwest Corner, Least Cost, and Vogel's Approximation for initial feasible solutions, refined by MODI or Stepping Stone for optimality. Linear programming and network flow algorithms also apply, focusing on cost minimization.

Practical Role

In logistics, these models cut costs and boost service via economies of scale and distance, where per-unit costs drop with larger loads or longer hauls. Modern extensions incorporate multi-objectives beyond cost, like time or sustainability.

DATA OF THE PROBLEM

The study analyzes a confidential leading oil company's northern India supply chain, where two refineries produce petroleum products monthly and distribute them to 15 depots via available rail, road, or pipeline modes at minimum costs per metric ton. Demand fluctuates seasonally due to high consumption by farmers during sowing/thrashing and by transporters, starting from crude refining to finished goods dispatch.

Supply Chain Structure

Refineries act as sources with fixed capacities, feeding depots as sinks where not all transport modes connect every pair, so costs reflect feasible routes only (e.g., ₹41–₹415.9/ton). This setup fits the classic transportation problem, solvable via methods like linear programming or goal programming for multi-objective optimization.

Model Testing Context

The paper tests advanced models on real data from this company, examining results for cost efficiency amid capacity and demand constraints, beyond basic minimization to include priorities like budget l

The monthly production capacities of oil products and the monthly demand of each depot and the cost per metric ton at the three plants are given in Table 1(a).

TABLE 1(a) Monthly Demand of Each Depot and Cost per Ton from Each Plant

The policy of the company in the past has been to solve transportation problems by using standard transportation algorithms or by adopting a standard linear programming problem, with the primary goal of cost minimization, and all other goals

		To Depots															**Capacity**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
From Refineries	**1**	41	145.1	147.1	124	272.3	196.4	255.8	153.8	46.1	107.6	119.8	72.8	408.6	370.6	414.5	**100000**
	2	398.2	58.8	247.3	140.9	365.5	276.4	410.4	175.1	310.5	390	415.9	53.2	200.6	158.2	119.8	**85000**
Min Demand		1260	165	3052	4220	8600	4030	10720	5605	2015	2240	4500	15600	1050	2018	1998	
Max Demand		2267	270	5352	6533	11895	6140	16724	7705	6588	6643	12543	24834	3663	6149	5244	

are specified as constraints. However, in most cases, companies face multiple objectives, and an alternative technique using the linear goal programming (LGP) model has been adopted. Even though all goals may not be exactly achieved under this technique, it provides the closest optimal solution to satisfying the given constraints of the problem.

Optimization Process

Solve sequentially: optimize P1 (e.g., full capacities), fix its deviations, then P2 (demands), cascading down using linear programming until all priorities achieve near-targets. This lexicographic order ensures critical goals like minimum depot supplies precede cost, yielding balanced solutions over single-objective methods.

Application Benefits

For the oil company case, it satisfies refinery outputs (100k/85k tons), depot mins/maxes, and cost under ₹19M, unlike basic LP which might violate priorities. Managers gain flexible logistics amid seasonal demands

3. MODEL FORMULATION VARIABLES AND CONSTANTS

The decision variables, deviational variables, and constants for model formulation are defined as follows:

$X_{i,j}$ = the amount of oil to be transported from the i^{th} refinery to the j^{th} depot.
S_i = the production capacity of the refinery i
R_i = minimum amount of oil to be supplied by the refinery i, at the crisis period
D_i = the demand at the depot j
C_{ij} = the unit transportation cost from the i^{th} refinery to the j^{th} depot.
TC = total transportation cost.
for I = 1, ….., m, j = l …., n

3.1 Constraints

(i) (a) Refineries have their installed production capacity. The refineries cannot supply more than their production capacity. The LGP constraints for supply can be given as follows:

$$\sum_{j=1}^{n} X_{i,j} + d_i^- + d_i^+ = S_i \qquad \forall i, \qquad \dots (7.1)$$

(b) In the crisis period, to ensure the minimum supply from the refineries the goal constraints can be developed as follows:

$$\sum_{j=1}^{n} X_{ij} + d_{m+i}^- - d_{m+i}^+ = R_i \qquad \forall i, \qquad \dots (7.2)$$

(ii) The oil transported from refineries to the depots should not exceed the depots-demand individually. The goal constraints for demand can be given as follows:

$$\sum_{i=1}^{m} X_{i,j} + d_{2m+j}^{-} - d_{2m+j}^{+} = D_j \qquad \forall j, \qquad \dots(7.3)$$

(iii) There should be a minimum amount of oil to be transported from refinery i to depot j. The goal constraint may be written as follows:

$$\sum_{i=1}^{m} X_{i,j} + d_{2m+n+j}^{-} - d_{2m+n+j}^{+} = L_j \qquad \forall j, \qquad \dots(7.4)$$

(iv) The budgetary constraint of total transportation cost can be written as:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{i,j} + d_{2m+2n+1}^{-} - d_{2m+2n+1}^{+} = TC \qquad \dots(7.5)$$

3.2 The Goals

Various goals set by the management in order of their importance are as follows:

P_1 Achieve the minimum amount to be supplied by refineries and the minimum demand of depots.

P_2 Achieve the installed production capacity of the refinery and maximum demand of depots.

P_3 Minimize the total transportation cost.

Solve using LP software

- Implement the model in any LP solver (LINGO, Gurobi, CPLEX, Excel Solver, R, Python-PuLP/Pyomo).
- For pre-emptive priorities, either:
    - Use a solver that supports lexicographic optimization, or
    - Solve sequentially: optimize P1, fix its optimal deviation value(s), then optimize P2, and so on

Interpret and adjust

- Check which goals are fully met (zero deviation) and which show unavoidable shortfalls.
- Analyze flows xij to see how shipments changed relative to a pure cost-minimization solution.
- If results are not satisfactory, adjust priorities or introduce new goals (e.g., cap on use of a risky route) and re-solve

3.3 Goal Constraints

The LGP model constraints for the transportation problem are formulated as follows:

Supply Constraints

(i) (a) Both the refineries have their installed production capacity. The refineries cannot supply more than their capacities. The LGP constraints for supply can be given as follows:

$$\sum_{j=1}^{15} X_{1,j} + d_1^- - d_1^+ = 100000 \quad \text{... (7.6)}$$

$$\sum_{j=1}^{15} X_{2,j} + d_2^- - d_2^+ = 85000 \quad \text{... (7.7)}$$

(b) In a crisis period, to ensure the minimum supply from the refineries the go constraints can be presented as follows:

$$\sum_{j=1}^{15} X_{1,j} + d_3^- - d_3^+ = 40000 \quad \text{... (7.8)}$$

$$\sum_{j=1}^{15} X_{2,j} + d_4^- - d_4^+ = 34000 \quad \text{... (7.9)}$$

3.4 Demand Constraints

(ii) The refined oil, shipped to the depots from the refineries should not exceed the depots-demand individually. The LGP constraints for demand can be given as follows:

$$\sum_{i=1}^{2} X_{i,1} + d_5^- - d_5^+ = 2267 \quad \text{...(7.10)}, \qquad \sum_{i=1}^{2} X_{i,2} + d_6^- - d_6^+ = 270 \quad \text{...(7.11)}$$

$$\sum_{i=1}^{2} X_{i,3} + d_7^- - d_7^+ = 5352 \quad \text{...(7.12)}, \qquad \sum_{i=1}^{2} X_{i,4} + d_8^- - d_8^+ = 6533 \quad \text{...(7.13)}$$

$$\sum_{i=1}^{2} X_{i,5} + d_9^- - d_9^+ = 5352 \quad \text{...(7.14)}, \qquad \sum_{i=1}^{2} X_{i,6} + d_{10}^- - d_{10}^+ = 6140 \quad \text{...(7.15)}$$

$$\sum_{i=1}^{2} X_{i,7} + d_{11}^- - d_{11}^+ = 16724 \quad \text{...(7.16)}, \qquad \sum_{i=1}^{2} X_{i,8} + d_{12}^- - d_{12}^+ = 7705 \quad \text{...(7.17)}$$

$$\sum_{i=1}^{2} X_{i,9} + d_{13}^- - d_{13}^+ = 6588 \quad \text{...(7.18)}, \qquad \sum_{i=1}^{2} X_{i,10} + d_{14}^- - d_{14}^+ = 6643 \quad \text{...(7.19)}$$

$$\sum_{i=1}^{2} X_{i,11} + d_{15}^- - d_{15}^+ = 12543 \quad \text{(7.20)}, \qquad \sum_{i=1}^{2} X_{i,12} + d_{16}^- - d_{16}^+ = 24834 \quad \text{...(7.21)}$$

$$\sum_{i=1}^{2} X_{i,13} + d_{17}^- - d_{17}^+ = 3663 \quad \text{...(7.22)}, \qquad \sum_{i=1}^{2} X_{i,14} + d_{18}^- - d_{18}^+ = 6149 \quad \text{...(7.23)}$$

$$\sum_{i=1}^{2} X_{i,15} + d_{19}^{-} - d_{19}^{+} = 5244 \quad ...(7.24)$$

(iii) The refined oil, shipped to the depots from the refineries, should not be below the depots' minimum demand. The LGP constraints for demand can be given as follows:

$$\sum_{i=1}^{2} X_{i,1} + d_{20}^{-} - d_{20}^{+} = 1260 \quad ...(7.25), \qquad \sum_{i=1}^{2} X_{i,2} + d_{21}^{-} - d_{21}^{+} = 165 \quad ...(7.26)$$

$$\sum_{i=1}^{2} X_{i,3} + d_{22}^{-} - d_{22}^{+} = 3052 \quad ...(7.27), \qquad \sum_{i=1}^{2} X_{i,4} + d_{23}^{-} - d_{23}^{+} = 4220 \quad ...(7.28)$$

$$\sum_{i=1}^{2} X_{i,5} + d_{24}^{-} - d_{24}^{+} = 8600 \quad ...(7.29), \qquad \sum_{i=1}^{2} X_{i,6} + d_{25}^{-} - d_{25}^{+} = 4030 \quad ...(7.30)$$

$$\sum_{i=1}^{2} X_{i,7} + d_{26}^{-} - d_{26}^{+} = 10720 \quad ...(7.31), \qquad \sum_{i=1}^{2} X_{i,8} + d_{27}^{-} - d_{27}^{+} = 5605 \quad ...(7.32)$$

$$\sum_{i=1}^{2} X_{i,9} + d_{28}^{-} - d_{28}^{+} = 2015 \quad ...(7.33), \qquad \sum_{i=1}^{2} X_{i,10} + d_{29}^{-} - d_{29}^{+} = 2240 \quad ...(7.34)$$

$$\sum_{i=1}^{2} X_{i,11} + d_{30}^{-} - d_{30}^{+} = 4500 \quad ...(7.35), \qquad \sum_{i=1}^{2} X_{i,12} + d_{31}^{-} - d_{31}^{+} = 15600 \quad ...(7.36)$$

$$\sum_{i=1}^{2} X_{i,13} + d_{32}^{-} - d_{32}^{+} = 1050 \quad ...(7.37), \qquad \sum_{i=1}^{2} X_{i,14} + d_{33}^{-} - d_{33}^{+} = 2018 \quad ...(7.38)$$

$$\sum_{i=1}^{2} X_{i,15} + d_{34}^{-} - d_{34}^{+} = 1998 \quad ...(7.39)$$

(iv) The total transportation cost should not be greater than the budgeted amount Rs. 19254710

$$\sum_{i=1}^{2}\sum_{j=1}^{15} C_{i,j} X_{i,j} + d_{35}^{-} - d_{35}^{+} = 19254710 \qquad \forall i,j \qquad ...(7.40)$$

3.5 The Objective Function

The priority structure of the problem is as follows:

Minimize $P_1[2d_3^{-} + 2d_4^{-} + d_{20}^{-} + d_{21}^{-} + d_{22}^{-} + d_{23}^{-} + 2d_{24}^{-} + d_{25}^{-}$

$+d_{26}^{-} + 2d_{27}^{-} + d_{28}^{-} + d_{29}^{-} + d_{30}^{-} + d_{31}^{-} + d_{32}^{-} + d_{33}^{-} + d_{34}^{-}]$

Minimize $P_2[d_1^+ + d_2^+ + d_5^+ + d_6^+ + d_7^+ + d_8^+ + d_9^+ + d_{10}^+ + d_{11}^+ + d_{12}^+ + d_{13}^+$
$+d_{14}^+ + d_{15}^+ + d_{16}^+ + d_{17}^+ + d_{18}^+ + d_{19}^+]$

Minimize $P_3[d_{35}^+]$

4. RESULTS AND ANALYSIS

The present GP transportation problem contains 30 variables, 35 constraints, 5 priorities, and an objective function. The solution to the problem is obtained, by using the QSB + software package. The results are as follows:

TABLE 1(b): Decision Variable Analysis

Decision Variable	Value	Decision Variable	Value	Decision Variable	Value	Decision Variable	Value
$X_{1,1}$	2267	$X_{1,9}$	2088	$X_{2,2}$	166.75	$X_{2,10}$	0
$X_{1,2}$	103.25	$X_{1,10}$	2413	$X_{2,3}$	2152.4	$X_{2,11}$	0
$X_{1,3}$	3199.6	$X_{1,11}$	4503	$X_{2,4}$	3393.5	$X_{2,12}$	14200
$X_{1,4}$	3139.5	$X_{1,12}$	10634	$X_{2,5}$	5090	$X_{2,13}$	1113
$X_{1,5}$	6805	$X_{1,13}$	0	$X_{2,6}$	2030	$X_{2,14}$	2129
$X_{1,6}$	4110	$X_{1,14}$	0	$X_{2,7}$	0	$X_{2,15}$	2005
$X_{1,7}$	16724	$X_{1,15}$	0	$X_{2,8}$	2055		
$X_{1,8}$	5650	$X_{2,1}$	0	$X_{2,9}$	0		

TABLE 1(c): Analysis of Objective Function

Priority	Achievement
P_1 P_2 P_3	Achieved Achieved Achieved

5. CONCLUSION

A study has been discussed in this paper, continuing in the previous studies, which clearly shows that in case of multiple conflicting goals multi-objective programming like GP should be used despite a single objective as minimizing total transportation cost, parallel to other objectives, outlined by the company that makes the problem as multi-objective. The solution is given with the use of LGP. Significantly, the study indicates that managers should receive the priority structure of goals to achieve the goals much more closely.

Solution Results:

LGP yields allocations achieving all priorities: minimum supplies, full capacities/demands, and cost goal. This outperforms single-objective methods by balancing conflicts, offering managers prioritized near-optimal logistics

6. REFERENCES:

1. **ABD EL-WAHED, WAIEL F, LEE AND SANG M [2006]:** Interactive fuzzy goal programming for multi-objective transportation problems, **Omega, 34(2), 158-166.**
2. **Ahem Aoife et al (2007),** Railway projects prioritization for investment. Application of Goal Programming Transportation Policy. **14(1). 70-80.**
3. **BIGI GIANCARLO [2006]:** On sufficient second-order optimality conditions in multi-objective optimization, **Mathematical Methods of Operations Research, 63(1), 77-85.**
4. **BUYUKOZKAN G, KAHRAMAN C, AND RUAN D [2004]:** A fuzzy multi-criteria decision approach for software development strategy selection, **International Journal of General Systems.**
5. **Calvete Herminia I et al (2007).** A Goal Programming Approach to vehicle routing problems with soft time windows. **European Journal of Operations Research 177(3). 1720-1733.**
6. **CARLOS A., BANA E COSTA, CARLOS S. OLIVEIRA, AND VICTOR VIEIRA [2008]:** Prioritization of bridges and tunnels in earthquake risk mitigation using multi-criteria decision analysis: Application to Lisbon. **Omega, 36(3), 442 – 450.**
7. **CHAKRABORTY M AND SINHA** A **[1995]:** Multi-objective Transportation problem-A Goal Programming Approach, **Industrial Engineering Journal 14[7], 17-22.**
8. **CHALAM GA [1994]:** Fuzzy goal programming approach to a stochastic transportation problem under budgetary constraint, **Fuzzy Sets and Systems 66, 293-299.**
9. **DIONYSIS LATINOPOULOS [2009]**: Multi-criteria decision-making for efficient water and land resources allocation in irrigated agriculture **Journal of Environment, Development, and Sustainability, 329-343.**

10. **DOMINIQUE BOLLINGER AND JACQUES PICTET [2008]:** Multiple criteria decision analysis of treatment and land-filling technologies for waste incineration residues. **Omega, 36(3), 418 – 428.**
11. **FERNANDO GARCÍA, FRANCISCO GUIJARRO , AND ISMAEL MOYA [2010]** A goal programming approach to estimating performance weights for ranking firms
12. **GANG KOU & YIPENG [2009]:** A bibliography Analysis of multi-criteria decision making in computer science **A journal of Communications in computer & information science. July 68-71.**
13. **JAVAD DODANGEH, ROSNAH BT MOHD YUSUFF, AND JAVAD JASSBI 2[2010]:** Using Tops is Method with Goal Programming for the Best Selection of Strategic Plans in BSC Model, **Journal of American Science 2010, 6(30).**
14. **JERBI, BADRE DDINE, KAMOUN, HICHEUS [2010]:** Using stochastic goal programming to rearrange beds inside hubib Bourguida Hospital. **International Applied Management Science Journal volume 2 Nov 2, 20 Jan 2010 122-135.**
15. **LI LYO AND** FU Z **[2002]:** The school bus routing problem: A case study, **Journal of the operational research, 52, 552-558.**
16. **LIS, BEULLENS P, JONES DF & TAMIZ M [2008]:** An Integrated queering & multi-Objective Bed allocation model with Application to hospital in China **Journal of the Operational research society 59, 1-9.**
17. **ODDOYE JP, JONES D F, TAMIZ M, FOUROUGHI A A SCHMITH P.[2007]:** A multi-Objective model to determine efficient resource-led medical assessment Unit **Journal of the operations research society 58, 1563-1573.**
18. **PAQUETE L. AND STÜTZLE T. [2009]:** Design and analysis of the stochastic local search for the multi-objective travelling salesman problem, **Computers & Operations Research, 36(9):2619-2631.**