INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 6)
Available online at: www.ijariit.com

Finding the optimal cost for transportation of plywood and hardware in Mumbai

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ABSTRACT

Transportation of raw materials within a city can be quite a daunting task. Various problems such as traffic conditions, temporary shut-down of roads, parking issues and low quantity of good increases the per unit cost of transportation and make it infeasible for the seller. The objective of this study is to provide a cost-minimizing solution by using the Modified Distribution Method on the transportation model. We quantify our hypothesis by using real life data of transportation of raw materials used by a furniture making firm based in Mumbai. Furthermore, additional restrictions were added to our model to reflect the real life problems that arise in transporting raw materials. The results showed that we were able to reduce the cost of transportation from ₹2,17,26,000 (quoted by the owner of the firm) to ₹1,98,50,000 (calculated using MODI method) by using the scientific method of the transportation problem. But when applying conditions like traffic movement & congestions and parking difficulties we notice an increase in cost. In conclusion, applying the Modified Distribution can help a firm manage its costs well and quote the appropriate price so as to not be in a loss-making solution.

Keywords— Operations research, Transportation problem, Modified distribution method, Optimal solution

1. INTRODUCTION

In India, the furniture industry is majorly controlled by independent stores and individual woodworkers who account for almost eighty percent of the total furniture retail market according to different appraisals. The Indian industry for furniture has generally been disorderly and apart from a few organized companies like Home Stop, Evok, and Home Town, there are no brands in the composed furniture retail space. Current strategies for furniture development are to a great extent in view of the accessibility of man-made materials, for example, dependable compressed wood, overlaid board, chipboard, and hardboard as unmistakable from regular strong wood and these different types of woods are transported to manufacturers via road.

Our research paper deals with the calculation of the optimum cost incurred in the delivery of wood through urban road transportation and the various barriers faced in obtaining the optimum cost. The manufacturers use road transportation as their main mode of transporting wood because of its versatility and variety of means to access field operation, processing centers and loading and unloading sites (Simões, Mosquera, Batistela, Passos & Fenner, 2016). But transportation via road is uncertain because of the operational cost, the amount of wood transported, the distance between the two destinations, its revenue, etc. Hence operations research is used to find out the actual optimum cost that a company should incur in order to maintain its operational cost to a level where it can still make profits.

2. LITERATURE REVIEW

Most of the urban areas in a country like India are experiencing multi-faceted issues because of the quick urbanization and sudden augmentation in private transport. Clog on the urban streets are distressing tore in India and impacts the urban economies in various ways. It leads to slower speeds, lining and expanded trek times, which force higher expenses on the economy and furthermore produce impacts on urban locales and their occupants. A large portion of the Indian urban communities are not well pre-arranged, Development Plan has its long-haul job in the improvement of the city. Yet, in Indian urban areas the absence of arranging shows up and in consequence of that the urban communities streets encountering clog have very little space to augmenting its streets and to present additional streets. The Indian Transportation framework lacks both in term of operational efficiencies and foundation. By thinking of some as approach holes in Indian transportation framework the measures are prescribed above to diminish movement blockage n the urban areas. There is a necessity of coordinated urban transport approaches to diminish the blockage on urban streets. (Kumar & Singh, 2017)

Parking demand is ravenous. The growth in economy brings about expanding reliance on mechanized vehicles significantly autos. Autos are aggressively infringing the restricted urban space that can have other and more vital employment. Because of impromptu arrangements of on-road areas, the street and pathways are being immersed to park the vehicles on it. Because of ill-advised stopping administration, the people on foot endure. Spontaneous and on-street stopping inundates the space for walkers. The fundamental spotlight ought to be on conveying the parking spots which are gathered in real fascination focuses which is impossible in separation. This must be accomplished by advancing blended land utilized, utilizing non-mechanized transport and different alternatives. Collection of parking spots over a little region makes such turmoil which on open space depicts itself as an issue to which stopping confinement is by all accounts an answer. Parking spots should spread, all through the city so that the base prerequisite of everyone is satisfied. (Dawra & Kulshreshtha, 2017)

Transportation cost corresponds to about one-third of the raw material cost within a wood processing plant, and it is complex to calculate because of plenty of variables involved in the transport operation. This cost is derived from the relationship between the amount of transported wood and the operational cost of the vehicle. The costs of fuel, driver manpower and tires are the most critical components of the operational costs, as they increase the level of financial risk, and may derail the investment in road transportation of wood. (Simões, Mosquera, Batistela, Passos & Fenner, 2016)

The problem of minimization of the total transportation cost is commonly treated as a basic single objective linear transportation model. The time of transport is a significant factor in several transportation problems. The efficiency of transportation has been introduced as an aggregate of the time and the number of goods on active transport operations, the longest time on single active transport operation, total time on all active transport operations, and the total quantity of goods with the longest time of transport etc. The question arises from this whether to perform optimization at the same time for more objectives, with eventual priorities for each or to treat single objective problems, which are of the great significance for the problem. (Nikolić, 2006)

3. RESEARCH METHODOLOGY

Transportation Problems allocates commodities that are similar in nature, a particular source and destination taking into consideration the various constraints. The resultant output is the minimized total shipment cost. By using the Transportation Problem in our paper, we try to calculate the optimal transportation cost for the transport of materials used in furniture including plywood, laminates, screws, nails, adhesive, etc. We have used the Modified Distribution Method to find the optimal cost.

Mathematical Model for a minimization transportation problem is defined as (Green, Cromley and Semple, 1980)

$$\text{Min Z} = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$$

Subject to constraints,

$$\sum_{j=1}^{n} X_{ij} \leq a_i \qquad i = 1,2,3, \dots m$$

$$\sum_{i=1}^{m} X_{ij} \geq b_j \qquad j = 1,2,3, \dots n$$

$$X_{ij} \geq 0$$

Where m is the number of supply origins:
n is the number of demand destinations;
C_{ij} is the per unit shipment cost from origin i to destination j;
X_{ij} is the amount of commodity flow from origin i to destination j;
a_i is the supply capacity at origin i;
b_j is the demand requirement at destination j.

Following are the parameters are taken into consideration while formulating the problem:
1. Distance
2. Traffic Movement and Congestion
3. Parking Difficulties
4. Environmental Impact
5. Temporary Non-functioning of Roads

3.1 Practical Application

Let's take an example of some wood materials like wooden furniture required at an interior designer's site which can be transported from suppliers C, Churchgate, Supplier K, Kandivali, supplier A, Andheri, and supplier S, Sion. At sites based in Kandivali, Andheri, Bandra, and Ghatkopar respectively. The costs for transportation from each supplier to each site is given below.

Table 1: Costs for transportation from each supplier to each site

	Site-K	Site-A	Site-B	Site-G	Supply
Supplier-C	1300	1000	800	1100	10000
Supplier-K	500	900	1100	1400	7000
Supplier-A	900	500	600	700	6500
Supplier-S	1200	900	600	600	15000
Demand	9000	5500	7500	10500	

3.2 Solution

In the problem the total demand is less than the total supply, so we need to add a dummy demand destination with unit cost as zero and total demand 6000.

Now, the modified table is:

Table 2: Solution

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply
Supplier-C	1300	1000	800	1100	0	10000
Supplier-K	500	900	1100	1400	0	7000
Supplier-A	900	500	600	700	0	6500
Supplier-S	1200	900	600	600	0	15000
Demand	9000	5500	7500	10500	6000	

Table 3: Initial feasible solution

	K	A	B	G	D	SS	P1	P2	P3	P4	P5	P6	P7	P8
C	1300	1000	800 (4000)	1100	0 (6000)	10000	800	200	200	200	300	-	-	-
K	500(7000)	900	1100	1400	0	7000	500	400	-	-	-	-	-	-
A	900(1000)	500(5500)	600	700	0	6500	500	100	100	100	100	-	-	-
S	1200(1000)	900	600 (3500)	600 (10500)	0	15000	600	-	-	-	-	-	-	-
DD	9000	5500	7500	10500	6000	38500								
P1	400	400	0	100	0									
P2	400	400	0	100	-									
P3	300	400	0	100	-									
P4	300	-	0	100	-									
P5	300	-	0	100	-									
P6	1200	-	600	600	-									
P7	-	-	600	600	-									
P8	-	-	-	600	-									

Here, the number of allocated cells = 8 is equal to m + n - 1 = 4 + 5 - 1 = 8

∴ The solution is non-degenerate

Minimum Feasible Cost = (800×4000) + (0×6000) + (500×7000) + (900×1000) + (500×5500) + (1200×1000) + (600×3500) + (600×10500) = ₹1,99,50,000

3.3 Optimality test using Modified Distribution Method

Table 4: Allocation Table

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply
Supplier-C	1300	1000	800 (4000)	1100	0 (6000)	10000
Supplier-K	500 (7000)	900	1100	1400	0	7000
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500
Supplier-S	1200 (1000)	900	600 (3500)	600 (10500)	0	15000
Demand	9000	5500	7500	10500	6000	38500

(i) Find u_i and v_j for all occupied cells (i,j), where $c_{ij} = u_i + v_j$

Substituting u4 = 0, we get

$$c_{41} = u_4+v_1 \Rightarrow v_1 = c_{41}-u_4 \Rightarrow v_1 = 1200-0 \Rightarrow v_1 = 1200$$
$$c_{21} = u_2+v_1 \Rightarrow u_2 = c_{21}-v_1 \Rightarrow u_2 = 500-1200 \Rightarrow u_2 = -700$$
$$c_{31} = u_3+v_1 \Rightarrow u_3 = c_{31}-v_1 \Rightarrow u_3 = 900-1200 \Rightarrow u_3 = -300$$
$$c_{32} = u_3+v_2 \Rightarrow v_2 = c_{32}-u_3 \Rightarrow v_2 = 500+300 \Rightarrow v_2 = 800$$
$$c_{43} = u_4+v_3 \Rightarrow v_3 = c_{43}-u_4 \Rightarrow v_3 = 600-0 \Rightarrow v_3 = 600$$
$$c_{13} = u_1+v_3 \Rightarrow u_1 = c_{13}-v_3 \Rightarrow u_1 = 800-600 \Rightarrow u_1 = 200$$
$$c_{15} = u_1+v_5 \Rightarrow v_5 = c_{15}-u_1 \Rightarrow v_5 = 0-200 \Rightarrow v_5 = -200$$
$$c_{44} = u_4+v_4 \Rightarrow v_4 = c_{44}-u_4 \Rightarrow v_4 = 600-0 \Rightarrow v_4 = 600$$

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply	U_i
Supplier-C	1300	1000	800 (4000)	1100	0 (6000)	10000	200
Supplier-K	500 (7000)	900	1100	1400	0	7000	-700
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500	-300
Supplier-S	1200 (1000)	900	600 (3500)	600 (10500)	0	15000	0
Demand	9000	5500	7500	10500	6000		
V_j	1200	800	600	600	-200		

(ii) Find d_{ij} for all unoccupied cells(i,j), where $d_{ij} = c_{ij} - (u_i+v_j)$

$$d_{11} = c_{11} - (u_1+v_1) = 1300 - (200+1200) = -100$$
$$d_{12} = c_{12} - (u_1+v_2) = 1000 - (200+800) = 0$$
$$d_{14} = c_{14} - (u_1+v_4) = 1100 - (200+600) = 300$$
$$d_{22} = c_{22} - (u_2+v_2) = 900 - (-700+800) = 800$$
$$d_{23} = c_{23} - (u_2+v_3) = 1100 - (-700+600) = 1200$$
$$d_{24} = c_{24} - (u_2+v_4) = 1400 - (-700+600) = 1500$$
$$d_{25} = c_{25} - (u_2+v_5) = 0 - (-700-200) = 900$$
$$d_{33} = c_{33} - (u_3+v_3) = 600 - (-300+600) = 300$$
$$d_{34} = c_{34} - (u_3+v_4) = 700 - (-300+600) = 400$$
$$d_{35} = c_{35} - (u_3+v_5) = 0 - (-300-200) = 500$$
$$d_{42} = c_{42} - (u_4+v_2) = 900 - (0+800) = 100$$
$$d_{45} = c_{45} - (u_4+v_5) = 0 - (0-200) = 200$$

(iii) The minimum negative value for d_{ij} (opportunity cost) is -100 for Path (P) P_{11}. We draw a closed loop from P_{11}. The closed path is $P_{11} \rightarrow P_{13} \rightarrow P_{43} \rightarrow P_{41}$. We allocate a (+) sign on P11 and then a negative sign, so on and so forth.

(iv) Minimum allocated value among all negative position (-) on closed path = 1000. Subtract 1000 from all (-) and add it to all (+).

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply
Supplier-C	1300 (1000)	1000	800 (3000)	1100	0 (6000)	10000
Supplier-K	500 (7000)	900	1100	1400	0	7000
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500
Supplier-S	1200	900	600 (4500)	600 (10500)	0	15000
Demand	9000	5500	7500	10500	6000	

(v) Repeat steps 2 to 4 until an optimal solution is obtained.

Step 2: Find d_{ij} for all unoccupied cells (i,j), where $d_{ij} = c_{ij} - (u_i + v_j)$

Substituting, $u_1 = 0$, we get

$$c_{11} = u_1+v_1 \Rightarrow v_1 = c_{11}-u_1 \Rightarrow v_1=1300-0 \Rightarrow v_1=1300$$
$$c_{21} = u_2+v_1 \Rightarrow u_2 = c_{21}-v_1 \Rightarrow u_2=500-1300 \Rightarrow u_2=-800$$
$$c_{31} = u_3+v_1 \Rightarrow u_3 = c_{31}-v_1 \Rightarrow u_3=900-1300 \Rightarrow u_3=-400$$
$$c_{32} = u_3+v_2 \Rightarrow v_2 = c_{32}-u_3 \Rightarrow v_2=500+400 \Rightarrow v_2=900$$
$$c_{13} = u_1+v_3 \Rightarrow v_3 = c_{13}-u_1 \Rightarrow v_3=800-0 \Rightarrow v_3=800$$
$$c_{43} = u_4+v_3 \Rightarrow u_4 = c_{43}-v_3 \Rightarrow u_4=600-800 \Rightarrow u4=-200$$
$$c_{44} = u_4+v_4 \Rightarrow v_4 = c_{44}-u_4 \Rightarrow v_4=600+200 \Rightarrow v4=800$$
$$c_{15} = u_1+v_5 \Rightarrow v_5 = c_{15}-u_1 \Rightarrow v_5=0-0 \Rightarrow v5=0$$

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply	U_i
Supplier-C	1300 (1000)	1000	800 (3000)	1100	0 (6000)	10000	0
Supplier-K	500 (7000)	900	1100	1400	0	7000	-800
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500	-400
Supplier-S	1200	900	600 (4500)	600 (10500)	0	15000	-200
Demand	9000	5500	7500	10500	6000		
Vj	1300	900	800	800	0		

Step3: Find d_{ij} for all unoccupied cells(i,j), where $d_{ij} = c_{ij} - (u_i+v_j)$

$$d_{12} = c_{12} - (u_1+v_2) = 1000-(0+900)=100$$
$$d_{14} = c_{14} - (u_1+v_4) = 1100-(0+800)=300$$
$$d_{22} = c_{22} - (u_2+v_2) = 900-(-800+900)=800$$
$$d_{23} = c_{23} - (u_2+v_3) = 1100-(-800+800)=1100$$
$$d_{24} = c_{24} - (u_2+v_4) = 1400-(-800+800)=1400$$
$$d_{25} = c_{25} - (u_2+v_5) = 0-(-800+0)=800$$
$$d_{33} = c_{33} - (u_3+v_3) = 600-(-400+800)=200$$
$$d_{34} = c_{34} - (u_3+v_4) = 700-(-400+800)=300$$
$$d_{35} = c_{35} - (u_3+v_5) = 0-(-400+0)=400$$
$$d_{41} = c_{41} - (u_4+v_1) = 1200-(-200+1300)=100$$
$$d_{42} = c_{42} - (u_4+v_2) = 900-(-200+900)=200$$
$$d_{45} = c_{45} - (u_4+v_5) = 0-(-200+0)=200$$

Since all $d_{ij} \geq 0$, optimal solution is arrived at.

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply
Supplier-C	1300 (1000)	1000	800 (3000)	1100	0 (6000)	10000
Supplier-K	500 (7000)	900	1100	1400	0	7000
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500
Supplier-S	1200	900	600 (4500)	600 (10500)	0	15000
Demand	9000	5500	7500	10500	6000	

Optimal Transportation Cost = (1300×1000) + (800×3000) + (0×6000) + (500×7000) + (900×1000) + (500×5500) + (600×4500) + (600×10500) = ₹1,98,50,000

4. FURTHER APPLICATIONS

The aforementioned solution is when there are no hindrances in the operations of the transportation consignment. We further analyze real-life situations that hinder the operations and the effect it has on the transportation problem.

4.1 Traffic movement and congestion

Activity clog happens when urban transport systems are not equipped for obliging with the volume of developments that utilize them. Levels of activity over-burdening fluctuate with time, with an exceptionally large number during the everyday venture to-work periods. Albeit most blockage can be ascribed to over-burdening. In the industrialized nations expanding volumes of private auto, open transport and business vehicle movement have uncovered the deficiencies of urban streets, particularly in more established downtown areas.

Taking the aspects of growing traffic in the Andheri and Bandra regions, ease commutes from the highway access of Ghatkopar or the south Bombay clear systems of traveling. We arrive at differently valued costs inculcating the changes in circumstances around.

	Site-K	Site-A	Site-B	Site-G	Supply
Supplier-C	1400	1100	850	1050	10000
Supplier-K	500	1000	1200	1350	7000
Supplier-A	900	500	650	700	6500
Supplier-S	1250	950	600	600	15000
Demand	9000	5500	7500	10500	

Final Optimal Solution arrived was as under:

	Site-K	Site-A	Site-B	Site-G	Dummy	Supply
Supplier-C	1400 (1000)	1100	850 (3000)	1050	0 (6000)	10000
Supplier-K	500 (7000)	1000	1200	1350	0	7000
Supplier-A	900 (1000)	500 (5500)	650	700	0	6500
Supplier-S	1250	950	600 (4500)	600 (10500)	0	15000
Demand	9000	5500	7500	10500	6000	

This presents us the updated transportation cost with external factor traffic and congestion is taken into consideration, the most common reason being the construction of the metro and new projects coming up in the areas.

Optimal Transportation Cost = (1400×1000) + (850×3000) + (0×6000) + (500×7000) + (900×1000) + (500×5500) + (600×4500) + (600×10500) = ₹2,01,00,000

Additional Cost = 2,01,00,000 – 1,98,50,000 = ₹2,50,000

4.2 Parking difficulties

Many automobile drivers stuck in town traffic jams don't seem to be truly attempting to travel anywhere: they're simply trying to find an area to park. For them, the parking drawback is that the urban transport problem: earning enough to shop for an automobile is one issue, however, is good enough to search out somewhere to park it's quite another. However, it's not simply the driver that suffers. Cities area unit ugly by ugly multi-storey parking garages and cityscapes area unit became seas of metal, as vehicles area unit crammed on to each area unit of the ground.

Public transport is slowed by clogged streets and movement on foot in something sort of a line becomes not possible. the availability of adequate automobile parking lot inside or on the margins of central business districts (CBDs) for town employees and shoppers could be a drawback that has serious implications for land use coming up with.

A proliferation of pricey and visually intrusive multi-story car-parks will solely offer a partial answer and supplementary on-street parking typically compound road congestion. The extension of pedestrian precincts and retail malls in town centers is meant to supply additional acceptable environments for shoppers and alternative users of town centers. However, such traffic-free zones successively manufacture issues as they produce new patterns of access to industrial centers for car-borne travelers and users of transport, whereas the latter typically lose their former advantage of being sent on to the central looking space.

This forces the costs to drive up in terms of parking charges and time exhausted in searching for availability. Which brings us to the new costs with changes in the values due to surroundings and area's reactivity to such an issue.

	Site-K	Site-A	Site-B	Site-G	Supply
Supplier-C	1300	1050	900	1100	10000
Supplier-K	500	900	1150	1400	7000
Supplier-A	900	500	600	700	6500
Supplier-S	1200	950	600	600	15000
Demand	9000	5500	7500	10500	

Final Optimal Solution arrived was as under

	Site-K	Site-A	Site-B	Site-G	Dummy)	Supply
Supplier-C	1300 (1000)	1050	900 (3000)	1100	0 (6000)	10000
Supplier-K	500 (7000)	900	1150	1400	0	7000
Supplier-A	900 (1000)	500 (5500)	600	700	0	6500
Supplier-S	1200	950	600 (4500)	600 (10500)	0	15000
Demand	9000	5500	7500	10500	6000	

Optimal Transportation Cost = (1300 x 1000) + (900 x 3000) + (0 x 6000) + (500 x 7000) + (900 x 1000) + (500 x 5500) + (600 x 4500) + (600 x 10500) = ₹ 2,01,50,000

Additional Cost = 2,01,50,000 – 1,98,50,000 = ₹ 3,00,000

5. CONCLUSION

The main premise of this paper was to present a model for optimizing the transportation cost for a firm in the furniture making industry. Having used scientific methods of operations research and theorized various models for restrictions imposed due to various factors we can conclude that our model helps in reducing the cost for a seller of raw materials. The urban area represents a complex nexus of roads with various restrictions hampering the optimal cost. Time delays are an important factor affecting the cost in this line of work which results in an increase in days of work with increase labor costs for the business overall. A seller is better-off using our model to inculcate these hindrances and quote an appropriate price.

6. REFERENCES

[1] Dawral M. & Kulshreshtha S.(2017). A Case Study: Growing Parking Issues and Effective Parking Management Strategies. International Journal of Innovative Research in Science,

[2] Engineering and Technology, 6(2).

[3] Green, M.B., Cromley, R.G., & Semple, R.K. (1980). The Bounded Transportation Problem. Economic Geography, 56(1), 30-44.

[4] Kumar A. & Singh R. R. (2017). Traffic Congestion and Possible Solutions in Urban Transportation System. International Journal of Advance Research in Science and Engineering, 6(7).

[5] Nikolić, I. (2007). Total Time Minimizing Transportation Problem. Yugoslav Journal of Operations Research,17(1), 125-133.

[6] Simões, D., Mosquera, G.A., Batistela, G.C., Passos, J.R. & Fenner, P.T. (2016). Quantitative Analysis of Uncertainty in Financial Risk Assessment of Road Transportation of Wood in Uruguay. Forests - Open Access Journal of Forestry, 7, 130.

