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# Solving a Transportation Problem of a Typical Dairy Firm Considering Fuzzy Environment

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## Abstract

*Generally material supplying quantity, product demand, conveyance capacity, transportation cost and others transportation related parameters are hardly specified. But in real life practice, it is found that they may be varied from one period to another period. So this variation should be considered for taking appropriate decision.In this paper a new approach has been proposed for special type of perishable product for the minimization of transportation cost considering an additional restriction on time. Primarily triangular fuzzy numbers are considered for each of the parameters then precise ranges valuesare also considered for each of the parameter. Based on second assumption randomly random value is generated from the range and evaluate the model. Then obtained results are compared with each other for taking feasible decision regarding on transportation problem.*

Keywords: Perishable items, Triangular fuzzy number, Random number and Precise range value.

## 1. Introduction

Transportation has contributed much to the development of economic, social, political and other fields for uplifting their condition. So now-a-days transportation cost is a sector of extreme interest for business persons and researchers to get a more improved and efficient system. Actually, in real problems approximated number instead of crisp one are used for input parameters because it is impossible to use fixed value to describe complicated transportation problems. Empirical surveys reveal that Linear Programming (LP) is one of the most frequently applied OR technique in real world transportation problems. The idea of Linear Programming was introduced by**Lilien and Tingley(1987).**The idea offuzzy set was first proposed by**Zadeh L.A. (1965).** Introducing a concept 'Approximate Reasoning' Zadeh successfully showed that vague logical statements enable the formation of algorithms that can be use vague data to derive vague inferences. Recently**, Gaurav Sharma, S.H. Abbas and Vijay Kumar Gupta (2012)** represented the transportation problem for a company to reduce transportation cost and solved the transportation problem with the help of dual simplex and two phase method.**S. Narayanamoorthy, S.Saranya and S. Maheswari (2013)** proposed a new algorithm of Russell's method for the initial basic feasible solution to a transportation problem. And we have solved the transportation cost minimization problem with an additional restriction and mixed constraints in which coefficients of objective functions, additional restriction function, and demand, supply and conveyance capacity are expressed as TFNs. Then it has been solved by MATLAB(R2011a) considering five cases of data format and made a comparison among them.

## 2. Mathematical Statement

Here, all the parameters that is needed to be considered and which have effect on the transportation cost have been considered as Triangular Fuzzy Number (TFN) to cope up with the uncertain behavior of parameters and get a result which is more realistic. We have tried to optimize the total cost of transportation of total products of an industry within a certain time considering uncertainty by this following way using LP model. There are one source, seven destinations and three type of convenience as shown in the figure 4. As illustrated in the figure, the entity labeled **S1** denotes only one supplier, those labeled **D1-D7** denote the destination zones and entities labeled **E1-E3** denote three types of conveyance.

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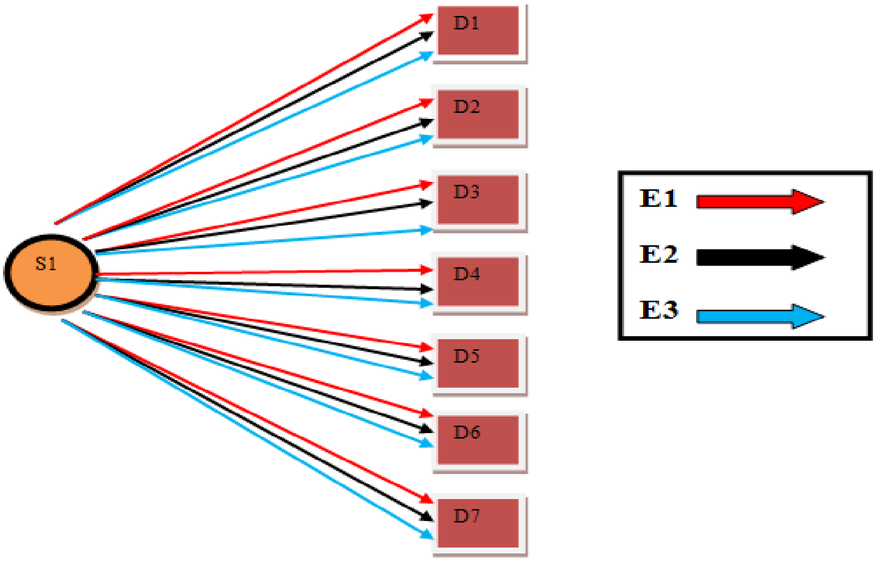


**Figure 1:** Transportation Model

Presented below is the formulation of the transportation problem. A short description of the data of values, constraints and parameters are presented in this section. The principal set of indices used to denote the entities and the interactions between entities in the supply chain is given in Table 1

**Table 1:** Indices Used in the Formulation

| Index | Meaning | Total |
|---|---|---|
| M | Supplier | 1 |
| N | Destination zone | 7 |
| K | convenience | 3 |

## Parameters

$O_i$ = Origins/sources (i=1, 2, 3,……. m)
$D_j$ = Destinations (j=1, 2, 3,……. n)
$a_i$= Amount of homogeneous product which we want to transport to destinations $D_j$.
$b_j$ = Demands for units of product to be satisfied at n destinations $D_j$
$e_k$ = Units of product which can be carried by K different modes of transportation (k =1,2,3,….,K)
$C_{ijk}$ = Cost associated with transportation of a unit of the product from source i to destination j by means of k-th conveyance
$t_{ijk}$ = Delivery time of unit item of transportation from i-th zone to j-th zone by means of k-th conveyance
T = Total delivery time

## Decision variables

$x_{ijk}$ = The unknown quantity to be transported from origin Oi to destination Dj by means of the k-th conveyance.
A general single objective transportation model with mixed constraints, written as follows-

$$\text{MinimumZ} = \sum_{i\in I}\sum_{j\in J}\sum_{k\in K} c_{ijk}x_{ijk}$$

Subject to

$$\sum_{j\in J}\sum_{k\in K} x_{ijk} = a_i \qquad i = 1,2,3\ldots\ldots\ldots m$$

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$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = b_j \qquad j = 1,2,3 \ldots\ldots\ldots n$$
$$\sum_{i\in I}\sum_{j\in J} x_{ijk} = e_k \qquad k = 1,2,3 \ldots\ldots\ldots k$$
$$x_{ijk} \geq 0$$

As we want to transport perishable goods for which restriction on total delivery time is necessary. We are now adding an additional restriction to the above model that the total delivery time $(\sum_i \sum_j \sum_k t_{ijk}\, x_{ijk})$ is not more than T units. As delivery time, demand and supply amount are somewhat uncertain, imprecise and vague in nature. So in real life situation, to depict this nature, all the parameters in the above model may be taken as fuzzy numbers.Then the above model in fuzzy environment for perishable product may be rewritten as-

$$\text{Minimum } Z = \sum_{i\in I}\sum_{j\in J}\sum_{k\in K} \widetilde{c_{ijk}} x_{ijk}$$

Subject to

$$\sum_{i}\sum_{j}\sum_{k} \widetilde{t_{ijk}}\, x_{ijk} \leq \tilde{T} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$
$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = \tilde{a}_i \qquad (i = 1,2,3 \ldots\ldots\ldots m) \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = \widetilde{b_j} \ (j = 1,2,3 \ldots\ldots\ldots n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$
$$\sum_{i\in I}\sum_{j\in J} x_{ijk} = \widetilde{e_k} \ (k = 1,2,3 \ldots\ldots\ldots k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$
$$x_{ijk} \geq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Here, $\tilde{A}$ denotes Triangular Fuzzy Number (TFN) value of any variable A.TFN $\tilde{A}$ is parameterized by a triplet$(a_1,a_2,a_3)$ where
$a_1$ = pessimistic value and the lower limit of the variable A
$a_2$ = most likely value of the variable A
$a_3$ = optimistic value and the upper limit of the variable A

## 3. Solution Technique

To solve the transportation problem MATLAB(R2011a) is used based on linear programming method. Equation are mentioned as follows:-

Minimize**,**

$$Z=\tilde{c}_{111}x_{111}+\tilde{c}_{112}x_{112}+\tilde{c}_{113}x_{113}+\tilde{c}_{121}x_{121}+\tilde{c}_{122}x_{122}+\tilde{c}_{123}x_{123}+\tilde{c}_{131}x_{131}+\tilde{c}_{132}x_{132}+\tilde{c}_{133}x_{133}+\tilde{c}_{141}x_{141}+\tilde{c}_{142}x_{142}+ \tilde{c}_{143}x_{143}+\tilde{c}_{151}x_{151}+\tilde{c}_{152}x_{1522}+\tilde{c}_{153}x_{153}+\tilde{c}_{161}x_{161}+\tilde{c}_{162}x_{162}+\tilde{c}_{163}x_{163}+\tilde{c}_{171}x_{171}+\tilde{c}_{172}x_{172}+\tilde{c}_{173}x_{173}$$

Subject to,

$$\tilde{t}_{111}x_{111}+\tilde{t}_{112}x_{112}+\tilde{t}_{113}x_{113}+\tilde{t}_{121}x_{121}+\tilde{t}_{122}x_{122}+\tilde{t}_{123}x_{123}+\tilde{t}_{131}x_{131}+\tilde{t}_{132}x_{132}+\tilde{t}_{133}x_{133}+\tilde{t}_{141}x_{141}+\tilde{t}_{142}x_{142}+ \tilde{t}_{143}x_{143}+\tilde{t}_{151}x_{151}+\tilde{t}_{152}x_{152}+\tilde{t}_{153}x_{153}+\tilde{t}_{161}x_{161}+\tilde{t}_{162}x_{162}+\tilde{t}_{163}x_{163}+\tilde{t}_{171}x_{171}+\tilde{t}_{172}x_{172}+\tilde{t}_{173}x_{173} \leq \tilde{T} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$x_{111}+x_{112}+x_{113}+x_{121}+x_{122}+x_{123}+x_{131}+x_{132}+x_{133}+x_{141}+x_{142}+x_{143}+x_{151}+x_{152}+x_{153}+x_{161}+x_{162}+x_{163}+x_{171}+ x_{172}+x_{173}=\tilde{a}_1 \ldots\ldots\ldots\ldots\ldots (2)$$

$$x_{111}+x_{112}+x_{113} = \widetilde{b_1} \ldots\ldots\ldots\ldots\ldots (3)$$
$$x_{121}+x_{122}+x_{123} = \widetilde{b_2} \ldots\ldots\ldots\ldots\ldots (4)$$
$$x_{131}+x_{132}+x_{133} = \widetilde{b_3} \ldots\ldots\ldots\ldots\ldots (5)$$
$$x_{141}+x_{142}+x_{143} = \widetilde{b_4} \ldots\ldots\ldots\ldots\ldots (6)$$
$$x_{151}+x_{152}+x_{153} = \widetilde{b_5} \ldots\ldots\ldots\ldots\ldots (7)$$
$$x_{161}+x_{162}+x_{163} = \widetilde{b_6} \ldots\ldots\ldots\ldots\ldots (8)$$
$$x_{171}+x_{172}+x_{173} = \widetilde{b_7} \ldots\ldots\ldots\ldots\ldots (9)$$

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$x_{111}+x_{121}+x_{131}+x_{141}+x_{151}+x_{161}+x_{171} = \tilde{e_1}$ ............... (10)
$x_{112}+x_{122}+x_{132}+x_{142}+x_{152}+x_{162}+x_{172} = \tilde{e_2}$ ............... (11)
$x_{113}+x_{123}+x_{133}+x_{143}+x_{153}+x_{163}+x_{173} = \tilde{e_3}$ ............... (12)

## 4. Data Collection and Analysis

To keep pace with the criterions of selection of data source, data needed for the transportation problem have been collected from nationally and internationally renowned PRAN DAIRY LIMITED for the specific dairy item 'Processed Pasteurized Milk' of 500ml packet because it has a restricted life time, specific customers demand

**Table 2:** Data of quantity of demand of 7 destination zones

| SL | Destination zone | Quantity of products transported from Narsingdi, Liter |
|---|---|---|
| 1 | Dhaka | 18000-21500 |
| 2 | Chittagong | 10000-12000 |
| 3 | Sylhet | 4000-5000 |
| 4 | Rajshahi | 3000-3600 |
| 5 | Khulna | 3000-3650 |
| 6 | Rangpur | 4500-5500 |
| 7 | Barisal | 5000-6000 |

**Table 3**: Data of time required to transport product by 3 types of conveyance from Narsingdi to 7 destination zones

| SL | Destination Zone | Time required to transport from Narsingdi, Hour | | |
|---|---|---|---|---|
| | | Conveyance 1 | Conveyance 2 | Conveyance 3 |
| 1 | Dhaka | 2-3 | 2-3 | 1.5-2 |
| 2 | Chittagong | 8-9 | 8-9 | 7.5-8 |
| 3 | Sylhet | 4.5-5 | 4.5-5 | 4-5 |
| 4 | Rajshahi | 7.5-8 | 7.5-8 | 7-8 |
| 5 | Khulna | 8-9 | 8-9 | 7.5-8 |
| 6 | Rangpur | 9-10 | 9-10 | 8.5-9 |
| 7 | Barisal | 8-9 | 8-9 | 7.5-8 |

**Table 4:** Data of costof transporting product by 3 types of conveyance from Narsingdi to 7 destination zones

| SL | Destination zone | Cost incurred to transport from Narsingdi, Taka | | |
|---|---|---|---|---|
| | | Conveyance 1 | Conveyance 2 | Conveyance 3 |
| 1 | Dhaka | 4000-5000 | 3900-4900 | 3800-4800 |
| 2 | Chittagong | 16000-17000 | 15900-16900 | 15800-16800 |
| 3 | Sylhet | 9000-10000 | 8900-9900 | 8800-9800 |
| 4 | Rajshahi | 15000-16000 | 14900-15900 | 14800-15800 |
| 5 | Khulna | 16000-17000 | 15900-16900 | 15800-16800 |
| 6 | Rangpur | 18000-19000 | 17900-18900 | 17800-18800 |
| 7 | Barisal | 16000-17000 | 15900-16900 | 15800-16800 |

**Table 5**: Data of daily production capacity of the plant

| Source | Production capacity per day, Liter |
|---|---|
| Narsingdi | 50000-60000 |

**Table 6**: Data of capacity range of the conveyance

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| Conveyance No. | Capacity, Liter |
|---|---|
| Conveyance 1 | 3000-3050 |
| Conveyance 2 | 2500-2530 |
| Conveyance 3 | 1500-1525 |

## 5.Results

Now, to find the optimum value of transportation cost and the optimum quantity (liter) of products (processed pasteurized milk) transported to 7 destinations from 1 source after fulfilling the given constraints, we use MATLAB(R2011a) software. Here, we have considered 5 formats of the data. To show the differences of the result that means optimum transportation cost and optimum quantities of product transported to 7 destinations by 3 types of conveyance, we have solved transportation problem firstly considering three values taken from the triangular membership function of the parameters (Optimistic, Most likely, Pessimistic) separately which are at last used as fixed values. Then at the 4$^{th}$ case, we have multiplied the 3 values of triangular membership function by their weight and then take a single value to use in the programming. Last the 5$^{th}$ case is our main consideration where we have taken a range of possible values for each of the parameters and solved the problem by taking into account possible uncertainty in the source supply, destinations demand, conveyances capacity, and unit cost of product, unit time for delivery and restricted delivery time. By doing this we have got a result more practical than other considerations which is shown in the Table 7.

**Table 7:**Comparison among the Results

| Cases | Optimum transportation cost, Taka | Case considering randomly generated value within the range | Optimum transportation cost, Taka | Difference between Cases considering precise value and randomly generated value, Taka | Decreased Percentage of TC of random case compare to precise cases % |
|---|---|---|---|---|---|
| Optimistic | 109230 | Randomly Generated Values within the Range | 107210 | 2020 | 1.85 |
| Most Likely | 118220 | | | 11010 | 9.31 |
| Pessimistic | 140900 | | | 33690 | 23.91 |
| Weighted Average | 120520 | | | 13310 | 11.04 |

## 6. Conclusion

The main objective of the paper is to present a solving technic for transportation problem in fuzzy environment which has considered uncertainty visible in the total transportation process from source to destination. Moreover, the special feature is to optimum the cost of transportation of a time sensitive product. By considering all needed factors we have collected our data from PRAN DAIRY LIMITED for Processed Pasteurized Milk and then solve the linear programming model to find the optimum cost of transportation and optimum quantities transported to each destination by conveyances of different capacities. But the limitation is hereonly fixed operating cost and trip related cost have been included in transportation cost but vehicle related cost, quantity related cost and overhead cost haven't been concluded. More work can be done on this model that can be on the time restriction function to get a more acceptable result from the transportation problem solving. Additionally, amulti-objective linear transportation problem which minimizes not only the transportation cost but also it includes other factors such as optimization of transportation time or minimization of deterioration amount can be solved using the proposed technic of solving the transportation considering the pattern of collected data concerning of transportation problem. Moreover, optimized result in uncertain environment of the transportation problem can be gained by any fuzzy solver such as Fuzzy Programming Technique, Fuzzy Decisive Method etc.

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