# A New Effective Approach to Solve Fuzzy Transportation Problems

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## Abstract

*In this article, we will take a look at FTP, and then present a way to solve many such problems by using the affected method for FN level. Some of the numbers in FTP may be sharp or sharp numbers. In many decision-making problems, numbers are represented in terms of FN. FN can be normal or oblique, triangular or trapezoidal or any other FN LR. So, some FNs do not compare immediately. First, we convert QF such as price, quantity, supply and demand, into accurate quantities by using our system, and then using sophisticated algorithms, we solve and solve the problem. The new system is a configuration, easy to install and can be used for all types of TP, or to increase or decrease the target function. In the end, this process is illustrated by digital examples.*

**Keywords:** Fuzzy Transportation Problem, Fuzzy Numbers, Optimization, Ranking of Fuzzy Numbers

## Abbreviations

| | | |
|---|---|---|
| Optimal Solution | : | OS |
| Linear Programming Problem | : | LPP |
| Fuzzy Number | : | FN |
| Transportation Problem | : | TP |
| Fuzzy Transportation Problem | : | FTP |
| Shipping Cost | : | SC |
| Transportation Model | : | TM |
| Fuzzy Quantities | : | FQ |
| Fuzzy Solution | : | FS |

| | | |
|---|---|---|
| Feasible Solution | : | FeS |
| Transportation Cost | : | TC |
| Right Hand Side | : | RHS |
| Transportation Tableau | : | TT |

## I. Introduction

TP is a unique LPP that manifests itself in many useful applications. In this issue, we determine the best shipping method between source or source and destination. Many terms unrelated to transportation have this system. Suppose *n* from the start will give me a place to use some products. Let $b_k$ be the number of products in the beginning *k*, and $c_l$ be the number of products required in place *l*. Also, we assume that the cost of shipping a unit of product from the beginning k to the destination l is $d_{kl}$, then we leave $y_{kl}$ to represent the cost from the beginning *k* to point *l*. In the case of SC, it is thought that the corresponding number of upgrades from each start to anywhere to reduce the total SC would be LPP. The TMs have fast and easy delivery and supply chain to reduce costs. When the price range and the number of supply and demand are well known, several algorithms are developed to optimize TP. But, in the real world, there are many cases where the cost factors and the amount of supply and demand are FQ. FTP is the TP of TC, the supply and the required number are FQs. Most of the current systems only provide a clear solution for FTP. [1-3] have devised a system to fix FTP. [4] obtained FS for two steps reducing the FTP value of the donor and the required trapezoidal FNs. [5] has developed a system, i.e. a zero-path path, to find an operating system for FTP where all parameters are trapezoidal FNs.

In many decision-making problems, data is represented in the FN system. In FTP, all parameters is FN. FN can be normal or irregular, triangular or trapezoidal. So, some FNs do not compare immediately. Comparisons between two or more NFs in terms of the numbers are one of the key topics, and how to describe the level of NF is one of the key topics. Introducing several methods for processing FN. Here, we want to use the introductory method for the design of FN, by [6]. Now we want to apply this method to all FTP, where all parameters can be trapezoidal FN, triangular FN, FN LR arbitrary, normal FN or negative FN. This process is very easy to understand and apply. Finally, the operating system of the problem can be accessed as FN or net number.

## II. Mathematical Formulation of a FTP

In mathematics, useful work can be said as follows:
Minimize

$$w = \sum_{k=1}^{n} \sum_{l=1}^{n} d_{kl} y_{kl} \tag{2.1}$$

Subject to

$$\begin{aligned} &\sum_{k=1}^{n} y_{kl} = b_k && k = 1, 2, 3..., n \\ &\sum_{k=1}^{n} y_{kl} = c_l && l = 1, 2, 3..., n \\ &y_{kl} \geq 0 && k = 1, 2, 3..., n \quad l = 1, 2, 3..., n \end{aligned} \tag{2.2}$$

where $d_{kl}$ is the TP of a unit from kth source to lth point, and the $y_{kl}$ value must be a positive or negative number, which is transmitted from kth source to lth point. What is clear is that the absolute conditions for the LPP given in (2.1) to find a solution are as follows

$$\sum_{k=1}^{m} b_k = \sum_{l=1}^{m} c_l \tag{2.3}$$

that is, assume that the available sum is equal to the required sum. If this is not true, the source or destination may be added. It should be noted that this problem has FeS if the (2.2) condition is satisfactory. Now the problem is to determine $y_{kl}$, so that the total TC total.

In mathematics, FTP can be defined as:

$$w = \sum_{k=1}^{n} \sum_{l=1}^{n} d^*_{kl} y_{kl} \tag{2.4}$$

Subject to

$$\begin{aligned} &\sum_{k=1}^{n} y_{kl} = b^*_k && k = 1, 2, 3..., n \\ &\sum_{k=1}^{n} y_{kl} = c^*_l && l = 1, 2, 3..., n \\ &y_{kl} \geq 0 && k = 1, 2, 3..., n \quad l = 1, 2, 3..., n \end{aligned} \tag{2.5}$$

of the number of TCs $d^*_{kl}$, supply $b^*_k$ and demand $c^*_l$ is FQ. An important and absolute condition for non-essential LPP given in (2.4) and (2.5) to find a solution is that

$$\sum_{k=1}^{m} b_k^* \cong \sum_{l=1}^{m} c_l^* \tag{2.6}$$

A large number of systems are provided for FTP. Some of them are based on FN level. Some of the NF-level systems, for example, have limitations, are difficult to compute, or lack understanding, making them ineffective and useful applications, especially in the decision-making process. However, in some of these methods, such as those compared to FN as their centroid point [7-11], the decision maker does not work it each with comparisons between FN. However, there are some ways to compare FNs individually [12-14]. It is not always the case that there is no point in the nature of uncertainty and incorrect title information, but these situations often occur in practice when expressing language words. For this reason, when comparing two FNs, it is natural that the results of the comparison are inaccurate or, at least, parametric, due to its own nature and specifications. This can also be seen in the variability of practitioners in the fuzzy set theory. We clearly see that non-parametric decision makers and non-parametric practitioners perform better than non-parametric practitioners with respect to experimental data [15, 16]. Two factors play an important role in the decision-making process: Contributor's decision-making and decision-making process, ease of total. This essay attempts to provide a system of degrees and compares NF to account as much as possible of the factors mentioned above. The expected mechanism was also discussed in the centroid system [17, 18].

## III. Definition of an Arbitrary FN

FN has been described in various forms. We use the next FN definition very accurately. We present the FN $B_w$ strongly by the two prescribed paths *(B (s), B * (s))*, where $0 \leq s \leq w$ and w are the fluctuations between zero and one *(0 ≤ w ≤ 1)*, with a parametric shape that meets the requirements:

- *B (s)* is a continuous function that does not go down the top left *[0, w]*.

- *B * (s)* is a continuous incremental function left at the top *[0, w]*.
- *B (s) ≤ B * (s), 0 ≤ s ≤ w.*

The net number "*i*" represents only $B(s) = B^*(s) = i,\ 0 \le s \le w$. By proper definition, the holes FNs *{B (s), B * (s)}*, becoming convex cone F1 are isomorphic and isometric embedded in the Banach hole. If B is FN then cut β of B is $[B^*]\beta = [B(\beta), B^*(\beta)],\quad 0 \le \beta \le w$. If $w = 1$, the coefficient described above is called the normal FN.

## IV. An Approach for Making Ranking FN

As mentioned earlier, it seems that the parametric method of FN comparison, mainly in the theory of non-parametric determination, is better than non-parametric methods. For example, in a centroid system from a study [19], FN was compared to their Euclidean origin from the beginning. Negative FN is not included in the Cheng centroid core system. Sometime later, however, [20] tried to solve this problem by using the area between the centroid point at the beginning. But their study was also flawless. [21] found that the regional systems of a study lead to some time in unintelligible planning. That study showed a marked eye pattern. But their method is not parametric and is only available in normal FN. It is well known that non-parametric methods compared to FN have some setbacks in practice.

According to the above definition of FN, as $B_w = (B(s), B^*(s)), (0 \le s \le w)$ $u_n$ FN, then the value $N(B_w)$, assigned to $B_w$ for decision. Levels greater than "*β*" calculated as follows:

$$N_\beta(B_w^*) = \frac{1}{2}\int_\beta^w \{B(s) + B^*(s)\}ds \quad \text{where} \quad 0 \le \beta < 1$$

This number will be used as a basis for comparing FN with a resolution level higher than β.

## V. Trapezoidal and Triangular FNs

The two major classes of FN, commonly used for practical and easy-to-use purposes, are the "trapezoidal and triangular FN", some ways of bringing the FN and the trapezoidal FN closer and closer, see also [22-24] and therefore there is no concern in this.

### I. Triangular FNs

FN, B is a triangular FN called *(σ, n, α)* where *σ*, *n* and *α* is a real number and its functions are given by $u_B(y)$ below,

$$u_B(y) = 0 \qquad \text{for } y \le \sigma$$

$$u_B(y) = \frac{y-\sigma}{n-\sigma} \qquad \text{for } \sigma \le y \le n$$

$$u_B(y) = 1 \qquad \text{for } y = n$$

$$u_B(y) = \frac{\alpha - y}{\alpha - n} \qquad \text{for } n \le y \le \alpha$$

$$u_B(y) = 0 \qquad \text{for } y \ge \alpha$$

According to the description above of the triangular FN, let *B = (B (s), B * (s)), (0 ≤ s ≤ 1)* one FN, then the value *N(B)*, to assign with B calculated as follows:

$$N - Tra(B) = \frac{1}{2}\int_0^1 \{B(s) + B^*(s)\}ds = \frac{1}{4}\left[2n + \sigma + \alpha\right]$$

that is very useful for calculations.

## II. Trapezoidal FNs

A FN, *B* is a trapezoidal FN identified by the symbol *(σ, n, m, α)*, where *σ, m, n, α* are real numbers and the membership function $u_B(y)$ is given below.

$$u_B(y) = 0 \qquad \text{for } y \le \sigma$$

$$u_B(y) = \frac{y - \sigma}{n - \sigma} \qquad \text{for } \sigma \le y \le n$$

$$u_B(y) = 1 \qquad \text{for } n \le y \le m$$

$$u_B(y) = \frac{m - y}{\alpha - m} \qquad \text{for } n \le y \le \alpha$$

$$u_B(y) = 0 \qquad \text{for } y \ge \alpha$$

According to the above definition of the FN trapezoid, let *B = (B (s), B * (s)), (0 ≤ s ≤ 1)* FN, then the value of *N (B)*, set B, as the following is calculated. :

$$N - Tra(B) = \frac{1}{2}\int_0^1 \{B(s) + B^*(s)\}ds = \frac{1}{4}\left[n + m + \sigma + \alpha\right]$$

that is very useful for calculations.

# VI. A Newly Developed Approach for Solving FTP

We are now introducing a new approach to FTP solutions where key contributors, resources and requests are FNs. FNs in each problem can be triangular, trapezoidal, or any FN or mixture. The FTP operating system can be downloaded explicitly or implicitly.

**First Step:** Calculate the values of N (.) For each fuzzy data, TC $d_{kl}$, supply $b_k$, and $c_l$ demand values, which are FQ.

**Second Step:** By replacing *N (* $d_{kl}$ *), N (* $b_k$ *)* and *N (* $c_l$ *)* which are fragile values with $d_{kl}$, $b_k$, and $c_l$ values which are FQ, you select a new fragile TP.

**Third Step:** Fix a new TP net, through the old system, and get the problematic network. Note that each answer in the laboratory will have a specific *(n-m-1)* point FS. We know that OS $y_{kl}$ must be an integer or an integer, but OS $y_{kl}$ for net TP may be an integer or not an integer, because the RHS of the problem is an FN which is an integer. If you accept a soft solution, stop. The OS is in your hands. If you want the kind of nonsense solution, go to the next step.

**Forth Step:** Determine where the FS are not missing in the TT. The background is a rooted tree, that is, there must be at least one cell in each row and in each column of the TT. In addition, the foundation must be wood, that is, cells *(n-m-1)* cells will not have a circle. Therefore, there are rows and columns with only one main cell. Starting with these cells, calculate the nonlinear core solution, and continue until you obtain a *(n-m-1)* foundation solution.

## VII. Examples

The following example may be useful to clarify the proposed procedure:

**Example:** Consider the following FTP which is in [25]. All data for this problem are trapezoidal FNs. We want to use our method to solve it, then we will compare the results.

**Table 1:** *FNs, Demand and Supply*

| | **1** | **2** | **3** | **4** | **Supply** |
|---|---|---|---|---|---|
| **1** | 4,5,6,7 | 4,6,7,9 | 12,14,15,17 | 8,10,11,14 | 4,9,10,13 |
| **2** | 3,4,5,7 | 2,3,4,5 | 8,9,10,11 | 3,4,5,6 | 3,4,5,6 |
| **3** | 6,8,9,11 | 8,11,12,15 | 15,18,19,22 | 10,12,13,15 | 8,13,15,20 |
| **Demand** | 8,10,11,13 | 4,8,9,13 | 4,6,7,9 | 4,5,6,7 | |

According to the description above of the trapezoidal FN or $A = (A(s), A^*(s))$, $(0 \le s \le 1)$ FN, then the value $N(A)$, is assigned and Calculated as part:

$$N - Tra(A) = \frac{1}{2}\int_0^1 \{A(s) + A^*(s)\}ds = \frac{1}{4}\left[n + m + \sigma + \alpha\right]$$

Thus, we obtain the values of $N(B_{kl})$, $N(b_k)$ and $N(c_l)$ according to the recommended formula:

**Table 2:** *Trapezoidal FNs*

| **FNs** | **Trapezoidal FNs** |
|---|---|
| B11=4,5,6,7 | N-Tra(B11)=1/4(4+5+6+7)=5.5 |
| B12=4,6,7,9 | N-Tra(B12)=1/4(4+6+7+9)=6.5 |
| B13=12,14,15,17 | N-Tra(B13)=1/4(12+14+15+17)=14.5 |
| B14=8,10,11,14 | N-Tra(B14)=1/4(8+10+11+14)=10.75 |
| B21=3,4,5,7 | N-Tra(B21)=1/4(3+4+5+7)=4.75 |
| B22=2,3,4,5 | N-Tra(B22)=1/4(2+3+4+5)=3.5 |
| B23=8,9,10,11 | N-Tra(B23)=1/4(8+9+10+11)=9.5 |
| B24=3,4,5,6 | N-Tra(B24)=1/4(3+4+5+6)=4.5 |
| B31=6,8,9,11 | N-Tra(B31)=1/4(6+8+9+11)=8.5 |
| B32=8,11,12,15 | N-Tra(B32)=1/4(8+11+12+15)=11.5 |
| B33=15,18,19,22 | N-Tra(B33)=1/4(15+18+19+22)=18.5 |
| B34=10,12,13,15 | N-Tra(B34)=1/4(10+12+13+15)=12.5 |

and fuzzy supplies are given as:

**Table 3:** *Trapezoidal Fuzzy Supplies*

| **Supply** | **Trapezoidal Fuzzy Supply** |
|---|---|
| b1=4,9,10,15 | N-Tra(b1)=1/4(4+9+10+15)=9.5 |
| b2=3,4,5,6 | N-Tra(b2)=1/4(3+4+5+6)=4.5 |
| b3=8,13,15,20 | N-Tra(b3)=1/4(8+13+15+20)=14 |

and fuzzy demands are given as:

**Table 4:** *Trapezoidal Fuzzy Demands*

| Demand | Trapezoidal Fuzzy Demand |
|---|---|
| c1=8,10,11,13 | N-Tra(c1)=1/4(8+10+11+13)=10.5 |
| c2=4,8,9,13 | N-Tra(c2)=1/4(4+8+9+13)=8.5 |
| c3=4,6,7,9 | N-Tra(c3)=1/4(4+6+7+9)=6.5 |
| c4=4,5,6,7 | N-Tra(c4)=1/4(4+5+6+7)=5.5 |

total fuzzy supply is given as: T = (9, 20, 24, 35) as well as total fuzzy demand is given as: F = (11, 20, 24, 33), hence:

**Table 5:** *Trapezoidal Total Fuzzy Demands and Supply*

| Demand / Supply | Trapezoidal Fuzzy Demand |
|---|---|
| T=9,20,24,35 | N-Tra(T)=1/4(9+20+24+35)=22 |
| F=11,20,24,33 | N-Tra(F)=1/4(11+20+24+33)=22 |

Since *N-Tra (T) = N-Tra (F)*, the given problem is a valid problem. Now using our system, we convert FTP to pure TP. So, we have these reduced FTP:

**Table 6:** *Reduced FTP*

| | 1 | 2 | 3 | 4 | Supply |
|---|---|---|---|---|---|
| **1** | 6.4 | 7.4 | 15.4 | 11.65 | 10.4 |
| **2** | 5.65 | 4.4 | 10.4 | 5.4 | 5.4 |
| **3** | 9.4 | 12.4 | 19.4 | 13.4 | 15 |
| **Demand** | 11.4 | 9.4 | 7.4 | 6.4 | |

As shown in Table 6, the defuzzification results of FN obtain values of non-numerical values. Therefore, the existence of a negative value in TP is next to the fact that the solution of net TP is not important. Note that the solution and the useful function are quantitative, because its matrix is uni-modular (26). If we solve the new problem, we will get the following answers:

$$y_{12} = 9.4\ ,\ y_{13} = 5\ ,\ y_{23} = 5.4\ ,\ y_{31} = 11.4\ ,\ y_{33} = 5\ ,\ y_{34} = 6.4\,,$$

and the total value of the problem is $y_0 = 160$.

**Table 7:** *Reduced Solution*

| | 1 | 2 | 3 | 4 | Supply |
|---|---|---|---|---|---|
| **1** | | 9.4 | 5 | | 14.4 |
| **2** | | | 5.4 | | 5.4 |
| **3** | 11.4 | | 5 | 6.4 | 22.8 |
| **Demand** | 11.4 | 9.4 | 15.4 | 6.4 | |

Now we can go back to the original problem and get the FS of FTP based on the data in table-7.

**Table 8:** *Reduced FNs, Demand and Supply*

| | 1 | 2 | 3 | 4 | Supply |
|---|---|---|---|---|---|
| **1** | | 4,8,9,13 | -6,3,5,14 | | 4,9,10,15 |
| **2** | | | 3,4,5,6 | | 3,4,5,6 |
| **3** | 8,10,11,13 | | -6,2,6,14 | 4,5,6,7 | 8,13,15,20 |
| **Demand** | 8,10,11,13 | 4,8,9,13 | 4,6,7,9 | 4,5,6,7 | |

where the default OS for FTP provided is:

$y_{12}^{*} = (4,8,9,13)$; $y_{13}^{*} = (-6,3,5,14)$; $y_{23}^{*} = (3,4,5,6)$; $y_{31}^{*} = (8,10,11,13)$; $y_{33}^{*} = (-6,2,6,14)$; $y_{34}^{*} = (4,5,6,7)$

The results are the same as to the previous studies (4, 8). Note that the benefits of the changes are the same, but the benefits of objective work are different. The best CT net value for the problem provided by the Pandian system is 132.17 where it is obtained from our system is 160. That seems clear is that there is no single system to compare FN, and that different approaches can meet different desirable requirements.

## VIII. Conclusion

In this article, a simple but effective parametric method has been introduced to configure FTP using the FN interface. This method can be used for all types of FTP, either triangular or trapezoidal FN with normal or negative data. The new system is a configuration, easy to install and can be used for all types of TP, or to increase or decrease the target function.

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