Mysterious Neutrosophic Linear Models

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Abstract:

Operations research often shortened to the initialism O.R., is a discipline that deals with the development and application of advanced analytical methods to improve decision-making. It is sometimes considered to be a subfield of mathematical sciences. The term management science is occasionally used as a synonym. It has the ability to express the concepts of efficiency and scarcity in a well-defined mathematical model for a specific issue. It has the ability to use scientific methods to solve complex problems in managing large scale systems for factories, institutions, and companies, and enables them to make optimal scientific decisions for the functioning of Its work.

Employing techniques from other mathematical sciences, such as modelling, statistics, and optimization, operations research arrives at optimal or near-optimal solutions to complex decision-making problems. Because of its emphasis on practical applications, operations research has overlapped with many other disciplines, notably industrial engineering. Operations research is often concerned with determining the extreme values of some real-world objective: the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost). Originating in military efforts before World War II, its techniques have grown to concern problems in a variety of industries. The mathematical model is the simplified image of expressing a practical system from a real life problem or an idea put forward for an executable system, as the mathematical models consist of a goal function through which we search for the maximum or minimum value subject to restrictions. Linear mathematical programming is one of the most important topics in the field of operations research due to their frequent use in most areas of life. When studying linear programming, the first step is to identify the various types of linear models and how to transition from one to the next. We realize that the ideal solution of the linear model is influenced by the coefficients

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of the variables of objective function that describes a profit if the model is a maximizing model or represents a cost if the model is a minimization model, which is affected by environmental conditions. The fixed values that represent the right side of the inequalities (constraints), which express the available capital, time, raw resources, and so on, have an impact on the optimum solution. They are also affected by environmental conditions. We used to take these values as fixed values in classical logic, which does not correspond to reality and leads to erroneous solutions to the problems described by the linear model. As a result, it was essential to reformulate the classical linear models' problems, taking into consideration all probable scenarios and changes in the work environment. In this study, we will look into linear models and their kinds in view of neutrosophic logic, which takes into account all of the data and all of the changes that may occur in the issue under investigation, as well as the uncertainty that is encountered in the problem's data. We'll also look at it if the coefficients of the variables in the objective function are neutrosophic values, and the accessible options are neutrosophic values because we'll reformulate the existing linear mathematical models using neutrosophic logic, and show how to convert from one to another using some examples.

Keywords:

Linear programming, Linear models, Neutrosophic Logic, Neutrosophic Linear Models, Uncertainty, Indeterminate.

1. Introduction:

The primary pivot of operations research is the existence of a problem that necessitates decision-making, which becomes more necessary as the problem's complexity grows. The success of operations research's methodologies, the model's data collection procedure, and the accuracy of its depiction of reality, all of these are dependent on decision-makers. When employing quantitative analysis to solve an issue, the analyst's primary focus will be on comprehending quantitative facts and data connected to the problem, then building a mathematical model based on that understanding and familiarity. The model must accurately represent the problem's goal, limitations, and interrelationships, and one of the most important factors that aided the operations research algorithms to solve complex problems was the development of the computer, which led to the establishment of companies specializing in the development of software and systems related to operations research methods. As a result, in order to get

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the most out of this development, the information we provide must be flexible with any changes that may occur in the workplace and take into account all available possibilities. Thus, in this article, we used neutrosophic logic, which is a new vision of modeling that is designed to effectively address the uncertainties inherent in the real world, by introducing a third state that can be interpreted as undetermined or uncertain, to replace the binary logic that admits merely right and wrong. Florentin Smarandache, an American mathematical philosopher [7,9-15]

In 1995, Florentin proposed neutrosophic logic as a generalization of fuzzy logic and an extension of Lotfi Zadeh's theory of fuzzy categories [6]. Ahmed A. Salama went on to present the theory of neutrosophic classical categories as a generalization of the theory of classical categories [12,16], and he used Neutrosophy to develop, introduce, and formulate new concepts in mathematics, statistics, computer science, and other fields [17].

Neutrosophic theory has gained popularity in recent years due to its use in measurement, groups, graphs, and a variety of other scientific and practical domains [8,18,21-24].

Recently, there were revolutionary movements to reformulate most mathematical branches, especially in operating research and optimization to reconstruct either its fuzzy or classical problems in the light of neutrosophic theory [19,20,25-27].

2. Discussion:

Many of the problems in our daily life have been handled by operations research topics, and one of the most essential elements that distinguish operations research science from other quantitative methods-based sciences is the description of the problem in a mathematical model. We've looked at a lot of operations research subjects using traditional logic, which relies on specific data from field studies of the case in question and leads to specific results that don't account for the changes and fluctuations we meet on the work that can lead to unexpected losses [1- 5]. This prompted the authors to conduct this study, in which they presented the most important forms of linear mathematical models known in classical logic utilizing neutrosophic mathematical relationships, which include a set of neutrosophic variables that can change as a function of the work environment. The presence of neutrosophic values ensures a safe workflow for the facility that follows these models and based on what has been clarified in the summary about the factors that influence the ideal solution, we will include all instances of the variables in the objective function as neutrosophic values., i.e. $c_j \pm \varepsilon_j; j = 1,2, \dots, n$ where ε_j is indeterminate and could be $\varepsilon_j = |\lambda_{1j}, \lambda_{2j}|$ or $\varepsilon_j \in \{\lambda_{1j}, \lambda_{2j}\}$.

Also, the values that express the available possibilities are neutrosophic values. This means that $b_i \pm \delta_i; i = 1,2, \dots, m$ where δ_i is the indeterminate part and it could be $\delta_i = [\mu_{1i}, \mu_{2i}]$ or $\delta_i \in \{\mu_{1i}, \mu_{2i}\}$.

Using the above assumptions, the upcoming section dedicated to formulate the most popular forms of linear models according to the neutrosophic theory.

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3. General Neutrosophic Linear Model:

The neutrosophic general form is given the linear mathematical model in the abbreviated form as follows:

$$\text{Max } or \text{ Min} f(x) = \sum_{j=1}^{n} (c_j \pm \varepsilon_j) x_j$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \pm \delta_i \quad ; \quad i = 1,2......m$$

$$\sum_{j=1}^{n} a_{ij} x_j \geq b_i \pm \delta_i \quad ; \quad i = 1,2......m$$

$$x_j \geq 0$$

Where $c_j + \varepsilon_j$, $b_i \pm \delta_i$, a_{ij}, $j = 1,2, \dots, n$, $i = 1,2, \dots, m$ are constants having set or interval values according to the nature of the given problem , x_j are decision variables.

Standard Form of the Neutrosophic Linear Model:

When the objective function is of the type maximization subject to less than or equal constraint, the neutrosophic linear model is in its standard form. Call the mathematical form of the neutrosophic linear programming:

$$\text{Max} f(x) = \sum_{j=1}^{n} (c_j \pm \varepsilon_j) x_j$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \pm \delta_i \quad ; \quad i = 1,2......m$$

$$x_j \geq 0$$

Where $c_j + \varepsilon_j$, $b_i \pm \delta_i$, a_{ij}, $j = 1,2, \dots, n$, $i = 1,2, \dots, m$ are constants having set or interval values according to the nature of the given problem , x_j are decision variables.

4. Canonical Neutrosophic Form of Linear Model:

The canonical form plays an important role in finding a solution to linear programming problems, as the issue of searching for a solution to a linear programming problem has been transferred to a process of searching for a solution to a set of linear equations consisting of the equation with anonymous. Solving this issue is useful if it is possible, that is, if it fulfils the conditions of non-negativity Hence, the optimal

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solution for the linear program is the ideal values of the variables that satisfy the constraints and give the objective function the greatest or smallest possible value according to the text of the problem under solution. The conventional neutrosophic form is given as follows:

$$\text{Max } or \text{ Min } f(x) = \sum_{j=1}^{n} (c_j \pm \varepsilon_j) x_j$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j = b_i \ ; \ i = 1,2,\dots,m \quad , \quad j = 1,2,\dots,n$$

$$x_j \geq 0$$

Except for the non-negative constraints, which remain inequalities, all of the constraints are of the equality type. In addition, each equality constraint's right-hand side must be non-negative, and all decision variables must be non-negative. In the neutrosophic standard form, the objective follower might be either a maximizing or a minimizing function.

5. The Neutrosophical Symmetry of the Linear Model:

The linear program is set symmetrically if all the variables are constrained to be non-negative and if all the constraints are given in the form of inequalities (the inequalities of the constraints of the maximization problem must be placed in the form (≤ is less than or equal to) while the inequalities of the constraints of the minimization problem must be in the form (≥ is greater than or equal to). The neutrosophic symmetric form is written in one of two ways in the following:

First pattern:

$$f(x) = \sum_{j=1}^{n} (c_j \pm \varepsilon_j) x_j \rightarrow Max$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \pm \delta_i \quad ; \quad \text{i} = 1,2......\text{m}$$

$$x_j \geq 0$$

Second Pattern:

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$$f(x) = \sum_{j=1}^{n} (c_j \pm \varepsilon_j) x_j \rightarrow Min$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j \geq b_i \pm \delta_i \quad ; \quad i = 1,2......m$$

$$x_j \geq 0$$

Where $c_j + \varepsilon_j$, $b_i \pm \delta_i$, a_{ij}, $j = 1,2,\dots,n$, $i = 1,2,\dots,m$ are constants having set or interval values according to the nature of the given problem , x_j are decision variables.

Following the presentation of the various patterns in which the neutrosophic linear model can be presented, it is worth noting that we can shift from one pattern to another by using the below primary transformations:

- Converting the minimum value of the objective function f(x) to a maximum value by taking a negative value of $f(x)$.
- If the inequalities were of the form (greater than or equal to) they will be converted to the form (less than or equal to) by multiplying both sides by (-1), and vice versa.
- The equality constraint can be converted into two inequalities of different direction.
- If the left side of an (inequality) constraint is given in absolute value, it can be converted into two regular inequalities.
- Constraint inequalities of the type (greater than or equal to) are converted to an equality constraint by subtracting an appropriate positive variable (i.e. artificial variable) from the left side of the inequality and this variable is entered into the objective function with zero coefficient.
- Constraint inequalities of the type (less than or equal to) are converted into an equality constraint by adding an appropriate positive variable (i.e. slack variable) to the left hand side of the inequality and then this variable is entered into the objective function with zero coefficient.
- If one of the decision variables x is not constrained by the non-negative condition (that is, it can be negative, positive or zero), then it can be expressed as the difference between two non-negative variables x', x''as follows $x = x' - x''$ where $x' \geq 0$ and $x'' \geq 0$.

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5.1 Practical Example 1:

Call the following Neutrosophic Linear Programming in its general form:

$$MinZ = (3 \pm \varepsilon_1)x_1 - (3 \pm \varepsilon_2)x_2 + (7 \pm \varepsilon_3)x_3$$

Subject to

$$x_1 + x_2 + 3x_3 \le 40 \pm \delta_1$$
$$x_1 + 9x_2 - 7x_3 \ge 50 \pm \delta_2$$
$$5x_1 + 3x_2 = 20 \pm \delta_3$$
$$|5x_2 + 8x_3| \le 100 \pm \delta_4$$
$$x_1 \ge 0 \quad , \quad x_2 \ge 0$$

where $c_j \mp \varepsilon_j\, , j = 1,2, \dots , n$; ε_j It is indeterminate and could be $\varepsilon_j = [\lambda_{1j}, \lambda_{2j}]$ or $\varepsilon_j \in \{\lambda_{1j}, \lambda_{2j}\}$. Also, the values that express the available possibilities are neutrosophic values. This means that $b_i \mp \delta_i$; $i = 1,2, \dots , m$; δ_i It is indeterminate and could be $\delta_i = [\lambda_{1j}, \lambda_{2j}]$ or $\delta_i \in \{\lambda_{1j}, \lambda_{2j}\}$

To convert the above problem into the neutrosophic standard form, we perform the following transformations:

• The objective function is a function of minimization that we turn into a function of maximization

$MinZ = (3 \pm \varepsilon_1)x_1 - (3 \pm \varepsilon_2)x_2 + (7 \pm \varepsilon_3)x_3$ transformed into

$$MaxZ = -(3 \pm \varepsilon_1)x_1 + (3 \pm \varepsilon_2)x_2 - (7 \pm \varepsilon_3)x_3$$

• The second constraint is given (greater than or equal to) is converted into (less than or equal) by multiplying both sides by (-1) we get $-x_1 - 9x_2 + 7x_3 \le -(50 \pm \delta_2)$

$$5x_1 + 3x_2 \le 20 \pm \delta_3$$
$$5x_1 + 3x_2 \ge 20 \pm \delta$$

• Third constraint $5x_1 + 3x_2 = 20 \pm \delta_3$ transformed into two entries

Then we turn the constraint $5x_1 + 3x_2 \ge 20 \pm \delta_3$ into $-5x_1 - 3x_2 \le -(20 \pm \delta_3)$

• The constraint $|5x_1 + 8x_2| \le 100 \pm \delta_4$ is equivalent to the two inequalities

$$-5x_1 - 8x_2 \le 100 \pm \delta_4$$
$$5x_1 + 8x_2 \le 100 \pm \delta_4$$

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• The variable x3 is not restricted by the non-negative constraint, so it is replaced by the following assumption $x_3 = x_3' - x_3''$ where $x_3'' \geq 0$, $x_3' \geq 0$.

The standard neutrosophic form becomes:

$$MaxZ = -(3\pm\varepsilon_1)x_1 + (3\pm\varepsilon_2)x_2 - (7\pm\varepsilon_3)x_3' + (7\pm\varepsilon_3)x_3''$$

Subject to

$$x_1 + x_2 + 3x_3' - 3x_3'' \leq 40 \pm \delta_1$$
$$-x_1 - 9x_2 + 7x_3' - 7x_3'' \leq -(50 \pm \delta_2)$$
$$5x_1 + 3x_2 \leq 20 \pm \delta_3$$
$$-5x_1 - 3x_2 \leq -(20 \pm \delta_3)$$
$$5x_2 + 8x_3' - 8x_3'' \leq 100 \pm \delta_4$$
$$-5x_2 - 8x_3' + 8x_3'' \leq 100 \pm \delta_4$$
$$x_1 \geq 0 \quad , \quad x_2 \geq 0 \quad , \quad x_3' \geq 0 \quad , \quad x_3'' \geq 0$$

5.2 Practical Example 2:

A factory produces four types of products S_4 , S_3 , S_2 , S_1. For this purpose, the following raw materials are used M_3 , M_2, M_1 . The factory management wants to study the optimal organization of production during a period of time (for example, a month) and determine the monthly production for each product in order to achieve a maximum profit, bearing in mind that the profit is directly proportional to the number of units sold of the products. The available quantities of raw materials needed for each product and the profit have been showed in the following table:

Raw Materials	Product Type				Available Quantities
	S_1	S_2	S_3	S_4	
M_1	1.5	1	2.4	1	$3000 \pm \delta_1$
M_2	1	5	1	3.5	$9000 \pm \delta_2$
M_3	1.5	3	3.5	1	$7000 \pm \delta_3$
win one product	$4 \pm \varepsilon_1$	$8 \pm \varepsilon_2$	$5 \pm \varepsilon_3$	$6 \pm \varepsilon_4$	

Let us suppose x_1 is the number of units produced from the first type, x_2 is the number of units produced from the second type, x_3 is the number of units produced from the third type, and x_4 is the number of units produced from the fourth type during the production period (a month for example), and accordingly, the consumed quantity of the raw material M_1 in the production of the four varieties will be:

$1.5x_1 + x_2 + 2.4x_3 + x_4$

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And it must not exceed $3000 \pm \delta_1$ from the available quantity, that is :

$$1.5x_1 + x_2 + 2.4x_3 + x_4 \leq 3000 \pm \delta_1 \quad (1)$$

Likewise, the amount of raw material M_2 consumed in the production of the four types is:

$$x_1 + 5x_2 + x_3 + 3.5x_4 \leq 9000 \pm \delta_2 \quad (2)$$

And the amount consumed of the raw material M_3 in the production of the four types is:

$$1.5x_1 + 3x_2 + 3.5x_3 + x_4 \leq 7000 \pm \delta_3 \quad (3)$$

In addition, the produced quantities must be non-negative, i.e.:

$$x_i \geq 0, i = 1,2,3,4 \quad (4)$$

And they are what is called non-negative conditions.

Thus, we have identified all the constraints imposed on the variables of the problem.

We now define the objective function. If quantified units x_1, x_2, x_3, x_4 of species are produced in order, then the profit during the productive period will be:

$$f(x) = (4 \pm \varepsilon_1)x_1 + (8 \pm \varepsilon_2)x_2 + (5 \pm \varepsilon_3)x_3 + (6 \pm \varepsilon_4)x_4$$

It represents the target function. Therefore, the mathematical model of the problem is:

$$Max \;\; f(x) = (4 \pm \varepsilon_1)x_1 + (8 \pm \varepsilon_2)x_2 + (5 \pm \varepsilon_3)x_3 + (6 \pm \varepsilon_4)x_4$$

Subject to

$$1.5x_1 + x_2 + 2.4x_3 + x_4 \leq 3000 \pm \delta_1$$

$$x_1 + 5x_2 + x_3 + 3.5x_4 \leq 9000 \pm \delta_2$$

$$1.5x_1 + 3x_2 + 3.5x_3 + x_4 \leq 7000 \pm \delta_3$$

Non-negative terms:

$$x_1 \geq 0 \, , \, x_2 \geq 0 \, , \, x_3 \geq 0 \, , \, x_4 \geq 0$$

We have obtained a neutrosophical standard linear model using the appropriate transformations, which can be written in the following neutrosophical standard form:

$$Maxf(x) = (4 \pm \varepsilon_1)x_1 + (8 \pm \varepsilon_2)x_2 + (5 \pm \varepsilon_3)x_3 + (6 \pm \varepsilon_4)x_4 + 0y_1 + 0y_2 + 0y_3$$

Subject to

$$1.5x_1 + x_2 + 2.4x_3 + x_4 + y_1 = 3000 \pm \delta_1$$

$$x_1 + 5x_2 + x_3 + 3.5x_4 + y_2 = 9000 \pm \delta_2$$

$$1.5x_1 + 3x_2 + 3.5x_3 + x_4 + y_3 = 7000 \pm \delta_3$$

Non-negative terms:

$$x_1 \geq 0 \, , \, x_2 \geq 0 \, , \, x_3 \geq 0 \, , \, x_4 \geq 0$$

6. Conclusion

Due to the great interdependence that exists between the topics of linear programming, it was necessary to reformulate the forms of linear models according to the Neutrosophic logic, because the uncertainty that we added to the data described by the linear model provides us with linear models that simulate the

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reality and take into account most of the changes that can occur in the working environment of the system represented by the model linear mathematics. It also enabled us to continue the study of linear programming topics, such as finding the accompanying programs that need to develop the mathematical model in a symmetrical form, and solving linear models in a simplex way that needs to model models in the standard form and other topics of linear programming, Therefore, reformulating the important forms of linear models according to neutrosophic logic is inevitable because it provides us with a more general and comprehensive study and enables us to provide quick and accurate treatment to avoid losses that may be incurred by institutions, companies, etc. that operate according to these models.

this article presents linear models and their kinds in view of neutrosophic logic, which takes into account all of the data and all of the changes that may occur in the issue under investigation, as well as the uncertainty that is encountered in the problem's data. also, we discuss the case of the variables in the objective function are neutrosophic values, and the accessible options are neutrosophic values because we reformulated the existing linear mathematical models using neutrosophic logic, and showed how to convert from one to another using some examples.

We look forward in the near future to studying other topics of linear programming and its applications in practical life using neutrosophic theory, such as accompanying programs, sensitivity analysis, transfer problem, ...etc.

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