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A Solution Technique of Transportation Problem in Neutrosophic Environment

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Abstract: In this article, we presented a ranking system based on the sign distance in a new direction such that to compare different single-valued neutrosophic numbers (SVN-numbers), a decision maker has the chance of flexibility. We also developed some important definitions, like level-(α,β,γ) neutrosophic point, and some properties related to the sign distance ranking function. Finally, the sign distance ranking function is applied to solving the neutrosophic transportation problem (NTP) with SVN-number converted into a transportation problem (TP) with crisp data, and to illustrate the appropriateness of this function we gave two numerical illustrations.

Keywords: SVN-numbers; Level-1 neutrosophic point; Sign distance ranking function; NTP.

1. Introduction

In the year 1941, the fundamental transportation diagram on crisp numbers with transportation con-straints was initiated. Recently, transportation parameters such as unit transportation cost, demand and supply have been unstable and inconsistent because of different unrestrained arguments. The law and hy-pothesis of crisp set (CS) theory are inappropriate to manage those problems because they only imply that whatever elements are either 0 or 1 if they belong to a set or not, respectively. In this situation, fuzzy sets (FS) [5] and intuitionistic fuzzy sets (IFS) [6] are suitable to handle those problems. For this reason, fuzzy and intuitionistic transportation problems [1, 2 , 3 , 4] were introduced and solved. The generalization of CS,FS, and IFS is called neutrosophic set (NS), which is classified by three independent components: truth(T) , indeterminacy (I) and falsity(F), and Smarandache [7, 8] introduced the notion of NS To handle uncertainty more accurately. The indeterministic part of inconsistent information plays a significant role in creating proper reason, which is not considered in IFS theory. Due to this, we introduced the NTP with SVN-numbers and solved it.

Here the idea of SVN-numbers is designed in a new way, and the ordering of SVN-numbers is described by λ −weighted sign distance. To establish the sign distance ranking function, we follow different ranking approaches in different fields. S.Abbasbandy, B.Asady [20] and Yao, Wu [19] define sign distance to determine the ordering of FS. De, Das [12] and Deng Feng et.el. [10] applied ranking function based on value and ambiguity to define ordering of IFS. Suresh Mohan et.al [11] use magnitude to determine the ranking of IFS. Qiang and Zhong [9] proposed score and accuracy function to define the ordering of IFS. Bera and Mahapatra [13] use values to determine the ordering of SVN-numbers. Deli and Subas [18] define ranking of SVN-numbers on the basis of value and ambiguity. Peng et.al [17] initiated the score, accuracy, and certainty function and applied this function to determine the ordering of SVN-numbers. Ye,J [14] also use the score and accuracy functions to describe the ordering of SVN-numbers.

In this article, let us remember some essential definitions from the preliminary section. In section 3, the idea of level (α, β, γ) −neutrosophic points is introduced, which is the generalisation of level α-fuzzy points[15], and we develop a sign distance ranking function to compare different types of neutrosophic numbers and establish some important properties of the sign distance ranking function. In section 4, we introduced NTP, and applied the sign distance methodology, converting NTP with single valued trapezoidal or triangular neutrosophic numbers (SVTN-numbers or SVTrN-numbers) to the transportation problems with crisp data, and then using VAM and MODI method we get initial and optimal solutions of the mentioned NTP. In the final, the proposed work is briefly described.

2. Preliminaries

Let us remind ourselves of a few significant definitions that are essential for developing the leading concept in this article.

Definition 2.1. [13] When an SVN-Set $\widetilde{M}$ is defined on $\Re$ and is presented as:
$\widetilde{M} =< [m_1, n_1, \sigma_1, \delta_1], [m_2, n_2, \sigma_2, \delta_2], [m_3, n_3, \sigma_3, \delta_3], >, where\ \sigma_i > 0, \delta_i > 0$ are the extensions of left and right, respectively and $[m_i, n_i]$ are the modal intervals of T, I, and F components respectively, for $i = 1, 2, 3$, then $\widetilde{M}$ is said to be SVN-number. The three neutrosophic components are drawn as follows.

$$T_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_1}(\xi - m_1 + \sigma_1) & m_1 - \sigma_1 \le \xi \le m_1 \\ 1 & m_1 \le \xi \le n_1 \\ \frac{1}{\delta_1}(n_1 - \xi + \delta_1) & n_1 \le \xi \le n_1 + \delta_1 \\ 0 & otherwise \end{cases}$$

$$I_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_2}(m_2 - \xi) & m_2 - \sigma_2 \le \xi \le m_2 \\ 0 & m_2 \le \xi \le n_2 \\ \frac{1}{\delta_2}(\xi - n_2) & n_2 \le \xi \le n_2 + \delta_2 \\ 1 & otherwise \end{cases}$$

$$F_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_3}(m_3 - \xi) & m_3 - \sigma_3 \le \xi \le m_3 \\ 0 & m_3 \le \xi \le n_3 \\ \frac{1}{\delta_3}(\xi - n_3) & n_3 \le \xi \le n_3 + \delta_3 \\ 1 & otherwise \end{cases}$$

Respectively

In parametric form, the three pairs of SVN-number $\widetilde{M}$ are $(T^l{}_{\widetilde{M}}, T^u{}_{\widetilde{M}}), (I^l{}_{\widetilde{M}}, I^u{}_{\widetilde{M}}), (F^l{}_{\widetilde{M}}, F^u{}_{\widetilde{M}})$, of functions $T^l{}_{\widetilde{M}}(\varepsilon), T^u{}_{\widetilde{M}}(\varepsilon), I^l{}_{\widetilde{M}}(\varepsilon), I^u{}_{\widetilde{M}}(\varepsilon), F^l{}_{\widetilde{M}}(\varepsilon), F^u{}_{\widetilde{M}}(\varepsilon), \varepsilon \in [0,1]$, and satisfies the following conditions.

(i) $T^l{}_{\widetilde{M}}, I^u{}_{\widetilde{M}}, F^u{}_{\widetilde{M}}$ are continuous, bounded and monotone increasing function.

(ii) $T^u{}_{\widetilde{M}}, I^l{}_{\widetilde{M}}, F^l{}_{\widetilde{M}}$ are continuous, bounded and monotone decreasing function.

(iii) $T^l{}_{\widetilde{M}}(\varepsilon) \le T^u{}_{\widetilde{M}}(\varepsilon), I^l{}_{\widetilde{M}}(\varepsilon) \ge I^u{}_{\widetilde{M}}(\varepsilon), F^l{}_{\widetilde{M}}(\varepsilon) \ge F^U{}_{\widetilde{M}}(\varepsilon)$

Definition 2.2. [13]: A SVN-number $\widetilde{M}$ defined in 2.1 is converted into a SVTN-number if all modal intervals of $\widetilde{M}$ are same

Thus $\widetilde{M} =< [m_1, n_1, \sigma_1, \delta_1], [m_1, n_1, \sigma_2, \delta_2], [m_1, n_1, \sigma_3, \delta_3] >$ is a SVTN-number whose membership functions are given below:

$$T_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_1}(\xi - m_1 + \sigma_1) & m_1 - \sigma_1 \le \xi \le m_1 \\ 1 & m_1 \le \xi \le n_1 \\ \frac{1}{\delta_1}(n_1 - \xi + \delta_1) & n_1 \le \xi \le n_1 + \delta_1 \\ 0 & otherwise \end{cases}$$

$$I_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_2}(m_1 - \xi) & m_1 - \sigma_2 \le \xi \le m_1 \\ 0 & m_1 \le \xi \le n_1 \\ \frac{1}{\delta_2}(\xi - n_1) & n_1 \le \xi \le n_1 + \delta_2 \\ 1 & otherwise \end{cases}$$

$$F_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_3}(m_1 - \xi) & m_1 - \sigma_3 \le \xi \le m_1 \\ 0 & m_1 \le \xi \le n_1 \\ \frac{1}{\delta_3}(\xi - n_1) & n_1 \le \xi \le n_1 + \delta_3 \\ 1 & otherwise \end{cases}$$

respectively.

Let us consider two SVTN-numbers $\widetilde{N} =< [m, n, \sigma_1, \delta_1], [m, n, \sigma_2, \delta_2], [m, n, \sigma_3, \delta_3 >$ and $\widetilde{N}_2 =< ([p, q, \mu_1, v_1], [p, q, \mu_2, v_2])$

Then for $k(\neq 0) \in \Re$

(i) $\widetilde{N}_1 \oplus \widetilde{N}_2 =< [m + p, n + q, \sigma_1 + \mu_1, \delta_1 + v_1], [m + p, n + q, \sigma_2 + \mu_2, \delta_2 + v_2], [m + p, n + q, \sigma_3 + \mu_3, \delta_3 + v_3] >$

(ii) $\widetilde{N}_1 \ominus \widetilde{N}_2 =< [m - q, n - p, \sigma_1 + v_1, \delta_1 + \mu_1], [m - q, n - p, \sigma_2 + v_2, \delta_3 + \mu_2], [m - q, n - p, \sigma_3 + v_3, \delta_3 + \mu_3] >$

(iii) $k\widetilde{N}_1 =< ([km, kn, k\sigma_1, k\delta_1], [km, kn, k\sigma_2, k\delta_2], [km, kn, kk\sigma_3, , k\delta_3]) > for\ k > 0$

$k\widetilde{N}_1 =< ([kn, km - k\delta_1, -k\sigma_1], [kn, km - k\delta_2, -k\sigma_2], [kn, km - k\delta_3, -k\sigma_3] > for\ k < 0$

The graphical representation of SVTN-number $\widetilde{N} = [0.4,0.9,0.3,0.6], [0.5,1,0.4,0.8], [0.8,1.6,0.3,0.6] >$ is given below:

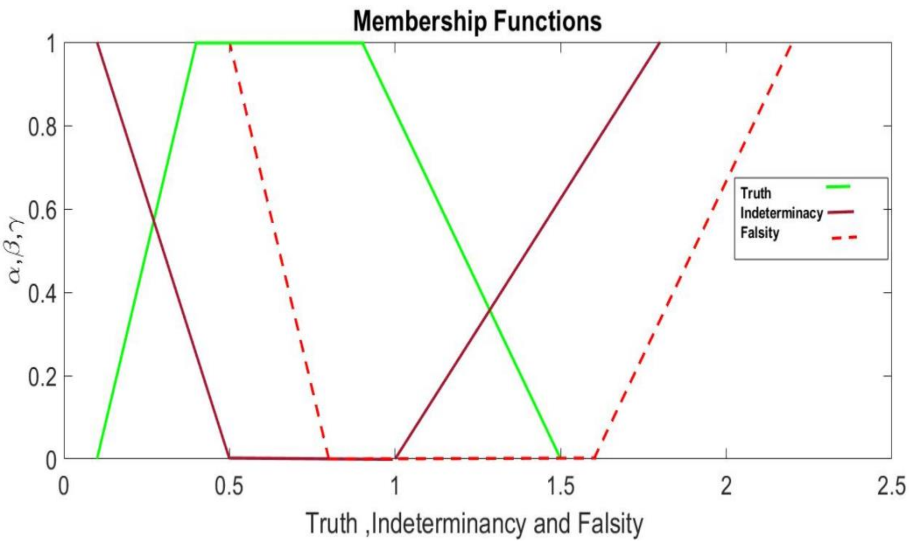

Figure1. The graphical representation of Single valued traoezoidal neutrosophic number(SVTN) $\widetilde{N}$.

Definition 2.3. [18, 13] The SVN-number $\widetilde{M}$ defined in 2.1 is turned into SVTrN-number if all three modal intervals of $\widetilde{M}$ are decreased into modal points and three modal points are equal. Thus $\widetilde{M} = [m_1, \sigma_1, \delta_1], [m_1, \sigma_2, \delta_2], [m_1, \sigma_3, \delta_3] >$is a SVTrN-number whose membership functions are given below.

$$T_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_1}(\xi - m_1 + \sigma_1) & m_1 - \sigma_1 \le \xi \le m_1 \\ 1 & \xi = m_1 \\ \frac{1}{\delta_1}(m_1 - \xi + \delta_1) & m_1 \le \xi \le m_1 + \delta_1 \\ 0 & otherwise \end{cases}$$

$$I_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_2}(m_1 - \xi) & m_1 - \sigma_2 \le \xi \le m_1 \\ 0 & \xi = m_1 \\ \frac{1}{\delta_2}(\xi - m_1) & m_1 \le \xi \le m_1 + \delta_2 \\ 1 & otherwise \end{cases}$$

$$F_{\widetilde{M}}(\xi) = \begin{cases} \frac{1}{\sigma_3}(m_1 - \xi) & m_1 - \sigma_3 \le \xi \le m_1 \\ 0 & \xi = m_1 \\ \frac{1}{\delta_3}(\xi - m_1) & m_1 \le \xi \le m_1 + \delta_3 \\ 1 & otherwise \end{cases}$$

respectively.

Let us consider two SVTrN-numbers $\widetilde{N_1} =< [m, \sigma_1, \delta_1], [m, \sigma_2, \delta_2], [m, \sigma_3, \delta_3] >$ and $\widetilde{N}_2 =< [p, \mu_1, v_1,], [p, \mu_2, v_2,], [p, \mu_3, v_3] >$ Then for $k(\neq 0) \in \Re$

(i) $\widetilde{N}_1 \oplus \widetilde{N}_2 =< [m + p, \sigma_1 + \mu_1, \delta_1 + v_1], [m + p, \sigma_2 + \mu_2, \delta_2 + v_2], [m + p, \sigma_3 + \mu_3, \delta_3 + v_3] >$

(ii) $\widetilde{N}_1 \ominus \widetilde{N}_2 =< [m - p, \sigma_1 + v_1, \delta_1 + \mu_1], [m - p, \sigma_2 + v_2, \delta_3 + \mu_2], [m - p, \sigma_3 + v_3, \delta_3 + \mu_3] >$

(iii) $k\widetilde{N}_1 =< ([km,, k\sigma_1, k\delta_1], [km, k\sigma_2, k\delta_2], [km, kk\sigma_3,, k\delta_3]) > for\ k > 0$

$$k\widetilde{N}_1 =< ([km, -k\delta_1, -k\sigma_1], [km, -k\delta_2, -k\sigma_2], [km, -k\delta_3, -k\sigma_3] > for\ k < 0$$

The graphical representation of SVTrN-number $\widetilde{N} = [1.6, 0.9, 0.9], [1.5, .5, .8], [1, .9, 1.1] >$ is given below:

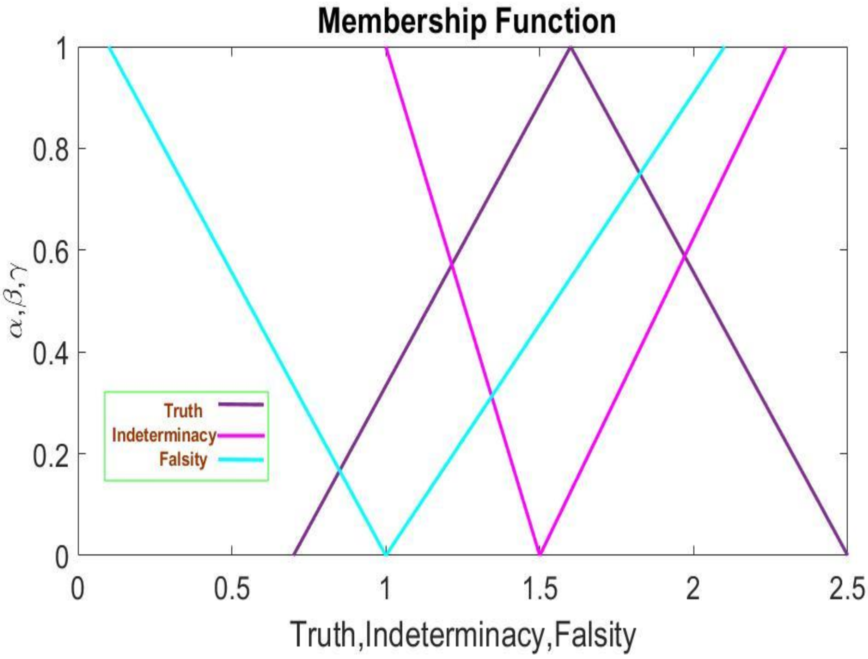

Figure 2. The graphical representation of Single valued triangular neutrosophic number(SVTrN) $\widetilde{N}$.

Definition 2.4. [18, 21] Let $\widetilde{M} =< [m_1, n_1, \sigma_1, \delta_1], [m_2, n_2, \sigma_2, \delta_2], [m_3, n_3, \sigma_3, \delta_3] >$ be an SVN number. Then (α, β, γ) cut of $\widetilde{M}$ is designed by $\widetilde{M}^{(\alpha,\beta,\gamma)}$and described as$\{\xi \epsilon X: T_{\widetilde{M}}(\xi) \geq \alpha, I_{\widetilde{M}}(\xi) \leq \beta, F_{\widetilde{M}}(\xi) \leq \gamma\}$for $0 \leq \alpha, \beta, \gamma \leq 3$.

Thus, (α, β, γ)cut of $\widetilde{M}$ for truth, indeterminacy, and falsity components is given by closed intervals a $[L_{\widetilde{M}}(\alpha), R_{\widetilde{M}}(\alpha)] = [m_1 - \sigma_1 + \sigma_1\alpha, n_1 + \delta_1 - \delta_1\alpha], [L'_{\widetilde{M}}(\beta), R'_{\widetilde{M}}(\beta)] = [m_2 - \sigma_2\beta, n_2 + \delta_2\beta]\ and\ [L''_{\widetilde{M}}(\gamma), R'_{\widetilde{M}}(\gamma)] = [m_3 - \sigma_3\gamma, n_3 + \delta_3\gamma]$ respectively, for $\alpha, \beta, \gamma \epsilon [0,1]$.

Where $L_{\widetilde{M}}, R'_{\widetilde{M}}, R''_{\widetilde{M}}$ are monotonic non-decreasing continuous functions, and $R_{\widetilde{M}}, L'_{\widetilde{M}}, L''_{\widetilde{M}}$ are monotonic nonincreasing continuous functions in their respectively intervals.

3. The Ranking Method of Neutrosophic Number on $\mathfrak{R}$

Here, the idea of sign distance between SVN-numbers is introduced in a new way, together with the development of its characteristics, and using this sign distance method, ordering between SVN-numbers is constructed.

Definition 3.1.

(i) The single valued neutrosophic set $\tilde{a}_\alpha (0 \leq \alpha \leq 1)$of $\mathfrak{R}$ is said to be a level α neutrosophic point for truth membership if

$$X\tilde{a}_\alpha(\xi) = \begin{cases} \alpha & \xi = \tilde{a} \\ 0 & \xi \neq \tilde{a} \end{cases}$$

Let us consider $N_t(1,0,0)$ to be the set of all level 1 neutrosophic points for truth membership.

(ii) The single valued neutrosophic set $\tilde{a}_\beta(0 \le \beta \le 1$ of $\Re$ is said to be a level β neutrosophic point for indeterminacy membership if

$$X\tilde{a}_\beta(\xi) = \begin{cases} \beta & \xi = \tilde{a} \\ 1 & \xi \neq \tilde{a} \end{cases}$$

Let us consider $N_i(1,0,0)$ to be the set of all level 1 neutrosophic points for indeterminacy membership.

(iii) The single valued neutrosophic set $\tilde{a}_\gamma$ $(0 \le \gamma \le 1$ of $\Re$ is said to be a level γ neutrosophic point for falsity membership

$$X\tilde{a}_\gamma(\xi) = \begin{cases} \gamma & \xi = \tilde{a} \\ 1 & \xi \neq \tilde{a} \end{cases}$$

Let us consider $N_f(1,0,0)$ to be the set of all level 1 neutrosophic points for falsity membership.

Definition 3.2. A neutrosophic number must satisfy the following conditions:

(i) A neutrosophic number $\widetilde{M}$ is normal i.e., $\exists\, \xi_0 \in \Re$ such that $T_{\widetilde{M}}(\xi_0) = 1$ and $I_{\widetilde{M}}(\xi_0)$=$F_{\widetilde{M}}(\xi_0) = 0$.

(ii) A neutrosophic number $\widetilde{M}$ is convex for $T_{\widetilde{M}}(\xi)$ $i.e$ $\forall \xi_1, \xi_2 \in \Re$ and $k \in [0,1]$ such that $T_{\widetilde{M}}(k\xi_1 + (1-k)\xi_2) \ge$mine $T_{\widetilde{M}}(\xi_1), T_{\widetilde{M}}(\xi_2)$.

(iii) A neutrosophic number $\widetilde{M}$ is concave for $I_{\widetilde{M}}(\xi)$ and $F_{\widetilde{M}}(\xi)$ i.e. $\forall \xi_1, \xi_2 \in \Re$ and $k \in [0,1]$ such that $I_{\widetilde{M}}(k\xi_1 + (1-k)\xi_2) \ge$ max $I_{\widetilde{M}}(\xi_1), I_{\widetilde{M}}(\xi_2)$ and $F_{\widetilde{M}}\big(k\xi_1 + (1-k)(\xi_2)\big)$ max $F_{\widetilde{M}}(\xi_1), F_{\widetilde{M}}(\xi_2)$.

Let us consider the set of whole SVN-numbers of the form $< [m_1, n_1, \sigma_1, \delta_1], [m_2, n_2, \sigma_2, \delta_2], [m_3, n_3, \sigma_3, \delta_3] >$ satisfying the above definition 3.3 [(i),(ii),(iii)] is named N_N.

Let $\Gamma = N_N \cup N_t(1,0,0) \cup N_i(0,1,0) \cup N_f(0,0,1)$. If $\tilde{a}_1 \in N_N \cup N_t(1,0,0) \cup N_i(0,1,0) \cup N_f(0,0,1)$ then each laft and right edge of (α, β, γ) $-$cut of $\tilde{a}_1$ is equal to a. Therefore, each (α, β, γ) $-$cut of $\tilde{a}_1$ are equal to $[a, a] = a, \forall\, \alpha, \beta, \gamma \in [0,1]$.

Property 3.1. For any $\widetilde{N}_1, \widetilde{N}_2 \in \Gamma$

(i) The $(\alpha, \beta, \gamma)-$ cut of $\widetilde{N}_1 \oplus \widetilde{N}_2$ are respectively $\big[L_{\widetilde{N}_1}(\alpha) + L_{\widetilde{N}_2}(\alpha), R_{\widetilde{N}_1}(\alpha) + R_{\widetilde{N}_2}(\alpha)\big]$, $\big[L'_{\widetilde{N}_1}(\beta) + L'_{\widetilde{N}_2}(\beta), R'_{\widetilde{N}_1}(\beta) + R'_{\widetilde{N}_2}(\beta)\big]$ and $\big[L''_{\widetilde{N}_1}(\gamma) + L''_{\widetilde{N}_2}(\gamma), R''_{\widetilde{N}_1}(\gamma) + R''_{\widetilde{N}_2}(\gamma)\big]$, and

(ii) The $(\alpha, \beta, \gamma)-$ cut of $\widetilde{N}_1 \ominus \widetilde{N}_2$ are respectively $\big[L_{\widetilde{N}_1}(\alpha) - L_{\widetilde{N}_2}(\alpha), R_{\widetilde{N}_1}(\alpha) - R_{\widetilde{N}_2}(\alpha)\big]$, $\big[L'_{\widetilde{N}_1}(\beta) - L'_{\widetilde{N}_2}(\beta), R'_{\widetilde{N}_1}(\beta) - R'_{\widetilde{N}_2}(\beta)\big]$ and $\big[L''_{\widetilde{N}_1}(\gamma) - L''_{\widetilde{N}_2}(\gamma), R''_{\widetilde{N}_1}(\gamma) - R''_{\widetilde{N}_2}(\gamma)\big]$

Property 3.2. For any $\widetilde{M} \in \Gamma$ and $\tilde{a}_1 \in N_N \cup N_t(1,0,0) \cup N_i(0,1,0) \cup N_f(0,0,1)$. The (α, β, γ) $-$cut of $\tilde{a}_1 \odot \widetilde{M}$ are respectively

(i) $[aL_{\widetilde{M}}(\alpha), aR_{\widetilde{M}}(\alpha)], [aL'_{\widetilde{M}}(\beta), aR'_{\widetilde{M}}(\beta)]$ and $[aL''_{\widetilde{M}}(\gamma), aR''_{\widetilde{M}}(\gamma)]$ if $a > 0$, and

(ii) $[aR_{\widetilde{M}}(\alpha), aL_{\widetilde{M}}(\alpha)], [aR'_{\widetilde{M}}(\beta), aL'_{\widetilde{M}}(\beta)]$ and $[aR''_{\widetilde{M}}(\gamma), aL''_{\widetilde{M}}(\gamma)]$ if $a < 0$.

Definition 3.3. For any $\lambda \in [0,1]$ and $\widetilde{N}_1, \widetilde{N}_2 \in \Gamma$, the sign distance of $\widetilde{N}_1, \widetilde{N}_2$ is designed by $d_\lambda(\widetilde{N}_1, \widetilde{N}_2)$ and described by $d\big(\widetilde{N}_1, \widetilde{N}_2\big) = \lambda d_T\big(\widetilde{N}_1, \widetilde{N}_2\big) + (1-\lambda) d_I\big(\widetilde{N}_1, \widetilde{N}_2\big) + (1-\lambda) d_F\big(\widetilde{N}_1, \widetilde{N}_2\big)$ where

$d_T(\tilde{N}_1,\tilde{N}_2)=\frac{1}{2}\int_0^1(L_{\tilde{N}_1}(\alpha)+R_{\tilde{N}_1}(\alpha)-L_{\tilde{N}_2}(\alpha)-R_{\tilde{N}_2}(\alpha))f(\alpha)d\alpha$, the sign distance of $\tilde{N}_1$ and $\tilde{N}_2$ for truth component.

$d_I(\tilde{N}_1,\tilde{N}_2)=\frac{1}{2}\int_0^1(L'_{\tilde{N}_1}(\beta)+R'_{\tilde{N}_1}(\beta)-L'_{\tilde{N}_2}(\beta)-R'_{\tilde{N}_2}(\beta))g(\beta)d\beta$, the sign distance of $\tilde{N}_1$ and $\tilde{N}_2$ for indeterminacy component, and

$d_F(\tilde{N}_1,\tilde{N}_2)=\frac{1}{2}\int_0^1(L''_{\tilde{N}_1}(\gamma)+R''_{\tilde{N}_1}(\gamma)-L''_{\tilde{N}_2}(\gamma)-R''_{\tilde{N}_2}(\gamma))h(\gamma)d\gamma$, the sign distance of $\tilde{N}_1$ and $\tilde{N}_2$ for falsity component.

Where $\lambda \in [0, 1]$ is weight of sign distance which indicates the decision maker's choice of information. If $\lambda \in [0, 0.5)$, then the decision-makers behaviour indicates pessimistic behaviour in the direction of negativity and uncertainty; if $\lambda \in (0.5, 1]$, then the decision-makers behaviour indicates optimistic behaviour in the direction of positivity and certainty, and if $\lambda = 0.5$, then the decision-makers behaviour indicates indifference between certainty and uncertainty.

Here $f(\alpha), g(\beta), h(\gamma) \in [0,1]$ and $f(0)=0, g(1)=0=h(1)$, and $f(\alpha)$ is continuous monotonic non decreasing function of $\alpha \in [0, 1]$, and $g(\beta)$, $h(\gamma)$ are continuous monotone non-increasing functions of β, γ respectively for $\beta, \gamma \in [0, 1]$.

Without loss of generality, from now on we will take the value of $f(\alpha)$, $g(\beta)$, and $h(\gamma)$ are α, $1-\beta$, and $1-\gamma$ respectively through the paper.

Corollary 3.4. For any two two SVTN-numbers $\tilde{N}_1 =< [m,n,\sigma_1,\delta_1],[m,n,\sigma_2,\delta_2], [m,n,\sigma_3,\delta_3] >$ and $\tilde{N}_2 =< [p,q,\mu_1,\vartheta_1],[p,q,\mu_2,\vartheta_2],[p,q,\mu_3,\vartheta_3] >$, the λ-weighted sign distance of $\tilde{N}_1$ and $\tilde{N}_2$ is described as $d_\lambda(\tilde{N}_1,\tilde{N}_2)=\frac{1}{12}[\{(3m+3n-\sigma_1+\delta_1)\lambda+(3m+3n-\sigma_2+\delta_2)(1-\lambda)+(3m+3n-\sigma_3+\delta_3)(1-\lambda)+\{(3p+3q-\mu_1+\vartheta_1)\lambda+(3p+3q-\mu_2+\vartheta_2)(1-\lambda)+(3p+3q-\mu_3+\vartheta_3)(1-\lambda)\}]$.

Corollary 3.5.: For any two two SVTrN-numbers numbers $\tilde{N}_1 =< [m,\sigma_1,\delta_1],[m,n,\sigma_2,\delta_2],[m,\sigma_3,\delta_3] >$ and $\tilde{N}_2 =< [p,\mu_1,\vartheta_1],[p,\mu_2,\vartheta_2],[p,\mu_3,\vartheta_3] >$ the λ-weighted sign distance of $\tilde{N}_1$and $\tilde{N}_2$ is described as

$$d_\lambda(\tilde{N}_1,\tilde{N}_2)=\frac{1}{12}[\{(6m+-\sigma_1+\delta_1)\lambda+(6m-\sigma_2+\delta_2)(1-\lambda)+(6m-\sigma_3+\delta_3)(1-\lambda)+\{(6p-\mu_1+\vartheta_1)\lambda+(6p-\mu_2+\vartheta_2)(1-\lambda)+(6p-\mu_3+\vartheta_3)(1-\lambda)\}]$$

Property 3.3. For any two PROPERTY 3.3. For any $\tilde{N}_1,\tilde{N}_2 \in \Gamma, d_\lambda(\tilde{N}_1,\tilde{N}_2)=d_\lambda(\tilde{N}_1,\tilde{0}_1)-d_\lambda(\tilde{N}_2,\tilde{0}_1)$.

Proof. From definition 3.3 easily ,it can be proved

PROPERTY 3.4 For any $k\epsilon \Re$ and $\tilde{N}_1,\tilde{N}_2 \in \Gamma$,

(i) $d_\lambda(\tilde{N}_1 \oplus \tilde{N}_2,\tilde{0}_1)=d_\lambda(\tilde{N}_1,\tilde{0}_1)+d_\lambda(\tilde{N}_2,\tilde{0}_1)$.

(ii) $d_\lambda(k\tilde{N}_1,k\tilde{N}_2,)=kd_\lambda(\tilde{N}_1,\tilde{N}_2,)$

(iii) $d_\lambda(\tilde{N}_1,\tilde{N}_2,)$ is constant or monotone increasing or decreasing according as $d_T(\tilde{N}_1,\tilde{N}_2,)=d_I(\tilde{N}_1,\tilde{N}_2,)+d_F(\tilde{N}_1,\tilde{N}_2)$ or $d_T(\tilde{N}_1,\tilde{N}_2)>d_I(\tilde{N}_1,\tilde{N}_2,)+d_F(\tilde{N}_1,\tilde{N}_2,)$ or $d_T(\tilde{N}_1,\tilde{N}_2)<d_I(\tilde{N}_1,\tilde{N}_2,)+d_F(\tilde{N}_1,\tilde{N}_2)$.

Proof (i) and (ii) are obvious by the definition of 3.4.

(iii)Here, $d_\lambda(\widetilde{N}_1, \widetilde{N}_2,) = \lambda d_T(\widetilde{N}_1, \widetilde{N}_2,) + (1-\lambda)d_I(\widetilde{N}_1, \widetilde{N}_2,) + (1-\lambda)d_F(\widetilde{N}_1, \widetilde{N}_2,)$

$$\frac{d}{d_\lambda}\left(d_\lambda(\widetilde{N}_1, \widetilde{N}_2)\right) = d_T(\widetilde{N}_1, \widetilde{N}_2) - d_I(\widetilde{N}_1, \widetilde{N}_2) - d_F(\widetilde{N}_1, \widetilde{N}_2)$$

So, $\frac{d}{d_\lambda}\left(d_\lambda(\widetilde{N}_1, \widetilde{N}_2)\right) =>, < 0$ according as $d_T(\widetilde{N}_1, \widetilde{N}_2) =>, <= d_I(\widetilde{N}_1, \widetilde{N}_2) + d_F(\widetilde{N}_1, \widetilde{N}_2)$. This clear the fact.

Property 3.5. for any four SVN-number $\widetilde{N}_1, \widetilde{N}_2, \widetilde{N}_3, \widetilde{N}_4$ and $\tilde{0}_1 \in N_t(1,0,0) \cup N_i(0,1,0) \cup N_i(0,1,0)$.

(i) $d(\widetilde{N}_1 \oplus \widetilde{N}_2, \widetilde{N}_3 \oplus \widetilde{N}_4 = d(\widetilde{N}_1, \widetilde{N}_3) + d(\widetilde{N}_2, \widetilde{N}_4) = d(\widetilde{N}_1, \widetilde{N}_4) + d(\widetilde{N}_2, \widetilde{N}_3) = d(\widetilde{N}_1, 0_1) + d(\widetilde{N}_2, 0_1) - d(\widetilde{N}_3, 0_1) - d(\widetilde{N}_4, 0_1)$.

(ii) $d(\widetilde{N}_1 \ominus \widetilde{N}_2, \widetilde{N}_3 \ominus \widetilde{N}_4 = d(\widetilde{N}_1, \widetilde{N}_3) - d(\widetilde{N}_2, \widetilde{N}_4) = d(\widetilde{N}_1, \widetilde{N}_2) - d(\widetilde{N}_3, \widetilde{N}_4) = d(\widetilde{N}_1, 0_1) + d(\widetilde{N}_4, 0_1) - d(\widetilde{N}_2, 0_1) - d(\widetilde{N}_3, 0_1)$.

Proof. Using definition 3.3 and property 3.3 we can easily prove the properties (i) and (ii) .

Definitio3.6. For any two SVN- numbers $\widetilde{N}_1, \widetilde{N}_2$ we define the ranking of $\widetilde{N}_1, \widetilde{N}_2$ by

$$d_\lambda(\widetilde{N}_1, \widetilde{N}_2) > 0 \; iff \; d_\lambda(\widetilde{N}_1, \tilde{0}_1) > d_\lambda(\widetilde{N}_2, \tilde{0}_1) iff \; \widetilde{N}_2 \prec \widetilde{N}_1$$

$$d_\lambda(\widetilde{N}_1, \widetilde{N}_2) < 0 \; iff \; d_\lambda(\widetilde{N}_1, \tilde{0}_1) < d_\lambda(\widetilde{N}_2, \tilde{0}_1) \; iff \; \widetilde{N}_1 \prec \widetilde{N}_2$$

$$d_\lambda(\widetilde{N}_1, \widetilde{N}_2) = 0 \; iff \; d_\lambda(\widetilde{N}_1, \tilde{0}_1) = d_\lambda(\widetilde{N}_2, \tilde{0}_1) iff \; \widetilde{N}_1 \approx \widetilde{N}_2$$

Then the order $\precsim$ is formulated as $\widetilde{N}_1 \precsim \widetilde{N}_2$ iff $\widetilde{N}_1 \approx \widetilde{N}_2$ or $\widetilde{N}_1 \prec \widetilde{N}_2$.

Property 3.6. The relation $\precsim$ fufil the three principles of partial order in Γ .Thus, for each $\widetilde{N}_1, \widetilde{N}_2, \widetilde{N}_3 \in \Gamma$ the principles of partial order are as follows:

(i) $\widetilde{N}_1 \precsim \widetilde{N}_1$ (reflexive law)

(ii) $\widetilde{N}_1 \precsim \widetilde{N}_2$ and $\widetilde{N}_1 \precsim \widetilde{N}_2 \Longrightarrow \widetilde{N}_1 \approx \widetilde{N}_2$ (antisymmetric law)

(iii) $\widetilde{N}_1 \precsim \widetilde{N}_2$ and $\widetilde{N}_2 \precsim \widetilde{N}_3 \Longrightarrow \widetilde{N}_1 \precsim \widetilde{N}_3$ (transitive law)

Proof (i),(ii), and (iii) are obvious by the Definitions 3.3 and 3.6.

Property 3.7. The relation $\precsim$ fulfil all the conditions of the law and trichonomity in Γ.

Proof It can be easily proved that by the Definition-3.3 and 3.6.

Remark 3.1. By the property 3.5 and 3.6, we can say that $\precsim$ is total ordering in Γ

Remark 3.2. $\widetilde{N}_1 \approx \widetilde{N}_2$ may not imply $\widetilde{N}_1 = \widetilde{N}_2$ and hence the relation $\approx$ may not equal to the relation $=$.

Property 3.8. if $\widetilde{N}_1, \widetilde{N}_2, \widetilde{N}_3, \widetilde{N}_4$ be four SVN-numbers, then

(i) $\widetilde{N}_2 \prec \widetilde{N}_1 \Longrightarrow \widetilde{N}_2 \oplus \widetilde{N}_3 \prec \widetilde{N}_1 \oplus \widetilde{N}_3$

(ii) $\widetilde{N}_2 \prec \widetilde{N}_1$ and $\widetilde{N}_4 \prec \widetilde{N}_2 \Longrightarrow \widetilde{N}_3 \oplus \widetilde{N}_4 \prec \widetilde{N}_1 \oplus \widetilde{N}_2$

(iii) $\widetilde{N}_2 \prec \widetilde{N}_1 \Longrightarrow \widetilde{N}_2 \ominus \widetilde{N}_3 \prec \widetilde{N}_1 \ominus \widetilde{N}_3$

(iv) $\widetilde{N}_1 \prec \widetilde{N}_3$ and $\widetilde{N}_2 \prec \widetilde{N}_4 \Longrightarrow \widetilde{N}_1 \ominus \widetilde{N}_4 \prec \widetilde{N}_3 \ominus \widetilde{N}_2$ and $\widetilde{N}_2 \ominus \widetilde{N}_3 \prec \widetilde{N}_4 \ominus \widetilde{N}_1$.

Proof. (i) By the definition 3.6. $\widetilde{N}_2 \prec \widetilde{N}_1$ iff $d_\lambda(\widetilde{N}_1, \widetilde{N}_2) > 0$

By property 3.4 and $d_\lambda(\widetilde{N}_1, \widetilde{N}_2) > 0, d_\lambda(\widetilde{N}_3, \widetilde{N}_3) = 0$ we have $d_\lambda(\widetilde{N}_1 \oplus \widetilde{N}_3, \widetilde{N}_2 \oplus \widetilde{N}_3) = d_\lambda(\widetilde{N}_1, \widetilde{N}_2) + d_\lambda(\widetilde{N}_4, \widetilde{N}_4) > 0.$ Therefore $\widetilde{N}_2 \oplus \widetilde{N}_3 \prec \widetilde{N}_1 \oplus \widetilde{N}_3$.

In a similar way, (ii), (iii), and (iv) can be proved.

4. Neutrosophic Transportation Problem

This section presents a specific type of linear programming problem (LPP) is called TP, which have a unique solution technique separate from general solutiuon. TP is connected to our real-life daily activities. The goal of TP is to minimise the cost of transaporting a single commodity from a number of sources to different destinations. The ability of manufacture at each source, the requirements at each destinations, and the cost of transportation of the goods from different sources to several destinations are known. It assumed that the cost of transportation on a given route is directly proportional to the number of units transported. But in current situation, because of different uncontrolled arguments,transportation parameters such as supply,demand, and unit transportation cost are unpredictable.Here we consider the neutrosophic transportation problem of SVTN-numbers and desire to define a methodology and solve.For simplicity,let us take λ = 0.96 to calculate the sign distance SVTN-numbers from $\tilde{0}1$ in the remainig paper because $\lambda = 0.96 \in (0.5,1]$ shows that the decision maker's behaviour indicates optimistic in the direction of positivity and certainty.

First of all, we described TP with crisp data. Let us consider there being r sources, each source possessing a_i units of a certain product, whereas there are s destinations (r may or may not equal to s) with destinations j requiring b_j units. Let c_{ij} be the one unit of transportation cost of the product from the source to j^{th} destination, and x_{ij} be the amount to be shipped from the i^{th} source to j^{th} destination. Then the mathematical formulation of TP is given below as follows:

Minimum $Z = \sum_{i=1}^{r} \sum_{j=1}^{s} x_{ij}\, c_{ij}$

Subject to,

$\sum_{j=1}^{s} x_{ij} = a_i$

$\sum_{i=1}^{r} x_{ij} = b_j$

and $x_{ij} \geq 0$ for $i = 1,2, \dots, r$ and $j = 1,2, \dots, s$.

Where, the total availabilities $\sum a_i$ may or may not equal to the total requirements $\sum b_j$ for $i = 1,2, \dots, r$ and $j = 1,2, \dots., s$.

Now we have to describe NTP with SVN-numbers in two cases.

Case-1: NTP with supplies or capacities and demands or requirements in terms of SVN-numbers.

Minimizing the total cost of transportation (shipping)

$Z = \sum_{i=1}^{r} \sum_{j=1}^{s} x_{ij} c_{ij}$ (objective function)

Subject to,

$\sum_{j=1}^{s} x_{ij} = \tilde{a}_i$

$\sum_{i=1}^{r} x_{ij} = \tilde{b}_j$

and $x_{ij} \geq 0$ for $i = 1,2, \dots, r$ and $j = 1,2, \dots., s$.

Where, c_{ij} are cost values with crisp data, and $\sum \tilde{a}_i$ and $\sum \tilde{b}_j$ are the supplies and demands respectively in terms of SVN- numbers for $i = 1,2, \dots, r$ and $j = 1,2, \dots., s$.

Case-2: NTP with cost values in terms of SVN-numbers

Minimizing the total cost of transportation (shipping)

$Z = \sum_{i=1}^{r} \sum_{j=1}^{s} x_{ij} \tilde{c}_{ij}$ (objective function)

Subject to,

$\sum_{j=1}^{s} x_{ij} = \tilde{a}_i$

$\sum_{i=1}^{r} x_{ij} = \tilde{b}_j$

and $x_{ij} \geq 0$ for $i = 1,2, \ldots, r$ and $j = 1,2, \ldots., s$.

Where, $\tilde{c}_{ij}$ are cost values in terms of SVN-numbers, and $\sum \tilde{a}_i$ and $\sum \tilde{b}_j$ are the supplies and demands respectively with crisp data for $i = 1,2, \ldots, r$ and $j = 1,2, \ldots., s$.

Methodology

Step 1. In a neutrosophic transportation problem with SVN-numbers, the SVN-numbers are converted to crisp numbers by using the sign distance method, and if we see the problem is unbalanced, i.e., total supply is less or greater than total demand, then we introduce a dummy row or a dummy column to balanced the neutrosophic transportation problem.

Step 2. VAM method is applied to determine the initial basic feasible solution.

Step 3. Finally, the MODI method is used to determine the optimal solution.

5. Numerical Example

In this section, we give two examples of NTP with SVTN-numbers. In the first examples, we take NTP with requirements and capacities in terms of SVTN-numbers, and in second example, we take NTP with transportation costs in terms of SVTN-numbers.

Examples 5.1 Let us consider five factories F_1, F_2, F_3, F_4, F_5 of a company from which goods have to be transported to the seven warehouses $W_1, W_2, W_3, W_4, W_5, W_6, W_7$. The warehouses are situated at varying distances from the factories, from where supplies are transported to them ; the transportation costs from the factories to warehouse thus naturally vary from Rs.3 to Rs.19 per unit, and the company desires to minimise these transportation costs. In the form of a 5 × 7 transportation problem with capacities and requirements in SVTN-numbers per unit, as shown in the given table below.

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	4	8	7	9	10	13	14	$\tilde{s}_1$
F_2	3	6	6	9	11	15	17	$\tilde{s}_2$
F_3	8	7	6	8	9	7	13	$\tilde{s}_3$
F_4	7	12	13	14	13	14	16	$\tilde{s}_4$
F_5	11	15	16	18	16	18	19	$\tilde{s}_5$
Required	$\tilde{d}_1$	$\tilde{d}_2$	$\tilde{d}_3$	$\tilde{d}_4$	$\tilde{d}_5$	$\tilde{d}_6$	$\tilde{d}_7$	

Where,

$\tilde{s}_1 =< [20,23,5,6], [20,23,7,8], [20,23,3,9] >, \tilde{s}_2 =< [15,17,3,7], [15,17,5,9], [15,17,2,8] >$

$\tilde{s}_3 =< [10,24,2,5], [10,24,3,10], [10,24,5,8] >, \tilde{s}_2 =< [7,18,4,9], [7,18,10,2], [7,18,6,12] >$

$\tilde{s}_5 =< [7,23,4,10], [7,23,3,8], [7,23,1,9] >, \ \tilde{d}_1 =< [9,17,2,7], [9,17,1,6], [9,17,5,10] >$

$\tilde{d}_2 =< [18,19,3,6], [18,19,4,9], [18,19,5,5] >, \tilde{d}_3 =< [27,29,3,8], [27,29,6,8], [27,29,3,5] >$

$\tilde{d}_4 =< [25,28,13,6], [25,28,4,7], [25,28,2,9] >, \tilde{d}_5 =< [8,9,2,7], [8,9,3,6], [8,9,7,7] >$
$\tilde{d}_6 =< [10,11,3,5], [10,11,7,8], [10,11,4,3] >, \tilde{d}_7 =< [19,20,6,5], [19,20,4,4], [19,20,3,4] >$

Solution:

Step-1: First of all, applying sign distance method to convert the supplies and demands in terms of SVTN-numbers to crisp data, we get an unbalanced transportation problem with crisp data given below.

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	3	8	7	4	5	1	8	11.28
F_2	5	2	9	5	3	6	7	8.67
F_3	4	3	6	2	10	9	8	9.11
F_4	10	7	3	6	7	4	5	6.89
F_5	1	6	8	3	8	10	7	8.35
Required	7.19	9.88	14.97	13.25	4.83	5.62	10.06	

Since in the above transportation problem, the total demand is greater than the total supply, we introduce a dummy row s_6 origin to balance the neutrosophic transportation problem given in the following below:

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	3	8	7	4	5	1	8	11.28
F_2	5	2	9	5	3	6	7	8.67
F_3	4	3	6	2	10	9	8	9.11
F_4	10	7	3	6	7	4	5	6.89
F_5	1	6	8	3	8	10	7	8.35
F_6	0	0	0	0	0	0	0	21.5
Required	7.19	9.88	14.97	13.25	4.83	5.62	10.06	

Step-2: In this step, we get the initial solution by using the VAM method, given in the below table

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	3	8	7 (1.47)	4 (4.19)	5	1 (5.62)	8	11.28
F_2	5	2 (8.67)	9	5	3	6	7	8.67
F_3	4	3 (1.21)	6	2 (7.9)	10	9	8	9.11
F_4	10	7	3 (6.89)	6	7	4	5	6.89
F_5	1 (7.19)	6	8	3 (1.16)	8	10	7	8.35
F_6	0	0	0 (6.61)	0	0 (4.83)	0	0 (10.06)	21.5
Required	7.19	9.88	14.97	13.25	4.83	5.62	10.06	

Therefore, the initial transportation cost is Rs. 100.78.

Step-3: In this step, we obtain the optimal solution of NTP by using the MODI method, and we get an alternative optimal solution that is given in the following tables:

First optimal solution table:

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	3	8	4.19 7	1.47 4	5	5.62 1	8	11.28
F_2	5	8.67 2	9	5	3	6	7	8.67
F_3	4	1.21 3	6	7.9 2	10	9	8	9.11
F_4	10	7	6.89 3	6	7	4	5	6.89
F_5	7.19 1	6	8	1.16 3	8	10	7	8.35
F_6	0	0	8.08 0	0	3.36 0	0	10.06 0	21.5
Required	7.19	9.88	14.97	13.25	4.83	5.62	10.06	

Second optimal solution table:

	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Capacity
F_1	3	8	7	$\boxed{2.98}$ 4	$\boxed{2.68}$ 5	$\boxed{5.62}$ 1	8	11.28
F_2	5	$\boxed{8.67}$ 2	9	5	3	6	7	8.67
F_3	4	3	6	$\boxed{9.11}$ 2	10	9	8	9.11
F_4	10	7	$\boxed{6.89}$ 3	6	7	4	5	6.89
F_5	$\boxed{7.19}$ 1	6	8	$\boxed{1.16}$ 3	8	10	7	8.35
F_6	0	$\boxed{1.21}$ 0	$\boxed{8.08}$ 0	0	$\boxed{3.36}$ 0	0	$\boxed{10.06}$ 0	21.5
Required	7.19	9.88	14.97	13.25	4.83	5.62	10.06	

Therefore, the unique optimum transportation cost is Rs. 97.84.

Example 5.2. There are three sources or origin which store a given product. These sources supply these products to five dealers and the cost of transportation from one source to one dealer varies. In the form of a 3 × 5 neutrosophic transportation problem with cost values in terms of SVTN-numbers per unit and the supply of sources, the demands are shown in the below table.

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	$\tilde{c}_{11}$	$\tilde{c}_{12}$	$\tilde{c}_{13}$	$\tilde{c}_{14}$	$\tilde{c}_{15}$	30
S_2	$\tilde{c}_{21}$	$\tilde{c}_{22}$	$\tilde{c}_{23}$	$\tilde{c}_{24}$	$\tilde{c}_{25}$	50
S_3	$\tilde{c}_{31}$	$\tilde{c}_{32}$	$\tilde{c}_{33}$	$\tilde{c}_{34}$	$\tilde{c}_{35}$	75
Demand	10	20	33	40	52	

Where,

$\tilde{c}_{11} =< [3,4,5,6], [3,4,4,7], [3,4,5,8] >$

$\tilde{c}_{12} =< [13,25,6,9], [13,25,5,8], [13,25,2,7] >$

$\tilde{c}_{13} =< [12,22,4,7], [12,22,2,5], [12,22,3,9] >$

$\tilde{c}_{14} =< [5,7,6,9], [5,7,4,5], [5,7,7,8] >$

$\tilde{c}_{15} =< [10,15,5,8], [10,15,3,8], [10,15,3,7] >$

$\tilde{c}_{21} =< [1,4,3,7], [1,4,4,6], [1,4,5,6] >$

$\tilde{c}_{22} =< [7,14,6,6], [7,14,7,8], [7,14,6,9] >$

$\tilde{c}_{23} =< [9,16,5,7], [9,16,3,6], [9,16,2,5] >$

$\tilde{c}_{24} =< [2,5,4,6], [2,5,2,7], [2,5,2,4] >$

$\tilde{c}_{25} =< [1,3,7,8], [1,3,5,6], [1,3,6,9] >$

$\tilde{c}_{31} =< [4,7,5,7], [4,7,4,5], [4,7,7,8] >$

$\tilde{c}_{32} =< [15,18,3,9], [15,18,7,8], [15,18,2,7] >$

$\tilde{c}_{33} =< [3,12,4,9], [3,12,2,9], [3,12,3,8] >$

$\tilde{c}_{34} =< [10,21,9,11], [10,21,9,12], [10,21,7,8] >$

$\tilde{c}_{35} =< [18,28,7,10], [18,28,8,11], [18,28,10,3] >$

Solution:

Step-1: First of all, applying sign distance method to convert the cost values in terms of SVTN-numbers to crisp data, we get a balanced TP with crisp data given below

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	1.92	10.15	9.11	3.37	6.77	30
S_2	1.47	5.47	6.68	2.00	1.13	50
S_3	3.03	9.08	4.34	8.24	12.22	75
Demand	10	20	33	40	52	

Step-2: Here, applying VAM method, we obtain an initial basic feasible solution (IBF-solution) as given in the following table:

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	1.92	10.15	9.11	28 3.37	2 6.77	30
S_2	1.47	5.47	6.68	2.00	50 1.13	50
S_3	10 3.03	20 9.08	33 4.34	12 8.24	12.22	75
Demand	10	20	33	40	52	

Therefore, the initial cost is Rs. 618.40.

Step-3: Now, we get the optimal solution by applying the MODI method, which is equal to the IBF-solution, and hence the optimal transportation cost is Rs. 618.40.

6. Conclusion

In this article, we define level-(α, β, γ) neutrosophic points which is the generalisation of level-α fuzzy point.We designed the sign sign distance ranking methodology in a new way and also established some importanr properties of this method.Finally, we discussed NTP, and using the propossed methodology, some neutrosophic transportation problems with SVTN-numbers were solved.In the future, the method can applied to several fields like assignment problems, game theory, multi-criteria decision-making problems,inventory, and so on.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that there is no conflict of interest in the research.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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