Neutrosophic Sets and Systems, Vol. 63, 2024
University of New Mexico

An Evaluation of Triangular Neutrosophic PERT Analysis for Real-Life Project Time and Cost Estimation

Priyadharsini. S[1], Kungumaraj.E[2] , Santhi. R[3]

[1] Assistant Professor, Department of Mathematics, Sri Krishna Arts and Science College, Coimbatore; priyamaths24@gmail.com priyadharsinis@skasc.ac.in

[2] Assistant Professor of Mathematics, Department of Management Studies, Sakthi Institute of Information and Management Studies, Pollachi, Coimbatore; kungum99522@gmail.com

[3] Associate Professor, Department of Mathematics, Nallamuthu Gounder Mahalingam College, Pollachi, Coimbatore; santhifuzzy@yahoo.co.in

* Correspondence: kungum99522@gmail.com;

Abstract: The textile industry sector's time and cost management issue led to a quest for contemporary tools that provide the best possible project time and cost prediction. Using a case study of Esa Textile in India, this paper assesses quantitative decision-making techniques in the textile industry. An extensive approach is provided so that specialists may utilise Triangular Neutrosophic Numbers (TNNs) to express their views about identifying features and indicators of a successful project. Determining the best approach to deal with removing interruptions that can cause delays and unnecessary expenses is also an essential responsibility. While commonly employed, traditional estimating methods like the Programme Evaluation and Review Technique (PERT) may find it difficult to adequately address the uncertainties present in real-world projects. This study examines and assesses the use of Triangular Neutrosophic PERT (TNP) analysis for project time and cost estimation in order to overcome this restriction. Neutrosophy, which allows for the depiction of inconsistent, ambiguous and partial data available in project parameters, is incorporated into the suggested TNP analysis. The efficiency of the suggested strategy has been verified by this analysis, and the network's unknown parameters are represented by triangle Neutrosophic numbers. This innovative method gives each of the three potential estimates—optimistic, most probable, and pessimistic which are all consisting of degree of membership, indeterminacy, or non-membership. This study's objective is to locate the work-network in a logical order once all of the processes at the Esa textile units have been completed. Planning is developed using the Triangular Neutrosophic Programme Evaluation and Review Techniques (TNP) even there is a time difference, which will speed up production and cut expenses. TNP provides a more thorough and adaptable depiction of uncertainty by utilizing the neutrosophic framework, which better captures the dynamic character of real-life projects.

Keywords: Neutrosophic number; Triangular Neutrosophic Number; Triangular Neutrosophic PERT, Critical Path of the Project, Scoring Function.

1. Introduction:

The textile industry is considered a central key symbol of the comprehensiveness of the country and is an important core industry that has a significant impact on the economy of the country. Branded clothing is in high demand in many industries including chemical, electronics, civil and mechanical as the country's economy continues to grow and the standard of living of its citizens is higher. Effective project management is crucial for the successful execution of complex projects, encompassing various industries such as construction, engineering, software development, and more. Among the key challenges faced by project managers is the accurate estimation of project time and cost, as deviations from initial estimates can lead to budget overruns, schedule delays, and overall project failure. To address these challenges, researchers and practitioners have continuously sought innovative methods for project estimation that can better capture uncertainties and vagueness associated with real-life project parameters. The success of large-scale projects heavily relies on the quality of planning, scheduling, and control throughout their various phases. Without effective planning and coordination tools, even a relatively small number of phases can lead to management losing control. Project Evaluation and Review Technique (PERT) is considered the best project management tool for organizing, scheduling, and coordinating tasks in such large-scale projects. Originally designed for manufacturing projects, PERT employs a network of interconnected activities to optimize cost and time. It emphasizes the relationship between activity times, associated costs, and the overall project completion time and cost.

The production process is a major problem in implementing the production of raw materials into finished materials. A significant obstacle to turning raw resources into completed goods is the production process. Inaccuracy and completion delays will add time and money to the process. One approach is to use network analysis to foresee such a scenario. Network analysis is referred to as a network that has to be operated and is time-limited. Various real-life scenarios are being considered and expressed using Triangular Neutrosophic values. These uncertain values are then converted into crisp values using Neutrosophic Scoring functions to facilitate analysis. Next, the NPT (Neutrosophic Project Technique) approach is being employed to assess the project's time and cost estimation for the company. The primary objective is to achieve an optimal (minimum) project duration and maximize profitability while minimizing manpower requirements. By utilizing this approach, project managers can make well-informed decisions to optimize project timelines, reduce costs, and maximize profits, all while efficiently allocating resources. .

In this section, some literatures associated with the field of this study are presented. Neutrosophic sets serve as a broader concept encompassing crisp sets, fuzzy sets, and intuitionistic fuzzy sets, allowing the representation of uncertain, inconsistent, and incomplete information in real-world problems. Elements of a neutrosophic set possess truth-membership, falsity-membership, and indeterminacy membership functions. Smarandache first put forward the philosophical idea of the neutrosophic theory, which is a popularization of the fuzzy set (FS) and the IFS [1]. Traditional project estimation techniques, such as the Program Evaluation and Review Technique (PERT), have been widely used to estimate project duration and critical path analysis. PERT involves the use of three-point estimates, where the most likely, optimistic, and pessimistic time estimates are combined to derive a probabilistic estimate. Several researchers developed and implemented the concept of PERT/CPM in various real-life situations [2,3,4,5,6]. However, PERT's deterministic nature lacks the capability to handle imprecision, ambiguity, and uncertainty in project parameters.

The subtraction and division of neutrosophic numbers have been thoroughly discussed [7]. CPM and PERT theory finds practical application in project planning decision-making [8]. Building upon the Neutrosophic framework, Triangular Neutrosophic PERT (TNP) has emerged as a novel approach for project time and cost estimation, aiming to provide a more flexible and accurate model to deal with the inherent uncertainties present in real-life projects [9,10,11]. The algorithm calculates critical paths, variances, expected task times, and probabilities of completing the project within expected time frames in a more efficient manner than existing methods. The studies [12,13,14,15,16,17,18] shows the implementation of algorithm for determining the project evaluation and review technique (TNP) using neutrosophic numbers for better results of other existing methods.

Uncertainty can affect the process of assessing risks and adopting the best alternative. To overcome this problem, Abdel-Baset et.al [19] suggested the neutrosophic set as an integrated neutrosophic ANP and VIKOR method, for achieving sustainable supplier selection. The neutrosophic theory has attracted the interest of researchers in a range of fields [20,21]. Abdel-Basset [22] analyzed the uncertainty that affect the process of waste water system using Risk Assessment Model. There are several challenges that hospitals are facing according to the emergency department (ED). The study [23] suggests an integrated evaluation model assess ED under a framework of plithogenic theory. The proposed framework addressed uncertainty and ambiguity in information with an efficient manner via presenting the evaluation expression by plithogenic numbers. Abdel-Basset et al [24] studied the emission crisis in the iron and steel sector prompted the search for modern systems that contribute to reducing the resulting emissions to alleviate the growing concerns about global warming. Rahnamay Bonab et al [25] studied logistic autonomous vehicles assessment using decision support model under spherical fuzzy set integrated Choquet integral approach. Jeyaramman et al [26] studied the statistical convergences within non-Archimedean Neutrosophic normed spaces. Jdid et al [27] formulated the general model for the optimal distribution of agricultural lands using the concepts of neutrosophic science. Recently Kungumaraj. E et.al [28] investigated Indefinite integrals, Heptagonal Topology [29] and Topological Vector Spaces [30] in Neutrosophic environment.

To the best of the authors' knowledge, very little literature has been performed to evaluate project implementation in the textile sector in generic, especially by applying the Triangular Neutrosophic Pert (TNP) approaches. This study presents a TNP approach that considers uncertainty in decision-making by applying Triangular Neutrosophic numbers. The suggested methodology adopts two techniques of decision-making, which are the PERT and CPM. They are implemented under a Triangular Neutrosophic environment. The TNP method is applied to evaluate the main aspects of optimal time and cost that have an impact on the project in the Textile sector.

All in all, the primary contributions of this study are outlined below.

- To suggest a TNP approach of the determined challenges based on a Triangular Neutrosophic environment to cope with the unpredictability inherent in decision-making, this is the first study to develop a TNP approach consisting of PERT and CPM methods for evaluating optimal cost and time in the textile sector
- The proposed approach that was described may be used to get reliable answers in situations when there is a lot of uncertainty
- The organizational repercussions of this study not only have the potential to provide important guidance to the textile industry but also to decision-makers and investors in other industries
- A TNP is applied to a real life data to demonstrate the reliability, and validity of the developed approach

The main aim of this work is to elucidate the advantage of TNP method in an ESA Clothing Company, which is the primary manufacturers of garments such as t-shirts, children wear and cotton shirts. From 05.06.2023 to 04.07.2023 the time taken to manufacture the products and construction of new block in Esa clothing company has been noted. The work-network in a logical work sequence, at the time the Esa textile units' entire process is observed. The TNP method is a probabilistic technique that analyses and represents the uncertainties associated with project activities and it is an advanced technique that can be utilized in any industry. The Neutrosophic Programme Evaluation and Review

Techniques (TNP) are used to develop planning. With the help of neutrosophic framework, TNP offers a more comprehensive and flexible representation of uncertainties. This paper is organized as follows. Section 2 furnish the preliminaries and basic definitions, while section 3 present the steps involved in TNP. In section 4 real life examples were solved with the help of proposed theory. Finally, conclusion is given in the last section. Advantage of TNP method is elucidated through numerical illustrations.

2. PRELIMINARIES:

Definition 2.1. Let E be a universe. A neutrosophic set A in E is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$ and a falsity-membership function $F_A(x)$. $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard elements of [0,1]. It can be written as $A = \{< x, (T_A(x), I_A(x), F_A(x)) >: x \in E; T_A(x), I_A(x), F_A(x) \in]0^-, 1^+[\ \}$. There is no restriction on the sum of $T_A(x), I_A(x),$ *and* $F_A(x)$. So $0 \le T_A(x), I_A(x), F_A(x) \le 3^+$.

Definition 2.2. Let E be a universe. A single valued neutrosophic set A, which can be used in real scientific and engineering applications, in E is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$ and a falsity-membership function $F_A(x)$. $T_A(x), I_A(x), F_A(x)$ are real standard elements of [0,1]. It can be written as
$A = \{< x, (T_A(x), I_A(x), F_A(x)) >: x \in E; T_A(x), I_A(x), F_A(x) \in [0, 1]\ \}$.

Definition 2.3. Let $(\alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}}) \in [0,1]$ and $a_1, a_2, a_3 \in R$ such that $a_1 \le a_2 \le a_3$. Then a single valued triangular neutrosophic number $\breve{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ is a special neutrosophic set on the real line set R, whose truth-membership, indeterminacy-membership and falsity-membership functions are given as follows

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\dfrac{x - a_1}{(a_2 - a_1)}\right) & if\ a_1 \le x \le a_2 \\ \alpha_{\tilde{a}} & if\ x = a_2 \\ \alpha_{\tilde{a}}\left(\dfrac{a_3 - x}{a_3 - a_2}\right) & if\ a < x \le a_3 \\ 0 & otherwise \end{cases}$$

$$I_{\tilde{a}}(x) = \begin{cases} \dfrac{(a_2 - x + \theta_{\tilde{a}}(x - a_1))}{(a_2 - a_1)} & if\ a_1 \le x \le a_2 \\ \theta_{\tilde{a}} & if\ x = a_2 \\ \dfrac{(x - a_2 + \theta_{\tilde{a}}(a_3 - x))}{(a_3 - a_2)} & if\ a_2 < x \le a_3 \\ 1 & otherwise \end{cases}$$

$$F_{\tilde{a}}(x) = \begin{cases} \dfrac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{(a_2 - a_1)} & if\ a_1 \le x \le a_2 \\ \beta_{\tilde{a}} & if\ x = a_2 \\ \dfrac{(x - a_2 + \theta_{\tilde{a}}(a_3 - x))}{(a_3 - a_2)} & if\ a_2 < x \le a_3 \\ 0 & otherwise \end{cases}$$

Where $\alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}}$ denote the maximum truth-membership degree, minimum indeterminacy-membership degree and minimum falsity-membership degree respectively. A single valued triangular neutrosophic number $\breve{a} = \langle (a_1, a_2, a_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ may express an ill-defined quantity about α, which is approximately equal to α.

Definition 2.4. Let $\breve{a} = \langle (a_1, a_2, a_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ and $\breve{b} = \langle (b_1, b_2, b_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ be two single valued triangular neutrosophic numbers and $\gamma \neq 0$ be any real number. Then,

$$\breve{a} + \breve{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}} \rangle$$

$$\breve{a} - \breve{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}} \rangle$$

$$\breve{a}.\breve{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}} \rangle \; if \; (a_3 > 0, b_3 > 0) \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}} \rangle \; if \; (a_3 < 0, b_3 > 0) \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}} \rangle \; if \; (a_3 < 0, b_3 < 0) \end{cases}$$

$$\gamma\breve{a} = \begin{cases} \langle (\gamma a_1, \gamma a_2, \gamma a_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle \; if \; (\gamma > 0) \\ \langle (\gamma a_1, \gamma a_2, \gamma a_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle \; if \; (\gamma > 0) \end{cases}$$

Definition 2.5. Let $\breve{a} = \langle (a_1, a_2, a_3); \alpha_{\breve{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ be a single valued triangular neutrosophic number then

$S(\breve{a}) = \frac{1}{16}[a_1 + b_1 + c_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} - \beta_{\tilde{a}})$ and

$A(\breve{a}) = \frac{1}{16}[a_1 + b_1 + c_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} + \beta_{\tilde{a}})$

are called the score and accuracy degrees of $\breve{a}$ respectively.

3. METHODOLOGY

The research used an integrated evaluation design that explored conceptual and empirical references to project evaluation review techniques and critical path methods, with particular attention to work examples and analyses. Project management involves the processes necessary to ensure the timely completion of a project. The procedures are: schedule management planning, defining activities, sequencing activities, estimating activity durations, creating a schedule and managing a schedule. The next section illustrates the methodology of Project Evaluation Review Technique in Neutrosophic Environment:

3.1. PROJECT EVALUATION REVIEW TECHNIQUE IN NEUTROSOPHIC ENVIRONMENT:

Triangular Neutrosophic PERT (Project Evaluation and Review Technique) analysis is an innovative extension of the conventional PERT, which introduces triangular neutrosophic numbers to effectively handle uncertainty and indeterminacy in the management of large-scale projects. While PERT has long been a valuable tool for coordinating and optimizing tasks in various industries, real-world projects often involve imprecise and uncertain data, which can pose challenges for traditional PERT methods. Triangular neutrosophic numbers offer a more comprehensive representation of uncertainty, incorporating membership, non-membership, and indeterminacy degrees. By integrating triangular neutrosophic numbers into PERT, this advanced analysis approach empowers project managers to efficiently model, evaluate, and control projects in complex scenarios where conventional PERT techniques may be limited. This introduction lays the foundation for exploring the advantages and practical applications of Triangular Neutrosophic PERT analysis, providing insights into how it addresses the complexities of uncertain and ambiguous project environments.

PERT Calculations consisting of three timings namely Optimistic, Pessimistic and Most likely times, which are defined in neutrosophic environment as follows:

Optimistic Time ($\bar{a}$): It refers to the minimum time required to complete an activity under the most favorable conditions or if everything proceeds smoothly without any hindrance or delay. The optimistic time serves as a baseline for calculating the expected duration and critical path in project management, providing insights into the best possible outcome for completing a specific task.

Pessimistic time($\tilde{b}$): It refers to the maximum time required to complete an activity when encountering challenges, obstacles, or delays at every stage of its execution. The pessimistic time provides a conservative estimate for project planning and risk management, allowing project managers to account for potential delays and allocate sufficient resources to handle adverse circumstances.

Most likely time($\tilde{m}$): It refers to the time required to complete an activity under normal or average conditions, without any significant favorable or unfavorable influences. The most likely time serves as a realistic estimate for project planning and scheduling, as it reflects the typical performance level and expected outcomes for the activity.

Where $\tilde{a}, \tilde{b}, \tilde{m}$, are triangular neutrosophic numbers.

In order to calculate the expected time and standard deviation of each activity based on the three-time estimates $(\tilde{a}, \tilde{b}, \tilde{m})$, it is necessary to obtain crisp values for these estimates. To achieve this, score functions and accuracy functions are utilized. By applying the score function, crisp values are obtained for each time estimate. Once the crisp values are acquired, the expected time and standard deviation of each activity can be calculated. The expected time represents the average duration for completing the activity, while the standard deviation provides a measure of the uncertainty or variability associated with the activity's completion time.

$$T_{ij} = \frac{a+4m+b}{6} \text{ and } \sigma_{ij} = \frac{b-a}{6}$$

Where a, m, b are crisp values of optimistic, most likely and pessimistic time respectively, T_{ij} is the expected time of ij activity and σ_{ij} standard deviation of ij activity.

After calculating the expected time and standard deviation of each activity, the PERT (Project Evaluation and Review Technique) network is treated similarly to the CPM (Critical Path Method) network for the purpose of calculating various network parameters. These parameters include the earliest and latest occurrence time of each activity, identifying the critical path, and determining the floats or slack times for non-critical activities.

Let a network N= $\langle E$ij$\rangle$, being a project model, is given. E is asset of events (nodes) and $A \subset E \times E$ is a set of activities. The set $E = \{1,2, \dots, n\}$ is labeled in such a way that the following condition holds: $(i, j) \in A$ and $i < j$. The activity times in the network are determined by T_{ij}.

Notations of network solution and its calculations as follows:

T_{ie} =Earliest occurrence time of predecessor event i,
T_{il} = Latest occurrence time of predecessor event i,
T_{je} =Earliest occurrence time of successor event j,
T_{jl} = Latest occurrence time of successor event j,
T_{ije} Start = Earliest start time of an activity ij,
T_{ije} Finish t=Earliest finish time of an activityij,
T_{ijl} Start=Latest start time of an Til activity ij,
T_{ijl} Finish t = Latest finish time of an activity ij,
T_{ij} = Duration time of activity ij,

Earliest and Latest occurrence time of an event:
T_{je} = maximum $(T_{je} + T_{ij})$, calculate all T_{je} for jth event, select maximum value.
T_{il} = minimum $(T_{jl} - T_{ij})$, calculate all T_{il} for ith event, select minimum value.
T_{ije} Start $= T_{ie}$,
T_{ije} Finish t $= T_{ie} + T_{ij}$,
T_{ijl} Finish t $= T_{jl}$,
T_{ijl} Start $= T_{jl} - T_{ij}$,

Critical path is the longest path in the network. At critical path, $T_{ie} = T_{il}$, for all i.
Slack or Float is cushion available on event/ activity by which it can be delayed without affecting the project completion time.
Slack for ith event $= T_{il} - T_{ie}$, for events on critical path, slack is zero.
The expected time of critical path (μ) and its variance (σ^2) calculated as follows;
$\mu = \Sigma T_{ij}$, for all ij on critical path.

3.3. TNP Algorithm

The proposed algorithm can be summarized as follows:

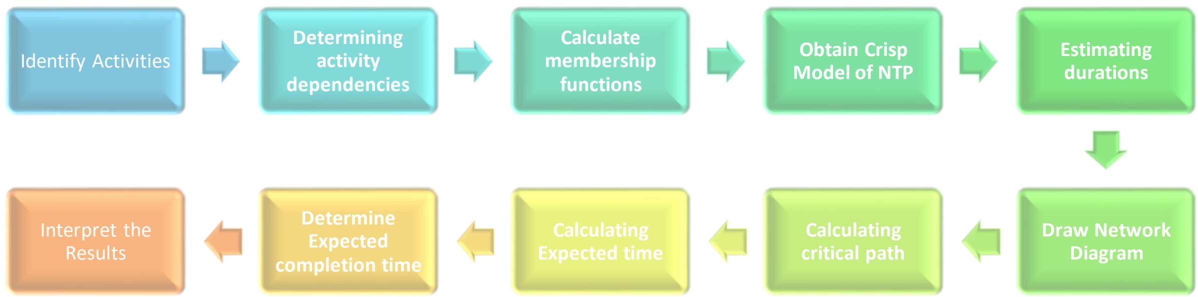


Fig.1. Flow chart

1. Addressing uncertain considered as membership $T_A(x)$ values, inconsistent mentioned as indeterminacy $I_A(x)$ and incomplete information taken as non-membership $F_A(x)$ regarding activity time involves representing the three-time estimates of the PERT technique as single-valued triangular neutrosophic numbers.
2. Calculate the membership functions for each single-valued triangular neutrosophic number using equations 1, 2, and 3.
3. Derive a crisp model of PERT three-time estimates by employing the score function equation as previously demonstrated.
4. Utilize the crisp values of the three-time estimates to compute the expected time and standard deviation for each activity.
5. Construct a PERT network diagram and calculate the project completion time for all the events using crisp values which has been taken from the single-valued triangular neutrosophic number.
6. Identify floats and determine the critical path, which represents the longest path in the network by using the formula T_{ije} Start $= T_{ie}$, T_{ije} Finish t $= T_{ie} + T_{ij}$, $Tijl$ Finish t $= T_{jl}$, T_{ijl} Start $= T_{jl} - T_{ij}$.
7. Calculate the expected time and variance of the critical path with the help of

$T_{ij} = \frac{a+4m+b}{6}$ and $\sigma_{ij} = \frac{b-a}{6}$

8. Determine the expected project completion time.
9. Assess the expected probability values for various project completion scenarios based on specific demands mentioned in the given real-life situation.

The next section illustrates the proposed algorithm with numerical example based on the real-life situation existed in a Reputed company situated in Tirupur, Tamilnadu, India.

4. APPLICATIONS

The main purpose of this section is to apply the proposed methodology in step by step process. This section is separated into three main parts. The first part offers an actual case study of the implementation of the recommended approach. The second part applies the steps of the proposed TNP approach. The third and final part discusses the results of the study.

4.1. NUMERICAL ILLUSTRATION

ESA Clothing Company established in 1997, which is the primary manufacturers of garments such as t-shirts, children wear and cotton shirts. It is infused with the aim to deal in best quality garments and the best garment solutions provider within the reach. Company made a continuous improvement in the supply of various genuine and trusted quality garments to meet the ever-increasing market requirements. They hereby introduce their company "JUBILEE TEX & ESA CLOTHING COMPANY" as one among the Leading Garment Manufacturing and Exporting Company situated at Tirupur, Tamilnadu, India, with high potential to serve and cater to the needs of the Quality conscious customers. They have a very good base in the garmenting field as their parent company was established in the year 1968 catering to the Indian domestic market. In the year 1989 their export division in the name of JUBILEE TEX was established with full focus on the export market. With a steady growth in business their new company in the name of ESA CLOTHING COMPANY was started in 2004 with wide focus on the Branded labels, Stores and importers all over Europe & U.S.

Having an initial capacity of producing 2500 Pcs per day. They have now reached a stage where they are producing 4,00,000 Pcs /month. Their focus is on the Babies, Children's, Women's, Men's wear market as this has been their prime product line since the day one of our export business. With factory spreading over 3 different premises and with 12 Lines they can dedicate each factory to different requirement of each customer. (Quantity and quality wise). They can do quantity ranging from 1,000pcs and more in three of the factories. Their factory is compliance with all Garment Factory Norms.

Between June 5, 2023, and July 4, 2023, the Esa Clothing Company diligently recorded the production timeline for their assorted products, which include boxers, track pants, and T-shirts. These products are crafted from various fabric materials such as single jersey, lycra derby, single rib, jacquard, lycra drop rib, waffle, and filament lycra jersey. Each fabric type demands a distinct duration for manufacturing. For instance, we have gathered specific data concerning the production time for T-shirts made from single rib fabric.

The manufacturing process for these T-shirts commenced on June 8, 2023, and reached completion on July 4, 2023. Notably, a substantial order of 1200 casual wear T-shirts was placed by a client in the USA. It's worth highlighting that the majority of the company's orders originate from the

USA. The entirety of the production process encompasses seven key components: knitting, dyeing, cutting, stitching, printing, ironing, and the final packing stage.

The company encounters significant challenges in securing the appropriate personnel for various roles due to a shortage of manpower. On certain days, individuals may be available for stitching tasks, while the demand lies in the packaging department, creating a similar predicament across different departments with varying availabilities. To address this uncertain, inconsistent, and indeterminacy scenario, the gathered data can be effectively presented in Table 1 using triangular neutrosophic numbers. In this context, the Triangular Neutrosophic PERT approach is adapted to optimize the projected timeline for completing the project. The project's pertinent data is presented as follows:

Table 1:

Activity	Score Function of $\underline{a}$=<(a_1,a_2,a_3,α_a,θ_a,β_a>	$S(a)$
Knitting	2=<(8,10,12).0.2,0.5,0.6>	2
Dyeing	3=<(5,8,10),0.8,0.2,0.6>	3
Cutting	4=<(9,17,25),0.3,0.6,0.4>	4
Stitching	5=<(20,25,30),0.7,0.4,0.6>	8
Printing	6=<(10,13,17).0.8,0.2,0.4>	6
Ironing	4=<(10,19,25),0.3,0.6,0.5)>	4
Packing	8=<(18,24,28).0.2,0.4,0.6>	5

Table 2:

Activity	Notation	Predecessor	Representation
Knitting	A	-	1-2
Dyeing	B	a	2-3
Cutting	C	b	3-4
Stitching	D	b	3-5
Printing	E	c	4-6
Ironing	F	d	5-6
Packing	G	e, f	6-7

In the following table t_m, t_o, t_p are optimistic, most likely and pessimistic time in neutrosophic environment, and considered as a single valued triangular neutrosophic numbers. To get the crisp values of each single valued triangular neutrosophic number, calculate score function of

$\boldsymbol{a} =< (a_1, a_2, a_3), \alpha_a, \theta_a, \beta_a >$ by using the below formula

$S(\boldsymbol{a}) = \frac{1}{16}\,(a_1 + a_2 + a_3\,) * (\alpha_a + (1-\theta_a\,) + (1-\beta_a\,))$.

Table 3:

ACTIVITY	t_o	t_m	t_p	t_e
a	2	4	6	4
b	2	3	4	3
c	3	4	6	4
d	4	5	6	5
e	4	6	8	6
f	2	3	4	3
g	2	4	6	4

From the calculated values in table 3 and from the given condition the network diagram with expectation time mentioned as single valued neutrosophic numbers (crisp numbers) in the following network diagram.

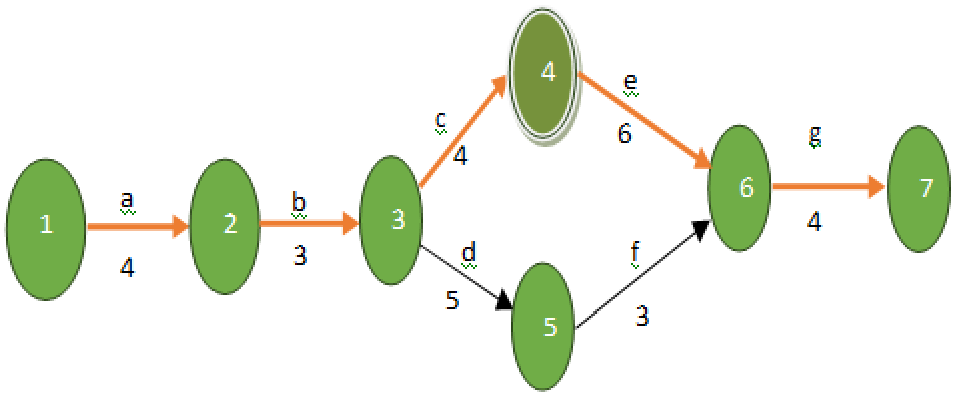


Fig2: Network Diagram

The critical path is a-b-c-e-g.

The T-shirts will be manufactured in =21 days

iii) Probability of manufacturing T shirt in 25 days

VARIANCE= $\left[\frac{6-2}{6}\right]^2 = \frac{16}{6}$; $\left[\frac{4-2}{6}\right]^2 = 4/6$; $\left[\frac{6-3}{6}\right]^2 = \frac{9}{6}$; $\left[\frac{8-4}{6}\right]^2 = 16/6$; $\left[\frac{6-2}{6}\right]^2 = \frac{16}{6}$

$$\Sigma V_{critical} = \frac{61}{36};\ \Sigma t_e critical = 26 \text{ days}$$

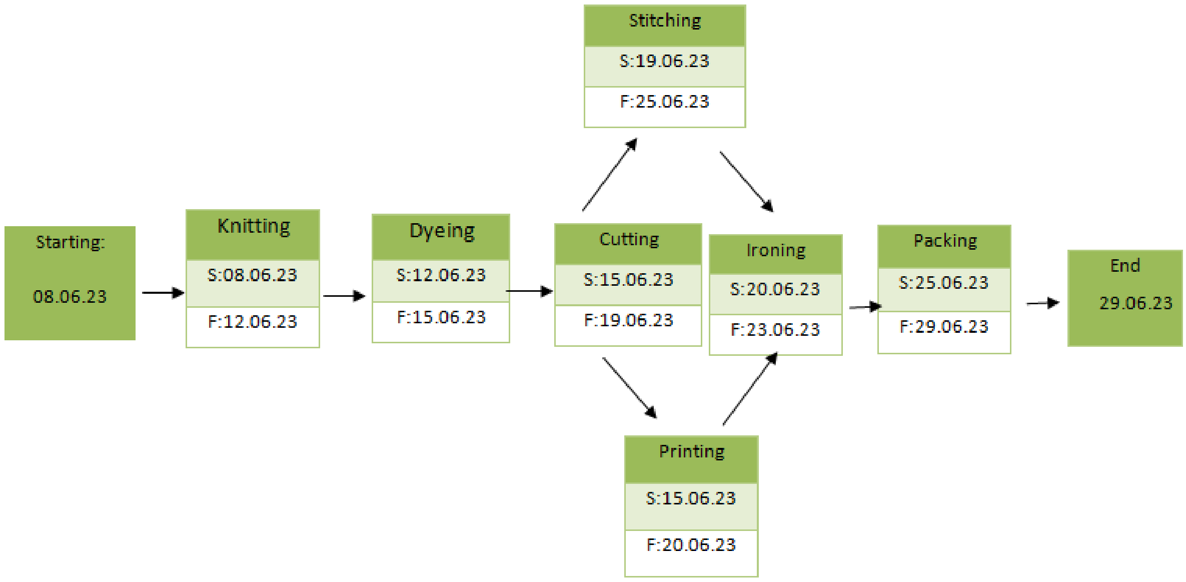
$$Z = \frac{X - \Sigma T_{e\,critical}}{\sqrt{\Sigma v_{critical}}} = \frac{25-21}{\sqrt{1.694}} = \frac{4}{1.30} = 3.076 = 0.4989 \text{ (from normal distribution table)}$$

Probability=1-0.4989 =0.5011

Table 4:

ACTIVITY	ACTIVITY	t_e	ES	EF	LS	LF	SH	ST
a	1-2	4	0	4	0	4	0	0
b	2-3	3	4	7	4	7	0	0
c	3-4	4	7	11	7	11	0	0
d	3-5	5	7	12	9	14	2	0
e	4-6	6	11	17	11	17	0	0
f	5-6	3	12	15	14	17	0	2
g	6-7	4	17	21	17	21	0	0

Network of Activities:



INTERPRETATION:

Based on the current observations, crafting a single rib T-shirt takes approximately 29 days using the existing manufacturing process. However, with the implementation of the proposed algorithm and the application of the Triangular Neutrosophic PERT process, the projected completion time for manufacturing these T-shirts is reduced to 21 days. This notable enhancement shortens the timeline by 8 days compared to the existing method. This reduction in manufacturing duration inherently leads to a corresponding decrease in the production costs associated with these T-shirts. The authors have recommended the adoption of this innovative TNP approach to the Esa Clothing Company, aiming to optimize machine time, human resources, and the overall expenses tied to the T-shirt manufacturing process.

4.2 NUMERICAL ILLUSTRATION

Esa Clothing Company extends its production to encompass men's track pants, driven by a surge in demand and usage. Much like the T-shirts, track pants come in diverse fabric materials including Lycra, blended cotton, and Dry Fit Fabrics. Traditionally, companies maintain sample garment pieces as reference; for instance, a pre-existing Lycra track pant fabric was readily available. This fabric merely needed cutting and stitching to transform into a finalized product. Specifically, the provided data focuses on the stitching aspect of crafting track pants. The stitching process is further subdivided into distinct tasks, such as folding pockets, sewing bar tracks, adding waistbands, and finalizing ankle cuffs.

Table 5:

Score Function of $\underline{a}$=<(a_1,a_2,a_3,α_a,θ_a,β_a>	$S(a)$
2=<(56,76,86), 0.8,0.2,0.4>	30
3=<(120,200,280), 0.7,0.5,0.6>	60
4=<(238,268,298), 0.4,0.2,0.4>	90
5=<(460,580,700), 0.2,0.5,0.6>	120
6=<(262,62,462), 0.8,0.2,0.4>	150
7=<(381,480,581), 0.6,0.2,0.4>	180
9=<(252,1005,1485), 0.4,0.6,0.4>	240
10=<(1200,1500,1800), 0.7,0.4,0.6>	340
11=<(1104,1204,1304),0.1,0.2,0.3)>	360
12=<(1388,1686,1988),0.3,0.6,0.5)>	380

Table 6:

Activity	Activity	Predecessor	Representation
Cutting	a	-	1-2
Sewing pocket	b	a	2-3
Joining pocket	c	a	2-4
Joining the sides	d	a	2-5
Add waist band and ankle case	e	b	3-5
Inset elastic	f	c	4-5
Sewing the bar tracks	g	d,e,f	5-6

A primary objective involves pinpointing the slack time for each activity and identifying potential modifications to minimize this slack period within each process. The ultimate aim is to establish the earliest feasible completion time for the project, facilitating a reduction in both process time and overall manufacturing duration. Apply the proposed algorithm to achieve this optimization for he given stitching durations (in minutes) of each process are detailed in the Table 5.

Table 7:

Activity	Activity	t_o (m's)	t_m (m's)	t_p (m's)	t_e (m's)	t_e (hrs)
a	1-2	5	7	8	180	3
b	2-3	2	3	4	60	1
c	2-4	2	3	4	60	1
d	2-5	10	11	12	360	6
e	3-5	5	9	11	240	4
f	4-5	4	5	6	120	2
g	5-6	5	9	11	240	4

Activity	Activity	t	ES	EF	LS	LF	SH	ST
a	1-2	3	0	3	0	3	0	0
b	2-3	1	3	4	4	5	0	1
c	2-4	1	3	4	6	7	0	3
d	2-5	6	3	9	3	9	0	0
e	3-5	4	4	8	5	9	1	0
f	4-5	2	4	6	7	9	3	0
g	5-6	4	9	13	9	13	0	0

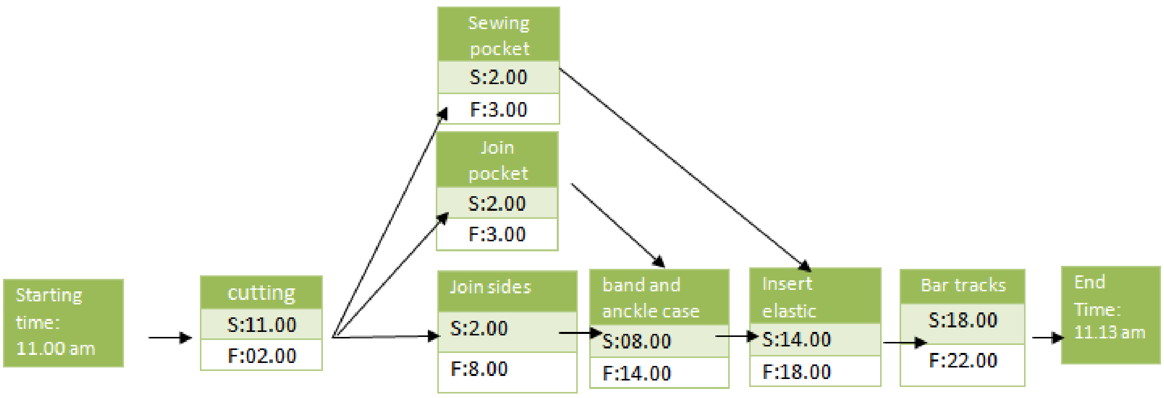


Fig 3: Network Diagram

Probability: Probability of completing the stitching process of track pants in 15 hours

Although the project is estimated to be completed within 15 hours there is no guarantee that it will actually be completed within the 15hours. If by some circumstances various activities take longer than their expected time, the project might not be completed within the desired schedule. Therefore, it will be useful to know the probability that the project deadline will be met. The first step is to find the variance and standard deviation of the total time along critical path, which is equal to the sum of the variances of activity times on the critical path.

Variance:

1) $\left[\frac{4-2}{6}\right]^2 = \frac{4}{36};\left[\frac{6-4}{6}\right]^2 = \frac{4}{36};\left[\frac{6-2}{6}\right]^2 = \frac{16}{36};$

$\sum \mathbf{t}_{\mathbf{e}_{critical}} = \mathbf{3+6+4}$ =15 hours $\sum \boldsymbol{v}_{critical}$= 0.66

$Z = \frac{X-\Sigma T_{e_{critical}}}{\sqrt{\Sigma v_{critical}}} = \frac{13-1}{\sqrt{0.66}} = \frac{1}{0.81}$= 1.2 =0.3907(by normal distribution)

$Probability = 1 - 0.3907 \ = \ 0.6093$

Thus, there is 60% chance to that the critical path will be completed in less than 15 hours.

INTERPRETATION:

As documented in the current records, the entire process currently requires 21 hours for completion. However, with the adoption of the suggested TNP methodology, the minimum time needed to finalize the process dwindles to 13 hours, thereby presenting an opportunity to economize 8 hours. Nevertheless, it's important to note that despite the potential to conclude the process within 13 hours, certain delays arise during the occurrence of events b, c, e, and f.

4.3 NUMERICAL ILLUSTRATION

Esa Clothing Company, as a manifestation of its expansion, has already established an additional production unit to meet the growing influx of orders. Presently, the company envisions the creation of yet another compact unit, dedicated to knitting activities and warehousing. To materialize this plan, an engineer has provided an estimated timeframe detailing the anticipated number of days required for the unit's completion. The construction process involves a range of activities, including basement construction, sidewall development, and roof assembly, all of which play a crucial role in the overall construction. Estimates from various companies and material quotations, based on responses received, have been compiled in a neutrosophic triangular number format, leading to the development of a new unit. In this context, the duration for executing these construction tasks extends from April 17, 2023, to July 5, 2023. To comprehensively assess the projected completion time for the project, it is imperative to consider both the factual duration and the potential timeline. This evaluation involves implementing the suggested Triangular Neutrosophic PERT (TNP) methodology, which aims to determine an optimal timeframe for achieving project culmination. The table provided outlines the specific timeframes, measured in days, allocated for each distinct construction activity.

Table: 8

Score Function of $\underline{a}$=<($a_1,a_2,a_3,\alpha_a,\theta_a,\beta_a$>	$S(a)$	Score Function of $\underline{a}$=<($a_1,a_2,a_3,\alpha_a,\theta_a,\beta_a$>	$S(a)$
1=<(8,10,12).0.2,0.5,0.6>	2	16=<(45,62,79),0.7,0.4,0.6>	17
2=<(5,8,10),0.8,0.2,0.4>	3	17=<(65,75,85),0.3,0.6,0.4>	18
3=<(10,15,20),0.3,0.6,0.2>	4	18=<(100,109,118),0.4,0.6,0.8>	20
4=<(18,24,28),0.2,0.4,0.6>	5	19=<(60,69,78),0.2,0.5,0.6>	14
5=<(10,13,17),0.8,0.2,0.4>	6	20=<(40,50,60).0.4,0.2,0.1>	20
6=<(10,19,25),0.3,0.6,0.5)>	7	21=<(49,67,84).0.8,0.4,0.6>	23
7=<(20,25,30),0.7,0.4,0.6>	8	22=<(70,74,78).0.8,0.5,0.5>	25
8=<(24,26,29),0.4,0.2,0.4>	9	23=<(55,80,105).0.7,0.2,0.5>	30
9=<(35,39,44),0.9,0.7,0.8>	10	24=<(10,13,17).0.8,0.2,0.4>	6
10=<(15,32,49),0.7,0.2,0.5>	12	25=<(70,74,78).0.8,0.5,0.5>	25
11=<(45,62,79),0.6,0.4,0.7>	17	26=<(55,80,105).0.7,0.2,0.5>	30
12=<(38,47,56),0.1,0.2,0.8>	10	27=<(75,86,97).0.8,0.2,0.4>	35
13=<(14,31,38),0.9,0.1,0.5>	12	28=<(10,19,25),0.3,0.6,0.5)>	7
14=<(65,74,83),0.2,0.5,0.6>	15	29=<(108,112,116).0.5,0.2,0.4>	40
15=<(50,52,54),0.3,0.4,0.6>	13		

Table 9:

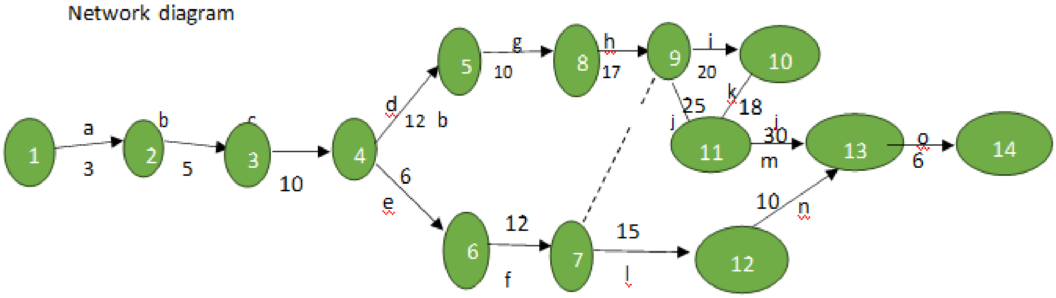
Activity	Activity	Predecessors	Activity
Raising base	a	-	1-2
Basement	b	a	2-3
Masonry work	c	b	3-4
Constructing roof	d	c	4-5
Fixing doors and windows	e	c	4-6
Plastering with cement	f	e	6-7
Fixing tiles	g	d	5-8
Fixing electrical lines& sanitary work	h	g	8-9
Plastering	i	f, h	9-10
Applying primer	j	f, h	9-11
Painting	k	i	10-11
Give provision to fix knitting machine	l	f	7-12
Fixing	m	j, k	11-13

Furniture works	n	l	12-13
Giving connections for electrical works	o	m, n	13-14

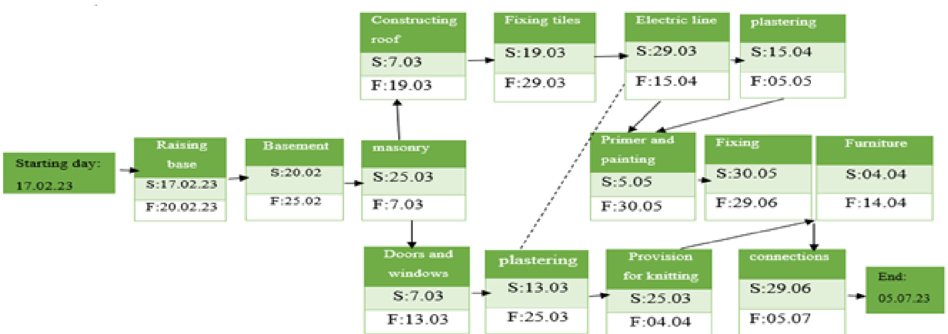
Table 10

Activity	Activity	to	tm	tp	te
a	1-2	1	2	3	3
b	2-3	1	4	7	5
c	3-4	9	12	14	11
d	4-5	9	10	11	13
e	4-6	4	5	7	6
f	6-7	10	13	17	13
g	5-8	9	12	15	10
h	8-9	14	16	18	17
i	9-10	18	20	22	21
j	9-11	22	25	27	27
k	10-11	14	17	21	18
l	7-12	15	14	17	15
m	11-13	23	26	29	32
n	12-13	8	12	19	11
o	13-14	5	24	28	6

Network diagram



Activity	Activity	to	tm	tp	te	ES	EF	LS	LF	FS	TS
a	1-2	2	3	4	3	0	3	0	3	0	0
b	2-3	3	5	8	5	3	8	3	8	0	0
c	3-4	10	10	15	11	8	19	8	19	0	0
d	4-5	10	12	17	13	19	32	19	32	0	0
e	4-6	5	6	8	6	19	25	19	46	0	21
f	6-7	12	12	18	13	25	38	40	59	15	21
g	5-8	8	10	13	10	32	42	32	42	0	0
h	8-9	15	17	20	17	42	59	42	59	0	0
i	9-10	20	20	25	21	59	80	59	80	0	0
j	9-11	25	25	35	27	59	98	59	98	13	13
k	10-11	15	18	23	18	80	98	80	98	0	0
l	7-12	13	15	18	15	38	53	59	119	21	66
m	11-13	30	30	40	32	98	130	98	130	0	0
n	12-13	9	10	14	11	53	130	119	130	66	0
o	13-14	6	6	7	6	130	136	130	136	0	0



The depicted network diagram above illustrates the start time, completion time, and float time for each event. These outcomes were derived using the TNPERT algorithm proposed in this study.

INTERPRETATION:

The concept of TNP entails an analytical approach crafted to aid in the orderly arrangement of activities that necessitate sequential execution. Upon further scrutiny, the average time for completing the construction of both a storage facility and a knitting unit is determined to be 173 days based on the available data. By effectively organizing tasks using TNPERT techniques, the construction process for a new branch is streamlined, resulting in a reduced timeline of 131 days. This discrepancy of 42 days signifies a significant time-saving measure. Capitalizing on this time differential can effectively enhance construction efficiency and lead to diminished production expenses.

RESULT AND FUTURE WORK:

This article exemplifies the practical application of triangular neutrosophic numbers in a real-life scenario within a manufacturing company. The presence of uncertainty and ambiguity is identified, particularly stemming from a significant volume of consignments. The operational gap between the production unit and the logistics department exacerbates the uncertain and ambiguous situations within the company. The application of triangular neutrosophic numbers effectively portrays and clarifies the prevailing circumstances. Employing a scoring function, the triangular neutrosophic numbers are transformed into single-valued numbers. Subsequently, the PERT procedure is applied to ascertain both the production completion time and the associated profit. This serves as an initial exploration, and in future endeavors, considering the multifaceted nature of departments and diverse categories within such companies, the application of neutrosophic numbers holds promise for mitigating uncertainty and ambiguity. Furthermore, employing neutrosophic numbers can contribute to optimizing profits or minimizing utilization periods across various departments and categories.

CONCLUSION:

Through this data it happened to learn how a garment is manufactured and what is all the process involved in. In business it is very important to keep up the timing. To keep up the timing scheduling the works accordingly is much needed. Here using Program evaluation and review technique and critical path method we have scheduled the works and found the minimum time that will be taken to manufacture the garments. This will help the company to gain profit with less working hours and with more production. In conclusion, this research article presents the practical implementation of Triangular Neutrosophic PERT analysis. Leveraging the advantages offered by Neutrosophic numbers, the study addresses a range of issues. Esa Clothing Company's multifaceted production of garments from diverse materials and processes has been explored. Notably, the company's competitiveness has been hindered by suboptimal profit margins, partly attributed to prolonged project durations. Through the innovative application of Triangular Neutrosophic numbers, these challenges have come to light, prompting recommendations to streamline project timelines by minimizing slack and delay times across the company's endeavors. The research encompasses thorough time calculations, yielding insights into actual project completion times, projected completions, and the probabilities associated with achieving revised timeframes. As this study concludes, the adoption of Triangular Neutrosophic PERT analysis offers a strategic avenue for enhancing efficiency, ultimately contributing to improved competitiveness and profitability for Esa Clothing Company.

Funding: We do not receive any external funding.

Acknowledgments: The authors are really thankful to the respected Editor in Chief and esteemed Reviewers for all their valuable comments and guidelines.

Conflicts of Interest: The author has no conflicts of interest to discuss about the article.

References:

[1] Smarandache F., Unifying Field in Logics. Neutrosophy: Neutrosophic Probability, Set and Logic., Rehoboth: American Research Press,1998.
[2] Smarandache F., Neutrosophic set, a generalisation of the intuitionistic fuzzy sets, Int. J. Pure Appl. Math. 2005; 24 ; 287-297.
[3] Jayagowri.P, G. Geetharamani, A Critical Path Problem Using Intuitionistic Trapezoidal Fuzzy Number, Applied Mathematical Sciences, Vol. 8, 2014, no. 52, 2555 - 2562.
[4] Thaeir Ahmed Saadoon Al Samman et al , Fuzzy PERT for project management, International Journal of Advances in Engineering and Technology, Sept., 2014.Vol. 7, Issue 4, pp. 1150-1160.
[5] Yang. M. F et al, Applying fuzzy time distribution in PERT Model, Proceedings of the International Multi Conference of Engineers and Computer Scientists 2014 Vol II, IMECS 2014, March 12 - 14, 2014, Hong Kong.
[6] Mete Mazluma et al, CPM, PERT and Project management with fuzzy logic technique and implementation on a business, Procedia - Social and Behavioral Sciences 210 (2015) 348 357.
[7] Smarandache F., Subtraction and Division of Neutrosophic Numbers, Critical Review. Volume XIII, 2016.
[8] Amit Adate et al, Analysis of project Planning using cpm and pert, International Journal of Computer Science and Mobile Computing, Vol.6 Issue.10, October- 2017, pg. 24-25.
[9] Abdel-Baset M, Mohamed M, Zhou Y, Smarandache. F, A Critical Path Problem using Triangular Neutrosophic Number, IEEE International Conference on Innovations in Intelligent Systems and Applications (INISTA), Gdynia Maritime, University, Gdynia, Poland, 3-5 July 2017.
[10] Mohamed. M, Abdel-Baset M, Abdel-Nasser Hussien, Smarandache. F, Neutrosophic Operations Research, Brussels: Pons Publishing House, 2017Vol 1, 2017, pp. 145-155.
[11] Sudha. G et al, Solving Critical Path Problem using Triangular Intuitionistic Fuzzy Number, Intern. J.Fuzzy Mathematical Archive, Vol. 14, No. 1, 2017, 1-8.
[12] Onifade Morakinyo Kehindeet et al, Application of Project Evaluation and Review Technique (PERT) in road construction projects in Nigeria, European Project Management Journal, Volume 7, Issue 2, December 2017.
[13]Smarandache F, Mohamed M, Zhou Y, Abdel-Baset M, A Critical Path Problem Using Triangular Neutrosophic Number." 2017 IEEE International Conference on INnovations in Intelligent SysTems and Applications (INISTA), Gdynia Maritime University, Gdynia, Poland, 3-5 July 2017 (2017): 403-407.
[14]Avishek Chakraborty et.al, Different Forms of Triangular Neutrosophic Numbers, De-Neutrosophication Techniques, and their Applications, MDPI, Symmetry, Vol.10 (327), 2018, 1-27.
[15] Muhammad Kholil, Bonitasari Nurul Alfa and Madjumsyah Hariadi, Scheduling of House Development Projects with CPM and PERT Method for Time Efficiency, IOP Conf. Series: Earth and Environmental Science, 140, 2018, pp. 1-8.

[16] Surapati Pramanik et al., Contributions of Selected Indian Researchers to Multi Attribute Decision Making in Neutrosophic Environment: An Overview, Neutrosophic Sets and Systems, Vol. 20, 2018.
[17] Samah Ibrahim Abdel Aal, Mahmoud M. A. Abd Ellatif, and Mohamed Monir Hassan, Two Ranking Methods of Single Valued Triangular Neutrosophic Numbers to Rank and Evaluate Information Systems Quality, Neutrosophic Sets and Systems, Vol.19, 2018, pp. 132-141
[18] Murali.M and Surya.R, Neutrosophic Project Evaluation and Review Techniques, Neutrosophic Sets and Systems, Vol.24, 2019, pp. 1-9.
[19] Abdel-Baset, M.; Chang, V.; Gamal, A.; Smarandache, F. An integrated neutrosophic ANP and VIKOR method for achieving sustainable supplier selection: A case study in importing field. Comput. Ind. 2019, 106, 94–110.
[20] Bolturk, E.; Gülbay, M.; Kahraman, C. Sustainable energy selection based on interval-valued intuitionistic fuzzy and Neutrosophic aggregation operators. J. Intell. Fuzzy Syst. 2020, 39, 6553–6563.
[21] Tapia, J.F.D. Evaluating negative emissions technologies using neutrosophic data envelopment analysis. J. Clean. Prod. 2021, 286, 125494.
[22]Abdel-Basset, M.; Gamal, A.; Moustafa, N.; Askar, S.S.; Abouhawwash, M. A Risk Assessment Model for Cyber-Physical Water and Wastewater Systems: Towards Sustainable Development. Sustainability 2022, 14, 4480.
[23] M. Abdel-Basset, A. Gamal, R. Mohamed, M. Abouhawwash, A. Almutairi et al., "Efficient model for emergency departments: real case study," Computers, Materials & Continua, vol. 70, no.2, pp. 4053–4073, 2022.
[24] Mohamed Abdel-Basset, Abduallah Gamal, Karam M. Sallam, Ibrahim M. Hezam, Ahmad M. Alshamrani, "Sustainable Flue Gas Treatment System Assessment for Iron and Steel Sector: Spherical Fuzzy MCDM-Based Innovative Multistage Approach", International Journal of Energy Research, vol. 2023, Article ID 6645065, 25 pages, 2023.
[25] S. Rahnamay Bonab, S. Jafarzadeh Ghoushchi, M. Deveci, and G. Haseli, "Logistic autonomous vehicles assessment using decision support model under spherical fuzzy set integrated Choquet integral approach," Expert Systems with Applications, vol. 214, article 119205, 2023.
[26] Jeyaraman M, Iswariya S, A new approach for the statistical convergence overnon-Archimedan fields in Neutrosophic normed spaces, Neutrosophic Systems with Applications, 9, 81-90, 2023.
[27] Jdid, M., & Smarandache, F, Optimal Agricultural Land Use: An Efficient Neutrosophic Linear Programming Method. Neutrosophic Systems with Applications, 10, 53–59, (2023).
[28] Manshath. A, Kungumaraj.E, Lathanayagam.E, Clement Joe Anand. M, Nivetha Martin,Elangovan Muniyandy,S. Indrakumar. (2024). Neutrosophic Integrals by Reduction Formula and Partial Fraction Methods for Indefinite Integrals. International Journal of Neutrosophic Science, 23 (1), 08-16, 2024
[29] Kungumaraj.E, Durgadevi.S, Tharani. N.P, Heptagonal Neutrosophic Topology, Neutrosophic Sets and Systems, Vol.60, 335 – 356, 2023.
[30] Kungumaraj. E, Lathanayagam. E, Utpal Saikia, Clement Joe Anand. M, Sakshi Taaresh Khanna, Nivetha Martin, Mohit Tiwari, Seyyed Ahamad Edalatpanah, Neutrosophic Topological Vector Spaces and its Properties, International Journal of Neutrosophic Science, Vol.23, No.2, 63-76, 2024

Received: Oct 12, 2023. Accepted: Jan 10, 2024