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TreeSoft Approach for Refining Air Pollution Analysis: A Case Study

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Abstract: The ongoing research employs both the neutrosophic set and the Decision Making and Evaluation Method (DEMATEL) to analyze and determine the factors influencing supplier selection within the realm of Supply Chain Management (SCM). Recognized as a proactive strategy for enhancing performance and securing competitive advantages, DEMATEL guides this investigation. The study utilizes neutrosophic set Theory to refine overall assessments, introducing a novel scale to distinctly represent each value. Through a practical case study focusing on selecting the optimal supplier for a distribution company, the proposed methodology's application is illustrated. The research framework integrates a neutrosophic DEMATEL approach for data collection, incorporating surveys among experts and interviews with professionals in management, procurement, and production. In addressing application-oriented challenges characterized by multiple criteria marked by ambiguity and varying degrees of accuracy, Smarandache introduced Treesoft sets an extension of hypersoft sets to effectively navigate through ambiguous and imprecise options.

Keywords: Air pollution, DEMATEL method, Neutrosophic set, Treesoft set.

1. Literature Review

Air pollution [1] stands as one of the most significant environmental hazards to human health. By mitigating air pollution, nations can alleviate the burden of diseases such as stroke, heart disease, lung cancer, chronic respiratory diseases, and asthma, both chronic and acute. Shockingly, in 2019, 99% of the global population inhabited areas failing to meet the air quality standards set by the World Health Organization (WHO). The combined impact of ambient air pollution and household air pollution contributes to approximately 6.7 million premature deaths annually. Specifically, outdoor air pollution was responsible for an estimated 4.2 million premature deaths worldwide in 2019, with 89% occurring in low- and middle-income countries, notably concentrated in the WHO Southeast Asia and Western Pacific Regions. Implementing policies and investments that promote cleaner transportation, energy-efficient housing, sustainable power generation, industrial practices, and enhanced municipal waste management would effectively curb major sources of outdoor air pollution. Additionally, ensuring access to clean household energy sources would significantly diminish ambient air pollution in various regions.

Decision-making encompasses a nuanced cognitive process aimed at problem-solving while considering multiple factors to achieve desired outcomes. This process may unfold rationally or irrationally, driven by implicit and explicit assumptions influenced by biological, cultural, physiological, and social dynamics. Decision-making complexity is further shaped by the level of risk and authority involved. In contemporary times, computer technologies facilitate automated calculations and estimations for decision-making conundrums, leveraging mathematical equations, diverse statistical approaches, and economic theories.

Multicriteria decision-making [6] (MCDM) endeavors to identify optimal choices by weighing several criteria throughout the selection process. These methods find application across diverse sectors like finance, engineering, and robotics[2]–[5].

In this realm, the Decision-Making Trial and Evaluation Laboratory [6] (DEMATEL) method emerges as a systematic approach for exploring cause-and-effect relationships among factors within complex systems, finding extensive utility across various domains. However, the DEMATEL method heavily relies on expert judgment, introducing a subjective element into the analysis[7], [8]. Overall, the DEMATEL method serves as a potent tool for dissecting intricate relationships and dependencies among factors within specific contexts, offering valuable insights for decision-makers[9], [10].

It's crucial to mitigate the subjectivity inherent in expert judgment, particularly in fields like aerospace where objective data are often scarce. Recent efforts have integrated methods such as Criteria Importance Through Intercriteria Correlation (CRITIC), artificial neural networks, analytic hierarchy process, and analytic network process into DEMATEL to lessen subjectivity by refining data processing techniques. However, these endeavors have not fully tackled subjectivity during the data acquisition phase.

To address this gap, fuzzy triangular numbers and the multi-criteria group-based decision-making (MCGDM) method have been extensively utilized to quantify the uncertainty surrounding expert opinions. While prior studies focused primarily on reducing subjectivity through either data processing or data collection alone, there's a notable absence of comprehensive research addressing subjectivity from both perspectives.

Thus, this study aims to establish a systematic framework for selecting influential factors and mitigating subjectivity in both the data collection and analysis processes, thereby offering a more holistic approach to addressing this issue.

The hypersoft sets, an extension of soft sets, utilize a multi-argument approximation function to address limitations in current structures for attribute-valued disjoint sets. Subsequently, Multi Soft sets were introduced to handle ambiguity in real-world scenarios, further evolving to include tree soft sets, which closely resemble hypersoft sets [11]. Treesoft sets focus on parameters, sub-parameters, and subsequent levels of granularity, whereas hypersoft sets deal with parameters and their sub-levels[12].

The TrSS model [13] is proposed to model specific criteria and elucidate their relationships, aiding in problem-solving. Treesoft sets aid in categorizing problems into functional and non-functional attributes, enhancing the clarity of the DEMATEL method. The DEMATEL method encompasses three main components: diverse criteria, a range of alternatives, and a comparison process among them.

2. Approach

This section is to propose the Neutrosophic DEMATEL method under the Tree-soft set.

2.1 Tree Soft Set

Smarandache proposes the definition of TreeSoft Set as:

Let U be the universe of discourse, and H be a non-empty subset of U, with P(H) being a power set of H.

Let A be a set of attributes (parameters, factors, etc.,), $A = \{A_1, A_2 \dots \dots . A_n\}, n \geq 1$, where $A_1, A_2 \dots \dots . A_n$ are considered attributes of the first level. Each attribute $A_i, 1 \leq i \leq n$, is formed by sub-attributes: $A1 = \{A1{,}1, A1{,}2, \dots\}$ $A2 = \{A2{,}1\ , A2{,}2\ , \dots\ \}$ $An = \{An, 1\ , An, 2\ , \dots\ \}$ where the above $A_{i,j}$ are sub-attributes (or attributes of the second level) (since they have two-digit indexes). Again, each sub-attribute $A_{i,j}$ is formed by sub-sub-attributes (attributes of the third level): $A_{i,j,k}$ and so on, as much refinement as needed into each application, up to sub-sub-…-sub-attributes (or attributes of m-level (or having m digits into the indexes).

Therefore, a graph tree is formed, which we denote as Tree(A), whose root is A (considered of level zero), then nodes of level 1, level 2, up to level m. We call the leaves of the graph-tree, all terminal nodes (nodes that have no descendants). Then the TreeSoft Set is:

$$F: P(Tree(A)) \rightarrow P(H)$$

Tree(A) is the set of all nodes and leaves (from level 1 to level m) of the graph tree, and P(Tree(A)) is the powerset of the Tree(A). All node sets of the TreeSoft Set of level m are:

$$Tree(A) = \{Ai1 \mid i1 = 1, 2, \dots\}$$

So, the Problem must be defined as the tree structure.

Example: Consider the set $A=\{A_1, A_2, A_3, A_4, A_5, A_6\}$ be the Air pollution symptoms and P(A) is the powerset of A with the corresponding attributes $T=\{T_1, T_2, T_3, T_4, T_5\}$.

Now let us assume that the classification of Air pollution and its effects are given by the following terms:

2.2 Air Pollutions

PM

T_{11} Heart Disease

T_{111} Angina

T_{112} Heart attacks

T_{113} Heart Failure

T_{12} Asthma

T_{121} Trigger Coughing

T_{122} Wheezing

T_{13} Low birth weight

T_{131} Improper Immune System

CO_2

T_{21} Headache

T_{211} Relative Humidity

T_{212} High Risk of Migraine

T_{22} Sleepiness

T_{221} Headaches

T_{222} Fatigue

T_{23} Stagnant

T_{231} Difficult to breath

T_{232} Cough

T_{233} Headache

O_3

T_{31} Chest Pain

T_{311} Shortness of breath

T_{312} Cough

T_{313} Wheezing

T_{32} Coughing

T_{321} Headaches

T_{322} Vomiting

T_{323} Dizziness

T_{33} Throat irritation

T_{331} Cough

T_{332} Tightness of the chest

NO_2

T_{41} Damage to the human respiratory tract

T_{411} Asthma

T_{412} Lung Cancer

T_{42} Asthma

T_{421} Trigger Coughing

T_{422} Wheezing

SO_2

T_{51} Damage trees and plants

T_{511} Increasing temperature

T_{512} Injury to foliage of leaf

T_{52} Inhibit plant growth

T_{521} Leaf cuticles

T_{522} Stomatal Conductance

3. Tree soft set Neutrosophic DEMATEL Approach

Step 1: Build a tree and define the nodes.

The tree has more than one level, in the first level, the main criteria and introduced as TrS_1, TrS_2…….. TrS_n. In the second level, the sub-criteria are introduced as TrS_{11}, TrS_{12}…….. TrS_{1n} and TrS_{21}, TrS_{22}……

Step 2: Define a problem with a set of criteria

The main and sub-criteria are defined in this step by problem definition.

Step 3: Identifying decision goals: collecting relevant information presenting the problem.

i. Selection of experts and decision-makers that have experience in the field.

ii. Identifying the relevant criteria to the problem.

Step 4: Pairwise comparison matrices between relevant criteria.

i. Identify the criteria.

ii. Experts make pairwise comparison matrices between criteria.

iii. Experts should determine the maximum truth-membership degree (α), the minimum indeterminacy-membership degree (β), and the minimum falsity membership degree (θ) of single-valued neutrosophic numbers.

iv. Determine the crisp value of each opinion, using the following equation:

Table 1: The pairwise comparison matrix between criteria

Criteria	A_1	A_2	….	A_n
A_1	(p_{11}, q_{11}, r_{11})	(p_{12}, q_{12}, r_{12})	….	(p_{1n}, q_{1n}, r_{1n})
A_2	(p_{21}, q_{21}, r_{21})	(p_{22}, q_{22}, r_{22})	….	(p_{2n}, q_{2n}, r_{2n})
….	….	….	….	….
A_n	(p_{n1}, q_{n1}, r_{n1})	(p_{n2}, q_{n2}, r_{n2})	….	(p_{nn}, q_{nn}, r_{nn})

Table 2: The pairwise comparison matrix between criteria with the T, F, and I values

Criteria	A_1	A_2	….	A_n
A_1	$(p_{11}, q_{11}, r_{11}; T, F, I)$	$(p_{12}, q_{12}, r_{12}\ ; T, F, I)$	….	$(p_{1n}, q_{1n}, r_{1n}\ ; T, F, I)$
A_2	$(p_{21}, q_{21}, r_{21}\ ; T, F, I)$	$(p_{22}, q_{22}, r_{22}\ ; T, F, I)$	….	$(p_{2n}, q_{2n}, r_{2n}\ ; T, F, I)$
….	….	….	….	….
A_n	$(p_{n1}, q_{n1}, r_{n1}\ ; T, F, I)$	$(p_{n2}, q_{n2}, r_{n2}\ ; T, F, I)$	….	$(p_{nn}, q_{nn}, r_{nn}\ ; T, F, I)$

Table 3: The crisp values of the comparison matrix

Criteria	A_1	A_2	....	A_n
A_1	CrV_{11}	CrV_{21}	....	CrV_{m1}
A_2	CrV_{12}	CrV_{22}	....	CrV_{m2}
....	....	....	....	....
A_n	CrV_{1n}	CrV_{2n}	....	CrV_{mn}

Step 5: Integration of matrices

All opinions of experts need to be integrated into one matrix presenting the average opinions of all experts about each criterion.

Table 4: Integration of the average opinions of all experts

Criteria	A_1	A_2	....	A_n
A_1	CrV_{11}	CrV_{21}	....	CrV_{m1}
A_2	CrV_{12}	CrV_{22}	....	CrV_{m2}
....	....	....	....	....
A_n	CrV_{1n}	CrV_{2n}	....	CrV_{mn}

Score function $S_f = \frac{1}{9}(a + b + c) \times (2 + T - F - I)$
Accuracy function $A_f = \frac{1}{9}(a + b + c) \times (2 + T - F - I)$

Step 6; Generating a direct relation matrix

An initial direct relation matrix A is a $n \times n$ matrix obtained by pairwise comparisons, $A = [A_{ij}]_{n \times n}$.

A_{ij} denotes the degree to which criterion i affects criterion j.

Step 7: Normalizing the direct relation matrix

The normalized direct relation matrix can be obtained using the equation:

$$K = \frac{1}{Max \sum_{j=1}^{n} a_{ij}}$$

$$N = K \times A$$

Step 8: Total relation matrix

A total relation matrix (T), in which (I) denotes the identity matrix, is shown as follows:

$$T = N \times (I - N)^{-1}$$

Step 9: Obtaining the sum of rows and columns

The sum of rows is denoted by (R), and the sum of columns is denoted by(C). Calculate $R + C$ and $R - C$.

$$C = \left[\sum_{i=1}^{n} a_{ij}\right]_{1\times n} = [a_j]_{n\times 1}$$

$$R = \left[\sum_{j=1}^{n} a_{ij}\right]_{1\times n} = [a_j]_{n\times 1}$$

Step 10: Draw the cause-and-effect diagram

The cause and effect diagram is in blue shade presented by $R + C$ and in orange shade presented by $R - C$ which is a degree of relation and it depicts the steps of the proposed model.

4. The proposed methodology in a case study

In this section, we describe the details of the proposed methodology of a Tree soft set approach of neutrosophic sets and the DEMATEL method of cause and effect for the air pollution criteria.

4.1. The calculation process of the Treesoft set-neutrosophic DEMATEL Approach

For collecting data, we are going to analyze the criteria of air pollution of cause and effect. The three experts determined the most important evaluation criterion to be used. The criteria symbols in this research are as follows: PM (T1), CO_2 (T2), O_3 (T3), NO_2 (T4), SO_2 (T5). The data collected from the three experts were analyzed by the Tree soft set of the Neutrosophic DEMATEL method. The steps that were conducted are the following.

Step 1: Build a tree and define the nodes.

The tree has more than one level, in the first level, the main criteria and introduced as TrS_1, TrS_2…….. TrSn. In the second level, the sub-criteria are introduced as TrS_{11}, TrS_{12}…….. TrS_{1n} and TrS_{21}, TrS_{22}……

Step 2: Define a problem with a set of criteria

The main and sub-criteria are defined in this step by problem definition.

Step 3: Identifying decision goals: collecting relevant information presenting the problem.

The first step of the Tree soft set Neutrosophic DEMATEL method is the selection of the best experts in the field of management purchasing and setup contracts. We selected three experts, to which we further refer as the first expert, the second expert, and the third expert. We sorted five evaluation criteria as selected by the team of experts, namely: PM (T1), CO_2 (T2), O_3 (T3), NO_2 (T4), SO_2 (T5)

Step 4: Pairwise comparison matrices between relevant criteria.

i. Identify the criteria.

ii. Experts make pairwise comparison matrices between criteria.

iii. Experts should determine the maximum truth-membership degree (T), the minimum indeterminacy-membership degree (I), and the minimum falsity membership degree (F) of single-valued neutrosophic numbers.

iv. Determine the crisp value of each opinion, using the following equation:

$$CrV = \frac{CrV_1 + CrV_2 + CrV_3}{3}$$

Table 5: The pairwise comparison matrix of criteria

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.3,0.6,0.4)	(0.3,0.4,0.2)	(0.3, 0.7, 0.8)	(0.8,0.3,0.5)	(0.5, 0.4, 0.8)
A_2	(0.5, 0.6, 0.2)	(0.4, 0.4 ,0.5)	(0.8, 0.2 ,0.4)	(0.4, 0.6, 0.4)	(0.9, 0.7 ,0.1)
A_3	(0.9, 0.7, 0.6)	(0.5, 0.9, 0.4)	(0.3, 0.7, 0.5)	(0.8, 0.3, 0.5)	(0.7, 0.5, 0.6)
A_4	(1.0, 0.4, 0.5)	(0.5, 0.5, 0.5)	(0.4, 0.6, 0.4)	(0.4, 0.5, 0.2)	(0.1, 0.6, 0.3)
A_5	(0.5, 0.5, 0.5)	(0.2, 0.4, 0.6)	(0.3, 0.7, 0.8)	(0.7, 0.5, 0.3)	(0.4, 0.6, 0.5)

Table 6: The pairwise comparison matrix of criteria

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.1, 0.5, 0.4)	(0.4, 0.5, 0.6)	(0.5, 0.7, 0.8)	(0.3, 0.2, 0.6)	(0.2, 0.4, 0.3)
A_2	(0.9, 0.6, 0.3)	(0.3, 0.6, 0.8)	(0.2, 0.7, 0.3)	(0.3, 0.4, 0.7)	(0.5, 0.3, 0.5)
A_3	(0.7, 0.5, 0.3)	(0.4, 0.2, 0.5)	(0.3, 0.4, 0.6)	(0.4, 0.2, 0.5)	(0.8, 0.6, 0.4)
A_4	(0.1, 0.5, 0.4)	(0.3, 0.5, 0.4)	(0.2, 0.3, 0.4)	(0.7, 0.5, 0.4)	(0.5, 0.7, 0.8)
A_5	(0.5, 0.5, 0.5)	(0.8, 0.5, 0.4)	(0.5, 0.5, 0.1)	(0.1, 0.5, 0.0)	(0.6, 0.4, 0.3)

Table 7: The pairwise comparison matrix of criteria

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.3, 0.6, 0.5)	(0.3, 0.4, 0.2)	(0.3, 0.7, 0.1)	(0.1, 0.5, 0.6)	(0.8, 0.4, 0.5)
A_2	(1.0, 0.4, 0.5)	(0.5, 0.9, 0.4)	(0.5, 0.4, 0.5)	(0.4, 0.1, 0.6)	(0.1, 0.6, 0.3)
A_3	(0.7, 0.7, 0.6)	(0.2, 0.4, 0.6)	(0.3, 0.7, 0.5)	(0.4, 0.7, 0.3)	(0.5, 0.4, 0.8)
A_4	(0.9, 0.7, 0.6)	(0.5, 0.5, 0.5)	(0.2, 0.8, 0.3)	(0.7, 0.2, 0.6)	(0.1, 0.6, 0.3)
A_5	(0.3, 0.6, 0.4)	(0.5, 0.9, 0.0)	(0.4, 0.5, 0.7)	0.4, 0.5, 0.2	(0.9, 0.4, 0.3)

Table 8: The pairwise comparison matrix of criteria with T, F, I values

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.3, 0.6, 0.4; 0.5, 0.3, 0.4)	(0.3, 0.4, 0.2; 0.7, 0.2, 0.5)	(0.3, 0.7, 0.8; 0.9, 0.4, 0.6)	(0.8, 0.3, 0.5; 0.4, 0.3, 0.5)	(0.5, 0.4, 0.8; 0.8, 0.2, 0.4)
A_2	(0.5, 0.6, 0.2; 0.5, 0.2, 0.1)	(0.4, 0.4, 0.5; 0.8, 0.5, 0.3)	(0.8, 0.2, 0.4; 0.4, 0.5, 0.6)	(0.4, 0.6, 0.4; 0.5, 0.2, 0.1)	(0.9, 0.7, 0.1; 0.7, 0.4, 0.6)
A_3	(0.9, 0.7, 0.6; 0.2, 0.4, 0.3)	(0.5, 0.9, 0.4; 0.9, 0.5, 0.4)	(0.3, 0.7, 0.5; 0.5, 0.7, 0.2)	(0.8, 0.3, 0.5; 0.7, 0.3, 0.4)	(0.7, 0.5, 0.6; 0.3, 0.4, 0.1)
A_4	(1.0, 0.4, 0.5; 0.7, 0.2, 0.4)	(0.5, 0.5, 0.5; 0.3, 0.1, 0.5)	(0.4, 0.6, 0.4; 0.9, 0.4, 0.6)	(0.4, 0.5, 0.2; 0.9, 0.1, 0.6)	(0.1, 0.6, 0.3; 0.7, 0.6, 0.5)
A_5	(0.5, 0.5, 0.5; 0.8, 0.4, 0.5)	(0.2, 0.4, 0.6; 0.4, 0.3, 0.6)	(0.3, 0.7, 0.8; 0.4, 0.2, 0.3)	(0.7, 0.5, 0.3; 0.5, 0.2, 0.9)	(0.4, 0.6, 0.5; 0.8, 0.3, 0.5)

Table 9: The pairwise comparison matrix of criteria with T, F, I values

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.1, 0.5, 0.4; 0.5, 0.6, 0.2)	(0.4, 0.5, 0.6; 0.2, 0.1, 0.7)	(0.5, 0.7, 0.8; 0.5, 0.4, 0.4)	(0.3, 0.2, 0.6; 0.2, 0.5, 0.7)	(0.2, 0.4, 0.3; 0.4, 0.3, 0.6)
A_2	(0.9, 0.6, 0.3; 0.5, 0.4, 0.6)	(0.3, 0.6, 0.8; 0.5, 0.2, 0.6)	(0.2, 0.7, 0.3; 0.2, 0.5, 0.7)	(0.3, 0.4, 0.7; 0.8, 0.7, 0.5)	(0.5, 0.3, 0.5; 0.4, 0.3, 0.2)
A_3	(0.7, 0.5, 0.3; 0.2, 0.3, 0.1)	(0.4, 0.2, 0.5; 0.2, 0.3, 0.5)	(0.3, 0.4, 0.6; 0.3, 0.6, 0.8)	(0.4, 0.2, 0.5; 0.4, 0.8, 0.1)	(0.8, 0.6, 0.4; 0.5, 0.3, 0.3)
A_4	(0.1, 0.5, 0.4; 0.4, 0.3, 0.5)	(0.3, 0.5, 0.4; 0.5, 0.4, 0.3)	(0.2, 0.3, 0.4; 0.2, 0.3, 0.9)	(0.7, 0.5, 0.4; 0.5, 0.7, 0.2)	(0.5, 0.7, 0.8; 0.4, 0.7, 0.2)
A_5	(0.5, 0.5, 0.5; 0.8, 0.6, 0.3)	(0.8, 0.5, 0.4; 0.6, 0.3, 0.8)	(0.5, 0.5, 0.1; 0.2, 0.6, 0.3)	(0.1, 0.5, 0.0; 0.2, 0.5, 0.4)	(0.6, 0.4, 0.3; 0.3, 0.8, 0.4)

Table 10: The pairwise comparison matrix of criteria with T, F, I values

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	(0.3, 0.6, 0.5; 0.5, 0.4, 0.6)	(0.3, 0.4, 0.2; 0.4, 0.5, 0.8)	(0.3, 0.7, 0.1; 0.7, 0.4, 0.1)	(0.1, 0.5, 0.6; 0.3, 0.1, 0.7)	(0.8, 0.4, 0.5; 0.3, 0.5, 0.4)
A_2	(1.0, 0.4, 0.5; 0.2, 0.1, 0.3)	(0.5, 0.9, 0.4; 0.8, 0.7, 0.9)	(0.5, 0.4, 0.5; 0.8, 0.4, 0.8)	(0.4, 0.1, 0.6; 0.4, 0.5, 0.6)	(0.1, 0.6, 0.3; 0.6, 0.5, 0.2)
A_3	(0.7, 0.7, 0.6; 0.4, 0.6, 0.9)	(0.2, 0.4, 0.6; 0.8, 0.6, 0.5)	(0.3, 0.7, 0.5; 0.7, 0.5, 0.8)	(0.4, 0.7, 0.3; 0.1, 0.5, 0.4)	(0.5, 0.4, 0.8; 0.7, 0.2, 0.1)
A_4	(0.9, 0.7, 0.6; 0.6, 0.5, 0.7)	(0.5, 0.5, 0.5; 0.4, 0.3, 0.5)	(0.2, 0.8, 0.3; 0.4, 0.3, 0.5)	(0.7, 0.2, 0.6; 0.2, 0.3, 0.6)	(0.1, 0.6, 0.3; 0.7, 0.4, 0.6)
A_5	(0.3, 0.6, 0.4; 0.3, 0.2, 0.4	(0.5, 0.9, 0.0; 0.4, 0.5, 0.8)	(0.4, 0.5, 0.7; 0.7, 0.5, 0.8)	(0.4, 0.5, 0.2; 0.7, 0.4, 0.6)	(0.9, 0.4, 0.3; 0.6, 0.5, 0.2)

Table 11: Crisp value of the comparison matrix

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	0.26	0.2	0.38	0.284	0.416
A_2	0.318	0.289	0.202	0.342	0.321
A_3	0.367	0.4	0.269	0.356	0.36
A_4	0.443	0.283	0.296	0.269	0.178
A_5	0.317	0.2	0.38	0.233	0.333

Table 12: Crisp value of the comparison matrix

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	0.189	0.233	0.378	0.1222	0.15
A_2	0.3	0.321	0.133	0.249	0.274
A_3	0.3	0.171	0.13	0.183	0.38
A_4	0.178	0.24	0.1	0.284	0.333
A_5	0.317	0.283	0.159	0.087	0.159

Table 13: Crisp value of the comparison matrix

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	0.233	0.11	0.269	0.2	0.264
A_2	0.38	0.24	0.249	0.159	0.211
A_3	0.2	0.227	0.233	0.187	0.453
A_4	0.342	0.267	0.231	0.217	0.189
A_5	0.246	0.171	0.249	0.208	0.338

Step 5: Integration of matrices

All opinions of experts need to be integrated into one matrix presenting the average opinions of all experts about each criterion.

Table 14: Integration of matrices

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	0.227	0.181	0.342	0.2021	0.277
A_2	0.333	0.283	0.195	0.25	0.269
A_3	0.289	0.266	0.211	0.242	0.398
A_4	0.321	0.263	0.209	0.257	0.233
A_5	0.293	0.218	0.263	0.176	0.277

Step 6: Generating a direct relation matrix

An initial direct relation matrix A is a $n \times n$ matrix obtained by pairwise comparisons, $A = [A_{ij}]_{n \times n}$.

A_{ij} denotes the degree to which criterion i affects criterion j.

Step 7: Normalizing the direct relation matrix

The normalized direct relation matrix can be obtained using the equation:

$$K = \frac{1}{Max \sum_{j=1}^{n} a_{ij}}$$

$$N = K \times A$$

Table 15: Normalizing the direct relation matrix

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	0.185	0.147	0.278	0.164	0.225
A_2	0.250	0.213	0.147	0.188	0.202
A_3	0.206	0.189	0.150	0.172	0.283
A_4	0.25	0.205	0.163	0.200	0.182
A_5	0.239	0.178	0.214	0.143	0.226

Step 8: Total relation matrix

A total relation matrix (T), in which (I) denotes the identity matrix, is shown as follows:

$$T = N \times (I - N)^{-1}$$

Table 16: Total relation matrix

Criteria	A_1	A_2	A_3	A_4	A_5
A_1	998.99	820.45	870.41	763.33	1001.49
A_2	999.99	821.29	872.41	764.07	1002.39
A_3	999.99	821.29	871.97	764.08	1002.51
A_4	999.99	821.28	872.27	764.08	1002.37
A_5	999.99	821.26	871.79	764.03	1002.43

Step 9: Find the sum of rows and columns

The sum of rows is denoted by (R), and the sum of columns is denoted by (C). Calculate $R + C$ and $R - C$.

$$C = \left[\sum_{i=1}^{n} a_{ij}\right]_{1\times n} = \left[a_j\right]_{n\times 1}$$

$$R = \left[\sum_{j=1}^{n} a_{ij}\right]_{1\times n} = \left[a_j\right]_{n\times 1}$$

Row + Column	Row - Column
9453.62	-544.28
8465.72	354.58
8818.69	100.99

8279.58	640.4
9470.69	-551.69

Step 10: Draw the cause-and-effect diagram

The cause-and-effect diagram is in blue shade presented by $R + C$ and in orange shade presented by $R - C$ which is a degree of relation, and it depicts the steps of the proposed model.

4.2. Analysing the evaluation criteria

The research results determine the most important criterion. From this causal chart, according to the Tree soft set Neutrosophic DEMATEL Method, the importance of all criteria was established. According to experts' opinions, NO_2 (A_4) had the greatest impact and SO_2 (A_5) had a lesser impact on the selection of the cause of air pollution.

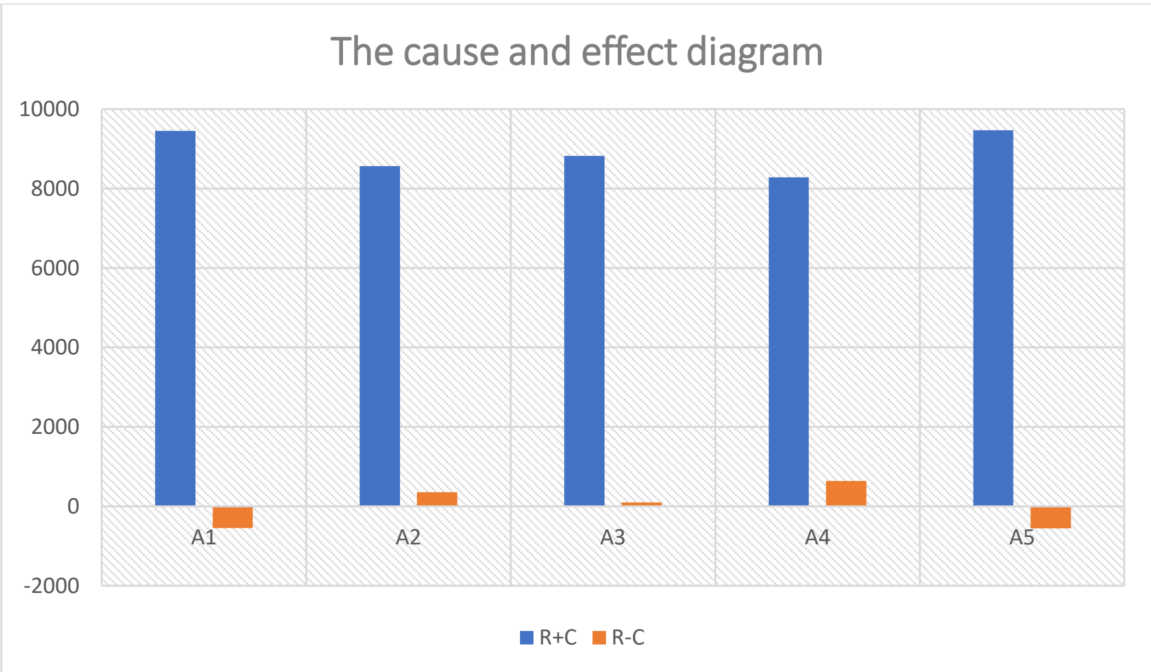

Figure 1. The cause-and-effect diagram.

5. Conclusions

Potential supply chain management practices have been developed and performed using the Tree soft set Neutrosophic DEMATEL Method to select the best standards that have a greater impact on other criteria. The proposed approach succeeded in developing the DEMATEL Method by applying to it the Neutrosophic Set Theory, using a new scale from 0 to 1 and employing the maximum truth membership degree (T), the minimum indeterminacy membership degree (I) and the minimum falsity membership degree (F) of a single-valued neutrosophic number. The opinions were collected from experts through interviews and consequently analyzed using the Neutrosophic DEMATEL Method, by comparisons of each criterion, according to each expert, and their formulation of each value according to a single-valued neutrosophic number.

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