Impact analysis of Macroeconomic Variables on Stock Market using Neutrosophic Interval Valued Dependent Matrix Model

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Abstract
Macroeconomic factors in general are crucial for developing a country's economy. This analysis takes into account the chosen macroeconomic factors for the years 2015 to 2019 including inflation, interest rate, GDP, and GDP per capita. The present study considered the new method of Neutrosophic environment in terms of the Fuzzy CETD matrix to determine the impact of the stock market for a particular year. This article describes a technique for examining how macroeconomic factors affect the stock market in a specific year. The proposed method reveals that the impact of the stock market is higher in 2015 than in 2016.

Keywords: Neutrosophic Logic; NRIVD matrix; NCEIVD matrix; Macro economic variables.

1. Introduction:

Investors can purchase and sell financial instruments, such as bonds and shares, in a place of the stock market. The stock market data pattern is extremely complex, volatile, and uncertain. Hence a Neutrosophic logic is used to investigate the way of application as Interval Valued Dependent matrix, NRIVD (Neutrosophic Refined Interval Valued Dependent) matrix, NCEIVD (Neutrosophic Cumulative Effective Interval Valued Dependent) matrix which are new Neutrosophic models, used in the present study.

In 1998, W. B. Vasantha and V. Indira used fuzzy matrix theory to investigate the passenger transportation problem [15]. They established the ATD (Average Time Dependent), RTD (Refined Time Dependent), and CETD (Cumulative Effective Time Dependent) matrix types to address this problem.

These four types of matrices are transformed into Interval-valued matrices, NRIVD (Neutrosophic Refined Interval Valued Dependent) matrices, and NCEIVD (Neutrosophic Cumulative Effective Interval Valued Dependent) matrices. The Neutrosophic Logic was used to determine the impact of Macroeconomic variables in the stock market in a specific year.

The fuzzy set theory enables us to handle only hazy and ambiguous information. Inconsistent and incomplete issues with the same information cannot be handled by it. As a result, set theory, logic, probability, and statistics can all be employed in the neutrosophy approach, a school of philosophy, to tackle these problems in a single framework. Neutrosophic logic, which uses a cutting-edge paradigm to handle particular problems that fuzzy logic is unable to address, is based on the philosophy of Neutrosophy. Smarandache describes the study of neutralities as a "new discipline of philosophy" that "explores the genesis, nature, and scope of neutralities, as well as their interactions with diverse ideational spectra."

Each occurrence has a specific degree of truth (T), falsity (F), and indeterminacy (I) according to the theory of neutrosophy. (I) that must be taken into account as distinct from each other. As a result,<"A"> denotes an idea, theory, event, concept, or another kind of thing; <"Anti-A">denotes the antithesis of<"A">and <"Neut-A"> denotes a state of limbo between the two extremes.

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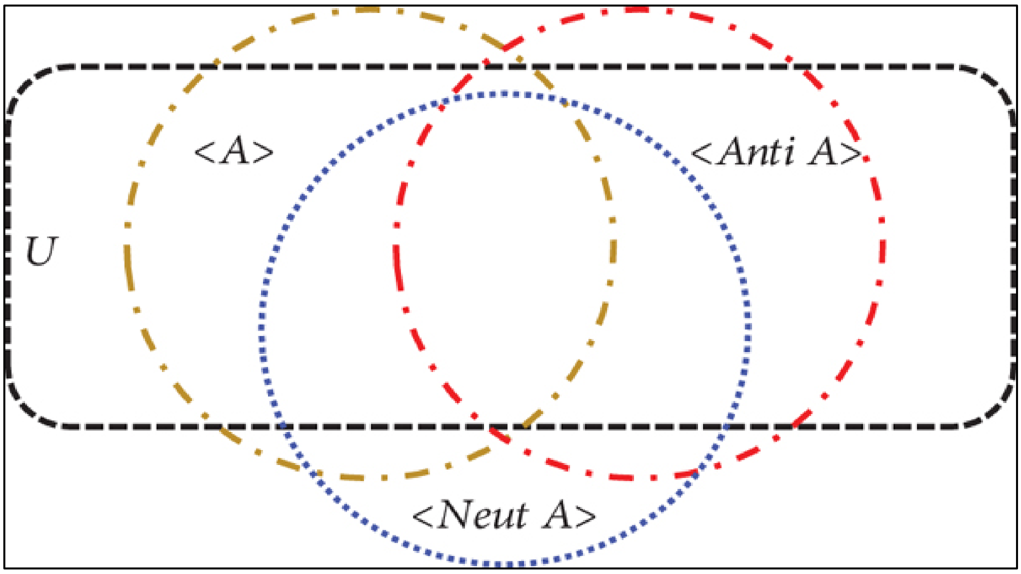

Figure 1: Neutrons

The objective of this paper, therefore, is focused on determining which year has a major impact on macroeconomic variables in the stock market using an Interval Valued matrix in a Neutrosophic environment. Section 2 illustrates the definition of the Neutrosophic set, Neutrosophic Logic, Inderminancy of Neutrosophic, IV matrix, NRIVD matrix, and NCEIVD matrix. Section 3 introduces a new form of the proposed method and Section 4 discusses the results of the Macro economic variables in the stock market and how it has an impact on the stock market in a particular year.

2. Preliminaries:

Definition 2.1:

Let N be a set with the following definition: N=(T, I, F): T, I, F ⊆ [0,1] A Neutrosophic valuation is a conversion from the Set of Proportional Formulas to N that is carried out for each sentence p. (T,I,F). As a result, each statement is given an ordered triplet that represents the degrees of truth, ambiguity, and falsity. According to intuition, the set I ⊆ [0,1] may only stand for determinacy, but it can also stand for vagueness, uncertainty, imprecision, inaccuracy, etc. Also take note that the so-called Neutrosophic components (T, I, and F) are subsets of [0, 1] and not necessarily intervals, allowing us to manage data from many, sometimes contradictory sources.

Definition 2.2:

Assume that the Neutrosophic components are T, I, and F. N's Neutrosophic set is a component of U if there is a discourse universe called U. A set N element is identified as y(T,F,I), where T signifies the set's true value, I denotes the set's indeterminate value, and F denotes the set's false value.

Definition 2.3:

Indeterminacy is defined to the largest extent conceivable in neutrosophy, a novel area of philosophy. Everything that lies in the middle of the two opposites is referred to as indeterminacy.

The Neutrosophic community prefers to use the more specific Neutrosophic triplet (T,I,F), where T denotes truth (or membership), I denotes indeterminacy (unclear, unknown, ambiguous, unsure, imprecise, etc.), and F denotes falsity (or nonmembership), with T,I,F being subsets of the range [0,1]. Indeterminacy I typically isn't a complement of Neutrosophic components T and F because they are independent of one another. <NeutA> is neither< A>nor< AntiA>, but rather lies somewhere in between the two or occasionally combines the two.

Definition 2.4:

From the initial raw data, taking the first column of maximum and minimum numbers and dividing by h, i.e, u-v/h, an equal length of subintervals is obtained. Similarly, it was obtained in the second, third, and fourth columns, thereby transforming the initial raw data into an INTERVAL VALUED matrix.

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Definition 2.5:
NEUTROSOPHIC REFINED INTERVAL VALUED DEPENDENT matrix
NRIVD matrix (m_{ij}) is obtained by using the following rule:

(i) If $a_{ij},b_{ij} < (\mu_{1j}, \mu_{2j} - \alpha(\sigma_{1j}, \sigma_{2j}))$then m_{ij} = (-1,-1)<antiA>

(ii) If $a_{ij},b_{ij} = (\mu_{1j}, \mu_{2j} - \alpha(\sigma_{1j}, \sigma_{2j}))$then m_{ij} = (0,0) <neut A>

(iii) If $a_{ij}b_{ij} > (\mu_{1j}, \mu_{2j} - \alpha(\sigma_{1j}, \sigma_{2j}))$ then m_{ij} = (1,1) <A>

Where μ and σ denote the mean and standard deviation in Neutrosophic statistics and α is a real number in [0,1].

Definition 2.6:
The NCEIVD matrix, which represents the cumulative impact of all entries in the NRIVD matrix, is obtained by adding up all NRIVD matrices for various values.

3. Proposed Method:
First stage: the raw data matrix

$$\begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ c_{m1} & c_{m2} & \cdots & c_{mn} \end{bmatrix}$$

From the above matrix we take the first column {C11, C_{21}, Cm1} that determines the
Maximum, minimum, and range choosing the number of equal subintervals to be partitioned. It may be defined and denoted as
Min {C_{11}, C21, C_{m1}} = u, max {C_{11}, C_{21}, C_{m1}} = v,
Range {C_{11}, C_{21}, and Cm1} = $\frac{max\{C_{11},C_{21},\ldots,C_{m1}\}-min\{C_{11},C_{21},\ldots,C_{m1}\}}{numberofsubintervals} = \frac{u-v}{h}$,
Where h' is for how many subintervals there are.

The number of subintervals selected will determine how many points the interval-valued partitioned data matrix will have. The interval-valued partitioning data matrix will contain h+1 points if the number of subintervals is assumed to be h'.
The interval-valued partitioned matrix denoted by

$$\begin{bmatrix} a_{11}, b_{11} & a_{12}, b_{12} & \cdots & a_{1n}, b_{1n} \\ a_{21}, b_{21} & a_{22}, b_{22} & \cdots & a_{2n}, b_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1}, b_{m1} & a_{m2}, b_{m2} & \cdots & a_{mn}, b_{mn} \end{bmatrix}$$

Second stage: calculates mean and standard deviation of each column using the formula,

$$\mu = \frac{\sum(a_{ij}, b_{ij})}{n} \sigma = \frac{\sqrt{\sum(a_{ij}, b_{ij} - \mu)^2}}{n}$$

Third Stage: The Interval valued matrix is converted into NRIVD matrix using the rule:

If ($a_{ij,}$ bij) < $(\mu_{1j}, \mu_{2j} - \alpha\ (\sigma_{1j}, \sigma_{2j}))$ then m_{ij} = (-1,-1) <antiA>
If ($a_{ij,}$ bij) = $(\mu_{1j}, \mu_{2j} - \alpha\ (\sigma_{1j}, \sigma_{2j}))$ then m_{ij} = (0, 0) <neut A>
If ($a_{ij,}$ bij) > $(\mu_{1j}, \mu_{2j} - \alpha\ (\sigma_{1j}, \sigma_{2j}))$ then m_{ij} = (1, 1) <A>

Final stage: Cumulate the entire row sum matrix we get the NCEIVD matrix.

4. Results and Discussion:
Data collected from World Bank and Yahoo finance on yearly basis. The various characteristics taken into account when examining macro variables are

Mv_1 – Inflation
Mv_2 – Interest rate
Mv_3 – GDP
Mv_4 – GDP per capita
The initial raw data matrix, IV matrices, average, and standard deviation are shown in tables 1, 2, and 3 below, respectively. The NCEIVD matrix's annual row sum is represented graphically.

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STEP 1:
Create the raw data (5x4) matrix by placing annual macroeconomic variables along the rows and columns.

Table 1: Initial raw data matrix

Year	Mv_1	Mv_2	Mv_3	Mv_4
2015	5.87	7.6	7.99	6.79
2016	4.94	6.2	8.25	7.08
2017	2.49	5.5	7.04	5.91
2018	4.86	4.7	6.12	5.02
2019	7.66	7	5.02	3.96

STEP 2: INTERVAL VALUED (IV) matrix
The raw data is transmuted into an interval-valued based matrix using [(u-v)/h] in each column. Six equal lengths of subintervals are then obtained.
1st column u=7.66, v=2.49, h=5 then the equal length of subintervals
[2.49 3.524 4.558 5.592 6.626 7.66]
2nd column u=7.6, v=4.7.h=5 then the equal length of subintervals
[4.7 5.28 5.86 6.44 7.02 7.6]
3rd column u=8.25, v=5.02, h=5
[5,02 5.666 6.312 6.958 7.604 8.25]
4th column u=7.08, v=3.96, h=5
[3.96 4.584 5.208 5.832 6.456 7.08]

Table 2: Interval Valued matrix

Year	Mv_1	Mv_2	Mv_3	Mv_4
2015	5.592, 6.626	7.02, 7.6	7.604, 8.25	6.456, 7.08
2016	4.558, 5.592	5.86, 6.44	7.604, 8.25	6.456, 7.08
2017	2.49, 3.524	5.28, 5.86	6.958, 7.604	5.832, 6.456
2018	4.558, 5.592	4.7, 5.28	5.666, 6.312	4.584, 5.208
2019	6.626, 7.66	7.02, 7.6	5.02, 5.666	3.96, 4.584

STEP 3:
The average and standard deviation are then calculated.
Mean (4.7648, 5.7988) (5.976, 6.556) (6.5704, 7.2164) (5.4576, 6.0816)
Standard Deviation (1.37176,1.37176) (.928,.928) (1.04963,1,04963) (1.01388,1,01388)

Table 3: The Average and the Standard Deviation (SD)

Average	4.7648, 5.7988	5.976, 6.556	6.5704, 7.2164	5.4576, 6.0816
SD	1.3717, 1.3717	0.928, 0.928	1.0496, 1.0496	1.0138, 1.0138

STEP 4: (NEUTROSOPHIC REFINED INTERVAL VALUED DEPENDENT (NRIVD) matrix
Select a parameter α from the range [0, 1] Utilising [def.2.5 NRIVD]'s matrix rules. The elements of the NRIVD matrix are derived from the IV matrix m_{ij}€ (-1,0,1). Each NRIVD matrix in relation to α€[0.1] is determined. When all the NRIVD matrices are joined, the NCEIVD matrix is obtained.

The NRIVD matrix α = 0.1 | The row sum matrix | NI

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$$\begin{pmatrix} (1,1) & (1,1) & (1,1) & (1,1) \\ (-1,-1) & (1,1) & (1,1) & (1,1) \\ (-1,-1) & (-1,-1) & (1,1) & (1,1) \\ (-1,-1) & (-1,-1) & (-1,-1) & (-1,-1) \\ (1,1) & (1,1) & (-1,-1) & (-1,-1) \end{pmatrix} \quad \begin{pmatrix} (4,4) \\ (2,2) \\ (0,0) \\ (-4,-4) \\ (0,0) \end{pmatrix} \quad \begin{bmatrix} \langle A \rangle \\ \langle A \rangle \\ \langle neutA \rangle \\ \langle antiA \rangle \\ \langle neutA \rangle \end{bmatrix}$$

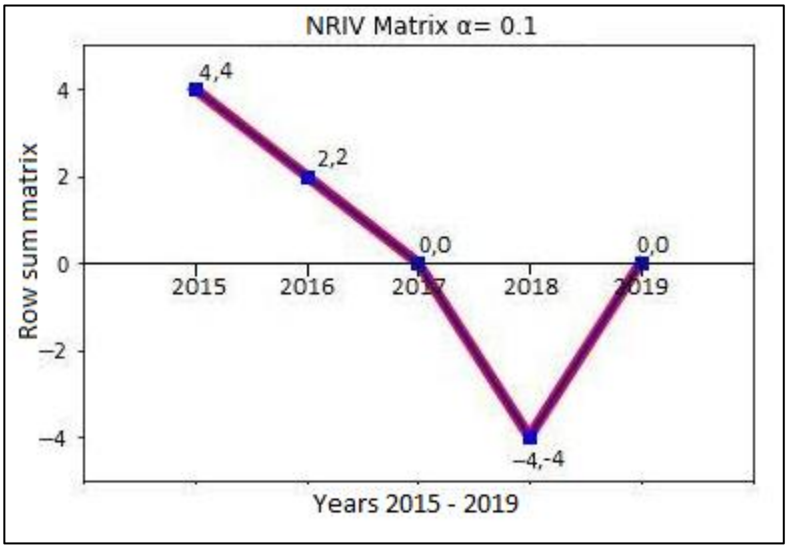

Figure 2: The graph depicting the impact of the stock market for =0.1

The NRIV matrix α= 0.2   The row sums matrix   NI

$$\begin{pmatrix} (1,1) & (1,1) & (1,1) & (1,1) \\ (1,1) & (1,1) & (1,1) & (1,1) \\ (-1,-1) & (-1,-1) & (1,1) & (1,1) \\ (1,1) & (-1,-1) & (-1,-1) & (-1,-1) \\ (1,1) & (1,1) & (-1,-1) & (-1,-1) \end{pmatrix} \quad \begin{pmatrix} (4.4) \\ (4,4) \\ (0,0) \\ (-2,-2) \\ (0,0) \end{pmatrix} \quad \begin{bmatrix} \langle A \rangle \\ \langle A \rangle \\ \langle neutA \rangle \\ \langle antiA \rangle \\ \langle neutA \rangle \end{bmatrix}$$

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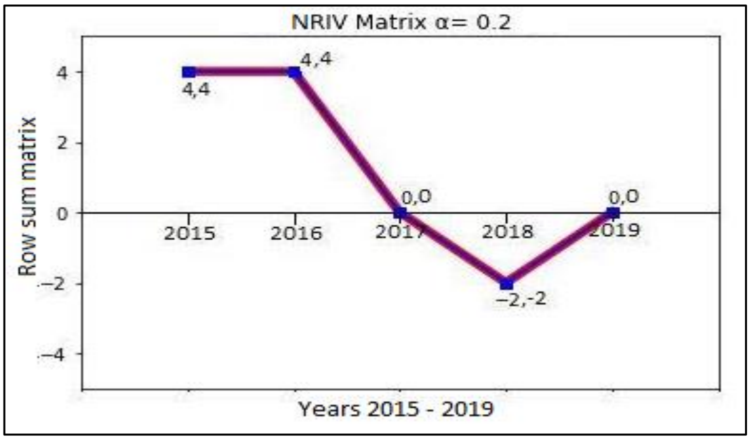

Figure 3: The graph depicting the impact of the stock market for = 0.2

The NRIV matrix for α=0.3 | The row sum matrix | NI

$$\begin{pmatrix} (1,1) & (1,1) & (1,1) & (1,1) \\ (1,1) & (1,1) & (1,1) & (1,1) \\ (-1,-1) & (-1,-1) & (1,1) & (1,1) \\ (1,1) & (-1,-1) & (-1,-1) & (-1,-1) \\ (1,1) & (1,1) & (-1,-1) & (-1,-1) \end{pmatrix} \quad \begin{pmatrix} (4,4) \\ (4,4) \\ (0,0) \\ (-2,-2) \\ (0,0) \end{pmatrix} \quad \begin{bmatrix} \langle A \rangle \\ \langle A \rangle \\ \langle neutA \rangle \\ \langle antiA \rangle \\ \langle neutA \rangle \end{bmatrix}$$

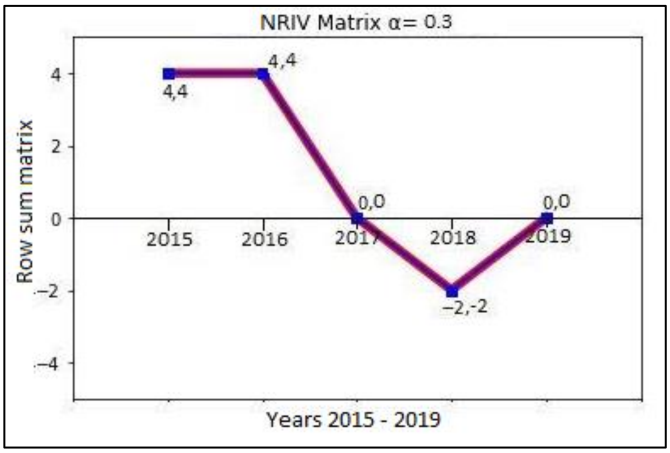

Figure 4: The graph depicting the impact of the stock market for α= 0.3

The NRIV matrix for α=0.4 | The row sum matrix | NI

$$\begin{pmatrix} (1,1) & (1,1) & (1,1) & (1,1) \\ (1,1) & (1,1) & (1,1) & (1,1) \\ (-1,-1) & (-1,-1) & (1,1) & (1,1) \\ (1,1) & (-1,-1) & (-1,-1) & (-1,-1) \\ (1,1) & (1,1) & (-1,-1) & (-1,-1) \end{pmatrix} \quad \begin{pmatrix} (4,4) \\ (4,4) \\ (0,0) \\ (-2,-2) \\ (0,0) \end{pmatrix} \quad \begin{bmatrix} \langle A \rangle \\ \langle A \rangle \\ \langle neutA \rangle \\ \langle antiA \rangle \\ \langle neutA \rangle \end{bmatrix}$$

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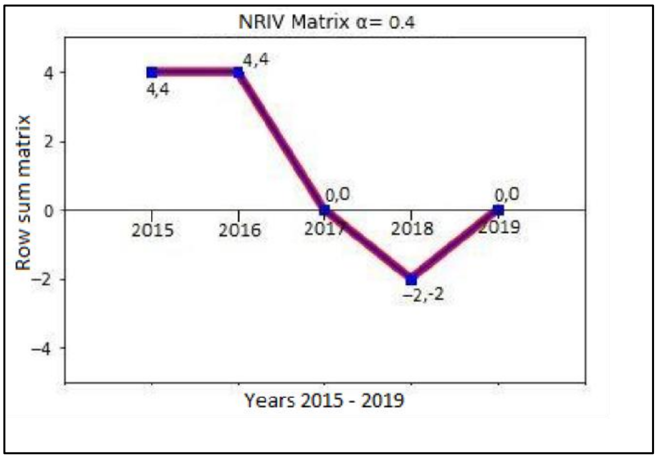

Figure 5: The graph depicting the impact of the stock market for α =0.4

STEP 5: (NEUTROSOPHIC COMBINED EFFECTIVE INTERVAL VALUED DEPENDENT (NCEIVD) matrix)

The NCEIVD matrix is a result of the Combination of all the NRIVD matrices.

The row sum of the CEIVD matrix along the y-axis and the year scale along the x-axis is depicted.

The NCEIVD matrix, The row sum Matrix, NI

$$\begin{pmatrix} (4,4) & (4,4) & (4,4) & (4,4) \\ (2,2) & (4,4) & (4,4) & (4,4) \\ (0,0) & (0,0) & (0,0) & (0,0) \\ (-4,-4) & (-2,-2) & (-2,-2) & (-2,-2) \\ (0,0) & (0,0) & (0,0) & (0,0) \end{pmatrix} \quad \begin{pmatrix} (16,16) \\ (14,14) \\ (0,0) \\ (-8,-8) \\ (0,0) \end{pmatrix} \quad \begin{bmatrix} \langle A \rangle \\ \langle A \rangle \\ \langle neutA \rangle \\ \langle antiA \rangle \\ \langle neutA \rangle \end{bmatrix}$$

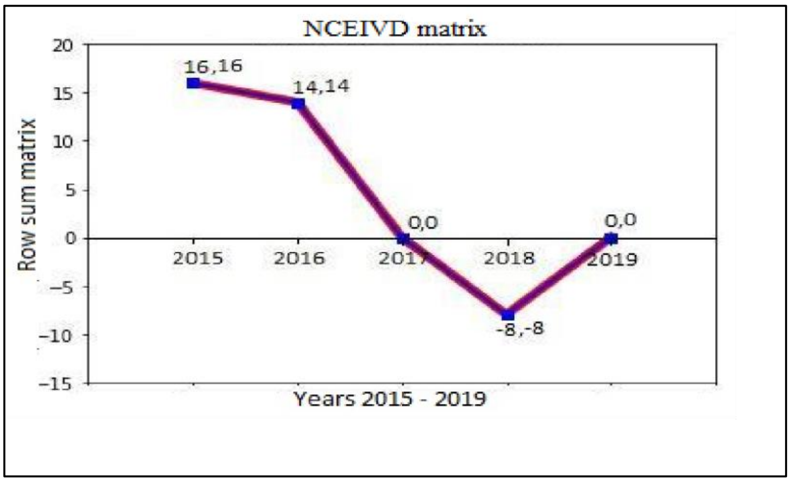

Figure 6: The graph depicting the impact of the stock market on NCEIVD matrix.

5. Conclusion

The paper analyses that 2015 and 2016 have a positive approach, that is, <A>. 2018 have the negative value i.e, <anti A>, and, 2017 & 2019 lie between the <A> and <anti A> i.e., <neut A>.

This NIVRD matrix implies that the study reveals that the impact of the stock market is a little higher in 2015 than in 2016. Between 2017 and 2019, it neither increased nor decreased while it was low in 2018 due to various factors. Several studies show that the CETD matrix is one of the solutions for various real-life problems. However,

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the present study involving the existing data and incorporating NEUTROSOPHIC Logic has proved that the same effective results may be obtained using the Interval valued matrix. It strongly proves that this is one of the ways to obtain results while taking the existing data from the stock market instead of a fuzzy CETD matrix.

6. References

[1] Aditya Prasad Sahoo, BCM Patnaik, and Ipseeta Satpathy. Impact of Macroeconomic Variables on Stock Market -A Study between India and America. European Journal of Molecular & Clinical Medicine, 7(11), pp.4469-4486, 2020.

[2] Anjanmukherjee and Abhikmukherjee. Application of fuzzy matrix theory in covid-19 pandemic. JOSR Journal of mathematics, 16(4), pp.52-56, 2020.

[3] F. Smarandache, Neutrosophy. Neutrosophic Probability, Set, and Logic, ProQuest Information & Learning, Ann Arbor, Michigan, USA, 105, 1998.

[4] F. Smarandache, R. Sunderraman, H. Wang, and Y. Zhang. Interval Neutrosophic Sets and Logic: Theory and Applications in Computing. HEXIS Neutrosophic Book Series, No. 5, Books on Demand, Ann Arbor, Michigan, 2005.

[5] Florentin Smarandache. Introduction to Neutrosophic Measure, Neutrosophic Integral, and Neutrosophic Probability, Sitech-Education Publisher, Craiova – Columbus, 2013.

[6] S. Obaid Jameel , A. Mahdi Salih , R. Adnan Jaleel , Musaddak M. A. Zahra, On The Neutrosophic Formula of Some Matrix Equations Derived from Data Mining Theory and Control Systems, International Journal of Neutrosophic Science, Vol. 19 , No. 1 , (2022) : 267-271

[7] Florentin Smarandache, Neutrosophic Statistics is an extension of Interval Statistics, while Plithogenic Statistics is the most general form of statistics (second version), International Journal of Neutrosophic Science, Vol. 19, No. 1 , (2022) : 148-165

[8] K. T. Atanassov, C. Cornelis, and E. E. Kerre. Intuitionistic Fuzzy Sets and Interval-Valued Fuzzy Sets: a Critical Comparison. In M. Wagenknecht and R. Hampel, editors, Proceedings of the Third International Conference on Fuzzy Logic and Technology, pages 159–163, 2003.

[9] K.Radhika, Anbalagan, Alexander and Suganthi Mariyappan. Risk factor of breast cancer using CETD matrix an analysis. International Journal of Applied Engineering Research, Research India publications, 14(4), 2019.

[10] M. Dummett. A Propositional Calculus with Denumerable Matrix. Journal of Symbolic Logic, 24(2), pp.97–106, 1959.

[11] M. Khoshnevisan and S. Bhattacharya. A Short Note on Financial Data Set Detection using Neutrosophic Probability. In F. Smarandache, editor, Proceedings of the First International Conference on Neutrosophy, Neutrosophic Logic, Neutrosophic Set, Neutrosophic Probability and Statistics, University of New Mexico, pp.75–80, 2002.

[12] M. Khoshnevisan and S. Singh. Neurofuzzy and Neutrosophic Approach to compute the Rate of Change in New Economies. In F. Smarandache, editor, Proceedings of the First International Conference on Neutrosophy, Neutrosophic Logic, Neutrosophic Set, Neutrosophic Probability and Statistics, University of New Mexico, pp.56–62, 2002.

[13] T. Subhramaniyan, S.Suruthi, M.S. Paulraj, M. G. Ragunathan, and J. Jayanthi. A Study On Finding The Most Prevalent Age Groups Of Diabetic Retinopathy Among Diabetic Population Using Fuzzy Matrix Theory, International Conference on Recent Trends in Computing (ICRTCE-2021), Journal of Physics: Conference Series, 1979. doi:10.1088/1742-6596/1979/1/012022.

[14] W.B.Vasantha Kandasamy, F.Smarandache. Fuzzy Cognitive Maps and Neutrosophic Cognitive Maps, Xiquan, Phoenix, 211, 2003.

[15] W.B.Vasantha Kandasamy and V.Indra. Maximizing the passengers comfort in the Madras transport corporation. Using fuzzy programming progress of mat. Banaras Hindu, Unit 3, 2, pp.91-134, 1998.

[16] Florentin Smarandache. Indeterminacy in Neutrosophic Theories and their Applications. International Journal of Neutrosophic Science (IJNS), 15(2), pp.89-97, 2021.

[17] Umberto Rivieccio. Neutrosophic Logics: Prospects and Problems. April 13, 2007

[18] E. H. Marcia Esther , F. H. Robert Alcides , P. P. Rene Estalin, Neutrosophic Statistics for Social Science, International Journal of Neutrosophic Science, Vol. 19 , No. 1 , (2022) : 250-259

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