Journal of Information Systems Engineering and Management
2025, 10(11s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Neutrosophic Interval Moving Average and Linear Regression Approach to Stock Market Volatility Prediction

S. Bhuvaneswari [1], G. Kavitha [2,*]

[1] Department of Mathematics, Hindustan Institute of Technology & Science, Tamil Nadu, India, prof.karuna@gmail.com
[2] Department of Mathematics, Hindustan Institute of Technology & Science, Tamil Nadu, India, kavithateam@gmail.com
*Corresponding Author: kavithateam@gmail.com

ARTICLEINFO

Received: 10 Nov 2024

Revised: 28 Dec 2024

Accepted: 16 Jan 2025

ABSTRACT

This study examines stock market closing prices using neutrosophic interval moving averages and neutrosophic interval linear regression techniques to address financial data uncertainty. The 5-day neutrosophic interval moving average achieved the lowest Mean Squared Error (MSE) of 43.43676, outperforming the 3-day (66.3552) and 10-day (89.1942) averages. In contrast, neutrosophic interval linear regression yielded a higher MSE of 126.7759, highlighting the superior accuracy of the 5-day moving average. This method successfully forecasted October values (25, 28, 29, 30), showcasing its reliability in trend analysis and prediction. The findings demonstrate the value of neutrosophic methods for enhanced stock market forecasting.

Keywords: Neutrosophic Time Series, Neutrosophic interval moving average, Neutrosophic interval linear regression, MSE.

INTRODUCTION

The stock market is a dynamic system influenced by economic, psychological, and geopolitical factors. Traditional methods often struggle to capture the uncertainties inherent in financial data. Neutrosophic logic, introduced by Florentin Smarandache, addresses these challenges by incorporating indeterminacy alongside truth and falsehood, making it well-suited for ambiguous data. This research explores the application of neutrosophic interval moving averages and neutrosophic interval linear regression techniques in predicting stock market closing prices.

A fundamental time series tool, the moving average smooths fluctuations to reveal trends. Integrating neutrosophic logic into 3-day, 5-day, and 10-day moving averages, the 5-day period demonstrated the lowest Mean Squared Error (MSE) of 43.43676, suggesting optimal predictive accuracy. Neutrosophic interval linear regression further enhances modeling by allowing partially true relationships, providing flexibility for real-world complexities. However, its higher MSE of 126.7759 indicates its limitations compared to moving average.

This study underscores the potential of neutrosophic techniques to manage uncertainty and improve prediction reliability. It highlights their applicability for smoothing data noise and accommodating market volatility. Future work could combine neutrosophic methods with nonlinear models or machine learning to capture complex patterns, expanding their utility for diverse financial applications.

METHODOLOGY OF NEUTROSOPHIC INTERVAL VALUED MOVING AVERAGE AND NEUTROSOPHIC INTERVAL VALUED LINEAR REGRESSION

Introduction	**Neutrosophic Interval Moving Average Method:** The neutrosophic interval moving average (NIMA) method provides an interval-based analysis of SBI stock's closing prices, including	**Neutrosophic Interval Linear Regression Method:** The procedure for Neutrosophic interval linear regression Method is as follows. Initially, obtain the historical data on SBI stock closing prices. The dataset is segmented

	trend detection and error measurement. Here is the step-by-step procedure:	in alignment with the moving average method as follows
Step - 1	Obtain the historical data on closing prices of the SBI stock. The data can be split, using the incremental height 'h' denoted by h = (mcp-MCP)/n , where 'mcp' is the minimum closing price, 'MCP' is the maximum closing price and n is the number of data. The split data partitioning is shown below as follows. mcp+h =np_1, np_1+h = np_2, np_2+h = np_3 ,..., np_{n-1}+h=np_n (MCP), and the split data of actual closing price can be represented by $'x_t'$.	The general form of the linear model of neutrosophic time series is given by $\hat{x}_t = \alpha_N + \beta_N\, t$ .where, $'x_t'$ be represented by the split data of the actual closing price. $'\hat{x}_t'$ represents the predicted closing price of the SBI stock price,$'\alpha_N'$ represents the constant coefficient, $'\beta_N'$ represents the regression coefficient and 't' represents time.
Step - 2	Calculate moving averages over different time frames (e.g., 3-day, 5-day, 10-day): • 3-day moving average: Add up the closing price of the last 3 days and divide by 3. • 5-day moving average: Add up the closing price of the last 5 days and divide by 5. • 10-day moving average: Add up the closing price of the last 10 days and divide by 10. The neutrosophic interval moving average is calculated using the formula, $NMA_t = \frac{1}{n}\,[\sum_{i=t}^{t+n-1}(LNP_i, RNP_i)\,]$ where 'n' is the degree of the closing price, 't' is the time, 'NMA_t' represents the neutrosophic interval moving average at the time t, 'LNP_t' represents the left side neutrosophic closing price at time 't' and 'RNP_t' represents the right side neutrosophic closing price at time 't'. $MA_t = \frac{1}{3}[\,[\sum_{i=t}^{t+2}(LNP_i, RNP_i)\,]$ n=3, $\frac{1}{3}[LNP_t + LNP_{t+1} + LNP_{t+2},\ RNP_t + RNP_{t+1} + RNP_{t+2}\,]$. For t=1, $NMA_1 = \frac{1}{3}[LNP_1 + LNP_2 + LNP_3, RNP_1 + RNP_2 + RNP_3]$ For t=2, $NMA_2 = \frac{1}{3}\,[\,LNP_2 + LNP_3 + LNP_4, RNP_2 + RNP_3 + RNP_4\,]$ Repeat this for other values of t. Similarly, calculate the 5-day and 10-day neutrosophic moving averages.	Compute $'\alpha_N'$, $'\beta_N'$ using the formulas, $\alpha_N = \bar{x}_t - \beta_{\bar{N}} t$ and $\beta_N = \frac{\sum(t-\bar{t})(x_t-\overline{x_t})}{\sum(t-\bar{t})^2}$. Next, find the Sum of the Squared Error (SSE) for the model using the formula given by, SSE = $\sum(NMA_i - \widehat{NPMA_I})^2$ where NMA_i is the neutrosophic interval moving average and $\widehat{NPMA_I}$ is the neutrosophic predicted interval moving average.
Step - 3	Determine trading signals based on the closing price's relationship to the moving average: • BUY (Green signal): If the closing price is above the moving average, indicating an uptrend. • SELL (Red signal): If the closing price is below the moving average, indicating a downtrend. • NEUTRAL (Black signal): If the closing price is approximately equal to the moving average.	Find the Sum of the Squared Error (SSE) using the formula given by, SSE = $\sum(x_t - \hat{x}_t)^2$

Step - 4	Calculate the Sum of the Squared Error (SSE) using the formula given by, SSE = $\sum(NMA_i - \widehat{NPMA_I})^2$.SSE can be converted into a single crisp value for comparison using the midpoint formula given by, $M_i = \frac{LNP_i + RNP_i}{2}$. where, $'M_i'$ denotes the midpoint of the interval value and $'\widehat{P}_I'$ denotes the midpoint of the predicted value.	SSE can be converted into a single crisp value using the midpoint formula given by, $M_i = \frac{LNP_i + RNP_i}{2}$ where, $'M_i'$ denotes the midpoint of the interval value, $'\widehat{P}_I'$ denotes the midpoint of the predicted value
Step - 5	The performance measures mean squared error is given by, MSE = $\frac{1}{n}\sum(NMA_i - \widehat{NPMA_I})^2$ This methodology allows for interval-based stock trend prediction while quantifying model accuracy through SSE and MSE.	Evaluate model performance by calculating the mean squared error (MSE) using the below formula, MSE = $\frac{1}{n}\sum((x_t - \hat{x}_t))^2$.This methodology allows us to use neutrosophic interval regression to predict future closing prices while providing an interval-based measure of uncertainty in the predictions.

RESULTS AND DISCUSSION

NEUTROSOPHIC MOVING AVERAGE

Collecting the one-month data from the State Bank of India (SBI) in 2024. In this analysis, we will calculate the moving averages for a given dataset using three different window sizes viz., 3, 5, and 10 periods. Table 1 represents the date and closing price of SBI and the interval valued are shown below.

Table 1: Data of closing price and interval valued of closing price

DATE	CLOSING PRICE (x)	x_t (INTERVALVALUE)
May 2	830.05	[829.08,830.59]
May 3	831.45	[830.59,832.1]
May 6	807.80	[806.43,807.94]
May 7	801.90	[801.90,803.41]
May 8	810.80	[809.45,810.96]
May 9	819.80	[818.51,820.02]
May 10	817.35	[817,818.51]
May 13	808.80	[807.94,809.45]
May 14	818.20	[817,818.51]
May 15	820.30	[820.02,821.53]]
May 16	811.95	[810.96,812.47]
May 17	817.85	[817.85,818.51]
May 21	830.65	[830.59,832.1]
May 22	818.75	[818.51,820.02]
May 23	832.10	[830.59,832.10]
May 24	828.60	[827.57,829.08]
May 27	833.70	[833.61,835.12]
May 28	831.15	[830.59,832.1]

May 29	822.65	[821.53,823.04]
May 30	825.85	[824.55,826.06]
May 31	830.35	[829.08,830.59]

Tables 2 represent the calculation of the 3-day moving average and the uptrend or downtrend signals and predicted error are calculated as shown below. Fig.1 represents the 3-day predicted closing price of the moving average as shown below.

Table 2. 3 -Day moving average and predicted error

x_t	3-DAY PREDICTED MOVING AVERAGE	UPTREND OR DOWNTREND	SIGNALS TO BUY OR SELL	PREDICTED ERROR
[829.08,830.59]				
[830.59,832.1]				
[806.43,807.94]	$(t_1+t_2+t_3)/3$			
[801.90,803.41]	$(t_2+t_3+t_4)/3$	[822,033,823.543]	red-sell	[-20.133, -20.133]
[809.45,810.96]	$(t_3+t_4+t_5)/3$	[812.973,814.483]	red sell	[-3.523, -3.523]
[818.51,820.02]	$(t_4+t_5+t_6)/3$	[805.927,807.437]	green-buy	[12.583, 12.583]
[818.51,820.02]	$(t_4+t_5+t_6)/3$	[805.927,807.437]	green-buy	[12.583, 12.583]
[817,818.51]	$(t_5+t_6+t_7)/3$	[809.953,811.463]	green-buy	[7.047, 7.047]
[807.94,809.45]	$(t_6+t_7+t_8)/3$	[814.987,816.497]	red-sell	[-7.047, -7.047]
[817,818.51]	$(t_7+t_8+t_9)/3$	[814.483,815.993]	green-buy	[2.517, 2.517]
[820.02,821.53]]	$(t_8+t_9+t_{10})/3$	[813.98,815.49]	green-buy	[6.040, 6.040]
[810.96,812.47]	$(t_9+t_{10}+t_{11})/3$	[814.987,816.497]	red-sell	[-4.027, -4.027]
[817.85,818.51]	$t_{10}+t_{11}+t_{12}/3$	[815.993,817.503]	green-buy	[1.857, 1.007]
[830.59,832.1]	$(t_{11}+t_{12}+t_{13})/3$	[816.277,817.503]	green-buy	[14.313, 14.597]
[829.08,830.59]	$(t_{12}+t_{13}+t_{14})/3$	[819.8,821.027]	green-buy	[-1.290, -1.007]
[830.59,832.10]	$(t_{13}+t_{14}+t_{15})/3$	[822.317,823.543]	green-buy	[8.273, 8.557]
[827.57,829.08]	$(t_{14}+t_{15}+t_{16})/3$	[826.563,828.073]	green-buy	[1.007, 1.007]
[833.61,835.12]	$(t_{15}+t_{16}+t_{17})/3$	[825.557,827.067]	green-buy	[8.053, 8.053]
[830.59,832.1]	$(t_{16}+t_{17}+t_{18})/3$	[830.59,832.1]	Neutral	[0, 0]
[821.53,823.04]	$(t_{17}+t_{18}+t_{19})/3$	[830.59,832.1]	red-sell	[-9.060, -9.060]
[824.55,826.506]	$(t_{18}+t_{19}+t_{20})/3$	[828.577,830.087]	red-sell	[-4.027, -4.027]
[829.08,830.59]	$(t_{19}+t_{20}+t_{21})/3$	[825.557,827.067]	green-buy	[3.523, 3.523]

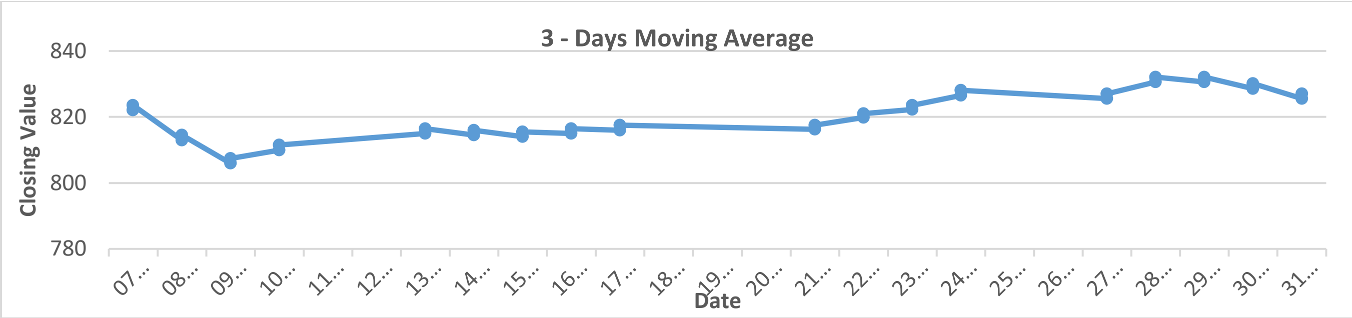

Fig. 1. 3-day moving average of closing price

Similarly, the same procedure followed to calculate 5-day and 10- day neutrosophic interval valued moving average and then calculate of performance measures of 3-day, 5-day, 10-day moving average are shown in Table 3.

Table 3 – Performance Measures of 3-day, 5-day and 10-day Neutrosophic Moving Average

Neutrosophic Moving Average	SSE	M_i	$M_i/2$	MSE
3- DAY	1199.333	2388.79	1194.395	66.35528
5- DAY	690.4417	1389.976	694.9882	43.43676
10 -DAY	940.1308	1874.272	937.1362	85.1942

NEUTROSOPHIC INTERVAL LINEAR REGRESSION ANALYSIS

Using the dataset and interval values from the above moving average dataset, neutrosophic interval linear regression technique was analyzed. In this analysis, neutrosophic interval linear regression was applied on a given dataset to understand the relationship between the two variables. Let us assume the following pair of data points for the independent variable (t) and the dependent variable (x_t). The predicted value of the closing price across various dates was calculated, as shown below.

$\bar{t} = \frac{\sum t}{n} = 16.9$

$\sum(t-\bar{t}) = 0.1$

$\sum(t-\bar{t})^2 = 1721.81$

$\bar{x}_t = \frac{\sum x_t}{n} = [820.64, 822.11]$

$(x_t - \bar{x}_t)$ = {[820.08,830.5] - [820.64,822.11]}, {[830.59,832.1] - [820.64,822.11]}, ..., {[829.08,830.59] - [829.08,830.59]}

$\sum(t-\bar{t})(x_t - \bar{x}_t) = [849.851, 849.770]$

Next, we calculated

α_N = [820.64,822.11] - [0.4934, 0.4935] (16.9)

= [[812.3015,813.7698]

β_N = [0.4934, 0.4935]

Substituting the above values in the formula, the results obtained are as follows.

$\hat{x}_t = \alpha_N + \beta_N t$

$\hat{x}_t$ = [812.3015,813.7698] + [0.4934, 0.4935] t

Similarly, substitute t =2, 3, ..., 31 to get the predicted values of neutrosophic interval linear regression on closing value. Additionally, the performance measures — sum of squared errors (SSE) of [1328.395,1333.899] and mean squared error (MSE) of 126.7759126.7759 — demonstrate the model's consistency with observed values. Fig. 2 and Fig. 3 shows the actual and predicted values of closing price in neutrosophic interval linear regression.

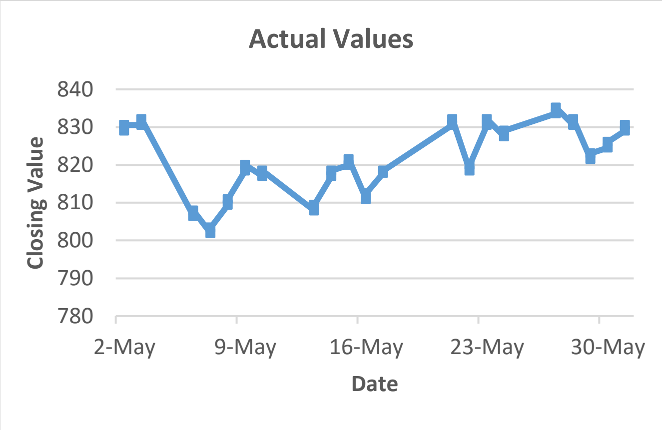

Fig. 2. Actual closing price

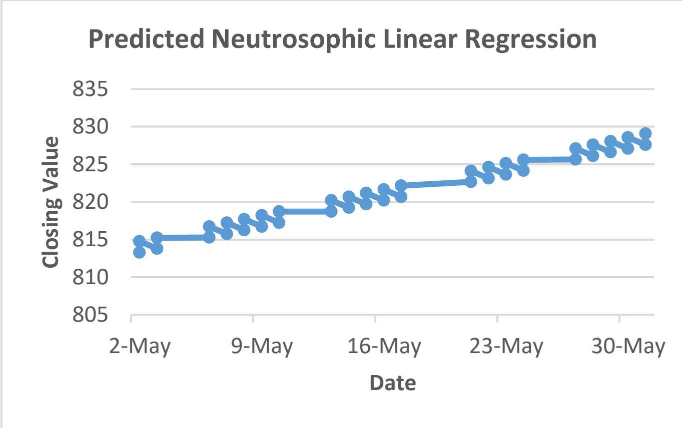

Fig. 3. Predicted closing price

We extended the model to forecast closing prices for future dates in October, specifically for days 25, 28, 29, and 30 using the below computation. $(t_{14}+t_{15}+t_{16}+t_{17}+t_{18})/5$ = [798.778, 801.708] [3176.36, 3188.08] + t_{18} = 5* [798.778, 801.70]. t_{18} = [817.53,821.27] Similarly, the other values of $t_{19}, t_{20}, t_{21}, \ldots$ are calculated as shown in Table 4.

Table 4 - Oct. month 5 days neutrosophic interval moving average and four future value (25,28,29,30) with performance measures

OCT MONTH	Neutrosophic Closing price	5 days predicted neutrosophic interval moving average
1	[794.090, 797.020]	
3	[794.090, 797.020]	
4	[794.090, 797.020]	
7	[770.650, 773.580]	
8	[779.440, 782.370]	
9	[797.020, 799.950]	[786.472, 789.402]
10	[797.020, 799.950]	[787.058, 789.988]
11	[797.020, 799.950]	[787.644, 790.574]
14	[802.880, 805.810]	[788.230, 791.160]
15	[802.880, 805.810]	[794.676, 797.606]
16	[802.880, 805.810]	[799.364, 802.294]
17	[808.740, 811.670]	[800.536, 803.466]
18	[817.530, 820.460]	[802.880, 805.810]
21	[811.670, 814.600]	[806.982, 809.912]
22	[788.230, 791.160]	[808.740, 811.670]
23	[785.300, 788.230]	[805.810, 808.740]
24	[791.16, 794.09]	[802.234, 805.224]
25	[817.53, 821.27]	[798.778, 801.708]
28	[794.39, 797.83]	[802.234, 805.224]
29	[805.51, 807.93]	[798.778, 801.87]

30	[768.02, 771.46]	[802.234, 805.224]
Performance Measures	SSE	4310.930968
	M_i	8724.240836
	$M_i/2$	4362.120418
	MSE	272.6325261

Using a 5-day neutrosophic interval moving average, predictions were made with an SSE of 4310.931, mean interval error Mi=8724.241 and MSE of 272.6325, as shown in Table 7. The results highlight the model's ability to capture variability and uncertainty in financial time series data, providing interval-based predictions close to observed values. This flexible approach benefits financial analysts by offering a broader view of potential price fluctuations, making it suitable for volatile datasets.

CONCLUSION

The application of neutrosophic interval techniques enhances stock market forecasting by addressing uncertainty in financial data. The 5-day neutrosophic interval moving average achieved the lowest MSE (43.43676), offering superior trend clarity compared to 3-day (66.3552) and 10-day (89.1942) periods. Neutrosophic interval linear regression, while robust in handling indeterminate behaviors, produced a higher MSE (126.7759). This highlights the 5-day moving average as an optimal method for reliable predictions. Limitations include linear assumptions, computational complexity, and reliance on historical trends. Future studies can integrate machine learning or nonlinear models to improve accuracy, expanding its application to dynamic markets and diverse variables.

CONFLICT OF INTEREST

The authors declare no conflict-of-interest diverse variables

REFERENCES

[1] Salama, A.A., et al (2014). Neutrosophic correlation and simple linear regression. Neutrosophic Sets and Systems, 5, 3. Gale Academic OneFile, link.gale.com/apps/doc/A436234703/AONE?u=anon~b969d970&sid=googleScholar&xid=af02d114

[2] Muhammad Aslam, & Muhammad Saleem (2023). Neutrosophic test of linearity with application [J]. *AIMS Mathematics*, 8(4), 7981-7989. doi: 10.3934/math.2023402

[3] RafifAlhabib&Salama A. A (2020). The Neutrosophic Time Series-Study Its Models (LinearLogarithmic) and test the Coefficients Significance of Its linear model. *Neutrosophic Sets and Systems*, 33, 105-115.

[4] RafifAlhabib&Salama A. A (2020). Using Moving Averages to Pave the Neutrosophic Time Series, *International Journal of Neutrosophic Science* (IJNS) 3(1), 14-20.

[5] Nagarajan D, Broumi S, Smarandache F &Kavikumar J (2021). Analysis of Neutrosophic Multiple Regression. *Neutrosophic Sets and Systems*, 43, 44-53.

[6] Rajarajeswari P & Uma N (2014). Correlation Measure For Intuitionistic Fuzzy Multi Sets, International *Journal of Research in Engineering and Technology*, 3(1), 611- 617.

[7] Karaaslan F (2019). Correlation Coefficient of Neutrosophic Sets and Its Applications in Decision-Making, Fuzzy Multi-criteria Decision-Making Using Neutrosophic Sets, Studies in Fuzziness and Soft Computing, 369, 327-360.

[8] Salama, A.A. &Elagamy H (2013). Neutrosophic Filters. *International Journal of Computer Science Engineering and Information Technology Reseearch*(IJCSEITR), 3(1), 307-312.

[9] Smarandach F (2003). Neutrosophic set a generalization of the intuitionistic fuzzy sets, Proceedings of the third conference of the European Society for fuzzy logic and Technolgye, EUSFLAT, SeptamperZittauGeamany; *Univ. of Applied Sciences at ZittauGoerlit* 2, 141-146.

[10] Ye, J. (2013) Multicriteria decision-making method using the correlation coefficient under single-valued Neutrosophic environment. *Int. J. Gen. Syst.* 42, 386–394.