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HYBRID GREY (1,1) FORECASTING MODEL FOR THE PREDICTION OF OPENING PRICE IN STOCK MARKET BASED ON GAME THEORETICAL MODEL UNDER UNCERTAINTY

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Abstract : Stock market prediction is act of determining the future value of market stock. The prediction of a stocks's future price could yield significant profit. However, the opening price of financial stock market is hard to predict because of its dynamic and unpredictable nature. These changes happen because of many internal and external factors. The research object of this paper is to introduce the methodology to predict future prices of nifty fifty stock price data based on GM(1,1) model with a triangular fuzzy number as parameter.

Keywords: Stock price, GM(1,1) Model, triangular fuzzy number, payoff, Forecasting

1. Introduction

The stock data are most demanding as because they are dynamic, non-liner and no common factor. So it's very difficult for the inverters to predict stock price without analyzing trends of stock price. The selection and performance of a proper forecasting methodology have always been an important planning and control issue for most firms and agencies.

The governmental and financial stability of an organization depends on the accuracy of the forecast since such information will most likely be used to make key decisions in the areas of human resources, purchasing, marketing, planning and development of any organization and firms.

Prediction stock price variation is a difficult task and the price movement behaves more like a random walk and various with time.Since the last decade, Stockpredictionhaslongattractedboth investors and researchers(Frankel,1995;Edwards et al., 2007; Bollen et al., 2011; Hu et al., 2018).

Recently, soft computing techniques are being increasingly employed. Artificial Neural Networks (ANNs) have been widely used prediction of financial time series. Comparison of the effectiveness of time delay, recurrent and probabilistic neural networks for prediction of stock trends based on historical data of the daily opening price is done in [2].Combinations of technical indicators and ANNs have been used in [8],[5],[3] and [9] for predicting of stock exchanges, exchange traded funds trading, determining buy/selling points for stocks and currency exchange rates, respectively. In [4], a Takagi–Sugeno– Kang type fuzzy rule based system using technical indexes as inputs, for stock price prediction. In this paper we make use of well established grey theory to predict stock prices for nifty fifty stock index.

The Grey Model GM(1,1) has been developed and successfully applied to many fields, in modern life such as social sciences, agriculture, traffic, transportation, marketing, business, engineering sciences etc[1], [6]. and achieved promising results. But as same as other forecasting models, the grey model GM(1,1) has some limitations. It is only applied to single exponential growth sequence, and the prediction results can achieve good accuracy. On the other hand, we can also know from the basic form of the grey prediction model that the GM(1,1) model is constructed according to the linear changing relationship between the raw data sequence and its 1-AGO sequence, but the variation usually appears in many systems is not linear between them, so many questions need to improve the GM(1,1) model for a higher prediction model accuracy. Details of proposed Model discussed in section 2.In section 3 lists experimental results obtained byusing GM(1,1) model and compare results obtained by using hybrid GM(1,1) model and finally section 4 concludes the paper.

2. The Basic Theory of Hybrid Grey System

2.1. Grey model

The steps of GM(1,1) model are shown as follows

Step 1: Original time sequence with n samples is define as:

$$O^{(0)} = \left(o^{(0)}(1), o^{(0)}(2), \ldots . o^{(0)}(n)\right). \quad (1)$$

Step 2: Construct monotonic increasing sequence O(1) by a one-time accumulated generating operation (I-AGO) expressed as:

$$O^{(1)} = \left(o^{(1)}(1), o^{(1)}(2), \ldots . o^{(1)}(n)\right), \quad (2)$$

where $o^{(1)}(k) = \sum_{i=1}^{k} o^{(0)}(i), \quad k = 1,2, \ldots . n.$

Step 3: From the GM(1,1) model by establishing a first order grey differential equation

$$o^{(0)}(k) + az^{(1)}(k) = b \quad (3)$$

where $z^{(1)}(k) = \frac{1}{2}(o^{(1)}(k) + o^{(1)}(k-1))$. In Equation (3),k(k=2,3,.....,n) is a time point,a is called the development coefficient and b is called grey action coefficient. Using least mean square estimation technique coefficients, [a ,b]T can be estimated as

$$[a ,b]T = (ATA)\text{-}1\ ATB \quad (4)$$

Where $B = \begin{bmatrix} O^{(0)}(2) \\ O^{(0)}(3) \\ \vdots \\ O^{(0)}(n) \end{bmatrix}, A = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix}.$

Step 4: According to the estimated coefficients A and B, the grey prediction equation can be obtained by solving differential equation in equation (3)

$$o^{(1)}(k+1) = \left(o^{(1)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a} \qquad (5)$$

where $o^{(1)}(k)$ denotes the prediction of o at k time point.

Step 5: To obtain the forecasting values of $o^{(0)}(k)$, $k = 2,3,\ldots\ldots n$,the inverse accumulated generating operation (I- AGO) is to establish the following grey model

$$\begin{cases} o^{(1)}(k+1) = \left(o^{(1)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a} \\ o^{(0)}(k+1) = o^{(1)}(k+1) - o^{(1)}(k) \end{cases} \qquad (6)$$

We can also simplify Equation (6) as

$$o^{(0)}(k+1) = (1 - e^{a})\left(o^{(1)}(1) - \frac{b}{a}\right)e^{-ak} \qquad (7)$$

The advantages of grey prediction model GM(1,1) is easy to calculate and suitable for many problems of approximate exponential change.

2.2. Triangular fuzzy number

The main purpose triangular fuzzy number is to increase the forecasting value. The residual time series[7] as the difference between real value and predicted value is obtained

$$\varepsilon^{(0)} = \{\varepsilon^{(0)}(2), \varepsilon^{(0)}(3), \ldots\ldots, \varepsilon^{(0)}(n)\}$$

Where $\varepsilon^{(0)}(k) = O^{(0)}(k) - \widehat{O}^{(0)}(k)$, $k = 2,3,3, \ldots\ldots, n$

Triangular fuzzy number

Let a, b and c be real numbers with a < b < c. Then the Triangular Fuzzy Number (TFN) A = (a, b, c) is the FN with membership function:

$$y = \varepsilon^{(0)}(k) = \begin{cases} 0 & k < a \\ \frac{k-a}{b-a} & a < k < b \\ \frac{c-k}{c-b} & b < k < c \\ 0 & k > c \end{cases}.$$

2.3 Game theory

Game theory is a multi-person decision making process or decision analysis. It is assumed that players have knowledge about situation, opponent player's strategies ,and preferences in game

theory. But most of the times, it is not possible to formulate all strategies implicitly because of the complexity of real situation (Law and Pan, 2008). A strategic game consists of set of players, strategies for each player and payoff for each strategy combination. If there is an interactive situation described as a game, a formal analysis should find optimal strategies for players and determine an expected outcome of game. A solution to a game is a certain combination of strategies.

Payoff Matrix and Optimal Strategies

In game theory [10], payoff matrix method is the most common method to analyzed time series. It is a mathematical representation of situation in which there are two players and one player's outcome is equal to the other's losses. Using above $\varepsilon^{(0)}(k)$to built game payoff matrix as follows

Table 1: Payoff Matrix

		Column player	
		Probability	y1 y2 ⋯yn
	Probability	Strategy	1 2⋯n
Row player	x1	1	a11 a12 ⋯ a1n
	x2	2	a21 a12 ⋯
	⋮	⋮	a2n
	xn .	M	⁝⁝⁝⁝
			am1 am2⋯ amn

Maximum (Row Minimum) = Minimum (Column Maximum)

2.4. Model evaluation

If the grey model achieves a certain predictive accuracy, not only the development coefficient, and takes a certain value ,but also the error of the grey model pass the error test. The calculation error can be defined as follows

The average absolute error (AAE): $\tilde{\varepsilon} = \frac{1}{n}\sum_{i=1}^{n} \tilde{o}^{(0)}(i) - o^{(0)}(i)$.

The average relative error (ARE): $\varepsilon_r = \frac{1}{n}\sum_{i=1}^{n} \left|\frac{\tilde{o}^{(0)}(i) - o^{(0)}(i)}{o^{(0)}(i)}\right|$.

3. Result and analysis

The nifty fifty data

The data chosen from 1stFebruary 2019 to 9thApril 2019 as table 2was obtain from nifty fifty stock indices.

Table 2: Nifty Fifty Stock Indices

Date	01-Feb-19	04-Feb-19	05-Feb-19	, , ,	.. ..	05-Apr-19	08-Apr-19	09-Apr-19
Open	10851.35	10876.75	10908.65	. . .	.. ..	11638.4	11704.35	11612.05

The grey GM(1,1) forecasting:

According to the formula equation (4) to calculate

$$[a, b]^{T} = [-0.002108434, 10622.15438]^{T}$$

And obtained corresponding function

$$\widehat{0}^{(1)}(k+1) = (50486786.593)e^{0.002108434k} - 5037935.243, k = 1,2,3, \ldots . . n$$

The real and forecast values shown in table 3 to compare GM(1,1) model accuracy and relative error Table 3: GM(1,1) Model value and predication error of stock market

Date	Open	GM(1,1)	relative error $\varepsilon_k^{(0)}$
01-Feb-19	10851.35	10851.35	0
04-Feb-19	10876.75	10656.26	2.027133
05-Feb-19	10908.65	10678.76	2.107446
06-Feb-19	10965.1	10704.18	2.379504
07-Feb-19	11070.45	10723.88	3.130568
08-Feb-19	11023.5	10746.52	2.512664
....	.....	.....	.....
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....	....	....	....
04-Apr-19	11660.2	11662.44	-0.01924
05-Apr-19	11638.4	11642.97	-0.03922
08-Apr-19	11704.35	11667.54	0.314503
09-Apr-19	11612.05	11692.17	-0.68994

Table 3

Now by applying triangular fuzzy number to improve our prediction value, first triangular fuzzy residuals are obtained as $\varepsilon_k^{(0)}$ as shown in table 3. Next corresponding triangular fuzzy membership function is:

$$y = \varepsilon^{(0)}(k) = \begin{cases} 0 & k < -2.1454 \\ \dfrac{k + 2.1454}{2.387969} & -2.1454 < k < 0.242569 \\ \dfrac{2.630568 - k}{2.387999} & 0.242569 < k < 2.630568 \\ 0 & k > 2.630568 \end{cases}$$

Here we use triangular fuzzy number as the entries in the payoff matrix, consider a fuzzy game between X and Y the fuzzified payoff matrix is given by A as follows.

$$A = \begin{bmatrix} 0.333 & 0.4444 & 0.2222 & 0 \\ 0.2941 & 0.52941 & 0.1765 & 0 \\ 0.0556 & 0.2222 & 0.6667 & 0.0556 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

In this game if X choose third row then Y will choose fourth column then X wins an value $x \in 0.0556$ is a triangular fuzzy number and Y losses the same value. According to the triangular fuzzy value, we obtain prediction value of stock opening price as shown in the figure1.

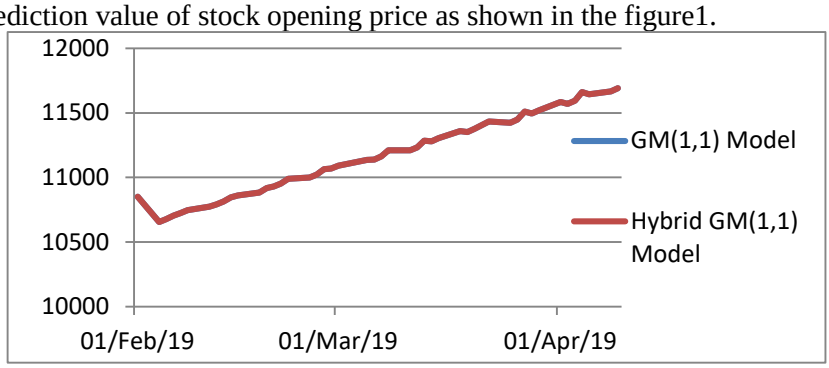

Figure :1 Nifty Fifty Prediction Value

Table 4:Relative Error –GM(1,1)&Hybrid GM(1,1)

Error Value	GM(1,1)Model	Game triangular fuzzy GM(1,1) Model
AAE	1.34%	0.03%
ARE	1.35%	0.04%

Form table 4 ,it is seen that relative error of GM(1,1)&Hybrid GM(1,1) model from 1stFeb, 2019 to 9th April, 2019.Hybird GM(1,1) has smallest error compared with GM(1,1) model, which means that hybrid GM(1,1) model reaches the adjective of minimizing of forecast error and has highly accurate forecasting power. Therefore we conclude that hybrid GM (1,1)significantly enhances the precision of a grey forecasting model.

4. Conclusion

The study result suggest that applying hybrid GM(1,1) to forecasting short term of number to open value in Nifty Fifty stock indices. In this paper, firstly, adding two additive factor to convert the row data into Grey series. Secondly, using a better solution to calculate backgroundseries.Finally,applying error correcting accumulation to eliminate residual error by using triangular fuzzy number. Then calculate the value of the game from residual error value of triangular fuzzy number.

As a result, the hybrid GM(1,1)model can we apply the predict the open value of Nifty Fifty stock indices with high accuracy. Therefore we believe that the GM(1,1) model and the grey forecasting theory have been deepened and expanded for our working. But still it is needed for further research about the application, optimization and other issues of the generalized GM(1,1)model and other forecasting grey system theories.

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