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Stock Price Forecast by Using Neuro-Fuzzy Inference System

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***Abstract*—**In this research, the researchers have managed to design a model to investigate the current trend of stock price of the "IRAN KHODRO corporation" at Tehran Stock Exchange by utilizing an Adaptive Neuro - Fuzzy Inference system. For the Long-term Period, a Neuro-Fuzzy with two Triangular membership functions and four independent Variables including trade volume, Dividend Per Share (DPS), Price to Earning Ratio (P/E), and also closing Price and Stock Price fluctuation as an dependent variable are selected as an optimal model. For the short-term Period, a neureo – fuzzy model with two triangular membership functions for the first quarter of a year, two trapezoidal membership functions for the Second quarter of a year, two Gaussian combination membership functions for the third quarter of a year and two trapezoidal membership functions for the fourth quarter of a year were selected as an optimal model for the stock price forecasting. In addition, three independent variables including trade volume, price to earning ratio, closing Stock Price and a dependent variable of stock price fluctuation were selected as an optimal model. The findings of the research demonstrate that the trend of stock price could be forecasted with the lower level of error.

***Keywords*—**Stock Price forecast, membership functions, Adaptive Neuro-Fuzzy Inference System, trade volume, P/E, DPS.

I. Introduction

NOWADAYS, Utilizing intelligent systems for the purpose of optimization and prediction in the various fields of Sciences, have extensive applications. Financial Management researchers have made extensive efforts to take advantage of Artificial Intelligence to optimize decision making process, extensive information processing and taking the opportunities to increase investment return. Their efforts have led to a relationship between the two human knowledge; that is, financial management and Artificial Intelligence which, in turn, have caused a new discipline been created as a financial Cybernetics. The efforts are being made for improving and utilizing Intelligent System such as neural networks, fuzzy systems and genetic algorithms in the field of financial decision making. The research taking advantage of one of the advanced techniques; that is, Neuro-Fuzzy Networks try to forecast and investigate stock price behavior.

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Fuzzy sets theory is a theory used for taking steps in an uncertainty. It could transform many concepts, variables, ambiguous and imprecise systems into mathematical models and paves the way for argumentation, inference, control and decision making in an uncertainty. A static or a dynamic system which uses fuzzy sets, fuzzy logics and/or analogous mathematical framework is called a fuzzy system.

In Adaptive Neuro- Fuzzy Inference System "ANFIS", a model such as "Takagi – Sugeno" is used for designing a pattern[1]. There are a few membership functions in this system which based on them the degree of membership of a variable in the domain (0,1) is determined. The most significant functions are triangular membership function with three parameters, trapezoidal membership function with four parameters, generalized bell membership function with three parameters, Gaussian curve membership function with two parameters, Gaussian combination membership function with four parameters, and sigmoidal membership function with four parameters.

Put it simply, we suppose that the desired fuzzy inference system has two inputs X_1, X_2 and an output Z. For first order Sugeno, the equation of If- Then is as follows:

$$\text{IF } (X_1 \text{ is } A_1) \text{ AND } (X_2 \text{ is } B_1) \text{ THEN } f_1 = P_1 X_1 + q_1 X_2 + r_1$$
$$\text{IF } (X_1 \text{ is } A_2) \text{ AND } (X_2 \text{ is } B_2) \text{ THEN } f_2 = P_2 X_1 + q_2 X_2 + r_2$$

When we calculate the equation of "First order Sugeno" the degree of membership variable of X_1 in membership function of A_1 are multiplied by the degree of membership variable of X_2 and in membership function B_1 and the product is deemed as a first Liner regression Weight (W_1).

Also, according to the second equation, the degree of membership variable X_1 in the membership function of A_2, is multiplied by the degree of membership variable of X_2 in the membership function of B_2 and the product is deemed as the second Linear regression weight (W_2).

As a result, the weighted average F_1 and F_2 is deemed as an ultimate output (Z) which is calculated as Follows: [1]

$$Z = \frac{W_1 \times f_1 + W_2 \times f_2}{W_1 + W_2}$$

II. Literature Review

The researches, conducted by "Chang & Chen", for forecasting Taiwan Stock exchange price deviation, "Takagi

and Sugeno" fuzzy system was used. This model forecasts stock price deviation with higher and positive reliance [2].

Also, in the researches carried out by "Afolabi & Olatoyosi" Some of the techniques such as fuzzy Logics, Neuro – fuzzy networks and Kohonen's Self – organizing plan were used for forecasting stock price. The results demonstrated that the deviation in Kohonen Self – Organizing plan was less than the other techniques [3].

In additional to that, the research done by "Bermudez & Segura" two fuzzy models have been introduced for Selecting Stock portfolio aiming at minimizing risk at the level of given return. In this research, securities yield is estimated by fuzzy figures of Linear programming as well as expected risk and return are calculated by spatial average. As a result, the selection of stock portfolio was formulated by linear programming with fuzzy figures [4].

Another research which was conducted by "Quek" in the area of using "ANFIS" and neuro- fuzzy network for forecasting investors' measures in the U.S. Stock Exchange Trade was studied. The model was pretty successful for predicting stock price in the U.S. Stock Exchange [5].

Also, in "Marcek" research, Box Jenkis analysis was introduced in time series analysis.

The utilization of auto regression model in forecasting stock price has previously been explained and following that, fuzzy – regression model and neuro – fuzzy network as two substitute methods for auto regression model for forecasting stock price are demonstrated [6].

III. Research Methodology and Objective

The prime objective of the research is designing and rendering a stock price forecast model with the help of "ANFIS" for IRAN KHODRO corporation. The research is aiming at to respond to the following question: Does "ANFIS" forecast IRAN KHODRO's stock price behavior at Tehran Stock Exchange?

Designing "ANFIS" is exclusive for any company and designed network is not applicable for other companies. For this reason, in the research, IRAN KHODRO Corporation is selected as statistical community. The core purpose of selecting the corporation for case study is its availability of stock price information, high liquidity of stock price, extensive ownership, daily high trade volume and high rate of free floatation stocks. In addition, the company is one of the large – sized manufacturing corporations which has a large volume of capital in comparison to other companies within the period of research. Moreover, the number of its traders at Tehran stock Exchange is higher in comparison to other companies as well as is among the seven companies in terms of liquidity.

Data has gathered from data base of Tehran stock exchange [7]. Since "ANFIS" requires extensive and inclusive observations due to indentifying a pattern and learning from it, all information relevant to IRAN KHODRO's stock price at Tehran Stock Exchange from the year 1997 to 2004 inclusive are used.

Training data period for the long-term is from 1997 to 2004. During this period 1599 days were selected for the training data and 90 days were selected for the testing data. MATLAB software is utilized for the research which its fuzzy logics tool kit is used for designing the model.

IV. Measurement of Errors and Data Analysis

In a bid to respond the research question two time periods are determined:

a. Long – term period includes stock price information from 1997 to 2004 and
b. Short – term period includes stock price information from the year 1997 to 2004 which are divided into four seasonal quarters.

In the long – term period, four variables include trade volume, DPS, P/E and closing price are deemed as independent variables and stock price fluctuation as a dependent variable.

In "ANFIS", trial and error test is used in order to identify the pattern. Therefore, different pattern with respect to membership functions and testing and training data are designed as well as with respect to the level of error of testing data, an optimum model been selected.

Training data are data which the system uses them for learning and model design. Testing data are used for made model test. Training error is a deviation which exists between the observed data in the training period and system outputs. Testing error is a deviation which exists between real value in the testing period and system outputs.

Since in this research, time series methods are used, stock price fluctuation is resulted from annual and extra ordinary General meeting decisions of the company must be adjusted. In a sense, influential factor on expected price fall subsequent to meeting decisions should be eliminated in a way that adjusted price fluctuations could be resulted from market supply and demand.

Thus, all stock prices subsequent to the meetings would increase as much as dividend Per Share (DPS) because the highest decrease of stock price subsequent to the meetings resulted from DPS payment. The results of the modeling are demonstrated in Table I.

TABLE I
System Testing Errors (Long-Term Period)

Types of Membership Function	Membership Functions No.	Testing Error
Triangular Membership Function	2	0.146
Trapezoidal Membership Function	2	0.152
Generalized bell Membership Function	2	0.330
Gaussian Curve Membership Function	2	0.176
Gaussian combination Membership Function	2	0.158
Sigmoidal Membership Function	2	0.160

As Table I demonstrates, the least testing error is related to triangular membership function. The best model neuro – fuzzy for forecasting IRAN KHODRO's stock price is a model with four input variables, including trade volume, DPS, P/E and closing price.

In a short – term value DPS variable in terms of its fix value in year is not deemed as input. Since "ANFIS" is an intelligent system, the variables with a fixed value don't affect the calculations.

Therefore, in this type of modeling, three input variables including trade volume, P/E and closing price are deemed as independent variables and stock price fluctuation as a dependent variable.

Training data in the modeling includes information of years 1997-2003 which is seasonally separated. In addition, testing data includes information of the year 2004 which is seasonally separated. The selection of optimal model is made with respect to the level of testing error data. The outcome of the modeling is introduced in Table II.

TABLE II
THE PERCENT OF THE SYSTEM TESTING ERROR (SHORT-TERM PERIOD)

	The Percent of Testing Errors			
Types of Membership Function	**First Quarter**	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
Triangular Membership Function	16.77	3.97	0.6	18.63
Trapezoidal Membership Function	77	3.43	223	1.19
Generalized bell Membership Function	279	4.88	0.88	2.62
Gaussian Curve Membership Function	20.8	5.44	0.8	2.44
Gaussian combination Membership Function	191	5.65	0.56	31.46
Sigmoidal Membership Function	44.77	5.89	3.4	4.79

As it is demonstrated in Table II, the least percent of the level of error in the first quarter, is related to triangular membership function, in the second quarter, to trapezoidal membership function, in the third quarter to Gaussian combination membership function, and in the fourth quarter, to trapezoidal membership function.

It should be noticed that the system are faced with a higher error, where it models through applying trapezoidal, generalized bell, and Gaussian combination membership functions for the first quarter as well as for the third quarter through applying trapezoidal membership function.

V. VALIDITY TEST OF THE MODEL

Following the designing the model, in order to investigate its accuracy and validity, the data of the first quarter of the year 2005, is introduced to the system as checking data and the output of the model is compared to real values.

The result of the investigation is demonstrated in Table III and Fig. 1.

In order to measure adaptation of a forecast by time series data pattern, from the error is used.

If Y_t is an indicator of real value of the variable in time (t) and $\hat{Y}$ is an indicator of forecasted value of the variable, as a result, the error is as follows:

$$e_t = Y_t - \hat{Y}_t$$

In Table III, the first column shows the days of trading in the first quarter of the year 2005, the second column, the percent of the real price fluctuation as compared with the previous day, the third column, the percent of forecasted price fluctuation based on four input variables, and the fourth column, shows the deviation between the percent of real price fluctuation and the percent of price fluctuation based on checking data.

As it is demonstrated, the real data and calculated data by the system are chiefly consistent.

In the Fig. 1, since vertical axis domain is small and confined. However, the deviation between the percent of real price and the percent of forecasted price fluctuation could be seen.

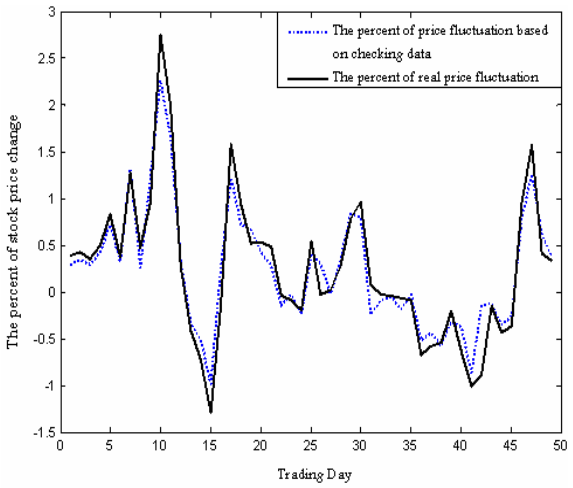

Fig. 1 The percent of real stock price fluctuation as compared with the percent of price fluctuation based on checking data for the first quarter of the year 2005

TABLE III
CHECKING ERROR PER DAY FOR THE FIRST QUARTER DATA IN THE YEAR 2005 BASED ON LONG-TERM OPTIMAL MODEL

Trading Day	The Percent of Real Price Fluctuation	The Percent of Price Fluctuation Based on Checking Data	Checking Errors
1	0.39	0.30	0.09
2	0.43	0.35	0.08
3	0.36	0.30	0.06
4	0.5	0.43	0.07
5	0.83	0.73	0.1
6	0.38	0.31	0.06
7	1.27	1.32	-0.05
8	0.48	0.26	0.22
9	0.96	1.24	-0.28
10	2.75	2.26	0.49
11	1.99	1.66	0.33
12	0.28	0.34	-0.06
13	-0.41	-0.32	-0.09
14	-0.72	-0.50	-0.22
15	-1.29	-0.98	-0.31
16	-0.13	0.27	-0.40
17	1.59	1.23	0.36
18	0.94	0.72	0.22
19	0.52	0.66	-0.14
20	0.54	0.43	0.11
21	0.49	0.28	0.21
22	-0.04	-0.15	0.11
23	-0.09	-0.03	-0.06
24	-0.19	-0.24	0.05
25	0.55	0.40	0.16
26	-0.02	0.31	-0.33
27	0.02	-0.01	0.03
28	0.28	0.36	-0.08
29	0.78	0.83	-0.05
30	0.97	0.8	0.17
31	0.08	-0.24	0.32
32	-0.02	-0.08	0.06
33	-0.04	-0.05	0.01
34	-0.06	-0.18	0.12
35	-0.08	-0.03	-0.05
36	-0.67	-0.51	-0.16
37	-0.57	-0.43	-0.14
38	-0.54	-0.58	0.04
39	-0.2	-0.31	0.11
40	-0.63	-0.36	-0.27
41	-1.01	-0.86	-0.15
42	-0.89	-0.14	-0.75
43	-0.15	-0.12	-0.03
44	-0.43	-0.35	-0.08
45	-0.36	-0.25	-0.11
46	0.95	0.79	0.16
47	1.57	1.26	0.31
48	0.42	0.62	-0.20
49	0.33	0.48	-0.15

Table IV, demonstrates several types of calculated errors for the first quarter of the year 2005.

TABLE IV
ERRORS INDEXES IN THE OPTIMAL MODEL

Errors Indexes	Error
Mean Absolut Deviation	0.1673
Mean Squar Error	0.0470
Mean Absolute Percentage Error	0.9147
Mean Percentage Error	0.4625
Bias	-0.0021

VI. RESEARCH OUTCOMES

Based on analyses made, the research outcomes are as follows:

1- Taking the low level of errors in the long and short – term modeling into account, it could be concluded that the "ANAFIS" is capable of forecasting IRAN KHODRO's stock price behavior.

2- The most significant outcome is that IRAN KHODRO's stock price behavior is non-linear model at Tehran Stock Exchange, because fuzzy models are basically among the non-linear models and also all the models include more than one independent variables. Thus, forecasting stock price with non-linear methods could decrease the error estimation of the stock price.

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