PREDICTING KSE 100 INDEX BY USING ARTIFICIAL NEURAL NETWORK

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Sadia Sheikh[1], Waqar Sethar[2], Dr Kamleshwer Lohana[3]
[1,2,3] *Mehran University, Institute of Science &Technology Development (MUISTD)*

Abstract: Predicting a stock exchange movement is becoming a new trend. Nowadays in finance because if it is better predicted, investors will get a more exact or ideal predictions and carry economic benefits as well. Recently, an artificial neural network have been popularly used to prediction of Stock Exchange movements. The key objective of this paper is to predict stock exchange movements by using NARX model with the help of Neural Network toolbox Tests and MATLAB. This study uses a non-linear autoregressive network with exogenous inputs (NARX) for period of July 2008 to July 2017 and data gathered from Karachi Stock Exchange website. The set of training comprises of 70% of data, 15% of validation and 15% used for testing respectively. Results demonstrate that the KSE-100 Index is forecast successfully by using ANNs with NARX methodology. Hence, this model gives more accurate, effective and optimal results as compared to other neural networks.

Keywords: *Artificial Neural Network (ANN), Karachi Stock Exchange (KSE), Feed Forward Neural Network (FFNN), Non-linear autoregressive with exogenous inputs (NARX), Matlab*.

1. Introduction

The Stock Market is a spot where stocks or shares are traded. It consists of two main categories;

-Primary Market
-Secondary Market

Primary Market is a marketplace where new shares are distributed and sold at first through Initial Public Offerings. (IPOs). Whereas, the Secondary Market is a place where investors sell securities among themselves and already own. Stocks of Larger Companies are sold and purchased through Exchanges. As is well known Stock Market have a nonlinear time series data and it is complicated in nature. Stock Market is a captivating abode for financiers to make plus earn a profit through short term and long term investments.

How to develop and use different methods to predict non-linear data accurately is recently a new agenda of discussions in today's suitable minds in the entire world. To predict more accurately and efficiently as compared to traditional statistical methods after the evolution of efficient programming technologies. Different linear models like AR, ARMA,ARIMA have been used for stock market predictions. The only issue with these models is that they are not suitable because of incomplete data as real life situations are very complex and cannot easily controlled by linear models. Predicting Stock Exchange Market carries a huge risk as compared to that of other sectors. This is one of the main reason for the difficulty in predicting Stock Exchange movements. The Application of ANN (Artificial Neural Network) is very successful in predicting problems due to following attributes:

- ✓ ANN has a great ability of modelling and processing complex relationship between inputs and outputs.
- ✓ ANNs can categorize new test samples even if they are not used throughout the training of the network.
- ✓ Artificial neural network also helps users to understand quickly the complexity of data and gives accurate and optimal predictions.

Predicting the growth of a financial instrument like Stock produced some economic benefits and there are numerous strategies that have been applied to make the prediction successful. After that, techniques of machine learning and of artificial intelligence have been used for predicting the stock movements and to model stock prices. The Stock Markets are one of the most captivating investment places for earning higher returns. The Stock Market is the most complicated, non-volatile and difficult to predict because of nonlinear data. It is all about demand and supply, influenced by macroeconomic factors such as inflation, interest rate, and political instability. Apart from that, it is also affected by many economic, psychological and political factors. All these can impact the whole market, while company financial announcements or products released by the company just affect individual stocks.

Corresponding author Email address: *sadia.shaikh73@hotmail.com*

Market participants are often divided into two groups, Traders who make a decision on the basis of market economic factors. Such type of analysis uses statistics, projections, demand, supply conditions, and everything from the overall economy and industry conditions are known as 'Fundamental analysts'. While, decisions based on the historical market data i.e. prices and volume, known as 'Technical analyst' or 'chartists', are used for foresee the behavior of the market by generating different patterns by the study of charts. Recently, machine learning approaches have been useful for linear and non-linear data on different patterns. This is also used to forecast the path of the Stock Market.

Through the development of new models which give more precise forecasts about the trend of stock prices through neural networks or other machine learning techniques is still a new concept from a research point of view. As all know that machine learning is the arena of computer science that uses statistical procedures & methods that will give the ability to the computer to work genuinely intelligent. It includes many models like ANN, SVM, ANFIS. Nowadays, usually, traders use machine learning methods to calculate the movement of Stock Markets. Basically, machine learning techniques have been adopted for incomplete data and accurate results. As, the fundamental approach is challenging, so it is difficult to evaluate stock with insufficient data.

In recent times, traders have used a computers with the fundamental approach because of the complexity of input, like news written in a natural language. This approach applies to natural language models together with the techniques called machine learning, to evaluate how a given news will affect a related stock in the upcoming future whereas, technical analysis uses a past trading history for evaluation of stocks which is also known as time series. The scope of machine learning techniques has been increasing day by day. Still, many researchers are exploring machine learning techniques by adopting numerous mathematical models. This study is based on a family of a model named as 'Artificial Neural Networks'. The most important difficulty in the Stock Market is to predict value of a company's stock or trend of the exchange market. It became very demanding for stockholders to make the correct decision in terms of buying or selling stock or for investing purposes.

Mainly, analysts use conventional methods i.e. fundamental analysis and technical analysis for the calculation and analysis of stock prices. Analysis based on Neural-Networks will give better and accurate predictions, especially when the data is non-linear. The significant aim of this is to forecast the KSE 100 index by using ANN for more accurate predictions. In this study, neural network has been applied to calculate stock exchange of Karachi- 100 index.

2. Related Work

The Stock Exchange Market is most complicated in nature, difficult to understand and measure its trends. This market also identified as "equity market" or "share market". Stocks are unpredictable so, for the investors, it is one of the biggest challenges to predict the movements of the following day prices or rates. To make predictions possible by applying different approaches or methods include; fundamental analysis, technical analysis, time series with traditional models and machine learning algorithm (De Oliveira, Nobre, & Zarate, 2013).

Chen (2003) carried out a study for predicting the way of movements by using different financial instruments to envisage the movements of the Stock Market Index in order to develop such trading strategies that help investors to predict/ forecast their profits or returns.

Because of machine learning techniques and different algorithms, it is easy to predict the future prices and Stock price movements and it becomes essential for creating better trading strategies and decision making for analysts, stockholders and specialists of that field. Also, it is reported that most common approaches adopted like Artificial Neural Networks (ANN) and Support Vector Machines (SVM). For prophesying the direction of stock prices using neural networks mostly by other countries. However in Pakistan, these techniques are not commonly used to forecast the rates of stock market prices as per initial information.

Manish and Thenmozhi (2005) investigated S&P CNX NIFTY to estimate the day-to-day movement of National Stock Exchange of India by using SVM and compared it with all traditional models. ANN is one of the finest technique to predict & model Stock Exchange Markets (Guresena, Kayakutlua, & Daimb, 2011).

Qiu (2012) tried to establish a new model for the forecast of the stock price of the Shanghai composite index by using Fuzzy Interference Systems based on Fuzzy time series. Correspondingly, George (2009) enhanced a model to forecast the movement of stock prices trend known as "Adaptive Neuro-fuzzy Interference Systems" and determine the capability of ANFIS for estimating the Exchange Index.

An artificial neural network is a computational model or learning model, deals especially with the data which is non-linear or intricate in nature. They have an ability of modelling, and process complex relationships between inputs and outputs. The field of artificial intelligence aims at enhancing the intellectual abilities of machines. It deals with subjects like natural language processing, reasoning, learning, visual perception and physical movement, among others. The sub-field of artificial intelligence known as machine learning seeks to make computers learn from observations. While statistical time series models are for specific kinds of tasks, machine learning algorithms are for a wide range of uses and can be fitted to an immense number of issues, such as; Stock price prediction.

According to Cao, Leggio and Schniederjans (2005) who examined and proved the ability of artificial neural network (ANN) for calculating Stock Exchange direction or movement of companies which are listed on the Shanghai Stock Exchange (SHSE). Also by comparing capital asset pricing model (CAPM) plus fama and french's 3-factor model to forecast different variables i.e. univariate and multivariate resulted reveals that neural networks have implemented better than Linear Models.

Egeli (2003) investigated the Istanbul Stock Exchange for calculating stock market index by means of artificial neural networks (ANNs). Results showed that the various traditional approaches compared to neural network indicated that Neural Networks are better than linear models. Although, Canadian stock exchange calculated by using accounting ratios, and their findings showed ANN gave more accurate predictions as compared to other approaches (Zahedi & Rounaghi, 2015).

According to Amin (2016) if ANN trained with back propagation algorithm using several feedforward ANNs to determine the forecasting ability of a model that shows more efficient results in terms of Stock Exchange Rate Prediction. Mostafa (2010) reported that Neural Networks (NN) is best for handling non-linear data and Neural Networks Models are more useful for understanding the complicated Stock Market. Their Performance and results are much better than other traditional techniques.

Artificial Neural Network provides better, effective and accurate results in terms of predicting stock prices as compared to all other techniques. For Karachi Stock Exchange (KSE) as per my opinion, the artificial neural network is the best method and model for calculation of stock rates/prices. Moreover, the direction of upcoming stock prices i.e. Interest rate, inflation, opportunities, sudden events, political uncertainty can be affected by the economic conditions of any country. ANNs is applied where the data is non-linear and the relationship between input and output is complicated in nature.

Working with ANNs has its own unique set of challenges; one of them is to find an optimal architecture. Many new temporal models of ANN could be used as an initial step. The majority of networks could further be developed as deep networks with additional architectural liberty. Experiments should indicate how contemporary neural networks work for non-linear time series prediction, particularly, and stock price forecasting.

3. Methodology

As it is a quantitative research study, data is collected from secondary sources through the Pakistan Stock Exchange official site. Basically, the methodology is the key element of research to obtain the research objectives. This study covers the past 10 years of prices of the Stock index, data used July 2008 to July 2018 through MATLAB analysis. The first few years of KSE 100 index will be used to train, validate and test the neural network, although the last few years of KSE 100 Index will be used to make future predictions. Meanwhile, the data includes open, high, closing prices of the day, volume and date.

Firstly, Stock Exchange data has been normalized before training the network. Data have been normalized by using SPSS to remove the bias. By normalizing all variables like open, close, high, low and volume. This makes all these variable perfectly normal. If you plot them on a histogram, they will show a perfectly normal distribution using functions in SPSS.

After collecting all required data, create and trained the two layer feed forward neural network with levenberg marquardt algorithm used in the Neural Network toolbox. Distributions of training data for each test was changed due to network reconfiguration and in every single sample has four inputs and one target that represents particularly the number of neurons which is used in the input and output layer. The main cause for choosing this training algorithm is that it suits and solves most of the problems regarding this issue, whereas other alternatives are suitable for smaller or larger problems.

Basically, network configuration depends mostly on changing the distribution of training data and number of hidden layer neurons as well each time network formation

was retained ten times. In lieu of all the anticipated values the mean accuracy, maximum, minimum, median, mode, standard deviation and range has recorded. This method is applied to all ten retained networks, through this process all mean values were measured to get the average accuracies for the following configuration.

Neural network performance is assessed using specified functions. Mainly, error functions are used, for instance, error histogram, training state, error autocorrelation, regression and sum of squared error. Although, the mean squared error (MSE) is the most common function and used in this study for ANN training. Data has been analysed with MATLAB and excel. Results are exhibited below.

4. Results and Discussion

The research under consideration made use of default MATLAB settings. These include default MATLAB values which are used for number of neurons and the distribution of training data sets. It has been stated earlier that the distribution of data represents 70% for training and 30% for the target that means 15% for validation and 15% for testing. Figure 1, illustrates the network infrastructure in this case. It is evident from the said figure that the hidden layer consists of 10 neurons, while the output layer contains a single neuron.in addition, training allows the 'weights' of these neurons to provide accurate outputs. Weights are represented in the following figure as 'w' while 'b' represents bias units.

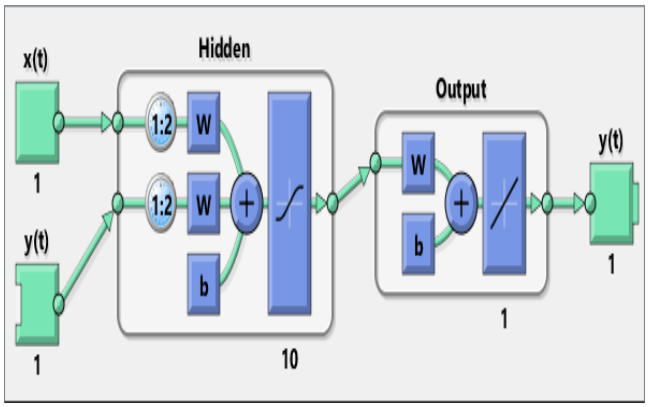

Figure 1. Two-layer NARX network Architecture with 10 hidden Layers

Above figure 1, showing the network structure composed of 10 hidden layer and 1 outer layer neurons. In addition to that, it also provides insights into the procedure used to create the network architecture in MATLAB.

Apart from that, it clearly demonstrates that first of all training is performed in open loop known as Series Parallel Architecture. This involves validation and testing steps. This entire process is focused on the formation of a network in an open-loop and after training, validation and testing, the network can be transformed into a closed-loop system. This conversion is justified by the fact that after completion of all three tests, the network served to make prediction which are more accurate and feasible regarding stock prices. R-value should be close to one that exhibits the data is perfectly fit.

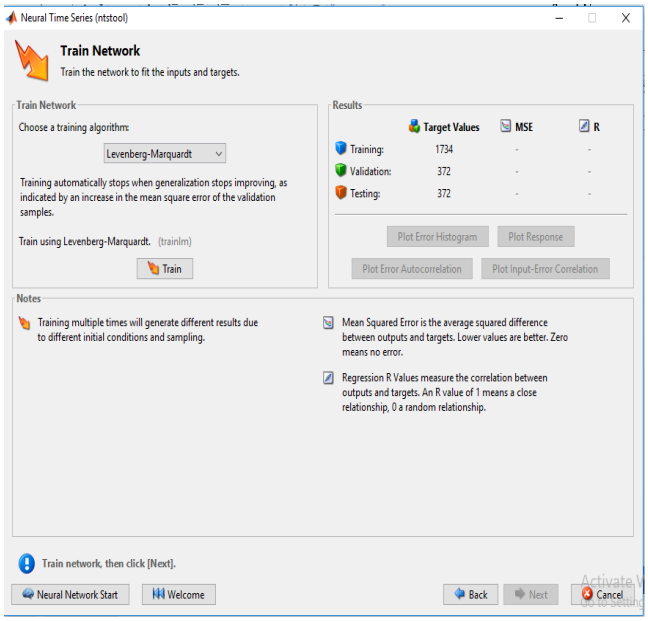

Figure 2. Training of Network

The figure 2 and 3 shown illustrates further information regarding the training phase pertaining to artificial neural network development. It provides insights into the following aspects related to training:

- ⇨ Input values
- ⇨ Target values
- ⇨ Details of the progress bar
- ⇨ Hidden neurons
- ⇨ Output
- ⇨ Network architecture input

In addition to that, it contains a separate section on algorithms, which provides information regarding:

- ⇨ Division of data
- ⇨ The training algorithm utilized here
- ⇨ Mean standard error
- ⇨ Overall performance

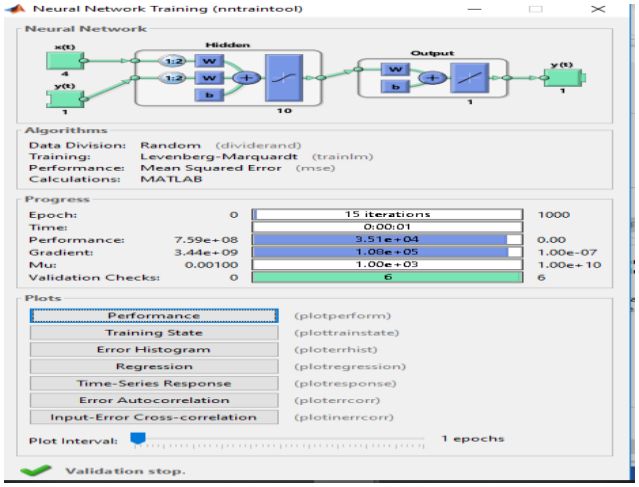

Figure 3. Neural Networking Training (nntraintool)

Moreover, the error has been tested with a histogram with 20 bins which shows that the vertical bars, a range of total errors are (-0.222) left bin to (0.1968) rightmost bin. Each vertical bar demonstrates a range of errors, and the number of values from the data set, that is, KSE stock prices, which lie within the error range covered by the said error bar. Each vertical bar shows a number of samples which taken from the Karachi index data (sample data). The range of errors is divided into 20 smaller bins so each bin has a width of (0.1968-(0.22))/20= 0.02095. Ten samples have been taken from the validation data set and its error has the range of -0. 0016. .It represents the zero-error line represents the point at which the model has not made errors. It is crucial to focus on the zero-error line as it can allow for improving the accuracy of the model by reducing errors made by it.

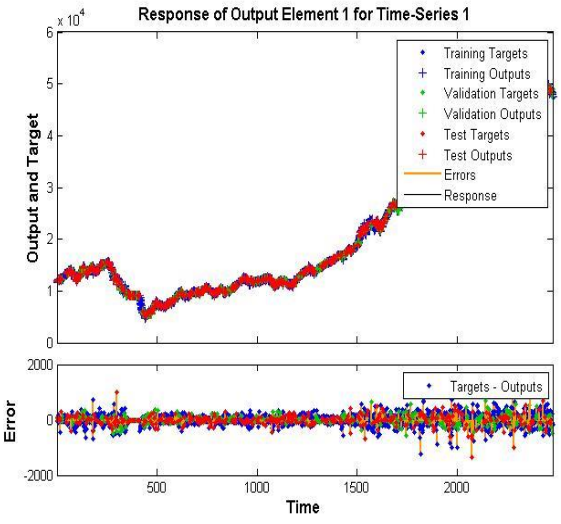

Figure 4. High Training (70% Training, 15% validation plus 15% testing)

The above mentioned figure 4, displays the consequence of the training of model, performed to enhance the overall accuracy of the results by putting in the input and simulating the model. The overall training percentage was high 70%. As evident from the above mentioned graph, the time is one the horizontal axis, whereas, the targets as well as the outputs are on the vertical axis. The error chart shown along with it clearly illustrates that there are certain deviations from the outputs defined in the initial data set. This shows that the time-series does not align completely with actual data and may provide flawed outputs. In addition to that, it represents the need for further training of the artificial neural network. However, the frequency of these errors is not quite high and therefore, the model may be considered adequate enough for predicting KSE stock prices. The graph begins from a lower value and attains a higher value over time. This is attributable to the fact that there was a growth in the key economic indicators over the course of time, which was reflected in the growth values, as can be seen in the above mentioned graphical depiction of the mode. This is evident from the above mentioned figure 4, the mean standard associated with the model falls within the range of confidence in all the instances, except at two instances, the first is at point 500 and the other one is after 200 point in time. Given the fact that the data associated with the model is very lengthy, the occurrence of error at two points in time does not have a deteriorating impact on the overall fit of the model.

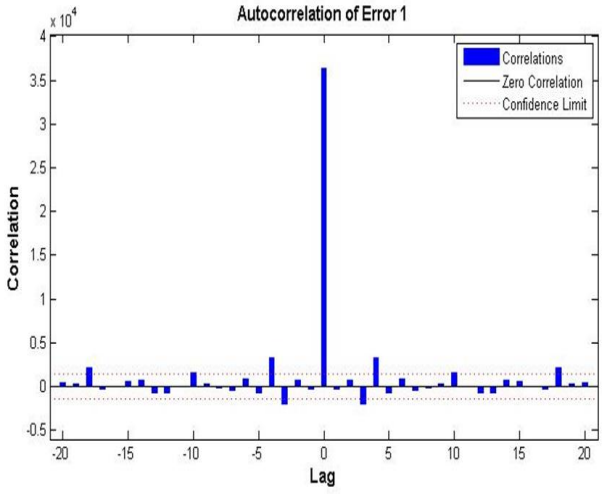

Figure 5. Autocorrelation of Error

Figure 5, represents the plot of the error autocorrelation function. It is representative of the correlation that exists between the errors over a given period of time. For a model to be effective and provide with accurate predictions, it is necessary that only one non-zero value occurs in the correlation function. This value should exist at the time lag

zero, which is reflective of the mean squared error. This will establish that only white noise, indicating that no correlation existed between the errors. The above-mentioned model, despite the occurrence of correlation, can be regarded as accurate as all the values are below the set confidence interval of 95%.

Table.1. Results of Overall R-Value and Mean Standard Error of the Model

	Target Value	**MSE**	**R-Value**
Training	1734	0.5337	0.9999
Validation	372	0	0.9999
Testing	372	0.17898	0.9999

By looking at the results for training, validation and testing we find that the mean standard error for the training is 0.5337, for validation, it is 0 while for testing it is 0.17898 which are generally considered acceptable, the lower the MSE, the more reliable the results. Similarly, the R-values for datasets (Training, Validation, and Testing) are close to 1, which is preferable. These values arise from the fact that we have a large sample of data set comprising more than two thousand trading days.

Testing of the Neural Network has yielded the following values of R and MSE which are given in Table No.2. The generally lower mean standard error is preferred for the model fit and R-value should be closer to 1. It means both mean standard error and R values fit perfectly the sample data, which gives satisfactory results to calculate the next day's closing price that should be closer to its original value.

Table 2.Results of MSE and R-Value for All Sample Data

MSE	**R-Value**
5.49	0.9999

After testing the developed neural network, the following graph was generated. Under this graph, the target value = original value and predicted = output values as shown below. As indicated by the following graph, both values are moving closely together. These values follow the trend and perfectly fit the requirements for forecasting the closing price of the subsequent day for Karachi Stock Exchange. While error graph at the bottom shows error range which is close to ideal value of 0, except the end of the end which shows response which is less than 0 or -0.9. So, in this case does not have an impact on the overall model that has been developed under this research.

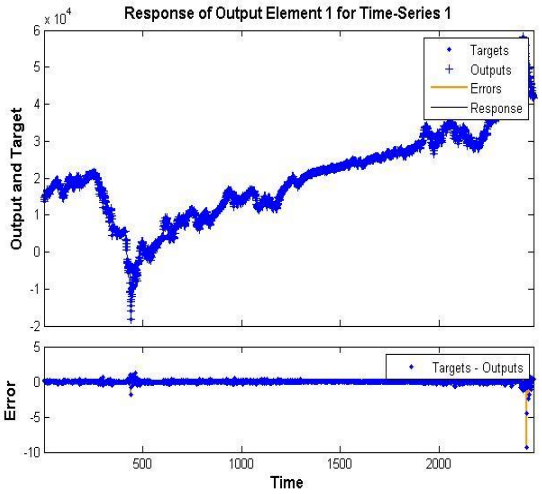

Figure 6. Target value = Original value and Predicted = Output values

The analysis of all the technicalities associated with the artificial neural network developed under this research indicated that this model has an error as well as MSE value under this model were effective. On the basis of the assessment of all the aspects of the model developed under this research, it was established that this model has the ability to predict the next day closing price of Karachi Stock Exchange.

5. Conclusion and Suggestions

In recent times changing in Stock market is most difficult task and is the agenda of discussions in today's brilliant minds globally in the entire world. Development of authentic market trading strategies is crucial, as ramification of stock market data to develop efficient models for proper prediction of stock prices or rate movements. The most important objective of this study is to predict the movement of Stock Exchange by using neural network based NARX model. In this paper Non-linear autoregressive network with exogenous inputs (NARX) has been used to predict the movements of Stock Exchange data taken from July 2008 to July 2018 and gathered from Karachi Stock Exchange website including open, high, closing prices of the day, volume and date. Data have been normalized by using SPSS in order to remove the bias. The set of training comprises 70% of data, 15% of validation and testing respectively.

The experimental results proved that by using NARX is effective, clearly shows that this technique predicts values which are close to the actual values. Results demonstrate that the KSE-100 Index is successfully forecasted by using ANNs with NARX methodology. Hence, this model is more effective and give more accurate and faster results by using

NARX as compared to other neural networks due to its progressive, mosaic as well as non-linear characteristics which solves real world situations and problems. It also portrays the impressive representation of time series analysis. Apart from that, results generated for R-values for data sets (Training, Validation, and Testing) are close to 1, which is preferable, these values arise from the fact that we have large sample of data set comprising more two thousands of trading days. The close to 1 value of R is also indicative of the strength and effectiveness of the model, which represents that it has a tendency to predict the market values with high levels of accuracy, perfect prediction. On the basis of the following results of the model, it can be established that the model has the potential to predict the overall outcomes of the Karachi stock exchange in an effective manner. However; this model can be amended with the help of more exogenous variables.

In this era, the higher the risk and the higher the expected return so predicting Stock Exchange rates are not just significant for researchers but for stockholders too and the such return are not easy to predict because the rates have a non-normal distribution and complexity of data. Artificial Neural Network helps users to quickly understand the complexity of data and gives accurate and optimal predictions. ANNs positively are good at simplifying and adapting to complications. The limitation of the study refers this method can also be used for other exchanges to forecast. In future studies that can be focused with cross-country comparison of developed and developing countries like China and Pakistan due to projects like CPEC, it will be seen that Pakistani Market has suffered an impact.

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