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EVALUATING THE PERFORMANCE PATTEN OF PNB STOCK PRICES IN INDIA USING FFNN IN TIME SERIES MODELS

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Abstract

In this study delivered the statistical models are used to predicting future Punjab National Bank stock prices in India. The forecasting models like auto regressive integrated moving average models and feed forward neural network models are used for next one month for daily stock prices of Punjab national bank in India. The model performances are estimated using the error measures such as mean absolute percentage error (MAPE), mean absolute error (MAE) and root mean square error (RMSE) on development and validation data sets. The mean absolute percentage error for FFNN model is Rs. 2.04%. The results show the feed forward neural network gives the better performance than the auto regressive integrated moving average model.

Keywords: ARIMA, FFNN, RMSE, MSE, MAPE.

1. Introduction:

Punjab National Bank (PNB) is stated on 12th April 1894 from Lahore. The PNB is a India public sector bank based in New Delhi and also PNB is third largest bank in India in terms of its business volume. The nine banks were joint with PNB and this bank completely organized by Indians. The daily stock prices of PNB are collected from 02nd January 2017 to 30th December 2022. The maximum stock prices are on 26th October 2017 (Rs. 213.60) and minimum stock prices on 19th May 2020 (Rs. 26.60). The stock prices are continuously decreasing from 2018 March and stabling May 2018 as shown in the following figure 1.1.

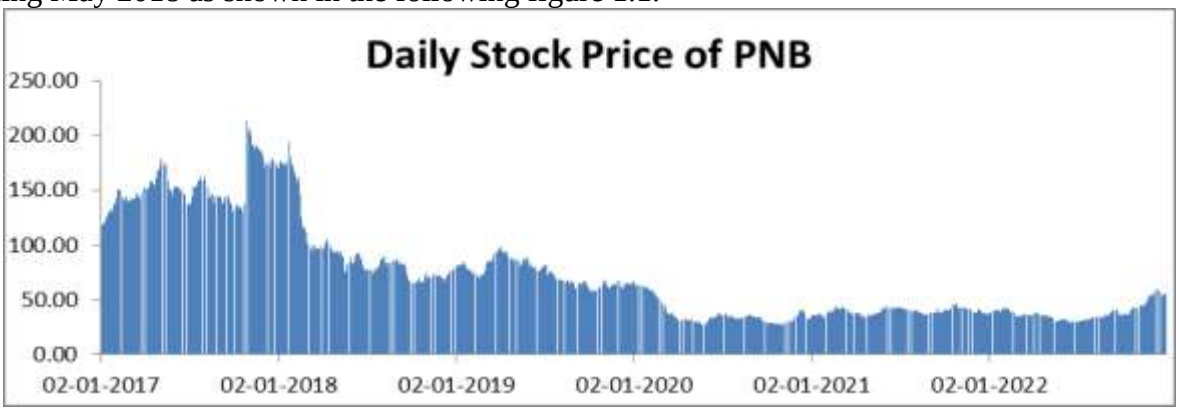

Figure 1.1: Time series plot for PNB daily stock prices in India.

2. Material and Methods:

A historical data of daily stock prices of Punjab National Bank (PNB) is received from Bombay Stock Exchange from 02nd January 2017 to 30th December 2022 in India. The Box-Jenkins methodology and feed forward neural network model are used to predict the future daily stock prices of Punjab National Bank and to provide the adequate model. In R software is used for model development and MS Excel is used to preparation of tables and charts.

2.1. Box- Jenkins Methodology:

In Box – Jenkins methodology is for identifying the best model by building the auto regressive integrated moving average model (ARIMA) on historical data set. The Box – Jenkins methodology consists of several benefits for obtaining the minimum number of parameters in

seasonal and non-seasonal. This methodology consists of four steps for developing model such as Identification, Estimation, Diagnostic checking and Forecasting **(Permanasari et al., 2009).** The first step is to model identification for determining the model parameters such as p and q by using the auto correlation and partial auto correlation function plots for the stationary data sets. The auto correlation is dies out for several lags and q spikes in the plot then q parameters will appear and partial auto correlation function dies out for several lags and p spikes in the plot then this is p parameter. Diagnostic checking is to test the model adequacy by using the LJung-Box Q Statistics and test the assumptions with respect to error are random. The Ljung Box Q Statistics test is used to test the randomness of the error and also test the parameters significance, if they are not significant then check the possible parameters and continue the process until to get the parameter significance. In this study, multiple models are tested for the given data sets and identified the best model for predicting the daily stock prices of Punjab National Bank in India according to their error measures such as MAPE, MAE and RMSE.

Therefore,

$$\Phi (B)\, \nabla^d Z_t = \theta (B)\, a_t$$

Where $\Phi (B) = 1 - \Phi_1(B) - \Phi_2(B)^2 - \ldots\ldots\ldots\ldots\ldots - \Phi_p(B)^p$

∇^d is $(1-B)^d$ and

$\theta (B) = (1 - \theta_1 B - \theta_2 B^2 - \ldots\ldots\ldots\ldots - \theta_q B^q$

d is non-seasonal and D is seasonal components. a_t is a white noise with zero mean and constant variance.

2.2. Artificial Neural Network Model

The Artificial Neural Network (ANN) models are very useful and helpful on biological neural networks and these networks are connected with several groups of nodes. The below figure is gives an idea on the architecture of the Feed Forward Neural Networks.

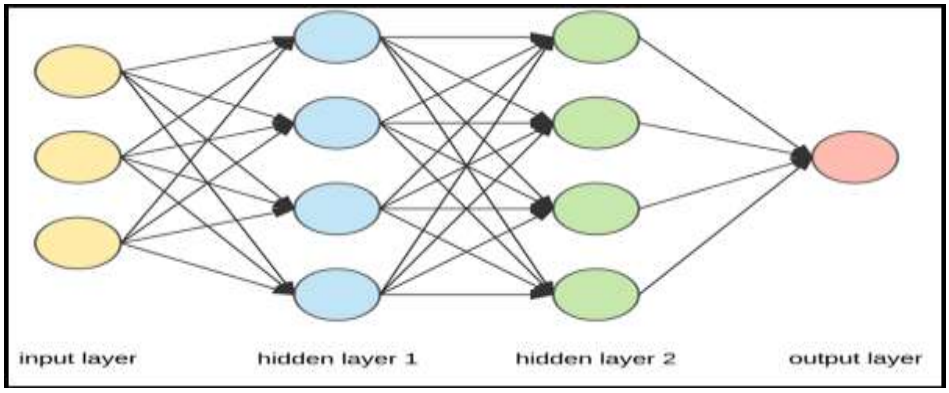

Figure 2.2: Feed Forward Neural Network diagram

The FFNN model is three layer architecture models and it consists of input layer, hidden layer and output layer. The flow of this work is first the data is transferred into input layer then hidden layer will presents and lastly output layer will work. The input and output layer are must be one only and hidden layer are depended upon the trail and error method, it will be more than one. The following table 2.2, gives the information of the network.

Input Layer	Covariates 1	Lag1
	Number of Units[a]	1Normalized
	Rescaling method of covariates	
Hidden Layer	Number of hidden layers	3
	Number of units in the hidden layer 1[a]	3
	Activation function	Hyperbolic Tangent
Output Layer	Dependent variable 1	Stock prices

	Number of units	1
	Rescaling method of scale dependent	Normalized
	Activation function	Identity
	Error function	Sum of squares

Table 2.2: Network Information:

3. Results and Discussion:

The time series plot of daily stock prices of Punjab National Bank collected data from 02nd January 2017 to 30th December 2022 is presented in the below figure. The entire historical data is separated two data sets such as training data set (containing of 1461 observation) for model development and the test data set (containing of 23 observations) for validation of the selected model.

3.1. ARIMA Model:

The stationary of the data is to test through the ACF (auto correlation function) and PACF (partial auto correlation function). The following time plot gives an idea of pattern of the stock prices of PNB in India from 02nd January 2017 to 30th December 2022..

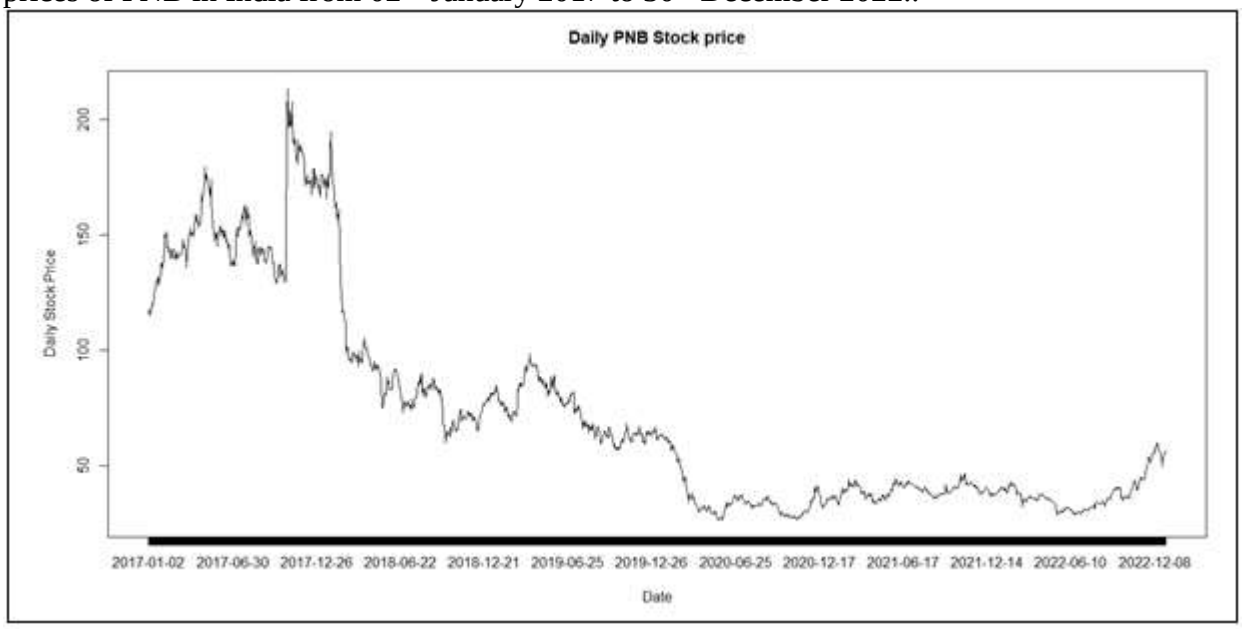

Figure 3.1: Time series plot of daily stock prices of PNB in India

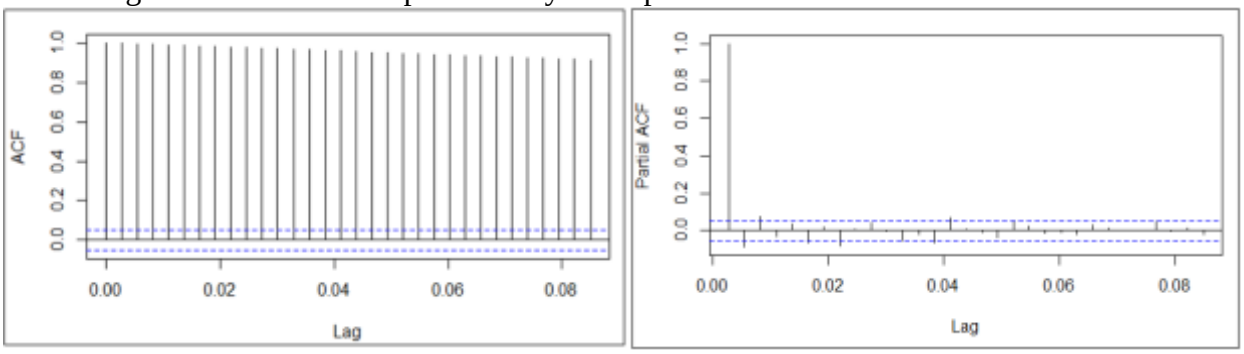

Figure 3.2: ACF and PACF plots of Daily stock prices of PNB in India.

From the figure 3.1 shows the pattern of daily stock prices of Punjab national bank from 02nd January 2017 to 30th December 2022. The data consist of the several fluctuations from one period to another period. The maximum stock prices are on 26th October 2017 (Rs. 213.60) and minimum stock prices on 19th May 2020 (Rs. 26.60). The data arise on 2017 to 2018 but the stock prices are slowly decreases from March 2018 in RS.95 and again raised April nearly Rs.7 and

immediately goes low for the several reasons. The time plot of daily stock prices shows the non-stationary series with includes the difference in mean and also checks the ACF and PACF plot.

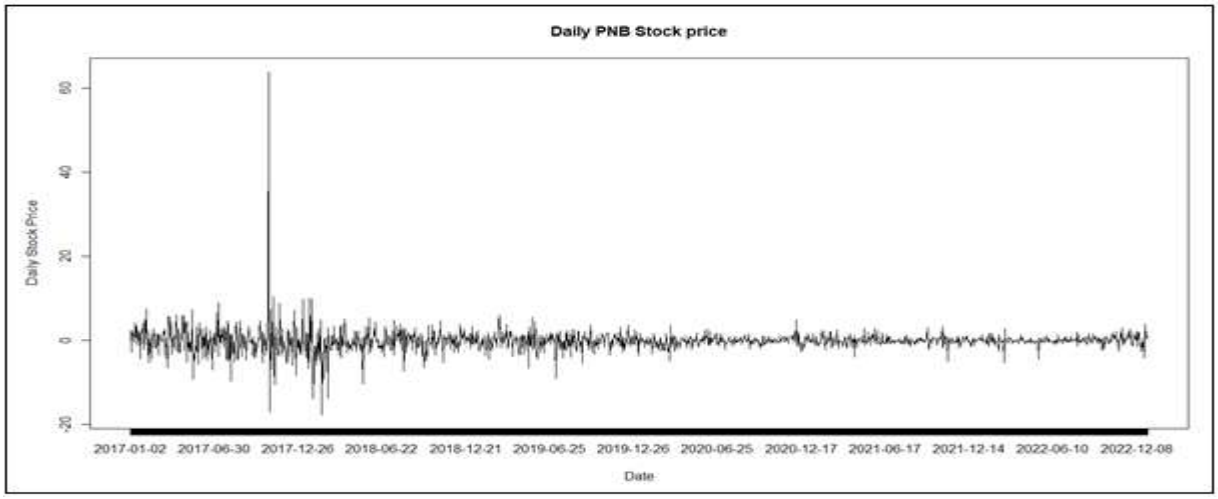

Figure 3.3: Transformed time series plot of daily stock prices of PNB in India

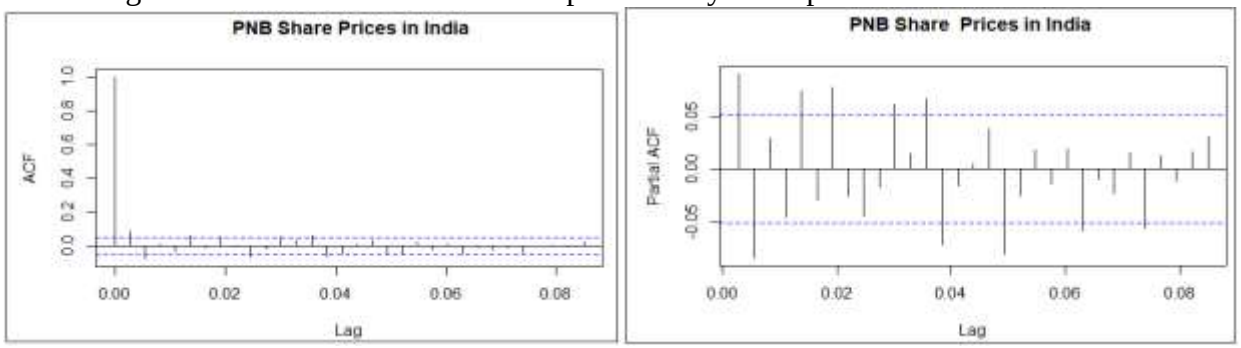

Figure 3.4: Transformed ACF and PACF plots of Daily stock prices of PNB in India.

From the figures 3.3, it was identified that the ACF dies out with first order difference. According to Augmented Dicky-Fuller Test the p-value is 0.01,this is smaller than the significant level. Hence reject the null hypothesis and the data is stationary. The Augmented Dicky-Fuller test results in first order difference data are stationary.

Table 3.1: Augmented Dicky-Fuller Test

P-Value	0.01
Lag Order	11
ADF	-10.52

The Identification of the model based on their parameters are selected from the ACF and PACF plots and also test their significance. The adequacy of the model is tested using LJung – Boc Q statistics. In this study, tested several model and verified all the criteria and identified the best model. The following table shows the some tentative models.

Table 3.2 : Possible model of ARIMA

ARIMA Models			AIC	BIC	Sig	LJung-box Q statistics	P-value	Adequacy
1	1	0	7165.2	7175.77	Significant	33.253	0.00012	Inadequacy
0	1	1	7162.84	7173.41	Significant	32.096	0.00014	Inadequacy
1	1	1	7137.66	7153.51	Significant	12.825	0.11800	Adequacy
2	1	0	7156.84	7172.7	Significant	25.296	0.00139	Inadequacy

0	1	2	7154.01	7169.87	Significant	23.737	0.00254	Inadequacy
2	1	1	7139.64	7160.79	Insignificant	12.831	0.07635	Adequacy
1	1	2	7139.64	7160.79	Insignificant	12.843	0.07602	Adequacy
1	1	3	7141.4	7167.83	Insignificant	12.323	0.05513	Adequacy
2	1	2	7141.6	7168.03	Insignificant	12.626	0.04938	Inadequacy
2	1	3	7143.07	7174.79	Insignificant	11.801	0.03761	Inadequacy
3	1	0	7157.61	7178.76	Insignificant	25.305	0.00067	Inadequacy
3	1	1	7141.36	7167.79	Insignificant	12.255	0.05651	Adequacy
0	1	3	7153.84	7174.98	Insignificant	22.646	0.00196	Inadequacy
1	1	3	7141.4	7167.83	Insignificant	12.323	0.05513	Adequacy

From the above table 3.2, it observed that the model ARIMA(1,1,1) is selected for the best for forecast the future daily stock prices of PNB in India based on the several criteria such as minimum AIC and BIC and Significance of the parameter and adequacy of the model. The estimated parameters of the selected model are listed in the following figure.

Table 3.3: Parameters of the ARIMA(1,1,1) Model

	Estimate	Std.Error	z value	Pr(>|z|)
ar1	-0.75129	0.046193	-16.264	<0.001
ma1	0.863743	0.034586	24.974	<0.001

From the table 3.3, the model ARIMA(1,1,1) model parameters are significant and this is the best model for forecasting the daily stock prices of PNB.

Now, The ARIMA(1,1,1) model equation is

$\Phi(B)\nabla^d Z_t = \theta(B) a_t$

$(1+0.7512B)\nabla Z_t = (1-0.8637B) a_t$

The adequacy of the model is tested based on the Ljung – Box Q Statistics. This test is uses the residuals of the series after building the model. Then the hypothesis of the model is

H_o: Model is adequate and H_1: Model is Inadequate

Table 3.4: Ljung-Box Q Statistics

Model	ARIMA(1,1,1)
Statistics	12.825
df	8
Significance	0.118

In the above table 3.4, the hypothesis value is greater than the significant value as 0.05, then accepts the null hypothesis (H_o) and concluded that the selected model is adequate model. Hence, the ARIMA(1,1,1) model is used for forecasting the future daily stock prices of PNB in India.

The forecasted daily stock prices of PNB in India are presented in the following table 3.5 from 1st December 2022 to 30th December 2022.

Table 3.5: Forecasting of daily stock prices of PNB in India using ARIMA(1,1,1) model

Date	Actual Daily Stock Prices	Forecast Daily Stock Prices		Date	Actual Daily Stock Prices	Forecast Daily Stock Prices
01-12-2022	53.25	53.59		16-12-2022	56.75	53.77
02-12-2022	54.00	53.90		19-12-2022	56.05	53.76
05-12-2022	55.15	53.67		20-12-2022	55.55	53.77
06-12-2022	55.45	53.84		21-12-2022	53.15	53.76
07-12-2022	55.45	53.71		22-12-2022	53.75	53.77
08-12-2022	57.70	53.81		23-12-2022	49.70	53.77
09-12-2022	56.25	53.74		26-12-2022	53.50	53.77
12-12-2022	58.10	53.79		27-12-2022	54.20	53.77
13-12-2022	59.90	53.75		28-12-2022	54.90	53.77
14-12-2022	59.25	53.78		29-12-2022	55.40	53.77
15-12-2022	59.30	53.76		30-12-2022	56.45	53.77

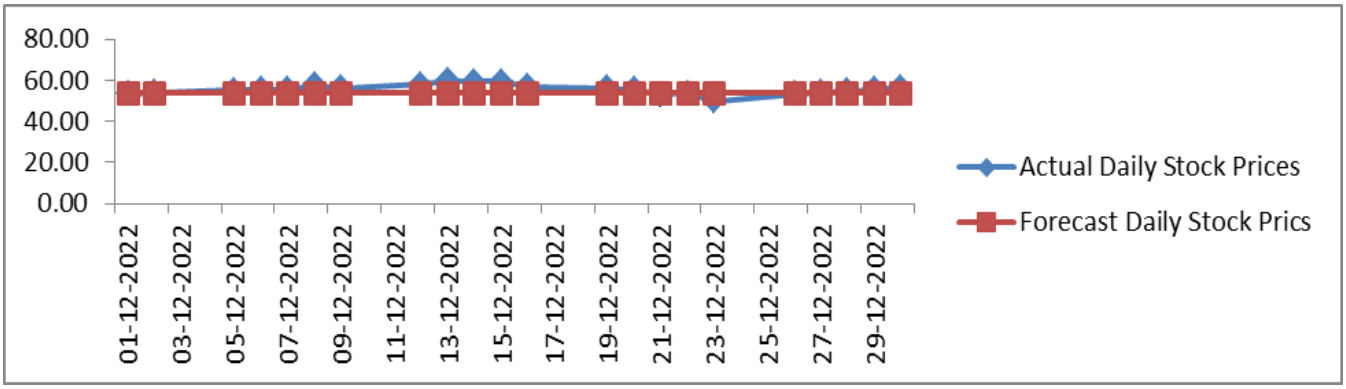

Figure 3.5: Forecast of daily stock prices of PNB in India.

Table 3.6: Error measures for ARIMA(1,1,1) model

Dat Set	RMSE	MAE	MAPE
Training Set	2.78	1.46	2.00
Test Set	3.10	2.53	4.46

From the above table 3.6, the selected model ARIMA (1,1,1) mean absolute error is Rs.1.46 and Rs.2.53, root mean square error was Rs. 2.78 and Rs. 3.10, mean absolute percentage error was Rs. 2 and Rs.4.4 respectively in training and test data sets. The error measures are very near to training test data sets and it was little above recommended level.

4. Feed forward Neural Network Model

The FFNN model consists of one number of neurons which is Lag1. In this model, the output layer is one and it gives the forecast of the daily stock prices of PNB in India. Then to identify the hidden layer, there is no simple procedure or method to identifying the number hidden layer without making the backward or forward selection process to obtain the hidden layers. In this study, the hyperbolic tangent function is used for activation function under the back propagation methodology. Therefore the forward selection process is applied and determines the some iterative models using random hidden layers and selected the best model using the minimum error measures such as MAPE, MAE and RMSE. The possible models are listed in the following table 4.1.

Table 4.1: Tentative model for FFNN model

Number of Layer	Train	Test

Input	hidden	Ouput	RMSE	MAE	MAPE	RMSE	MAE	MAPE
1	2	1	3.06	1.63	2.05	1.03	0.69	1.78
1	3	1	3.08	1.66	2.12	1.06	0.73	1.91
1	4	1	3.06	1.62	2.04	1.02	0.69	1.77
1	5	1	3.06	1.63	2.06	1.03	0.70	1.81

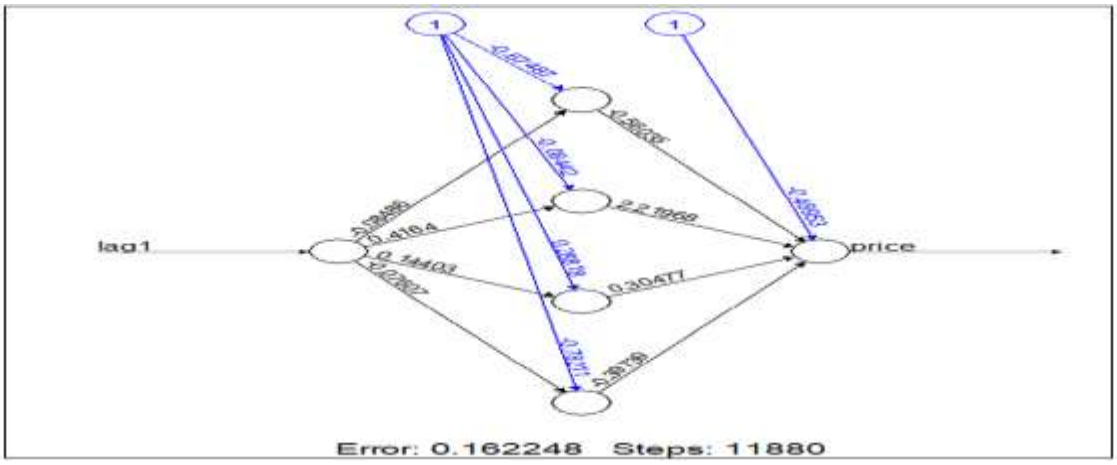

Figure 4.1: Feed Forward Neural Network architecture

The FFNN model is developed using the R software and model parameters are presented in the following table 4.2.

Table 4.2 : Parameters of the Model FFNN (1-4-1)

Parameters	
error	0.165
reached.threshold	0.010
steps	3282
Intercept.to.1layhid1	0.044
lag1.to.1layhid1	1.017
Intercept.to.1layhid2	-0.553
lag1.to.1layhid2	-1.517
Intercept.to.1layhid3	-0.103
lag1.to.1layhid3	-2.046
Intercept.to.1layhid4	0.946
lag1.to.1layhid4	1.006
Intercept.to.price	-1.991
1layhid1.to.price	1.414
1layhid2.to.price	-1.679
1layhid3.to.price	1.429
1layhid4.to.price	1.662

The hidden neurons are

H_1 = Tanh [-0.6748-0.084 $\bar{z}_{t-1}$]

H_2 = Tanh [-0.0844+0.4164 $\bar{z}_{t-1}$]

H_3 = Tanh [0.2881 +0.1440 $\bar{z}_{t-1}$]

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H_4 = Tanh [-0.7811-0.0760 $\bar{Z}_{t-1}$]

Where $\bar{Z}_{t-1}$ = (lag1-min(lag1)/max(lag1)-min(lag1))
$\bar{Z}_{t-1}$ is a rescaled input variables.

Then the model equation is
O_t = -0.56035 H_1 +2.21968 H_2 +0.30477 H_3 -0.39739 H_4 +0.48953

Now, the performance of the model in the fitting and forecasting stage is given below.

Table 4.3: FFNN model performance

Data Set	RMSE	MAE	MAPE
Training Set	3.06	1.62	2.04
Test Set	1.02	0.69	1.77

From the above table 4.3, shows the mean absolute error was Rs.1.62 and Rs.0.69, root mean square error was Rs.3.06 and Rs.1.02, mean absolute percentage error was Rs. 2.04 and Rs.1.77 respectively in training and test data sets.

Table 4.4: Forecasting of daily stock prices of PNB in India using FFNN(1-4-1) model

Date	Actual PNB Stock Prices	Forecasted PNB Stock prices		Date	Actual PNB Stock Prices	Forecasted PNB Stock prices
01-12-2022	53.25	51.24		16-12-2022	56.75	59.33
02-12-2022	54.00	53.21		19-12-2022	56.05	56.75
05-12-2022	55.15	53.97		20-12-2022	55.55	56.04
06-12-2022	55.45	55.13		21-12-2022	53.15	55.54
07-12-2022	55.45	55.44		22-12-2022	53.75	53.11
08-12-2022	57.70	55.44		23-12-2022	49.70	53.72
09-12-2022	56.25	57.71		26-12-2022	53.50	49.62
12-12-2022	58.10	56.25		27-12-2022	54.20	53.46
13-12-2022	59.90	58.12		28-12-2022	54.90	54.17
14-12-2022	59.25	59.94		29-12-2022	55.40	54.88
15-12-2022	59.30	59.28		30-12-2022	56.45	55.39

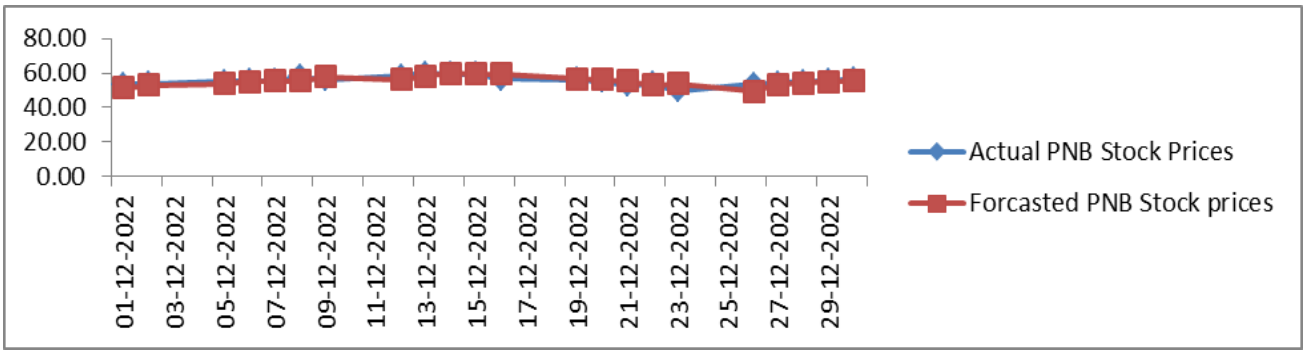

Figure 4.2: Testing sample using FFNN model

The above figure 4.2, shows the FFNN model gives the better results and graph also provides the better performance.

5. Comparison of forecasted models for daily stock prices of PNB in India.

The Performance of the selected models such as ARIMA and FFNN models on training and test data sets results are shows the significant difference in the error measures. The FFNN models error measures are better and flexible for the training and testing data sets as compared with the ARIMA model. Therefore the FFNN model forecast is better than the ARIMA model. The following table 5.1 gives the results comparison for the both the models.

Table 5.1: Comparison of ARIMA and FFNN models

	ARIMA			FFNN		
Model	**RMSE**	**MAE**	**MAPE**	**RMSE**	**MAE**	**MAPE**
Training set	2.78	1.46	2.00	3.06	1.62	2.04
Test Set	3.10	2.53	4.46	1.02	0.69	1.77

6. Conclusion

From the above analysis, it was finalized that the feed forward neural network model is shows the good results as compared to auto regressive integrated moving average model for the forecasting the daily stock prices of PNB in India. Therefore, FFNN model has been used for forecasting the future daily stock prices of PNB in India. The forecasts of ARIMA and FFNN models are in the following table 6.1 and figure 6.1.

Table 6.1: Forecasts of ARIMA and FFNN models

Date	Actual Daily Stock Prices	ARIMA Daily Stock Prices	FFNN Daily Stock prices
01-12-2022	53.25	53.59	51.24
02-12-2022	54.00	53.90	53.21
05-12-2022	55.15	53.67	53.97
06-12-2022	55.45	53.84	55.13
07-12-2022	55.45	53.71	55.44
08-12-2022	57.70	53.81	55.44
09-12-2022	56.25	53.74	57.71
12-12-2022	58.10	53.79	56.25
13-12-2022	59.90	53.75	58.12
14-12-2022	59.25	53.78	59.94
15-12-2022	59.30	53.76	59.28
16-12-2022	56.75	53.77	59.33
19-12-2022	56.05	53.76	56.75
20-12-2022	55.55	53.77	56.04
21-12-2022	53.15	53.76	55.54
22-12-2022	53.75	53.77	53.11
23-12-2022	49.70	53.77	53.72
26-12-2022	53.50	53.77	49.62
27-12-2022	54.20	53.77	53.46
28-12-2022	54.90	53.77	54.17
29-12-2022	55.40	53.77	54.88
30-12-2022	56.45	53.77	55.39

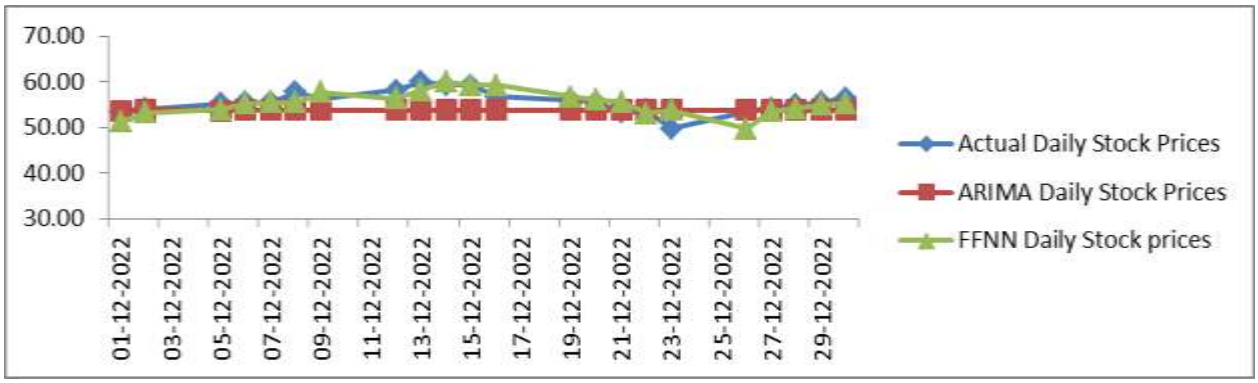

Figure 6.1 : Forecasts of ARIMA and FFNN models

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