ISSN: 2278-4632
Vol-13, Issue-05, May 2023

ACCURACY POWER OF SILVER PRICES IN INDIA USING TIME SERIES ANALYSIS

K Vijendar Reddy[1] and Dr. M UdayShankar[2] and Dr. M Raghavender Sharma[3]

1. *Research Scholar, Department of statistics, Osmania University, Hyderabad, Telangana. Email:kanaganti.vijendherreddy@gmail.com, , Cell: 9030442441*
2. *Assistant Professor, Department of statistics, Osmania University, Hyderabad, Telangana. Email:udayshankar.malyala@gmail.com , Cell: 9538002202.*
3. *Assistant Professor, Department of statistics, Osmania University, Hyderabad, Telangana. Email:drmrsstatou@gmail.com , Cell: 919441090239.*

Abstract:

This paper analysed for forecasting the silver prices in India using time series elements. In this study, the predicted models are used for forecasting the future silver prices in India. The forecasted models are auto regressive integrated moving average model and feed forward neural network models for used and predicted the next 30 days on daily silver prices in India. The entire data sets separated into two sets such as development set (training) and validation set (testing). The model performance is used to test validation data based on the minimum error measures like mean absolute percentage error, mean absolute error and root mean square error. The final results of the analysis are FFNN model gives the better result compares to ARIMA and MPAE is 1.4 percentage.

Keywords: ARIMA, FFNN, MAE, RMSE and MAPE.

1. Introduction:

The each day expenses forecasting of silver is quintessential a part of bullion market and rate evaluation. Forecasts of each day costs of silver are intended to be beneficial for people, governments, and financial institutions, industries as they have an effect on the decision taken by way of people and policy makers. Particularly, the charges of silver play a important position in the worldwide marketplace and investment opportunity for individuals. The metals like silver are part of the lives of human beings within the United States of America like India. These metals are not simply used within the commercial manufacturing however also blanketed inside the embellishes which can be commonly ordinary for human beings in India. The cultural and conventional practices of Indians contain the substantial utilization of silver within the every own family. The forecasting potential of the specific time association models is a studies trouble around there because the elements of the prices are changing with the aid of time to time. The objective of the analysis is to made on this evaluation to estimate

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

the charges of metals using conventional time collection fashions, artificial neural networks (ANN) models.

2. Material and Methods:

The historical data of daily silver prices (1Kg) in India is received from Silverpricesindia.com from 1st January 2017 to 30th October 2022. The ARIMA (auto regressive integrated moving average) and FFNN (Feed Forward Neural Network) models are used to forecast the daily silver prices (1Kg) in India and to get the accuracy of the model. MS-Excel and R – Software are used to create the charts and models.

2.1. ARIMA Model:

The Box-Jenkins technique uses an auto-regressive integrated moving average model to analyse historical data series and choose an optimum model. This methodology has various benefits, including a minimum number of auto-regressive and moving average parameters, such as p and q, and the ability to check the data for seasonality and non-seasonality, and stationary and non-stationary data patterns. The four steps of the Box-Jenkins technique are used to create the model. Identification, estimate, diagnostic evaluation, and forecast Using the ACF and PACF plots for the stationary data series, model identification is the process of obtaining the model parameters p and q. In the ACF plot, the ACF dies out for more lags and q spikes; this is parameter q; in the PACF plot, the PACF dies out for more lags and p spikes; this is parameter p. The Ljung-Box Q statistics test is used to confirm the model's suitability, and the assumption that the mistakes are random is checked. The Ljung-Box test is useful for determining whether the residuals are random. Check the parameters' adequacy and relevance; if not, repeat the process, create some tentative models, and determine the model's adequacy. The best model for predicting the daily Silver prices in India, was chosen after a number of models were tested using the provided training data set. Error measures like mean absolute error (MAE), mean absolute percentage error (MAPE), and root mean square error (RMSE) are used to verify a good model based on minimum error values.

The Box-Jenkins technique uses an auto-regressive integrated moving average model to examine historical statistics series and pick out a finest model. This technique has various benefits, inclusive of a minimal wide variety of auto-regressive integrated moving average parameters, together with p and q, and the capacity to check the information for seasonality and non-seasonality, and stationary and non-stationary data patterns. The four steps of the Box-Jenkins approach are used to create the model. Those are Identification, estimate,

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

diagnostic evaluation, and forecast. Using the ACF and PACF plots for the desk bound statistics series, model identity is the method of acquiring the model parameters p and q. In the ACF plot, the ACF dies out for more lags and q spikes; that is parameter q; in the PACF plot, the PACF dies out for greater lags and p spikes; this is parameter p. The Ljung-Box Q statistics test is used to verify the model suitability, and the belief that the errors are random is checked. The Ljung-Box check is beneficial for figuring out whether or not the residuals are random. Check the parameters' adequacy and relevance; if not, repeat the method, create a few tentative models, and decide the model adequacy. The good model for predicting the daily silver expenses in India, changed into chosen after some of models have been examined the based on training data set. To get the model performance using minimum error measures like mean absolute error (MAE), mean absolute percentage error (MAPE), and root mean square errors (RMSE).

1.2 FFNN (Feed Forward Neural Network) model

The FFNN models are biological neural networks inspired. The nodes that make up neural networks are interconnected. The architecture of the feed-forward neural community is depicted in the following figure

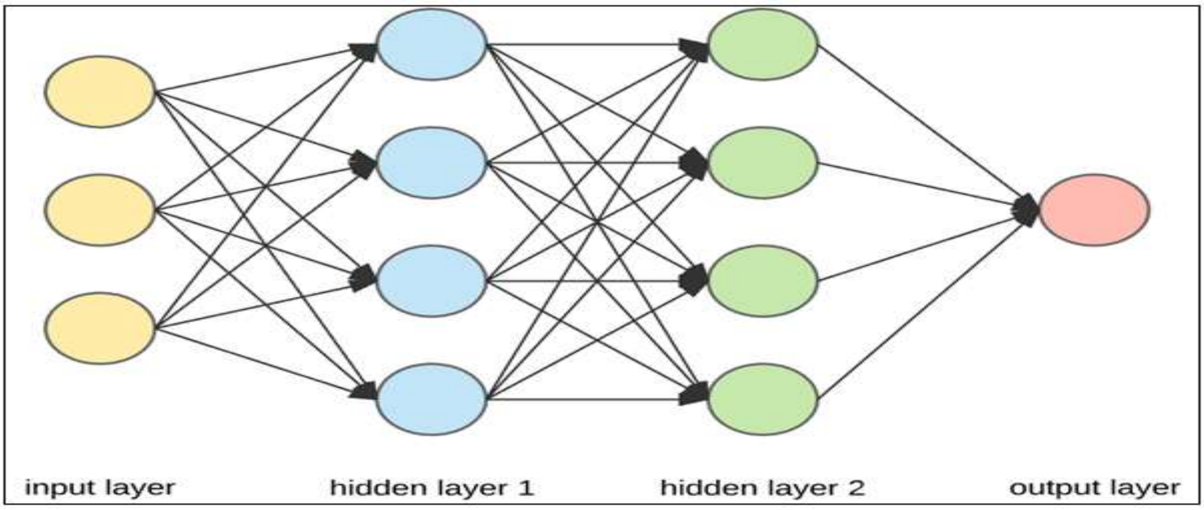

Figure 2.2.1: Feed Forward Neural Network diagram.

There are 3 layers that make up the architecture of the feed-forward neural network model. It has an output layer, a hidden layer, and one enter layer. Data is first transformed at the input layer, then at the hidden layer, and eventually on the output layer. The input of the following layer is the output of the node in the previous layer. Lag1 is the final version facts for neurons

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

on this projected model. Information about the community is provided within the table underneath.

Table 2.2.1: Neural Network Layer Information

Input Layer	Covariates 1	Lag1
	Number of Units	1 Normalized
	Rescaling method of covariates	
Hidden Layer	Number of hidden layers	1
	Number of units in the hidden layers 1	2
	Activation functions	Hyperbolic Tangent
Output Layer	Number of units	1
	Rescaling method of scale dependent	Normalized
	Activation functions	Identity
	Error functions	Sum of squares

3 Results and Discussion

The time series plot of daily prices of Silver collected from Indiagoldprices.com from 1st January 2017 to 30th October 2022 .The entire data set is separated into two sets, such as training and testing data sets. The training data set contains (1st January 2017 to 30th September 2022) for model building and testing data set contains (1st October 2022 to 30th October 2022) for model performance.

3.1 ARIMA (Auto Regressive Integrated Moving Average) Model

The auto correlation (ACF) and partial auto correlation (PACF) functions are used to check the model stationary behaviour. The correlation functions are proven inside the following graph.

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

Figure 3.1.1: Daily Silver prices in India(1 Kg)

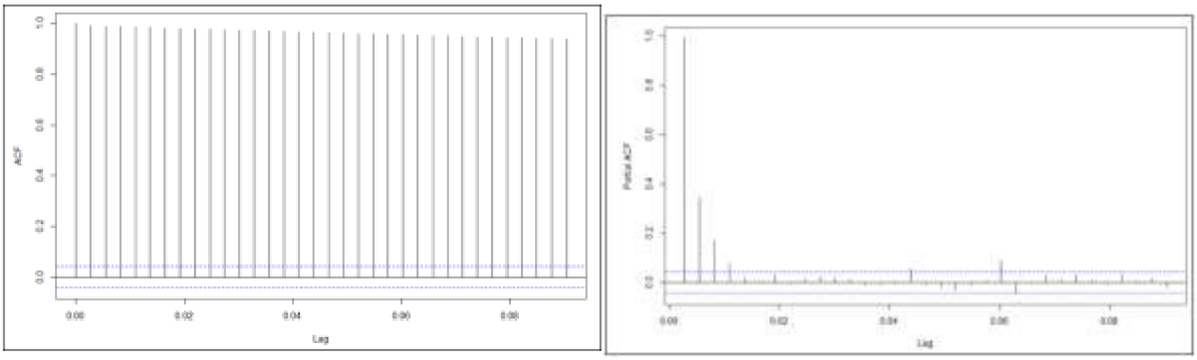

Figure 3.1.2: ACF and PACF plots for the Silver prices in India (1 Kg)

The temporal plot of Silver prices shows an upward trend over time with seasonal variation; see figures 3.1.1 and 3.1.2 above. The time plot demonstrates that the collection is non-stationary bound with a variable suggests. Additionally, the data is a non-stationary and requires the creation of ACF and PACF plots due to the fact that in ACF the dies aren't out for longer delays.

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

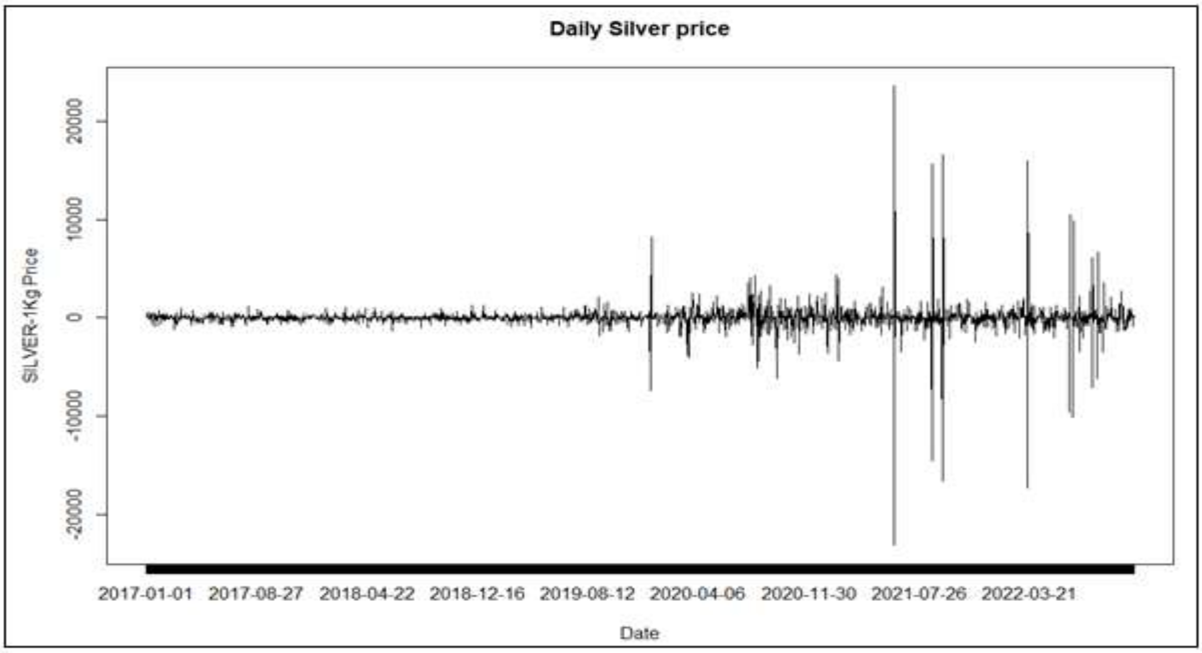

Figure 3.1.3: Transformed (d=1) series plot for Silver prices in India(Rs/1 Kg)

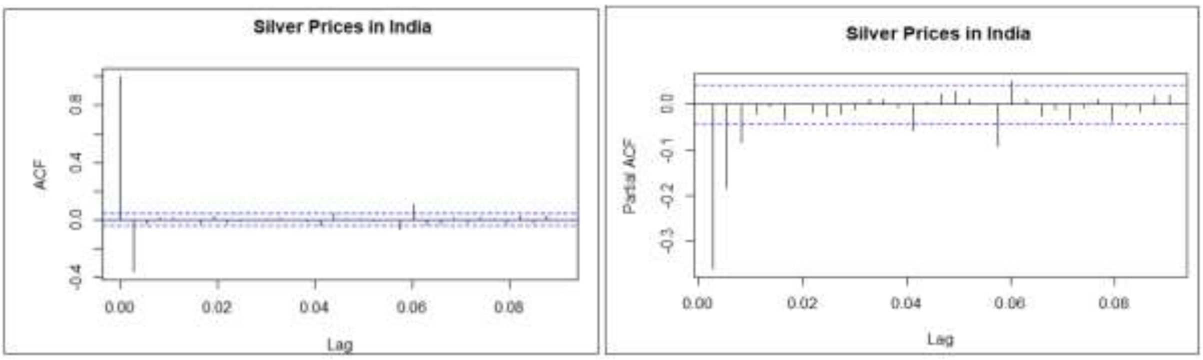

Figure 3.1.4: ACF and PACF plots for transformed series of Silver prices in India

As visible in determine 3.1.4 above, the autocorrelation disappears with the onset of the first seasonal difference. The information is stationary right now. The ACF and PACF charts are used to pick out the ARIMA model and pick out its parameters. Using Ljung-Box Q facts, the model suitability is tested, and the parameter's importance is confirmed. The following desk 3.1.1 provides a tentative model.

Table 3.1.1: Tentative models of ARIMA(3,1,0)

ARIMA(p,d,q)			AIC	BIC	Significance of the parameter	LJ Q statistics	P-Value	Adequacy
1	1	0	36182.36	36193.66	Yes	86.812	0.000007	Inadequacy
0	1	1	36095.03	36106.33	Yes	6.9274	0.6447	adequacy
1	1	1	36096.21	36113.15	no	6.125	0.6332	adequacy
2	1	0	36111.52	36128.47	Yes	19.395	0.01288	Inadequacy
0	1	2	36096.15	36113.1	no	6.0651	0.6399	adequacy

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

2	1	1	36097.65	36120.25	no	5.5103	0.5979	adequacy
1	1	2	36097.94	36120.53	no	5.8364	0.559	adequacy
3	1	0	36098.97	36121.56	Yes	6.4782	0.4851	adequacy

The above desk 3.1.1 shows that the model ARIMA (3,1,0) is selected above alternative model for forecasting future daily prices of silver based on low AIC and BIC values with Q statistics of 5.14. The ARIMA (3,1,0) model, that is anticipated with future daily prices of silver in India, is the maximum appropriate one. The following table 3.1.2 carries the predicted parameters.

Table 3.1.2 Model Parameters

Parameters	Estimate	Std.Error	z value	Pr(>|z|)
ar1	-0.44494	0.02176	-20.446	<0.001
ar2	-0.22042	0.02334	-9.4432	<0.001
ar3	-0.08315	0.02176	-3.8217	<0.001

The parameters are substituted within the ARIMA (3,1,0) in table 3.2.2 above, and the first-rate model is

$$(1-\varnothing_1 B-\varnothing_2 B^2-\varnothing_3 B^3)(1-B)z_t=\epsilon_t$$
$$(1+0.44B+0.22B^2+0.08B^3)(1-B)z_t=\epsilon_t$$

The autocorrelation and partial autocorrelation functions of diverse appearances are used to check the residuals plots.

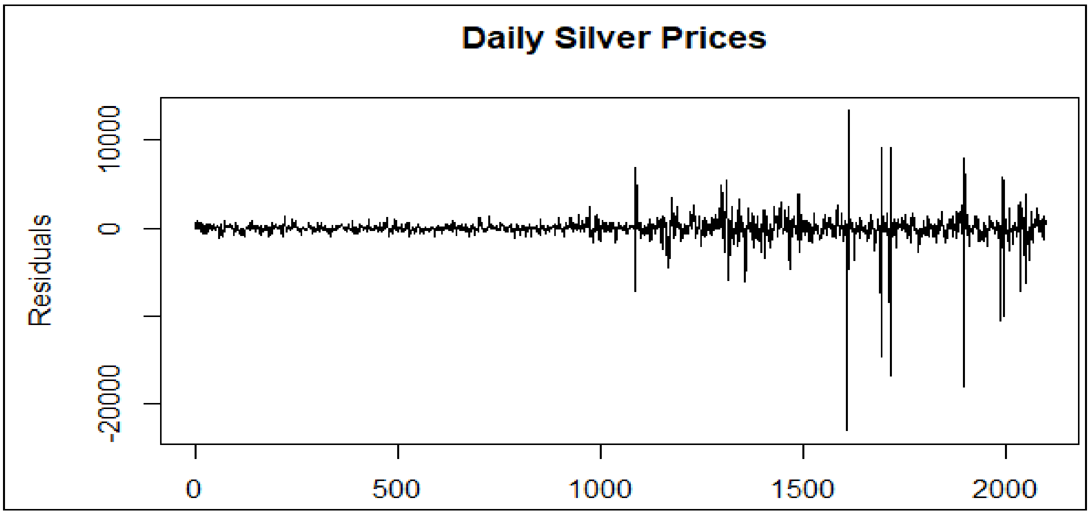

Figure 3.1.5: Residulas series for Silver prices.

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

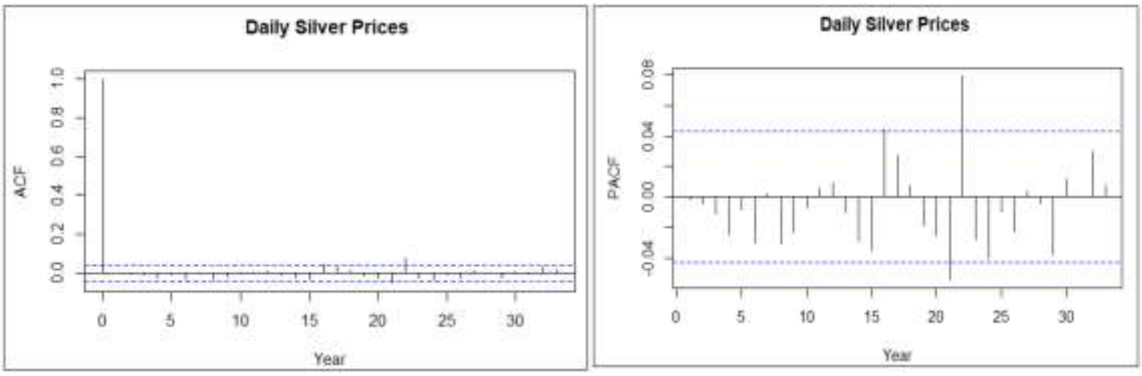

Figure 3.1.6: ACF and PACF residulas plot for Silver prices

The residuals plot for PACF may be seen inside the above figures to be extensively distinct from the variety of 0 to 0.04. The LJung-Box check is used to validate the model's suitability. After creating the model, this test is used to observe the series' residuals. So, Ho: the version is good enough, and H1: the model is inadequate, are the respective hypotheses for the model.

Table 3.1.3: LJung Box_ Q test Statistics

Model	ARIMA(3,1,0)
Statistics	6.48
Degrees of freedom	7
Significance	0.49

In table 3.1.3, the hypothesis is grater than the significant level of 0.05, resulting that the accepting the null hypothesis and the conclusion that the model is ok. As a result, the ARIMA (3,1,0) model works better for predicting silver costs on a daily basis in India. Table 3.1.4 under lists expected daily prices of silver(1 kg) in India from October 1st, 2022, to October 30th, 2022.

Table 3.1.4 Forecasts of daily prices of Silver in India using ARIMA (3,1,0)

Date	Actual Silver Prices	Forecast Silver Prices		Date	Actual Silver Prices	Forecast Silver Prices
01-10-2022	56868	56593		16-10-2022	55803	56690
02-10-2022	59603	56664		17-10-2022	56711	56690
03-10-2022	61532	56708		18-10-2022	56179	56690
04-10-2022	61859	56695		19-10-2022	56067	56690
05-10-2022	61291	56685		20-10-2022	56716	56690
06-10-2022	60825	56689		21-10-2022	57670	56690
07-10-2022	61968	56691		22-10-2022	57670	56690
08-10-2022	60755	56690		23-10-2022	57543	56690

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

09-10-2022	59486	56690		24-10-2022	57758	56690
10-10-2022	58477	56690		25-10-2022	58295	56690
11-10-2022	57581	56690		26-10-2022	58258	56690
12-10-2022	56452	56690		27-10-2022	57353	56690
13-10-2022	56303	56690		28-10-2022	57500	56690
14-10-2022	55295	56690		29-10-2022	57500	56690
15-10-2022	55295	56690		30-10-2022	57786	56690

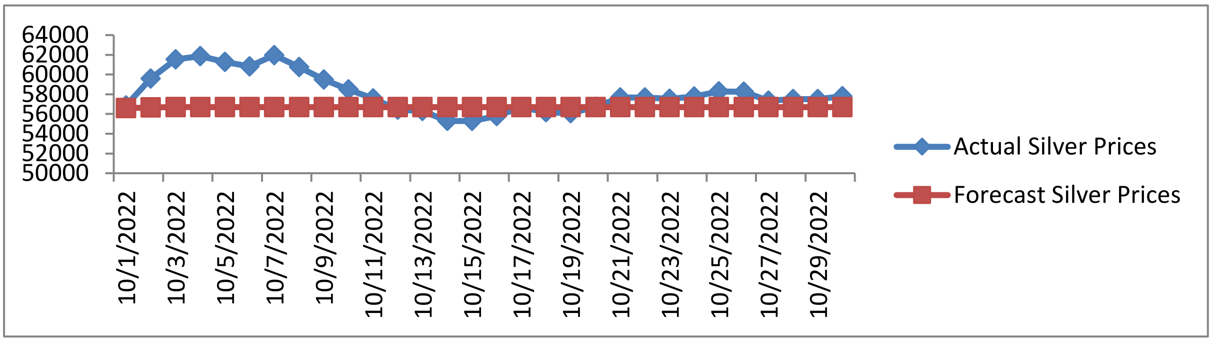

Figure 3.1.7: Forecasts of daily prices of Silver in India using ARIMA (3,1,0)

The test data set is used to validate the model overall performance once it's been evolved the usage of the training data set. The following table 3.5.5 presentations the model performance within the test pattern.

Table 3.5.5: Performance of the ARIMA (3,1,0) Model

Data Set	RMSE	MAE	MAPE
Training Set	1191.98	430.05	0.85
Test Set	2205.37	872.17	1.49

The mean absolute error for the training and test sets, as shown in table 3.5.5 above, was Rs 430.05 and Rs 872.17, respectively. In the training and test a look at units, the toot mean square error became Rs 1191.98 and Rs 2205.37 rupees, respectively. The mean absolute percentage error was Rs. 0.85 percentage and Rs. 1.49 percentage within the training and test data sets, respectively, slightly higher than the amount that was suggested.

3.2 Feed Forward Neural Network Model

The total variety of neurons within the FFNN model is one, and it displays lag1 values. One output layer is needed in this model, and it shows the forecast for silver prices in India. Without appearing a forward or backward selection method to acquire the hidden layers, there may be no truthful method to decide the quantity of hidden neurons. Under the back

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

propagation technique, the hyperbolic tangent feature is used as the activation function. In order to compute a few iterative models making use of random hidden neurons and arrive on the excellent model, the forward choice manner is used. The good model is decided the use of the minimum error measures. The following table 3.2.1 lists the preliminary model.

Table 3.2.1: Tentative models in FFNN Model (1-3-1)

Number of Layer			Train			Test		
Input	hidden	Output	RMSE	MAE	MAPE	RMSE	MAE	MAPE
1	2	1	1188.65	431.63	0.85	2145.07	891.67	1.52
1	3	1	1189.93	433.94	0.86	2130.41	862.93	1.47
1	4	1	1188.81	430.79	0.85	2139.16	879.51	1.50
1	5	1	1188.73	430.75	0.85	2140.05	881.10	1.50

According to the above table, the 1-3-1 network has decrease error measurements than other networks. The FFNN 1-3-1 network used for the information is proven within the following diagram.

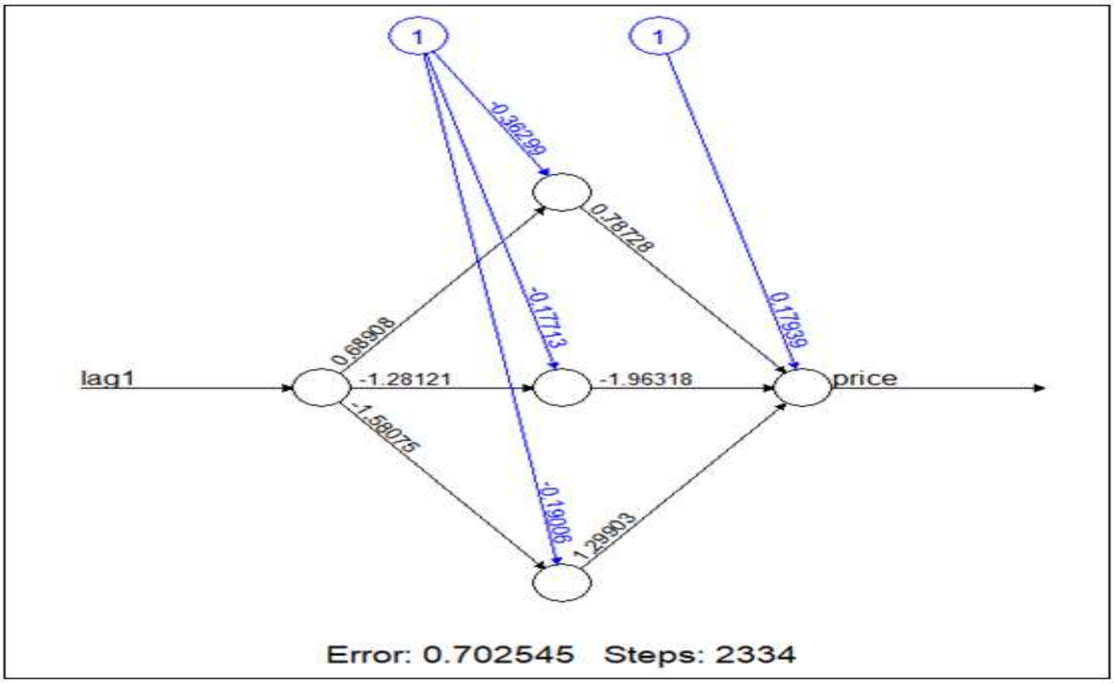

Figure 3.3.1: FFNN model diagram

The 1-3-1 model turned into chosen based on model overall performance after building the network model and trying out a couple of models. The better hidden layers have been constructed in the R programming language. The following table 3.2.2 shows the parameters and the best model, that is 1-3-1.

Table 3.2.2 Parameters of the FFNN Model

Parameter estimates	
error	0.70
reached.threshold	0.01
steps	2334
Intercept.to.1layhid1	-0.36
lag1.to.1layhid1	0.69
Intercept.to.1layhid2	-0.18
lag1.to.1layhid2	-1
Intercept.to.1layhid3	-0.19
lag1.to.1layhid3	-1.58
Intercept.to.price	0.18
1layhid1.to.price	0.92
1layhid2.to.price	-1.96
1layhid3.to.price	1.30

Now, the activation functions are

$$H_1 = \text{Tanh}[-0.36-0.69\ \bar{Z}_{t-1}\ ]$$

$$H_2 = \text{Tanh}[-0.18+0.98\ \bar{Z}_{t-1}\ ]$$

$$H_3 = \text{Tanh}[0.19+1.58\ \ \bar{Z}_{t-1}\ ]$$

$$\text{Where } \bar{Z}_{t-1} = \frac{lag1-\min(lag1)}{\max(lag1)-\min(lag1)}$$

$\bar{Z}_{t-1}$ is rescaled input variable.

Now, the FFNN model equation is

$$O_t = 0.92\ H_1\ -1.96\ H_2\ +1.30\ H_3\ +0.18$$

The following desk 3.2.3 provides the fitted forecasting model and test sample used to evaluate the model overall performance.

Table 3.2.3: Performance of the FFNN 1-3-1 model

Data Set	RMSE	MAE	MAPE
Training Set	1189.93	433.94	0.86
Test Set	2130.41	862.93	1.47

According to the above findings, the mean absolute error for the training and test data sets turned into Rs 433.94 and Rs 862.93, respectively. In the training and test sets, the root means rectangular errors became Rs 1189.93 and Rs 2130.41, respectively. The mean absolute percentage error was 0.86 percentages in the training set and 1.47 percentage in the

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

test data set, respectively, rather over the extent this is suggested. The following table 3.4.5 below lists the daily silver prices as determined by means of the forecasting model.

Table 3.2.4: Forecasts of daily prices of Silver in India using FFNN 1-3-1 Model.

Date	Actual Silver Prices	Forecasted Silver Prices		Date	Actual Silver Prices	Forecasted Silver Prices
01-10-2022	56868	57293		16-10-2022	55803	55691
02-10-2022	59603	57293		17-10-2022	56711	56210
03-10-2022	61532	60027		18-10-2022	56179	57134
04-10-2022	61859	61908		19-10-2022	56067	56593
05-10-2022	61291	62223		20-10-2022	56716	56479
06-10-2022	60825	61676		21-10-2022	57670	57139
07-10-2022	61968	61224		22-10-2022	57670	58102
08-10-2022	60755	62327		23-10-2022	57543	58102
09-10-2022	59486	61156		24-10-2022	57758	57974
10-10-2022	58477	59912		25-10-2022	58295	58190
11-10-2022	57581	58910		26-10-2022	58258	58728
12-10-2022	56452	58012		27-10-2022	57353	58691
13-10-2022	56303	56871		28-10-2022	57500	57783
14-10-2022	55295	56720		29-10-2022	57500	57931
15-10-2022	55295	55691		30-10-2022	57786	57931

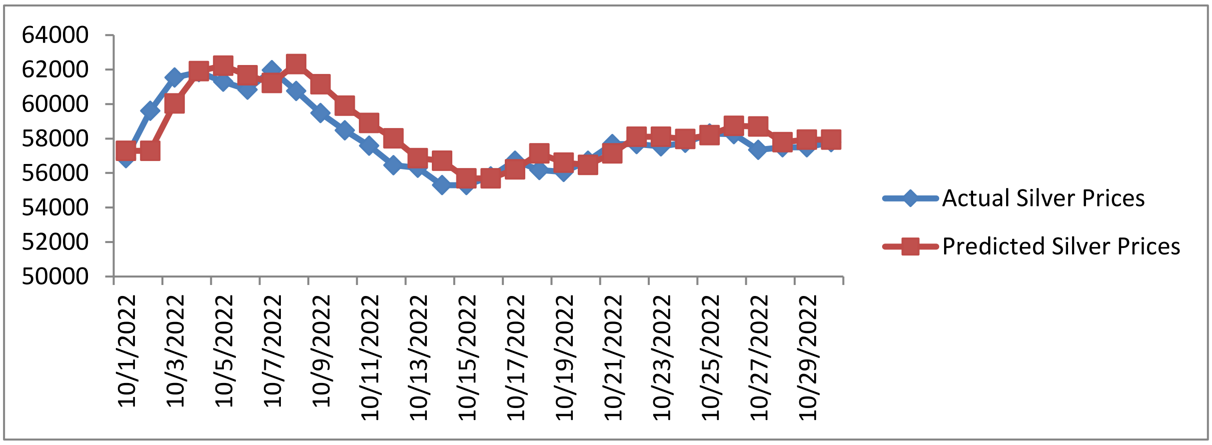

Figure 3.3.2: Testing sample forecasting using FFNN

In the above determine 3.3.2, it turned into noted that the FFNN models produce better outcomes, and the graph additionally plays better.

4 Comparison of Forecasts models for daily prices of silver (1 Kg) in India.

In above outcomes, the accuracy measures of the model performances on training samples and test pattern effects differ drastically. When as compared to the ARIMA, the FFNN model error measures are greater effective and adaptable for training and test samples.

Consequently, the FFNN model forecast outperforms the ARIMA. The comparison of the models is in the table below.

Table 4.1: Comparison of Forecasts models for daily prices of silver (1 Kg) in India

	ARIMA			FFNN		
Data Set	RMSE	MAE	MAPE	RMSE	MAE	MAPE
Training set	1315.60	566.40	1.09	1189.93	433.94	0.86
Test Set	2344.65	1737.47	2.96	2130.41	862.93	1.47

5 Conclusion

From the above analysis, it is able to be seen that the FFNN models outperform the ARIMA model when it comes to forecasting silver prices. As a result, the FFNN model has been used to project future daily prices of silver in India. The ARIMA and FFNN model predictions are shown in Tables 5.1 and Figures 5.1.

Table 5.1: Forecasted values of ARIMA and FFNN models

Date	Actual Silver Prices	ARIMA Forecasted Silver Prices	FFNN Forecasted Silver Prices
01-10-2022	56868	56593	57293
02-10-2022	56868	56664	57293
03-10-2022	59603	56708	60027
04-10-2022	61532	56695	61908
05-10-2022	61859	56685	62223
06-10-2022	61291	56689	61676
07-10-2022	60825	56691	61224
08-10-2022	61968	56690	62327
09-10-2022	60755	56690	61156
10-10-2022	59486	56690	59912
11-10-2022	58477	56690	58910
12-10-2022	57581	56690	58012
13-10-2022	56452	56690	56871
14-10-2022	56303	56690	56720
15-10-2022	55295	56690	55691
16-10-2022	55295	56690	55691
17-10-2022	55803	56690	56210
18-10-2022	56711	56690	57134
19-10-2022	56179	56690	56593

20-10-2022	56067	56690	56479
21-10-2022	56716	56690	57139
22-10-2022	57670	56690	58102
23-10-2022	57670	56690	58102
24-10-2022	57543	56690	57974
25-10-2022	57758	56690	58190
26-10-2022	58295	56690	58728
27-10-2022	58258	56690	58691
28-10-2022	57353	56690	57783
29-10-2022	57500	56690	57931
30-10-2022	57500	56690	57931

Figure 5.1, which shows a forecast comparison usage of ARIMA and FFNN models, suggests that the performance of the latter model is better than that of the nearer.

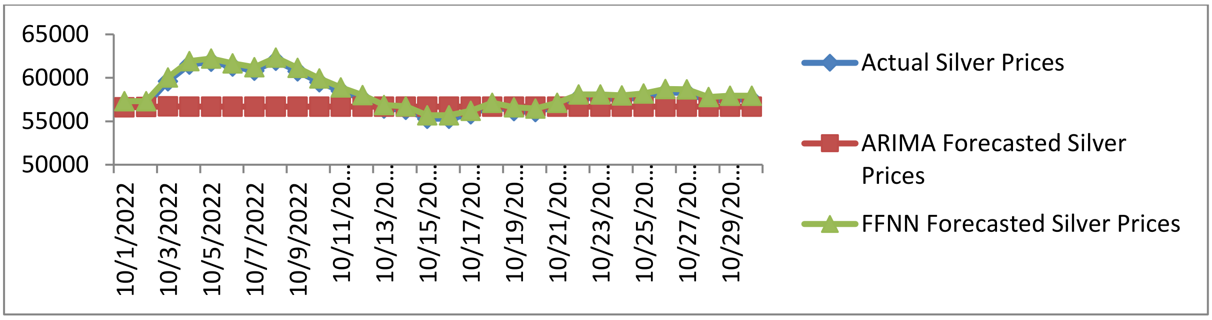

Figure 5.1: Forecasted values of ARIMA and FFNN models.

6. References:

1. Dr.M.Massarrat Ali Khan,Forecasting of Silver Prices Internal Journal Emerging Technology and Advanced Engineering. ISSN 2250-2459, ISO 9001:2008 Volume 3, Issue 3, March 2013

ISSN: 2278-4632
Vol-13, Issue-05, May 2023

2. Raghavender, M. (2010), Forecasting paddy production in Andhra Pradesh with ARIMA model, Int. J. Agricult. Stat. Sci., Vol 6 (1), pp 251-258.

3. M.Basikhasteh, M.A. Movafaghpour and M.Saadatifara, 2014, “Time Series Forecasting Model for Iranian Silver Price”. Indian J.Sci.Res., Vol.7, no.1, pp.1227-1232.

4. Dr. M Udayshankar et al, Forecasting of Egg Prices in Telangana using FFNN and Hybrid in Time Series Model, IJAR,ISSN no.2249-555X,Volume 10,Issue 3, March 2020.

5. Banhi Guha and Gautam Bandyopadhyay,Silver Price Forecasting using Arima model, Journal of Advanced Management Science, Vol 4, No.2, March 2016.

6. Raghavender, M. (2009), Forecasting paddy yield in Andhra Pradesh using seasonal Time Series Model, Bulletin of Pure and applied sciences.

7. R.Rama Krishna & Naveen Kumar.B, 2013, Forecasting yield per Hectare of Rice in AP; IJMCAR, ISSN 2249-6955, Volume 3, Issue 1, March 2013, 9-14.

8. Hornik, 1993, Some New result on neural network approximation, Neural Network, 6(1993), pp. 1069-1072.

9. Dr. M. Raghavender Sharma et al., Forecasting of silver prices using Artificial Neural Networks. JARDCS, Volume 10, 06 issues 2018.

10. Adanacioglu,H.And Yercan, M., 2012,An Analysis of Tomato Prices at Wholesale level in Turkey: An Application of SARIMA model. Custose agronegocio, 8 (4): 52-75.

11. M.A.Khan, 2013, “Forecasting of Silver Prices (Box Jenkins Approach)”. ‘International Journal of Emerging Technology and Advanced Engineering, Vol.3, PP.662-67.

12. MAKRIDAKIS S., WHEEL WRIGHT. S.C., HYNDMAN R.J., 2003, Forecasting Methods and Applications, (John Wiley & Sons).

13. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C., (1994), “Time Series Analysis Forecasting and Control”, 3rd ed., Englewood cliffs, N.J.Prentice Hall.