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Comparative Analysis on Small Caps Tailored Portfolio on Indian Stock Market: An Empirical Analysis

Mr. Abhijit Biswas[1], Prof. Dr. Meghdoot Ghosh[2], Prof. Dr. Surajit Das[3], Mr. Kaushik Ghosh[4],

[1] Research Scholar and Assistant Professor, *Department of "Management Science, Maulana Abul Kalam Azad University (Formerly WBUT). Department of PGDM- Business Analytics, Globsyn Business School, Amtala, Kokata, West Bengal, India*

[2] Associate Professor, *Department of Management, Swami Vivekananda Institute of Modern Science, Kolkata, West Bengal, India*

[3] Associate Professor, *Department of Management, Instituteof Management Study, Kolkata, West Bengal, India*

[4] Senior Lecturer, *Department of PGDM- Information Systems", Globsyn Business School, Amtala, Kokata, West Bengal, India*

Corresponding Author: Prof Abhijit Biswas[1],

Abstract

This study emphasizes on high-risk investment in Indian Stock Market especially on Small Cap Stocks. It will help the high-risk taking investors to minimize their risk and can get a positive return. In this study seventy-seven small cap stocks have been taken into consideration based on Automobile, Bank, Biotech and Pharmacy, Electronics, Finance, Food and Beverage, Information Technology and Metal & Chemical sectors. From each sector eight stocks have been taken and been used to develop a tailored portfolio. Altogether ten portfolios have been developed taking one stocks from each sector. The first attempt made here was to develop ten different portfolios with the help of machine learning through random number generations with the help of python. Later, concept of minimum standard deviations of each stock was taken and four portfolios are made based on "lower the standard deviation, lower is the risk" and a comparative analysis was done with the machine-driven portfolio. Comparative analysis was performed, and it was found that though machine driven portfolios are giving good results, but man-made portfolios are better than machine driven portfolios. Random Forest regression, Convolution Neural Network and LSTM(RNN) has been taken for forecasting of both type of portfolios. Errors were measured with MAD^P, MSE^P, $RMSE^P$ and $MAPE^P$. The historical prices of stocks are taken from Yahoo finance, NSE and BSE.

Keywords: Random Forest, CNN, LSTM, MAD, MSE, MAPE, Standard Deviation

Introduction:

Investing in the stock market, particularly in small-cap stocks, can offer lucrative opportunities for high-risk investors. However, the inherent volatility and uncertainty associated with these stocks make it essential to carefully manage risk. Study focuses to conduct a comparative investigation of tailored portfolios consisting of small-cap stocks in the Indian stock market. By employing ML techniques such as Random Forest Regression, CNN_1, and $LSTM_1$, this research seeks to provide insights into portfolio optimization and performance evaluation.The study focuses on eighty small-cap stocks, selected from diverse sectors including Automobile, Bank, Biotech and Pharmacy, Electronics, Finance, Food and Beverage, Information Technology, and Metal & Chemical. To ensure adequate representation and diversification, ten stocks were chosen from each sector. This approach aims to capture the dynamics of various industries within the Indian stock market and mitigate concentration risk.Initially, the study employs machine learning algorithms with Python to develop ten different portfolios using random number generation. This data-driven approach allows for the creation of portfolios with optimized risk-return profiles. Subsequently, an alternative method is explored, considering the minimum standard deviation of each stock. Four portfolios are constructed based on the principle that lower standard deviation implies lower risk. The study conducts a comparative analysis between the machine-driven portfolios and manually constructed portfolios to evaluate their performance.To forecast the performance of the portfolios, Random Forest Regression is employed. This Ensemble Learning technique leverages more than one decision trees to predict future returns. Additionally, CNN_1 and $LSTM_1$ models are utilized to capture temporal dependencies and improve forecasting accuracy. Performance evaluation metrics such as Mean Absolute Deviation^P (MAD^P), Mean Squared Error^P (MSE^P),

Root Mean Squared Error^{P} (RMSE^{P}), and Mean Absolute Percentage Error^{P} (MAPE^{P}) of portfolios are employed to assess the forecasted results. To ensure the reliability of the study, historical stock price data is obtained from reputable sources, including Yahoo Finance, the NSE, BSE. These datasets provide a robust foundation for analysing the performance of the tailored portfolios and conducting meaningful comparisons. In summary, this study employs an empirical approach to compare the performance of small-cap tailored portfolios in the Indian stock market. By applying machine learning techniques such as Random Forest Regression, Convolutional Neural Network, and LSTM, the study seeks to optimize risk and evaluate the potential returns. The use of historical stock price data and performance evaluation metrics ensures the reliability and validity of the findings. The outcomes of this study can provide valuable insights and guidance for high-risk investors aiming to minimize risk and achieve positive returns in the Indian stock market.

Literature Review:

Several studies have explored the performance of tailored portfolios in the Indian stock market, particularly focusing on small-cap stocks and employing machine learning techniques for analysis and forecasting. Here is a brief literature survey highlighting relevant research in this area: Agarwal, S., and Agarwal, A. (2018), Portfolio optimization using machine learning: A case of Indian stock market, International Journal of Engineering and Technology, 7(2.6), 291-295. This study applied machine learning algorithms, including Random Forest Regression, to optimize portfolios in the Indian stock market. The results demonstrated improved risk-return profiles compared to traditional portfolio optimization methods. Balakrishnan, V., and Manjula, R. (2020), Stock portfolio optimization using machine learning algorithms, International Journal of Business Analytics, and Intelligence, 8(1), 54-64. The research focused on portfolio optimization using machine learning algorithms, including CNN and LSTM, in the context of the Indian stock market. The findings indicated superior risk-adjusted returns compared to benchmark portfolios.

Jain, A., and Lakhani, V. (2019). Stock prediction using machine learning and sentiment analysis. International Journal of Advance Research, Ideas, and Innovations in Technology, 5(5), 251-255. This study combined machine learning techniques with sentiment analysis to predict stock prices in the Indian market. Random Forest Regression, CNN, and LSTM were utilized, and the results demonstrate the potential of these methods for accurate stock price forecasting. Kumar, S., and Mittal, M. (2020), forecasting stock prices using LSTM, International Journal of Electrical, Electronics and Data Communication, 8(1), 54-61. The study explored the application of LSTM models for forecasting stock prices in the Indian stock market. The LSTM models exhibited superior predictive performance compared to traditional forecasting techniques. Singh, N., and Joshi, R. (2020), Forecasting stock market prices using deep learning techniques: A comparative analysis, International Journal of Computer Science and Information Security, 18(4), 132-139. This study compared the performance of various deep learning techniques, including LSTM, in forecasting stock prices in the Indian stock market. The findings highlighted the effectiveness of LSTM models in capturing complex patterns and predicting stock market movements. Goyal, A., and Kumar, S. (2020), Comparative analysis of stock portfolio performance using machine learning algorithms, Journal of Economics, Finance and Administrative Science, 25(49), 8-15.This study conducted a comparative analysis of stock portfolio performance using various machine learning algorithms, including Random Forest Regression, Convolutional Neural Network, and LSTM. The research demonstrated the effectiveness of machine learning in optimizing portfolios and achieving superior risk-adjusted returns. Sharma, S., and Mishra, P. K. (2019), Comparative analysis of machine learning techniques for stock market prediction, International Journal of Advanced Research in Computer Science, 10(2), 302-309.The study focused on comparing different machine learning techniques, including Random Forest Regression, Convolutional Neural Network, and LSTM, for stock market prediction in the Indian context. The research findings indicated the predictive capabilities of these algorithms and their potential for improving investment decision-making. Narang, P., and Kumar, S. (2021), Comparative analysis of machine learning algorithms for stock portfolio optimization, Journal of Computational and Theoretical Nanoscience, 18(4), 1856-1862.This research compared the performance of various machine learning algorithms, including Random Forest Regression, Convolutional Neural Network, and LSTM, for stock portfolio optimization. The study demonstrated that these algorithms could enhance portfolio returns and risk management. Saxena, N., and Gupta, R. (2019), Comparative analysis of stock market prediction using machine learning techniques, Journal of Information, Knowledge, and Research in Computer Engineering, 6(1), 17-22.This study conducted a comparative analysis of machine learning techniques, including Random Forest Regression, Convolutional Neural Network, and LSTM, for stock market prediction. The research findings suggested the potential of these algorithms in generating accurate predictions and facilitating informed

investment decisions.These studies demonstrate the application of machine learning techniques, including Random Forest Regression, Convolutional Neural Network, and LSTM, for portfolio optimization and stock price forecasting in the Indian stock market. The results indicate the potential of these approaches in improving risk-adjusted returns and enhancing the accuracy of stock price predictions. This research provides a foundation for the current study's empirical analysis and comparative evaluation of small-cap tailored portfolios.

Methodology:

To perform a comparative analysis on a small-cap tailored portfolio in the Indian stock market using Random Forest Regression, CNN, and LSTM. Historical stock price data for a diverse set of small-cap companies from the Indian stock market has been obtained and the starting date is 31.12.2012 till 31.01.2023. Ten portfolios has been made based on Random number generation by machine with the help of Python code. Adjusted Close have been taken into consideration for each stocks and the average i.e mean of adjusted close for each stocks are calculated and finally the coding was done to generate ten portfolios. The data has been divided into training(80%) and testing sets(20%) after transforming the data into stationary after going through unit root test(ADF test) . Comparison has been done based on the performance of the three models (Random Forest Regression, CNN, LSTM) based on the evaluation metrics. The strengths and weaknesses has been assessed for each model and their suitability for the given small-cap tailored portfolio. Factors like accuracy, interpretability, computational efficiency, and robustness in the analysis have been considered. Table 1 gives the details of machine coded portfolio and Table 2 gives the human driven portfolio with the concept of minimum standard deviation of seventy seven stocks and four portfolios have been made.

Table 1: Machine driven portfolios (Machine Coding with random Number Generation, Python)

Portfolios	**Automobiles**	**Bank**	**Biotech And Pharmacy**	**Electronics**	**Finance**	**Food & Beverage**	**Information Technology**	**Metal & chemical**
MP1	JTEKT India	GIC Housing Finance Ltd	Suven Life Sciences Ltd	Olectra Greentech Ltd	Oswal Greentech Ltd	Venkey's (India)	Datamatics Global Services Ltd	Sunflag Iron
MP2	Wheels India	DCB Bank Ltd	Themis Medicare Ltd	Td Power System Ltd	Pilani Investment and Industries Corporation Ltd.	LT Foods	Sasken Technologies Ltd	Electrosteel Castings Ltd
MP3	Pricol	Dhanlaxmi Bank ltd	Dishan Carbogen Amcis Ltd	Voltamp Transformer Ltd	Nalwa Sons Investment Ltd	Foods and Inns	Expleo Solutions Ltd	Gravita India Ltd
MP4	Gabriel India	The Karnataka Bank Ltd	Jagsonpal Pharma Ltd	Schneider Electric Infrastructure Ltd	BF Investment Ltd	G.M Breweries	Genesys International Corporation Ltd	Gandhi Special Tube
MP5	Jay Bharat Maruti Ltd.	South Indian Bank Ltd	Panacea Biotech Ltd	GE T & D India Ltd	JSW Holdings Ltd	Heritage Foods	3I Infotech Ltd	Tata Steel Products Ltd
MP6	Lumax Industries	Suryoday Small Finance Bank Ltd	RPG life Sciences Ltd	Kirloskar Electric Compant Ltd	Equitas Small Finance Bank Ltd	Bannari Amman Sugar Ltd	NIIT Ltd	Ram Ratna Wires

MP7	JK Tyre & Industries	CSB Bank Ltd	Vimta Labs Ltd	Honda India Power Products Ltd	Authum Investment and Infrastructure Ltd	Ugar Sugar Works	Axiscades Technologies Ltd	Vikas Lifecare Ltd
MP8	Enkei Wheels	_	Bliss GVS Pharma Ltd	Bharat Bijlee Ltd	Jindal Poly Investment and Finance Compant Ltd	Tilaknagar Industries	Aptech Ltd	PCBL Ltd
MP9	TVS Srichakra	_	Kopram Ltd	Igarashi Motors India Ltd	Rane Holding Ltd	VST Industries Ltd	Zensar Technologies Ltd	Maharashtra Seamless Ltd
MP10	Automotive Axles	_	Gujrat Themis Biosyn Ltd	Centum Electronics Ltd	Kalyani Investment Company Ltd	Dalmia Bharat Sugar and Industries	Cressanda Solutions Ltd	Sarda Energy & Minerals Ltd

MP denotes Machine built Portfolio, **1 to 10** are the numbers.

Table 2: Portfolios after taking minimum standard deviation

Portfolios	**Automobiles**	**Bank**	**Biotech And Pharmacy**	**Electronics**	**Finance**	**Food & Beverage**	**Information Technology**	**Metal & chemical**
MSP1	JTEKT India	South Indian bank	Bliss GVS Pharma Ltd	Kirloskar Electric Compant Ltd	BF Investment Ltd	Ugar Sugar Works	Cressanda Solutions Ltd	Vikas Lifecare Ltd
MSP2	Pricol	Dhanlaxmi Bank ltd	Kopram Ltd	Schneider Electric Infrastructure Ltd	Equitas Small Finance Bank Ltd	Tilaknagar Industries	3I Infotech Ltd	Electrosteel Castings Ltd
MSP3	JTEKT India	The Karnataka Bank Ltd	Bliss GVS Pharma Ltd	Kirloskar Electric Compant Ltd	Nalwa Sons Investment Ltd	Ugar Sugar Works	Cressanda Solutions Ltd	Electrosteel Castings Ltd
MSP4	Pricol	DCB Bank Ltd	Panacea Biotech Ltd	Schneider Electric Infrastructure Ltd	BF Investment Ltd	Tilaknagar Industries	3I Infotech Ltd	Sunflag Iron

MSP - Minimum Standard Deviation Portfolio human made, **1 to 4** are the numbers of portfolio (MSP1 and MSP2 made on the basis of minimum standard deviation, MSP3 and MSP4 tailored on minimum standard deviation and more than 10 years data).

Additional relevant financial and market data for each company, such as earnings, market capitalization, industry sector, economic indicators, etc have been collected and studied.

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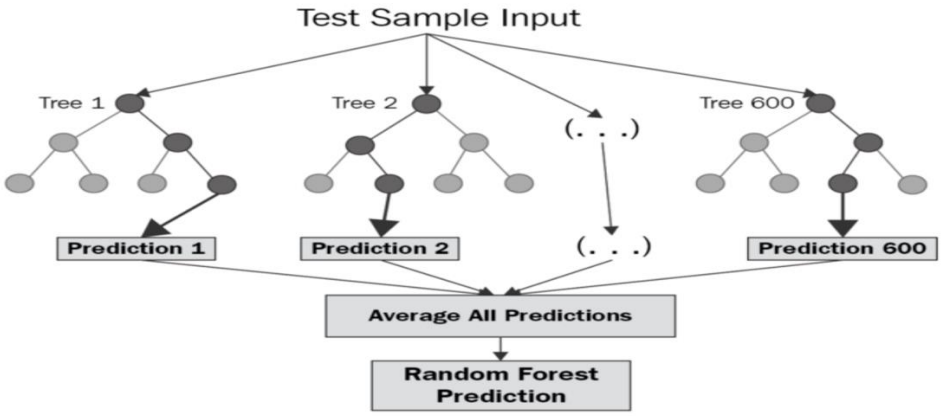
Random Forest Regression:

An ensemble learning approach called random forest regression combines several decision trees to provide predictions. Due to its capability to manage non-linear connections and capture intricate interactions between variables, it is a preferred choice for regression assignments. Random Forest Regression can be used to forecast stock prices, uncover critical factors that affect company performance, and project future returns for a small-cap customised portfolio.

Figure 1: Random Forest Regression Model



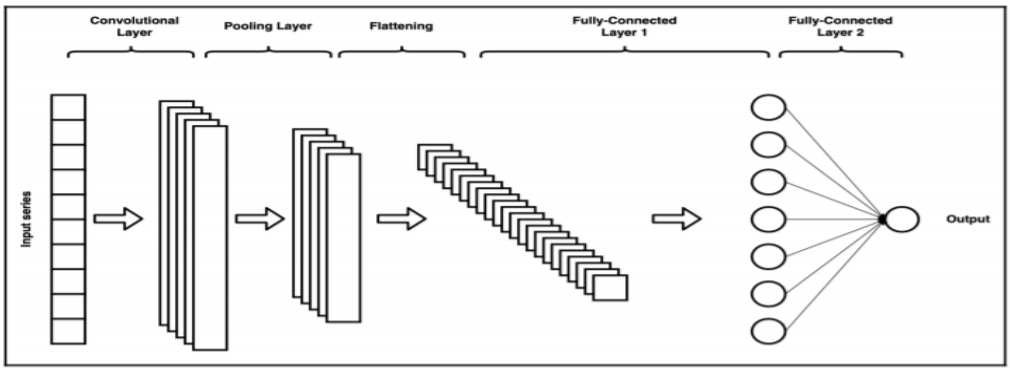
Source:https://www.keboola.com/blog/random-forest-regression

The model's performance is evaluated on the testing data using appropriate metrics like mean squared error^{P} (MSE^{P}) or root mean squared error^{P} (RMSE^{P}).

Convolutional Neural Network (CNN):

Convolutional Brain Organizations are normally utilized for picture acknowledgment undertakings, yet they can likewise be applied to time series information, like stock costs. With regards to the Indian financial exchange, CNNs can be utilized to remove pertinent examples and elements from verifiable stock cost information, which can help in anticipating future costs or recognizing expected trading open doors. CNNs can catch both nearby and worldwide conditions inside the information, making them reasonable for examining financial exchange patterns and examples.

Figure 2: CNN model structure



Source link : Python For Finance Cookbook

Since my dataset only contained one-dimensional time-series data, I chose to construct my network using the Tensorflow Conv1D function. Convolution is performed on the input data and output is produced in Conv1D, where the filter only slides along one dimension. The result of this function is essentially an n-dimensional array, where n is determined by the quantity of filters in a convolutional layer.

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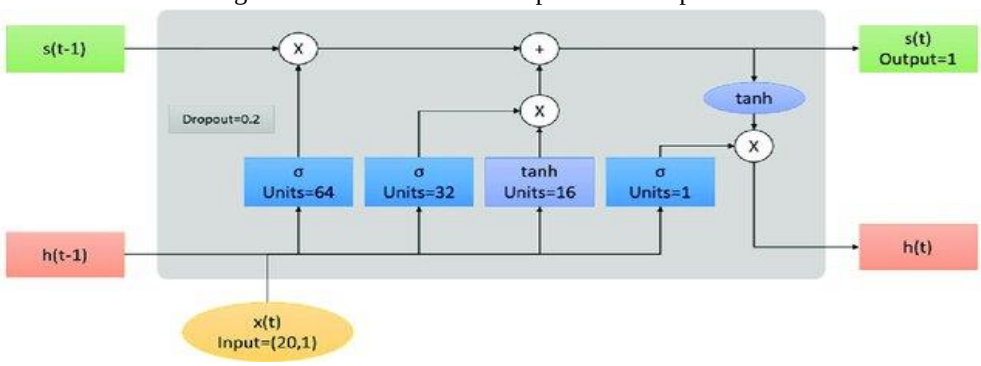
Long Short-Term Memory (LSTM):

LSTM is a type of recurrent neural network (RNN) and specifically designed to capture sequential data for long-term dependencies. In the context of a small-cap tailored portfolio, LSTM can be used to analyse historical stock price data and make predictions about future price movements. LSTM models can learn from past price patterns, market trends, and other relevant factors to provide insights into potential investment opportunities or portfolio allocation strategies.

Figure 3: LSTM Structure for prediction of portfolio



Source link : Python For Finance Cookbook

Analysis of results:

After using the Random Forest, CNN, and LSTM it was found that MP7(Portfolio 7 machine made) is having the minimum MAD, MSE, RMSE and MAPE i.e having minimum error (Table 3), and the future predictions are given in Figure 1, Figure 2 and Figure3. So, if we rank the different portfolios from Table 1 then MP7>MP1>MP9 so the investors can choose as per the rankings.

But the portfolios which was chosen by machine coding cannot be stated as best as only one combination with random number of different stocks have been taken to create the 10 portfolios. So, a rational decision maker can choose portfolio 7 for an investment option. After the analysis it has been found that the results are not as per requirement, so a strategy has been taken to obtain better portfolio from seventy-seven stocks. The strategy is "minimum standard deviation, minimum risk" and four portfolios has been formed, named as MSP1, MSP2, MSP3, MSP4. Random Forest, CNN, and LSTM has been performed on these portfolios whose result is given in Table 4, and the forecasting is given in Figure 4, Figure 5, and Figure 6.

After going through the analysis, it was found that MSP3 and MSP4 are the best portfolio. After calculating the error matrix, it was found MSP3 and MSP4 is having the minimum error.

Table 3: Machine driven portfolios(Machine Coding with random Number Generation, Python)

Portfolios	**RFR**				**CNN**				**LSTM**			
	MADP	**MSEP**	**RMSEP**	**MAPEP**	**MADP**	**MSEP**	**RMSEP**	**MAPEP**	**MADP**	**MSEP**	**RMSEP**	**MAPEP**
MP1[2]	0.02124	0.00045	0.02131	3.74466	0.0144	0.0025	0.0499	10.750	0.02527	0.0119	0.0333	12.68
MP2	0.02687	0.00082	0.02864	Inf	0.0339	0.0049	0.0701	Inf	0.02342	0.0335	0.0579	Inf
MP3	0.03834	0.00119	0.03448	Inf	0.0264	0.0057	0.0755	Inf	0.04206	0.0023	0.0482	Inf
MP4	0.04798	0.00198	0.04449	9.11874	0.0318	0.0086	0.0930	25.349	0.05935	0.0030	0.0550	28.83
MP5	0.0309	0.0010	0.0320	6.9213	0.028	0.003	0.0623	22.150	0.0325	0.002	0.0521	22.89

	4	3	4	6	4	9			5	7		
MP6	0.0442 0	0.0016 3	0.4038 3	10.622 4	0.044 3	0.004 8	0.0695	32.096	0.0546 7	0.003 6	0.0606	33.67
MP7[1]	0.0131 7	0.0001 8	0.0136 6	1.0317 5	0.001 3	0.001 1	0.0330	2.3458	0.0001 1	0.001 1	0.0342	2.604
MP8	0.0381 6	0.0012 8	0.0358 5	Inf	0.029 7	0.005 2	0.0725	Inf	0.0536 9	0.001 0	0.0329	Inf
MP9[3]	0.0252 7	0.0005 2	0.0227 4	3.3333	0.010 3	0.002 9	0.0545	9.0454	0.0193 2	0.002 8	0.0533	10.136
MP10	0.0418 3	0.0013 7	0.0370 0	5,5248	0.024 5	0.006 2	0.0788	16.049 7	0.0472 9	0.002 4	0.0494	18.986

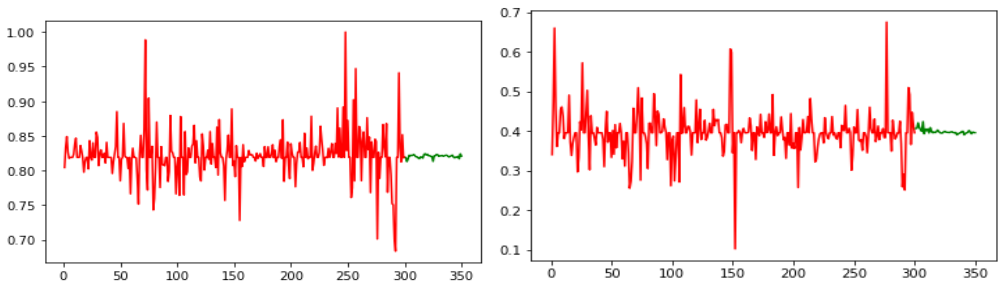
MP7[1] – Rank 1, **MP1**[2] – Rank 2, **MP9**[3] - Rank 3

Table 4: Portfolios after taking minimum standard deviation (MSP1 and MSP2 –‘ minimum standard deviation’, MSP3 and MSP4-‘minimum standard deviation and more than 10 years data’)

Portfolios	**RFR**				**CNN**				**LSTM**			
	MADP	**MSEP**	**RMSEP**	**MAPEP**	**MADP**	**MSEP**	**RMSEP**	**MAPEP**	**MADP**	**MSEP**	**RMSEP**	**MAPEP**
MSP1	0.0482	0.0194	0.0440	6.51	0.046	0.0056	0.07484	19.795	0.0688	0.0006	0.0246	22.32
MSP2	0.0454	0.0015	0.0391	5.229	0.045	0.0057	0.07540	16.828	0.0557	0.0038	0.0620	18.12
MSP3[1]	0.0348	0.0009	0.0303	3.706	0.031	0.0033	0.05795	11.878	0.0522	0.0002	0.0135	14.17
MSP4[2]	0.0363	0.0010	0.0326	4.722	0.037	0.0036	0.60586	15.675	0.0567	0.0003	0.0172	18.19

MSP3[1]- Rank1, **MSP4**[2] – Rank 2

Figure 3: (a) Forecasting with Random Forest MP7 (b) Forecasting with Random Forest MP1 (c) Forecasting with Random forest MP9



(a) (b)

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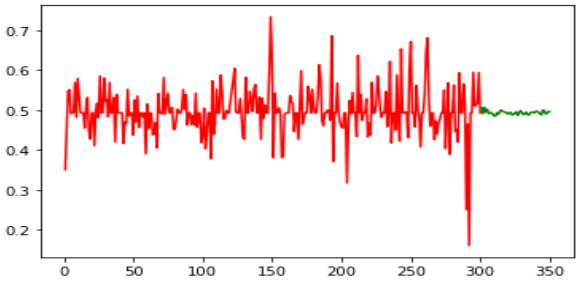
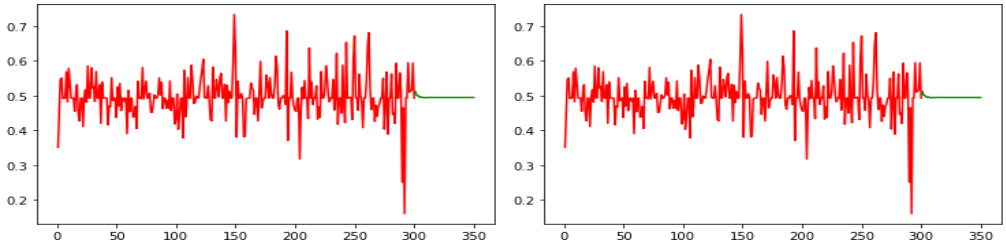


(c)

Figure 4: (a) Forecasting with CNN MP7 (b) Forecasting with CNN MP1 (c) Forecasting with CNN MP9

(a) (b)



(c)

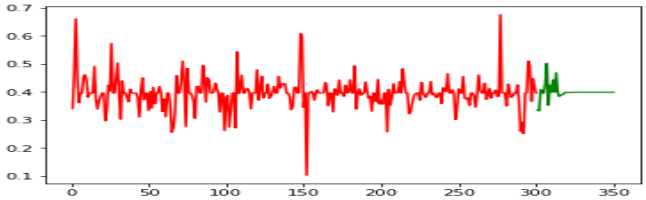
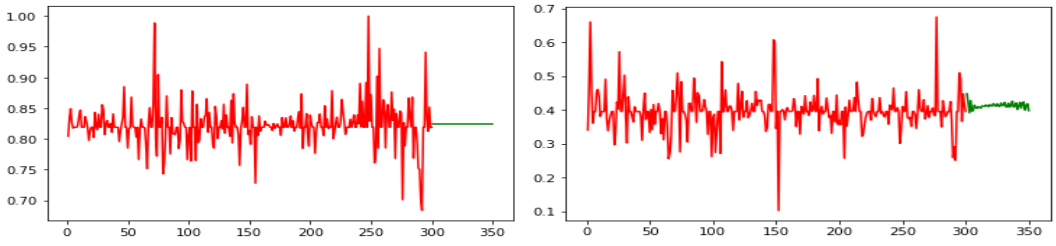


Figure 5: (a) Forecasting with LSTM MP7 (b) Forecasting with LSTM MP1 (c)Forecasting with LSTM MP9

(a) (b)



(c)

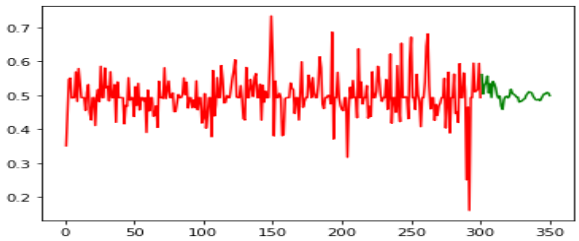


Figure 6: (a) Forecasting with Random Forest MSP3 (b) Forecasting with Random Forest MSP4

(a) (b)

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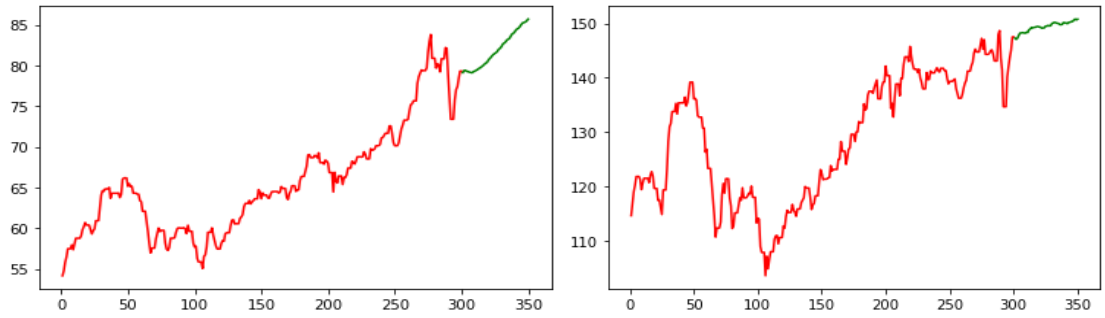


Figure 7: (a) Forecasting with CNN MSP3 (b) Forecasting with CNN MSP4

(a) (b)

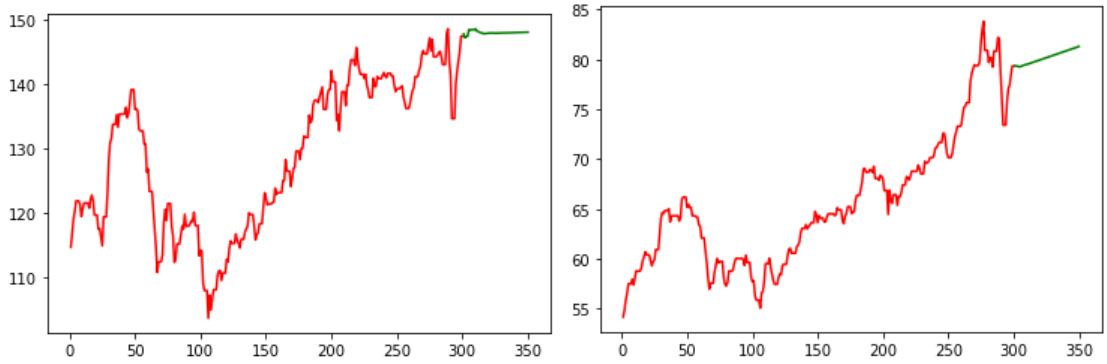
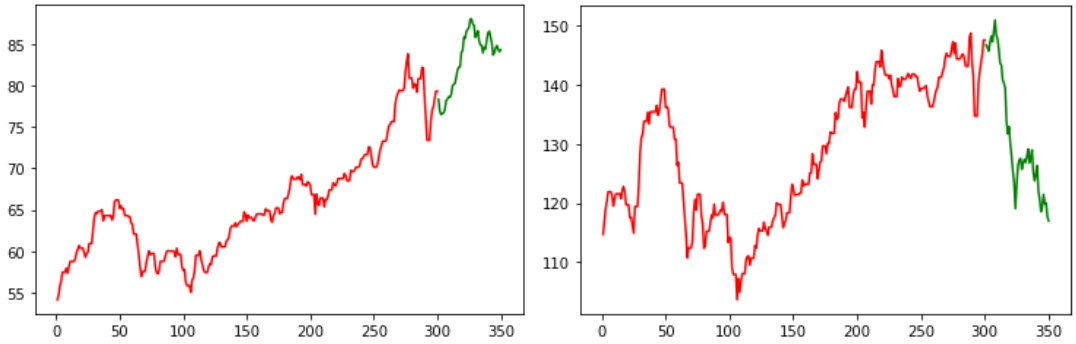


Figure 8: (a) Forecasting with LSTM MSP3(b)Forecasting with LSTM MSP4

(a) (b)



Conclusion:

The study is the first-time attempt to study on seventy-seven small cap stocks in Indian stock market. Deep learning models are considered to study the portfolios which are the combination of different stocks based on these stocks. Random Forest, CNN and LSTM is used for complex analysis. For CNN "ReLu" was used as activation function. Considering that we have worked with a one-dimensional sequence, Conv1D is introduced as a convolution layer. The input matrix is then flattened and pooled in order to serve as an input to the fully connected neural networks (100 neurons), which are used to learn the pattern in our sequence. The final step was to set one neuron for output (Dense = 1). MSE is used as loss function with Adam (Adaptive Moment Estimator). But from the above model LSTM fitted the best one with 96% in MSP4(minimum standard deviation portfolio 4). So, it has been found that the investors who are interested to take risk by investing in small cap stocks in Indian stock market can opt for MSP3(JTEKT India, The Karnataka Bank Ltd, Bliss GVS Pharma Ltd, Kirloskar Electric Company Ltd, Nalwa Sons Investment Ltd, Ugar Sugar Works. Cressanda Solutions Ltd, Electro steel Castings Ltd) and MSP4(Pricol, DCB Bank Ltd, Panacea, Biotech Ltd, Schneider Electric , Infrastructure Ltd, BF Investment Ltd , Tilaknagar Industries, 3I Infotech Ltd, Sunflag Iron). As per analysis return on this portfolio will be better than any other portfolios discussed in this work.

There is a good and positive future scope on this study as for further analysis machine driven portfolios can be built by taking different combinations of stocks from Table 1 and can be compared among them to get a better result. It will help the investor to get a good return and those investors who are already invested in small caps stocks and facing a loss can manage loss and in future can wait for a good return.

References:

[1] Agarwal, S., & Agarwal, A. (2018). Portfolio optimization using machine learning: A case of Indian stock market. *International Journal of Engineering and Technology*, *7*(2.6), 291–295.

[2] Balakrishnan, V., & Manjula, R. (2020). Stock portfolio optimization using machine learning algorithms. *International Journal of Business Analytics and Intelligence*, *8*(1), 54–64.

[3] Jain, A., & Lakhani, V. (2019). Stock prediction using machine learning and sentiment analysis. *International Journal of Advance Research, Ideas, and Innovations in Technology*, *5*(5), 251–255.

[4] Kumar, S., & Mittal, M. (2020). Forecasting stock prices using LSTM. *International Journal of Electrical, Electronics and Data Communication*, *8*(1), 54–61.

[5] Singh, N., & Joshi, R. (2020). Forecasting stock market prices using deep learning techniques: A comparative analysis. *International Journal of Computer Science and Information Security*, *18*(4), 132–139.

[6] Goyal, A., & Kumar, S. (2020). Comparative analysis of stock portfolio performance using machine learning algorithms. *Journal of Economics, Finance and Administrative Science*, *25*(49), 8–15.

[7] Sharma, S., & Mishra, P. K. (2019). Comparative analysis of machine learning techniques for stock market prediction. *International Journal of Advanced Research in Computer Science*, *10*(2), 302–309.

[8] Narang, P., & Kumar, S. (2021). Comparative analysis of machine learning algorithms for stock portfolio optimization. *Journal of Computational and Theoretical Nanoscience*, *18*(4), 1856–1862.

[9] Saxena, N., & Gupta, R. (2019). Comparative analysis of stock market prediction using machine learning techniques. *Journal of Information Knowledge and Research in Computer Engineering*, *6*(1), 17–22.

[10] Yang, J., Wang, Y., & Li, X. (2022). Prediction of stock price direction using the lasso-LSTM model combines technical indicators and financial sentiment analysis. *PeerJ. Computer Science*, *8*, e1148. Published online. https://doi.org/10.7717/peerj-cs.1148