ORIGINAL PAPER

DOI: 10.26794/2587-5671-2024-28-2-40-49
JEL C45, C53

A Comparative Study of the Envisaged and Definite Stock Prices of BSE SMEs Using RNN during the COVID-19 Pandemic

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ABSTRACT

The stock market is unstable, but the use of machine learning algorithms allows to predict its future dynamics before spending. The most popular area of scientific research right nowadays is machine learning, which involves enabling computers to perform tasks that often require human intelligence. The **purpose** of this paper is to construct a model using a network of Long-Short Term Memory model (LSTM) to forecast future stock market values. The paper presents the advantages and disadvantages of machine learning for assessing and forecasting the stock market. A review of literature on the application of machine learning models in key areas of finance using methodological model assessment and data manipulation is also available. This paper focuses on the losses of the SME sector due to COVID-19 by doing a comparative study using secondary data collection between the predicted closed stock prices and actual stock prices of the BSE SME IPO index for the period from 1 January 2018 to 30 April 2021.The LSTM network of Recurrent Neural Networks (RNNs) most effective deep learning model, is used to predict stock prices. The study provides insight and direction on where lockdown has a massive impact on the stock prices of BSE SME IPOs. The authors developed a **model** for predicting the future value of stock in the market, the application of which gave some positive results, demonstrating the need for machine learning and how it can change the world of finance. The **novelty** of the study is that in India, machine learning and deep learning methods in the field of finance are used much less often than in other countries.

Keywords: Deep learning; MSME sector; SMEs; BSE SME IPO; RNN; LSTM

For citation: **Kaur S., Munde A., Goyal A.K. A comparative study of the envisaged and definite stock prices of BSE SMEs using RNN during the COVID-19 pandemic. *Finance: Theory and Practice.* 2024;28(2):40-49. DOI: 10.26794/2587-5671-2024-28-2-40-49**

ОРИГИНАЛЬНАЯ СТАТЬЯ

Сравнительное исследование с помощью рекуррентных нейронных сетей предполагаемых и фактических цен на акции малых и средних предприятий Бомбейской фондовой биржи в период пандемии COVID-19

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АННОТАЦИЯ

Фондовый рынок нестабилен, но использование алгоритмов машинного обучения позволяет спрогнозировать его будущую динамику перед расходованием средств. Самой популярной областью научных исследований в настоящее время является машинное обучение, которое предполагает предоставление компьютерам возможности выполнять задачи, часто требующие человеческого интеллекта. **Целью** данной статьи является построение модели, использующей сеть долгосрочной и краткосрочной памяти (LSTM), для прогнозирования будущей стоимости акций на рынке. Представлены преимущества и недостатки машинного обучения для оценки и прогнозирования фондового

рынка. Сделан обзор литературы по применению моделей машинного обучения в ключевых областях финансов с использованием методической оценки модели и манипулирования данными. Основное внимание уделено убыткам сектора ММСП из-за COVID-19 путем сравнительного исследования прогнозируемых цен на акции на момент закрытия и фактических цен на акции индекса IPO малых и средних компаний BSE за период с 1 января 2018 по 30 апреля 2021 г. Для прогнозирования цен на акции использована модель глубокого обучения LSTM как наиболее эффективная среди рекуррентных нейронных сетей (RNN). Исследование дает представление о том, какое влияние оказывает карантин на цены акций при IPO малого и среднего бизнеса на BSE. Авторы разработали **модель** для прогнозирования будущей стоимости акций на рынке, применение которой дало несколько положительных результатов, что продемонстрировало необходимость машинного обучения и то, как оно может изменить мир финансов. **Новизна** исследования состоит в том, что в Индии методы машинного обучения и глубокого обучения в области финансов используются гораздо реже, чем в других странах.
Ключевые слова: глубокое обучение; МСП; IPO; Бомбейская фондовая биржа; RNN; LSTM

Для цитирования: **Kaur S., Munde A., Goyal A.K. A comparative study of the envisaged and definite stock prices of BSE SMEs using RNN during the COVID-19 pandemic. *Финансы: теория и практика*. 2024;28(2):40-49. DOI: 10.26794/2587-5671-2024-28-2-40-49**

INTRODUCTION

Throughout the last few decades, the global economy has evolved drastically. Nevertheless, just because the economy is growing, it does not eliminate future outbreaks. Beginning with the Great Depression in the early 1930s, the global economy was heavily impacted. It began in the United States in 1929 and quickly spread throughout the world. Businesses were closed, poverty and unemployment increased, and global trade was disrupted. The major impact was on the stock market, which crashed badly at the time of the Great Depression.

According to Ben Bernanke (Former head of the Federal Reserve), "2008 financial crisis was the worst in global history, surpassing even the Great Depression" [1].

The main cause of the great recession was non-intervention in the financial industry. Banks decreased their consumer credit rate, from which people took advantage, which further led to international banking crises at the start of the great recession. GDP was affected, which led to unemployment, a crash in the stock market, etc. At the time of the great recession, the massive impact was not seen in developing countries like India, but a minor effect was visible post-recession.

And after 11 years of the worst financial crisis, it was expected to have another financial crisis in 2020 due to COVID-19. COVID-19, sometimes known as coronavirus, is a contagious disease that started in the city of Wuhan in China. It started in December 2019, spread worldwide by March 2020 and is still at its utmost in various countries.

According to the WHO, coronavirus is an infectious disease that causes respiratory sickness, especially targeting older people, people with low immunity, and people with heart disease, cancer, and diabetes.[1]

In 2020, the UN (United Nations) predicted a 1% shrink in the global economy due to COVID-19, whereas growth of 2.5% was expected before.[2] It showed how the coronavirus adversely impacted the global economy in the beginning.

Due to the center's sudden lockdown, GDP growth decreased by 23.9%. In the years 2020–2021, India's GDP shrank by 7.3%. Since independence, the Indian economy has never performed worse than it did this year.[3]

A huge decline was visible in the stock market. Shares were not bought by customers due to lack of money, which led to a loss in various businesses, especially for people with small businesses who earn on a daily basis. The situation showed that the major impact was on the MSME sector. The MSME sector is known as micro, small and medium enterprises. The MSME sector generates around 11 crore employment in the country and contributes 48% of its share to Indian exports and 29% to India's GDP.[4]

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[1] WHO. Coronavirus disease (COVID-19). 2022. P. 1–6. URL: https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (accessed on 20.08.2022).

[2] UN-DESA. Global economy could shrink by almost 1% in 2020 due to COVID-19 pandemic: United Nations. Econ Times. 2020;1–12. URL: https://economictimes.indiatimes.com/news/international/business/global-economy-could-shrink-by-almost-1-in-2020-due-to-covid-19-pandemic-united-nations/articleshow/74943235.cms (accessed on 20.08.2022).

[3] Times of India. Impact of Covid-19 on Indian economy. 2021. URL: https://timesofindia.indiatimes.com/readersblog/shreyansh-mangla/impact-of-covid-19-on-indian-economy-2–35042/ (accessed on 20.08.2022).

[4] Wire. Why India's MSME Sector Needs More Than a Leg-Up. 2020. URL: https://thewire.in/business/why-indias-msme-sector-needs-more-than-a-leg-up (accessed on 20.08.2022).

Uttar Pradesh has the most estimated MSMEs, accounting for 14.20% of the total MSMEs in the country. West Bengal ranks second with 14%, followed by Tamil Nadu and Maharashtra, both with 8% [2]. Stock prices of BSE SMEs continuously declined as customers were not purchasing new stocks, and it was more challenging for the MSME sector due to a lack of capital and innovation, poor infrastructure, being unable to employ talented staff, having low or no knowledge of technology, etc.[5]

Predictions of the impact of the coronavirus on various sectors are important for investors, companies, and the government, as various policies and actions can be taken in the future. The term "artificial intelligence" refers to a variety of methods involving machine intelligence that are primarily predictive. Machine learning is considered the most relevant AI method in the field of finance. It is used to make predictions from data related to statistical learning [3]. ANN is a part of machine learning where neural networks learn from experience. It is inspired by neurons in the nervous system of the human body.

Deep learning is the most recent approach, which evolved from past ANN [3]. Being a subset of machine learning, deep learning is more complex as a large amount of data is learned by artificial neural networks. Deep learning is preferred due to its deep layers that enable learning. As it is said that humans learn from their experiences similarly to deep learning algorithms, performing a task repetitively increases the chances of improved outcomes.

Several models are employed to anticipate the effects, but the most recent and effective model is the Recurrent neural networks (RNN) model. In the late 1980s, RNN was initially created but is currently in more use due to the huge amount of data and increased use of computers. RNN was brought to the forefront after the invention of LSTM in the 1990s [4]. In comparison to the traditional approach, LSTM may change the information and the relationship between the information and yield, leading to preferred prediction accuracy [5].

LSTM (Long Short-Term Memory) is an upgraded version of RNN as it is difficult to train an RNN model, i.e., LSTM is used as it uses back-propagation to train the model and it ensures that past data is remembered easily in memory [6]. The RNN is preferred for sequential data like financial data, time series, text, audio, speech, weather, etc. due to its internal memory. The LSTM is an addition to RNN. The LSTM helps RNN remember for a longer period, which makes RNN better than feed-forward networks as feed-forward networks cannot remember anything from the past. In a feed-forward neural network, information is moved in one direction, whereas in an RNN, information cycles through a loop [4]. The method of using components of previous sequences to predict future data is referred to as recurrent. Long Short-Term Memory (LSTM) built on a "memory line" was found to be immensely useful in forecasting scenarios with long-term data because RNN is unable to store long-term memory [7].

216 countries were affected by COVID-19 and the resultant lockdown. Major countries were the USA, Brazil, India, Mexico, Chile, the UK, Russian Federation, etc. Approximately more than 31,000,000 deaths and 15 crore confirmed cases were witnessed by April 2021 due to COVID-19.[6]

This paper shows the importance and inclusion of machine learning in today's world. The paper aims to show how machine learning has developed for the benefit of society by showing how it can be used in the prediction of the stock market. Given the variety of applications, it is possible that machine learning will broaden the scope of various fields. The main objective of this paper is to show how machine learning can produce outstanding results while reducing human labor.

This research differs from other research studies on a related topic since it places significant importance on LSTM. It is also being discussed how approaches to technology have changed after the introduction of techniques like RNN or LSTM.

LITERATURE REVIEW

In contrast to Asian nations, where COVID-19 had the greatest influence, Europe experienced a more mild impact [8]. Asian nations experienced abnormal returns more negatively than other nations. The major countries affected by COVID-19 were the USA, Japan, Italy, Korea, Germany, the UK and Singapore [9].

A significant change was visible in SMEs due to a decline in debt maturity and firm leverage in both developing countries that have not experienced a crisis and advanced economies at the time of global

[5] News S. SME Landscape in India — Growth, Challenges and Opportunities. Bus Stand. 2019;22–5. URL: https://www.business-standard.com/content/specials/sme-landscape-in-india-growth-challenges-and-opportunities-119062100357_1.html (accessed on 20.08.2022).

[6] WHO. Coronavirus disease (COVID-19). 2022. P. 1–6. URL: https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (accessed on 20.08.2022).

financial crises [10]. Due to a lack of growth, the Indian MSME sector was facing various problems like a shortage of finances, an increase in competition locally and globally, market volatility, etc. [11]. Strict follow of social distancing and lockdown was advised in the most affected states of India to control the virus [12]. The lockdown caused a fall in production and the labour force, which had an impact on the profit of companies [9]. In comparison to a 46% fall during the nationwide lockdown in 2020, the average business turnover of Indian MSMEs has decreased by 11% in 2021.[7]

The COVID-19 outbreak caused a sharp decline in the stock market in the impacted countries and areas [9]. A negative impact was seen on the emerging stock market in March 2020 due to COVID-19 [8]. An increase in the number of COVID-19 cases led to a decline in the stock market of 64 countries. The impact of the number of cases was more than the number of deaths due to COVID-19. The result varies from time to time as per the stage of COVID-19 [13].

A heavy decrease in both NIFTY and SENSEX was witnessed in the mid of February 2020 and fell more rapidly after 3rd March 2020. Because there was no drop in COVID-19 cases, it was extremely difficult to regain investor confidence in the market [14].

Categories like asset modelling and forecasting, risk management and investment analysis are identified as the finance categories having more scope for machine learning applications. Risk management is considered more advanced in machine learning applications, whereas asset modelling and forecasting are advanced in financial time series modelling. Corporate finance is one of the topics that has not yet been referred to by machine learning [3]. The APGARCH model was applied to evaluate the non-linear performance of the stock market during the GFC period, and the COVID-19 period in Japan, the US, China, Germany, and Italy which showed that COVID-19 had a greater impact than the GFC (Global Financial Crises) period. Market returns in Japan and the US were more impacted by COVID-19 [15].

Various tests and methods were being used to predict the impact of COVID-19. Impact on US data was predicted by using wavelet-based Granger causality tests [16] and predicted by using event study methods, VAR and GARCH (1.1) [17]. In India's COVID-19 data, a sensitivity analysis was conducted [18]. Genetic programming (GP) based prediction models were applied to the data of the 3 most affected states of India, i.e., Maharashtra, Delhi and Gujarat for the death cases and the confirmed cases [12]. A crisis management model was developed for SMEs to deal with the impact of the crisis, as financial crises impact SMEs directly [19].

Later, the development of artificial intelligence (AI) methods like ANN has drawn more focus in studies on stock market predictions [20]. The most used machine learning approach for stock market prediction is supervised learning [21]. These methodologies, as opposed to conventional time series methods, can manage chaotic and complicated stock market data, resulting in more accurate predictions [20]. As a result, these techniques offer unique and beneficial possibilities, making it appealing for researchers to use them for financial market predictions [21].

The ANN is useful for the prediction of the stock market as its ability is checked by assessing the backpropagation algorithm to train various feed-forward ANNs [22]. The improved accuracy will be achieved by both ANN and LSTM but in terms of global and adaptable technology, LSTM is the ideal forecasting algorithm for the structure of the data set. It provided the result based on the inputted predicted values and trained values [5]. LSTM is likely to outperform methods like a dense-connected neural network, linear models, and support vector regression models if it is applied cautiously [23].

Various approaches for solving financial market problems are summarized as well as a comparative study of ML-based approaches and traditional methods to discuss the effective model by analysing time series problems considering the current financial scenario. Recent studies have been witnessed using RNN and LSTM for forecasting time series data compared with the ANN model. Better results and accuracy are given by these methods in forecasting because of their ability to obtain hidden relationships within data [24].

A study was conducted in which, in order to predict the prices of the three stocks, a recurrent neural network (RNN) was applied. It was discovered that the predicted price fit the actual price more closely when historical data and economic indicators were used as input [25]. A comparative study was conducted using Deep Feed Forward Neural Networks (DNN), Long Short Term Memory Networks (LSTM), Gated Recurrent Unit Networks (GRU), and Recurrent Neural Networks (RNN) deep learning models out of which LSTM performed better than others [26].

[7] Times of India. MSMEs in India — Post COVID Scenario. 2021. URL: https://timesofindia.indiatimes.com/blogs/agyeya/msmes-in-india-post-covid-scenario/ (accessed on 20.08.2022).

Because of its distinct memory function, the LSTM is applied in deep learning for natural language processing and other serial data, however, there are few predictions for stock time-series data [27].

The LSTM is a unique type of RNN since it can memorize data sequences. The upper line in each cell connects the models as a transport line, handing over information from the past to the present. Every LSTM node must consist of a set of cells responsible for storing passed data streams [7]. Input, forget, and output are the three main gates of LSTM, which help it write, delete, and read information from its memory [4]. One of the main advantages of LSTM gates is that they prevent the "vanishing gradient problem" which is a drawback in the RNN model [24].

RESEARCH OBJECTIVES

i. To check the efficiency of the model in tracking the closing price of BSE SMEs IPO and to check the accuracy of the LSTM model for prediction of actual stock market values.

ii. To check the impact of the lockdown on the MSME sector using the LSTM model.

iii. To perform a comparative analysis of various LSTM models pre- and post-COVID.

RESEARCH METHODOLOGY

Data Collection

Secondary data collection is done. Closing stock prices of the BSE SME IPO INDEX were collected from 1 January 2018 to 30 April 2021 from the BSE dataset.[8]

Figure 1 represents the closing stock prices of BSE SMEs collected from the BSE SME IPO Index from the period of 1 January 2018 to 30 April 2021.

Data on COVID-19 including the number of confirmed cases and the number of deaths per day in India was collected from the WHO dataset[9] from 30 January 2020 to 31 July 2020.

Methodology

Stock prediction is done using the LSTM network under the Keras model of RNN in Python. Data were divided into training and testing periods for all three models, and then preprocessing was done using MinMaxScaler. 70% of the data was trained, and 30% of the data was tested for prediction.

[8] BSE. S & P BSE SME IPO. Historical — Indices. 2021. URL: https://www.bseindia.com/Indices/IndexArchiveData.html (accessed on 20.08.2022).

[9] WHO. India: WHO Coronavirus Disease (COVID-19) Dashboard. 2022. URL: https://covid19.who.int/region/searo/country/in (accessed on 20.08.2022).

DATA ANALYSIS & INTERPRETATION

Data Analysis

Three sets were predicted:

1. Prediction of stock prices before COVID-19
2. Prediction of stock prices during the lockdown
3. Prediction of stock prices after the lockdown period

Prediction of Stock Prices before COVID-19

The data selected is from the period 1January 2018 to 29 January 2020. The data were divided into training and testing periods (*Fig. 2*).

In *Fig. 2*, the X-axis represents the total period used for prediction. The training period is from 1 January 2018 to 17 June 2019 whereas the testing period is from 18 June 2019 to 29 January 2020. Y-axis represents closing stock prices both actual and predicted. The RMSE of the prediction of stock prices before COVID-19 is 20.37. The red line represents the actual stock value, the blue line represents the training data, and the yellow line represents the predicted data. The average value of the BSE SME IPO over the testing data interval of 153 is 0.13 which is between the 0.1 and 0.5 thresholds [28]. It means that this model has an accuracy of 87%, and this model can be used to further predict stock prices after COVID-19.

[The root mean square error is the difference between predicted values by the model and observed values].

Prediction of Stock Prices During the Lockdown Period

The data selected is from 1 January 2018 to 31 July 2020. The data were divided into training and testing periods.

In *Fig. 3*, the X-axis represents the total period used for prediction. The training period is from 1 January 2018 to 26 August 2019 is showing whereas the testing period is from 27 August 2019 to 31July 2020. Y-axis represents closing stock prices, both actual and predicted. The RMSE of LSTM is 76.02. The average value of BSE SME IPO over the testing data interval of 191 is 0.4 which is still between the 0.1 and 0.5 thresholds, but there is a high difference in the predicted and actual stock values after COVID-19 as the accuracy of the model decreased to 60%. The model was trained on the data before COVID, and the model was tested on the data after COVID. The difference in prices showed the impact of COVID in the lockdown period as the model was not able to predict the prices in the COVID phase.

Fig. 1. **Bse Sme Ipo Stock Prices**

Source: BSE SME IPO index.

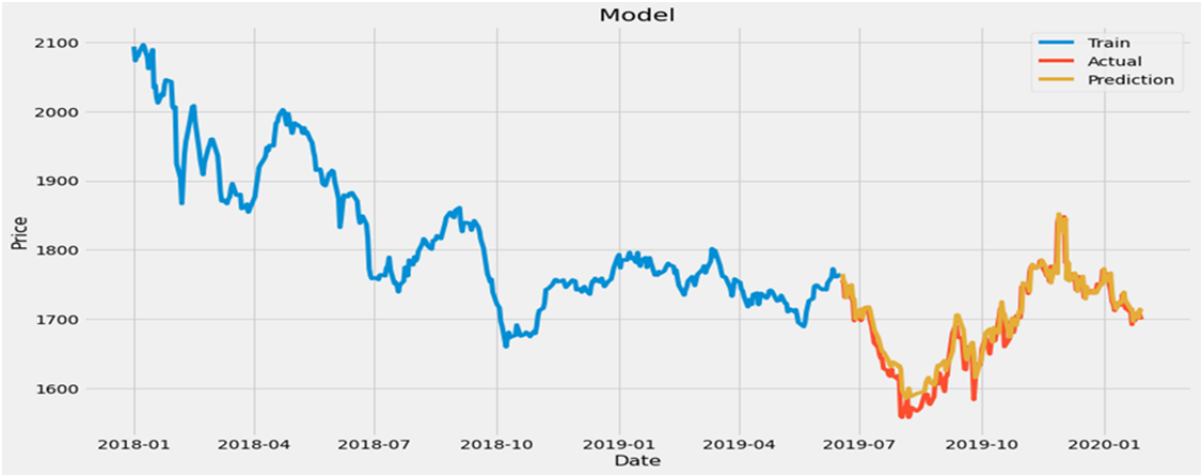

Fig. 2. **Prediction of Stock Prices before COVID-19**

Source: Compiled by the authors.

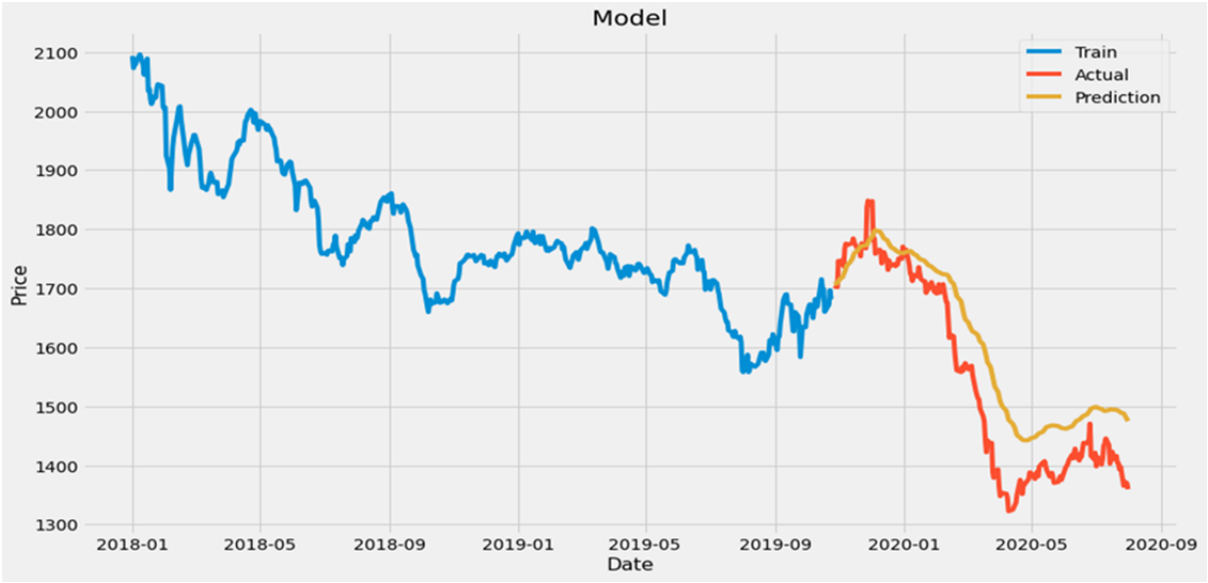

Fig. 3. **Prediction of Stock Prices during the Lockdown Period**

Source: Compiled by the authors.

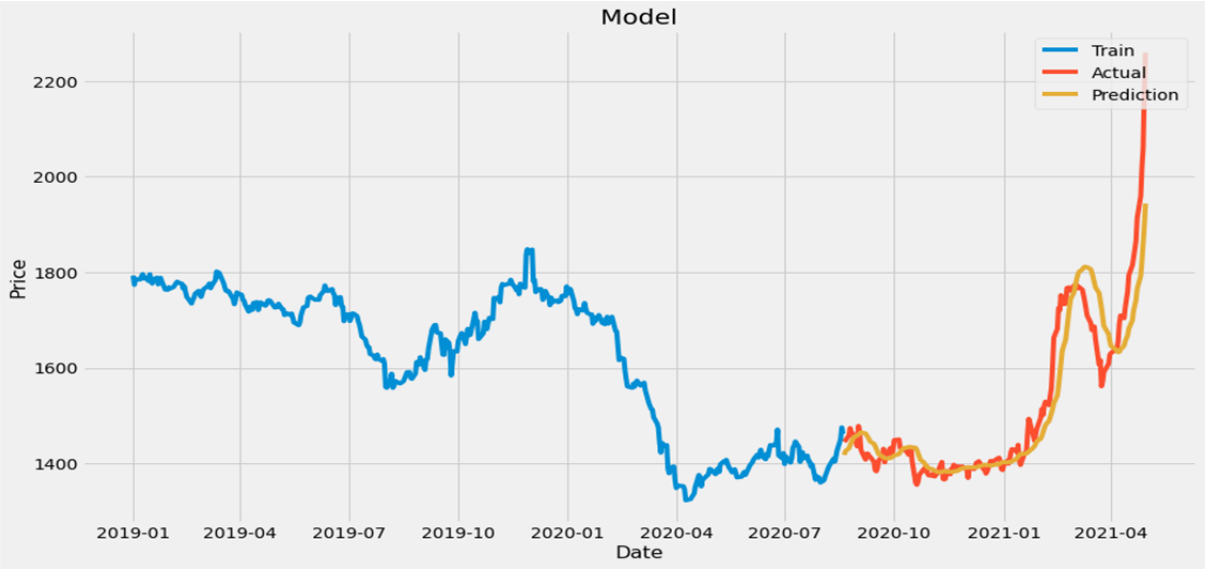

Fig. 4. **Prediction of Stock Prices after the Lockdown Period**

Source: Compiled by the authors.

Prediction of Stock Prices after the Lockdown Period

The data selected is from 1 January 2019 to 30 April 2021. The data were divided into training and testing periods.

In *Fig. 4*, the X-axis represents the total period used for prediction. The training period is from 1 January 2019 to 19 August 2020, whereas the testing period is from 20 August 2020 to 30 April 2021. In this prediction, data is taken from 1 Jan 2019 and not from 2018 because the COVID-19 period was needed in the training period. The Y-axis represents closing stock prices, both actual and predicted. The RMSE of LSTM is 67.41. The average value of BSE SME IPO over the testing data interval of 173 is 0.39, which is still between the 0.1 and 0.5 thresholds but slightly better than the previous model as the accuracy minutely increased to 61%. The difference in the actual and predicted price is visible in the months of March and April 2021, in which 2nd wave of COVID-19 was recorded in India, due to which cases of COVID-19 started increasing.

Data Interpretation

The market was less volatile prior to the outbreak of COVID-19. It is seen in *Fig. 2* that the model was able to accurately predict stock prices with the highest accuracy of 87%, it showed the accuracy of the LSTM model in predicting stock prices before COVID. When lockdown was implemented in India and all businesses were shut down, the stock market became more volatile, and a huge fall in the market was witnessed. The actual stock prices showed the impact of the lockdown in *Fig. 3* and there was an enormous difference in the actual and predicted prices as the accuracy of the prediction model was reduced to 60%. Our LSTM model has lost trace of closing prices around the start of COVID-19 in the testing period.

In *Fig. 4*, after the lockdown, the impact of COVID-19 was still visible, as there was still a difference in prices, but it was mostly visible in the months of March and April 2021, when another lockdown was implemented due to the new variant of COVID. The LSTM model lost track of closing prices in the testing period around the time of this other lockdown.

A massive impact was seen after the start of the lockdown period. Lockdown Phase 1 started on 23 March 2020 in India and differences in actual and predicted stock prices were seen during the period of lockdown.

It showed that after the lockdown, COVID-19 still had an impact on BSE SME IPO stock prices as the accuracy of the model slightly changed but not drastically.

CONCLUSION

Managerial Implications

One of the most vital and growing topics in finance is the application of machine learning tools for prediction. The prediction approaches used must be accurate. If a method for stock market prediction is more accurate, investors will have the choice of investing in a company or not.

MSME is one of the biggest sectors that contributes to the GDP of India. Losses in the MSME sector affect the Indian economy very badly. The government shows a keen interest in encouraging the MSME sector, as various actions have been taken by the government specifically in the COVID-19 period to boost the MSME sector. BSE and NSE also launch various schemes to encourage the MSME sector. High-accuracy predictions of the stock market will help the government monitor the difficulties in the sector. The LSTM model is useful not only for the prediction of the stock market but also for complex data calculations. It is being used not only in the finance field but in other fields too. If the prediction accuracy of the LSTM model is high, then it can be considered in future research by various disciplines.

Conclusion

In this study, the LSTM model showed remarkably high accuracy before COVID-19 from which it can be said that it is a good technique to use for the prediction of the stock market. The outcomes demonstrate that the LSTM model is capable of identifying the patterns existing in the BSE SMEs stock market. This highlights the underlying nature of the BSE SME IPO. Due to the lockdown period, a massive impact on the SME stock price was seen as a difference in predicted price and the actual price, which was mostly seen in predictions done during the lockdown period. In the comparative analysis of three different LSTM models, it is seen that post COVID the accuracy of LSTM models reduced as compared to pre-COVID, especially during the lockdown period as businesses were shut at the time of lockdown, and the difference between predicted and actual price is greater.

To help the MSME sector, RBI released guidelines for a reduction in CRR, payments rescheduling, and export proceeds' realisation period extension and in April released a second set of measures having TLTRO 2.0, AIFIS having refinancing facilities for the MSME sector.[10] Rebate of 25% by BSE and NSE on the listing fee paid by SME companies annually listed on NSE's EMERGE platform as well as the BSE SME platform to save the MSME sector.[11]

LIMITATIONS

a. Only the MSME sector is considered in this research.

b. Only BSE SMEs stock prices are being considered, unlisted MSME companies may also have an impact due to COVID-19.

c. Only the LSTM model is considered in this research.

d. The data in this paper is limited; further studies can be done with a huge dataset.

FUTURE SCOPE

i. Researchers can do stock market predictions for other sectors also.

ii. A comparative analysis of various other predictive models can be done to check which has the highest accuracy for stock market prediction.

[10] Ministry of MSME. RBI relief measures | Ministry of Micro, Small & Medium Enterprises. 2020. URL: https://msme.gov.in/gallery/people/rbi-relief-measures (accessed on 20.08.2022).

[11] Economic Times. SME: SME platforms of BSE and NSE cut annual listing fee by 25%. The Economic Times. 2020. URL: https://economictimes.indiatimes.com/small-biz/sme-sector/bses-sme-platform-cuts-down-annual-listing-fee-by-25/articleshow/75805143.cms (accessed on 20.08.2022).

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Заявленный вклад авторов:
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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.
Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

The article was submitted on 21.09.2022; revised on 27.10.2022 and accepted for publication on 26.11.2022.
The authors read and approved the final version of the manuscript.
Статья поступила в редакцию 21.09.2022; после рецензирования 27.10.2022; принята к публикации 26.11.2022.
Авторы прочитали и одобрили окончательный вариант рукописи.