Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 12, Issue. 2 : 2021
ISSN : **1906-9685**

FORECASTING OF SILVER PRICES IN INDIA USING DEEP LEARNING METHODS

Dr.G. Sunitha, Assistant Professor of Statistics, Govt Degree College for Women(A), Begumpet, Hyderabad, Telangana.

Abstract

Accurately forecasting silver prices in India is crucial for investors and market participants. This study explores the potential of deep learning techniques for predicting silver prices in the Indian market. We investigate the effectiveness of various deep learning architectures, such as Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and Gated Recurrent Units (GRUs), in capturing complex patterns and relationships within historical silver price data and relevant economic indicators. Predicting the prices of commodities like silver is crucial for investors and stakeholders in the financial markets. Traditional methods of forecasting often rely on statistical models that may not capture complex patterns in the data. In recent years, deep learning has emerged as a powerful tool for time series forecasting due to its ability to handle non-linear relationships and temporal dependencies in data. This study explores the application of deep learning methods, specifically Long Short-Term Memory (LSTM) networks, for forecasting silver prices in the context of the Indian market. LSTM networks are a type of recurrent neural network (RNN) designed to capture long-term dependencies in sequential data, making them suitable for modeling time series like silver prices which exhibit trends and seasonal patterns. The dataset used in this study consists of historical silver prices in India, along with relevant economic indicators that may influence silver prices. The LSTM model is trained on this data to learn patterns and relationships, and then used to make future price predictions. The performance of the LSTM model is compared with traditional time series forecasting methods such as ARIMA to evaluate its effectiveness.

Keywords: *Silver price forecasting, Deep learning, Long Short-Term Memory (LSTM), Time series forecasting, Financial markets, Predictive modelling*

Introduction

Silver, a precious metal with significant economic value, plays a crucial role in various industries and investment portfolios worldwide. In India, like many other countries, the price of silver is influenced by global market trends, industrial demand, geopolitical factors, and investor sentiment. Accurately forecasting silver prices is essential for stakeholders such as investors, traders, and industries to make informed decisions and manage risks effectively. Traditional methods of forecasting, such as time series analysis and econometric models, have limitations in capturing the complex nonlinear patterns and dependencies present in financial data. Deep learning, a subset of machine learning that utilizes neural networks with multiple layers to extract intricate patterns from data, has emerged as a powerful tool for forecasting financial time series. In this study, we explore the application of deep learning methods for forecasting silver prices in India. Specifically, we investigate how neural networks can be trained on historical silver price data to predict future price movements. By leveraging the capabilities of deep learning models, we aim to improve the accuracy of forecasts compared to traditional methods.

History of silver

Silver's history is long. The first evidence of silver mining dates back to 3000 B.C., in Turkeyand Greece, according to the RSC. Ancient people even figured out how to refine silver. Theyheated the

silver ore and blew air over it, a process called cupellation. The silver does not reactto the air, but the base metals such as lead and copper oxidize and separate from the precious metal. Silver forms in star explosions called supernovae, as does gold. A study published in September 2012 in the journal Astronomy and Astrophysics found that explode producesilver, while larger stars produce gold.
Silver really exploded on Earth, however, when Europeans landed on the New World in 1492.Spanish conquerors discovered that South America was home to rich veins of silver and silverore, and they mined that wealth enthusiastically; according to the Silver Institute, an industry trade group, 85 percent of the silver produced worldwide came from Bolivia, Peru and Mexicobetween 1500 and 1800.

Silver played a big role in making early photography possible. Silver nitrate (silver combined with nitrogen and oxygen molecules) was used on photographic plates in the first, clunky cameras, according to the RSC, because it reacts to light by turning black — enabling photographers to capture an instant of light. Even with the rise of digital cameras, silver remains part of the traditional photographic process. As of 2003, the most recent year data is available,1,920 metric tons of silver each year went to use for photographic purposes. Electrical and electronic uses were the second most-common single industrial use for silver, with 1,230 metrictons going into wires and gadgets in 2003. Jewelry, sterling silver and silver electroplated objects ran a distant third, using only 486 metric tons. Another 1,810 metric tons went to various other uses.

- Silver's atomic symbol is Ag, which seems to bear little relation to the name of the element.In fact, Ag is short for argentums, the Latin word for silver. The word "silver" is from the Anglo-Saxon word seafloor.
- The first huge silver strike in the United States was Nevada's Comstock Lode, first discovered in 1857 by two brothers who died before they could reap the benefits of their claim. According to Online Nevada, $305,779,612.48 of silver was pulled from the groundbetween 1859 and 1992.
- There's no doubt about it; silver is pretty, and humans have long thought so. In February 2014, archaeologists uncovered a trove of silver, including five hoop earrings, at a 3,200-year-old site in Israel.
- Silver has antimicrobial properties, but that doesn't make it a good option for home remedies. Homeopathy providers sometimes sell colloidal silver for a variety of health complaints, but drinking the stuff has a weird side effect: It turns the skin blue.
- Leave the good silver in a drawer between Christmases and it's likely to tarnish. So how do amuseum's silver pieces stay so shiny? They're coated with transparent lacquers. Researchers
are working to create nanometer-thick coatings that can replace the current hand-paintedlacquers with something thinner, completely invisible and longer lasting.

What Is Silver?
The term silver refers to a precious metal commonly used in the production of jewelry, coins, electronics, and photography. It has the highest electrical conductivity of any metal and is, therefore, a highly valuable substance. Silver is used in many global cultures and religions in traditional ceremonies and worn as jewelry during important occasions. Investors may hold physical silver or other investments that are backed by the precious metal itself.

Silver is a soft, white metal that usually occurs in nature in one of four forms: 1) as a native element; 2) as a primary constituent in silver minerals; 3) as a natural alloy with other metals;and, 4) as a trace to minor constituent in the ores of other metals. Most of the silver producedtoday is a product of the fourth type of occurrence. Silver is known as a "precious metal" because it is rare and because it has a high economicvalue. It is valuable because it has a number of physical properties that make it the best possible metal for many different uses. Silver has an electrical and thermal conductance that is higher than any other metal. It has ahigher reflectivity at most temperatures than any other metal. It has an attractive color
and luster that resist tarnish and make the metal desirable in jewelry, coins, tableware, andmany other

objects. These are just a few of silver's important properties. When performance is more importantthan price, silver is often the material of choice.

Silver as a Native Element Mineral

Silver is rarely found as a native element mineral. When found, it is often associated with quartz, gold, copper, sulfides of other metals, arsenides of other metals, and other silverminerals. Unlike gold, it is rarely found in significant amounts in placer deposits.

Native silver is sometimes found in the oxidized zones above the ores of other metals. It persists there because silver does not readily react with oxygen or water. It does react with hydrogen sulfide to produce a tarnished surface that is composed of the silver sulfide mineralknown as acanthite. Many specimens of native silver that have been exposed to the atmosphere or to hydrothermal activity have an acanthite coating.

Minerals that Contain Silver

The number of minerals that contain silver as an essential constituent is surprising. The greentable on this page contains a partial list of silver minerals that includes 39 different species. Each of these is a distinct silver mineral. All of them are rare, but a few (such as acanthine,prostate, and pyrargyrite) can be found in sufficient quantities to warrant mining. Silver minerals can be sulfides, tellurides, halides, sulfates, sulfosalts, silicates, borates, chlorates,iodates, bromates, carbonates, nitrates, oxides, and hydroxides.

Understanding Silver

Precious metals are metals that are highly valued because of their scarcity. This group is generally comprised of platinum, gold, and silver. Although gold is favored by most investors, silver is also a highly sought-after metal because of its price and its application. Asmentioned above, silver is commonly used in the production of jewelry and coins and was also commonly used in the photography industry. It is also a key element of electronics sinceit has the highest conductivity of any other metal.

Many silver companies own and operate their own mines, where they mine for silver and other precious metals. The majority of these companies are also involved in the actual production of silver itself. More than 26,600 tons of silver were excavated in 2018.[1] China, Mexico, and Peru mined the most silver in that year. Around 870 tons of silver came from theUnited States. Most of the world's silver production came as a byproduct from lead-zinc, copper, and gold mines.

Investors and traders buy silver through commodities markets. Common commodities markets for precious metals exist in Japan, London, mainland Europe, and the United States.Individuals can buy silver in bars, coins, and bullion. Investors can also purchase assets that are backed by the precious metal without having to hold the actual commodity, such as exchange-traded funds (ETFs), stocks in silver companies, and mutual funds.

Special Considerations

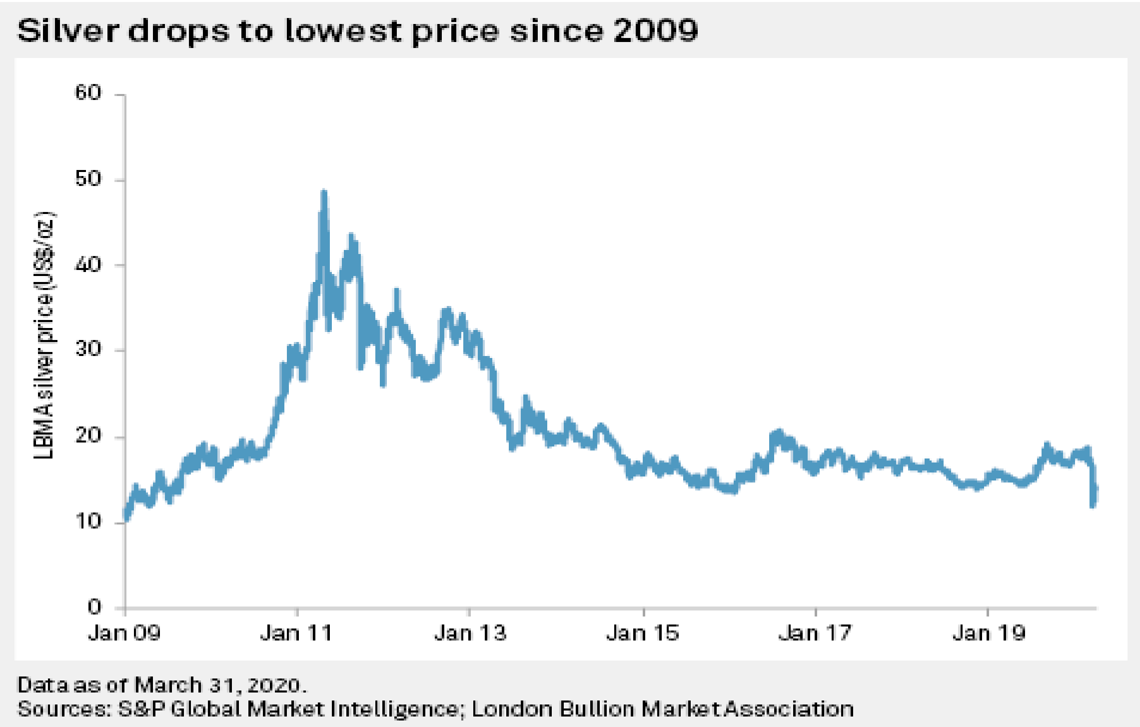
Silver's spot price is the amount that an investor pays to purchase a single ounce of the metalfor immediate delivery. Investors are normally charged an additional premium on top of this price for any purchasethey make. The value of silver is priced per ounce. While the majority of attention is given to price movements of gold in the global marketplace, silver is also viewed by many to hold key importance in understanding the potential movements of commodities markets and the overall marketplace as well. This is dueto the fact that many buyers and sellers trade silver based on global-macro trends.

Silver prices move based on a variety of factors including supply and demand, inflation, andthe strength of the dollar. Prices rise when the supplies are low, pushing up demand from consumers and manufacturers. When the dollar weakens, investors begin to look to more stable investments like precious metals, such as silver, as a safe place to park their cash. The per-ounce price of silver reached highs in the early 1980s of more than $20 per troy ounce, before dipping back down in the 1990s.[3] By 2014, the price rose to around $19 per ounce for the year. The average closing price for silver in 2020, as of Dec. 17, 2020, was $20.49 per ounce.

COVID-19 SCENARIO IN INDIA:

Silver: Double hit with not much light at the end of the tunnel

The silver price, which has largely traded sideways since 2015, has plummeted to multiyear lows. Starting March 12, when U.S. stock markets had their greatest single-day fall since the 1987 crash, silver fell from US$17.02/oz to US$12.01/oz on March 19, a fall of 29%. That is the lowest price forsilver since April 17, 2009. Although the price has recovered slightly in recent weeks, at around US$14/oz it remains near the lows of 2019 and has wiped out the brief rally enjoyed in the secondhalf of 2019 and the first two months of 2020.



Being both a financial and an industrial metal, silver has been dealt a double blow. With manufacturing purchasing manager indexes down across the board, silver industrial demand, whichlargely comes from brazing alloys and electronic and photovoltaic fabrication, is forecast to decline.On the financial side, traders have been closing out their positions on the futures markets to meet margin calls and to raise cash to buy government bonds much like the situation with gold.

Having said that, demand for physical silver in the Western world had skyrocketed when stock markets crashed and silver prices went down, with bullion and coin merchants reporting unprecedented demand. Indeed, at the time of writing, none of the main U.K. online dealers had anysilver bars in stock. This has been matched in the ETF markets, with reports of huge inflows.

While silver was dragged down during the stock market crash, the weakness of industrial demand has acted as a lead weight for silver, leaving it unable to ride gold's coattails upward on the back of safe-haven buying. According to The Silver Institute, in 2018 the ratio of industrial demand over investment demand was 2.5. In the short term, the outlook for the precious metal is bleak given the weak economic conditions. If this crisis continues into the third quarter, however, we expect that reductions in mine supply due to a national shutdown in Peru, the second-largest producer of silver,will have an impact on the net balance.

What is ARIMA model?

ARIMA models provide another approach to time series forecasting. Exponential smoothing and ARIMA models are the two most widely used approaches to time seriesforecasting, and provide complementary approaches to the problem. While exponentialsmoothing models are based on a description of the trend and seasonality in the data, ARIMA models aim to describe the autocorrelations in the data.

Before we introduce ARIMA models, we must first discuss the concept of stationarity andthe technique of differencing time series. A stationary time series is one whose properties do not depend on the time at which the series is observed. Thus, time series with trends, or with seasonality, are not stationary —the trend and seasonality will affect the value of the time series at different times. On the other hand, a white noise series is stationary — it does not matter when you observe it, it should look much the same at any point in time.

Some cases can be confusing — a time series with cyclic behaviour (but with no trend or seasonality) is stationary. This is because the cycles are not of a fixed length, so before weobserve the series we cannot be sure where the peaks and troughs of the cycles will be.

In general, a stationary time series will have no predictable patterns in the long-term. Timeplots will show the series to be roughly horizontal (although some cyclic behaviour is possible), with constant variance.

Therefore, it has three model parameters AR(p), I(d) and MA(q) all combined to formARIMA(p, d, q) model where

p = order of autocorrelation

d = order of integration (differencing)

q = order of moving averages

A non-seasonal stationary time-series can be modeled as a combination of the past valuesand the errors which can be denoted as ARIMA (p, d, q) or can be expressed as

$$X_t = \theta_0+\varphi_1 X_{t-1}+\varphi_2 X_{t-2}+ +\varphi_p X_{t-p}+ e_t -\theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_q e_{t-q}$$

An autoregressive integrated moving average, or ARIMA, is a statistical analysis model thatuses time series data to either better understand the data set or to predict future trends. A statistical model is autoregressive if it predicts future values based on past values. For example, an ARIMA model might seek to predict a stock's future prices based on its pastperformance or forecast a company's earnings based on past periods.

ARIMA Parameters

Each component in ARIMA functions as a parameter with a standard notation. For ARIMA models, a standard notation would be ARIMA with p, d, and q, where integer values substitute for the parameters to indicate the type of ARIMA model used. The parameters canbe defined as:

- *p*: the number of lag observations in the model; also known as the lag order.
- *d*: the number of times that the raw observations are differenced; also known as the degree of differencing.
- q: the size of the moving average window; also known as the order of the movingaverage.

In a linear regression model, for example, the number and type of terms are included.A 0 value, which can be used as a parameter, would mean that particular component should not be used in the model. This way, the ARIMA model can be constructed to perform the function of an ARMA model, or even simple AR, I, or MA models.

Statistical stationarity:

A *stationary* time series is one whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time. Most statistical forecasting methods are basedon the assumption that the time series can be rendered approximately stationary (i.e., "stationarized") through the use of mathematical transformations. A stationarized series is relatively easy to predict: you simply predict that its statistical properties will be the same in the future as they have been in the past! (Recall our famous forecasting quotes.) The predictions for the stationarized series can then be "untransformed," by reversing whatever mathematical transformations were previously used, to obtain predictions for the original series. (The details are normally taken care of by your software.) Thus, finding the sequence of transformations needed to stationarize a time series often provides important clues in the search for an appropriate forecasting model. Stationarizing a time series through differencing(where needed) is an important part of the process of fitting an **ARIMA model**, as discussed in the ARIMA pages of these notes.

Another reason for trying to stationarize a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables. Such statistics are useful as descriptors of future behavior *only* if the series is stationary. For example, if the series is consistently increasing over time, the sample mean and variance will grow with the size of the sample, and they will always underestimate the mean and variance in future periods. And if the mean and variance of a series are not well-defined, then neither are its correlations with other variables. For this reason, you should be cautious about trying toextrapolate *regression* models fitted to nonstationary data.

Most business and economic time series are far from stationary when expressed in their original units of measurement, and even after deflation or seasonal adjustment they will typically still exhibit trends, cycles, random-walking, and other non-stationary behavior. If the series has a stable long-run trend and tends to revert to the trend line following a disturbance, it may be possible to stationarize it by de-trending (e.g., by fitting a trend line and subtracting it out prior to fitting a model, or else by including the time index as an independent variable in a regression or ARIMA model), perhaps in conjunction with loggingor deflating. Such a series is said to be

trend-stationary.
However, sometimes even de- trending is not sufficient to make the series stationary, in which case it may be necessary to transform it into a series of period-to-period and/or season-to-season *differences*. If the mean, variance, and autocorrelations of the original series are not constant in time, even after detruding, perhaps the statistics of the *changes* in the series between periods or between seasons *will* be constant. Such a series is said to be difference-stationary.

Current research
Silver's antimicrobial properties have put this element in the doctor's bag of tricks; according to Wounds International, silver has been used to prevent the infection of injuries for hundredsof years. Silver doesn't kill microbes in its metallic form, in which it is unreactive. The metal works against bacteria only in ion form — it must lose an electron to become positively charged. The positively charged silver ion interferes with bacterial cell walls and disrupts other microbial processes.

Burn patients may use silver-antibiotic creams on their injuries, and some hospitals use silver-infused dressings for skin ulcers and other wound care. There are debates within the field, however, about the efficacy of these dressings, particularly after a 2010 review published in the Cochrane Database of Systemic Reviews found that they don't speed wound
healing. A Wounds International working group of medical professionals, however, argued in2012 that the dressings can be useful for localized infections. Some manufacturers have taken silver's antimicrobial magic as a marketing opportunity, creating silver-infused textiles that purport to stop smelly bacteria from setting up shop in thefabric. The problem, according to Bernd Nowack, a researcher at Empa, the Swiss Federal Laboratories for Materials Science and Technology, is that you don't know what you're getting in these silver-infused fabrics. In fact, manufacturers may not even know what they'remaking.

"They may add a compound but maybe during the manufacturing, all this dying and making of the fabric, they may transform some of the materials," Nowack told Live Science. In multiple studies, he and his colleagues have found that the forms of silver supposedly presentin these high-tech textiles are rarely what are actually embedded in the fabric.
"They all contain a huge variety of different silver forms and sometimes the form that shouldhave been in there was maybe 30 percent and the other 70 percent were other silver forms," Nowack said. That matters, because some forms of silver don't interact as readily with bacteria as others. For example, fiber-embedded silver exposed to air literally tarnishes, combining with sulfurto make silver sulfide. Silver sulfide, Nowack said, is non-functional. It doesn't react to kill bacteria.

Ideally, a silver-infused fabric will use nanoparticles instead of conventional silver, because nanoparticles release at the right rate to keep a thin silver film on the fabric, preventing a bacterial foothold. Currently, though, Nowack said, there is no good way to point to a fabric
and say for sure that the silver it contains is in nano-form. In fact, running a shirt with conventional silver threads through the washer will release more silver nanoparticles thanrunning a nanosilver-infused shirt through the rinse cycle, Nowack and his colleagues reported in the journal ACS Nano in June 2014.

There are ways to improve the performance of silver-infused textiles, Nowack said, including embedding the silver directly into the fibers rather than giving them a surface treatment. Ultimately, though, silver may be too reactive to be a good fit for fabric. It does no good,after all, if your clothes tarnish like your silverware. "As long as you have it exposed to air, you cannot inhibit this [tarnish], it can just happen,"Nowack said. "It's something that so far hasn't really been considered."

Facts About Silver

Silver often plays second fiddle to another precious metal, gold, but this element has specialproperties that deserve a good look. For example, of all the metals, pure silver is the best conductor of heat and electricity, according to the Jefferson National Linear Accelerator Laboratory. It's also the best reflectorof visible light, which is why it is commonly used to make mirrors — though silver does tarnish and turn dark grey when exposed to air, requiring periodic polishing.

Pure silver is too soft for products like jewelry and tableware, so the family's finest forks andknives are most likely sterling silver, an alloy of 92.5 percent silver and 7.5 percent copper (though sometimes other metals are used). Silver is also used in some electronics and batteries. Because the metal has antimicrobial properties, nanoparticles of silver can be woven into clothing to prevent bacteria from building up on deposits of sweat and oils, according to the Royal Society of Chemistry (RSC).

Harmful effects:

Silver is considered to be non-toxic. However, most silver salts are poisonous and some maybe carcinogenic.

Characteristics:

Silver is a soft, ductile, malleable, lustrous metal. It has the highest electrical and thermalconductivity of all metals. Silver is stable in oxygen and water, but tarnishes when exposed to sulfur compounds in airor water to form a black sulfide layer.

Uses of Silver

Sterling silver (an alloy of 92.5% silver and 7.5% copper) or Britannia silver (an alloy of95.8% silver and 4.2% copper) are used for jewelry and silverware. Silver is used as a food additive/coloring and is given the E number E174. About 30% of silver produced is used in the photographic industry, mostly as silver nitrate. Silver is used in solders, electrical contacts, and silver-cadmium and silver-zinc batteries.Silver paints are used in the manufacture of electronic printed circuits. It is used in superior mirror production, as silver is the best known reflector of visible light,although it does tarnish over time. Silver iodide is used in artificial rain making to seed clouds. Silver compounds were used successfully to prevent infection in World War 1.

The value of silver

Silver puts the luster in jewelry, helps our cell phones and MP3 players work better, and evenmakes hospitals safer. Let’s explore the many roles that silver has played throughout history. What makes silver more valuable to us than other minerals? Its beauty is one thing. This attractive and reflective metal has fascinated men and women for a long time. Silver alsois fairly scarce — and things that are both beautiful and rare tend to be worth a lot (think diamonds, gold, and masterpieces of art). Silver is very durable, too. And it’s malleable, meaning it’s easy to shape. All these qualities have made silver very useful and valuable to this day. Silver’s monetary value has long been appreciated. Thought to be perhaps the oldest coin, the “Lydian Lion” was minted in modern-day Turkey some 2,700 years ago; early metalworkers — chemists of sorts — made the coins from electrum, an alloy of gold and silver. The Minoan civilization, which flourished on the island of Crete around 2000 BCE, and the Mycenaean people of early mainland Greece imported great amounts of silver mined in ancient Armenia. Transport of the metal between all of these places helped to accelerate trade throughout the Mediterranean region.

After the catastrophic destruction of the Minoan civilization in 1600 BCE, and the decline ofthe Mycenaean culture around 1200 BCE, silver’s prominence continued as production shifted with the rising civilization of Classical Greece. The silver mines of Laurium (near Athens) paid for the Italian lumber used to build the fleets of triremes (warships with three levels of rowers) that made ancient Athens a naval superpower. The Romans would later adopt silver as one of their main currencies as well.

Silver helped advance global civilization by connecting East and West through trade. Silver was scarce in China, but nonetheless much valued as currency. So, during the Middle Ages, Europeans used silver to buy Chinese goods — gunpowder, tea, ceramics, and silk — which were then carried over the fabled “Silk Road.” Later, when the Spanish discovered silver mines in Mexico and Peru, they established a sailing route across the Pacific, trading South American silver, some of it plundered, for Chinese silk. Silk was desirable because it made light and cool clothing much in demand by Spanish settlers in the hot, humid climate in partsof Mexico, Central America, and South America. As we’ll see elsewhere in this course, whengoods get traded, so do ideas. So silver played a role in advancing collective learning.

Conclusion

Deep learning offers promising tools for forecasting silver prices in India. Here's a summary of the key takeaways: Effectiveness: Deep learning models like LSTMs, CNNs, and their hybrids have shown potential in capturing complex relationships within historical silver price data. This can lead to more accurate forecasts compared to traditional methods. Improved Accuracy: Studies suggest that deep learning models can achieve lower Mean Absolute Percentage Error (MAPE) and Root Mean Squared Error (RMSE) compared to simpler models. This translates to forecasts that are closer to the actual prices. Hybrid Power: Combining multiple deep learning architectures (like CNN-LSTM-GRU) can leverage the strengths of each model, potentially leading to even better forecasting performance.

However, it's important to remember that: Market Volatility: Silver prices are inherently volatile due to various global and local factors. Deep learning models may struggle to predict sudden shifts caused by unforeseen events. Data Dependence: The accuracy of these forecasts heavily relies on the quality and completeness of the training data. Limited Scope: Deep learning forecasts are best suited for short-term predictions. Long-term forecasts remain challenging due to the dynamic nature of the market. Overall, deep learning offers a valuable approach for silver price forecasting in India. By acknowledging the limitations and continuously improving models, researchers can develop increasingly reliable tools to aid decision-making in the Indian silver market. ARIMA is one of the useful techniques in forecasting the data. In this paper, the data is analyzed using ARIMA model. The results are summarized in time series plot and ARIMA model and the future values are forecasted using the model. Then afterwards the prices of SILVER were increasing due to major crisis. It is substantially less important and remains economically in the nineteenth century than it is today. The prices of SILVER in the upcoming year will in an increasing manner. Even though the use of METAL is different, the prices of SILVER should be maintained or at some instance, it will lead to a huge problem to the economy of a country. Hence, the prices should be normalized and special care should be given in monitoring the prices of SILVER. We have examined The data and applied a log normal transformation and differencing of one to make it stationary. We have used to fit various ARIMA model. We find that ARIMA (0,1,1)is the best fit for the said data. This model can be used to estimate the price of silver in the future.

Reference

1. Deep Learning for Time Series Forecasting by N.D. Lewis - This book provides a comprehensive overview of deep learning techniques applied to time series data, including forecasting. It covers RNNs, LSTMs, and other relevant architectures.
2. Deep Learning for Time Series Forecasting: Predict the Future with MLPs, CNNs, and LSTMs in Python by N.D. Lewis - Another practical guide that focuses specifically on applying deep learning to time series forecasting tasks using Python.
3. Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville This is a foundational textbook on deep learning, covering various aspects of neural networks, including architectures suitable for time series forecasting.
4. Hands-On Time Series Analysis with R: Perform Time Series Analysis and Forecasting Using R by Rami Krispin - Although focused on R, this book offers practical insights into time series analysis and forecasting techniques that can be adapted to deep learning approaches.
5. https://rbi.org.in/Scripts/PublicationsView.aspx?id=19898 2
6. https://www.machinelearningplus.com/time-series/arima-model-time-series-forecasting-python/ https://machinelearningmastery.com/arima-for-time-series-forecasting-with-python/
7. https://www.researchgate.net/publication/223860884_An_assessment_of_time_series_methods_in_metal_price_forecasting
8. https://www.researchgate.net/publication/343902137_Prediction_of_Gold_and_Silver_Prices_in_an_Emerging_Economy_Comparative_Analysis_of_Linear_Nonlinear_Hybrid_and_Ensemble_Models
9. Practical Time Series Forecasting: A Hands-On Guide by Galit Shmueli and Kenneth C. Lichtendahl Jr. - This book provides a solid foundation in time series forecasting techniques, which can complement your understanding of deep learning approaches.
10. Research Papers and Online Resources - Explore recent research papers in the field of deep learning and time series forecasting. Websites like arXiv.org and Google Scholar are good starting points to find relevant papers and articles.