



Design of an Intelligent Predictive Framework for Financial Value Chain Dynamics and Stock Performance in Energy-Intensive Industries under Energy Price Fluctuations

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Article Info

Article type:

Research Article

Article history:

Received 6 January 2026

Received in revised form
10 August 2026

Accepted 15 September
2026

Available online 30
September 2026

Keywords:

energy resource management,
intelligent decision-making
system, artificial neural
network, value chain
sustainability, energy-
intensive industries

ABSTRACT

This study aims to design an intelligent decision support system (DSS) to evaluate and predict the sustainable financial value chain of cement companies under energy price fluctuations. This research integrates fundamental management principles with advanced technical components. Using time-series data mining and a sequential artificial neural network architecture equipped with an advanced optimizer, the study models the hidden patterns of electricity and gas price fluctuations on corporate financial statements. KMO and Bartlett's tests were employed to confirm sampling adequacy, while RSI and MACD indicators were adapted to capture price momentum and trends. The findings reveal that changes in energy carrier prices directly affect industry returns and financial sustainability by altering price momentum and trend indicators. The proposed intelligent model demonstrated high accuracy in predicting the financial behavior of production chain, achieving a significantly reduced Mean Squared Error and an exceptionally high coefficient of determination. This study contributes to the literature by bridging technical data mining techniques with financial sustainability management.

Cite this article: Kiyanfard, K., et. al. (2026). Design of an Intelligent Predictive Framework for Financial Value Chain Dynamics and Stock Performance in Energy-Intensive Industries under Energy Price Fluctuations. *Journal of Data Analytics and Intelligent Decision-Making (JDAID)*, 2(3), 240-255.
<https://doi.org/10.22091/jdaid.2026.16733.1095>



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Publisher: University of Qom.

DOI: <https://doi.org/10.22091/jdaid.2026.16733.1095>

Introduction

Financial market predictions have occurred in three areas. The first area examines market structure, existing stocks, and industries, and by identifying the specific characteristics of these markets, it identifies and introduces superior industries or stocks, thereby assisting investors. The second area focuses on creating a model for investment strategies, attempting to identify stock buying and selling points to enable investors to buy at the lowest price and sell at the highest price. The third area, however, deals with stock price prediction, where the widest range of algorithms and different models are used. More than 26% of Iran's total energy is consumed in the industrial sector. Cement is one of the important sub-sectors of the industry that is highly dependent on energy and mineral resources, such that more than 15% of the energy related to the industrial sector is consumed in this sub-sector. With the aim of targeting subsidies and liberalizing energy prices, the current situation of cement in energy consumption requires a serious review. Today, major suppliers of cement equipment, when offering their products, introduce the index numbers of energy consumption values as advantages and features of their products. Paying attention to the specific energy values in each device is effective in evaluating its performance, and a low value can be considered an advantage. Given the discussion of targeting subsidies, the largest part pertaining to the liberalization of energy prices, activists in the entire industry, particularly the cement sector, are called upon to find solutions to reduce energy consumption. Cement companies, as one of the key pillars of infrastructure development and civil industries in the country, have always held a special position in the national economy, and the shares of these companies in the capital market are recognized as one of the important options for individual and institutional investors. Given the vital role of this industry in advancing construction projects, road construction, dam construction, urban and rural development, and even non-oil exports, the accurate prediction of cement company stock prices is of double importance. In recent years, the rapid progress of machine learning, particularly deep learning, has encouraged researchers to use data-driven approaches for stock market prediction because the stock market, due to severe fluctuations, non-linear behaviors, and susceptibility to macroeconomic variables, is considered a serious challenge for traditional methods (Saberironaghi et al., 2025).

A review of research shows that classic statistical analysis and old models such as moving average, ARIMA, and linear regression are usually unable to extract complex patterns and long-term dependencies in financial time series, and models based on Long Short-Term Memory (LSTM), due to their gate mechanism and internal memory, can automatically identify non-linear relationships and hidden dependencies (Singh & Sahani, 2025). The literature review also emphasizes that "data quality" and "interpretability" are two key issues in market prediction. Although deep learning models often achieve high predictive performance, they are frequently regarded as black-box models. In practice, therefore, feature selection and dimensionality reduction techniques are often required to control model complexity and enhance interpretability (Saberironaghi et al., 2025). For example, a 2025 review in *AppliedMath*, by examining various datasets and evaluation metrics, concludes that LSTM and CNN-based methods outperform classical methods as well as some machine learning models in many scenarios; however, challenges such as data quality, generalization stability, and explainability

still remain (Saberironaghi et al., 2025). Similar approaches, using meta-heuristic algorithms to tune LSTM parameters and combining signal decomposition with optimization, have also reported better performance in predicting building material prices compared to basic neural networks and simple LSTMs. Given the role of material prices in risk management and project budgeting, this category of hybrid models can also be important from a practical perspective (Xiong et al., 2025). One of the strengths of recent research is the emphasis on integrating fundamental and technical data. According to market efficiency theory, depending on the level of efficiency, the possibility of using information to achieve excess returns can vary (Fama 1970). A study published in *Scientific Reports* in 2024 integrated symbolic genetic programming with LSTM and, through an extensive analysis of the Chinese stock market, demonstrated that incorporating fundamental indicators alongside technical indicators can significantly improve information-based metrics and predictive performance (Li et al., 2024). Additionally, a 2025 study focusing on the Pakistan Stock Exchange reported that LSTM, using price and volume data along with common technical indicators (such as moving averages, MACD, and Bollinger Bands), can provide a high coefficient of determination for some highly liquid stocks, and in emerging markets, the use of repeatable frameworks and the combination of information sources (technical and fundamental) is recommended (Yaqoob & Abdullah, 2025). Alongside global research, it can be argued that some industries, including the cement industry, have received less specific attention. Cement company stocks are heavily influenced by variables such as energy prices, transportation costs, exchange rates, and environmental policies, and therefore, in designing model inputs, these external factors should be considered alongside company fundamental data and technical indicators. Evidence from case studies on predicting material and stock prices in Asian markets also shows that hybrid frameworks based on signal decomposition and feature selection can significantly improve upon baseline models in many scenarios (Xiong et al., 2025; Zhang et al., 2025). Considering these findings, a multilevel and hybrid approach appears essential for predicting the stock prices of cement companies. Such an approach involves the simultaneous integration of technical and fundamental indicators with macroeconomic variables, noise reduction using methods such as Variational Mode Decomposition (VMD), dimensionality reduction through feature selection, and, ultimately, the training of LSTM or hybrid architectures. In addition, hyperparameter optimization techniques can be employed to enhance predictive accuracy and achieve more stable generalization performance (Mostafavi & Hooman, 2025).

There are two main approaches to stock price analysis and prediction: technical analysis and fundamental analysis. Technical analysis operates based on price patterns and historical data, such as trends, moving averages, and trading volume, and uses various tools to identify future market behavior. On the other hand, fundamental analysis examines fundamental factors such as revenue, profitability, financial ratios, interest rates, and economic policies to determine the intrinsic value of a stock. Each of these two methods alone has its advantages and disadvantages and cannot fully cover all complex and multidimensional aspects of the market. Therefore, a combined approach that utilizes both methods can provide greater accuracy in predictions. For example, a study investigated the design of a model for predicting the probability of stock price collapse or decline in the stock exchange using an artificial neural network approach (Vahedi

& Anvary Rostamy, 2022). This study emphasizes the importance of accurate stock price collapse prediction and proposes a method for prediction using artificial neural networks. This article discusses the architecture of neural network models and their application in predicting stock price collapse. This research evaluates the effectiveness of the proposed models using data from a specific period. The study concludes that artificial neural network models show suitable performance in predicting stock price collapse. This article also highlights the importance of this research in the context of stock market dynamics and investor behavior. This study focuses on predicting stock price collapse using neural networks and addresses critical and risky aspects of pricing. In another study, stock prediction in the financial market using a hybrid GA-SVM algorithm was investigated (Ebadati et al., 2022). This study proposes a hybrid GA-SVM model to improve prediction accuracy by reducing uncertainty and identifying optimal parameters for stock price prediction. The hybrid GA-SVM model combines the optimization capabilities of Genetic Algorithms (GA) with the regression and classification capabilities of Support Vector Machines (SVM). This study used historical stock price data from eight international companies (Apple, Google, Facebook, IBM, Ford, Yahoo, Microsoft, Twitter). Predicting negative shocks on stock prices with an emphasis on financial ratios is investigated in another study (Fadaei & Zare, 2022). This study examined the factors influencing stock price shocks and their prediction based on data from 140 companies. For this purpose, two optimization algorithms, including the Genetic Algorithm and the Particle Swarm Optimization evolutionary algorithm, were used to select the best variables from 96 variables. In this research, eight key variables were identified, and their impact on permanent and temporary shocks was investigated using a regression model. The results showed that the RMSE value for permanent shock using the Genetic Algorithm was 5.8433, and with the Particle Swarm Optimization evolutionary algorithm, it was 5.6284. Additionally, the RMSE for temporary shock using the Genetic Algorithm was reported as 7.537, and with the Particle Swarm Optimization evolutionary algorithm, it was 7.295. Overall, the results indicated that regression based on the Particle Swarm Optimization evolutionary algorithm acts as a stronger predictive tool than the Genetic Algorithm.

Given the importance of stock price prediction for investors and capital market participants, providing reliable models for analyzing and forecasting price fluctuations is of particular significance. However, the stock prices of cement companies are influenced by a combination of internal and external factors such as macroeconomic conditions, exchange rates, inflation, monetary and fiscal policies, energy carrier prices, supply and demand, and developments in the construction market, challenging making accurate predictions. On the other hand, many existing methods use fundamental analysis or technical analysis separately and have rarely focused on providing a combined and practical model. Accordingly, the present study aims to design a decision support model for predicting the stock prices of cement companies. It attempts to provide a hybrid model that can predict the high and low prices of target stocks with greater accuracy by identifying the most effective technical analysis indicators, utilizing time series data mining to find similar series, and employing the capabilities of artificial neural networks. The main innovation of this research lies in integrating fundamental and technical analysis with

data mining methods and neural networks to predict the stock price range, contributing to the improvement of decision-making for investors and capital market analysts.

Literature Review

Martínez-Barbero et al. (2025) investigated the integration of machine learning techniques, particularly Long Short-Term Memory (LSTM) neural networks, to improve portfolio optimization processes in financial markets. The authors believe that integrating fundamental concepts with the classical Mean-Variance (MV) portfolio selection theory is effective in forming optimal portfolios. However, the limitations of this classical model, especially its sensitivity to inaccurate input estimates, have been highlighted, leading to poor out-of-sample performance. In another paper, the authors addressed stock market movement prediction using neural networks (Oyewole et al., 2024). This paper aims to analyze the effectiveness of neural network models compared to traditional forecasting methods for accurate stock market predictions, which is crucial for informed decision-making by investors and financial institutions. A new neural network framework using informative stock analysis based on LSTM is introduced, aiming to enhance stock market prediction and investment advice through the integration of advanced machine learning techniques and textual data (Ricchiuti & Sperlí, 2025). This study recommends using LSTM neural networks for analyzing data forms that influence stock prices and trends. Dong and Liang (2025) proposed the use of artificial neural networks, specifically the Multi-Layer Perceptron (MLP) model, to predict the price elasticity of stocks for companies listed on the Tehran Stock Exchange from 2009 to 2019. The authors emphasized the need for sophisticated forecasting methods to guide investment decisions and risk management. For this purpose, Autoregressive (AR), Autoregressive Moving Average with Exogenous Inputs (ARMAX), Nonlinear Autoregressive (NAR), and Nonlinear Autoregressive with Exogenous Inputs (NARX) methods, all implemented within the MATLAB framework, were used. In another study, Oyewole et al. (2024) explored the transformative capabilities of neural network models in predicting stock market trends and examined their advantages over traditional forecasting models. Additionally, Singh and Sahani (2025), investigated the effectiveness of a novel neural network-based method for predicting upward trend reversals in falling stock markets, with a particular focus on the KOSDAQ market. This approach involves incorporating additional input features into existing neural network models, enhancing their predictive capabilities beyond conventional methods. Their findings indicated that stock price declines generally cannot continue indefinitely. Uygun and Sefer (2025) addressed the use of Graph Neural Networks (GNNs) for simultaneous price prediction of multiple financial assets. In this research, three advanced models, including MTGNN, StemGNN, and FourierGNN, were employed to model spatio-temporal dependencies among assets in Forex and cryptocurrency markets. The results show that these models perform better in the volatile cryptocurrency market than traditional methods such as LSTM, ARIMA, and VAR; however, their advantage is less pronounced in the relatively stable Forex market, and in some cases, ARIMA shows better performance.

Method

The present research investigates predicting the stock prices of cement companies in Iran because the cement industry, as a fundamental and strategic industry, plays a crucial role in the economic growth and development of the country. It is always recognized as an indicator for evaluating the overall economic conditions, fluctuations in the housing market, and construction activities. Cement companies, by supplying raw materials for infrastructure projects, urban and rural construction, road building, dam construction, and the development of transportation infrastructure, play a key role in advancing national and regional plans. Therefore, the financial and economic developments of these companies directly impact other economic sectors. The main goal of this research is to develop a native intelligent model for predicting the stock prices of cement companies in the country. By combining technical and fundamental indicators and utilizing advanced intelligent systems, especially long short-term memory neural networks, this model can increase the accuracy of predictions and provide a scientific and practical tool for decision-making by investors, financial analysts, cement company managers, and economic policymakers, thereby improving capital market efficiency and reducing investment risks. The main objectives of the present study are to: (1) mine time-series data using technical analysis to identify time series that exhibit the greatest similarity to the target time series; (2) predict future changes in the target stock based on historical price movements of similar stocks; and (3) design and develop a neural network model to predict fluctuations in the price of the target stock.

Technical Analysis

Technical analysis is a method for predicting prices in the market by studying past market conditions. In this analysis, by examining price changes and fluctuations, trading volume, and supply and demand, future price movements can be predicted. This analytical method is widely used in foreign exchange markets, stock exchanges, and the gold and other precious metals markets. This type of analysis is carried out by studying the past behavior and movements of stock prices and volume to determine the future price and trend of a stock. Stock price changes are analyzed by a technical analyst using historical data and charts. This method is primarily employed by speculators seeking to maximize their returns from increases in stock prices. In fact, short-term investors benefit from this method. Technical analysis predicts future price movements by examining past prices and trading volumes. The basis of these analyses focuses on using charts and mathematical and geometric relationships to derive small and large trends. In this regard, buying or selling opportunities are identified by estimating the range of market fluctuations.

Fundamental Analysis

The price-to-earnings (P/E) ratio, represents a company's share price relative to its earnings per share (EPS). Calculating the P/E ratio in the stock market is one of the common methods for valuing stocks in fundamental analysis. Through this, the value of stocks is assessed by estimating the net profit of companies. A company's fundamental analysis includes analyzing its financial reports and financial health, management and competitive advantages, competitors, and relevant markets. When this analysis is applied to futures and forex markets, the main focus is on economic conditions, interest rates, production, profitability, and management. When stocks, futures contracts, or currencies are subjected to fundamental analysis, there are two basic

approaches: bottom-up analysis and top-down analysis. These terms are used to distinguish such analyses from other investment analyses, such as quantitative and technical ones. Fundamental analysis is performed based on past and current data with the aim of financial forecasting. There are multiple objectives for this analysis. In fundamental analysis, determining the intrinsic value of a company's shares, forecasting future price movements, assessing business performance and management quality, and making internal decisions related to credit risk are all based on the company's actual financial performance and underlying economic conditions. Traders predict the market by analyzing real-world events and news, based on their knowledge and strategy. Strategy is the method for calculating market entry and exit points. The basic view of fundamental analysts is that all changes in prices must have a fundamental economic cause.

Neural Network

In the late 1940s, neural network pioneers, McCulloch and Pitts, studied the ability of internal communication in a neuron model. They presented a computational model based on a simple neuron-like element. At the same time, other scientists like Donald Hebb were also working on adaptation rules in neural systems. In 1949, Donald Hebb proposed a learning rule for adapting connections between artificial neurons. Shortly after, in 1958, Rosenblatt introduced the perceptron and then developed the theory of statistical separation accordingly.

To capture the long-term temporal dependencies and non-linear dynamics inherent in energy price fluctuations and stock movements, a Sequential hybrid LSTM-Dense neural network was constructed. The architecture consists of stacked Long Short-Term Memory (LSTM) layers to extract temporal hidden features, followed by Fully Connected (Dense) layers to map the learned representations to the predicted stock values. To prevent overfitting, a Dropout regularization layer is incorporated between the LSTM layers.

Neural Network Activation Functions

Several types of activation functions are introduced in Table 1. Figure 1 illustrates the graph of each function.

Table 1. Activation Function of Different Neurons in Neural Networks

Function with limiting capability (threshold)	$F(net) = \frac{1}{1 + e^{-g \cdot net}}$
Piecewise linear function	$F(net) = \begin{cases} 1, & \text{if } net \geq \frac{1}{2} \\ net, & \text{if } \frac{1}{2} > net \geq \frac{-1}{2} \\ 0, & \text{if } net \leq \frac{-1}{2} \end{cases}$
Unipolar sigmoid function	$F(net) = \begin{cases} 1, & \text{if } net \geq 0 \\ 0, & \text{if } net < 0 \end{cases}$
Gaussian function	$g = \frac{x - \bar{x}}{\sigma}, (x = net) F(net) = e^{-g^2}$
Linear function	$F(net) = net$
Bipolar sigmoid function	$F(net) = \frac{1 - e^{-g \cdot net}}{1 + e^{-g \cdot net}}$

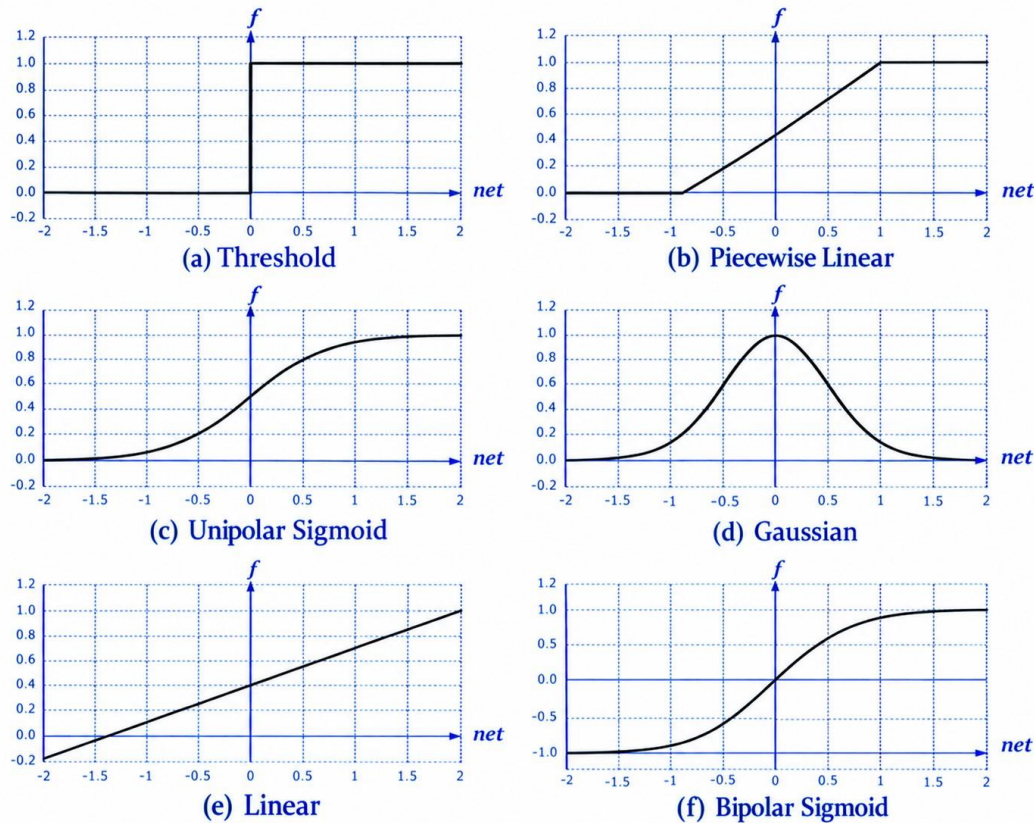


Figure 1. Activation Functions

Findings and Discussion

As mentioned, studies conducted in the capital market fall into three general areas: identifying suitable stocks for investment, identifying and employing appropriate buying and selling strategies in the market, and predicting future stock prices. Additionally, possible analyses regarding future stock prices fall into three general categories: technical analysis, fundamental analysis, and analysis using mathematical methods. Mathematical methods are also categorized and examined into two groups: classical methods and artificial intelligence methods. In the continuation of this research, first, the possibility of prediction and the theory of capital market efficiency will be examined, and then neural networks and data mining will be explained.

Moreover, the financial statements (profit and loss statements) of Khuzestan Cement Company in different years with different energy rates are presented in Tables 2, 3, and 4.

Table 2. Electricity and Natural Gas Prices: 1,600 Rials per Kilowatt-Hour of Electricity and 5,000 Rials per Cubic Meter of Natural Gas

Description	Amount (Million Rials)
Net profit (loss)	5,229,789
Accumulated profit (loss) at the beginning of the period	3,242,063
Annual adjustments	0
Adjusted accumulated profit (loss) at the beginning of the period	3,242,063
Dividend approved (previous year's general meeting)	-3,080,000
Changes in capital from accumulated profit (loss)	0
Unallocated accumulated profit at the beginning of the period	162,063
Transfer from other equity items	1,073

Table 2. Electricity and Natural Gas Prices: 1,600 Rials per Kilowatt-Hour of Electricity and 5,000 Rials per Cubic Meter of Natural Gas

Description	Amount (Million Rials)
Allocated profit	5,392,925
Transfer to legal reserve	0
Transfer to other reserves	0
Accumulated profit (loss) at the end of the period	5,392,925
Dividend approved (current year's general meeting)	-4,838,400
Accumulated profit (loss) at the end of the period (including general meeting approvals)	554,525
Net profit (loss) per share (Rials)	3,736
Cash profit per share (Rials)	3,456

Table 3. Electricity Price of 1,800 Rials per Kilowatt-Hour and Gas Price of 9,000 Rials per Cubic Meter

Description	Amount (Million Rials)
Net profit (loss)	10,065,669
Accumulated profit (loss) at the beginning of the period	5,392,925
Annual adjustments	0
Adjusted accumulated profit (loss) at the beginning of the period	5,392,925
Dividend approved (previous year's general meeting)	-4,838,400
Changes in capital from accumulated profit (loss)	0
Unallocated accumulated profit at the beginning of the period	554,525
Transfer from other equity items	0
Allocated profit	10,620,194
Transfer to legal reserve	0
Transfer to other reserves	0
Accumulated profit (loss) at the end of the period	10,620,194
Dividend approved (current year's general meeting)	-9,562,000
Accumulated profit (loss) at the end of the period (including general meeting approvals)	1,058,194
Net profit (loss) per share (Rials)	7,190
Cash profit per share (Rials)	6,830
Capital	1,400,000

Table 4. Electricity Price of 2,000 Rials per Kilowatt, and Gas Price of 10,000 Rials per Cubic Meter

Description	Amount (Million Rials)
Net profit (loss)	9,355,686
Accumulated profit (loss) at the beginning of the period	10,620,194
Annual adjustments	0
Adjusted accumulated profit (loss) at the beginning of the period	10,620,194
Dividend approved (previous year's general meeting)	-9,562,000
Changes in capital from accumulated profit (loss)	0
Unallocated accumulated profit at the beginning of the period	1,058,194
Transfer from other equity items	0
Allocated profit	10,413,880
Transfer to legal reserve	0
Transfer to other reserves	0
Accumulated profit (loss) at the end of the period	10,413,880
Dividend approved (current year's general meeting)	-9,380,000
Accumulated profit (loss) at the end of the period (including general meeting approvals)	1,033,880
Net profit (loss) per share (Rials)	6,683
Cash profit per share (Rials)	6,700

In this section, some of the important components evaluated include moving average, RSI index, MACD index, trading volume, combined prediction model, and energy carrier price. By using the collected data and neural network techniques, we tried to identify hidden relationships and patterns in the data and clarify the various effects on the stock price prediction of cement companies. This analysis helps design more accurate prediction models and provides solutions for improving performance and more effective decision-making.

In this regard, a neural network algorithm has been used. The data was divided into training and testing sets, so that the algorithm could be trained on the training data and then evaluated on the testing data. In this algorithm, a neural network composed of a Sequential model and Dense layers is used. Dense layers are commonly known as fully connected perceptrons. The model was fitted using the Mean Squared Error (MSE) loss function and the Adam optimizer. The model was trained on the training data for a specified number of epochs. To reduce training time, the data was divided into smaller batches, and model training was performed using these batches. Finally, the model was evaluated using the testing data. Metrics such as mean squared error and coefficient of determination were used to evaluate the model's performance. To ensure the adequacy of the collected sample, two criteria, KMO and Bartlett's test, were used, and the results obtained from these two tests are presented in Table 5.

Table 5. Results of Sampling Adequacy Assessment Using KMO and Bartlett's Tests

Dimensions	Symbol	Number of Indicators	KMO Test	Bartlett's Test
Moving average	x_1	6	0.833	Sig. = 0.000
RSI indicator	x_2	5		
MACD indicator	x_3	5		
Trading volume	x_4	4		
Hybrid prediction model	x_5	4		
Energy carrier rates	x_6	4		

Prior to training the neural system, feature adequacy and inter-correlation among the technical and fundamental inputs were validated using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity. Although traditionally employed in factor analysis, applying these diagnostic tests to financial time-series indicators helps ensure that the selected feature space exhibits sufficient structural variance without excessive redundancy, thereby validating the suitability of the input dimensionality for nonlinear neural network mapping.

The required limit for the KMO test was greater than or equal to 0.6, and according to the results obtained in Table 5, these two tests are confirmed for all the dimensions of the research. The final neural network model developed in the present study consists of five input variables, which are initially fed into the network. Subsequently, the corresponding input layers are established, and membership functions are defined for these variables.

- Normalization of weights (summation)
- Creation of weighted outputs
- Sum
- Output

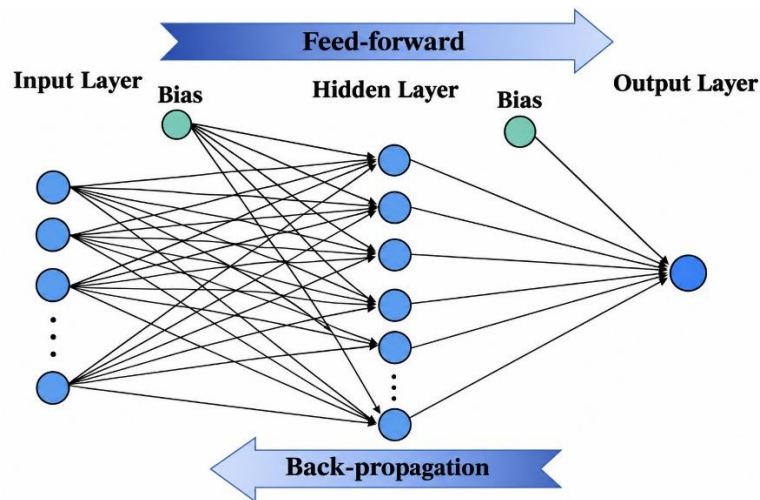


Figure 2. Neural Network Structure for Prediction

Given the limited availability of data and the importance of membership-function differentiability in the initial definition of the input variables, this issue must be carefully considered. In the present study, as in many previous studies, a Gaussian membership function is employed. The range of variation for both the input and output variables is between 6 and 16.

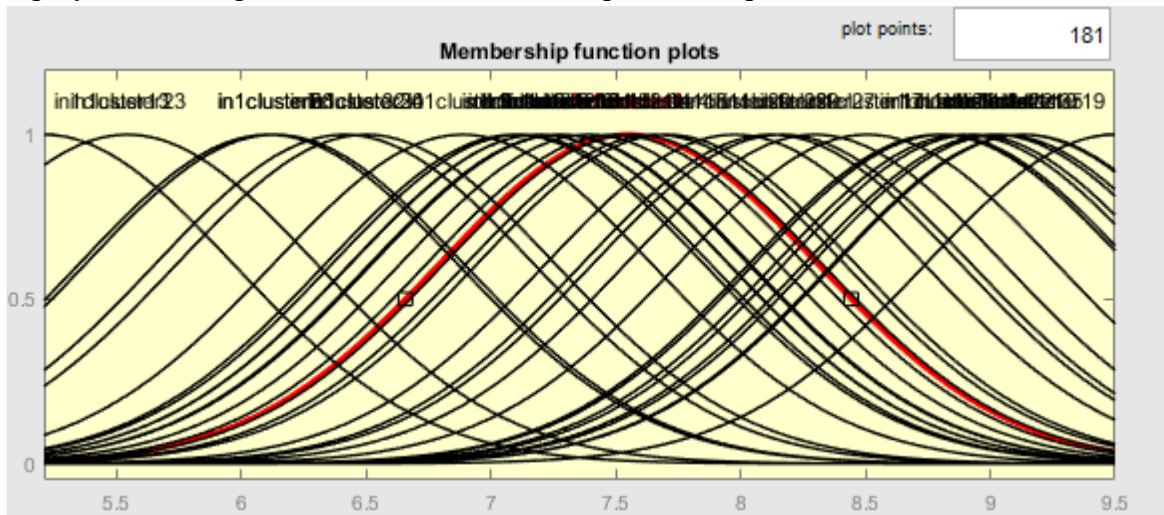


Figure 3. Membership Function Structure of the Neural Network for Prediction

To fit the model and evaluate the factors affecting the prediction of cement company stock prices, the proposed model was designed and fitted to the available data. The structure of this model includes six input stages, with the first layer comprising:

- Moving Average
- RSI Indicator
- MACD Indicator
- Trading Volume
- Hybrid Prediction Model
- Energy Carrier Prices

The intermediate layers included the input membership functions, rules, and the output membership function of the model. In the last layer, the model's output, which is the calculation

of the model's efficiency score, is observable. Then, each of the considered model inputs and their corresponding subsets were fitted. In this section, the conformity graph between the model's output and the expected output is examined, showing how closely the obtained output matches the actual output for each sample. The vertical axis of this graph represents the efficiency of banks and the normalized predicted value, and the horizontal axis represents the number of samples. Additionally, the error fluctuation graph is examined in Figure 4, illustrating how much the error should fluctuate for each sample. The vertical axis of this graph represents the error amount, and the horizontal axis represents the number of samples. Finally, Figure 5 presents the error histogram graph, indicating the range in which errors occurred most.

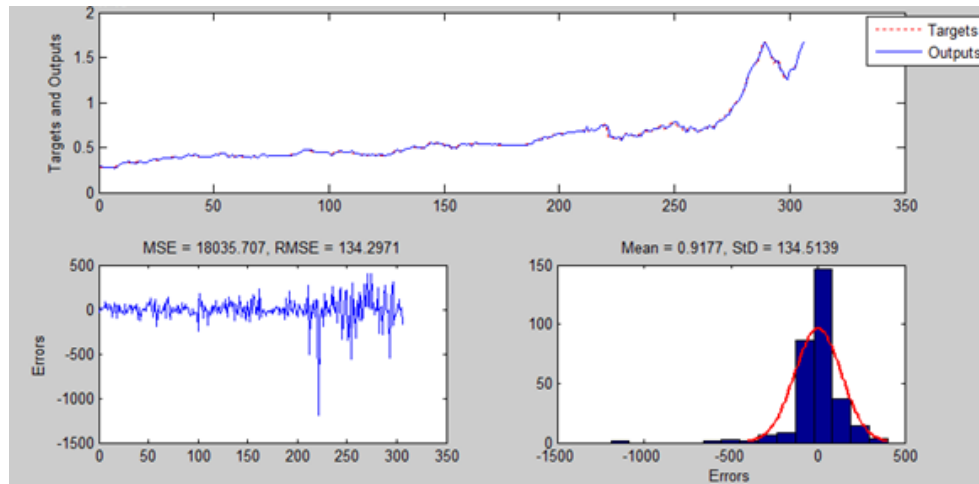


Figure 4. Data Training Process in a Neural Network for Prediction

Subsequently, the test data, which were not used during the model training process, were fed into the model to evaluate the performance of the proposed approach. The difference between the actual value and the predicted value in the examined range is shown in Figure 5. As can be seen, the model has very good prediction accuracy in different samples, and the lines corresponding to the actual performance and the predicted performance are almost perfectly aligned.

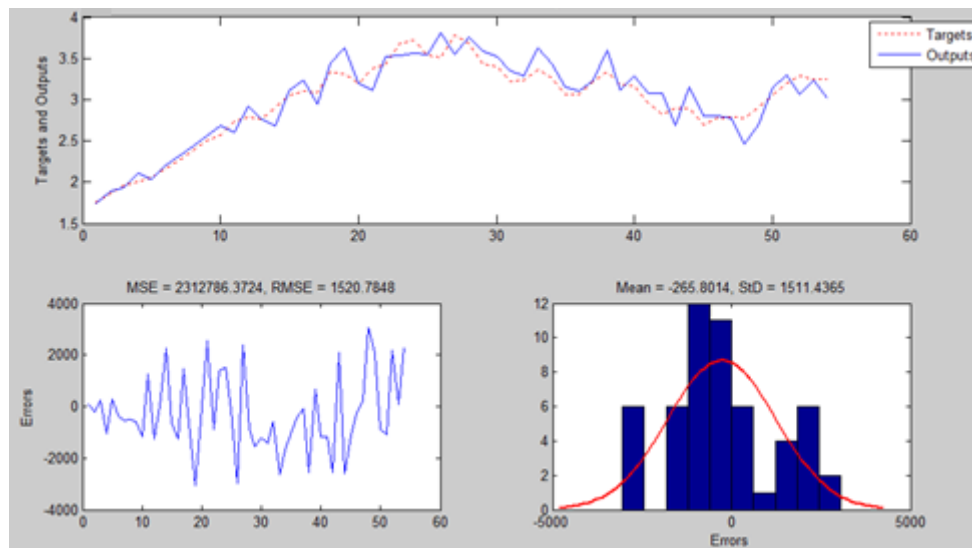


Figure 5. Comparison of Training and Prediction Values in the Neural Network Model

The performance of the neural network model for efficiency estimation is summarized in Table 6.

Table 6. Summary of Neural Network Method Performance

Method	Training Data		Prediction Data	
	RMSE	Error Percentage	RMSE	Error Percentage
Neural network	0.00293	16.25%	0.00288	16.94%
	MSE		0.0069	
	R^2		0.9964	

Based on the calculated error values, the training and prediction data using the neural network method are 16.25% and 16.94%, respectively. Given the results presented, the difference between the model's predicted values and the actual observations as measured by the mean squared error (MSE), is very small (approximately 0.0069). This result indicates that the proposed neural network model provides accurate predictions with a relatively low prediction error. The coefficient of determination indicates the degree of the model's fit to the actual data. The obtained coefficient of determination is very close to 1 (approximately 0.9964), indicating a high level of agreement between the predicted and actual values. This result suggests that the six identified components collectively provide a strong explanation of the variation in cement company stock prices. Therefore, based on these two evaluation criteria, the proposed model demonstrates high predictive accuracy and satisfactory predictive capability.

Conclusion

To improve the accuracy of stock price forecasting for companies active in the cement industry, this study presented a combined approach based on fundamental analysis, technical analysis, and artificial neural network. The results of the proposed model indicate that the synergy between selected variables from fundamental and technical analysis, along with the nonlinear learning ability of the artificial neural network, has significantly reduced the prediction error and increased the model determination coefficient approximate to 0.9964. Accordingly, it can be concluded that the application of intelligent methods based on machine learning, along with traditional economic and financial indicators, can be used as an effective tool in predicting stock price behavior in manufacturing industries such as cement. This approach not only improves the performance of forecasting models but also enables a more accurate analysis of the complex relationships between market variables and fundamental factors. Given the results obtained from this research and the high efficiency of the combined model based on fundamental analysis, technical analysis, and artificial neural network in predicting the stock prices of cement companies, several practical and managerial suggestions can be made.

First, investors and capital market analysts can increase the accuracy of stock price prediction by using models based on artificial neural networks alongside conventional fundamental and technical analysis methods, thereby reducing the risk of investment decisions. The use of such intelligent models enables the identification of hidden patterns in financial and price data and can lead to more informed decision-making in buying, holding, or selling stocks. On the other hand, investment companies, brokerages, and other institutions

active in the capital market can improve the market analysis and forecasting process by designing and implementing decision support systems based on data mining and machine learning. The development of such systems can help to analyze large volumes of financial data more quickly and provide more accurate predictions, ultimately increasing the efficiency and effectiveness of management decisions in the field of investment. Additionally, managers of companies active in the cement industry can improve the company's operational and financial performance by considering the fundamental variables affecting stock value, including energy costs, production volume, sales level, and market conditions. Continuous monitoring of these indicators and efforts to optimize them can, in addition to increasing the company's profitability, enhance investor confidence and improve the company's position in the capital market. Overall, the results of this research show that the use of hybrid approaches and intelligent analytical tools can play an important role in improving the quality of analysis and prediction in the capital market. Therefore, developing data infrastructures, strengthening analytical capabilities, and more widespread use of modern data mining and machine learning methods in financial institutions and investment companies can pave the way for more accurate decision-making and more efficient capital management in the capital market. Given the energy-intensive nature of the cement industry and its susceptibility to macroeconomic variables, it is suggested that future research use more multilayered models and broader datasets, including national and global macroeconomic indicators, to strengthen the stability and generalizability of the forecast model. Overall, the results of this study confirm the effectiveness of hybrid and intelligent approaches in capital market management and analysis. It can also serve as the basis for more scientific decision-making for investors and financial managers.

Theoretical Achievements

The results of data analysis show that the stock prices of companies active in the cement industry are simultaneously affected by technical variables and fundamental factors, including energy carrier rates. The analysis of price trends and technical indicators highlights that changes in energy costs, as a critical production inputs in the cement industry, can affect the share price behavior of cement companies in the capital market by affecting investor expectations and assessments of their future profitability. The study of short-term and long-term moving averages showed that in periods when energy carrier rates increased, the probability of downward crossings of moving averages increased, indicating a decrease in the strength of the upward trend and an increase in the probability of price correction in cement company stocks. Additionally, analysis of the Relative Strength Index (RSI) and Moving Average Convergence Divergence (MACD) indicators showed that increases in energy costs were frequently associated with declining price momentum and the shares entering oversold conditions. Furthermore, the results of the time-series and neural-network-based forecasting model indicate that incorporating the energy carrier price variable into the set of model input variables improved the accuracy of stock price forecasting. A comparison of model performance showed that the combined model, incorporating technical indicators and fundamental variables related to energy costs, achieved lower prediction errors and was better able to capture actual market fluctuations than models relying solely on historical price data.

Overall, the findings of this study indicate that changes in energy carrier prices, as a key component of the cement industry's cost structure, can indirectly influence stock price patterns through changes in market expectations and corporate profitability. Therefore, integrated approaches that combine technical analysis with fundamental variables may provide a more comprehensive framework for predicting the stock price behavior of cement companies in the capital market.

Limitations and Future Research Directions

As other empirical studies, this study has limitations that can affect the generalizability of the results. One of the most important limitations of the study is that the statistical population is limited to companies active in the cement industry; therefore, generalization of the results to other industries should be done with caution, because the financial structure, operating conditions, and the degree of influence of economic variables in different industries are different. Another limitation of this study is the dependence of the model on historical stock data and financial and technical indicators. It is obvious that sudden changes in economic, political, and regulatory conditions can transform past patterns and affect the accuracy of the model's predictions in future periods. In other words, although the model presented based on past data has performed well, there is no guarantee that it will maintain the same level of accuracy in unstable and unpredictable market conditions. Furthermore, this research uses a specific set of fundamental and technical variables, and some other influential factors, including macroeconomic variables, international indicators, political news, and investor behavioral expectations, may not be included in the model. Failure to include these variables could result in some of the stock price changes not being explained by the model. On the other hand, the use of artificial neural networks, despite their high ability to identify complex and nonlinear relationships, is also associated with interpretability limitations. This means that although the model has high predictive power, it is more difficult to accurately describe the effect of each variable on the final output, compared to some classical statistical methods.

Ethics Statement: The author declares that this study was conducted in accordance with established ethical principles and guidelines. All sources of information have been properly cited and acknowledged. Where applicable, ethical approval was obtained, and informed consent was secured from all participants. The research did not involve any form of plagiarism, fabrication, or falsification of data.

Use of Artificial Intelligence: The author acknowledges that AI-based tools were used solely for language editing and grammar checking. All AI-assisted content was carefully reviewed, verified, and edited by the author, who takes full responsibility for the accuracy, originality, and integrity of the final manuscript. AI tools were not used to generate or manipulate research data or to replace critical scholarly judgment.

Originality and Publication: The author declares that this work has not been published previously and is not under consideration for publication elsewhere.

Conflicts of Interest: Any potential conflicts of interest, including financial or personal relationships that could influence the research, are disclosed. The author declares no competing interests.

Compliance with Regulations: The author confirms that the study complied with all applicable institutional, national, and international regulations, and that any necessary permissions for data use and reproduction have been obtained.

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