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The Stock Prices Prediction Model for Construction Companies Using Artificial Neural Network in Vietnam

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KEYWORDS

Stock prices,
Forecasting,
Artificial Neural Networks,
Steel Price.

ABSTRACT

This study aims to predict the stock prices based on factors affecting the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange by using Artificial Neural Networks (ANN). The research data is collected from 22 construction companies listed on the HOSE over a period of 29 quarters, with a total of 595 samples. Study primarily uses the Artificial Neural Network (ANN) model and uses Multivariate Linear Regression (MLR) for comparison. The results show that the ANN model performs better, with six significant variables: Earning Per Share (EPS), Book Value Per Share (BVPS), Return on Assets (ROA), Inflation Rate (INF), Interest Rate (INT), and Construction Steel Price (SP). Meanwhile, the linear regression model only identifies three significant variables. This study also ranks the independent variables based on their impact level, in descending order: BVPS, EPS, ROA, Inflation Rate, Interest Rate, and Construction Steel Price.

1. Introduction

Nowadays, with the development of the stock market, stock price forecasting has become an interesting topic that attracts the attention of many investors, experts, and scientists. To forecast stock prices, it is neccessary to identify the factors that influence stock prices. However, the stock market, characterized by its dynamic nature, unpredictability, and non-linearity, cannot be predicted by models that only forecast linear patterns. Machine learning techniques in this field have proven to improve efficiency by 60-86% compared to previous methods (Li et al., 2017). Among these, due to their learning abilities, parallel generalization and information processing capabilities, Artificial Neural Networks (ANN) have demonstrated their effectiveness in solving forecasting problems (Pham, 2021). Therefore, ANN can be considered a good option for evaluating influencing factors and making stock prices prediction.

About the factors affect the stock prices, current studies over the world have shown a consensus on the influence of financial indicators on stock prices. However, there is no consensus on the impact and direction of correlation of macroeconomic

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indicators on stock price fluctuations, suggesting that the effect of macroeconomics on stock prices varies significantly depending on the market size, country, and period. The Vietnamese stock market is considered a frontier market, therefore, the impact of macroeconomic factors on stock prices in Vietnam will differ from other markets around the world. Moreover, investors face many challenges when accessing information about companies in the Vietnamese stock market. A common feature of listed companies in Vietnam is that their market capitalization is still low, ownership is highly concentrated, and the state-owned shareholding ratio is significant. According to Le (2019), more than 75% of companies choose to pay dividends in cash, while the rest either pay dividends in shares or a combination of both, therefore, leads to differences in the impact of financial indicators on stock prices in Vietnam compared to other global markets (Le, 2019).

On the other hand, the construction industry plays a key role in the economy of every country, especially in developing nations. Fluctuations in the stock prices of construction companies can signal changes within these sectors. Therefore, the volatility in stock prices of construction firms directly affects the stability and growth of the national economy, making it distinct from other industries. Studying the stock prices of construction companies helps investors gain a comprehensive understanding of the development trends across various sectors, allowing them to make more informed investment decisions compared to other industries. In 2023, the construction stock sector rose by 42%, outperforming the VN-Index by 30% (Hai, 2024). However, stock prices in the construction industry remain subject to differentiation influenced by both macroeconomic and microeconomic factors (Putra et al., 2021). It is a burgeoning stock market that requires highly applicable scientific research to contribute to its efficient operation in a competitive securities market. Researching the factors that impact the stock market yields significant results and provides timely insights and recommendations for organizations and individual investors (Dang et al., 2024). Moreover, in terms of valuation, the low profitability leads to a relatively high P/E ratio for construction stocks. This high P/E could be due to the declining and unstable profits of contractors. This suggests that construction stocks are not yet attractive for long-term investment, alongside the factors of high leverage and low profitability (Hai, 2024).

The above-mentioned points affirm the important role of a model that analyses the factors affecting stock prices in order to develop a new general framework for predicting stock indices and integrating approaches with ANN, especially considering that there are currently not too many studies on the factors influencing stock prices using ANN. Therefore, this study uses ANN to analyse the factors affecting the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange (HoSE) and also compares the effectiveness of models for factors influencing stock prices using ANN model with the Multiple Linear Regression (MLR) model.

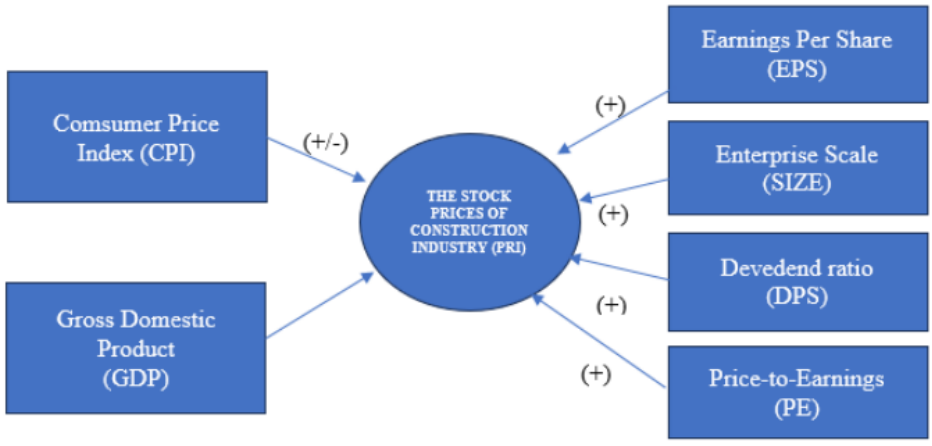

Figure 1. Research model (Dang et al., 2024)

2. Literature review

Currently, there is limited specific research on the construction industry in Vietnam, such as the study by Dang et al. (2024). This study determined the impact of macroeconomic factors and microeconomic factors on stock prices in the construction sector. The study used quarterly financial reports from 56 construction companies listed on the Vietnam Stock Exchange between 2016 and 2022 to examine the factors influencing stock prices in this industry. The analysis results showed that the Random Effects Model (REM) was the most suitable model for this data. The findings showed that factors such as the Consumer Price Index (CPI), earnings per share (EPS), company size (SIZE), and the P/E ratio all had a positive impact on stock prices in the construction sector.

Previous studies have largely focused on market price ratios and profitability ratios when discussing financial ratios, with less emphasis on other groups of ratios. For the construction industry, one of the key financial ratios in industry analysis is the debt-to-equity ratio. This ratio is used to assess the financial leverage of a company and serves as an important measure for investors and the company itself to evaluate its financial capacity, identify potential risks, and take timely countermeasures. According to Bui et al. (2022), D/E ratio varies across industries, and for the construction sector, companies typically have a high D/E ratio due to the capital-intensive nature of the industry. This sector requires businesses to raise large amounts of capital through both equity and debt. As a result, a company's ability to repay debt is closely related to its stock price (Bui et al., 2022).

Additionally, previous research has mostly focused on the impact of fundamental factors found in a company's financial statements, without considering external factors such as the price of raw materials, particularly steel prices, on construction companies. According to Hai (2022), after 2021, considered a challenging year for both the economy in general and the construction industry in particular, experts expected that, in 2022, the revenue of construction companies would grow strongly and return to pre-pandemic levels, as public investment was still expected to drive macroeconomic growth. However, in the first quarter of 2022, construction stock prices dropped after a period of strong growth due to the sharp rise in raw material prices, particularly the price of steel in Vietnam, which followed the global upward trend in steel prices. The soaring cost of building materials could slow the progress of public investment projects, even those with assigned tenders. The price increases make construction costs higher, leading to concerns among contractors. The old unit price norms in tender documents no longer reflect market prices. As a result, construction stocks declined because contractors were seen as disadvantaged, as most investors use fixed-price contracts that do not adjust at the time of signing. Contractors had to cover the deficit themselves, leading to a reduction in company profits (Hai, 2022). Therefore, analyzing the impact of steel prices on the stock price of construction companies is essential. This is another reason why authors chose this factor for analysis in the study.

Earning Per Share

In determining value relevance, often, investors and analysts would select ratios that can be used to determine stock price. Among the ratios is EPS, which is the most critical factor in determining share price and firm value (Dang et al., 2024). Olaoye and Kolawole (2020) described EPS as a performance indicator showing the financial standing of a company during the financial year. Studies by Sukmadilaga et al. (2023); Dang et al. (2024) show that EPS has a positive correlation with stock prices. However, the study by Olaoye and Kolawole (2020) shows that EPS has no impact on stock prices during the study period. The following hypothesis is proposed:

H1: Earning Per Share (EPS) has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Book Value Per Share

Olaoye and Kolawole (2020) asserted that book value per share (BVPS) is one of the important variables that affect the market value of equity share as it is the value of a company's funds per share. Sukmadilaga et al. (2023) described it as a reflection of the company's past earnings, dividend distribution policy, and investment decisions as it indicates the book value of each share. Studies by Olaoye and Kolawole (2020), Sukmadilaga et al.

(2023) show that BVPS has a positive correlation with stock prices. A hypothesis can be proposed as follows:

H2: Book Value Per Share (BVPS) has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Price to Earning Ratio

Price to Earning Ratio (P/E) of a stock is equal to the price of a share of the stock derived from dividing price by earnings per share (Azizan and Abidin, 2024). Studies by Dang et al. (2024), Azizan and Abidin (2024) show that P/E has a positive correlation with stock prices. However, study by Dang et al. (2023) shows that P/E does not impact stock prices. The following hypothesis is proposed:

H3: Price to Earning Ratio (P/E) has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Return on Assets

Return on Assets (ROA) is a ratio of net profit to assets; it measures the profitability of a company that can use its financial resources to generate value for shareholders (Sukesti et al., 2021). Studies by Sukesti et al. (2021); Al-Dwiry et al. (2022) show that ROA has a positive impact on stock prices. By contrast, the study by Amogha and Suresh (2019) shows a negative correlation between ROA and stock prices; while the studies by Nurwulandari and Wahid (2023); Dang et al. (2023) show that ROA does not affect stock prices. The following hypothesis is proposed:

H4: Return on Assets (ROA) has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Debt to Equity Ratio

Debt to Equity Ratio (D/E) is a ratio used to assess debt to equity. This ratio compares all debt including current money with all equity, knowing the amount of funds provided by the creditor and the owner of the company (Rusdiyanto et al., 2020). Studies by Sukesti et al. (2021), Nurwulandari and Wahid (2023) show that D/E has a significant positive impact on stock prices. However, the study by Bui et al. (2022) shows that D/E does not affect the stock prices of construction companies in Vietnam during 2012-2019 period. The following hypothesis is proposed:

H5: Debt to Equity Ratio (D/E) has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

GDP Growth

Economic growth is understood as the increase in the real output of an economy over a period of time. A common measure is the growth in Gross Domestic Product (GDP) within a year or the increase in GDP per capita in a year (Ahmad et al., 2010). Study by Dinh et al. (2020) shows that GDP has a positive impact on stock prices. However, the study by Trinh et al. (2024) shows a negative correlation between stock prices and GDP growth. Meanwhile, the study by Bui and Nguyen (2022) shows that GDP has no statistical significance to stock prices. The following hypothesis is proposed:

H6: GDP growth has a positive correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Inflation Rate

Inflation Rate (INF) is a ratio used to assess debt to equity. This ratio compares all debt including current money with all equity, knowing the amount of funds provided by the creditor and the owner of the company (Putra et al., 2021). Study by Trinh et al. (2024) shows that the inflation rate has a negative correlation with stock prices. However, the study by Putra et al. (2021) shows a positive correlation between the inflation rate and stock prices. The following hypothesis is proposed:

H7: Inflation rate (INF) has a negative correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Interest Rate

Interest Rate (INT) is the price of borrowing money or it can also be defined as the cost of money (Ahmad et al., 2010). Study by Trinh et al. (2024)

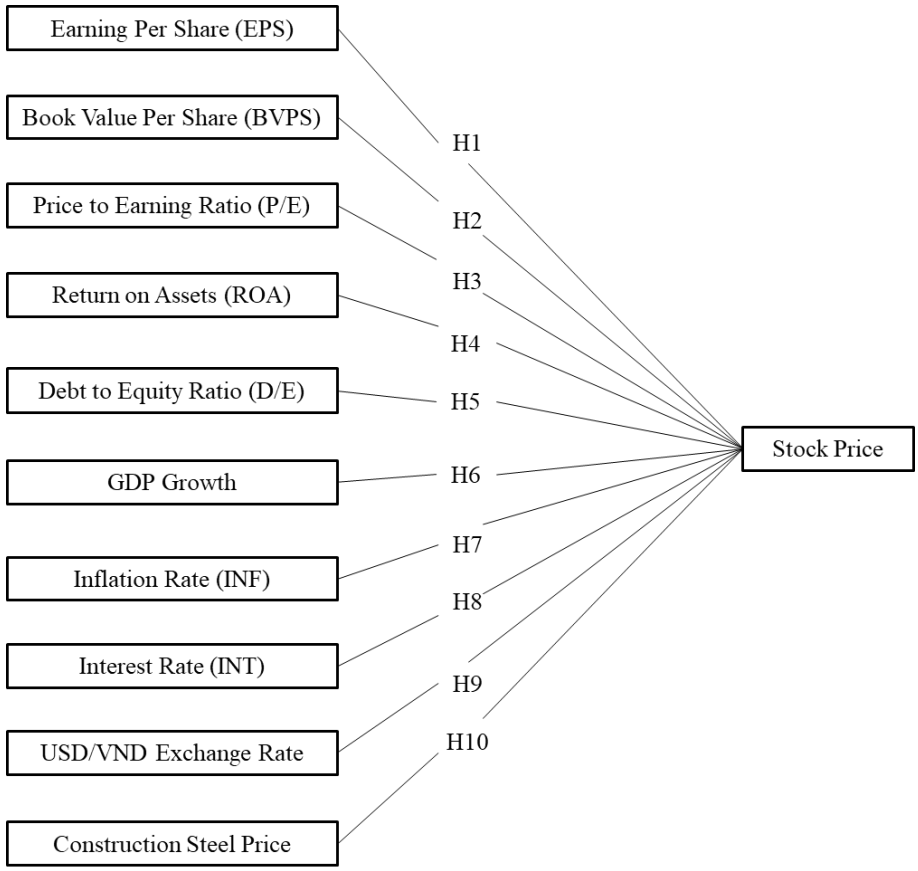

Figure 2. The proposed research model

shows that interest rate has a significant negative impact on stock pric. However, the study by Dinh et al. (2020) shows that interest rate has a significant positive impact on stock prices. The following hypothesis is proposed:

H8: Interest rate (INT) has a negative correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

USD/VND Exchange Rate

The exchange rate (EX) is the rate at which one currency can be converted into another currency (Ahmad et al., 2010). Study by Dinh et al. (2020) shows that the exchange rate has a significant negative impact on stock prices. The following hypothesis is proposed:

H9: The USD/VND exchange rate has a negative correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exhange.

Construction Steel Price

For construction materials, steel is a crucial component used to lay foundations and create sturdy, sustainable structures. Therefore, in any construction project, steel is often the first material chosen and receives significant investment. Due to rising raw material costs can impact production and business operations, empirical research results show that indicators reflecting business performance, such as net revenue (Bui et al., 2022), ROA (Sukesti et al., 2021) or ROE (Azizan and Abidin, 2024), generally have a positive correlation with stock prices. Therefore, the following hypothesis is proposed:

H10: Construction steel price has a negative correlation with the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange.

Research model

Based on research model of the study by Dang

et al. (2024) and the above research hypotheses, authors propose the following research model:

3. Research Methodology

3.1. Artificial Neural Networks (ANN)

ANNs, also often known as NNs, are an AI system in which the information processes build the models by mimicking the learning ability of biological systems in understanding an unknown behaviour. The general architecture of an ANN consists of three components: the Input Layer, which receives external information for sequence classification; the Hidden Layer; and the Output Layer, which addresses the problem (Pham, 2021).

3.2. Data analysis

The data for this study was collected from construction companies listed on the Ho Chi Minh City Stock Exchange. The observed variables were gathered from the data of 22 construction companies over the period from 2017 to 2024, including: stock prices (PRICE), earning per share (EPS), book value per share (BVPS), price to earning ratio (P/E), return on assets (ROA), debt to equity ratio (D/E), GDP growth (GDP), inflation rate (INF), interest rate (INT), exchange rate (EX), and construction steel price (SP). The financial indicator data were collected from the official consolidated financial reports published by the companies. The macroeconomic indicator data were sourced from Hoa Phat Group (https://www.hoaphat.com.vn), the State Bank of Vietnam (www.sbv.gov.vn), and stock prices data were obtained from the Vietstock Financial and Securities Portal (www.vietstock.vn). Totally, this study collected 638 samples, and to ensure data integrity, authors removed 29 samples with missing data or high risk regarding the reliability of the information, along with 14 outlier samples. This helps ensure that the results of the analysis and predictions from the model are not affected by incomplete, unreliable, or excessively different data. Finally, 595 samples were used for further data analysis. Explanation of the independent variables are provided in Table 1.

Table 1. Explanation of the independent variables

Code	Meaning
EPS	Earning Per Share
BVPS	Book Value Per Share
P/E	Price to Earning Ratio
ROA	Return on Assets
D/E	Debt to Equity Ratio
GDPG	GDP Growth
INF	Inflation Rate
INT	Interest Rate
EX	USD/VND Exchange Rate
SP	Construction Steel Price

4. Research findings

Artificial Neural Networks (ANN) Model

For 2017-2024 dataset, this study created 20 experimental models divided into three main purposes for: training, validation, and testing (Table 2).

Earning Per Share

Experimental model number 1 includes EPS as the input. The MSE results for the training dataset, validation dataset, and testing dataset range from 140,760,000 to 209,570,000, representing the mean squared error of the difference between predicted output of the network and the actual target output. This is a relatively high MSE range, indicating that the model struggles to accurately predict stock prices based on EPS. However, because stock prices data is highly volatile and difficult to predict, a high MSE may not entirely reflect the inefficiency of the model. Additionally, the R values, which represent the correlation with stock prices in this dataset, range from 36.13% to 45.45%, indicating the relationship between outputs and targets. These R values suggest a weak to moderate relationship. This implies that EPS affects stock prices but is not the sole factor.

In Vietnam's construction industry, EPS exhibits high volatility due to significant and irregular business cycles, government policies, and high debt levels. During 2017-2018, the government implemented policies to stimulate investment in infrastructure and real estate, including capital support and tax incentives for the construction sector. However, from 2019-2020, the government introduced new regulations on environmental protection and labor

Table 2. ANN model for 2017-2024 dataset

Test	IN1	IN2	IN3	IN4	IN5	IN6	IN7	IN8	IN9	IN10	Result 1	Result 2	Result 3	Result 4	Result 5	Result 6	RANKING
No.	EPS	BVPS	P/E	ROA	D/E	GDPG	INF	INT	EX	SP	Training MSE	Validation MSE	Testing MSE	Training R	Validation R	Testing R	ALL
1	X										162,820,000	209,570,000	140,760,000	0.4545	0.3613	0.3954	II
2	X	X									95,059,000	96,107,000	85,043,000	0.7322	0.7562	0.6262	
3	X	X	X								84,937,000	109,340,000	137,300,000	0.7402	0.7341	0.6142	
4	X	X	X	X							92,246,000	75,096,000	174,740,000	0.7261	0.7095	0.6914	
5	X	X	X	X	X						82,761,000	116,750,000	123,880,000	0.7315	0.7285	0.7003	
6	X	X	X	X	X	X					90,830,000	104,390,000	112,550,000	0.7431	0.7217	0.6117	
7	X	X	X	X	X	X	X				86,790,000	73,126,000	129,740,000	0.7367	0.7783	0.7057	
8	X	X	X	X	X	X	X	X			76,213,000	79,825,000	98,729,000	0.7883	0.7276	0.7162	
9	X	X	X	X	X	X	X	X	X		75,456,000	103,190,000	111,770,000	0.7698	0.7388	0.7627	
10	X	X	X	X	X	X	X	X	X	X	72,597,000	93,493,000	103,430,000	0.7904	0.7197	0.7331	
11		X									92,483,000	133,470,000	101,150,000	0.706	0.7244	0.6282	I
12			X								512,690,000	716,930,000	412,250,000	0.014	0.062	0.0556	REJECT
13				X							168,780,000	201,220,000	210,670,000	0.3048	0.2614	0.2388	III
14					X						192,410,000	167,340,000	232,320,000	0.0936	0.0811	0.0985	REJECT
15						X					191,710,000	168,180,000	203,290,000	0.2086	0.1188	0.1635	REJECT
16							X				165,690,000	162,430,000	313,750,000	0.2321	0.2222	0.1557	IV
17								X			188,570,000	187,190,000	176,740,000	0.237	0.1827	0.1923	V
18									X		200,190,000	189,240,000	158,860,000	0.1686	0.1392	0.0352	REJECT
19										X	179,490,000	118,540,000	305,300,000	0.2089	0.1373	0.1387	VI
20	X	X		X			X	X		X	73,483,000	118,780,000	75,651,000	0.7761	0.7267	0.8163	FINAL

safety, requiring companies to invest more in compliance with these standards, thereby increasing costs and impacting profits, leading to a decline in EPS. Finally, construction companies often rely on debt to finance large projects. During periods of low interest rates and favorable market conditions (2017-2018), this strategy helped companies grow their profits and EPS. When interest rates rose and market conditions deteriorated (2019-2020), high interest expenses impacted company profits. The increase in financing costs amidst declining revenue led to a sharp decline in EPS. This research is supported by previous studies (Al-Dwiry et al., 2022; Sukmadilaga et al., 2023; Dang et al., 2024), suggesting that EPS does indeed influence stock prices.

Book Value Per Share

Experimental model number 2, with inputs including EPS and BVPS, shows results with MSE ranging from 84,937,000 to 137,300,000, while the R values for these datasets range from 62.62% to 73.22%. Comparing the results between models 1 and 2, there is a decrease in MSE and a significant increase in R values. Therefore, it can be concluded that the performance of the ANN has significantly improved. Consequently, the study further developed experimental model number 11, which includes only BVPS as the input, to test the impact of BVPS on stock prices. The MSE results range from 92,483,000 to 133,470,000, which is still relatively high. However, the R values range from 62.78% to 72.44%, indicating good results as these R values show that BVPS contributes from 62.78% to 72.44% to the stock prices model. The results suggest that BVPS could be an important factor in the model.

However, the finding that EPS has a weaker impact on stock prices compared to BVPS is a unique aspect of this study, as most previous studies have shown that EPS has a stronger influence on stock prices than BVPS (Sukmadilaga et al., 2023; Ha et al., 2024). This difference can be explained by the fact that during the study period, the construction industry was affected by macroeconomic factors, government policies, and economic cycles. Following the period of instability due to the Covid-19 pandemic, the profits of companies decreased significantly, making EPS be less reliable for assessing stock value. By contrast, BVPS, which is based on the net asset value of the company, provides a more stable view of the true value of the stock during the study period.

Price to Earning Ratio

Experimental model number 3, with inputs including EPS, BVPS, and P/E, shows results with MSE ranging from 85,043,000 to 96,107,000, while the R values for these datasets range from 61.42% to 74.02%. Comparing the results between models 2, 3, and 12, the results suggest that the P/E ratio has an insignificant impact on the stock prices model, leading to its exclusion from the model. This finding is consistent with the study of Dang et al. (2023).

Return on Assets

Experimental model number 4, with inputs including EPS, BVPS, P/E, and ROA, shows results with MSE ranging from 75,096,000 to 174,740,000, while the R values for these datasets range from 69.14% to 72.61%. Comparing the results between models 3, 4, and 13, the results suggest that ROA does have an impact on the stock prices model. The construction industry, characterized by low ROA due to substantial fixed assets and long business cycles, often experiences delayed returns from projects, impacting ROA in the early stages of project implementation. However, investors still pay attention to how companies manage costs and assets to maintain or improve ROA, which influences investor sentiment and stock prices. This finding is supported by previous studies (Sukesti et al., 2021; Al-Dwiry et al., 2022), indicating that ROA does indeed influence stock prices.

Debt to Equity Ratio

Experimental model number 5, with inputs including EPS, BVPS, P/E, ROA, and D/E, shows results with MSE ranging from 82,761,000 to 123,880,000, while the R values for these datasets range from 70.03% to 73.15%. Comparing the results between models 4, 5, and 14, the results suggest that the D/E ratio has an insignificant impact on the stock prices model, leading to its exclusion from the model. This finding is consistent with the study of Nurwulandari and Wahid (2023).

GDP Growth

Experimental model number 6, with inputs including EPS, BVPS, P/E, ROA, D/E, and GDPG, shows results with MSE ranging from 90,830,000 to 112,550,000, while the R values for these datasets range from 61.17% to 74.31%. Comparing the results between models 5, 6 and 15, the results suggest that GDPG has an insignificant impact on the stock prices model, leading to its exclusion from the model. This finding is consistent with the study of Bui and Nguyen (2022).

Inflation Rate

Experimental model number 7, with inputs including EPS, BVPS, P/E, ROA, D/E, GDPG, and INF, shows results with MSE ranging from 73,126,000 to 129,740,000, while the R values for these datasets range from 70.57% to 77.83%. Comparing the results between models 6, 7, and 16, the results suggest that INF does have an impact on the stock prices model.

Interest Rate

Experimental model number 8, with inputs including EPS, BVPS, P/E, ROA, D/E, GDPG, INF, and INT, shows results with MSE ranging from 76,213,000 to 98,729,000, while the R values for these datasets range from 71.62% to 78.83%. Comparing the results between models 7, 8, and 17, the results suggest that INT does have an impact on the stock price models. Inflation in Vietnam is subject to frequent fluctuations, and interest rates exhibit cyclical patterns. These factors directly impact the profitability of construction companies through their effects on raw material costs, borrowing costs, and market demand, which in turn influences construction and real estate demand. This finding is supported by previous studies (Putra et al., 2021; Trinh et al., 2024), suggesting that inflation and interest rates indeed influence stock prices.

USD/VND Exchange Rate

Experimental model number 9, with inputs including EPS, BVPS, P/E, ROA, D/E, GDPG, INF, INT, and EX, shows results with MSE ranging from 75,456,000 to 111,770,000, while the R values for these datasets range from 70.03% to 73.15%. Comparing the results between models 8, 9, and 18, the results suggest that EX has an insignificant impact on the stock prices model, leading to its exclusion from the model. This finding is consistent with the study of Putra et al. (2021).

Construction Steel Price

Experimental model number 10, with inputs including EPS, BVPS, P/E, ROA, D/E, GDPG, INF, INT, EX, and SP, shows results with MSE ranging from 72,597,000 to 103,430,000, while the R values for these datasets range from 71.97% to 79.04%. Comparing the results between models 9 and 10, there is a significant improvement in performance. Therefore, the study developed experimental model number 19, which includes only SP as the input, to assess the impact of SP on stock prices. The MSE results range from 118,540,000 to 305,300,000, which is quite high. The R values range from 13.73% to 20.89%, indicating a weak to moderate relationship, and showing that SP contributes from 13.73% to 20.89% to the model. The results suggest that SP does have an impact on the stock prices model.

This result is a novel finding of this study. When comparing Vietnamese steel prices to global prices in 2023, it is evident that global steel prices have decreased compared to 2022, driven by slower demand in some regions and production adjustments in major countries like China. Meanwhile, domestically produced construction steel in Vietnam is often lower than global prices due to lower labor and production costs compared to many developed countries. However, imported steel prices are higher due to import costs, transportation, and other factors. This significantly impacts the selling prices and profits of construction companies as well as investor sentiment. Although steel is just one of many construction materials, the impact of steel prices on stock prices is the lowest among the significant variables. This finding suggests that if steel prices increase due to rising demand in the construction industry, it reflects positive growth in the construction sector. Increased construction activities can lead to increased profits for construction companies, thereby driving up stock prices. Rising steel prices may reflect an increase

in the value of construction materials and products, which can lead to a higher market valuation of companies in the construction industry.

To conclusion, this result indicates that for the dataset from 2017-2024, there are six significant variables: EPS, BVPS, ROA, INF, INT, and SP. On the other hand, four insignificant variables are P/E, D/E, GDPG, and EX. Compared to previous related studies, this result shows a similarity in indicating the existence of a relationship between stock prices and financial ratios such as EPS, BVPS, ROA, and macroeconomic indicators such as INF and INT. However, the result is different when excluding variables P/E, D/E, GDPG, and EX. This reflects the significant change in the impact of the macroeconomy on stock prices depending on market size, country, and period; and in which, for the construction industry in Vietnam during the period 2017-2024, GDP and exchange rate have no impact on the stock prices of construction enterprises. Meanwhile, the fact that P/E does not affect stock prices shows that the P/E ratio is only relative, for the construction industry, stock prices often increase or decrease independently of the company's profits, no longer depend on EPS, then the P/E ratio will be affected by other factors (Dang et al., 2023), making P/E unstable and not reflecting the actual situation. Besides, the removal of the D/E variable, although for the construction industry, this is one of the important financial ratios when analyzing the industry, has shown that not evaluating this variable in previous studies is reasonable.

Ranking of significant factors

After identifying the significant variables in the model, including EPS, BVPS, ROA, INF, INT, and SP, the study continued to develop individual test models to examine the impact of each factor in order to evaluate and rank their importance. The test models are ranked in terms of importance from highest to lowest as follows: Model 11, Model 1, Model 13, Model 16, Model 17, and Model 19.

Based on the test results, it can be seen that BVPS has the highest R values, ranging from 62.78% to 72.44%. The second is EPS, with R values ranging from 36.13% to 45.45%. Next, ranked third in importance in the model is ROA, with R values ranging from 23.88% to 30.48%. Inflation is the fourth most important factor, with R values ranging from 15.57% to 23.21%. The fifth important factor is the interest rate, with R values ranging from 18.27% to 23.7%. The final significant factor in

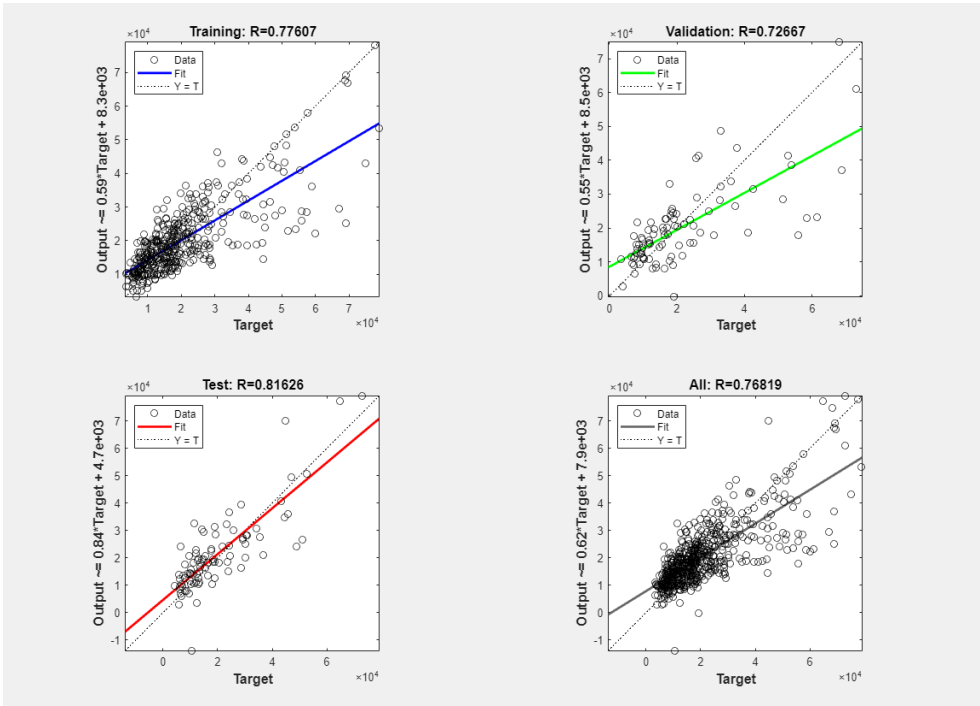

Figure 3. Regression chart for the ANN model 2017-2024

Table 3. Evaluation of the Model Fit

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.696[a]	.484	.476	10146.649	.484	54.882	10	584	.000	1.014

a. Predictors: (Constant), SP, BVPS, P/E, ROA, D/E, INT, GDPG, EX, EPS, INF

b. Dependent Variable: Stock Prices

Table 4. The impact level of variables in the regression equation

Coefficients[a]											
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	24592.668	33233.231		.740	.460					
	EPS	4.836	1.052	.227	4.598	.000	.335	.187	.137	.361	2.768
	BVPS	.536	.029	.588	18.342	.000	.628	.605	.545	.860	1.163
	P/E	-2.250	3.426	-.020	-.657	.512	-.030	-.027	-.020	.987	1.013
	ROA	-700.096	709.253	-.047	-.987	.324	.159	-.041	-.029	.383	2.610
	D/E	55.806	93.199	.018	.599	.550	-.061	.025	.018	.942	1.061
	GDPG	-81.379	230.696	-.014	-.353	.724	.049	-.015	-.010	.526	1.902
	INF	-1154.956	1037.244	-.109	-1.113	.266	-.184	-.046	-.033	.092	10.889
	INT	-171.965	550.370	-.022	-.312	.755	-.162	-.013	-.009	.172	5.815
	EX	-1.228	1.539	-.040	-.798	.425	-.068	-.033	-.024	.348	2.874
	SP	1.042	.271	.141	3.844	.000	.152	.157	.114	.658	1.519

a. Dependent Variable: Stock Price

the model is the price of construction steel, with R values ranging from 13.73% to 20.89%.

Regression chart for the ANN model 2017-2024

Figure 3 presents four regression charts for the results of training data, testing data, validation data, and all data. In each plot, the dashed line represents the ideal result, where the output equals the target (Y = T) (Pham, 2021). The colored line represents the best-fit line, which expresses the model equation: Output = 0.62 * Target + 7900. In this study, the training data shows a good fit with an R value of approximately 77.607%. The other results also display similar significant R values: 72.667% for the testing data, 81.626% for the validation data, and 76.819% for all data. These scatter plots provide the best-fit results for the final ANN model for the 2017-2024 dataset.

Multiple linear regression model (MLR)

The adjusted R^2 value of 0.476 indicates that the independent variables included in the regression analysis explain 47.6% of the variation in the dependent variable, while the remaining 52.4% is attributed to factors outside the model and random error.

It can be observed that only three variables, EPS, BVPS, and SP, are statistically significant with Sig < 0.05. In terms of direction of impact, all three variables have a positive relationship with the potential for stock prices increase, with significance levels of 4.836%, 0.536%, and 1.042%, respectively. This means that if each variable - EPS, BVPS, and SP - increases by 1%, the potential increase in stock prices will be 4.836%, 0.536%, and 1.042%, respectively.

Comparison of two models

Both the ANN and linear regression models include statistically significant variables. However, there is a discrepancy in the results between the two models. The most effective ANN forecast

Table 5. Comparison results for ANN model and MLR model

Categories	ANN	MLR
The number of the significant variables	- 6 variables: EPS, BVPS, ROA, INF, INT, SP	- 3 variables: EPS, BVPS, SP
The meaning of the significant variables	- 3 variables representing the financial factors of the company: EPS, BVPS, ROA - 3 variables representing the macroeconomic indicators: INF, INT, SP	- 2 variables representing the financial factors of the company: EPS, BVPS - 1 variable representing the macroeconomic indicators: SP
R value	76.82%	47.6%

model includes six variables: Earnings Per Share (EPS), Book Value Per Share (BVPS), Return on Assets (ROA), Inflation Rate (INF), Interest Rate (INT), and Steel Price (SP). On the other hand, the Market Price to Earnings Ratio (P/E), Debt to Equity Ratio (D/E), GDP Growth (GDPG), and USD/VND Exchange Rate (EX) are variables that do not have a significant impact on stock prices. In contrast, the linear regression model includes only three statistically significant variables: Earnings Per Share (EPS), Book Value Per Share (BVPS), and Steel Price (SP).

Based on the results above, it can be concluded that the ANN model has higher accuracy than the multiple linear regression model in analyzing the impact of factors influencing the stock prices of construction companies on the Ho Chi Minh City Stock Exchange. The ANN model shows an R-value of 76.82%, indicating a strong relationship between the forecasted and actual results. In contrast, the multiple linear regression model shows an R-value of 47.6%, reflecting a weaker relationship between the predictions and actual outcomes.

5. Conclusion

Firstly, it can be concluded that the Artificial Neural Network (ANN) model has higher accuracy than the multiple linear regression model in analysing the factors affecting the stock prices of construction companies on the Ho Chi Minh City stock market. The ANN model shows an R-value of 76.82%, while the multiple linear regression model shows an R-value of only 47.6%.

Secondly, compared to previous related studies, the results of this study are consistent in indicating a relationship between stock prices and financial factors such as EPS, BVPS, ROA, as well as macroeconomic factors such as INF and INT. However, the results differ by excluding variables such as P/E, D/E, GDPG, and EX. This reflects that the impact of macroeconomic factors on stock prices changes significantly depending on market size, country, and period. Specifically, for the construction sector in Vietnam during the 2017-2024 period, GDP and exchange rate do not affect the stock prices of construction companies listed on the Ho Chi Minh City Stock Exchange (HoSE).

Thirdly, the impact of construction steel price on stock prices is a new aspect of this study. It suggests that the assertion that construction steel price may have both direct and indirect effects on the stock prices of construction companies in Ho Chi Minh City is valid, and including steel price in this study is justified. However, imported steel is more expensive due to costs of raw materials, transportation, and other factors. This significantly impact the selling prices and profitability of construction companies, as well as investor sentiment. The result of this study indicates that if steel price increases due to rising demand in the construction sector, it often reflects positive development in the industry.

Finally, the finding that EPS has a lower impact on stock prices compared to BVPS is a distinguishing point of this study, as most previous studies have shown that EPS has a stronger impact on stock prices than BVPS. This is a novel finding of this study when most previous studies have shown that EPS has a stronger influence on stock prices than BVPS.

Theoretical contributions

This study has ranked the independent variables based on their impact on the model of influencing factors, thereby identifying which independent variable is the most important and which is less significant for the model of factors affecting stock prices. Additionally, another important contribution of this study is the analysis of the impact of construction steel price on the stock prices of construction companies. Previous studies

have mainly focused on analysing macroeconomic factors affecting the stock market. However, there is a lack of research on the impact of raw materials, which are crucial for the production process of the company itself, on its stock prices. It is important to carry out close monitoring the impact of these variables in order to reduce the adverse effects of global disruption (Ghosh et al., 2021).

Research limitations

The study faces several limitations when applying the results in practice. One of these is that the ANN model requires a large amount of data, with input data needing to be complete, accurate, and continuously updated to accurately predict future stock prices increases. However, in Vietnam, collecting stock market data and financial information of companies is challenging due to the lack of a unified database system, transparency issues, and infrequent updates. These things limit the accuracy of the ANN model, leading to the possibility that the ANN may not achieve optimal performance due to insufficient and inaccurate data.

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