

# Long Short Term Memory For Comparison Between Bank Syariah Indonesia And PT Bank Artos Indonesia Shares

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**Abstract** – The growth of the capital market in Indonesia has increased from year to year. Based on data from the Indonesia Central Securities Corporation (KSEI), there has been an increase in investor growth in the capital market by 2.34%, mutual funds by 2.44%, and shares by 1.34% until August 2024. The demographic of individual investors in the capital market is dominated by Generation Z who are younger than from 30 years as much as 55.07% in August 2024 (KSEI, 2024). Shares are a form of investment that has the potential for large profits but with small risks. One sector that Gen Z is interested in investing in is the financial sector. The aim of this research is to compare the share prices of Bank Syariah Indonesia and Bank PT Ban Artos Indonesia Tbk using a Neural Network with the Long Short Term Memory (LSTM) algorithm. The data used in this research is secondary data on BSI and PT Bank Artos Indonesia Tbk share prices taken from the investing.com website. The data period used is from 01 September 2021 – 01 September 2024. Based on the results of stock price forecasting using a Neural Network with the LSTM algorithm, RMSE value for both models is for BSI 75.0757 and 91.795 for PT. Bank Artos Indonesia Tbk. A comparison of the predicted share prices of PT Bank Arto Indonesia Tbk and BSI shows that BSI's share price performance is superior to that of PT Bank Arto Indonesia Tbk.

**Keywords** – Financial Sector; Neural Network; Shares

## I. INTRODUCTION

The growth of the capital market in Indonesia has increased from year to year. Based on data from the Indonesian Central Securities Company (KSEI), there was an increase in investor growth in the capital market by 2.34%, mutual funds by 2.44%, and stocks by 1.34% until August 2024. The demographics of individual investors in Indonesia's capital market are dominated by Generation Z, which is less than 30 years old, totaling 55.07% in August 2024 (KSEI, 2024). This shows that Generation Z is very interested in long-term investments. One of the investments that Gen Z is interested in is stocks. Stocks are a form of investment that has the potential for large profits but with little risk. Stock price risk is supported by dynamic stock price fluctuations, so it requires stock price forecasting analysis so that losses can be minimized [1].

One of the sectors that Gen Z is interested in investing in is the financial sector, especially banking stocks. Based on the KSEI 2022 press release, the stock sector that Gen Z and Millennials are most interested in is the financial sector with 209,053 and 418,197 investors. Banking dominates the financial sector because it plays an important role in the country's economy by collecting and channeling public funds [2]. Banking stocks are heavily influenced by changes in economic conditions and banking regulations, changes in interest rates, fluctuations in loan performance, and other external events may impact the movement of financial stock prices (Hijrah et al., 2023).

This study aims to compare the stock prices of Islamic banks and conventional banks based on digital or digital banks which are useful for investors in seeing the potential movement of banking stock prices. The growth of digital banks in Indonesia continues to grow consistently. Bank Indonesia noted that the nominal digital banking

transactions reached Rp. 5570.49 trillion or an increase of 10.82% on an annual basis in May 2024. Digital banking is growing positively due to several factors including data and transaction security, flexibility in accessing applications, complete application features, integration with other financial services and special promos (detikFinance.com, 2024; Purwanto & Perkasa, 2024). The growth of digital banking is driven by Gen Z, which is the largest generational group in Indonesia today. Generation Z is a generation that has grown up with access to technology and the internet since they were young, so they can play an important role in the digital economy. There are seven issuers that are purely digital banks, one of which is PT Bank Artos Indonesia Tbk. There are still few investors in the digital banking sector so this sector offers vast potential to investors [5].

Meanwhile, the growth of Islamic banking in Indonesia tends to be stable. Based on Islamic Banking Statistics, the performance of Islamic banking as seen from its capital decreased by 2.77% until July 2024 compared to 2022, and increased by 0.76% compared to 2023 (Otoritas Jasa Keuangan, 2024). Although the financial performance of Islamic banking has increased and decreased every year, the banking sector in Indonesia has an important role in the economy in Indonesia. Basically, Islamic banking in Indonesia incorporates Islamic economic principles in its banking activities. One of the factors driving the development of Islamic banking in Indonesia is public awareness of sharia principles in financial activities as well as the role of government support through policies and incentives [6]. One of the Islamic banks in Indonesia is Bank Syariah Indonesia (BSI). BSI is a combination of 3 banks, namely Bank Mandiri Syariah, BRI Syariah, and BNI Syariah, which was merger on February 1, 2021. Because, the development of Islamic financial performance



is still fluctuating, investors must understand the stock movements of this Islamic banking.

Volatile stock movements can be seen by analyzing and predicting using analysis that is in accordance with stock price data. One analysis that can be used to predict stock prices is time series analysis. Time series analysis is a statistical analysis used to analyze data based on the time period [7]. A statistical method that can be used to predict stock prices in general is ARIMA. ARIMA is considered less effective for predicting stock prices because the structure of stock prices has a complex nonlinear component [8]. One alternative method that can be used to predict stock prices is machine learning, using neural network algorithms. The neural network algorithm can be used to predict stock prices because this algorithm can manage complex data and has good accuracy. One of the common neural network algorithms to predict stock prices is the Long Short Term Memory (LSTM) algorithm. LSTM is well used to predict stock prices because it has the ability to understand temporal dependencies in time series data and can be used for long-term data (Cahyani et al., 2023; Mushliha, 2024).

Some research on the LSTM algorithm includes research by Khumaidi et al., (2020) regarding the prediction of air quality and temperature in Bandung City, which states that the accuracy value of the research is good.. Researched by Setiawan & Susanti (2023) The comparative analysis of stock price forecasting results using the ARIMA and LSTM models concluded that the accuracy of the LSTM model for forecasting is very accurate because it has a MAPE value of 10%. Researched by Pahlevi (2023) about bitcoin price prediction using the LSTM algorithm which produces an RMSE accuracy value of 17318.40 for training data and 27921.84 for testing data. Researched by Siregar & Widyasari (2023) regarding crude oil price forecasting using the LSTM method in a recurrent neural network produces an RMSE accuracy of 2.665 for 2018-2020 data, and an RMSE of 2.630 for 2020-2023 data. Through this research, it is hoped that readers, especially Gen Z and Milineal, can gain resources about comparison forecast shares between BSI and PT Bank Artos Tbk.

## II. RESEARCH METHODOLOGY

Islamic banks are banks that use sharia principles to carry out all their activities. In general, Islamic banks are divided into two, namely Islamic Commercial Banks and Islamic People's Financing Banks. Sharia principles in Islamic bank activities are based on fatwas issued by Islamic financial institutions [14]. The following are some of the financing provided by Islamic banking, among others [15]

1. Financing is based on the principle of profit sharing
2. Financing based on the principle of equity contribution
3. Financing is based on the principle of buying and selling goods that are profitable
4. Financing of production facilities from the principle of pure lease without option
5. Transfer of ownership of leased goods based on the bank to another party.

Based on the Financial Services Authority (OJK) Regulation number 12/PJOK.02/2021, digital banks are banking institutions that provide services and carry out banking operations online without having a physical office or only a head office with limited physical offices. Digital bank services such as financial transactions, credit applications, checking account printing, etc. can be done online without direct interaction between customers and banks. One of the requirements that must be met in the OJK regulation for digital banks is a business model with a strong risk management system and innovative technology that is safe in meeting customer needs (Saputra et al., 2024).

The stock price is the market value determined by the interaction of supply and demand in the capital market. The share price is a reflection of investors' assessment of the value and potential of a company in the long term [17]. Stock price fluctuations are caused by many factors both external and internal to the company. So that companies that are able to maintain the credibility of their financial performance in increasing their share price will be the goal of investors [18].

The research method used in the study is to use the Long Short Term Memory (LSTM) algorithm with "Adam" optimization. LSTM is a type of artificial neural network in the field of Deep Learning which is a development of Recurrent Neural Network (RNN) designed to overcome vanishing gradient problems and retain important information in long sequential data sequences. LSTM has a special memory structure consisting of cells and gates that allow the network to store or ignore information as needed. LSTM was chosen because it is very effective in handling tasks involving sequential data, one of which is time series data [19].

1. Raw Data  
The data used in this study are the daily closing share prices of PT Bank Artos Indonesia Tbk and PT Bank Syariah Indonesia Tbk (BRIS) shares taken from the investing.com website, with a period of time starting from 1 September 2021 – 24 September 2024.
2. Data Preprocessing  
At this stage, unused data, namely "Open", "High", "Low", "Volume" & "Change" are deleted, and only "Date" & "Close" data are used. After that, the data is normalized with an interval scale of 0-1. Furthermore, the dataset is divided into two for the training and testing process with a ratio of 80% for training data and 20% for testing data.
3. Training and Testing  
After the data preprocessing stage, the data training process is then carried out using the LSTM algorithm. The training process is carried out by training the model using training data, while the testing process is carried out by testing the training model using testing data to determine the effectiveness of the model that has been made.  
In the training and testing process, parameters are needed to get the best LSTM model. The parameters used are tested by trial and error to get the best results. In this study, the parameters used are as listed in Table 1.

Table 1 LSTM Model Parameter Combinations



Parameter	Value
Neuron	20, 50, 70
Epoch	20, 50, 70, 100
Batch	5, 10, 30
Dropout	0.2

4. Denormalization

After the model is applied to the training and testing data, at this denormalization stage the model output data which was previously still on a 0-1 scale is returned to its original form according to the actual value of the data, before then calculating evaluation metrics and visualization.

5. Model Evaluation

The performance evaluation of the model that has been made is obtained using *Root Mean Squared Error* (RMSE), *Mean Absolute Error* (MAE), dan *R-squared* or  $R^2$  [19]. RMSE measures the square root of the average of the squared differences between predicted and actual values. It provides a measure of the magnitude of errors and is sensitive to large errors.

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n}}$$

with n is number of observation,  $y_i$  is actual value of observations, and  $\hat{y}_i$  is fitted value.

MAE represents the average absolute difference between predicted and actual values. It is less sensitive to outliers compared to RMSE and provides a straightforward measure of forecast accuracy.

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i|$$

with n is number of observation,  $y_i$  is actual value of observations, and  $\hat{y}_i$  is fitted value.

R-squared is a statistical metric that reveals how well the machine learning model fits the data it was trained on. It represents the proportion of the variance in the dependent variable that can be explained by the independent variables.

$$R^2 = \frac{\sum_{i=1}^n (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^n (y_i - \bar{y})^2}$$

with n is number of observation,  $y_i$  is actual value of observations, dan  $\hat{y}_i$  is fitted value, and  $\bar{y}$  is mean value of  $y_i$ .

6. Long Short Term Memory (LSTM)

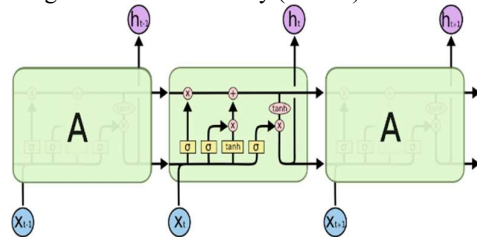


Figure. 1 LSTM Architecture

The LSTM architecture can overcome long-term memory storage because memory cells have been added, so it can overcome the vanishing gradient in RNN when processing long sequential data.

There are three gates in the LSTM architecture, namely forget gate, input gate, and output gate. Forget gate functions to remove information from the cell state. Input gate decides the new information that enters the cell state. The output gate functions to sort out useful information from the cell state and make it the output. The LSTM model can be written with the following formula

$$\begin{aligned} i_t &= \sigma(W_{ii}x_t + W_{hi}h_{t-1} + b_{hi} + b_{ii}) \\ f_t &= \sigma(W_{if}x_t + W_{hf}h_{t-1} + b_{hf} + b_{if}) \\ c_t &= f_t c_{t-1} + i_t \tanh(W_{ic}x_t + W_{hc}h_{t-1} + b_{hc}) \\ o_t &= \sigma(W_{io}x_t + W_{ho}h_{t-1} + b_{io} + b_{ho}) \\ h_t &= o_t \cdot \tanh(c_t) \end{aligned}$$

with  $f, i, o, c$  are forget gate, input gate, output gate, dan cell state. Meanwhile  $\sigma$  is sigmoid function.  $x_t$  and  $h_{t-1}$  is the input at time t and the hidden state from the previous time.  $W_{ii}, W_{hi}, b_{hi}, W_{if}, b_{hf}, b_{if}, W_{io}, b_{io}, b_{ho}$  are weights dan biases from LSTM unit. The LSTM architecture allows for the modeling of sequential dependencies over long time horizons, making it particularly effective for tasks such as time series prediction.

III. RESULTS AND DISCUSSION

The following is a descriptive description of the share prices of PT Bank Artos Indonesia Tbk and BSI for the period September 2021 to September 2024.

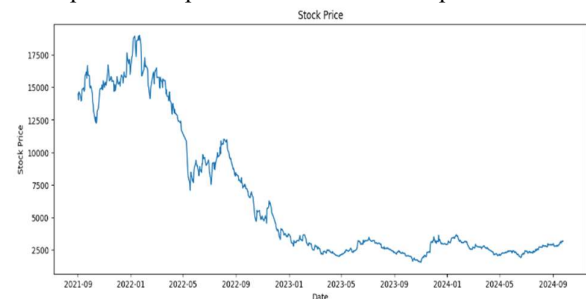


Figure.2 Stock Price of PT Bank Artos Indonesia Tbk

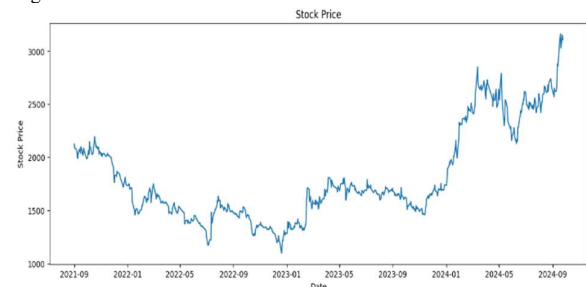


Figure.3 Stock Price of BSI

Based on Figures 2 and 3 above, it can be seen that the share price of PT Bank Artos Indonesia Tbk



experienced a significant increase at the end of 2021 until the beginning of 2022. Then the share price of PT Bank Artos Indonesia Tbk experienced a gradual decline in mid-2024 and continued to decline until mid-2024. Although it had experienced an increase in share price at the beginning of 2024, this increase was not as significant as in 2021 and 2022. Based on the figure above, it can be seen the pattern of BSI stock movement. At the beginning of the BSI merger in 2021, BSI's share price decreased significantly from 2021 to early 2023. Although there was an increase in shares in mid-2022 and early 2023, the increase was not very significant. The increase in BSI's share price only began to show a significant increase in early 2024 to mid-2024.

The model built using the LSTM algorithm was initiated by trial and error, with a composition ratio of 80: 20 for training and testing data. The following are the results of modeling using the LSTM algorithm with various combinations of neurons, epochs, and batch sizes for PT Bank Artos Indonesia Tbk and BSI.

Table 2 Hyperparameter of PT Bank Artos Indonesia Tbk

Neuron	Epoch	Batch Size	MAE	RMSE	R2
20	20	5	191.45	219.64	0.424
		10	115.699	147.043	0.741
		30	162.024	190.219	0.568
	50	5	107.956	140.021	0.765
		10	202.083	239.09	0.317
		30	181.34	227.662	0.381
	70	5	101.974	128.476	0.803
		10	115.365	150.588	0.729
		30	179.683	208.104	0.483
	100	5	100.816	124.87	0.813
		10	96.98	126.113	0.81
		30	118.604	151.311	0.726
50	20	5	194.724	220.279	0.42
		10	101.251	132.723	0.789
		30	142.434	185.924	0.586
	50	5	158.009	178.84	0.618
		10	83.8	112.633	0.848
		30	106.21	136.628	0.777
	70	5	182.338	201.483	0.515
		10	107.305	132.425	0.79
		30	111.388	145.188	0.748
	100	5	78.688	98.532	0.884
		10	87.045	111.29	0.852
		30	92.119	121.453	0.824
70	20	5	92.937	120.146	0.827
		10	100.925	131.897	0.792
		30	186.857	251.583	0.445
	50	5	216.029	234.197	0.345
		10	82.709	108.104	0.86
		30	179.765	208.377	0.481

70	5	84.159	103.474	0.872
	10	173.195	193.708	0.552
	30	88.53	117.105	0.836
100	5	179.418	196.478	0.539
	<b>10</b>	<b>66.896</b>	<b>91.795</b>	<b>0.899</b>
	30	89.829	117.363	0.835

Table 3 Hyperparameter of BSI

Neuron	Epoch	Batch Size	MAE	RMSE	R2
20	20	5	78.453	106.659	0.694
		10	94.537	123.526	0.589
		30	110.014	143.761	0.444
	50	5	63.76	87.658	0.793
		10	71.209	96.708	0.748
		30	107.591	144.359	0.439
	70	5	103.964	122.763	0.594
		10	69.627	92.92	0.767
		30	97.286	123.254	0.591
100	5	57.575	77.655	0.837	
	10	78.122	97.79	0.749	
	30	118.518	149.453	0.399	
<b>50</b>	20	5	68.596	93.063	0.767
		10	91.558	118.544	0.622
		30	100.47	126.006	0.573
	50	5	65.089	86.792	0.797
		10	96.803	120.375	0.61
		30	76.587	104.003	0.709
	70	5	74.619	95.82	0.753
		10	58.695	79.862	0.828
		30	71.46	95.218	0.756
<b>100</b>	<b>5</b>	<b>54.124</b>	<b>75.057</b>	<b>0.848</b>	
	10	54.901	75.191	0.848	
	30	68.105	92.434	0.77	
70	20	5	85.326	109.728	0.676
		10	86.08	112.026	0.662
		30	137.565	159.889	0.312
	50	5	57.676	78.192	0.835
		10	63.791	86.263	0.799
		30	85.337	109.268	0.679
	70	5	54.637	75.951	0.844
		10	91.38	110.264	0.673
		30	74.305	100.549	0.728
100	5	78.339	99.292	0.735	
	10	55.031	76.022	0.844	
	30	59.149	82.407	0.817	

Tables 2 and 3 show various combinations of neurons, epochs, and batch size that give various values of MAE, RMSE dan  $R^2$  differently. Based on Table 1, it can be seen that the larger the batch size will give a decreasing



accuracy value, so the good batch size is batch size 10. Likewise, Table 3 shows that the accuracy of the model is strongly influenced by the selection of batch size, the batch size that gives the most accuracy value is 5. Based on the results of modeling using the LSTM algorithm, the best model for PT Bank Artos Indonesia Tbk is with 70 neurons, 100 epochs, and batch size 10 with MAE of 66.896, RMSE of 91.795, and  $R^2$  of 0.899. While the best model for BSI is with 50 neurons, epoch 100, batch size 5 with MAE of 54.124, RMSE of 75.0757, and  $R^2$  of 0.848. Based on Figures 4 and 5, we can see the comparison between the actual value and the predicted value of stock price from both of bank.

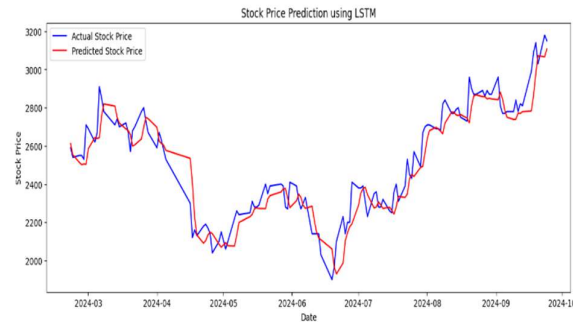


Figure.4 Plot Actual Stock Price vs Predoected Stock Price PT Bank Artos Indonesia Tbk

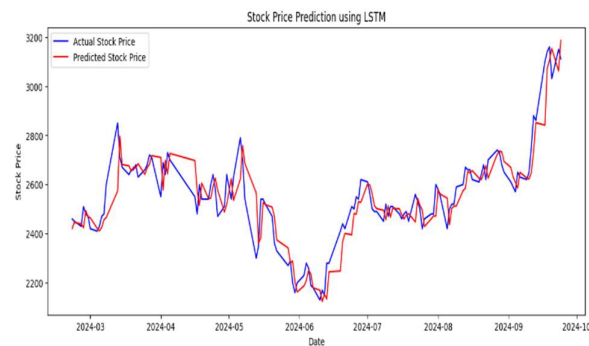


Figure.5 Plot Actual Stock Price vs Predoected Stock Price BSI

Figures 4 and 5 show the actual stock price and the predicted value obtained from the best model. Based on both Figures, the red color or predicted stock value is close to the actual stock value for both Banks, so the model that has been built is good enough with the accuracy value of the model with  $R^2$  of 89.9% and 84.8%.

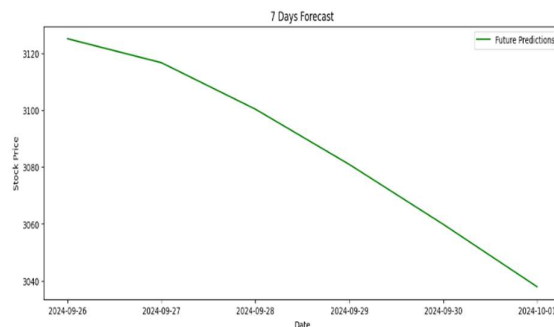


Figure 6 Plot Predicted Stock Price of PT Bank Artos Indonesia Tbk

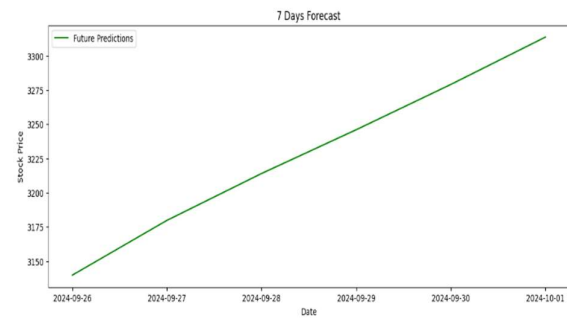


Figure.7 Plot Predicted Stock Price of BSI

Based on Figures 6 and 7 shows the predicted stock price for the next 7 days. The figure shows the predicted share price of PT Bank Artos Indonesia Tbk, which at the beginning of the week experienced an increase in share price, then in the middle and end of the week the share price will decrease. While the figure shows the predicted stock price for BSI which has increased significantly from the beginning to the end of the week. In Table 4, the predicted stock prices for PT Bank Artos Indonesia Tbk and BSI are known with an average predicted stock price for each bank of 3026.565 and 3228.703.

Table 4 Predicted Stock Price of PT Bank Artos Indonesia Tbk and BSI

Predicted Stock Price of PT Bank Artos Indonesia Tbk	Predicted Stock Price of BSI
3097.0518	3139.8188
3075.275	3179.7961
3044.7043	3214.0178
3012.4946	3245.9639
2980.5085	3279.0168
2949.354	3313.6045

Based on the results of the analysis using the Neural Network based on the LSTM algorithm, it can be seen that the predicted price of BSI shares is superior to the predicted stock price of PT Bank Artos Indonesia Tbk. This is reinforced by a descriptive analysis of the actual share price of PT Bank Artos Indonesia Tbk with BSI in 2024 where the BSI share price has increased significantly compared to PT Bank Artos Indonesia Tbk. The increase in the share price of PT Bank Artos Indonesia Tbk at the beginning of 2021-2022 was due to the large number of retail investors who purchased shares due to the public issue of digital banks. However, this did not last long, namely in mid-2022 the share price of PT Bank Artos Indonesia Tbk began to decline. This is due to the perception created by influencers who lead the opinions of retail investors, especially from millennials who have no experience without understanding the micro fundamentals of stocks based on the financial condition of a company (Asykarulloh, et. al, 2023).

Based on researched by Safira & Hidayatullah (2024) The growth of digital bank financial performance has increased and decreased every year. The financial performance of digital banks is seen from several aspects, namely the capital adequacy ratio, loan deposit ratio, operating costs to operating income, and non-performing loans. The decline in digital bank share prices is due to the lack of public knowledge about digital banks, making capital less channeled to get profits. Capital adequacy ratio is one of the indicators of financial performance by



investors to see fluctuations in stock prices in the long term[4]. In addition, the source of digital bank income is not entirely from interest income, but comes from service products such as transactions made by customers. Lack of information about digital bank products such as online credit makes people less confident in digital banks.

While the predicted share price for BSI experienced a significant increase. Based on researched by Santoso (2023), BSI's earnings per share experienced positive growth due to the merger so that it had a good effect on BSI's financial statements. When viewed in the descriptive analysis in Figure 1, it can be seen that the BSI share price has decreased at the end of 2022. This decline is due to the issue of the right issue until the price is approved by the company [22]. In 2023, BSI's share price experienced a significant increase despite the issue of cyber attacks that resulted in transaction paralysis. Based on researched by Solikhawati dan Samsuri (2023), After the cyber attack, BSI's share price fluctuated for 10 days. However, BSI's financial performance is still considered good enough so that it does not have a significant impact on long-term investment. This can be seen from the increasing BSI stock price in 2024 as well as the predicted BSI stock price in Figure 7.

Comparison of the predicted stock price results of the two banks can provide an overview of the predicted stock price movements of the two banks. However, the results of this analysis are not the only tool used as an investor's decision maker to invest. Investors can use fundamental analysis based on financial performance to see how the long-term stock price movements of the two banks. The results of this analysis can be used as recommendations for investors, especially gen z, millennial, and beginner investors.

#### IV. CONCLUSION

Based on the analysis results using the LSTM model, the best model for PT Bank Artos Indonesia Tbk is with 70 neurons, 100 epochs, and batch size 10 with MAE of 66.896, RMSE of 91.795, and  $R^2$  of 0.899. While the best model for BSI is with 50 neurons, epoch 100, batch size 5 with MAE of 54.124, RMSE of 75.0757, and  $R^2$  of 0.848. A comparison of the predicted share prices of PT Bank Arto Indonesia Tbk and BSI shows that BSI's share price performance is superior to that of PT Bank Arto Indonesia Tbk.

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