CHAPTER V
CLOSING

5.1 Conclusion

Based on the results of the research and a comprehensive discussion of the application of the Temporal Fusion Transformer (TFT) model with hyperparameter optimization using the Optuna framework for forecasting the stock prices of state-owned enterprises across various sectors in Indonesia, the following conclusions can be drawn:

1. The Temporal Fusion Transformer model was applied using historical stock data for BMRI, PGAS, and TLKM, involving the following stages: preprocessing, normalization using a Group Normalizer, feature engineering, creation of a time-series dataset, and hyperparameter optimization using Optuna. The study tested 3 feature engineering scenarios, 3 data splitting scenarios, and 20 hyperparameter optimization scenarios. The test results show that hyperparameter optimization yields a significant performance improvement compared to the baseline model. Among all tested scenario combinations, the best configuration was obtained in the FE1–S1–O14 scenario with an MAE of 151.32, an RMSE of 220.93, a MAPE of 4.90%, and an sMAPE of 5.07%, which outperformed the baseline model. These results demonstrate that Optuna is capable of finding the optimal combination of parameters, enabling the TFT model to learn historical stock price patterns more effectively and generate more accurate predictions.
2. The Temporal Fusion Transformer (TFT) model performs well in multi-horizon forecasting across short-, medium-, and long-term horizons, although accuracy decreases as the forecast horizon increases. At the short-term horizon (H-5), the optimized model achieved an sMAPE of 4.36%, indicating an excellent level of accuracy. At the medium-term horizon (H-10), the sMAPE increased to 5.56%, while at the long-term horizon (H-15), it rose to 7.94%. Although errors increase as the forecast horizon lengthens, the optimized TFT model still outperforms the Baseline model across all

testing horizons. These findings indicate that the model maintains its generalization ability and forecast stability across various forecasting timeframes, making it suitable for short-, medium-, and long-term forecasts.

3. The evaluation results for each stock show that the optimized model (O14) consistently outperformed the Baseline model for all three stocks representing different sectors: BMRI (banking), PGAS (energy), and TLKM (telecommunications). The sMAPE values obtained were 4.30% for BMRI, 6.76% for PGAS, and 5.34% for TLKM. These results indicate that the model is capable of adapting to the distinct price movement characteristics of each sector. The best performance was achieved for BMRI, while PGAS had the highest error rate due to its more volatile price movements. Nevertheless, the model was still able to produce accurate predictions for all tested stocks. This proves that TFT possesses good generalization capabilities in forecasting the stock prices of state-owned enterprises across sectors.

5.2 Recommendations

Based on the findings, limitations, and experiences gained during the research process, the following recommendations are presented, which are expected to serve as valuable input for future studies aiming to develop or continue similar topics:

1. Future research is recommended to expand the scope of the model's input features by integrating macroeconomic variables relevant to stock price movements of state-owned enterprises (SOEs) in Indonesia, such as Bank Indonesia's benchmark interest rate, the exchange rate of the rupiah against the U.S. dollar, the inflation rate, global commodity prices such as crude oil and natural gas, and national economic growth indicators such as Gross Domestic Product (GDP). The inclusion of these variables is expected to enhance the model's ability to capture the dynamics of stock price movements that cannot be fully explained by historical technical data alone, given that the stock prices of SOEs across various sectors are significantly influenced by overall macroeconomic conditions. By integrating macroeconomic variables as "known reals" features within the

TimeSeriesDataSet framework of the TFT model, the model is expected to have a broader and more comprehensive context for the forecasting process, thereby producing more accurate and relevant predictions regarding actual market conditions.

2. Future research may consider further development regarding the selection and utilization of features used in the model training process. The addition of a variety of relevant information whether derived from historical market data or other supporting data sources has the potential to provide a more comprehensive representation of stock market conditions. With a broader scope of information, the model is expected to better capture price movement patterns, thereby improving prediction accuracy and the model's generalization ability across various dynamic market conditions.