ABSTRACT

HYBRID MULTIVARIATE VARIMAX-LSTM MODEL FOR TIME SERIES DATA FORECASTING WITH EXOGENOUS FACTORS (Analysis of PTBA and ADRO Stocks with Exogenous Factors of Rupiah Exchange Rate against USD)

By

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The Vector Autoregressive Integrated Moving Average (VARIMAX) and Long ShortTerm Memory (LSTM) hybrid model is a development of the concept of time series data forecasting by combining classical statistical methods and deep learning to improve forecasting accuracy. The VARIMAX-LSTM hybrid model is designed to overcome the limitations of the VARIMAX model in capturing nonlinear patterns of time series data and the limitations of the LSTM model in capturing linear data patterns as a whole. The forecasting process involves the closing price of PT. Bukit Asam (PTBA) and PT. Adaro Energi Indonesia (ADRO) as endogenous variables and the rupiah exchange rate against the USD as an exogenous variable with a data range from January 2016 to December 2024. The VARIMAX-LSTM hybrid model is built with two approaches, starting with prediction and forecasting using the VARIMAX model. The prediction results and residuals of the VARIMAX model are used as input for the prediction and forecasting of the hybrid model. The first approach is the VARIMAX-E_LSTM hybrid model which is built by combining the prediction results of the VARIMAX model and the prediction results of the E_LSTM model with the input of the residual results of the VARIMAX model. The second approach is the hybrid VARIMAX-EP_LSTM model which is a combination of the prediction results of the hybrid P_LSTM model with the input of the prediction results of the VARIMAX model and the E_LSTM model. The final results of the study show that the hybrid VARIMAX-EP_LSTM model has the best ability in the forecasting process when compared to the VARIMAX model, the individual LSTM model, and the hybrid VARIMAX-E_LSTM model which is based on the smallest Kolmogorov Smirnov test statistic value. Thus, the hybrid VARIMAX-EP_LSTM model is the model with the most optimal ability in the process of forecasting the closing prices of PTBA and ADRO shares.

Keywords*: time series, forecasting*, *hybrid* VARIMAX-LSTM, VARIMAX, LSTM, *stock market.*

ABSTRAK

MODEL *HYBRID* MULTIVARIAT VARIMAX-LSTM PADA PERAMALAN DATA DERET WAKTU DENGAN FAKTOR EKSTERNAL (Analisis Saham PTBA dan ADRO dengan Faktor Eksternal Nilai Tukar Rupiah terhadap USD)

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Model *hybrid Vector Autoregressive Integrated Moving Average* (VARIMAX) *dan Long ShortTerm Memory* (LSTM) merupakan pengembangan konsep peramalan data deret waktu dengan penggabungan metode statistika klasik dan *deep learning* dalam meningkatkan akurasi peramalan. Model *hybrid* VARIMAX-LSTM dirancang untuk mengatasi keterbatasan model VARIMAX dalam menangkap pola nonliner data deret waktu dan keterbatasan model LSTM dalam menangkap pola data linier secara menyeluruh. Proses peramalan melibatkan harga penutupan saham PT. Bukit Asam (PTBA) dan PT. Adaro Energi Indonesia (ADRO) sebagai variabel endogen serta nilai tukar rupiah terhadap USD sebagai variabel eksogen dengan rentang data sejak Januari 2016 hingga Desember 2024. Model *hybrid* VARIMAX-LSTM dibangun dengan dua pendekatan, diawali dengan prediksi dan peramalan menggunakan model VARIMAX. Hasil prediksi dan residual model VARIMAX digunakan sebagai input pada prediksi dan peramalan model *hybrid*. Pendekatan pertama yaitu model *hybrid* VARIMAX-E_LSTM yang dibangun dengan menggabungkan hasil prediksi model VARIMAX dan hasil prediksi model E_LSTM dengan input hasil residual model VARIMAX. Pendekatan kedua yaitu model *hybrid* VARIMAX-EP_LSTM yang merupakan penggabungan hasil prediksi model *hybrid* P_LSTM dengan input hasil prediksi model VARIMAX dan model E_LSTM. Hasil akhir penelitian menunjukan bahwa model *hybrid* VARIMAX-EP_LSTM memiliki kemampuan terbaik pada proses peramalan apabila dibandingkan dengan model VARIMAX, model LSTM individu, serta model *hybrid* VARIMAX-E_LSTM yang didasarkan pada nilai statistik Kolmogorov Smirnov terkecil. Sehingga, model *hybrid* VARIMAX-EP_LSTM merupakan model dengan kemampuan paling optimal dalam proses peramalan harga penutupan saham PTBA dan ADRO.

Kata kunci: deret waktu, peramalan, *hybrid* VARIMAX-LSTM, VARIMAX, LSTM, saham.