Evaluasi Model Hybrid Autoregressive Integrated Moving Average-Cumulative Sum-Long Short-Term Memory
(Hybrid ARIMA-CUSUM-LSTM) untuk Peramalan Harga Emas Global
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INTISARI

EVALUASI MODEL *HYBRID AUTOREGRESSIVE INTEGRATED MOVING AVERAGE-CUMULATIVE SUM-LONG SHORT-TERM MEMORY* (HYBRID ARIMA-CUSUM-LSTM) UNTUK PERAMALAN HARGA EMAS GLOBAL

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Emas global (XAU/USD) merupakan aset *safe haven* yang harganya fluktuatif, non-linear, dan rentan terhadap pergeseran rezim, sehingga sulit diramalkan. Model *Autoregressive Integrated Moving Average* (ARIMA) menangkap pola linear dan *Long Short-Term Memory* (LSTM) memodelkan pola non-linear pada residualnya, namun kerangka hibrida konvensional belum mampu mengenali kapan struktur data bergeser. Penelitian ini mengembangkan dan mengevaluasi model *Hybrid Autoregressive Integrated Moving Average-Cumulative Sum-Long Short-Term Memory* (Hybrid ARIMA-CUSUM-LSTM) untuk peramalan harga emas global, dengan *Cumulative Sum* (CUSUM) sebagai lapisan diagnostik pemeta pergeseran rezim volatilitas pada residual ARIMA. Data harian XAU/USD periode 31 Mei 2022–29 Mei 2026 (1.039 observasi) dibagi secara kronologis menjadi data latih, validasi, dan uji. CUSUM yang dikalibrasi dari residual data latih mendeteksi 57 titik perubahan dengan proporsi meningkat dari 0,45% (latih), 5,73% (validasi), hingga 25,00% (uji). Pada data uji, model hibrida mencapai MAE 61,60 USD, RMSE 89,41 USD, dan MAPE 1,33%. Dibandingkan ARIMA(3,1,3) tanpa konstanta sebagai *baseline*, model hibrida konsisten lebih baik atau setara meskipun perbaikannya kecil (0,01%-0,22%) karena residual ARIMA telah menyerupai derau acak (*white noise*), sehingga nilai tambah utama CUSUM dan LSTM lebih menonjol pada pemetaan rezim volatilitas dibandingkan peningkatan akurasi titik.

Kata Kunci: peramalan, harga emas global, model hibrida, *Autoregressive Integrated Moving Average*, *Cumulative Sum*, *Long Short-Term Memory*, deteksi titik perubahan, rezim volatilitas.

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ABSTRACT

EVALUATION OF A HYBRID AUTOREGRESSIVE INTEGRATED MOVING AVERAGE-CUMULATIVE SUM-LONG SHORT-TERM MEMORY (HYBRID ARIMA-CUSUM-LSTM) MODEL FOR FORECASTING GLOBAL GOLD PRICES

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Global gold (XAU/USD) is a safe-haven asset whose price is volatile, non-linear, and prone to regime shifts, making it difficult to forecast. The *Autoregressive Integrated Moving Average* (ARIMA) model captures linear patterns and *Long Short-Term Memory* (LSTM) models the non-linear patterns in its residuals, yet conventional hybrid frameworks cannot recognize *when* the underlying structure shifts. This study develops and evaluates a *Hybrid Autoregressive Integrated Moving Average-Cumulative Sum-Long Short-Term Memory* (Hybrid ARIMA–CUSUM–LSTM) model for global gold price forecasting, with *Cumulative Sum* (CUSUM) serving as a diagnostic layer that maps volatility-regime shifts in the ARIMA residuals. Daily XAU/USD data from 31 May 2022 to 29 May 2026 (1,039 observations) are split chronologically into training, validation, and test sets. CUSUM, calibrated from the training residuals, detects 57 change-points whose proportion rises from 0.45% (training), 5.73% (validation), to 25.00% (test). On the test set, the hybrid model attains an MAE of 61.60 USD, RMSE of 89.41 USD, and MAPE of 1.33%. Compared with ARIMA(3,1,3) without a constant as the baseline, the hybrid model is consistently better than or equal to the baseline, although the improvement is small (0.01%-0.22%) because the ARIMA residuals already resemble white noise; thus the principal added value of CUSUM and LSTM lies more in mapping volatility regimes than in improving point-forecast accuracy.

Keywords: forecasting, global gold price, hybrid model, *Autoregressive Integrated Moving Average*, *Cumulative Sum*, *Long Short-Term Memory*, change-point detection, volatility regime.