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MACHINE LEARNING FOR OPTIMIZED RISK MANAGEMENT IN CRUDE PALM OIL FUTURES: A REVIEW

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ABSTRACT

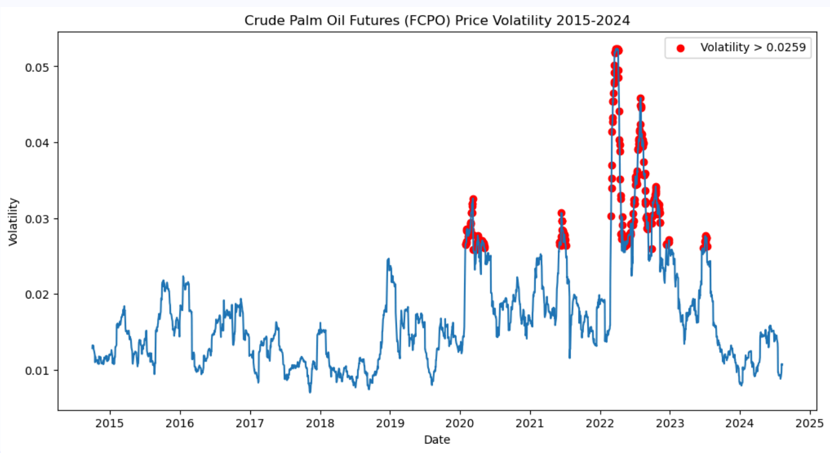
- Palm oil is a significant commodity for Malaysia's economy, with the industry contributing **5% to 7% of GDP** on average. Industry players use Crude Palm Oil Futures (FCPO) as the key tool for risk management. As price volatility is innate in FCPO, it becomes a major risk factor, as inaccurate forecasts may lead to **significant losses** and **suboptimal hedging**. Thus, accurate volatility forecasting is essential for risk management.
- Despite growing interest in Machine Learning (ML) applications in the financial markets, there is a paucity of literature specifically focused on **applying ML to FCPO volatility forecasting** within a risk management framework. This review examines the literature on ML models for forecasting, primarily focusing on FCPO and critically evaluates their potential for risk management applications.
- Our findings indicate that while traditional econometric methods such as GARCH are established benchmarks for FCPO volatility forecasting, ML methods such as SVR, Random Forests, GBM and Deep Learning (DL) approaches (LSTM) have shown superior performance in **price prediction** and volatility forecasting in the broader **energy and commodity** markets. The superior performance is attributed to the ability to capture complex patterns, non-linearities and adapt to dynamic market conditions.
- Despite the outperformance, a key finding indicates that direct application of ML for FCPO risk management is underexplored due to the challenges of integrating external factors as well as **model interpretability**. An inherent tradeoff persists between the accuracy and interpretability of ML models. Advanced DL models tend to be complex "black boxes", while simpler, more transparent models are less accurate. This review highlights the urgent need for research to realise ML's potential for improved volatility forecasting and to develop and validate interpretable ML or explainable AI (XAI) models for FCPO risk management.

METHOD

- A Narrative Literature Review was conducted, synthesizing post-2019 findings.
- Reviewed academic databases for studies on FCPO, volatility, GARCH, and Machine Learning.
- Evaluated methodologies based on predictive accuracy, interpretability, and practical risk management application.

KEY GAPS

- **FCPO Volatility Forecasting Gap**: ML has been successfully applied to FCPO price prediction, but its direct application and validation for volatility forecasting remain scarce.
- **The "Black Box" Problem**: The lack of transparency in complex ML models is a major barrier to their adoption in risk governance, where model justification is crucial.
- **Lack of Risk Outcome Validation**: There is a gap between demonstrating ML's statistical accuracy and proving tangible improvements in FCPO risk management outcomes



FINDINGS

Model	FCPO Research
GARCH Family	GARCH(3,1) effectively captured the volatility dynamics observed for the entire sample period. GARCH (1,1) was the best model in describing pre- and post-COVID-19 FCPO volatility. [1].
Ensemble Methods	RF model consistently outperformed LSTM, achieving a MAPE of 7.45% compared to LSTM's 13.36% in multivariate analysis [2]
Deep Learning	LSTM model with news sentiment using a six-month sliding window produced the best result in CPO price prediction [3] GRU and LSTM showed outstanding CPO price prediction in MAE, MAPE, RMSE, and R-squared metrics. [4].
Hybrid	Hybrid wavelet-modified GMDH model achieved MAPE less than 4 % with a coefficient of correlation (R) of 0.99 for monthly CPO price [5].

FUTURE WORKS

- Develop & Validate ML for FCPO Volatility: Shift focus from price prediction to direct volatility forecasting using diverse ML models (LSTM, XGBoost, etc.) and benchmark them against GARCH.
- Bridge the Application Gap: Conduct studies that explicitly measure the impact of ML-based forecasts on risk outcomes.
- Prioritize Explainable AI (XAI): Apply techniques like SHAP and LIME to high-performing ML models to "open the black box," making them transparent and trustworthy for practical use.

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