Forecasting Model Performance Report

Executive Summary:

This project aimed to develop an accurate forecasting model for avocado sales volume using machine learning. The goal was to enable data-driven decisions for inventory management and marketing strategies. After evaluating two models—XGBoost (optimized with Particle Swarm Optimization) and LSTM—the LSTM neural network demonstrated superior performance with an **R^2 score of 0.9209** on the test set. The final model was deployed as a **FastAPI RESTful service** for real-time forecasting.

Key Metrics & Model Comparison:

The table below summarizes the performance of both models on the test set:

Model	MSE	MAE	R^2
XGBoost (PSO)	**2.22×1011**	**198,852.97**	**0.8965**
LSTM	**1.69×1011**	**169,825.36**	**0.9209**

Final Evaluation of LSTM Model

- Mean Squared Error (MSE): 169,268,756,844.33
- Mean Absolute Error (MAE): 169,825.36
- R^2 Score: 0.9209

The **LSTM** model outperformed **XGBoost** due to its ability to capture temporal dependencies in sales data, making it the best choice for deployment.

Model Selection & Optimization

1. **XGBoost with PSO Optimization**
   - Optimized Parameters: Number of estimators, max depth, learning rate, subsample ratio.
   - PSO Benefits: Efficient hyperparameter tuning without exhaustive grid sear

2. **LSTM Neural Network**
    - Strengths: Excels in sequential/time-series data prediction.
    - Training: Implemented using TensorFlow/Keras.

Challenges & Solutions

- Data Imbalance: Addressed with careful preprocessing & feature engineering.
- Hyperparameter Tuning: PSO provided an efficient alternative to grid search.
- Deployment: FastAPI ensured scalability and ease of integration.

Future Enhancements

- Incorporate economic indicators & weather data for better accuracy.
- Experiment with Transformer-based models.
- Add authentication & a frontend UI to the API.

Conclusion:

The **LSTM-based forecasting model** provides highly accurate predictions, enabling businesses to optimize inventory and marketing strategies effectively. The deployed **FastAPI service** ensures real-time accessibility for decision-makers. Future enhancements will further improve model robustness and usability.
