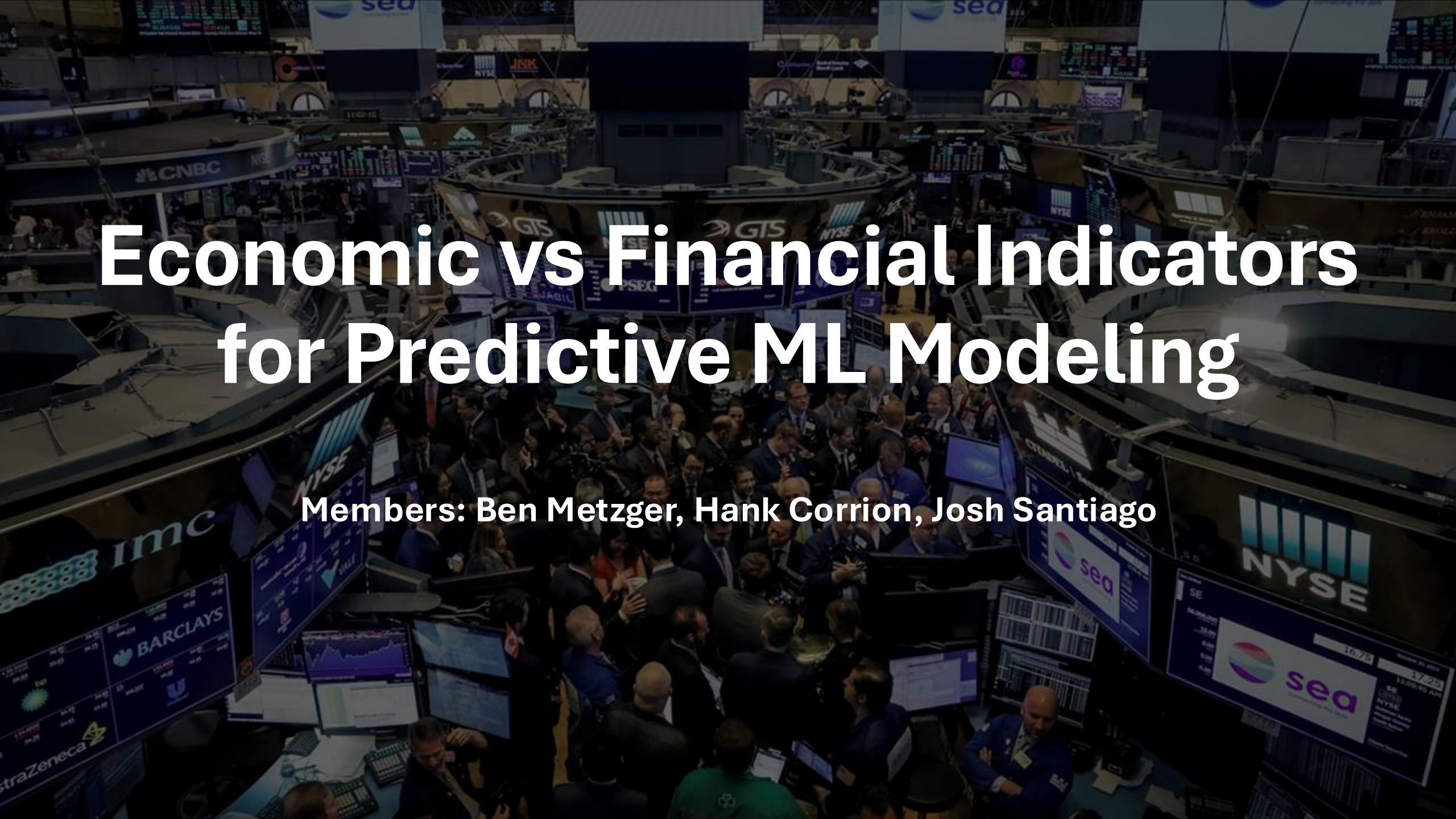


Economic vs Financial Indicators for Predictive ML Modeling

Members: Ben Metzger, Hank Corrion, Josh Santiago

Intro to Our Project and Quant Finance

Quant Finance

- Quantitative finance is a field that uses mathematical models, data analysis, and software automation to study financial markets, identify investment opportunities, and manage risk.
- This project uses a simplified version of those methods to gather data, extract signals, and produce basic insights, following the same core principles as large institutional systems but on a smaller scale.

Our Project

- Build a monthly S&P 500 forecasting model by curating key economic and market indicators and evaluating their predictive potential using ML models.
- Evaluate how economic and market-based indicators differ in their predictive strength and overall model accuracy and search for other relationships and tendencies in each feature set.

Dataset Building – Tools and Considerations

Tools

- To build our dataset, we utilized the Yahoo Finance and St. Louis Federal Reserve's (FRED) Python APIs.
- Raw financial data is widely available and reported in real-time, while macroeconomic data is published on several different timeframes (weekly, bi-weekly, monthly, quarterly).

Considerations and Standardization of Features

- Indicators were selected for their historical predictive power, their relationship to market prices, or their fundamental ties to the economy (e.g., VIX as a measure of market volatility, a 6-month S&P 500 moving average as a measure of directional momentum, and monthly jobless claims as a measure of economic uncertainty).
- We maintained a strict separation between economic and financial features to preserve clarity between signal sources and to allow for clear conclusions without overlap.
- Proper time alignment of financial and economic data included handling different reporting frequencies, applying consistent computational methods across variable timeframes, verifying release schedules, and performing thorough data cleaning.

Differences in Economic and Financial Model Features

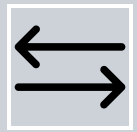
Economic

Objective measurements of the U.S. economy, collected through surveys and reports produced by government agencies

Released on a quarterly, monthly, or weekly schedule, often making them lagging indicators

Provides a stable reference point for how markets interpret underlying and big-picture economic conditions

Financial



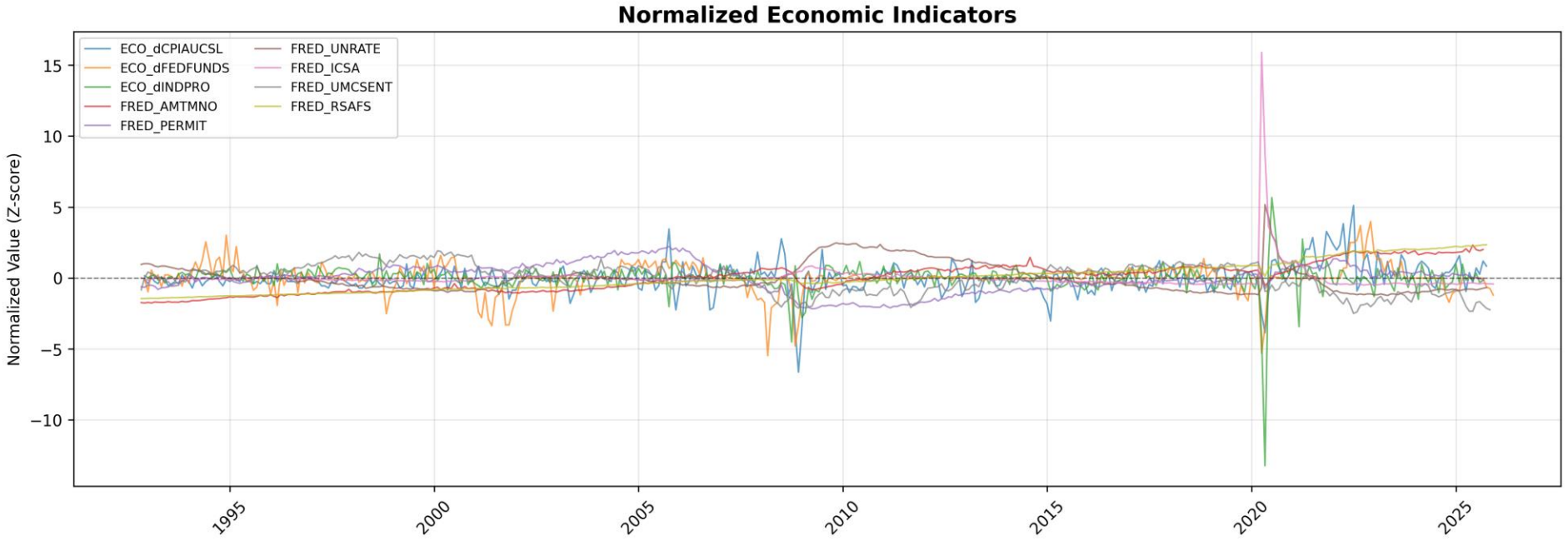
Based on direct market prices or quantities derived mathematically from tradable financial instruments

Updated daily or in real time, making them coincident/current indicators

Moves quickly, tends to be volatile, and often captures market sentiment or expectations

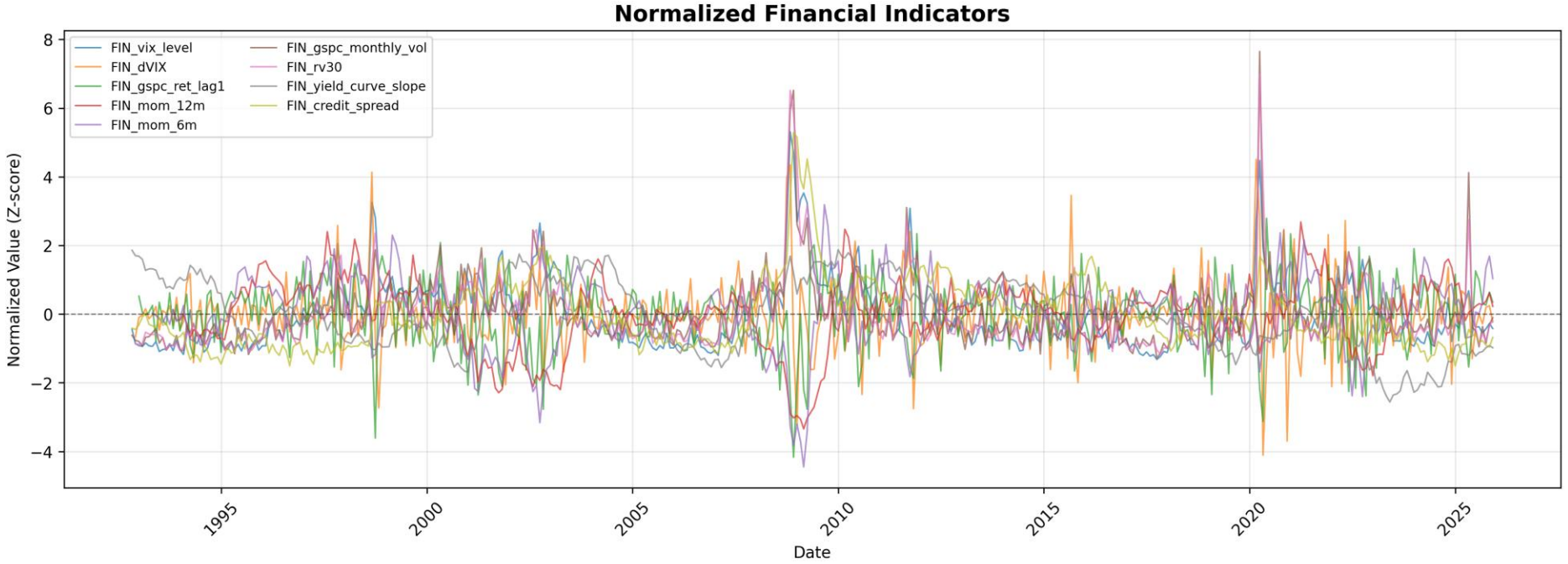
Economic Indicators

- CPI / Inflation
- Federal Funds Rate change
- Industrial production
- Manufacturing orders
- Building permits
- Unemployment rate
- Jobless claims
- Consumer sentiment
- Retail sales



Financial indicators

- VIX level
- Change in VIX
- Previous S&P 500 return
- 12-month momentum
- 6-month momentum
- Monthly S&P 500 volatility
- 30-day realized volatility
- 3M & 10Y Yield Curve
- BAA Corporate & 10Y T Spread



Models

Linear Regression

- Naïve model that predicts solely based on market delta

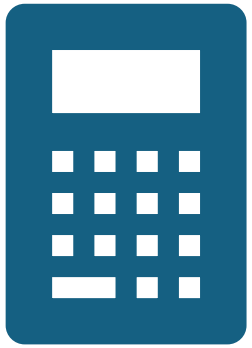
Random Forest

- Uses ensemble of decision trees with bagging and boosting

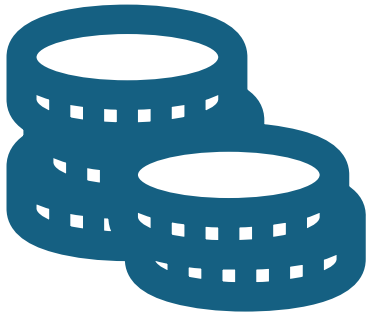
Long Short-Term Memory Neural Network

- Recurrent Neural Network which learns from timeseries data

Linear Regression



Simple supervised method that computes the market delta by fitting feature coefficients



Two separate models were created for Economic features and Financial features

Coefficient Importance

Economic: Labor market + Production amount

FRED_UNRATE	0.018552
FRED_ICSA	-0.011841
FRED_UMCSENT	0.007873
FRED_AMTMNO	-0.004879
ECO_dINDPRO	-0.003662
ECO_dFEDFUNDS	-0.002749
FRED_PERMIT	0.002655
ECO_dCPIAUCSL	0.002150
FRED_RSAFS	0.001415

Intercept: 0.006840

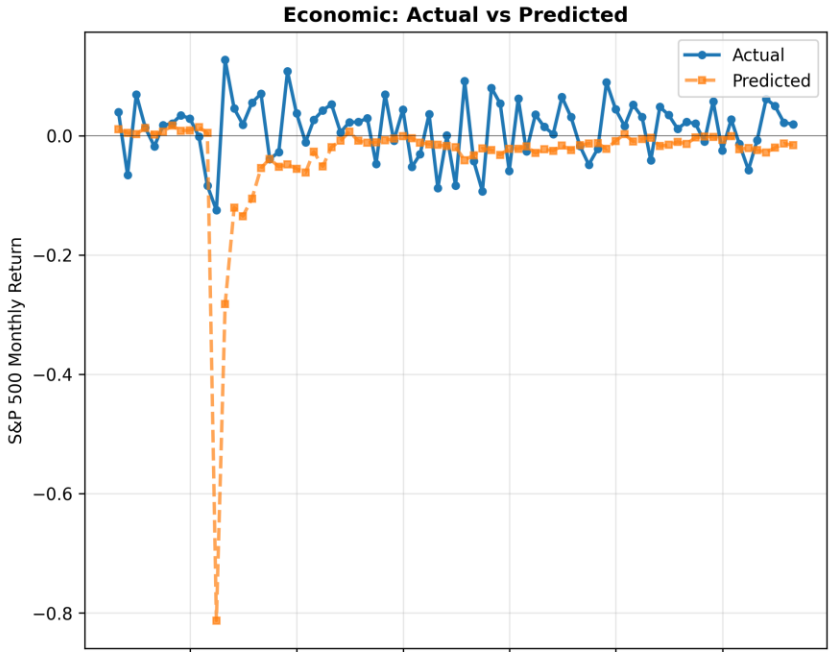
Financial: Volatility measures + direction of sentiment

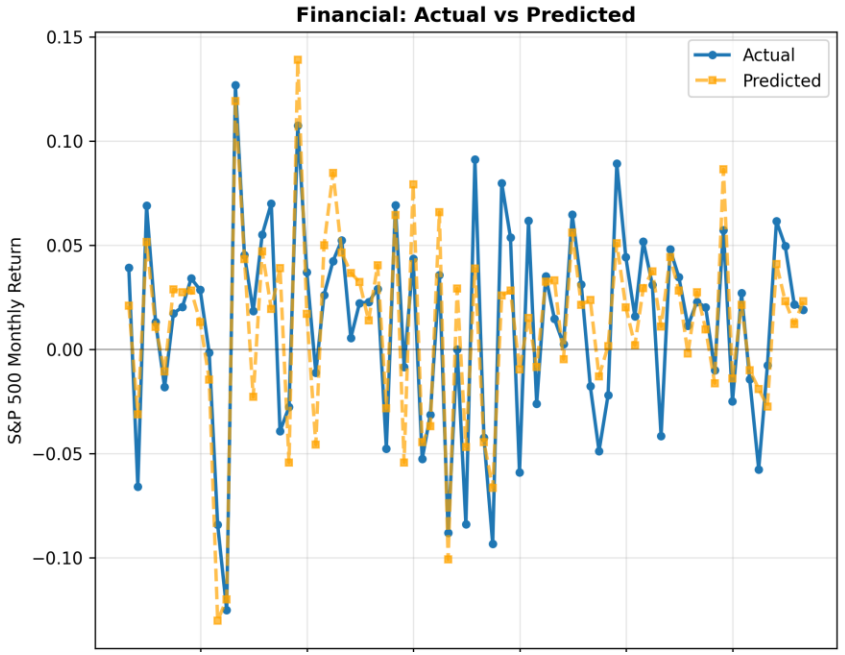
FIN_dVIX	-0.027750
FIN_mom_6m	0.012862
FIN_credit_spread	0.003514
FIN_mom_12m	0.003390
FIN_gspc_monthly_vol	-0.002350
FIN_yield_curve_slope	-0.002232
FIN_rv30	-0.001659
FIN_vix_level	0.001336
FIN_gspc_ret_lag1	-0.000662

Intercept: 0.006840

Performance

- Financial performed substantially better
- Economic R^2 shows a poor fit
- Financial features had a lower RMSE and MAE





Metric	Economic	Financial
Test R^2	-4.1603	0.6993
Test RMSE	0.111223	0.026849
Test MAE	0.063558	0.021310
Train R^2	0.0515	0.6492

Random Forest Regressor

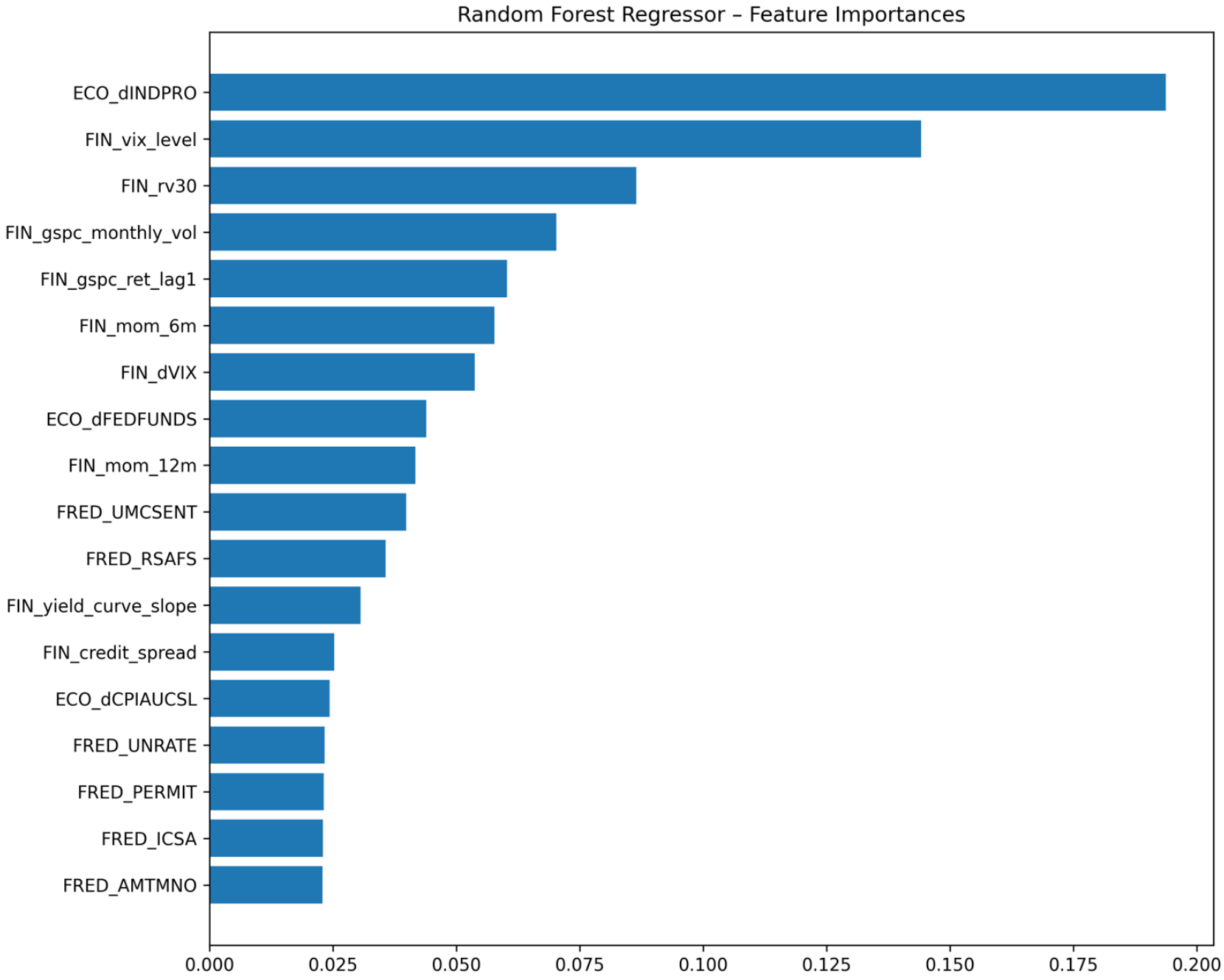
Uses ensemble of decision trees with bagging and boosting

- **MAE = 0.0473**
  The model's average prediction error is about 4.7 percentage points each month.
  (Market goes +2%, model might guess –3%, etc.)
- **RMSE = 0.0599**
  The typical squared error is even higher at ~6%, meaning the model frequently produces large misses.
- **R^2 = –0.49**
  This score indicates the model is worse than predicting the average return every month.
  A negative R^2 means the model adds noise instead of explaining variance

```
=== Loading Dataset ===

=== Training Random Forest Regressor ===

MAE:  0.0473
RMSE: 0.0599
R²:   -0.4989
```



Feature Importances

- **Industrial Production Growth** (ECO_dINDPRO) is the strongest leading indicator of next-month S&P direction. Real economic activity changes have meaningful forward-looking influence on market direction.
- **Volatility indicators** — including **VIX level**, **realized volatility (rv30)**, and **monthly S&P volatility** — rank very high.
  This suggests the model relies heavily on **market uncertainty and volatility regime changes** when estimating future returns.
- **Momentum factors** — such as **lag-1 return**, **6-month momentum**, and **12-month momentum** — remain meaningful predictors.
  These capture medium-term trend persistence and continuation effects.
- **Monetary policy changes** (e.g., **Federal Funds Rate changes**) contribute moderately, indicating that **interest-rate shocks influence expected returns**.
- **Traditional macro indicators** (unemployment, CPI, jobless claims, sentiment, etc.) appear near the bottom of the ranking.
  These slower-moving macroeconomic variables show **limited short-term predictive power** for monthly forecasts.

Model Takeaways

- The model cannot reliably predict monthly S&P 500 returns.
  - A negative R^2 shows it performs worse than simply guessing the average return.
- Errors remain small only because market returns themselves are small.
  - MAE ≈ 4.7% and RMSE ≈ 6% reflect typical month-to-month volatility, not true predictive skill.
- Short-term market noise overwhelms the model.
  - The regressor cannot extract a stable signal from monthly data.
- Useful insight comes from feature importance, not predictive accuracy.
  - The model is weak at forecasting, but it still highlights which economic and financial variables matter most.

Long Short-Term Memory Neural Network

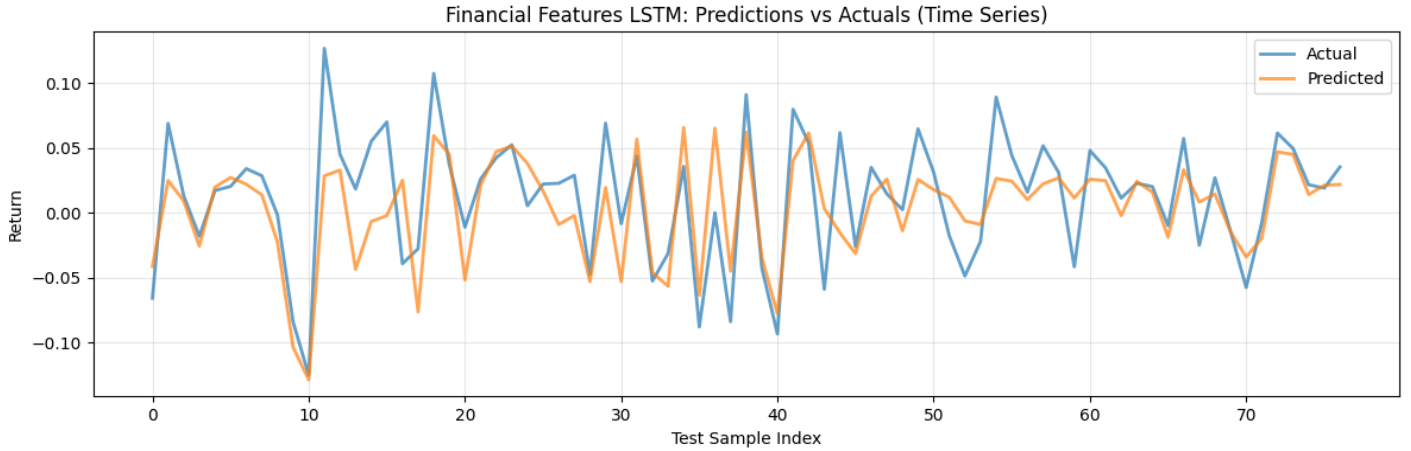
- Recurrent neural network
- Uses Mean Squared Error Loss, 80/20 training split
- Two models created for Economic and Financial features
  - Decision to exclude S&P 500 Index from model

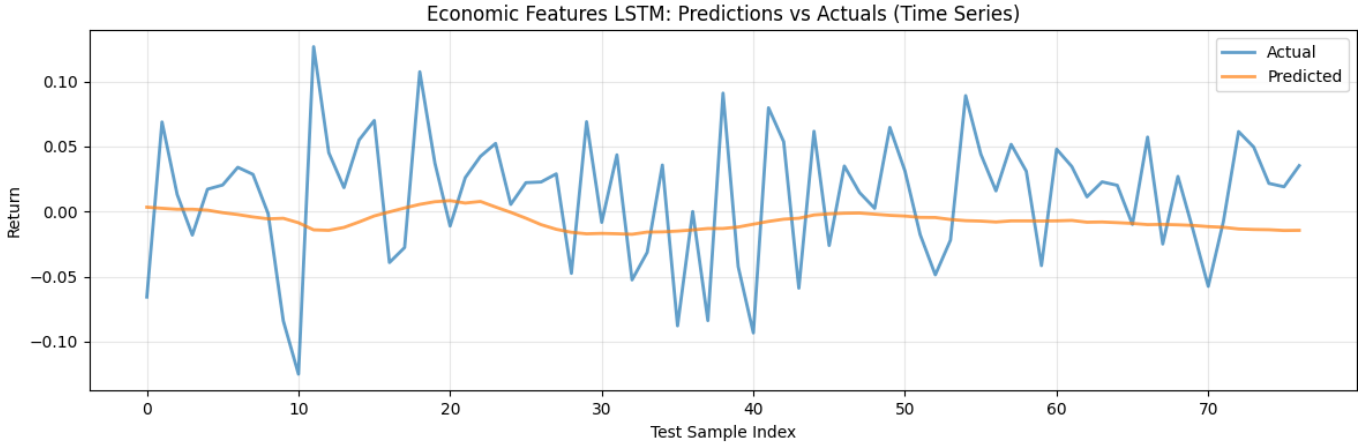
Model Layers

Input Recurrent Layer	• Processes input sequentially
Dropout layer 1	• Randomly sets some activations to 0
Second Recurrent Layer	• Condenses full sequence of timeseries into a vector
Dropout layer 2	
Dense layers 1 and 2	• Uses Relu activation to prevent linearity
Output Layer	• Returns a continuous value

Performance

- Financial performed substantially better
- Improvements on economic predictors but overall, a poor fit





Metric	Economic	Financial
Test R^2	-0.1427	0.5509
Test RMSE	0.052310	0.032792
Test MAE	0.043781	0.024748

Results

- Financial indicators predicted monthly S&P 500 returns much better than economic indicators
  - (Higher R^2, lower MAE/RMSE across all models)
- Economic indicators showed weak or unstable predictive power
  - (Often negative R^2 — added noise instead of signal)
- Volatility + momentum were the strongest overall predictors
  - (VIX, realized volatility, 6–12 month momentum)
- Traditional macro metrics (CPI, unemployment, jobless claims) had very little short-term forecasting value

Conclusion

- **Financial data consistently outperformed economic data** across Random Forest, Linear Regression, and LSTM models.
- **Volatility and momentum signals carry the most short-term predictive power**, not macroeconomic fundamentals.
- **Economic indicators are too slow-moving** to forecast month-ahead S&P 500 returns effectively.
- Markets react faster than the economy — so financial indicators reflect price changes long before economic data is released. No model achieved strong predictive accuracy, showing that monthly S&P forecasting remains a very hard problem. However, the models still revealed where real signal exists: volatility regimes, trend persistence, and market sentiment.