## Portfolio Risk Analysis

1. **Introduction:** This project performs a multi-factor risk analysis on a U.S. equity portfolio, aiming to build predictive models for portfolio returns and identify key risk exposures. Techniques used include Lasso, Gradient Boosting, and PCA regression. Additionally, the analysis estimates downside risk through Value at Risk (VaR) and Expected Shortfall (ES).

### 2. Data Sources

| Factor Category | Key Components | Data Sources |
|---|---|---|
| **Macroeconomic** | 10Y-2Y Treasury Spread, CPI, GDP Growth, Credit Spread | FRED |
| **Style** | Fama-French 5F (Mkt, SMB, HML) | Kenneth French Data Library |
| **Market** | S&P500, Gold, Crude Oil | yfinance |

### 3. Methodology

- **Predictive Modeling**:
  - Applied Lasso, Gradient Boosting, and PCA regression to model portfolio returns.
  - PCA extracted uncorrelated components capturing 90% of variance to identify latent risk drivers.
- **Model Evaluation**: Assessed model performance using $R^2$, RMSE, MAE, and Q-Q plots.
- **Risk Attribution**: Calculated Marginal Risk Contribution (MRC) to quantify each factor's impact on overall risk.
- **VaR and ES Estimation**: Backtested VaR and ES using historical simulations, ARIMA+GARCH, and predictive model outputs.

### 4. Results and Findings

- Highlighted dominant macroeconomic and style factors influencing portfolio returns.
- Revealed sector-level and factor-level contributions to risk, supporting more effective diversification.
- Backtesting provided clear estimates of potential downside risk through VaR and ES metrics.

### 5. Future Enhancements

- **Rolling Window Models**: To capture time-varying risk dynamics and improve predictive robustness.
- **Expanded Factor Set:** Incorporating global macro indicators, sentiment data, and alternative style factors for deeper insights.