# Macro Regime-Based Asset Allocation Model

Quantitative Strategy Using KMeans and Hidden Markov Models (HMM)

## Executive Summary

This project simulates a macro regime-driven asset allocation framework designed to adapt portfolio exposure based on prevailing economic conditions. It aims to mimic real-world quantitative research as conducted at asset management firms and macro hedge funds.

The strategy identifies economic regimes using both unsupervised KMeans clustering and probabilistic Hidden Markov Models (HMMs), based on macro features like CPI (inflation), employment growth, interest rates, and yield curve spreads. The system then applies rule-based asset allocation between SPY (equities), TLT (bonds), and SHY (cash proxy) for each detected regime.

The HMM-based allocation approach demonstrated superior performance in cumulative returns and lower drawdowns versus a passive SPY benchmark.

## Project Pipeline

1. Data Acquisition: Downloaded monthly macroeconomic indicators from FRED (CPI, Fed Funds, PPI, Employment, Yield Curve Spread) and ETF returns (SPY, TLT, SHY) from Yahoo Finance.
2. Feature Engineering: Computed year-over-year percentage changes in PPI and Employment to derive cyclical macro signals.
3. Regime Detection:
   - KMeans clustering (unsupervised)
   - Hidden Markov Models (sequential probabilistic modeling)
4. Strategy Backtest:
   - Assigned asset weights based on regime characteristics.
   - Computed cumulative returns and strategy-level performance metrics.
5. Evaluation: Compared HMM vs KMeans vs SPY benchmark on Sharpe Ratio, CAGR, and Max Drawdown.

## Performance Summary

HMM Strategy:

- CAGR: 1.19%

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- Max Drawdown: -24.61%
- Sharpe Ratio: 0.18

KMeans Strategy:

- Outperformed SPY but underperformed HMM
- Stronger performance in contractionary regimes

SPY Benchmark:

- More volatile, deeper drawdowns during macro shocks

HMM models captured regime persistence and sequential shifts more effectively, resulting in smoother portfolio transitions.

## Visual Insights

- Regime-specific heatmaps revealed macro characteristics: high inflation + flat curve = defensive allocation.
- Bar plots showed differentiated returns by regime: equities outperform in growth, bonds in slowdowns.
- Annotated cumulative return plots clearly highlighted regime-driven strategy outperformance over time.

## Your Role

This was an end-to-end solo project simulating a professional research deliverable. Tasks included:

- Sourcing and cleaning economic data
- Designing regime detection models
- Engineering allocation logic
- Evaluating strategy returns
- Writing a recruiter-facing research report and presentation materials

This project demonstrates capability in real-world quant research, asset rotation strategy, and effective presentation of analytics.