QF 623 Portfolio Management

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Portfolio Management Overview

Objectives, investment strategy, and portfolio management framework

1. The objectives of the investment portfolio are to:
   - Achieve **consistent and strong risk-adjusted returns**
   - **Outperform the market index** in the long-run
   - **Mitigate steep market drawdowns** during "risk-off " market environments

2. Investment objectives are achieved by:
   - **Diversification** across asset classes - allows **for tactical rotations** to uncorrelated assets; **reduce exposure** to **market risk premium** in times of sharp market downturns
   - Identification of key return drivers for broad asset classes which will drive returns/alpha forecasts - **enhance returns through exposure to positive idiosyncratic risk**
   - Economic regime modelling to **model probability of market shocks** - input for portfolio construction

3. Portfolio Management Framework:

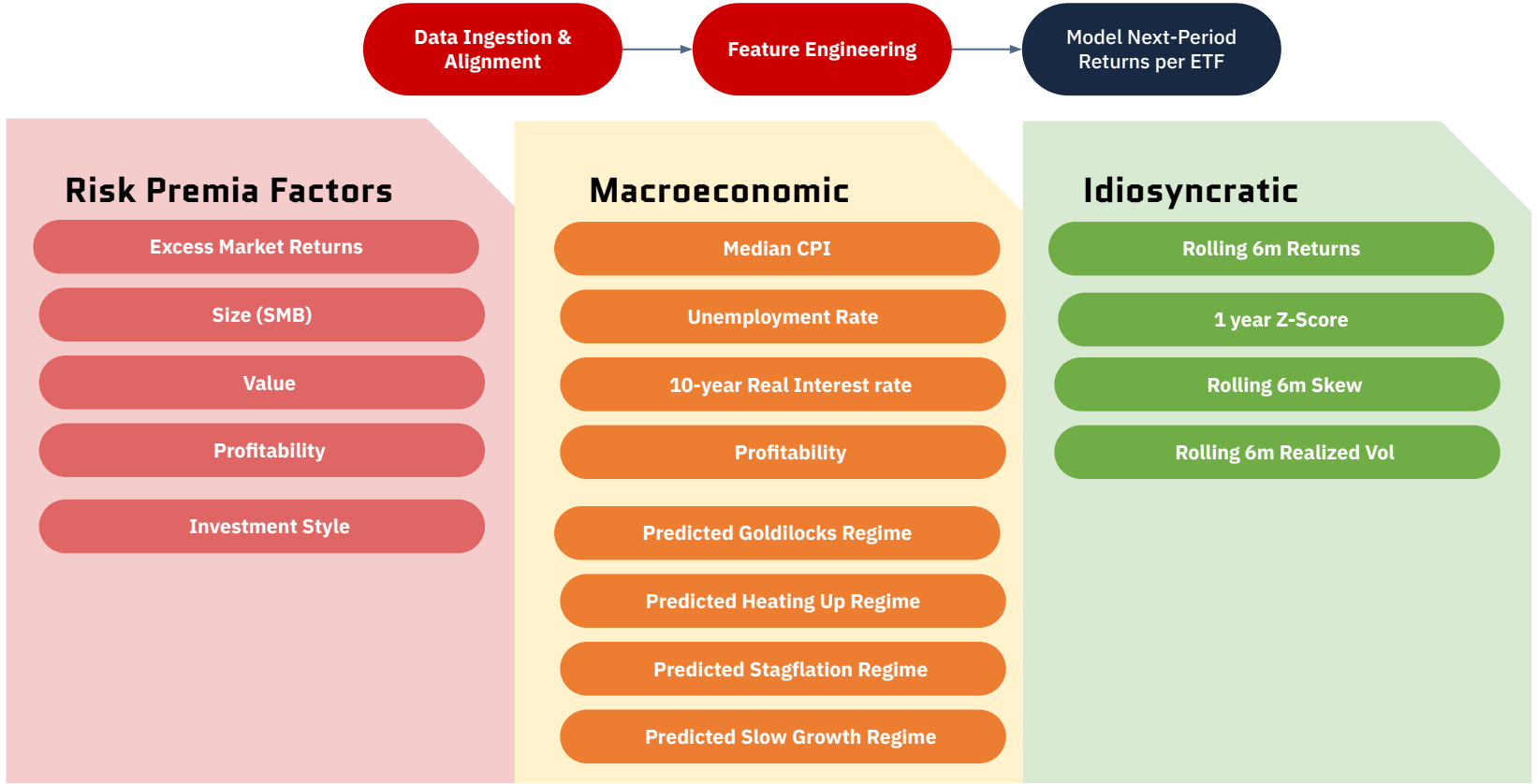
ETF Investment Universe Selection

Objectives, investment strategy, and portfolio management framework

Column1	Ticker	Asset Class	Inception	Expense Ratio	AUM (USD bn)	Regime Role	Rationale for inclusion
1	SPY	U.S. Large-Cap Equity	Jan 22 1993	0.09%	400	Equity Benchmark	Broad large-cap U.S. equity; ultra-liquid low-cost beta anchor.
2	MTUM	U.S. Equity Momentum	Apr 16 2013	0.15%	25	Momentum Tilt	Systematic U.S. price momentum factor; enhances trend following in risk-on regimes.
3	VLUE	U.S. Equity Value	Apr 16 2013	0.15%	10	Value Tilt	Large-cap value factor exposure; mean-reversion anchor in valuation sell-offs.
4	USMV	U.S. Equity Minimum Volatility	Oct 18 2011	0.15%	35	Defensive Tilt	Low-volatility U.S. equities; cushions drawdowns in high-vol regimes.
5	EFA	Developed ex-U.S. Equity	Aug 14 2001	0.32%	70	Global Equity Diversifier	Diversified developed-markets exposure; reduces home-bias in equity allocation.
6	EEM	Emerging Markets Equity	Apr 07 2003	0.68%	40	Growth Tilt	High-growth EM equity premium; adds cyclical carry in global risk-on cycles.
7	AGG	U.S. Aggregate Bond	Sep 22 2003	0.04%	120	Risk-Off Anchor	Core USD investment-grade bonds; ballast in equity drawdowns and rising-rate regimes.
8	HYG	U.S. High-Yield Credit	Apr 04 2007	0.49%	30	Credit Carry	High-yield corporate carry; boosts income in stable-credit regimes.
9	TLT	U.S. Long-Duration Treasuries	Jul 22 2002	0.15%	15	Duration Tilt	Long-dated Treasury exposure; macro hedge when growth slows.
10	TIP	Treasury Inflation-Protected (TIPS)	Dec 04 2003	0.19%	25	Inflation Hedge	Real-return protection; key in high-inflation regimes.
11	GLD	Physical Gold Shares	Nov 18 2004	0.40%	50	Tail-Risk Diversifier	Gold as store-of-value and crisis hedge; diversifies equity/bond risk.
12	DBC	Broad Commodity Index Fund	Feb 03 2006	0.89%	6	Commodity Carry	Broad commodity roll-yield; positive carry in backwardation regimes.
13	VNQ	U.S. Real Estate (REITs)	Sep 23 2004	0.12%	40	Income-Generating Tilt	U.S. real estate income; diversifies equity beta with rental yield.
14	BIL	Ultra-Short U.S. T-Bills	May 25 2007	0.14%	20	Cash Proxy	Near-cash equivalent; safe-haven in volatility spikes and deflationary regimes.

Modelling of Asset Forward Returns/Alpha

Feature Engineering for Prediction



Modelling of Asset Forward Returns/Alpha

Alpha Framework

Alpha Type	Signal	Lookback	Alpha Role
1. Price Momentum	6-Month Momentum	126 trading days	*Medium-term trend capture*
	12-Month Momentum	252 trading days	*Long-term trend anchor*
2. Mean Reversion	5-Day Reversal	5 trading days	*Short-term pullback exploitation*
	20-Day Reversal	20 trading days	*Medium-pullback signal*
3. Trend & Vol Filters	MA200 Crossover	200 trading days	*Entry/exit gate*
	20-Day ATR Breakout	20 trading days	*Volatility breakout trigger*
	20-Day Realized Vol Filter	20 trading days	*Dampens signals in high-vol regimes*
4. Carry & Macro	Bond Carry (YTM - 3M T-Bill)	Spot	*Income in stable/slow-growth*
	Yield Curve Slope (10Y - 3M)	Spot	*Macro regime timing*
5. Style Tilts	Value (VLUE): NAV/Price – 1	Spot	*Valuation mean reversion*
	Low Vol (USMV): 1/σ20	20 trading days	*Defensive stability tilt*
	Quality (QMJ) Factor	Daily	*Quality income buffer*
	Momentum (UMD) Factor	Daily	*Cross-checked factor momentum*
6. Liquidity & Sentiment	Volume Z-Score	20 trading days	*Spike/liquidity signal*
	Implied Vol Filter (VIX/VVIX)	Threshold	*Risk-sentiment gate*

Modelling of Asset Forward Returns/Alpha

Modeling Returns

Models	Considerations		
	Linear Regression	ElasticNet	XGBoost
Training	• Linear Regression: sets as a benchmark • Complex models do not necessarily beat complex • Willing to give up a bit of accuracy for better speed, explainability of model • Training cost for complex models, especially with need for rolling approach and scaling up number of assets	• ElasticNet shrinks coefficients and L1 peanltyzeroes out factors that do not explain returns adequatly (feature selection) • Regularization areduces overfit. L2 shrinrakge reduces coefficients for correlated factors, addressing multicollinearity weakness • Small weights also ensure out of sample stability -> more robust to regime shifts	• Ensemble of boosted decision trees learn non-linear relationships, threshold effects and and factor interactions (e.g., ΔVIX matters only when momentum is negative) • Gradient boosting re-weights difficult observations each round → adapts to varying noise levels across regimes., unlike LR which assume constant residual variance across states • Robust: Loss function + tree structure isolate outliers to their own leaves
• LRolling window prevent lookahead buas • Each ETF gets its own model with set of features (due to idiosyncratic, features) •			

Regime Modelling

MSCI rule-based 4 regimes benchmark: Intro

Objective: To classify the global economic environment into one of four distinct regimes based on signals for grown and inflation.

The Four Regimes:
1. Goldilocks: Strong Growth, Falling Inflation
2. Heating Up: Strong Growth, Rising Inflation
3. Stagflation: Slowing Growth, Rising Inflation
4. Slow Growth: Slowing Growth, Falling Inflation

Key Ingredients:
1. Growth Signal: Composite Leading Index from both China and United States.
2. Inflation Signal: CPI from United States.

Regime Modelling

MSCI rule-based 4 regimes benchmark: Formulas

Intuition:

1. To measure **momentum** or **acceleration** not just the direction
2. Calculates the chg. in YoY growth rate. “Is the economy’s growth **speeding** up or **slowing** down compared to a **few months ago**?

$$US-CLIYOY_{qoq\ change} = \frac{US-CLI_{(t)}}{US-CLI_{(t-12m)}} - \frac{US-CLI_{(t-3m)}}{US-CLI_{(t-15m)}}$$

$$CN-CLIYOY_{qoq\ change} = \frac{CN-CLI_{(t)}}{CN-CLI_{(t-12m)}} - \frac{CN-CLI_{(t-3m)}}{CN-CLI_{(t-15m)}}$$

$$US-CPIYOY_{qoq\ change} = \frac{US-CPI_{(t)}}{US-CPI_{(t-12m)}} - \frac{US-CPI_{(t-3m)}}{US-CPI_{(t-15m)}}$$

MSCI

3) Rules to Assign Economic Regimes

Economic Regime	Short-term and Long-term Signals
Stagflation	($US-CLIYOY_{qoq\ change}$<=0 and $CN-CLIYOY_{qoq\ change}$<=0) and ($US-CPIYOY_{qoq\ change}$>0)
Heating Up	($US-CLIYOY_{qoq\ change}$ >0 or $CN-CLIYOY_{qoq\ change}$ >0) and ($US-CPIYOY_{qoq\ change}$>0)
Slow Growth	($US-CLIYOY_{qoq\ change}$<=0 and $CN-CLIYOY_{qoq\ change}$<=0) and ($US-CPIYOY_{qoq\ change}$ <=0)
Goldilocks	($US-CLIYOY_{qoq\ change}$ >0 or $CN-CLIYOY_{qoq\ change}$ >0) and ($US-CPIYOY_{qoq\ change}$ <=0)

De-coding the Signals:

- **US-CLI**YOYqoq chg > 0: US **growth** accelerating

- **US-CPI**YOYqoq chg > 0: US **inflation** accelerating

Regime Modelling

Finding the next regime using SVM

Objective: To create stable and forward-looking regime prediction model that filters short-term “noise”

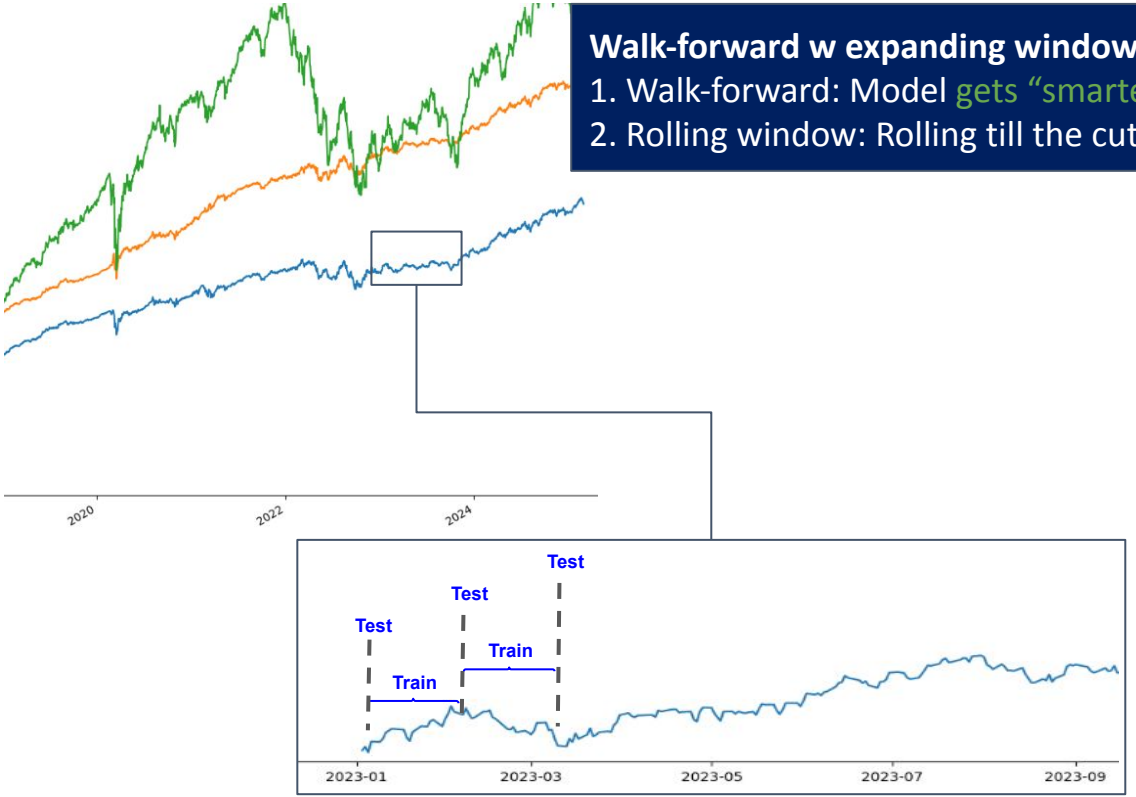
Features:
- Global growth:
Lagged US & CN CLI
- Inflation pressure:
Short-term vs long-term trend CPI
- Monetary policy stance:
FED funds

Walk-Forward approach:
- Train before 2016
- Expend rolling window 1 month basis
- 0 data leak like train_test_split()
- RBF to handle unknown data rs

Benchmark comparison:
- Low accuracy != bad thing
- Benchmark data is “noisy” due to frequent flickering regime chg.
- Low turnover & costs
- Deliver actionable signals

Regime Modelling

Finding the next regime using SVM

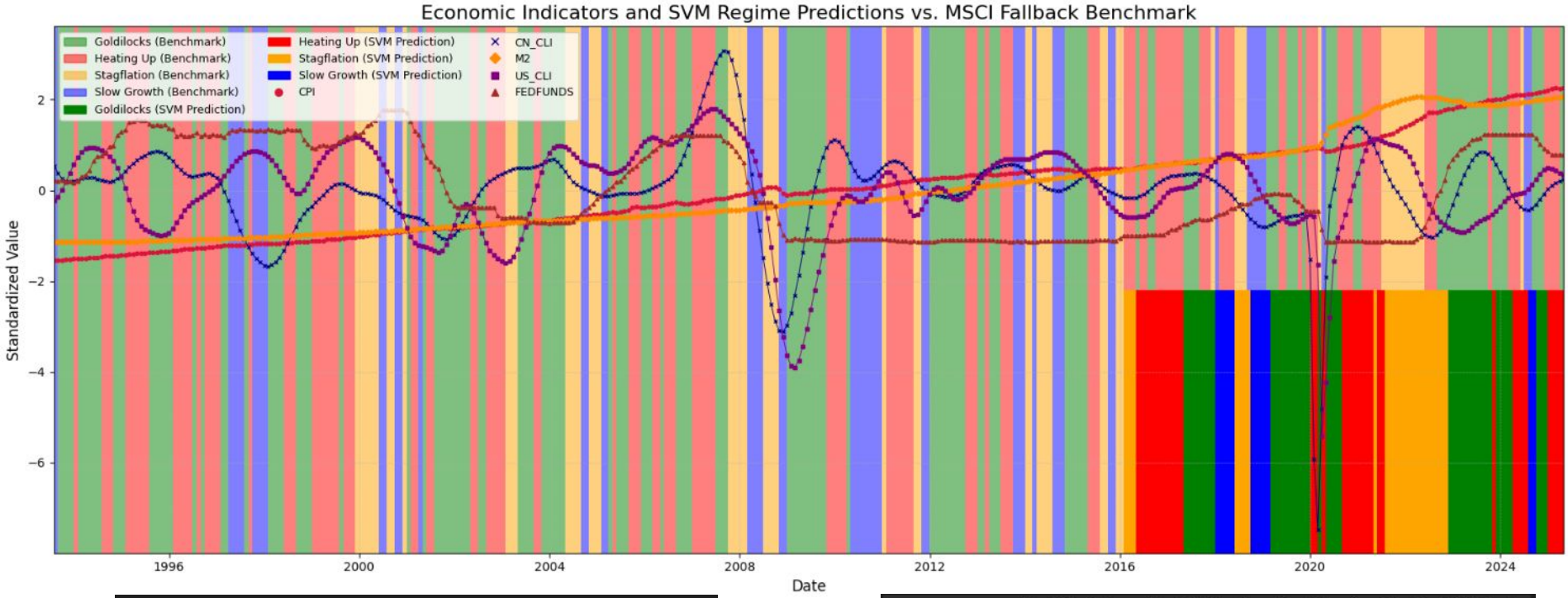


Walk-forward w expanding window training:

1. Walk-forward: Model gets “smarter” overtime
2. Rolling window: Rolling till the cutoff date

Regime Modelling

Benchmark vs Prediction

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--- SVM Performance Against MSCI Fallback Benchmark ---

Walk-forward overall accuracy: 0.634
1.0    0.633929
0.0    0.366071
Name: frequency, dtype: float64
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	Pred_Stagflation	Pred_Heating Up	Pred_Slow Growth	Pred_Goldilocks
True_Stagflation	13	2	0	2
True_Heating Up	7	23	4	11
True_Slow Growth	1	2	6	0
True_Goldilocks	3	7	2	29

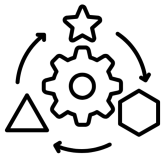
Portfolio Construction & Implementation

Objective, Model Selection

Objective: Construct a long-only, well-diversified, fully invested portfolio, that is stable and automatically adapts to the changes in regime

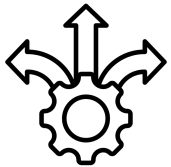
- Model of choice: Mean Variance Optimization **(MVO)**

Why MVO?



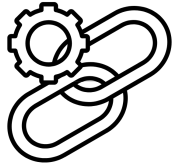
Adaptable

to regime changes and new market conditions. Express return views



Flexible

with constraints, easily allowing us to incorporate real-world constraints



Robust

risk-management and ensures diversified portfolio

Portfolio Construction & Implementation

Methodology

Methodology:

Generate Expected Returns (μ) using predictive models (Linear Regression, Elastic Net, XGBoost) to forecast 1-month forward **alpha** over a 60/40 SPY-TLT benchmark.

→

Estimate Risk (Σ) by computing covariance matrix using a 5-year rolling window of daily ETF returns.

→

Run MVO Optimization to maximise sharpe ratio using predicted alpha and estimated risk. If market overlay is used, blend with static 60/40 weights.

↓

Constraints for MVO:

1. Long only/ Market Neutral
2. Max & Min weight per asset (1/13)
3. Fully invested

←

Compute Portfolio Weights balancing alpha signal strength and risk. Rebalance monthly to reduce turnover.

←

Rebalance Monthly using latest signals. This helps capture fresh alpha and reduce signal decay, while minimizing trading impact.

Portfolio Construction & Implementation

Transaction Cost Assumptions:

Ticker	Category	Typical Cost Range	Transaction Cost Estimated
SPY	Broad Market Index ETF	0.00% – 0.10%	**5 bps** (0.05%)
AGG	U.S. Bond ETF	0.05% – 0.15%	**10 bps** (0.10%)
GLD	Commodity ETF (Gold)	0.25% – 0.75%	**40 bps** (0.40%)
TLT	U.S. Bond ETF (long duration)	0.05% – 0.15%	**10 bps** (0.10%)
HYG	U.S. Bond ETF (high yield)	0.05% – 0.15%	**12 bps** (0.12%)
DBC	Commodity ETF (broad basket)	0.25% – 0.75%	**50 bps** (0.50%)
EFA	Intl Developed Market ETF	0.12% – 0.30%	**20 bps** (0.20%)
MTUM	Factor ETF (Momentum)	0.12% – 0.30%	**20 bps** (0.20%)
TIP	U.S. Bond ETF (inflation-linked)	0.05% – 0.15%	**10 bps** (0.10%)
BIL	U.S. Treasury (ultra-short)	0.00% – 0.10%	**5 bps** (0.05%)
USMV	Factor ETF (Min Volatility)	0.12% – 0.30%	**20 bps** (0.20%)
VLUE	Factor ETF (Value)	0.12% – 0.30%	**20 bps** (0.20%)
VNQ	Real Estate ETF (REITs)	0.12% – 0.50%	**30 bps** (0.30%)

Source: [Investopedia](https://www.investopedia.com/ask/answers/071816/how-are-etf-fees-deducted.asp)

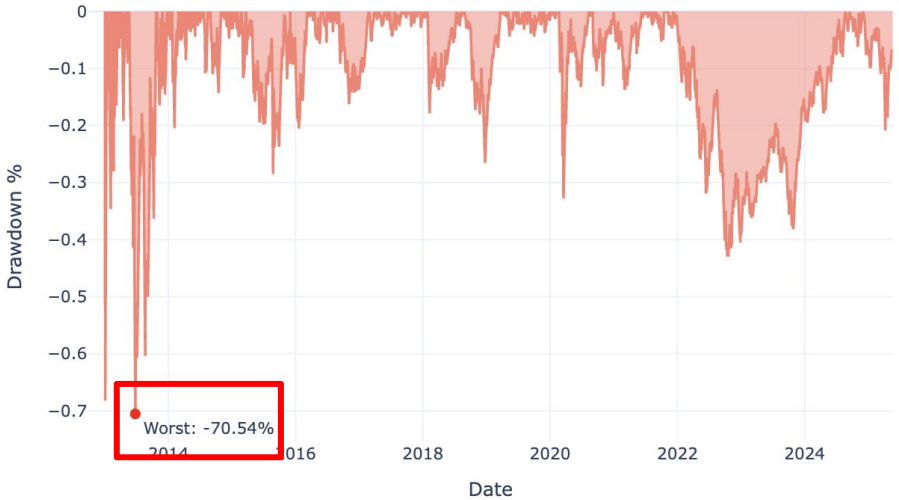
Portfolio Performance

Backtest Results:

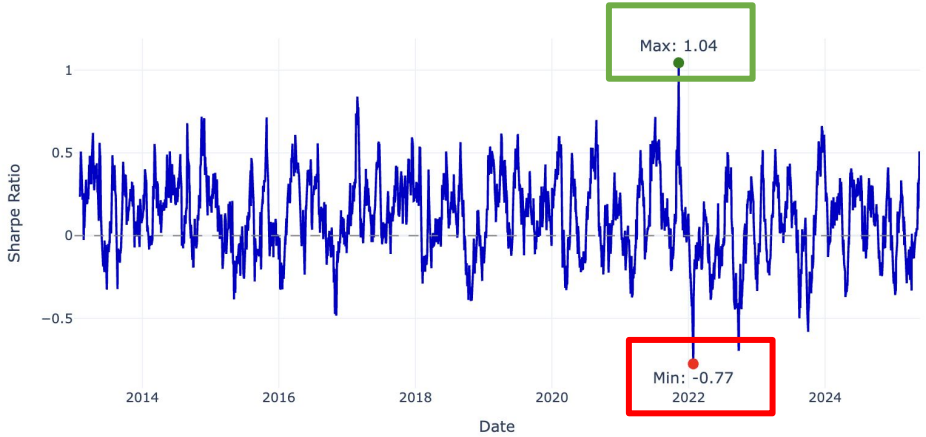
Portfolio Performance

Key Performance Metrics

Drawdown

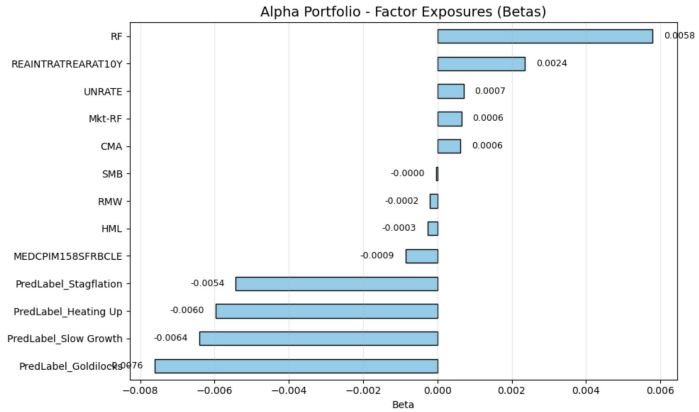


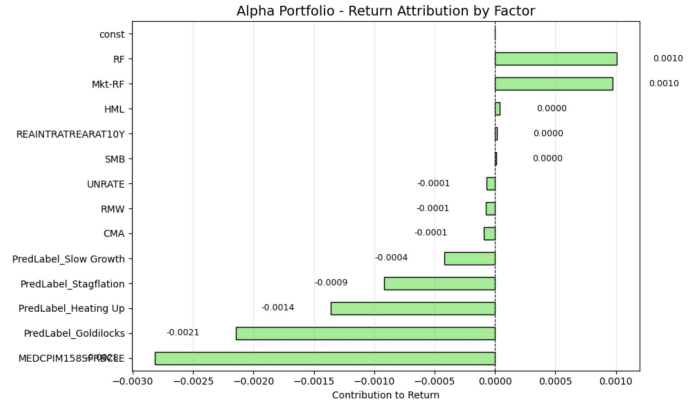
21 Day Rolling Sharpe Ratio



Portfolio Attribution

Key Performance Drivers





1. Exposure to growth and rates

RF β +0.0037 → +1.38% p.a.

10Y Real Estate β +0.0024 →0.57% p.a.

UNRATE β +0.0007 → -0.08% p.a.

- Strategy captures carry as rates rise and duration exposure,, but underperforms modestly when unemployment surprises positive

2. Equity and style tilts

Mkt-RF β +0.0006 → +0.92% p.a.

SMB β ~0.000 → Neutral

CMA β +0.0006 → –0.11% p.a.

- Portfolio maintains a modest market beta with low exposure , with negligible tilt towards small or large caps. Offset by conservative-aggressive drags.

3. Sensitivity to inflation and quality

CPI Surprise β -0.0009 → -3.60% p.a.

RMW β –0.0002 → -0.09% p.a.

HML β -0.0003 → +0.07% p.a.

- Sharp losses in inflation-shock months, compounded by minimal quality tilt in volatile regimes

4. Regime-driven risks

Goldilocks β -0.0076 → -2.57% p.a. *Largest drag*

Heating Up β -0.0060 → -1.64% p.a.

Slow Growth β -0.0064 → -1.83% p.a.

Stagflation β -0.0054 → -1.29% p.a.

- All regimes penalize the strategy, with Goldilocks and Slow Growth delivering the biggest drawdowns

Future Model Improvements

What Could Be Done Differently

1. Exposure to growth and rates

- Scale RF carry exposure dynamically with yield-curve steepness (10Y-3M) to boost RF/AGG weight when the curve steepens.
- Implement an adaptive duration tilt by shifting a portion of IG bond weight into TLT when UNRATE rises MoM.
- Stress-test Fed-pivot scenarios (e.g. 50 bps cut) and establish stop-loss triggers to auto-reduce carry positions on sharp rate moves.

2. Equity and style tilts

- Optimize factor weights via a grid search for maximum Information Ratio across MKT, SMB, CMA signals.
- Scale SMB and CMA tilts inversely to their realized volatility to smooth style exposures in choppy equity markets.
- Introduce a quality overlay by constraining model to allocate to USMV or a QMJ basket whenever RMW β drops below -0.02%.

3. Sensitivity to inflation and quality

- Hedge inflation spikes by allocating 5-10% to TIP and DBC when CPI surprises exceed +50 bps.
- Activate a “quality floor” by reserving 5% for USMV whenever RMW β is negative to cushion high-vol environments.
- Incorporate 5Y breakeven-inflation as a gating filter to mute momentum signals when inflation expectations hit the 90th percentile.

4. Regime-driven risks

- Enforce a hard constraint of >=25% in USMV + AGG when Slow Growth probability >50% to cap momentum at 50%.
- Define a 10% defensive bucket that rotates among BIL, USMV, and AGG based on the highest regime probability.
- Adjust rebalance freq to quarterly during rapid regime shifts to reduce turnover costs and whipsaw losses.

Conclusion and Discussion

How can we possibly improve?

- Optimize Rebalancing Frequency: Evaluate performance under bi-monthly or quarterly rebalancing to reduce turnover
- Incorporate actual transaction fee per ETF, based on its category, instead of a simple average
- Use rolling smoothed portfolio weights to reduce turnover and lower transaction cost, due to lesser abrupt weight shifts.
- Regime benchmark smoothening: Due to naive assumption of MSCI fallback mechanism formula, benchmark regimes are too “noisy”. Applying quarterly adjustment will greatly reduce the noise to improve forecasting accuracy.