QF623 Project Presentation

Group 9

Week 10

ETF Pairs Trading Portfolio

- This presentation outlines a complete quantitative pipeline for building and testing a **mean-reversion-based ETF pairs trading portfolio.**
- The methodology is based on cointegration testing, Ornstein-Uhlenbeck (OU) process calibration, and dynamic portfolio construction.
- We evaluate three weighting approaches over a quarterly rebalancing schedule and analyse both performance and macro factor attribution.
- We use 2022–2023 as in-sample window to perform signal selection, hedge ratio optimization, and strategy weight construction.
- The backtest evaluates three strategies (EW, MRB, MRR) with trading rules applied out-of-sample to 2024–2025 without re-tuning, thereby simulating live deployment.

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01

Universe Construction

ETF Pair Selection

- ➔ Commodities vs commodity producers (eg GLD vs GLX)
- ➔ Regional plays (eg EWA vs EWC)
- ➔ Related sectors (eg XLK vs XLC)
- ➔ Related asset classes (eg SPY vs TLT)

ETF Pair Selection

Type	Pairs
Fixed Income	(IEF, LQD), (HYG, SHY), (LQD, SHY)
Equity Size	(QQQ, MDY)
Equity Region	(QQQ, VT), (EWL, VGK), (EWA, ILF), (EWU, ISRA)
Equity Asia	(EWJ, GXC)
Emerging Markets	(EEM, IEMG)
Sector Defensive	(XLV, XLP), (XLP, XLU)
Sector Cyclical	(XLB, XLP)
Sector Mixed	(XLB, XLV)
Commodity vs Miners	(GDX, GLD), (SLV, SIL)
Commodities vs Sector	(DBB, XLB)
Agriculture	(DBA, MOO)
Oil Exposure	(USO, XOP)

02

Strategy Formulation

OLS Regression

Estimate the hedge ratio:

$$P_t^{(1)} = \alpha + \beta P_t^{(2)} + \varepsilon_t$$

- $P_t^{(1)}$: price of ETF1
- $P_t^{(2)}$: price of ETF2
- β: **hedge ratio**
- ε_t: **spread** (residual series)

CADF Test on Residual Spread

Whether two non-stationary time series share a stable long-run relationship:

$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \sum_{i=1}^{k} \phi_i \Delta\varepsilon_{t-i} + u_t$$

Hypotheses:

- H_0: $\rho = 0$ → spread has a unit root (non-stationary)
- H_1: $\rho < 0$ → spread is stationary ⇒ the pair is cointegrated

OU Model Hedge Ratio Optimisation

Once the pair passes the CADF test, we perform a grid search around the β from our OLS regression, to find the value of *b* that makes the makes the following spread fit the OU process most closely — i.e., maximises the OU (Ornstein-Uhlenbeck) model's log-likelihood: $X_t = P_t^{(1)} - b \cdot P_t^{(2)}$

The OU SDE is represented by:

$$dX_t = \mu(\theta - X_t)dt + \sigma dW_t$$

Where:

- X_t: the spread (e.g., ETF1 – b·ETF2)
- μ: **speed of mean reversion**
- θ: **long-term mean** of the spread
- σ: **volatility** of the spread
- W_t: standard Brownian motion (randomness)

03

Portfolio Construction

Trading Signals

Rolling Z-score of spread across a rolling window:

$$Z_t = \frac{X_t - \text{mean}(X_{t-60:t})}{\text{std}(X_{t-60:t})}$$

Apply threshold-based rules with risk control:

- **Enter Long**: if $Z_t < -z_{\text{entry}}$
- **Enter Short**: if $Z_t > z_{\text{entry}}$
- **Exit**: when Z_t crosses back toward zero (i.e., $|Z_t| < z_{\text{exit}}$)
- **Forced Exit (Kill-Switch)**: if $|Z_t| > z_{\text{kill}}$

Rebalance with Lookback and Rolling

z_{entry} & z_{exit}

- Dynamic z-score calculation
- z_{entry} (1.0 to 1.8)
- z_{exit} (0.2 to 0.5)

z_{kill}

- Breakdown in pairs cointegration
- Limiting drawdown and tail risk (3.0)
- Preserve capital

Weighting Methods

Equal Weight	Mean-Reversion Based (MRB)	Mean-Reversion to Risk (MRR)
All pairs are assigned equal weighting. *Pros:* Simple and transparent baseline; no dependence on parameter estimation. *Cons:* Ignores signal strength or risk differences - may overweight weak or volatile trades.	Favours pairs with stronger OU signals (higher average log-likelihood). *Pros:* Rewards stronger mean-reversion speed, ignores volatility *Cons:* Can be overly concentrated if a few pairs dominate in signal strength.	Signal strength normalised by spread volatility: $\text{Weight} \propto \frac{\text{Avg Log-Likelihood}}{\text{Spread Std Dev}}$ *Pros:* Produces a more risk-aware allocation; outperforms in stable regimes. *Cons:* Requires more parameters and may be more sensitive to noise.

Capital Allocation

EW

Quarter	EEM-IEMG	IEF-LQD	LQD-SHY	XLV-XLP	EWU-ISRA	SLV-SIL	QQQ-MDY	EWA-ILF	GDX-GLD	XLB-XLV	EWJ-GXC	QQQ-VT	XLB-XLP	HYG-SHY	DBA-MOO	EWL-VGK	XLP-XLU
2022Q1	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	-	-	-	-	-	-	-	-
2022Q2	25.00%	25.00%	-	-	-	-	-	-	-	25.00%	25.00%	-	-	-	-	-	-
2022Q3	-	14.29%	-	14.29%	14.29%	14.29%	-	14.29%	-	-	-	14.29%	14.29%	-	-	-	-
2022Q4	-	20.00%	20.00%	20.00%	-	20.00%	20.00%	-	-	-	-	-	-	-	-	-	-
2023Q1	20.00%	-	20.00%	-	-	-	-	-	-	-	-	-	20.00%	20.00%	20.00%	-	-
2023Q2	-	20.00%	-	-	-	20.00%	-	-	-	-	-	-	-	20.00%	-	20.00%	20.00%
2023Q3	-	-	-	-	25.00%	-	-	-	-	25.00%	-	-	-	25.00%	-	25.00%	-
2023Q4	-	-	-	-	16.67%	16.67%	-	-	16.67%	16.67%	-	-	-	16.67%	-	16.67%	-

MRB

2022Q1	16.27%	13.75%	11.96%	10.23%	9.87%	9.84%	9.61%	9.54%	8.95%	-	-	-	-	-	-	-	-
2022Q2	33.79%	26.92%	-	-	-	-	-	-	-	19.72%	19.57%	-	-	-	-	-	-
2022Q3	-	18.08%	-	14.08%	13.10%	13.29%	-	13.27%	-	-	-	15.60%	12.59%	-	-	-	-
2022Q4	-	23.68%	21.21%	18.38%	-	18.06%	18.66%	-	-	-	-	-	-	-	-	-	-
2023Q1	28.68%	-	19.53%	-	-	-	-	-	-	-	-	-	15.91%	18.36%	17.53%	-	-
2023Q2	-	23.45%	-	-	-	16.86%	-	-	-	-	-	-	-	19.15%	-	20.50%	20.04%
2023Q3	-	-	-	-	23.38%	-	-	-	-	22.46%	-	-	-	26.93%	-	27.23%	-
2023Q4	-	-	-	-	16.94%	15.08%	-	-	14.37%	15.50%	-	-	-	19.09%	-	19.02%	-

MRR

2022Q1	54.65%	16.39%	10.60%	4.10%	3.92%	3.66%	2.41%	2.61%	1.66%	-	-	-	-	-	-	-	-
2022Q2	79.55%	13.20%	-	-	-	-	-	-	-	3.56%	3.69%	-	-	-	-	-	-
2022Q3	-	31.87%	-	10.58%	10.96%	9.54%	-	7.14%	-	-	-	22.91%	6.99%	-	-	-	-
2022Q4	-	41.30%	17.94%	12.25%	-	17.15%	11.36%	-	-	-	-	-	-	-	-	-	-
2023Q1	77.24%	-	7.41%	-	-	-	-	-	-	-	-	-	3.66%	5.67%	6.03%	-	-
2023Q2	-	42.32%	-	-	-	7.36%	-	-	-	-	-	-	-	14.21%	-	22.61%	13.50%
2023Q3	-	-	-	-	15.40%	-	-	-	-	14.45%	-	-	-	41.29%	-	28.86%	-
2023Q4	-	-	-	-	15.53%	9.47%	-	-	10.97%	9.65%	-	-	-	27.41%	-	26.96%	-

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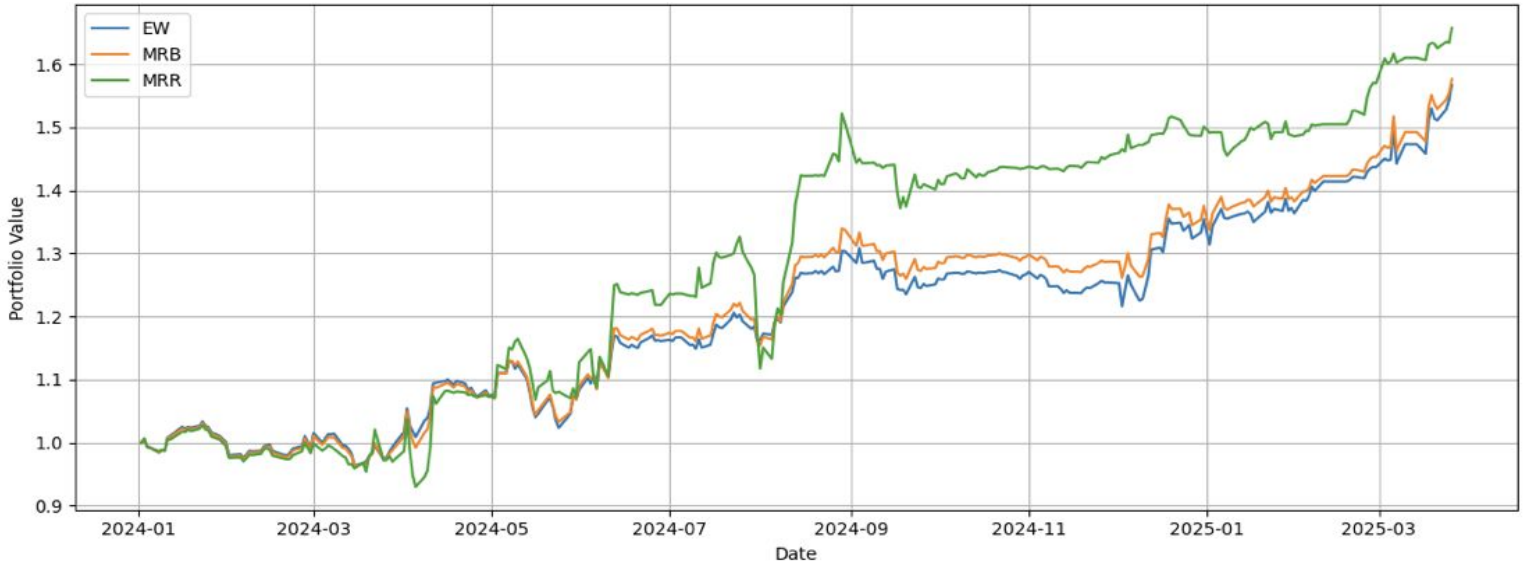
Performance

Cumulative Return

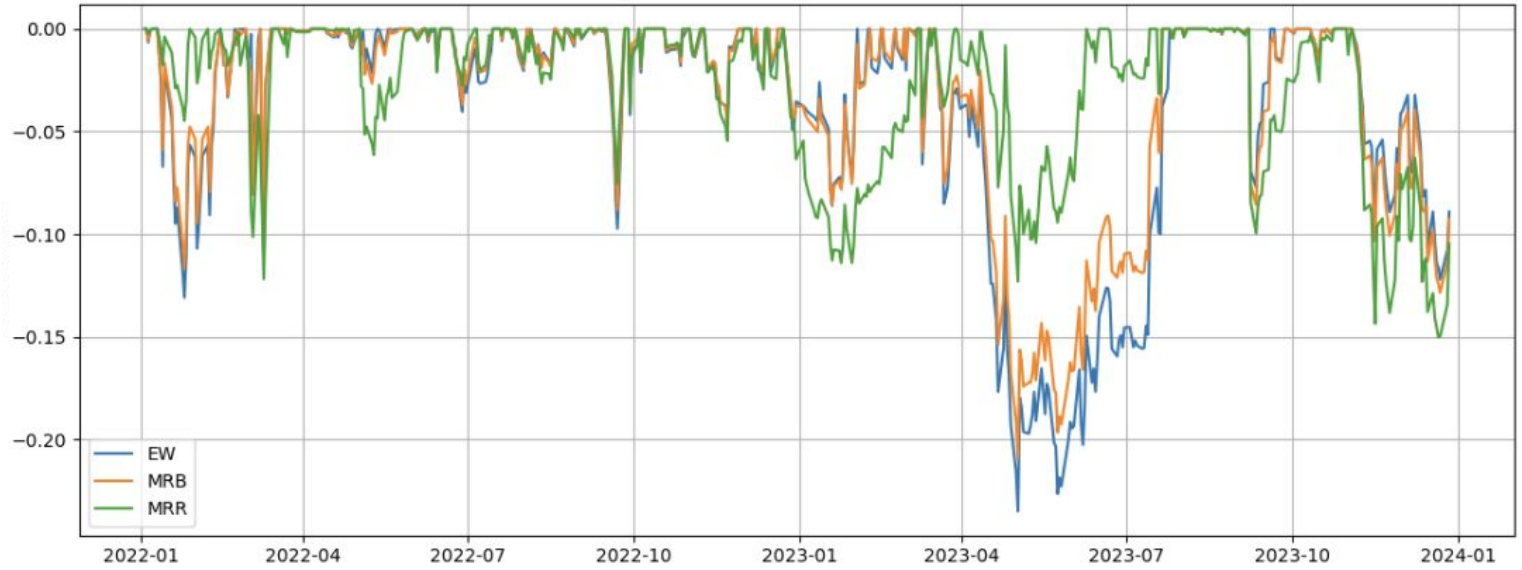
In Sample

Out of Sample



Drawdown

In Sample



Out of Sample

Performance Comparison

In Sample

Strategy	Total Return	Annual Return	Annual Volatility	Sharpe Ratio
EW	401.91%	125.85%	33.50%	2.60
MRB	351.67%	114.14%	31.75%	2.56
MRR	197.23%	73.35%	28.51%	2.07

Out of Sample

Strategy	Total Return	Annual Return	Annual Volatility	Sharpe Ratio
EW	56.69%	44.23%	18.47%	2.08
MRB	57.62%	44.93%	18.80%	2.07
MRR	65.76%	51.01%	26.01%	1.71

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Performance attribution

Macro Attribution

Metric	EW	MRR	MRB
R^2	0.008	0.036	0.010
p-value	0.879	0.322	0.817
MKT (SPY)	-0.0903	-0.0519	-0.0880
US10Y (TNX)	-0.0519	0.0010	-0.0661
DXY (US Dollar)	-0.0779	-0.4162	-0.1400
DBC (Commodity)	-0.1158	0.1396	-0.0874
TLT (20Y UST)	-0.0367	0.1229	-0.0147
VIX (Volatility)	-0.0038	-0.0531	-0.0116

Pair Attribution

In Sample

	EW	MRB	MRR
SLV-SIL	23.46%	23.09%	22.39%
EWL-VGK	14.55%	16.10%	22.03%
XLB-XLP	14.39%	12.52%	5.11%
XLB-XLV	13.13%	11.72%	5.75%
IEF-LQD	7.45%	9.24%	17.81%
QQQ-MDY	7.51%	7.16%	3.76%
DBA-MOO	6.91%	6.49%	3.07%
XLV-XLP	3.70%	3.77%	3.44%
EWU-ISRA	2.84%	3.06%	3.68%
HYG-SHY	1.95%	2.05%	2.56%
EEM-IEMG	1.05%	1.60%	6.54%
EWA-ILF	1.21%	1.19%	0.82%
QQQ-VT	0.95%	1.11%	2.25%
LQD-SHY	0.33%	0.35%	0.25%
GDX-GLD	0.36%	0.34%	0.41%
XLP-XLU	0.14%	0.15%	0.14%
EWJ-GXC	0.08%	0.06%	0.02%

Out of Sample

	EW	MRB	MRR
IEF-LQD	28.79%	36.75%	66.06%
SLV-SIL	34.10%	26.66%	8.52%
EWL-VGK	17.03%	15.99%	3.52%
DBB-XLB	15.19%	13.01%	4.52%
EEM-IEMG	9.50%	12.35%	23.53%
EWJ-GXC	9.88%	8.64%	2.12%
XLB-XLV	7.24%	6.97%	5.58%
HYG-SHY	1.00%	1.04%	0.84%
LQD-SHY	0.39%	0.40%	0.27%
XLV-XLP	-1.82%	-1.57%	-0.53%
GDX-GLD	-2.90%	-2.33%	-0.55%
EWA-ILF	-2.60%	-2.36%	-0.75%
XLP-XLU	-1.51%	-2.42%	-4.74%
EWU-ISRA	-7.66%	-6.43%	-1.59%
DBA-MOO	-6.63%	-6.69%	-6.81%

THANK YOU

Q&A