Executive Summary

- Objective: Design an equity long/short portfolio that profits when both the S&P 500 and USD weaken (126-day rolling window) in elevated stress environments (VIX ≥ 18), targeting regimes that challenge conventional long-biased and factor-neutral portfolios.
- This study constructs two 30-stock long/short spreads monetizing defensive-vs-cyclical compression during S&P 500/USD co-declines. Across seven stress regimes since 2009, the PC1 static sleeve earned 1.34 Sharpe with 4.8% max drawdown, while z-score timing halved risk at the cost of carry. The diversified Multi-PC variant improved tail robustness, achieving an everage of 2.28 Sharpe across 8 stress tests. Factor regressions confirm market-neutral, short-value, long-low-vol exposures. Sized at ~2% of NAV, the static PC1 sleeve contributes 10-15 bp of annual 'crisis alpha' as a targeted, macro-coherent overlay for discretionary-macro or equity L/S desks.

1. Factor discovery	Ran PCA on the two deepest USD-stress bear markets (May 2002–Jan 2003; Nov 2007–Aug 2008).	Extracts the latent spread that widens when risk and the dollar both deteriorate.
2. Basket design	• **PC1**: long defensives, short cyclicals. • **Multi-PC**: PC1 plus smaller PC2/PC3 tilts.	PC1 captures the pure "cyclical-vs-defensive" premium; PC2 and PC3 capture different factors.
3. Execution	*Static* (always on; short leg vol-scaled to 22 %) and *Dynamic* (z-score triggers, best pairs: **–0.5/0.5** for PC1, **–1/1** for Multi-PC; short leg re-scaled weekly).	Best pairs found during calibration applied across 5 periods.
4. Tests	Seven post-2009 co-decline regimes and eight shock periods (GFC, Covid, Brexit, SVB, etc.) with 4 bps per transaction (8 bps round-trip); full Fama-French & ETF attribution.	Checks repeatability, crisis alpha and diversification value.

Strategy	Avg Sharpe	Avg Max DD	Comment
PC1 Static	**1.34**	–4.8%	Highest carry; best Post-GFC, Covid Summer & 2025 windows
PC1 Dynamic	0.8	**–2.7 %**	Lower risk; mixed hit-rate
Multi-PC Static	1.01	–4.4%	Broader factor mix smooths tails
Multi-PC Dynamic	**1.6**	**–1.9 %**	Best risk-adjusted after costs

Fama-French 5-Factor	PC1 Static · 2023	Multi-PC Static · 2023	Comment
Alpha (bps/day)	**2.97**	1.01	Modest alpha; stronger in PC1
t(Alpha)	0.27	0.11	Not statistically significant
R^2	0.41	**0.5**	Better model fit with multi-PC exposures
MKT	–0.03	0.03	Mild market neutrality
SMB	–0.51	–0.33	Tilted short small caps
HML	–0.68	–0.71	Deep value short bias
RMW	–0.23	–0.41	Low profitability exposure
CMA	0.58	**0.7**	Strong tilt to conservative investment styles
UMD	0.21	0.27	Moderate momentum tilt

- Key Takeaways
  - Universal positive performance: Both static baskets generated positive returns across all 7 core regimes.
  - Stress-test excellence: Sharpe ratios peaked at 4.8 (PC1, Taper Tantrum) and 8.7 (Multi-PC, Brexit) during acute crises.
  - Effective hedging: Short cyclicals provided 40-100% long-side protection when VIX > 25 and 10-year yields moved ±40 bp.
  - Complementary implementation: Static PC1 as permanent macro-hedge for prolonged stress / Dynamic Multi-PC for event-risk windows and factor diversification.
  - Robust validation: Stress-test Multi-PC Sharpe of 2.28 (vs 1.65 for PC1) demonstrates additive crisis alpha during multi-factor dislocations.
  - Key limitation: Strategy vulnerable to COVID-style panic crashes (-31% max DD) but excels during orderly, factor-divergent stress.
  - Next step: Address survivorship bias by including delisted names (PCA currently on 340 stocks for 2002/2003, 376 for 2008).
  - Bottom line: The strategy offers a targeted hedge that converts USD/SPX co-declines into alpha and could add value to both discretionary-macro and equity L/S books as an add-on crisis sleeve.

Calibration and OOS Periods

Set	Regime Window	Calendar	Trading Days	Regime Description
Calibration (5 events · 169 days)				
C-1	Post-GFC Snap-back	22 Apr 2009 → 14 May 2009	**17**	Oldest slice; GFC-related but short.
C-2	QE-2 Anticipation	20 Sep 2010 → 29 Oct 2010	**30**	Rates-down, USD-weak, low-growth.
C-3	US Debt-Ceiling Downgrade	01 Aug 2011 → 09 Sep 2011	**30**	High-vol, policy shock; equity stress.
C-4	China Deval / Global-Growth Scare	24 Aug 2015 → 15 Oct 2015	**39**	EM-led risk, USD bid then faded.
C-5	Covid "Summer Consolidation"	04 Jun 2020 → 17 Aug 2020	**53**	Same year but structurally different (rates floored, vol ≥ 18).
Out-of-Sample (2 events · 114 days)				
OOS-1	Post-Inflation-Peak Unwind	21 Dec 2022 → 16 Mar 2023	**58**	Falling CPI and USD; fresh macro mix.
OOS-2	2025 Macro-Risk Regime	03 Apr 2025 → 24 Jun 2025	**56**	"Live" slice; most recent regime observed.

Stress Tests Periods

#	Label	Start date	End date	Catalyst / Notes
1	Euro-area debt crisis – Wave 1	**26-Apr-2010**	**10-Jun-2010**	Greek junk downgrade: ECB SMP / Bundestag vote
2	2013 Taper-Tantrum	**22-May-2013**	**24-Jun-2013**	Bernanke “taper” testimony: UST-yield spike & EM rout
3	Oil-price collapse / deflation scare	**28-Nov-2014**	**20-Jan-2015**	OPEC refuses cuts: WTI lows, ECB QE announcement
4	Brexit referendum shock	**24-Jun-2016**	**01-Jul-2016**	GBP collapse: BoE easing signals steady markets
5	US–China tariff re-escalation	**06-May-2019**	**28-Jun-2019**	Trump 25 % tariff tweet: G-20 Osaka “truce”
6	COVID-19 crash	**20-Feb-2020**	**23-Mar-2020**	Global lockdowns: Fed “QE-infinite” & CARES Act
7	2022 inflation / Fed shock	**03-Jan-2022**	**16-Jun-2022**	CPI surge & FOMC 75 bp lift-off: YTD SPX low
8	SVB banking panic	**06-Mar-2023**	**30-Mar-2023**	SVB warning/FDIC takeover: funding stress eases

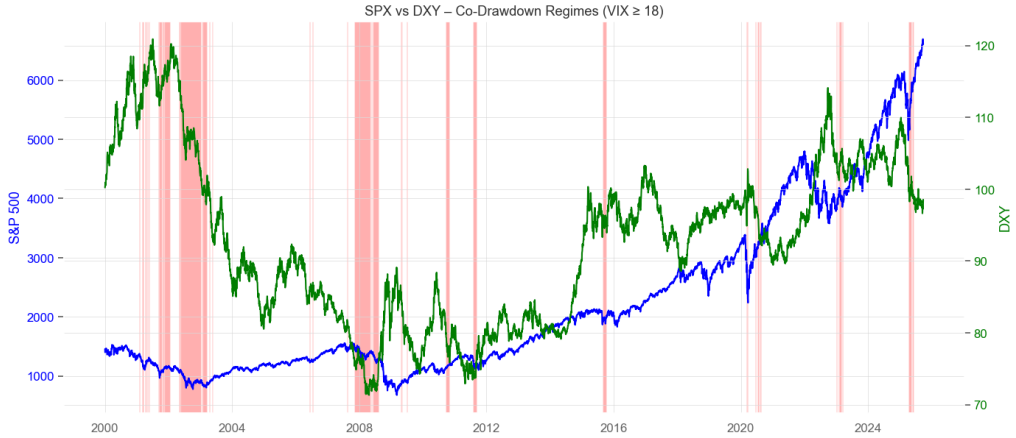
Macro Rationale

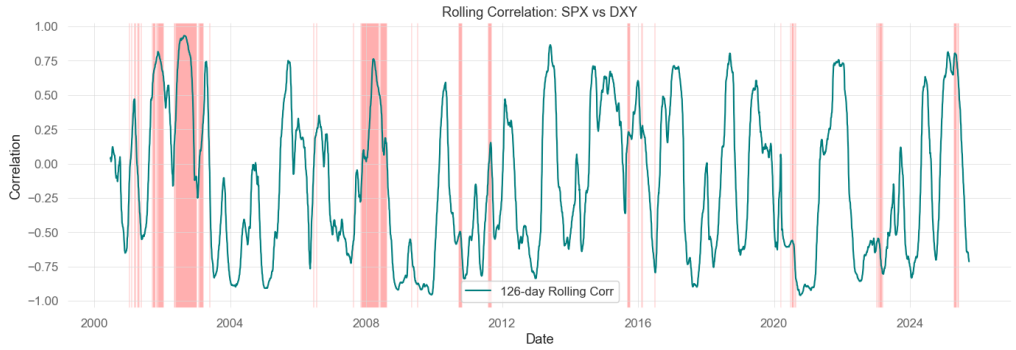
- The US Dollar typically strengthens during risk-off episodes as global capital seeks safe-haven US Treasuries. However, the USD can co-decline with equities during periods of US-specific stress, as witnessed in April 2025. We identified two historical regimes, post-Dot-com Bubble (2002-2003) and GFC buildup (2007-2008), where the Dollar Index and S&P 500 both declined over 126-day windows amid elevated volatility (VIX ≥ 18), providing more than 300 trading days of data in total for robust PCA analysis.
- These dual declines occurred under distinct macroeconomic backdrops. 'Growth scare' episodes see Treasury yields plunge on safe-haven flows and Fed easing expectations, while 'inflation scare' environments feature bonds and stocks selling off together as the Fed tightens or lugs behind the curve. Crucially, both regimes exhibited elevated volatility (VIX often >20), reflecting market stress when traditional equity-dollar correlations break down. Both periods represented crises of US financial leadership, corporate governance failures and mortgage market collapse, where global capital reassessed US asset quality, creating simultaneous pressure on equities and the dollar.
- Given current macro challenges (trade tensions, fiscal deficits, de-globalization), the probability of similar S&P 500/USD co-decline regimes has increased. The April 2025 stress episode demonstrated this dynamic, and further periods could emerge, particularly if trade conflicts escalate into financial capital restrictions.

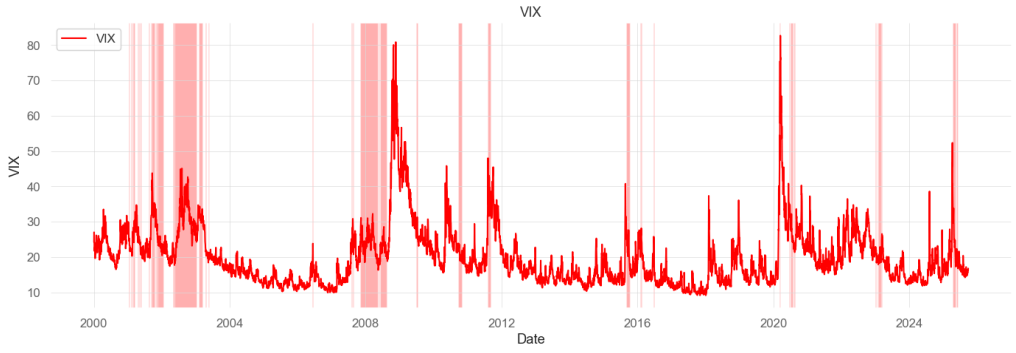
Methodology

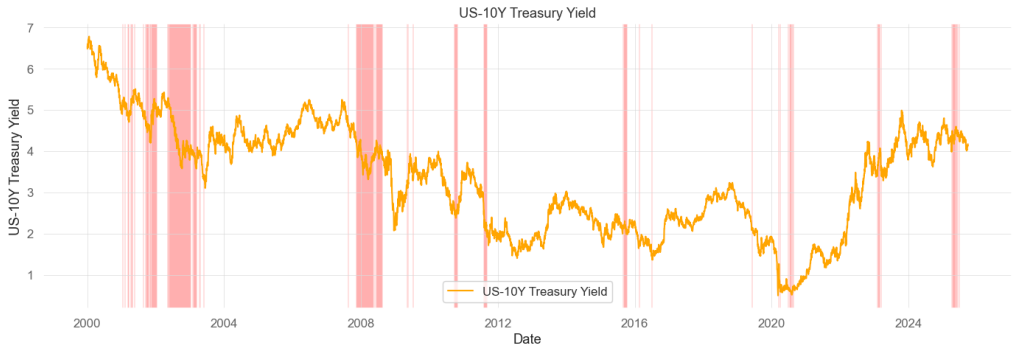
- We compute daily returns of current S&P 500 constituents during two identified stress regimes: post-Dot-com Bubble and GFC buildup. Principal Component Analysis (PCA) is performed separately on each period's return matrix after standardization, retaining only stocks common to both periods to ensure consistency. The analysis assumes that during S&P 500/USD co-declines, typically episodes of global deleveraging or crisis-driven capital flight, cross-sectional dispersion increases as crowded trades unwind. We hypothesize that PC1 captures this 'stress factor' representing latent market sentiment that may mean-revert after peak stress periods. Statistically significant higher-order components (PC2, PC3) are evaluated for potential factor diversification benefits. Using the averaged PC loadings across both historical regimes, we construct two 30-stock long/short portfolios (15 stocks per leg): PC1 Portfolio, extreme PC1 loaders only, and Multi-PC Portfolio, combined PC1, PC2, and PC3 loadings. We explicitly acknowledge survivorship bias from using only currently listed stocks, which may overstate long-leg performance and understate short-leg returns. Portfolio backtests apply 22% volatility scaling to the short leg with weekly rebalancing, incorporating 8-basis-point round-trip transaction costs.

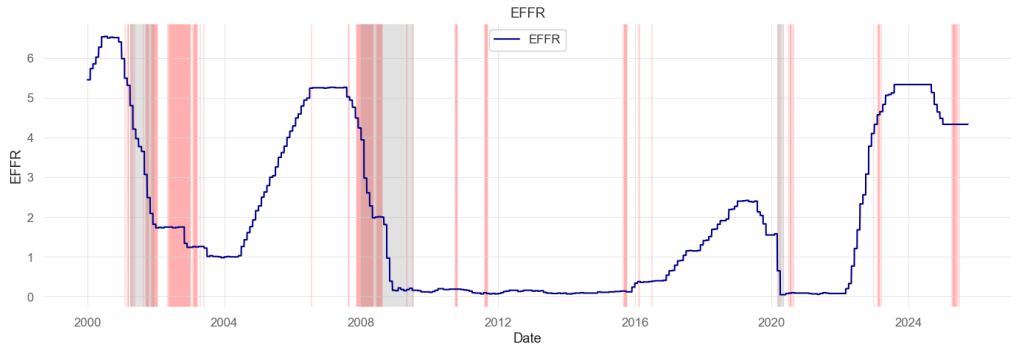
- Macro Charts with Regime Periods Highlighted in Red (Jan 2000 - Sep 25th 2025)

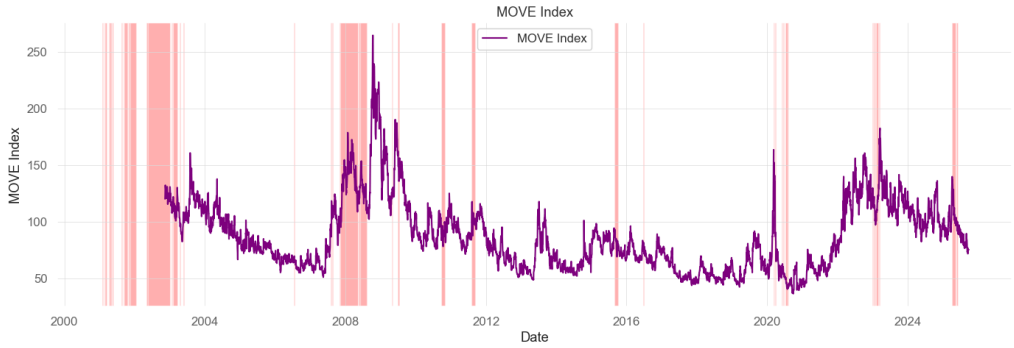

SPX vs DXY – Co-Drawdown Regimes (VIX ≥ 18)
S&P 500
DXY
6000
5000
4000
3000
2000
1000
120
110
100
90
80
70
2000
2004
2008
2012
2016
2020
2024

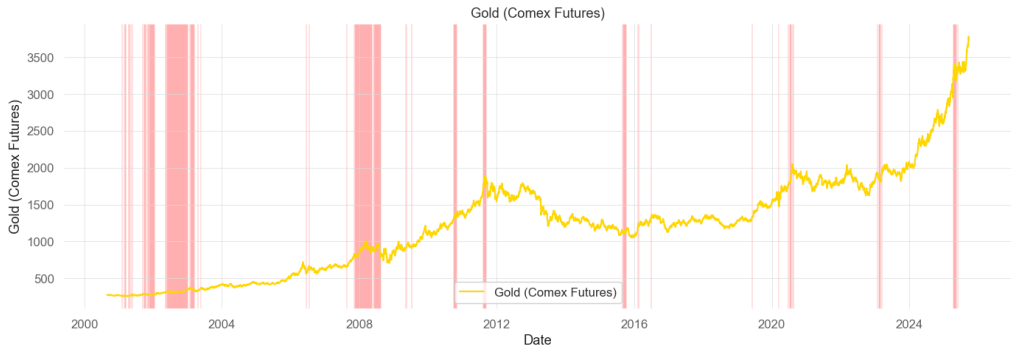

Rolling Correlation: SPX vs DXY
Correlation
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
126-day Rolling Corr
2000
2004
2008
2012
2016
2020
2024
Date

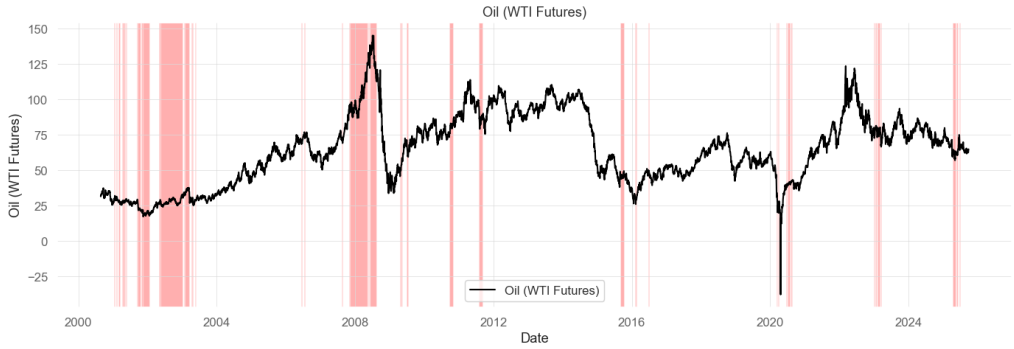

VIX
VIX
80
70
60
50
40
30
20
10
2000
2004
2008
2012
2016
2020
2024
Date


US-10Y Treasury Yield
US-10Y Treasury Yield
7
6
5
4
3
2
1
US-10Y Treasury Yield
2000
2004
2008
2012
2016
2020
2024
Date


EFFR
EFFR
6
5
4
3
2
1
0
2000
2004
2008
2012
2016
2020
2024
Date

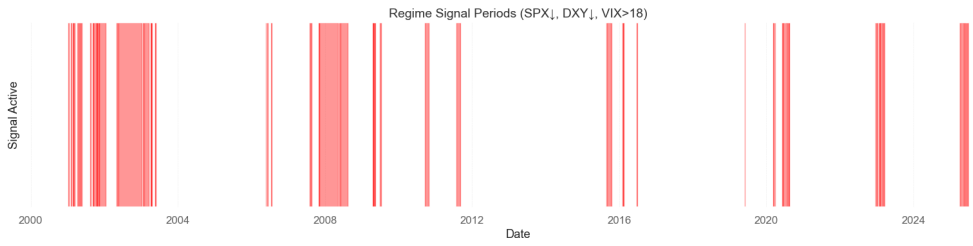




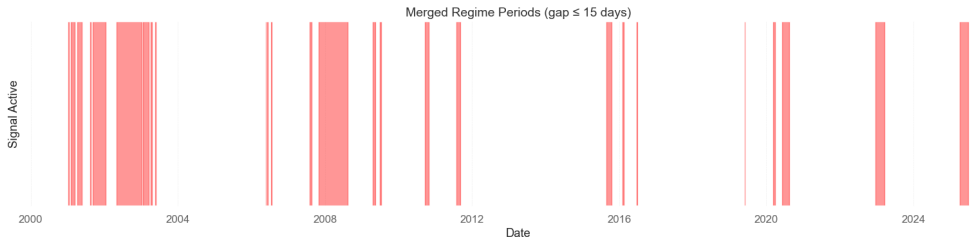


- SPX and DXY recently entered a co-downward move (Apr 3 - Jun 24) validated by a 126-day rolling window, with the VIX above or equal to 18.
- VIX reached the elevated intraday level of 60, on April 7 and closed at 46.98, marking its highest closing level of 2025.
- YTD the US 10-Year Treasury Yield has been in a range of 3.98% to 4.8%.
- We can see from the EFFR chart that post Dot-com bubble was preceded by a recession during which the Fed lowered rates while the GFC buildup experienced lower rates before and during a recession.
- VIX decreased but the MOVE Index remains elevated.
- Gold is up more than 40% YTD.

- In total, we identified 70 periods of various lengths where we can observe a co-downward move of SPX and DXY (based on a 126-day rolling window) when the VIX was at 18 or higher.



- To reduce noise, we apply a ≤ 15-calendar day gap rule and obtain 26 merged blocks.

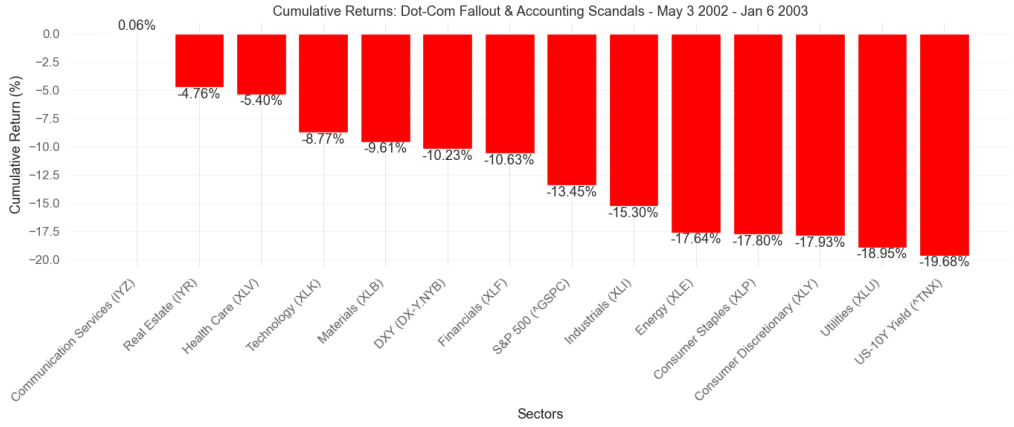


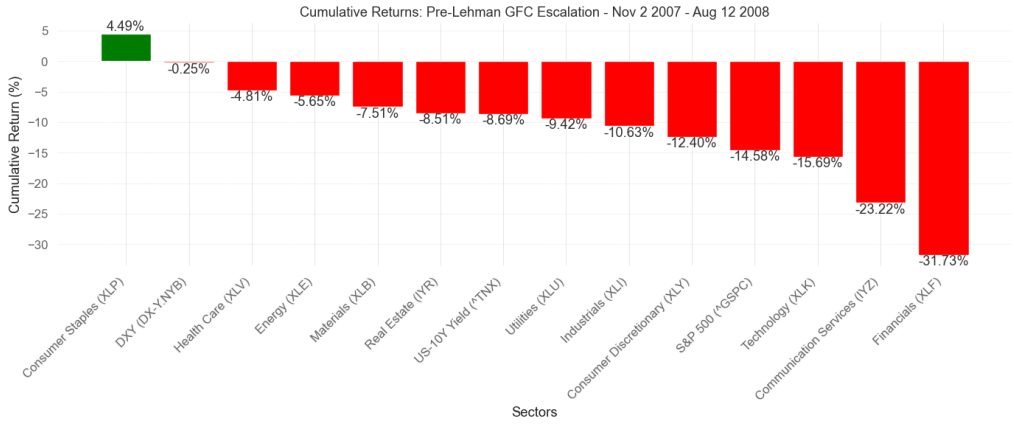
	start	end	trading_days
1	2001-01-11	2001-01-15	2
2	2001-01-31	2001-03-16	32
3	2001-04-06	2001-05-23	33
4	2001-08-16	2001-08-20	3
5	2001-09-07	2002-01-16	87
6	2002-05-03	2003-01-06	171
7	2003-01-22	2003-03-17	38
8	2003-04-09	2003-04-21	8
9	2003-05-19	2003-05-27	6
10	2006-05-23	2006-05-24	2
11	2006-06-09	2006-06-15	5
12	2006-07-14	2006-07-18	3
13	2007-08-03	2007-08-22	14
14	2007-11-02	2008-08-12	195
15	2009-04-22	2009-05-14	17
16	2009-07-01	2009-07-10	7
17	2010-09-20	2010-10-29	30
18	2011-08-01	2011-09-09	29
19	2015-08-24	2015-10-15	38
20	2016-02-03	2016-02-16	9
21	2016-06-24	2016-06-29	4
22	2019-06-03	2019-06-04	2
23	2020-03-06	2020-03-30	17
24	2020-06-04	2020-08-17	52
25	2022-12-21	2023-03-16	58
26	2025-04-03	2025-06-24	56

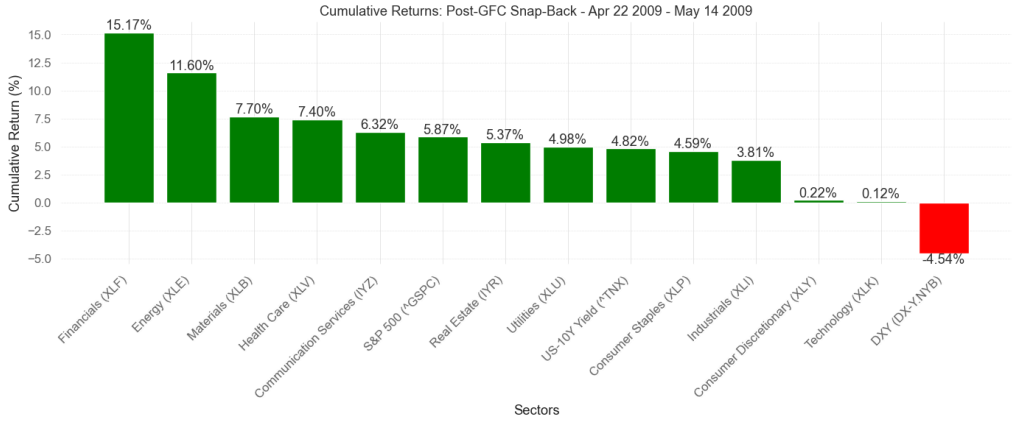
- Out of the 26 periods, the US 10Y yield traded higher only on 9 occurrences (35%).

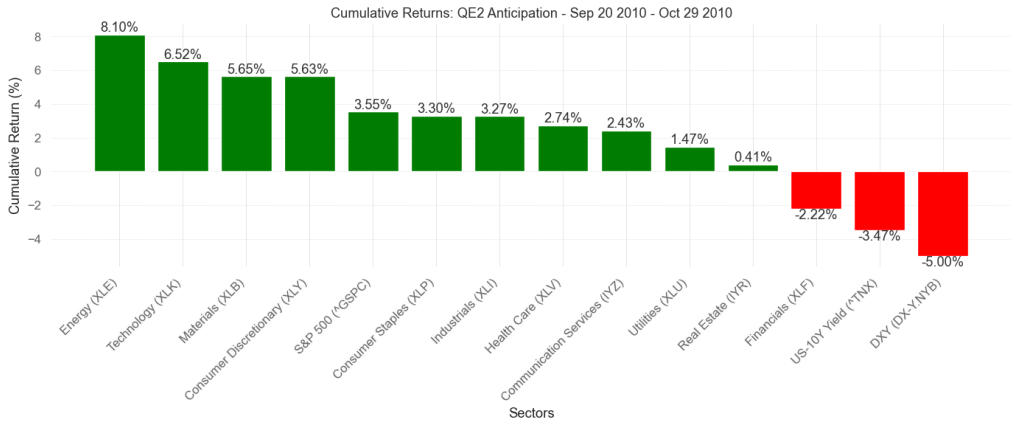
Start	End	Start Yield	End Yield	Yield Change (bps)
2001-01-11	2001-01-15	5.12%	5.23%	11.4 bps
2001-04-06	2001-05-23	4.87%	5.39%	51.7 bps
2001-09-07	2002-01-16	4.80%	4.84%	4.3 bps
2003-04-09	2003-04-21	3.90%	3.98%	7.8 bps
2006-06-09	2006-06-15	4.98%	5.10%	11.7 bps
2006-07-14	2006-07-18	5.06%	5.13%	7.1 bps
2009-04-22	2009-05-14	2.96%	3.11%	14.3 bps
2015-08-24	2015-10-15	2.00%	2.02%	2.6 bps
2019-06-03	2019-06-04	2.08%	2.12%	3.8 bps

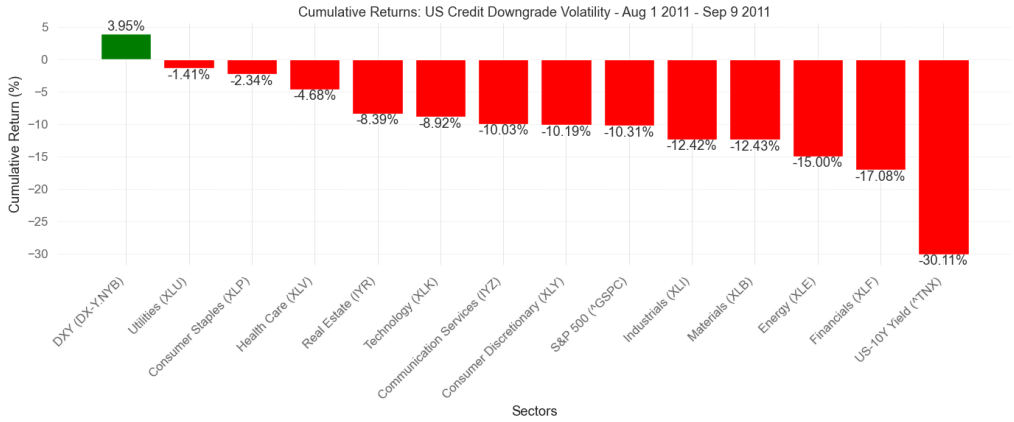
- Performance charts during regimes used for PCA, Calibrations and Backtests.

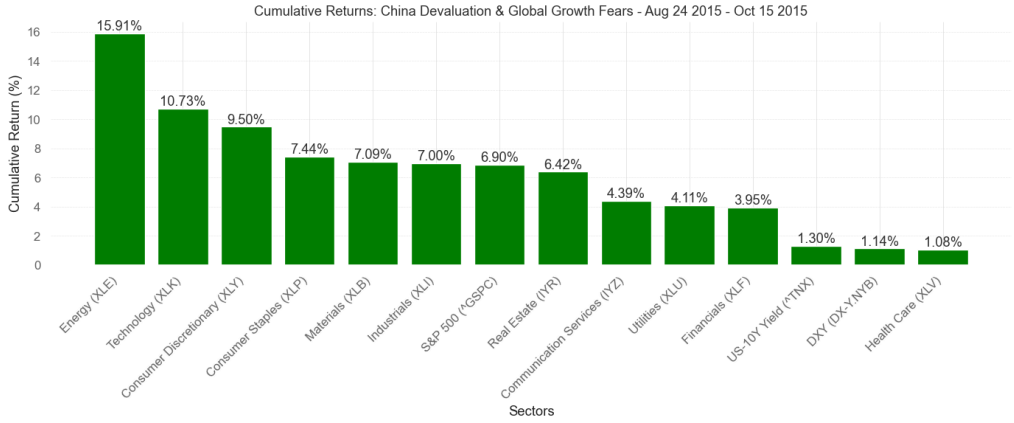

Cumulative Returns: Dot-Com Fallout & Accounting Scandals - May 3 2002 - Jan 6 2003
Cumulative Return (%)
0.0
−2.5
−5.0
−7.5
−10.0
−12.5
−15.0
−17.5
−20.0
0.06%
-4.76%
-5.40%
-8.77%
-9.61%
-10.23%
-10.63%
-13.45%
-15.30%
-17.64%
-17.80%
-17.93%
-18.95%
-19.68%
Communication Services (IYZ)
Real Estate (IYR)
Health Care (XLV)
Technology (XLK)
Materials (XLB)
DXY (DX-YNYB)
Financials (XLF)
S&P 500 (^GSPC)
Industrials (XLI)
Energy (XLE)
Consumer Staples (XLP)
Consumer Discretionary (XLY)
Utilities (XLU)
US-10Y Yield (^TNX)
Sectors

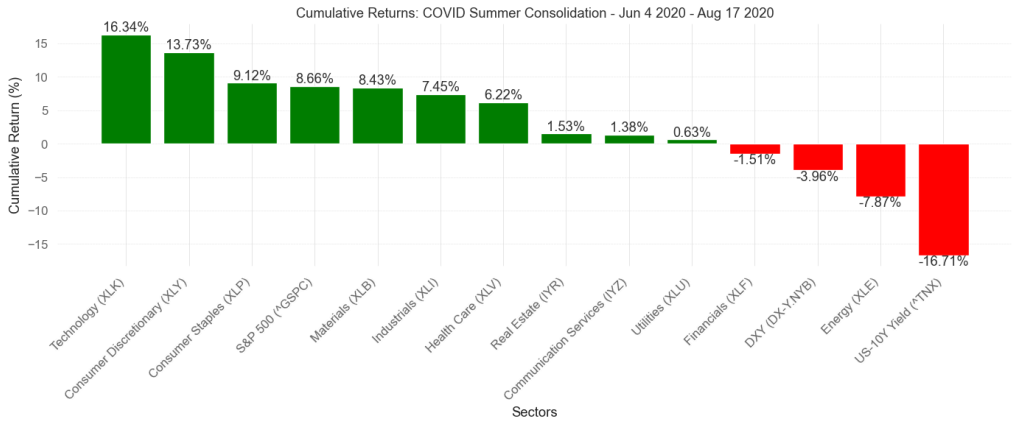

Cumulative Returns: Pre-Lehman GFC Escalation - Nov 2 2007 - Aug 12 2008
Cumulative Return (%)
5
0
−5
−10
−15
−20
−25
−30
4.49%
-0.25%
-4.81%
-5.65%
-7.51%
-8.51%
-8.69%
-9.42%
-10.63%
-12.40%
-14.58%
-15.69%
-23.22%
-31.73%
Consumer Staples (XLP)
DXY (DX-YNYB)
Health Care (XLV)
Energy (XLE)
Materials (XLB)
Real Estate (IYR)
US-10Y Yield (^TNX)
Utilities (XLU)
Industrials (XLI)
Consumer Discretionary (XLY)
S&P 500 (^GSPC)
Technology (XLK)
Communication Services (IYZ)
Financials (XLF)
Sectors

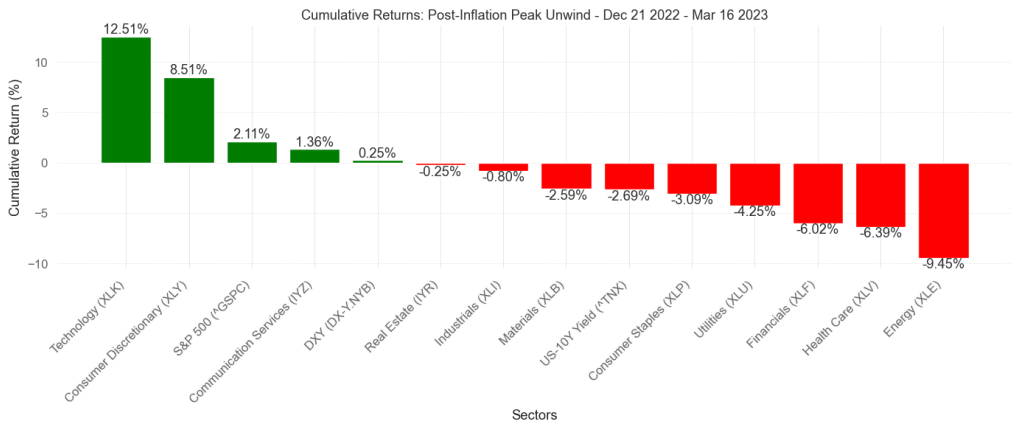

Cumulative Returns: Post-GFC Snap-Back - Apr 22 2009 - May 14 2009
Cumulative Return (%)
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
15.17%
11.60%
7.70%
7.40%
6.32%
5.87%
5.37%
4.98%
4.82%
4.59%
3.81%
0.22%
0.12%
-4.54%
Financials (XLF)
Energy (XLE)
Materials (XLB)
Health Care (XLV)
Communication Services (IYZ)
S&P 500 (^GSPC)
Real Estate (IYR)
Utilities (XLU)
US-10Y Yield (^TNX)
Consumer Staples (XLP)
Industrials (XLI)
Consumer Discretionary (XLY)
Technology (XLK)
DXY (DX-YNYB)
Sectors

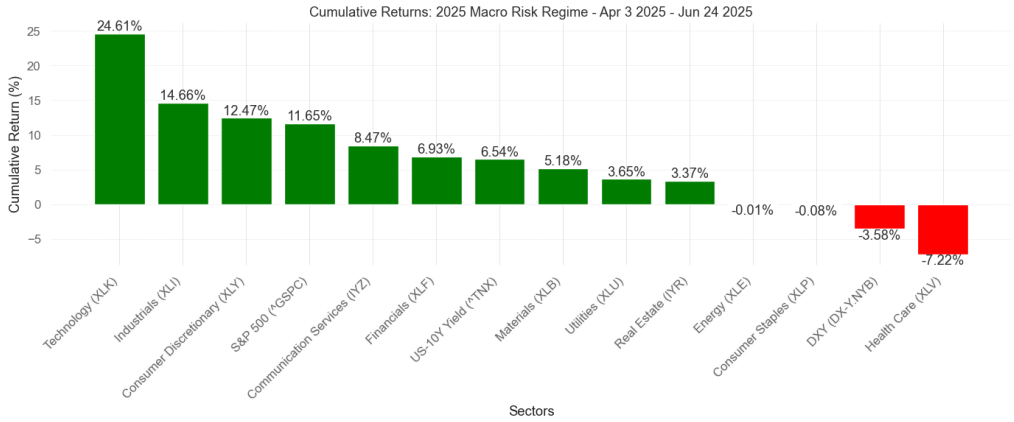

Cumulative Returns: QE2 Anticipation - Sep 20 2010 - Oct 29 2010
Cumulative Return (%)
8
6
4
2
0
−2
−4
8.10%
6.52%
5.65%
5.63%
3.55%
3.30%
3.27%
2.74%
2.43%
1.47%
0.41%
-2.22%
-3.47%
-5.00%
Energy (XLE)
Technology (XLK)
Materials (XLB)
Consumer Discretionary (XLY)
S&P 500 (^GSPC)
Consumer Staples (XLP)
Industrials (XLI)
Health Care (XLV)
Communication Services (IYZ)
Utilities (XLU)
Real Estate (IYR)
Financials (XLF)
US-10Y Yield (^TNX)
DXY (DX-YNYB)
Sectors


Cumulative Returns: US Credit Downgrade Volatility - Aug 1 2011 - Sep 9 2011
Cumulative Return (%)
5
0
−5
−10
−15
−20
−25
−30
3.95%
-1.41%
-2.34%
-4.68%
-8.39%
-8.92%
-10.03%
-10.19%
-10.31%
-12.42%
-12.43%
-15.00%
-17.08%
-30.11%
DXY (DX-Y.NYB)
Utilities (XLU)
Consumer Staples (XLP)
Health Care (XLV)
Real Estate (IYR)
Technology (XLK)
Communication Services (IYZ)
Consumer Discretionary (XLY)
S&P 500 (^GSPC)
Industrials (XLI)
Materials (XLB)
Energy (XLE)
Financials (XLF)
US-10Y Yield (^TNX)
Sectors


Cumulative Returns: China Devaluation & Global Growth Fears - Aug 24 2015 - Oct 15 2015
Cumulative Return (%)
16
14
12
10
8
6
4
2
0
15.91%
10.73%
9.50%
7.44%
7.09%
7.00%
6.90%
6.42%
4.39%
4.11%
3.95%
1.30%
1.14%
1.08%
Energy (XLE)
Technology (XLK)
Consumer Discretionary (XLY)
Consumer Staples (XLP)
Materials (XLB)
Industrials (XLI)
S&P 500 (^GSPC)
Real Estate (IYR)
Communication Services (IYZ)
Utilities (XLU)
Financials (XLF)
US-10Y Yield (^TNX)
DXY (DX-Y.NYB)
Health Care (XLV)
Sectors

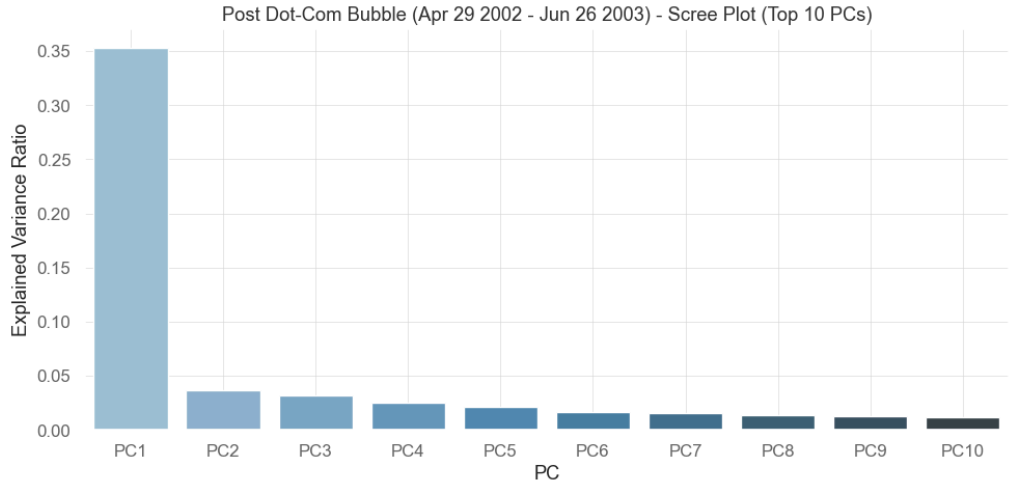

Cumulative Returns: COVID Summer Consolidation - Jun 4 2020 - Aug 17 2020
Cumulative Return (%)
15
10
5
0
−5
−10
−15
16.34%
13.73%
9.12%
8.66%
8.43%
7.45%
6.22%
1.53%
1.38%
0.63%
-1.51%
-3.96%
-7.87%
-16.71%
Technology (XLK)
Consumer Discretionary (XLY)
Consumer Staples (XLP)
S&P 500 (^GSPC)
Materials (XLB)
Industrials (XLI)
Health Care (XLV)
Real Estate (IYR)
Communication Services (IYZ)
Utilities (XLU)
Financials (XLF)
DXY (DX-Y.NYB)
Energy (XLE)
US-10Y Yield (^TNX)
Sectors

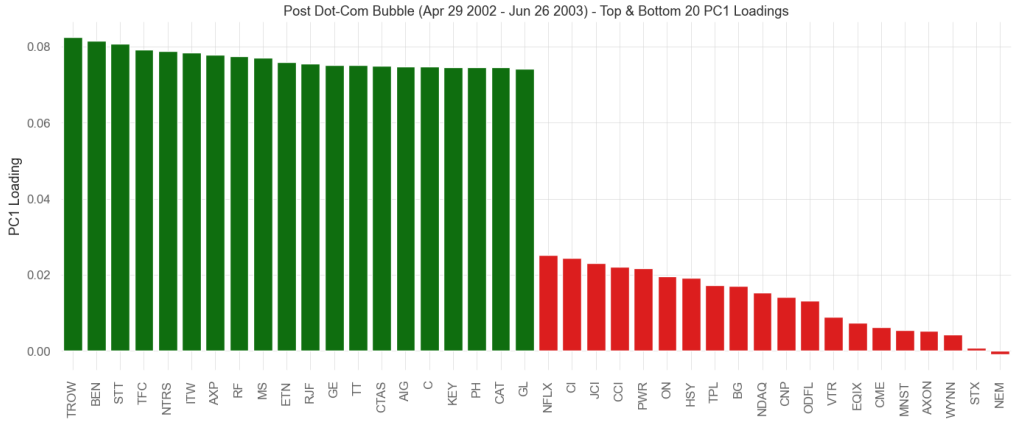

Cumulative Returns: Post-Inflation Peak Unwind - Dec 21 2022 - Mar 16 2023
Cumulative Return (%)
10
5
0
−5
−10
12.51%
8.51%
2.11%
1.36%
0.25%
-0.25%
-0.80%
-2.59%
-2.69%
-3.09%
-4.25%
-6.02%
-6.39%
-9.45%
Technology (XLK)
Consumer Discretionary (XLY)
S&P 500 (^GSPC)
Communication Services (IYZ)
DXY (DX-Y.NYB)
Real Estate (IYR)
Industrials (XLI)
Materials (XLB)
US-10Y Yield (^TNX)
Consumer Staples (XLP)
Utilities (XLU)
Financials (XLF)
Health Care (XLV)
Energy (XLE)
Sectors



- The first two periods (The Dot-Com fallout and GFC buildup) experienced broad market drawdowns.
- Financials underperformed across all the periods except the Post GFC Snap-Back and this year's period.
- Energy traded lower over 5 periods out of 9.

- PCA



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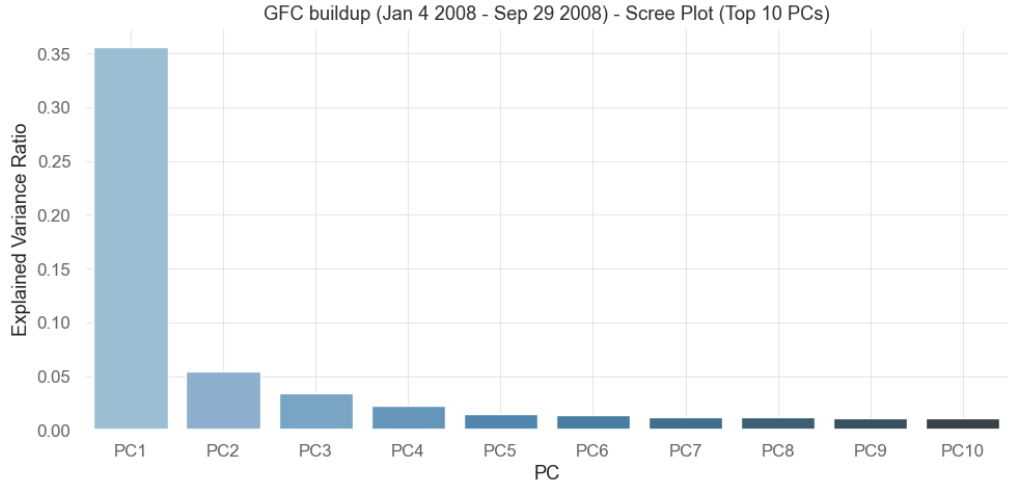
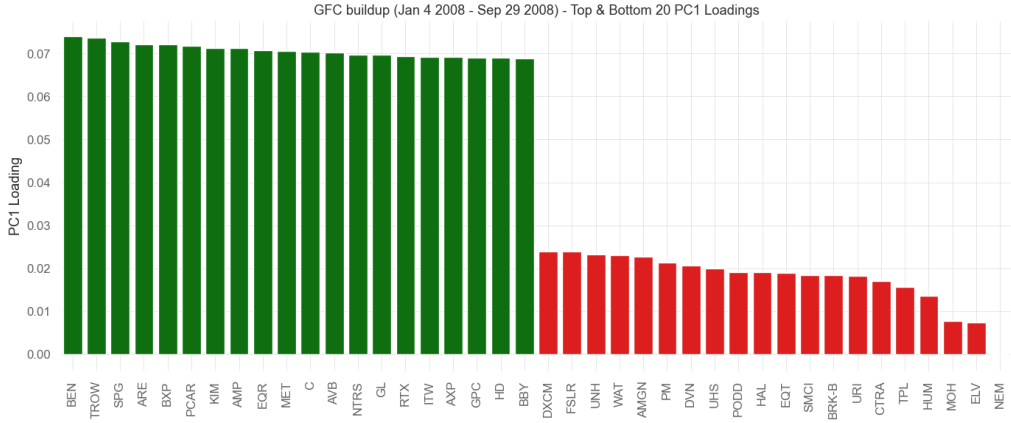
=== Explained Variance Ratio (Top 5 PCs) ===
PC1 explains 35.25% of the variance
PC2 explains 3.66% of the variance
PC3 explains 3.14% of the variance
PC4 explains 2.56% of the variance
PC5 explains 2.17% of the variance
```





```
=== Explained Variance Ratio (Top 5 PCs) ===
PC1 explains 35.58% of the variance
PC2 explains 5.43% of the variance
PC3 explains 3.39% of the variance
PC4 explains 2.26% of the variance
PC5 explains 1.43% of the variance
```

- We regress sector ETF returns (e.g., XLF, XLK, XLU…) on the principal components PC1, PC2 and PC3.

Post Dot-Com Bubble (2002–2003)

	ETF	Sector	PC	Beta	t-Stat	p-Value
1	^GSPC	S&P 500	PC1	0.0184	65.7	0.000000
2	XLI	Industrials	PC1	0.0183	37.7	0.000000
3	XLF	Financials	PC1	0.0209	34.6	0.000000
4	XLK	Technology	PC1	0.0246	31.1	0.000000
5	XLY	Consumer Discretionary	PC1	0.0186	29.4	0.000000
6	XLB	Materials	PC1	0.0178	24.6	0.000000
7	XLV	Health Care	PC1	0.0149	18.9	0.000000
8	XLE	Energy	PC1	0.0161	17.9	0.000000
9	XLP	Consumer Staples	PC1	0.0093	16.1	0.000000
10	XLU	Utilities	PC1	0.0162	15.8	0.000000
11	XLK	Technology	PC2	0.0121	15.3	0.000000
12	IYR	Real Estate	PC1	0.0068	14.3	0.000000
13	IYZ	Communication Services	PC1	0.0193	12.9	0.000000
14	IYR	Real Estate	PC3	0.0050	10.6	0.000000
15	XLU	Utilities	PC3	0.0104	10.1	0.000000
16	XLP	Consumer Staples	PC2	-0.0054	-9.4	0.000000
17	XLP	Consumer Staples	PC3	-0.0043	-7.4	0.000000
18	XLY	Consumer Discretionary	PC3	-0.0039	-6.1	0.000000
19	^GSPC	S&P 500	PC3	-0.0014	-5.0	0.000002
20	IYR	Real Estate	PC2	-0.0021	-4.4	0.000020
21	XLU	Utilities	PC2	-0.0045	-4.4	0.000022
22	^GSPC	S&P 500	PC2	0.0012	4.2	0.000044
23	XLV	Health Care	PC2	-0.0031	-3.9	0.000142
24	XLV	Health Care	PC3	-0.0029	-3.7	0.000317
25	IYZ	Communication Services	PC2	0.0048	3.3	0.001361
26	XLY	Consumer Discretionary	PC2	0.0019	3.1	0.002592
27	XLE	Energy	PC2	-0.0027	-3.0	0.002763
28	XLB	Materials	PC2	-0.0021	-2.9	0.003986
29	XLB	Materials	PC3	-0.0019	-2.6	0.008978
30	XLE	Energy	PC3	-0.0022	-2.5	0.014600
31	XLI	Industrials	PC3	-0.0011	-2.3	0.025112
32	XLI	Industrials	PC2	0.0010	2.0	0.044325
33	XLF	Financials	PC2	0.0010	1.7	0.094413
34	IYZ	Communication Services	PC3	0.0025	1.7	0.094499
35	XLK	Technology	PC3	-0.0010	-1.3	0.202681
36	XLF	Financials	PC3	0.0004	0.7	0.460866

GFC buildup (2008)

	ETF	Sector	PC	Beta	t-Stat	p-Value
1	^GSPC	S&P 500	PC1	0.0134	82.4	0.000000
2	XLF	Financials	PC1	0.0253	33.0	0.000000
3	XLI	Industrials	PC1	0.0137	28.6	0.000000
4	IYR	Real Estate	PC1	0.0207	28.5	0.000000
5	XLY	Consumer Discretionary	PC1	0.0155	28.1	0.000000
6	XLE	Energy	PC2	0.0163	22.1	0.000000
7	XLK	Technology	PC1	0.0123	20.9	0.000000
8	IYZ	Communication Services	PC1	0.0142	20.6	0.000000
9	XLB	Materials	PC1	0.0128	19.8	0.000000
10	XLV	Health Care	PC1	0.0077	17.2	0.000000
11	XLU	Utilities	PC3	0.0069	16.3	0.000000
12	XLP	Consumer Staples	PC1	0.0071	15.7	0.000000
13	XLB	Materials	PC2	0.0101	15.5	0.000000
14	XLU	Utilities	PC1	0.0062	14.6	0.000000
15	XLE	Energy	PC1	0.0097	13.2	0.000000
16	XLU	Utilities	PC2	0.0054	12.8	0.000000
17	^GSPC	S&P 500	PC2	0.0019	12.0	0.000000
18	XLF	Financials	PC2	-0.0084	-11.0	0.000000
19	IYR	Real Estate	PC2	-0.0064	-8.9	0.000000
20	XLV	Health Care	PC3	0.0038	8.4	0.000000
21	XLB	Materials	PC3	-0.0041	-6.3	0.000000
22	XLY	Consumer Discretionary	PC2	-0.0032	-5.8	0.000000
23	XLI	Industrials	PC2	0.0025	5.3	0.000000
24	XLP	Consumer Staples	PC3	0.0023	5.0	0.000002
25	XLE	Energy	PC3	-0.0033	-4.5	0.000012
26	XLI	Industrials	PC3	-0.0019	-3.9	0.000138
27	XLK	Technology	PC3	-0.0022	-3.6	0.000345
28	XLK	Technology	PC2	0.0021	3.6	0.000406
29	IYZ	Communication Services	PC2	0.0024	3.5	0.000587
30	XLV	Health Care	PC2	0.0010	2.3	0.024868
31	^GSPC	S&P 500	PC3	-0.0004	-2.2	0.029352
32	IYR	Real Estate	PC3	-0.0015	-2.1	0.041167
33	XLF	Financials	PC3	-0.0016	-2.0	0.043264
34	IYZ	Communication Services	PC3	0.0013	1.9	0.055081
35	XLP	Consumer Staples	PC2	0.0001	0.2	0.828878
36	XLY	Consumer Discretionary	PC3	0.0001	0.1	0.918985

- Top and Bottom Loaders for PC1, PC2, PC3

PC1 Top 20 Ticker	PC1 Top 20 Loading	PC1 Bottom 20 Ticker	PC1 Bottom 20 Loading
TROW	0.0781	NEM	-0.0006
BEN	0.0777	STX	0.0132
NTRS	0.0743	TPL	0.0165
ITW	0.0738	MNST	0.0199
AXP	0.0735	BG	0.0218
PCAR	0.0729	ELV	0.0238
C	0.0726	HUM	0.0258
STT	0.0724	EQIX	0.0261
MS	0.0723	AXON	0.0261
GL	0.0719	TTWO	0.0266
RJF	0.0717	WYNN	0.0266
TFC	0.0715	BRK-B	0.0267
GPC	0.0713	CI	0.0288
CTAS	0.0712	UHS	0.0292
RTX	0.0705	CNP	0.0297
GE	0.0705	CNC	0.0299
GS	0.0702	DVA	0.0300
GWW	0.0700	UNH	0.0300
BAC	0.0699	NFLX	0.0302
JPM	0.0697	CME	0.0305

PC2 Top 10 Ticker	PC2 Top 10 Loading	PC2 Bottom 10 Ticker	PC2 Bottom 10 Loading
NVDA	0.0955	HSY	-0.0766
QCOM	0.0888	K	-0.0762
LRCX	0.0837	UDR	-0.0746
CTRA	0.0810	CLX	-0.0638
WMB	0.0799	SYY	-0.0616
AAPL	0.0799	CPT	-0.0610
EOG	0.0774	PLD	-0.0603
FFIV	0.0770	TFC	-0.0579
SLB	0.0747	CL	-0.0573
A	0.0742	HBAN	-0.0559

PC3 Top 10 Ticker	PC3 Top 10 Loading	PC3 Bottom 10 Ticker	PC3 Bottom 10 Loading
D	0.1522	DE	-0.0629
WEC	0.1501	IFF	-0.0627
ES	0.1368	NUE	-0.0585
CNP	0.1363	EA	-0.0561
AEE	0.1353	STLD	-0.0555
NEE	0.1316	NDAQ	-0.0535
SO	0.1309	AKAM	-0.0527
PPL	0.1296	EQIX	-0.0500
DTE	0.1291	WSM	-0.0499
FE	0.1278	LEN	-0.0497

PC1 Macro Correlations (21-Day rolling):

Post Dot-Com Bubble - PC1 vs SPX: Average 21D Corr = 0.32
Post Dot-Com Bubble - PC1 vs VIX: Average 21D Corr = -0.34
Post Dot-Com Bubble - PC1 vs DXY: Average 21D Corr = 0.21

GFC buildup - PC1 vs SPX: Average 21D Corr = 0.32
GFC buildup - PC1 vs VIX: Average 21D Corr = -0.34
GFC buildup - PC1 vs DXY: Average 21D Corr = 0.19

```
PC2 Macro Correlations:

Post Dot-Com Bubble - PC2 vs SPX: Average 21D Corr = 0.06
Post Dot-Com Bubble - PC2 vs VIX: Average 21D Corr = -0.05
Post Dot-Com Bubble - PC2 vs DXY: Average 21D Corr = -0.02

GFC buildup - PC2 vs SPX: Average 21D Corr = 0.25
GFC buildup - PC2 vs VIX: Average 21D Corr = -0.23
GFC buildup - PC2 vs DXY: Average 21D Corr = -0.02


PC3 Macro Correlations:

Post Dot-Com Bubble - PC3 vs SPX: Average 21D Corr = 0.12
Post Dot-Com Bubble - PC3 vs VIX: Average 21D Corr = -0.18
Post Dot-Com Bubble - PC3 vs DXY: Average 21D Corr = -0.02

GFC buildup - PC3 vs SPX: Average 21D Corr = -0.07
GFC buildup - PC3 vs VIX: Average 21D Corr = 0.06
GFC buildup - PC3 vs DXY: Average 21D Corr = -0.08
```

Observations from PCA

- During drawdowns, cross-sectional correlations increase. Most stocks tend to fall together, which inflates the first eigenvalue (PC1). Assets with high PC1 loadings will be those contributing most to the market panic (e.g., high-beta names, cyclicals, or crowded trades). We can see that PC1 behaves similarly to the market index (S&P 500) — high correlation (t-stats ~65–80). PC1 explains around 35% of variance and captures systematic market risk, with high exposure to financials, cyclicals, and beta-heavy sectors. Stocks with large negative loadings are defensives and low-beta names. Highest loadings are dominated by banks and financials (TROW, BEN, NTRS, AXP, C, STT, MS, JPM, etc.). Bottom 20 includes defensive healthcare (UNH, CI, CNC), gold miner (NEM), EQIX, etc.). Across the two periods, the strongest loading increase (0.0191 → 0.0253) is for XLF (Financials) while XLK (Tech) saw its loading decreased. This aligns with Financials' greater sensitivity to systemic shocks during the GFC versus 2002.
- When the crisis dissipates or overreaction unwinds, high PC1 loaders often snap back more strongly, leading to a potential mean-reversion opportunity.The mean-reverting behavior of high PC1 loaders post-crisis supports a signal-driven long/short approach. However, this requires distinguishing temporary stress from structural bear markets—mean-reversion fails in prolonged downturns like 2008. The moderate 21-day correlations (+0.3 with SPX, -0.35 with VIX) provide supportive but not conclusive evidence for this approach.
- While PC1 captures the dominant co-movement across equities during stress regimes, regression analysis reveals that PC2 and PC3 carry statistically and economically meaningful sector-specific signals. Across both the 2002–2003 post–Dot-Com bubble period and the 2008 GFC buildup, PC2 exhibited strong and significant positive loadings on the Technology (XLK) and Energy (XLE) sectors, suggesting that it captures a latent sector rotation or macro re-pricing dynamic not captured by PC1. Likewise, PC3 demonstrated consistently significant exposures to traditionally defensive sectors such as Utilities (XLU), Consumer Staples (XLP), and Real Estate (IYR), particularly during periods of elevated volatility. These results confirm that PC2 and PC3, despite explaining a smaller share of total variance, reflect orthogonal risk premia aligned with observable economic themes. Therefore, their inclusion in the strategy could contribute to factor diversification.
- PC2 explains 3.6% to 5.4% of variance and likely captures the growth vs value trade (or momentum vs defensive tilt). Its dominant sector exposure is to Technology (XLK). Top 10 stocks are all semiconductors or tech hardware (NVDA, QCOM, AAPL, LRCX, FFIV, NTAP). The bottom stocks are all consumer staples or REITs (bottom 10: HSY, CLX, K, UDR, PSA, AVB). We observe many sign flips between the two periods, XLE (Energy) had a strong reversal, XLP (Staples) flattened and XLU (Utilities) reversed also. It suggests a regime shift in relative factor structure, perhaps from a defensive-led rotation (2002) to a more uniform sector response (2008).
- PC3 explains a little bit more than 3% of the variance. It has high ETF loadings to XLU (Utilities), moderate betas on REITs (IYR), Health Care (XLV). Top 10 stocks are pure-play Utilities (D, WEC, AEE, SO, NEE…) and bottom 10 stocks are Cyclicals with housing/industrial exposure (DE, LEN, PHM, STLD, DHI). PC3 is likely a duration/fixed income sensitivity factor. Utilities are sensitive to long-term bond yields. The negative side is populated with economically sensitive, rate-sensitive sectors like homebuilders, steel, and machinery. PC3 exposure is key when inflation expectations or interest rates shift. Utilities shine in risk-off, falling-rate environments driven by recession fears or financial stress. They are "long duration". Homebuilders, steel, machinery benefit from growth rebounds that may also involve lower rates — but only if investors believe in an economic recovery. They are pro-cyclical and need real activity to pick up. Thus, PC3 seems to be not just about "interest rates" but also about how sensitive a stock is to the type of regime where rates are falling as top PC3 (duration-driven defensives) would rally in slowdowns or panics while bottom PC3 (growth-sensitive cyclicals) would rally when stimulus (lower rates, fiscal deficits) revives the economy.
- PC2 does not capture a mean-reverting behaviour nor does PC3. There is no stable relationship between the principal components and the dollar index across both periods.

Portfolio Construction

- We construct two 30-stock portfolios (15 longs, 15 shorts), equally-weighted within each leg. The short book is volatility-scaled to a 22 % target, so the overall portfolio is volatility-balanced rather than dollar-neutral.
- We stay consistent with the statistical/PCA logic so the long basket is made of the lowest PC loaders and the short basket is made of the highest PC loaders.
- The first portfolio, called "PC1 Portfolio", contains only the bottom 15 PC1 loaders in the long leg and top 15 PC1 loaders in the short leg.
- The second portfolio, called "Multi PC Portfolio", is made of the bottom 12 PC1, 1 PC2, 2 PC3 loaders in the long leg and the top 12 PC1, 1 PC2 and 2 PC3 loaders in the short leg. This portfolio is also mostly market-neutral, short cyclicals vs. defensives, but with a long value vs. momentum tilt and another long rate-sensitive cyclical vs. short bond proxies tilt. In theory, this portfolio could be relevant if investors believe the market is overpricing growth (PC2) but rates have peaked and housing/cyclicals will rebound (PC3).

Risk Management

- The short basket consists of highly cyclical and levered names whose realised volatility in stress regimes is on average 32% higher than the long basket (based on the backtest periods - see table below). Capping the short book at 22 % annualised volatility reins-in its crisis-period risk to roughly three-quarters of the long book's 75-th-percentile σ (≈ 29 %), which is tight enough to tame tail shocks without muting alpha.
- We therefore scale the short leg to a 22 % annualised volatility target using a 60-day exponentially weighted moving average forecast. The 60-day lookback balances statistical robustness with regime-change sensitivity, providing stable vol estimates while adapting to market conditions.
- The long basket is already defensively tilted by design. Leaving it un-scaled preserves the intended beta-compression exposure while keeping turnover and fees low.

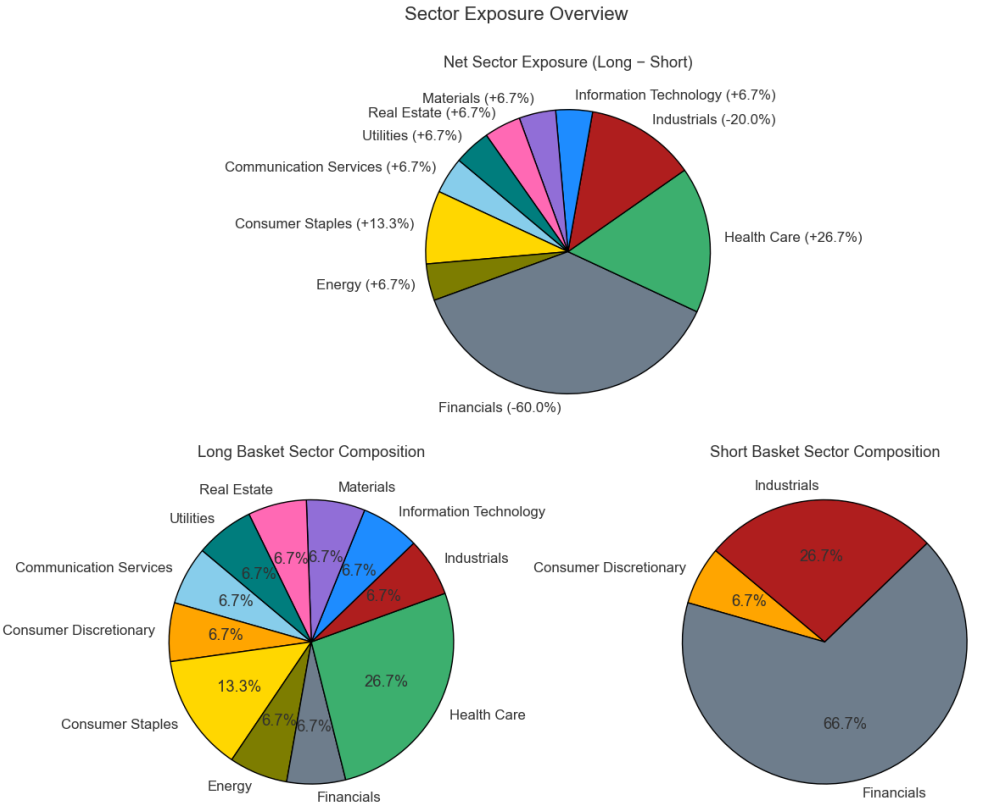
Regime	Long σ	Short σ	Ratio
Post-GFC Snap-Back	29%	56%	1.91
QE2 Anticipation	20%	18%	0.88
US Credit Downgrade	50%	59%	1.17
China Devaluation	24%	26%	1.06
COVID Summer	24%	34%	1.42
Post-Inflation Unwind	15%	21%	1.39
2025 Macro Risk Regime	25%	35%	1.39
Average	27%	36%	1.32

Backtests

- We test the same portfolio construction using two trading approaches: static (buy-and-hold) and dynamic (tactical timing using z-score signals to enter/exit the same portfolio multiple times).
- We use the same time windows - the 7 longest stress regime periods out of the 26 periods identified.
- The static strategy is backtested across all 7 periods.
- The dynamic strategy is calibrated across the first 5 periods and the out of sample backtests are done over the latest 2 periods.
- Fixed parameters:
  - Transaction cost: 4 bps per trade (8 bps round trip).
  - Target volatility on the short leg only: 22% annualized (applied via scaling, transaction cost applied too).
  - Volatility lookback: 60 trading days.
  - Dynamic only:
    - Z-score smoothing: 60-day exponential smoothing span.
    - Signal timing: Close-to-close (T signal; T+1 execution).
- Calibration (Dynamic only):
  - Entry Z and Exit Z used: (-1, -0.75, -0.50, -0.25) and (0.25, 0.50, 0.75, 1).
  - We calibrate by selecting the entry/exit Z-score pair with the highest average Sharpe ratio across periods, requiring at least 2 trades per period and valid Sharpe calculations in at least 3 out of 5 calibration periods.
  - The entry/exit pair selected is then applied to calibration and OOS backtest periods.

Set	Regime Window	Calendar	Trading Days	Regime Description
Calibration (5 events · 169 days)				
C-1	Post-GFC Snap-back	22 Apr 2009 → 14 May 2009	**17**	Oldest slice; GFC-related but short.
C-2	QE-2 Anticipation	20 Sep 2010 → 29 Oct 2010	**30**	Rates-down, USD-weak, low-growth.
C-3	US Debt-Ceiling Downgrade	01 Aug 2011 → 09 Sep 2011	**30**	High-vol, policy shock; equity stress.
C-4	China Deval / Global-Growth Scare	24 Aug 2015 → 15 Oct 2015	**39**	EM-led risk, USD bid then faded.
C-5	Covid "Summer Consolidation"	04 Jun 2020 → 17 Aug 2020	**53**	Same year but structurally different (rates floored, vol ≥ 18).
Out-of-Sample (2 events · 114 days)				
OOS-1	Post-Inflation-Peak Unwind	21 Dec 2022 → 16 Mar 2023	**58**	Falling CPI and USD; fresh macro mix.
OOS-2	2025 Macro-Risk Regime *(Live)*	03 Apr 2025 → 24 Jun 2025	**56**	"Live" slice; most recent regime observed.

- PC1 Portfolio



	Long Ticker	Long Sector	Long Mkt Cap (B)	Long Avg Vol (M)	Long Beta	Short Ticker	Short Sector	Short Mkt Cap (B)	Short Avg Vol (M)	Short Beta
1	AXON	Industrials	55.65	0.64	1.40	AXP	Financials	237.77	2.62	1.29
2	BG	Consumer Staples	16.40	2.04	0.65	BEN	Financials	12.08	3.75	1.54
3	BRK-B	Financials	1078.55	4.54	0.78	C	Financials	190.39	14.62	1.40
4	CI	Health Care	76.39	1.75	0.49	CTAS	Industrials	82.30	1.77	1.00
5	CNP	Utilities	25.34	5.12	0.56	GL	Financials	11.71	0.63	0.56
6	ELV	Health Care	71.74	2.50	0.60	GPC	Consumer Discretionary	19.15	1.23	0.76
7	EQIX	Real Estate	77.35	0.51	0.91	ITW	Industrials	76.09	0.93	1.11
8	HUM	Health Care	30.66	1.79	0.45	MS	Financials	255.59	5.29	1.34
9	MNST	Consumer Staples	63.80	5.67	0.54	NTRS	Financials	25.42	1.34	1.32
10	NEM	Materials	93.64	11.09	0.35	PCAR	Industrials	52.77	2.90	0.94
11	STX	Information Technology	46.32	3.77	1.55	RJF	Financials	35.03	1.05	1.06
12	TPL	Energy	21.94	0.15	1.20	RTX	Industrials	218.65	4.31	0.66
13	TTWO	Communication Services	47.25	1.75	1.00	STT	Financials	32.83	1.90	1.52
14	UHS	Health Care	12.78	0.84	1.28	TFC	Financials	59.34	7.67	0.86
15	WYNN	Consumer Discretionary	13.41	1.93	1.36	TROW	Financials	22.73	1.57	1.53
16	Average		115.41	2.94	0.87	Average		88.79	3.44	1.13

- PC1 Portfolio Composition
  - The largest net exposures of the strategy are Financials (-60%), Health Care (+27%), Industrials (-20%), and Staples (+13%)
  - The strategy ends up with no exposure to Consumer Discretionary.
  - The long basket is made of 11 sectors and is quite defensive as 47% are Health Care, Staples and Utilities stocks.
  - The short basket contains three sectors, all cyclicals, dominated by Financials.

- PC1 Static Backtests

Period	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Scaling_Factor	VIX_Avg	US10Y_Δ_bps
Post-GFC Snap-Back	+4.04%	+6.07%	-1.92%	3.88	4.86	1.01	-0.75	-1.80%	0.396	34.8	+14.3
QE2 Anticipation	+1.45%	+4.55%	-2.88%	0.85	0.90	0.29	-1.61	-4.85%	1.000	21.1	-9.4
US Credit Downgrade	+0.60%	-6.12%	+6.15%	0.33	0.42	0.11	-0.47	-8.29%	0.374	35.0	-82.5
China Devaluation	+2.50%	+2.49%	+0.14%	1.38	1.94	0.53	0.13	-3.93%	0.847	23.8	+2.6
COVID Summer	+3.94%	+3.58%	+0.51%	1.51	2.33	0.68	-0.04	-3.01%	0.644	27.8	-13.7
Post-Inflation Unwind	+2.88%	+1.74%	+1.64%	0.95	1.91	0.44	1.44	-7.33%	1.000	20.7	-9.9
2025 Macro Risk Regime	+1.11%	+8.82%	-7.62%	0.51	0.66	0.23	-0.87	-4.52%	0.628	24.2	+23.8

```
Average Sharpe Ratio: 1.34
Average Max Drawdown: −4.82%
Average Skew: −0.31
Average Scaling Factor: 0.698
```

Observations

- All total returns are positive (avg 2.4%). Return profile is mildly left-tailed (skew –0.31).
- In the two stress episodes when VIX > 30 (Post-GFC, Credit-downgrade) the basket is positive with average max draw-downs of 5.1%.
- Out of the 3 highest sharpe ratio, 2 happened during higher rates and 2 when VIX > 27. Net wins tend to scale with VIX and the direction of the 10-year move, reinforcing the narrative: when USD & SPX co-decline and stress vol surfaces, PC1 spread widens.
- With an average max drawdown of ~4.8%, sizing the basket at 2% of NAV limits potential loss to under 10 bps per event. At the observed Sharpe ratio of ~1.3, this translates into an expected annual alpha of roughly 25 bps.
- Bottom line: the PC1 static book tends to bring small positive carry and higher payoff when stress hits.

- PC1 Dynamic Strategy: Calibration and Backtests

```
Optimal z−pair across calibration windows: Entry −0.5, Exit 0.5
```

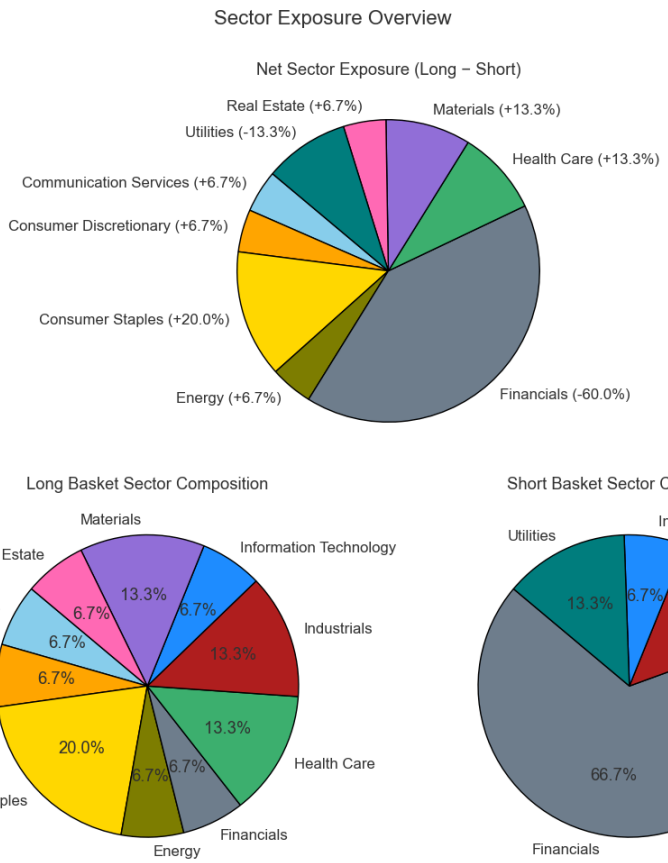
Period	Entry_z	Exit_z	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Hit_Ratio	PF	Trades	R
Post-GFC Snap-Back	-0.50	0.50	+0.21%	+5.83%	-5.18%	0.36	0.20	0.08	-1.48	-2.69%	50.0%	3.66	2	
QE2 Anticipation	-0.50	0.50	-2.34%	-0.42%	-1.41%	-1.99	-0.93	-0.57	-3.69	-4.70%	66.7%	0.26	3	
US Credit Downgrade	-0.50	0.50	+6.93%	+7.33%	+0.21%	6.89	nan	1.91	2.71	-0.08%	100.0%	inf	4	
China Devaluation	-0.50	0.50	-0.46%	+2.39%	-2.12%	-0.52	-0.27	-0.17	-2.83	-2.61%	75.0%	0.67	4	
COVID Summer	-0.50	0.50	+1.55%	+2.23%	+0.54%	0.99	1.00	0.37	0.18	-2.09%	50.0%	1.75	6	
Post-Inflation Unwind	-0.50	0.50	-0.99%	+1.79%	-1.31%	-0.82	-0.72	-0.32	-0.66	-3.82%	37.5%	0.56	8	
2025 Macro Risk Regime	-0.50	0.50	+0.90%	+5.24%	-3.08%	0.70	0.91	0.26	0.85	-2.77%	66.7%	1.43	6	

```
Average Sharpe Ratio: 0.80
Average Max Drawdown: −2.68%
Average Skew: −0.70
Average Weekly Rebalances: 2.0
```

Observations

- Performance is lumpy: Sharpe 6.9 in US-Credit but three negative sharpes out of seven.
- Trades per window range between 2 and 8, with some large idiosyncratic P&L swings.
- Drawdowns smaller than static (avg –2.7 %) thanks to exits but average total return only 0.83%.
- Bottom line: Timing adds value only when factor snap-backs are violent; otherwise the signal chops. Better risk control, but we pay with lower, less predictable edge.

- Multi PC Portfolio



	Long Ticker	Long Sector	Long Mkt Cap (B)	Long Avg Vol (M)	Long Beta	Short Ticker	Short Sector	Short Mkt Cap (B)	Short Avg Vol (M)	Short Beta
1	AXON	Industrials	55.65	0.64	1.40	AXP	Financials	237.77	2.62	1.29
2	BG	Consumer Staples	16.40	2.04	0.65	BEN	Financials	12.08	3.75	1.54
3	BRK-B	Financials	1078.55	4.54	0.78	C	Financials	190.39	14.62	1.40
4	DE	Industrials	125.43	1.35	1.01	D	Utilities	51.49	4.81	0.59
5	ELV	Health Care	71.74	2.50	0.60	GL	Financials	11.71	0.63	0.56
6	EQIX	Real Estate	77.35	0.51	0.91	ITW	Industrials	76.09	0.93	1.11
7	HSY	Consumer Staples	38.13	1.60	0.26	MS	Financials	255.59	5.29	1.34
8	HUM	Health Care	30.66	1.79	0.45	NTRS	Financials	25.42	1.34	1.32
9	IFF	Materials	15.56	2.14	1.09	NVDA	Information Technology	4338.39	172.39	2.10
10	MNST	Consumer Staples	63.80	5.67	0.54	PCAR	Industrials	52.77	2.90	0.94
11	NEM	Materials	93.64	11.09	0.35	RJF	Financials	35.03	1.05	1.06
12	STX	Information Technology	46.32	3.77	1.55	STT	Financials	32.83	1.90	1.52
13	TPL	Energy	21.94	0.15	1.20	TFC	Financials	59.34	7.67	0.86
14	TTWO	Communication Services	47.25	1.75	1.00	TROW	Financials	22.73	1.57	1.53
15	WYNN	Consumer Discretionary	13.41	1.93	1.36	WEC	Utilities	36.32	2.05	0.42
16	Average		119.72	2.76	0.88	Average		362.53	14.90	1.17

- Changes compared to PC1 portfolio
  - Long: DE, HSY, IFF replaced CI, CNP, UHS
  - Short: D, NVDA, WEC replaced CTAS, GPC, RTX
- We have no net exposure to Information Technology and Industrials.
- We went from being net long Utilities to being net short while the net long exposure of Consumer Staples increased from 13% to 20%.
- The net defensive profile (Health Care, Staples, Utilities) decreased from 47% to 20%.

- Multi PC Static Backtests

Period	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Scaling_Factor	VIX_Avg	US10Y_Δ_bps
Post-GFC Snap-Back	+2.57%	+3.94%	-1.34%	2.43	3.45	0.63	-0.27	-2.36%	0.422	34.8	+14.3
QE2 Anticipation	+0.82%	+3.92%	-2.93%	0.55	0.66	0.19	-0.97	-3.66%	1.000	21.1	-9.4
US Credit Downgrade	+1.44%	-5.13%	+6.00%	0.60	0.80	0.20	-0.37	-7.41%	0.379	35.0	-82.5
China Devaluation	+2.03%	+3.13%	-0.97%	1.18	1.63	0.45	0.45	-3.72%	0.854	23.8	+2.6
COVID Summer	+3.07%	+4.04%	-0.74%	1.25	1.93	0.56	0.10	-2.76%	0.740	27.8	-13.7
Post-Inflation Unwind	+0.03%	+2.26%	-1.69%	0.08	0.15	0.04	1.44	-7.32%	0.999	20.7	-9.9
2025 Macro Risk Regime	+2.16%	+10.27%	-7.99%	0.97	1.27	0.44	-0.63	-3.34%	0.614	24.2	+23.8

```
Average Sharpe Ratio: 1.01
Average Max Drawdown: −4.37%
Average Skew: −0.04
Average Scaling Factor: 0.715
```

Observations

- Positive performance in all seven windows (avg 1.7%); Sharpe peaks (2.4) Post-GFC, sinks during Post-Infl (0.08).
- Long leg dominates in late-cycle easing (2025 +10.3%), while short alpha cushions crashes (US-Credit +6 %).
- Lower average Sharpe than PC1 Static, but tighter tails (skew ≈ 0) and slightly lower drawdowns.
- Bottom line: The diversified factor basket smooths returns as we observe lower headline Sharpe vs PC1 but steadier contribution mix and no heavy tails.

- Multi PC Dynamic Strategy: Calibration and Backtests

```
Optimal z-pair across calibration windows: Entry −1, Exit 1
```

Period	Entry_z	Exit_z	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Hit_Ratio	PF	Trades	F
Post-GFC Snap-Back	-1.00	1.00	-0.58%	+4.89%	-4.91%	-0.63	-0.43	-0.14	-1.42	-3.00%	33.3%	0.79	3	
QE2 Anticipation	-1.00	1.00	+1.45%	+2.12%	-0.34%	4.34	nan	1.25	3.73	-0.08%	100.0%	inf	2	
US Credit Downgrade	-1.00	1.00	+3.05%	+5.23%	-1.98%	4.22	nan	1.17	4.77	-0.08%	100.0%	inf	1	
China Devaluation	-1.00	1.00	+1.26%	+5.59%	-3.86%	1.24	0.90	0.39	2.42	-1.94%	50.0%	2.34	2	
COVID Summer	-1.00	1.00	+3.62%	+6.49%	-2.12%	2.42	2.66	0.90	0.88	-1.81%	66.7%	53.76	3	
Post-Inflation Unwind	-1.00	1.00	-3.35%	+2.89%	-5.88%	-2.85	-1.65	-1.10	-1.85	-4.58%	33.3%	0.00	3	
2025 Macro Risk Regime	-1.00	1.00	+3.09%	+4.87%	-1.02%	2.41	2.73	0.91	1.16	-1.92%	66.7%	38.49	3	

```
Average Sharpe Ratio: 1.59
Average Max Drawdown: −1.92%
Average Skew: 1.38
Average Weekly Rebalances: 1.6
```

Observations

- Four big winners (QE2, US Credit, Downgrade, Covid Summer, and 2025) and one large loser (Post-Infl).
- Average Sharpe 1.6, lifted by fat-right-tail outcomes (skew +1.4).
- Max-DD only –1.9 %.
- Bottom line: A convex, opportunistic overlay with low bleed and strong upside when factors gap, but edge concentrates in few events.

- Fama-French Five-Factor Regressions against the returns of the dynamic strategies (PC1/Multi PC) for OOS 2023 period (2025 data not yet available)

	PC1 Static · 2023	Multi-PC Static · 2023
Alpha (bps/day)	2.97	1.01
t(Alpha)	0.27	0.11
R^2	0.41	0.50
MKT	-0.03	0.03
SMB	-0.51	-0.33
HML	-0.68	-0.71
RMW	-0.23	-0.41
CMA	0.58	0.87
UMD	0.21	0.27

Observations

- The Fama-French regressions show no statistically significant alpha for either basket in 2023. PC1 displays a small positive intercept of ≈ 3 bp/day (t ≈ 0.27), while the Multi-PC sleeve shows a slightly positive ≈ 1 bp/day (t ≈ 0.11). In both cases, the t-stats are well below significance thresholds, confirming that any apparent edge in 2023 was fully explained by systematic exposures rather than idiosyncratic stock-selection.
- Both baskets remain essentially market-neutral (β close to 0) and tilted against small caps (SMB ≈ –0.5 for PC1, –0.3 for Multi-PC), in line with an orientation toward large, defensive stocks. The anti-value stance is again strong (HML ≈ –0.7), echoing 2023's growth leadership.
- The conservative investment (CMA) tilt is positive for both, slightly stronger in the Multi-PC sleeve (≈ 0.87 vs 0.58 for PC1). This points to a bias toward mature, low-investment firms over capex-heavy cyclicals—consistent with "quality defensives" exposure in a stress-regime framework. Profitability (RMW) betas are modestly negative, reinforcing that this quality tilt comes more from capital discipline than from earnings strength.
- Momentum (UMD) exposures are small but positive for both baskets (≈ 0.2–0.3), consistent with leaning into the prevailing mega-cap growth trend.
- The Multi-PC portfolio shows a higher R^2 (≈ 0.50 vs 0.41 for PC1), meaning a greater share of its return variance is captured by standard factors. PC1 remains the more idiosyncratic sleeve, while Multi-PC offers more factor-aligned performance. Taken together, this suggests that PC1 retains greater potential for macro-driven alpha, whereas Multi-PC offers a steadier, more diversified expression of the theme.

- ETF Sector and Factor Regressions

	PC1 Static · 2023			PC1 Static · 2025			Multi-PC Static · 2023			Multi-PC Static · 2025		
	Beta	t-Stat	p-Value	Beta	t-Stat	p-Value	Beta	t-Stat	p-Value	Beta	t-Stat	p-Value
Intercept	0.00	1.68	0.11	-0.00	-0.54	0.60	0.00	0.70	0.49	-0.00	-0.64	0.53
CL=F (Oil (WTI Futures))	0.01	0.26	0.79	0.15	2.00	0.06	-0.02	-0.40	0.69	0.15	2.27	0.03
DX-Y.NYB (DXY)	0.11	0.30	0.77	-0.02	-0.07	0.95	0.40	1.08	0.29	-0.20	-0.71	0.48
ESMV (Enhanced Min Vol)	0.83	1.03	0.32	-0.25	-0.16	0.88	0.60	0.70	0.49	-0.78	-0.53	0.61
GC=F (Gold (Comex Futures))	0.17	1.04	0.31	-0.02	-0.17	0.87	0.13	0.76	0.45	-0.04	-0.32	0.75
IEF (7-10Y Treasuries)	-1.29	-0.87	0.39	-1.82	-0.44	0.67	-1.96	-1.26	0.22	-2.98	-0.77	0.45
IEI (3-7Y Treasuries)	0.46	0.23	0.82	0.03	0.01	1.00	2.59	1.20	0.24	2.25	0.49	0.63
IYR (Real Estate)	0.01	0.12	0.91	0.27	0.94	0.36	0.08	0.63	0.53	0.25	0.95	0.35
IYZ (Communication Services)	-0.25	-1.37	0.18	-0.07	-0.23	0.82	0.08	0.40	0.69	-0.02	-0.08	0.94
MTUM (Momentum)	0.67	1.40	0.18	-0.33	-0.89	0.38	0.27	0.53	0.60	-0.37	-1.07	0.30
NOBL (SPX Dividend Aristocrats)	-0.50	-1.10	0.28	-1.07	-1.74	0.10	-1.06	-2.24	0.04	-1.05	-1.85	0.08
QUAL (Quality)	-0.58	-0.94	0.36	-0.33	-0.61	0.55	-0.94	-1.44	0.16	-0.53	-1.07	0.30
SHY (1-3Y Treasuries)	-0.06	-0.03	0.97	4.01	1.14	0.27	-1.69	-0.88	0.39	1.28	0.39	0.70
SIZE (Size)	0.24	0.48	0.64	-0.22	-0.66	0.52	-0.11	-0.21	0.83	-0.28	-0.90	0.38
SMMV (Small Cap Min Vol)	0.07	0.35	0.73	-0.21	-0.35	0.73	0.08	0.35	0.73	-0.09	-0.16	0.87
TLH (10-20Y Treasuries)	0.05	0.05	0.96	0.64	0.33	0.75	0.29	0.26	0.79	1.40	0.77	0.45
TLT (20+Y Treasuries)	-0.11	-0.16	0.87	-0.31	-0.29	0.78	-0.01	-0.02	0.98	-0.67	-0.67	0.51
USMV (Min Volatility)	-0.43	-0.53	0.60	1.51	1.18	0.25	-0.35	-0.41	0.69	1.60	1.35	0.19
VLUE (Value)	0.55	1.85	0.08	-0.01	-0.03	0.98	0.13	0.42	0.68	0.40	0.84	0.41
XLB (Materials)	0.27	1.18	0.25	0.45	1.52	0.14	0.52	2.15	0.04	0.39	1.44	0.17
XLE (Energy)	-0.11	-0.63	0.53	-0.18	-1.21	0.24	0.01	0.04	0.96	-0.16	-1.19	0.25
XLF (Financials)	-0.92	-4.14	0.00	0.39	0.93	0.36	-0.76	-3.24	0.00	0.32	0.82	0.42
XLI (Industrials)	-0.69	-2.63	0.02	0.15	0.45	0.66	0.12	0.42	0.68	0.26	0.87	0.40
XLK (Technology)	-0.13	-0.35	0.73	0.66	1.08	0.29	-0.22	-0.57	0.57	0.50	0.90	0.38
XLP (Consumer Staples)	0.03	0.14	0.89	-0.09	-0.26	0.80	0.10	0.37	0.72	0.23	0.69	0.50
XLU (Utilities)	0.02	0.16	0.88	0.24	0.82	0.42	-0.08	-0.60	0.56	-0.12	-0.42	0.68
XLV (Health Care)	0.15	0.45	0.66	0.27	1.39	0.18	0.41	1.17	0.26	0.20	1.08	0.29
XLY (Consumer Discretionary)	-0.04	-0.19	0.85	0.37	1.11	0.28	-0.14	-0.67	0.51	0.22	0.72	0.48
^GSPC (S&P 500)	0.82	0.63	0.53	-1.19	-0.75	0.46	1.54	1.13	0.27	-0.51	-0.35	0.73
^MOVE (MOVE Index)	0.01	0.32	0.75	-0.02	-0.62	0.54	0.05	1.78	0.09	0.01	0.21	0.83
^TNX (US-10Y Treasury Yield)	-0.37	-1.66	0.11	-0.08	-0.25	0.80	-0.16	-0.68	0.50	-0.07	-0.22	0.83
^VIX (VIX)	-0.01	-0.51	0.61	0.03	1.19	0.25	0.02	0.89	0.38	0.04	1.41	0.17

Observations

- 2023 – SVB / Rate-Shock Regime: PC1 Static shows heavy shorts in Financials (XLF, β ≈ –0.92, t ≈ –4.1) and Industrials (XLI, β ≈ –0.69, t ≈ –2.6), which directly captured the banking/funding stress and industrial slowdown that defined the post-SVB period. A modest long in Materials (XLB, β ≈ 0.27, t ≈ 1.2) and a tilt to Value (VLUE, β ≈ 0.55, t ≈ 1.9) round out the profile. Multi-PC Static shares the core Financials short (β ≈ –0.76, t ≈ –3.2) but disperses risk further: a larger, significant short in Dividend Aristocrats (NOBL, β ≈ –1.06, t ≈ –2.2), a small but statistically relevant long in Materials (XLB, β ≈ 0.52, t ≈ 2.2), and mild positive exposure to Quality, Min Vol, and even Gold. Compared with PC1, the Multi-PC sleeve looks broader, with factor tilts that raise explanatory power and reduce single-theme concentration.
- 2025 – Stagflation / Twin-Deficit Scare: PC1 Static rotated sharply into inflation hedges, most notably a long in Oil (CL=F, β ≈ 0.15, t ≈ 2.0) and Materials (XLB, β ≈ 0.45, t ≈ 1.5), alongside a positive tilt to Technology (XLK, β ≈ 0.66, t ≈ 1.1). Treasuries are mixed, with small longs in TLH and SHY but little significance. The sleeve clearly leaned toward commodities and real assets as protection against stagflation risk. Multi-PC Static picks up similar macro signals but with greater diversification. Oil again shows up (CL=F, β ≈ 0.15, t ≈ 2.3), supported by Value (VLUE, β ≈ 0.40, t ≈ 0.8), and defensive tilts in Min Volatility (USMV, β ≈ 1.6, t ≈ 1.4) and Health Care (XLV, β ≈ 0.20, t ≈ 1.1). Cyclicals such as Industrials, Energy, and Financials are more muted. The effect is a more factor-aligned return stream: less punchy than PC1, but smoother across sectors.
- Bottom-Line: ETF regressions validate the design: PC1 expresses high-conviction macro trades with greater idiosyncratic risk, while Multi-PC smooths those same ideas into a more diversified factor profile. Together, they remain complementary sleeves for monetising SPX/USD co-decline regimes: one focused, one stabilised.

- Stress Test Periods

#	Label	Start date	End date	Catalyst / Notes
1	Euro-area debt crisis – Wave 1	**26-Apr-2010**	**10-Jun-2010**	Greek junk downgrade: ECB SMP / Bundestag vote
2	2013 Taper-Tantrum	**22-May-2013**	**24-Jun-2013**	Bernanke “taper” testimony: UST-yield spike & EM rout
3	Oil-price collapse / deflation scare	**28-Nov-2014**	**20-Jan-2015**	OPEC refuses cuts: WTI lows, ECB QE announcement
4	Brexit referendum shock	**24-Jun-2016**	**01-Jul-2016**	GBP collapse: BoE easing signals steady markets
5	US–China tariff re-escalation	**06-May-2019**	**28-Jun-2019**	Trump 25 % tariff tweet: G-20 Osaka “truce”
6	COVID-19 crash	**20-Feb-2020**	**23-Mar-2020**	Global lockdowns: Fed “QE-infinite” & CARES Act
7	2022 inflation / Fed shock	**03-Jan-2022**	**16-Jun-2022**	CPI surge & FOMC 75 bp lift-off: YTD SPX low
8	SVB banking panic	**06-Mar-2023**	**30-Mar-2023**	SVB warning/FDIC takeover: funding stress eases

- Static PC1 Stress Tests

Period	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Scaling_Factor	VIX_Avg	US10Y_Δ_bps
Euro-area Debt Crisis (Wave 1)	+1.34%	-5.30%	+6.49%	0.87	1.54	0.31	-0.05	-3.48%	0.559	30.5	-49.6
2013 Taper Tantrum	+2.41%	-4.17%	+6.57%	2.82	4.23	0.83	-0.12	-2.67%	1.000	16.4	+52.2
Oil Price Collapse / Deflation	+3.70%	+0.91%	+2.90%	2.36	4.34	0.83	0.17	-4.01%	1.000	17.4	-38.7
Brexit Referendum Shock	+1.49%	+2.44%	-0.90%	4.60	6.03	0.71	-0.03	-1.01%	0.360	19.2	-12.3
US–China Tariff Re-Escalation	+3.97%	+3.46%	+0.76%	2.46	4.94	0.95	0.06	-3.02%	1.000	16.5	-50.0
COVID-19 Crash	-29.87%	-39.84%	+13.01%	-5.21	-6.57	-1.57	-0.55	-31.14%	0.224	47.8	-76.1
2022 Inflation / Fed Shock	+4.60%	-12.84%	+17.17%	0.71	0.90	0.47	-0.55	-7.25%	0.875	26.2	+167.9
SVB Banking Panic	+4.88%	-1.47%	+6.26%	4.60	10.23	1.26	1.17	-1.68%	0.677	22.1	-43.2

```
Average Sharpe Ratio: 1.65
Average Max Drawdown: −6.78%
Average Skew: 0.01
Average Scaling Factor: 0.712
```

Observations

- Five Sharpe ratios above 2, works well in classic macro shocks (Taper, Oil price collapse, Brexit, Tariff, SVB).
- Covid crash largely affected the long book (-40 %), overpowering short hedge, which led to a Sharpe of –5.2 (the only negative Sharpe).
- Average Sharpe 1.65, but important dispersion; performance tightly linked to whether sell-off is factor-divergent (positive) or beta-compression (negative).
- Bottom line: Reliable when stress expresses through factor spreads; vulnerable to one-way index meltdowns.

- Dynamic PC1 Stress Tests

Period	Entry_z	Exit_z	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Hit_Ratio	PF	Trades
Euro-area Debt Crisis (Wave 1)	-0.50	0.50	+0.15%	-4.98%	+4.54%	0.21	0.21	0.06	0.22	-1.89%	50.0%	1.12	4
2013 Taper Tantrum	-0.50	0.50	+2.31%	-5.43%	+7.58%	4.76	6.49	1.17	0.49	-1.75%	66.7%	3.06	3
Oil Price Collapse / Deflation	-0.50	0.50	+0.44%	-2.83%	+2.65%	0.75	0.79	0.22	1.93	-2.05%	25.0%	1.22	4
Brexit Referendum Shock	-0.50	0.50	-0.08%	-0.08%	-0.08%	-7.80	nan	-1.00	-1.79	-0.08%	0.0%	0.00	1
US–China Tariff Re-Escalation	-0.50	0.50	+1.10%	+1.44%	-1.19%	1.15	1.43	0.37	0.64	-2.19%	66.7%	1.49	6
COVID-19 Crash	-0.50	0.50	-21.71%	-30.32%	+9.94%	-6.07	-4.13	-1.52	-2.23	-22.52%	20.0%	0.03	5
2022 Inflation / Fed Shock	-0.50	0.50	-1.02%	-17.16%	+15.71%	-0.17	-0.13	-0.09	-0.72	-8.56%	50.0%	0.91	16
SVB Banking Panic	-0.50	0.50	+1.46%	+1.37%	-0.38%	2.39	2.91	0.54	0.12	-1.81%	66.7%	6.90	3

```
Average Sharpe Ratio: −0.60
Average Max Drawdown: −5.11%
Average Skew: −0.17
Average Weekly Rebalances: 2.4
```

Observations

- Strong in factor-driven shocks (Taper Sharpe 4.8) and flips out early in SVB (+2.4), but fails hard in Brexit (no exit) and Covid (-6 Sharpe).
- Average Sharpe -0.6; drawdowns capped except Covid (-22 %).
- Decent hit-ratio (≥ 50 %) yet profit-factor collapses when volatility vertical.
- Bottom line: Timing helps only when price discovery is orderly; during a decrease of liquidity the exit-grid cannot react fast enough.

- Static Multi PC Stress Tests

Period	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Scaling_Factor	VIX_Avg	US10Y_Δ_bps
Euro-area Debt Crisis (Wave 1)	-0.03%	-7.07%	+6.94%	0.04	0.07	0.02	0.17	-3.78%	0.564	30.5	-49.6
2013 Taper Tantrum	+1.68%	-4.90%	+6.62%	2.09	2.99	0.62	-0.37	-2.53%	1.000	16.4	+52.2
Oil Price Collapse / Deflation	+4.32%	+1.55%	+2.88%	2.83	4.77	0.99	0.05	-3.56%	1.000	17.4	-38.7
Brexit Referendum Shock	+2.56%	+3.46%	-0.83%	8.65	16.05	1.33	-0.21	-0.67%	0.386	19.2	-12.3
US–China Tariff Re-Escalation	+5.29%	+4.79%	+0.69%	3.47	5.96	1.35	-0.32	-3.15%	1.000	16.5	-50.0
COVID-19 Crash	-26.54%	-35.92%	+11.74%	-5.01	-6.38	-1.51	-0.49	-27.65%	0.222	47.8	-76.1
2022 Inflation / Fed Shock	+7.08%	-13.37%	+19.59%	1.07	1.50	0.71	-0.33	-6.61%	0.865	26.2	+167.9
SVB Banking Panic	+4.89%	-0.80%	+5.62%	5.12	14.32	1.41	1.67	-1.18%	0.719	22.1	-43.2

```
Average Sharpe Ratio: 2.28
Average Max Drawdown: −6.14%
Average Skew: 0.02
Average Scaling Factor: 0.720
```

Observations

- Positive six times out of eight; best Sharpe 8.7 (Brexit micro-window).
- Fails in Covid (same beta-compression issue as PC1).
- Short book a consistent profit engine (> +5 % in five shocks).
- Average drawdowns slightly lower to PC1 Static, but higher average Sharp (2.28 vs. 1.65). When rate, FX and commodity shocks overlap (e.g., Oil-collapse 2015, SVB 2023) the dispersion captured by PC-2/3 pays off even when PC1 is only middling.
- Bottom line: More factor-diversified but still long-beta exposed; does well in rotational turmoil, less so in crash-down events.

- Dynamic Multi PC Stress Tests

Period	Entry_z	Exit_z	Total	Long	Short	Sharpe	Sortino	t_Stat	Skew	Max_DD	Hit_Ratio	PF	Trades
Euro-area Debt Crisis (Wave 1)	-1.0	1.0	+1.02%	-1.31%	+1.65%	1.08	1.09	0.32	0.79	-2.69%	66.7%	3.92	3
2013 Taper Tantrum	-1.0	1.0	-0.39%	-4.95%	+4.60%	-0.60	-0.60	-0.15	-0.47	-2.57%	0.0%	0.00	1
Oil Price Collapse / Deflation	-1.0	1.0	-0.85%	-2.53%	+1.52%	-3.78	-0.89	-1.10	-5.21	-0.85%	0.0%	0.00	1
Brexit Referendum Shock	-1.0	1.0	+0.00%	+0.00%	+0.00%	inf	nan	nan	nan	+0.00%	nan%	nan	0
US–China Tariff Re-Escalation	-1.0	1.0	+3.27%	+5.82%	-2.82%	3.28	3.36	1.06	-0.47	-2.01%	66.7%	2.73	3
COVID-19 Crash	-1.0	1.0	-21.00%	-24.70%	+3.47%	-6.27	-3.73	-1.57	-2.09	-21.00%	0.0%	0.00	4
2022 Inflation / Fed Shock	-1.0	1.0	-6.37%	-9.02%	+1.94%	-2.03	-1.04	-1.12	-2.64	-7.85%	25.0%	0.10	4
SVB Banking Panic	-1.0	1.0	+1.11%	+2.95%	-1.85%	3.39	3.26	0.77	0.61	-1.03%	100.0%	inf	1

```
Average Sharpe Ratio: −0.70
Average Max Drawdown: −4.75%
Average Weekly Rebalances: 1.8
Periods with trades: 7/8
```

Observations

- Average Sharpe -0.7, mixed performances: large wins (Tariff Sharpe 3.3, SVB 3.4) and heavy losses (Covid –6.3, Oil –3.8).
- Based on 4 bps one-way transaction costs applied only to the short leg (half the book), average turnover of ~1.8 rebalances/week during active periods translates into ~7 bps/week cost when active, or under 5 bps/week averaged over the full period.
- Bottom line: It pays off when multi-factor divergence is sharp; unsuitable as core hedge.

Conclusion

- Across seven SPX/DXY co-decline regimes since 2009, this strategy demonstrated repeatable crisis alpha. The PC1 basket captured defensive-vs-cyclical compression with highest standalone Sharpe, while Multi-PC diversification muted tail risk across orthogonal factors. Static versions harvest carry during prolonged stress; dynamic timing reduces drawdowns but sacrifices returns. The short book consistently acted as the primary shock-absorber, neutralizing 40-100% of long-side losses during high-volatility regimes. The strategy's large COVID drawdown (between 21% and 31%) highlights its vulnerability to extreme beta-compression events.
- Implementation: Use Static PC1 as a standing hedge for slow-burn stress periods, overlaying Dynamic Multi-PC around known event windows. Avoid deployment during COVID-style systemic panics where factor relationships break down. This modular approach provides portfolio managers with both steady stress-alpha accumulation and tactical crisis defense capabilities.

Strategy	Avg Sharpe (7 core windows)	Avg Max DD	Stress-test Sharpe (8 stress tests)	Worst DD
PC-1 Static	**1.34**	–4.8%	**1.65**	–31.1% (Covid)
PC-1 Dynamic	0.8	**–2.7%**	–0.60	–22.5% (Covid)
Multi-PC Static	1.01	–4.4%	**2.28**	–27.7% (Covid)
Multi-PC Dynamic	**1.6**	**–1.9%**	–0.70	–21% (Covid)

ANNEX

PCA Based Periods

- PCA run on 340 stocks for 2002/2003 and 376 stocks for 2008.

Theme	2002–2003	2007–2008
Trigger	Tech crash + accounting scandals	Subprime mortgage crisis escalation
Main sector pain	Tech, Telecom, Financials	Financials, Housing, Structured Credit
Risk sentiment	Loss of trust in earnings + transparency	Liquidity crisis + counterparty fears
Policy action	Sarbanes-Oxley, accommodative Fed	Emergency liquidity programs, aggressive cuts
Equity trend	Bear market bottoming	Bear market in mid-descent
Macro context	Slow recovery post-2001 recession	Pre-GFC recession buildup

- Dot-Com Fallout & Accounting Scandals (May 2002 – Jan 2003)

The U.S. was in the late stages of the 2000–2002 bear market, grappling with the dot-com crash aftermath and a crisis of corporate credibility. High-profile accounting scandals (Enron's collapse in late 2001, WorldCom in mid-2002) eroded investor confidence. The economy was sluggish coming out of the 2001 recession, and the Fed was cutting rates aggressively toward generational lows to ward off deflation. Geopolitically, the post-9/11 environment added uncertainty, but the main issues were domestic (corporate governance and tech bubble unwinding). Market Performance: The S&P 500 continued to grind lower through most of 2002, ultimately bottoming in October 2002. From May 3, 2002 to early January 2003, the index lost a significant portion of its value (the S&P was down roughly -24% in 2002 calendar-year. The VIX was persistently high (ranging in the 20s and spiking above 30 during panicky moments in July and October 2002) reflecting ongoing fear. Notably, the U.S. dollar index (DXY), which had hit multi-year highs in early 2002, fell steadily over this period – investors moved out of U.S. assets and the USD weakened ~10% (the DXY slid from ~108 in May 2002 to the mid-90s by Jan 2003, a reaction to Fed easing and waning foreign appetite for U.S. stocks). Overall, defensive, non-cyclical sectors (Staples, Utilities, Health) emerged as relative outperformers – some even had positive returns – while high-beta or overvalued sectors (Tech, Telecom, Consumer Discretionary) were hit the hardest. Consumer staples stocks were among the only winners during the 2000–02 bear, while tech collapsed nearly 80% peak-to-trough

- Pre-Lehman Global Financial Crisis Escalation (Nov 2007 – Aug 2008)

In late 2007 through summer 2008, the financial crisis was intensifying. The U.S. housing bubble had burst in 2006–07, subprime mortgage defaults were soaring, and by 2007 Q4 the stress had spread to major financial institutions. This period covers just before the worst phase of the Global Financial Crisis: it begins near the S&P 500's October 2007 peak and ends a month before Lehman Brothers' collapse (Sept 2008). Key events included the failure of Bear Stearns in March 2008, a rapid Fed easing cycle (Fed funds rate cut from ~5% in mid-2007 to ~2% by mid-2008), and mounting global inflation pressures (oil and commodity prices were spiking to record highs by mid-2008, even as growth slowed). Geopolitically, there were no major new shocks – the turmoil was largely economic/financial. Equities entered a bear market – the S&P 500 declined roughly -20% from Nov 2, 2007 to mid-Aug 2008 (and it would fall much further after our cutoff). The dollar (DXY) was weak and trending down for most of this period. In fact, by mid-2008 the dollar index was near multi-year lows as the U.S. economic outlook deteriorated and Fed rate cuts made USD-funded carry trades attractive. (The DXY fell from ~78 in Nov 2007 to the low 70s by mid-'08 – a significant decline – before bottoming in summer 2008.) The VIX was elevated above 18 throughout and began climbing into the 20s; it wasn't at panic extremes yet, but volatility was notably higher than the benign 2006–07 period. In this pre-Lehman regime, Energy and Materials were standout outperformers (riding the commodity bubble), defensive sectors (Staples, Utilities, Health Care) fell less than the market, and Financials and Consumer Discretionary were the worst performers (directly hit by the crisis and consumer pullback). This underscores that in an inflationary-stagflationary stress (growth down, prices up), commodity-linked sectors can diverge positively, whereas credit-sensitive and consumer sectors get hit hardest.

Periods of SPX/ DXY co-decline with US rates reactions

- Lower rates:

Period (Duration)	S&P 500 Decline	DXY Decline	10Y Yield Change	Fed Policy Stance	Key Macro Drivers
Mid-2002 (Apr–Oct 2002)	–30% (bear market)	–10% (approx.)	**Fell** (5.4%→~4.0%)	**Dovish** – rate cuts	Post-dotcom recession; corporate scandals (Enron, WorldCom); **deflationary** pressures (CPI <2%); safe-haven Treasury bid. VIX spiked >40.
Late 2007–Mar 2008 (Q4'07–Q1'08)	–15% (pre-GFC selloff)	–5% (USD weakness)	**Fell** (4.5%→3.3%) by Mar	**Dovish** – emergency cuts	**Growth scare** as credit crunch began (subprime crisis); Fed slashed rates; USD fell as Fed eased faster than ECB; VIX > 25.
Jan–Feb 2016 (6 weeks)	–12% (sharp correction)	–5%	**Fell** (2.3%→1.7%)	**Dovish** – hike paused	China slowdown & oil price crash; global **recession** fears; Fed paused tightening after 2015 hike; safe-haven Treasury rally. VIX ~28.
Q4 2018 (Sep–Dec 2018)	–20% (near-bear)	~–2% (mild)	**Fell** (3.2%→2.7%)	**Dovish shift** by end	"Fed-too-hawkish" growth scare; rising trade war uncertainty; financial conditions tightened until Fed signaled a pause; VIX > 30 by Dec.
Mar 2023 (Feb–Mar 2023)	–8% (banking scare)	–2%	**Fell** (4.0%→3.3%)	**Dovish** – emergency loans	Regional **bank failures** (SVB, etc.) spurred recession fears; investors anticipated Fed rate cuts, slamming yields down; USD weakened as rate outlook shifted; VIX mid-20s.

- Higher rates:

Period (Duration)	S&P 500 Decline	DXY Decline	10Y Yield Change	Fed Policy Stance	Key Macro Drivers
Mid-2006 (May–Jun 2006)	–8% (selloff)	–2%	**Rose** (≈5.0%→5.25%)	**Hawkish** – hiking cycle	Late-cycle **inflation fears** (energy prices rising); Fed continued tightening to 5.25%; global "risk-off" in emerging markets; VIX > 20.
Feb 2007 (late Feb 2007)	–6% (sharp drop)	–2%	**Rose** (trend ↑ to 5% by mid-07)	**On hold** (tight bias)	**Global jitters** (China stock crash, yen carry trade unwind); underlying inflation still a concern; dollar on a downtrend; VIX ~18.
Stagflation Summer 2008 (May–Jul 2008)	–15% (into bear market)	~0% (USD at lows)	**Rose** (3.5%→4.1% by Jun)	**Hawkish pause** – Fed on hold at 2%	**Stagflation fears**: Oil price spike to $140+ drove headline inflation >5%; despite a 20% stock drop, commodity stocks soared; Fed paused cuts and signaled inflation concern; USD remained weak near record lows, exacerbating oil's rise. VIX ~20–25.
Jan–Feb 2018 (Feb 2018 correction)	–10% (volatility shock)	~–2% (USD weak YTD)	**Rose** (2.4%→2.9%)	**Hawkish** – steady hikes	**Inflation surprise**: wage growth jump stoked **inflation expectations**; 10Y yield hit a 4-year high; fear of faster Fed hikes triggered equity correction; VIX spiked >37 (volatility event). *(Notably, the dollar was near 3-year lows despite U.S. rate hikes, reflecting global growth optimism and twin-deficit worries.)*
Early 2022* (Jan–Mar 2022)	–12% (market pullback)	*USD **rose** in 2022*	**Rose** (1.5%→2.5%)	**Hawkish** – rapid hikes	**Post-pandemic inflation boom**: Although not a DXY-down episode (the USD **strengthened** as the Fed led globally), this period typifies an inflation-driven selloff – multi-decade high inflation, aggressive Fed tightening, **stocks & bonds sold off together**. Tech and rate-sensitive sectors plunged, while energy stocks (buoyed by $100+ oil) **soared**. VIX > 30.

Factor ETF Descriptions

- MTUM – iShares MSCI USA Momentum Factor ETF Factor: Momentum Seeks to track U.S. large- and mid-cap stocks that have high recent total returns over 6–12 months. The momentum factor assumes stocks that have performed well recently will continue to do so in the short term.
- USMV – iShares MSCI USA Minimum Volatility ETF Factor: Minimum Volatility Designed to provide exposure to U.S. stocks with lower historical volatility, aiming for smoother performance. It selects stocks that reduce overall portfolio variance using an optimization algorithm.
- QUAL – iShares MSCI USA Quality Factor ETF Factor: Quality Focuses on companies with high return on equity, stable earnings, and low debt. The quality factor favors financially healthy firms with strong profitability and balance sheets.
- VLUE – iShares MSCI USA Value Factor ETF Factor: Value Targets U.S. stocks with lower valuation multiples (e.g., price-to-book, price-to-earnings) relative to peers. The value factor bets that undervalued stocks will eventually revert to fair value.
- SIZE – iShares MSCI USA Size Factor ETF Factor: Size Emphasizes exposure to smaller market-cap U.S. stocks within the large- and mid-cap universe. The size factor posits that smaller companies can outperform larger ones over time due to inefficiencies.
- SMMV – iShares MSCI USA Small-Cap Minimum Volatility ETF Factor: Small-Cap Minimum Volatility Invests in U.S. small-cap stocks with historically low volatility, combining the size and low-volatility factors. Designed to capture small-cap return potential with lower risk.
- ESMV – iShares MSCI USA Enhanced Minimum Volatility ETF Factor: Enhanced Minimum Volatility A more aggressive version of USMV. It optimizes for low volatility with higher expected returns, factoring in earnings quality and sentiment. It blends low-volatility and quality-style enhancements for a refined defensive exposure.

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