Volatility Regimes and Trend-Following Performance in U.S. Equities: An Empirical Deconstruction

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Abstract

This paper evaluates a standard trend-following rule ($P_t > SMA_{50,t}$) on SPY over a 33-year sample (1993-01-29 to 2026-02-13). Unconditionally, the strategy underperforms buy-and-hold on Sharpe (**0.32** vs. **0.46**) and CAGR (**3.83%** vs. **8.68%**), but materially improves downside containment (MaxDD **-36.46%** vs. **-56.47%**). A regime-conditional decomposition reveals structural asymmetry: quality is concentrated in Low Volatility (Sharpe 1.55) and decays through volatility expansion (Normal 0.11, High 0.21). Walk-forward validation remains directionally consistent (OOS Sharpe 0.33 across 61 test windows), supporting robustness of the central result.

1 Introduction

Trend-following in equities is frequently framed as "crisis alpha," i.e., superior return quality during volatility shocks. We test that claim by conditioning performance on out-of-sample volatility regimes instead of relying on unconditional averages. This framing is closely related to the momentum and time-series trend literature [2, 3, 1].

The empirical profile in this sample is not a smile; it is closer to a checkmark. Performance quality is strongest in Low Volatility and degrades in Normal and High Volatility states. The strategy still provides material drawdown truncation, but that benefit is risk-management oriented, not broad crisis-state alpha.

1.1 Hypotheses and contributions

Hypotheses tested:

- **H1 (Crisis alpha):** trend-following quality is highest in High Volatility states.
- **H2 (Low-vol dominance):** trend-following quality is highest in Low Volatility states.
- **H3 (Transition bleed):** the largest quality decay occurs during $Low \rightarrow Normal$ transitions.

Contributions:

- OOS regime decomposition with expanding-window state labels.
- Transition-level microstructure diagnostics for where quality is lost.
- Robustness stack across walk-forward, cost/rebalance, SMA sweep, and cross-asset checks.
- Explicit hypothesis-to-evidence mapping.

2 Data and Methodology

2.1 Sample and signal

Instrument: SPY (robustness assets: QQQ and IWM). Raw sample window: 1993-01-29 to 2026-02-13. Effective analysis starts 1993-04-12 after indicator warm-up and out-of-sample regime eligibility.

Trading signal:

$$\text{Position}_t = \begin{cases} 1 & \text{if } P_t > SMA_{50,t} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Execution assumptions: monthly rebalance, 10 bps turnover cost.

2.2 Regime definition and validation

Regimes are defined from annualized 21-day realized volatility using expanding-window quantiles: Low ($<$ 25th percentile), Normal (25th–75th), and High ($>$ 75th). This prevents look-ahead in threshold construction.

Validation stack:

- Bootstrap confidence intervals and p-values for strategy-minus-benchmark differences by regime.
- High-minus-Normal spread test for strategy-only quality decay.
- Rolling walk-forward evaluation (24-month train / 6-month test).

3 Results

3.1 Unconditional performance: insurance cost vs. tail truncation

- Strategy CAGR: 3.83%; Benchmark CAGR: 8.68%.
- Strategy Sharpe: 0.32; Benchmark Sharpe: 0.46.
- Strategy MaxDD: -36.46%; Benchmark MaxDD: -56.47%.
- Strategy Win Rate: 34.81%; Benchmark Win Rate: 53.66%.

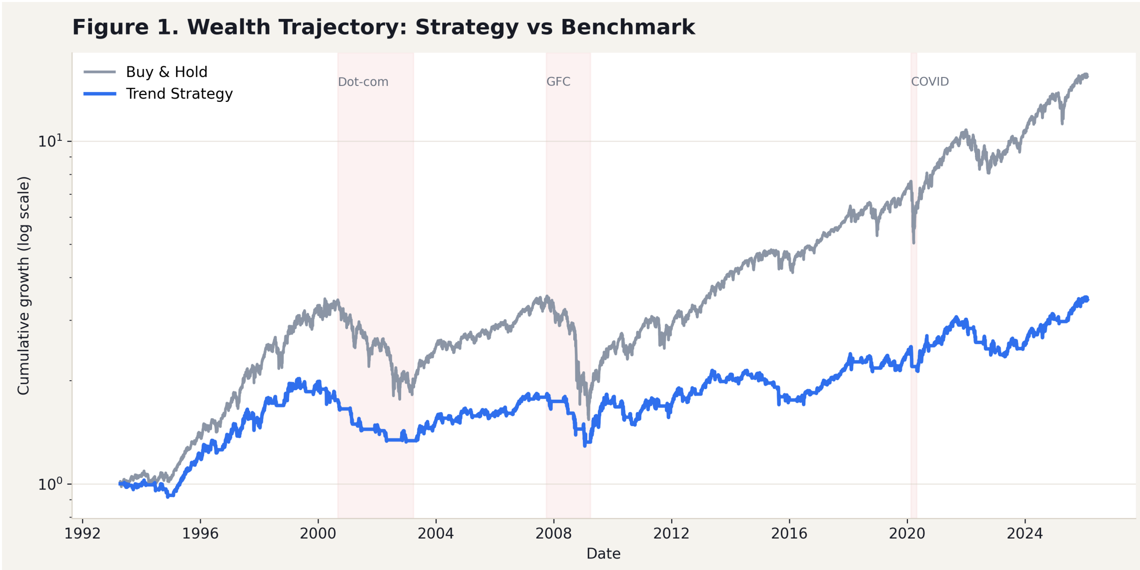

Figure 1: Figure 1. SPY equity curves (log scale), trend strategy vs. buy-and-hold.

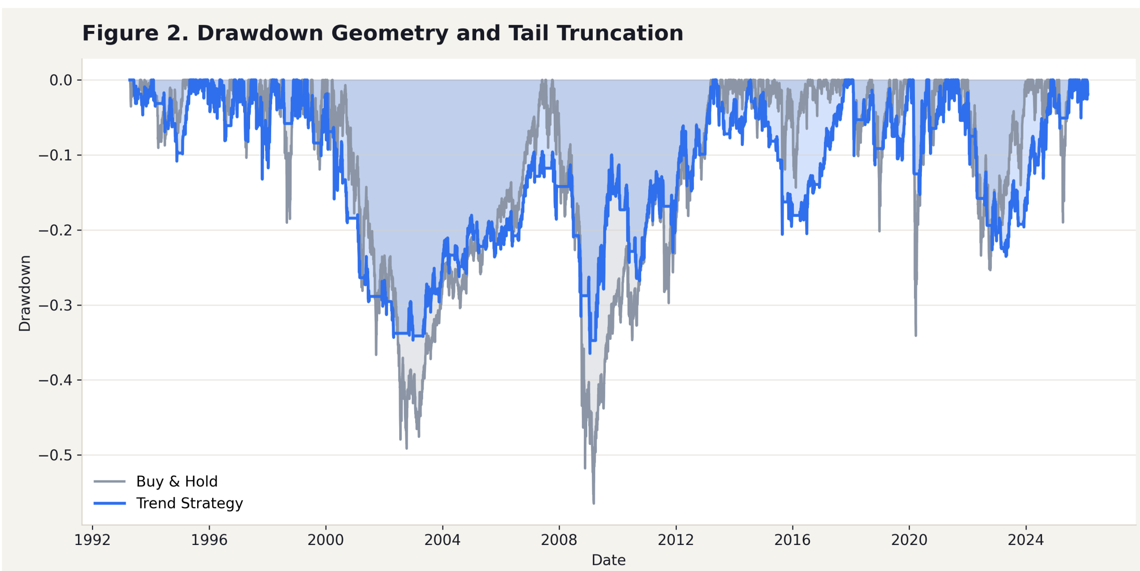

Figure 2: Figure 2. SPY drawdown curves showing tail-risk truncation.

Figures 1 and 2 show the key trade-off: lower trend participation in long bull runs, but materially reduced tail-depth and faster drawdown recovery dynamics.

3.2 Regime anomaly: where quality actually lives

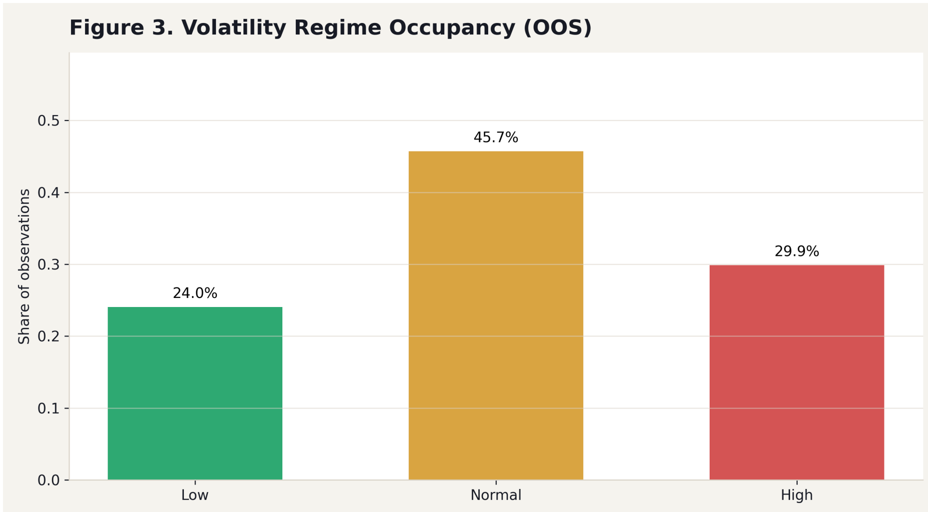

Figure 3: Figure 3. OOS volatility-regime occupancy for SPY.

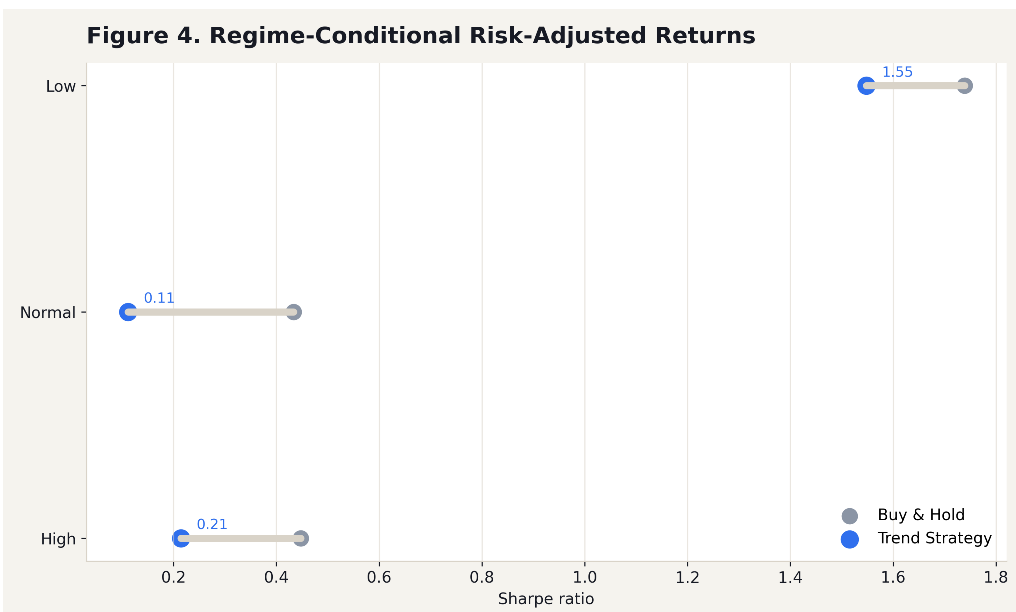

Figure 4: Figure 4. Regime-conditional Sharpe ratios (strategy vs. benchmark).

Figure 3 confirms occupancy is meaningful in all states (Low 24.04%, Normal 45.72%, High 29.86%), so the conditional profile is not a sparse-sample artifact. Figure 4 directly shows the checkmark profile.

- Strategy Sharpe by regime: Low 1.55, Normal 0.11, High 0.21.
- Benchmark Sharpe by regime: Low 1.74, Normal 0.43, High 0.45.
- High-minus-Normal strategy Sharpe spread: 0.10 (95% CI [-0.75, 0.89], p=0.799).

3.3 Transition microstructure and robustness

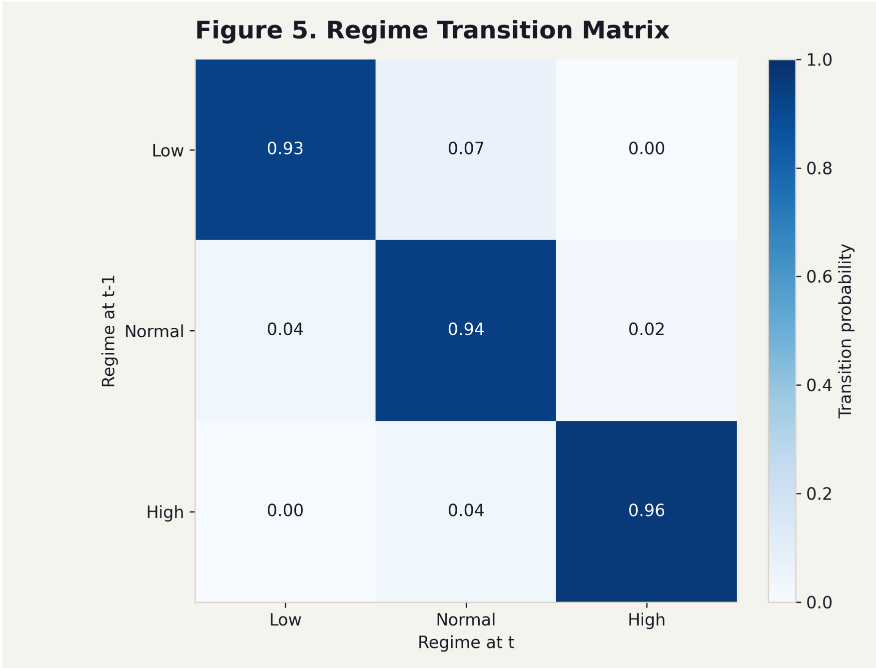

Figure 5: Figure 5. Volatility regime transition matrix.

Figure 5 provides the transition diagnostics:

- $P(\text{High}_t \mid \text{High}_{t-1}) = 96.19\%$.
- $P(\text{Normal}_t \mid \text{Low}_{t-1}) = 6.79\%$.
- Sharpe during $Low \rightarrow Normal$ transitions = -5.09.

The $Low \rightarrow Normal$ handoff is the primary bleed regime: trend smoothness breaks, realized volatility expands, and lagged signals adapt late.

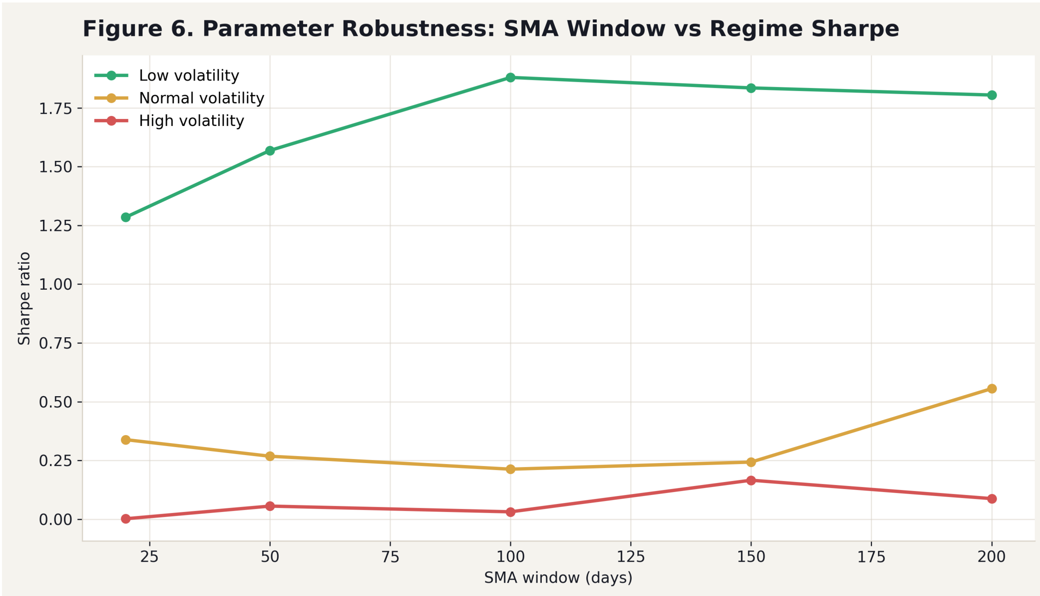

Figure 6: Figure 6. SMA lookback sweep by regime-level Sharpe ratio.

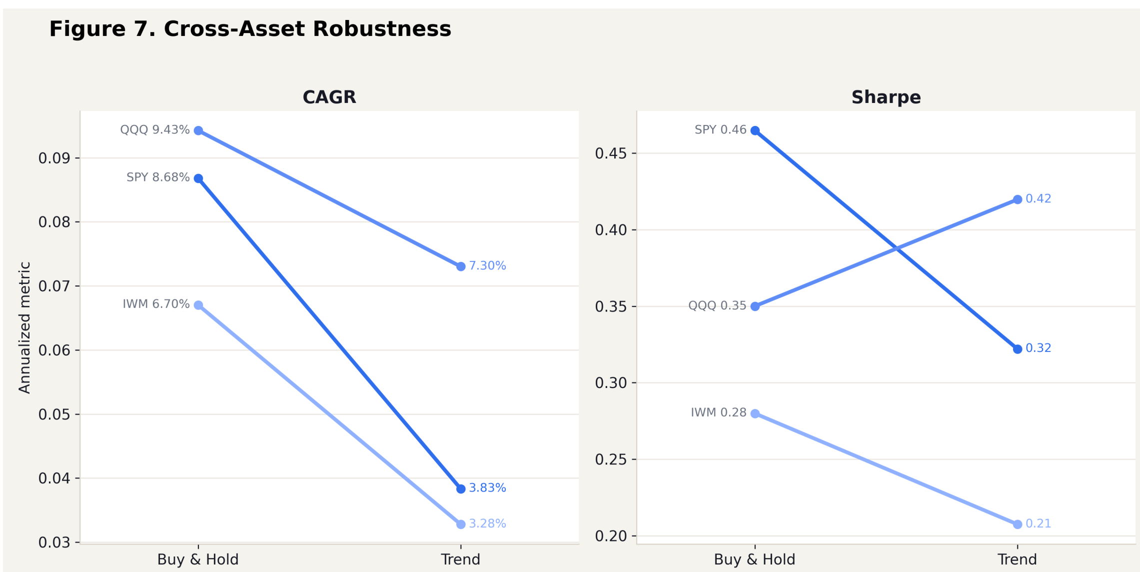

Figure 7: Figure 7. Cross-asset robustness across SPY, QQQ, and IWM.

Additional robustness diagnostics:

- OOS walk-forward summary: CAGR 3.61%, Sharpe 0.33, MaxDD -33.22%, periods 61.
- Cost sensitivity: strategy CAGR declines from 4.29% (0 bps) to 2.01% (50 bps).
- Rebalance sensitivity: strategy Sharpe is 0.17 (daily) vs. 0.32 (monthly).
- Baseline comparison: SMA50 Sharpe 0.33 vs. SMA200 Sharpe 0.70 on common sample.

Figures 6 and 7 align with the core interpretation: low-volatility trend quality is persistent across parameterizations and strongest in momentum-rich indices.

4 Hypothesis-to-Evidence Alignment

- **H1 (Crisis alpha): Rejected.** Figure 4 shows High-vol strategy Sharpe (0.21) below Low-vol strategy Sharpe (1.55) and below High-vol benchmark Sharpe (0.45).
- **H2 (Low-vol dominance): Supported.** Figure 4 shows highest strategy quality in Low volatility, and Figure 6 shows this ordering is robust across lookbacks.
- **H3 (Transition bleed): Supported.** Figure 5 isolates severe quality decay in the $Low \rightarrow Normal$ handoff (Sharpe -5.09).

5 Appendix: Inference and Robustness Tables

Table 1: Strategy minus Benchmark by regime (bootstrap).

Regime	Sharpe Diff (S-B)	Sharpe CI Low	Sharpe CI High	Sharpe p-value	CAGR Diff (pp)	CAGR CI Low (pp)	CAGR CI High (pp)	CAGR p-value
Low	-0.191	-1.148	0.819	0.732	-2.39%	-11.43%	7.16%	0.656
Normal	-0.322	-1.036	0.392	0.519	-4.61%	-14.65%	4.66%	0.518
High	-0.233	-1.100	0.668	0.666	-6.97%	-30.53%	13.57%	0.616

Table 2: High minus Normal differences (strategy only).

Metric	Estimate	CI Low	CI High	p-value
Sharpe (High - Normal)	0.103	-0.751	0.891	0.799
CAGR (High - Normal)	1.48%	-9.47%	12.41%	0.809

Table 3: Transaction cost sensitivity.

Cost (bps)	Strategy CAGR	Strategy Sharpe	Strategy MaxDD	Delta CAGR vs Buy-Hold	Delta Sharpe vs Buy-Hold
0	4.29%	0.360	-33.47%	-4.39%	-0.104
5	4.06%	0.341	-34.98%	-4.62%	-0.124
10	3.83%	0.322	-36.46%	-4.85%	-0.143
20	3.37%	0.284	-39.31%	-5.31%	-0.181
50	2.01%	0.169	-47.14%	-6.67%	-0.296

Table 4: Rebalance frequency sensitivity.

Rebalance Frequency	Strategy CAGR	Strategy Sharpe	Strategy MaxDD	Delta CAGR vs Buy-Hold	Delta Sharpe vs Buy-Hold
Daily	1.88%	0.174	-52.76%	-6.80%	-0.291
Weekly	3.03%	0.273	-40.66%	-5.66%	-0.191
Monthly	3.83%	0.322	-36.46%	-4.85%	-0.143

Table 5: Baseline signal comparison.

Model	CAGR	Sharpe	Max Drawdown
BuyHold	8.68%	0.461	-56.47%
SMA50	3.95%	0.330	-36.46%
SMA200	8.71%	0.696	-26.29%

6 Interpretation and Limits

Bootstrap inference supports directionality but indicates non-trivial uncertainty in several effect-size gaps. Strategy-minus-benchmark Sharpe p-values by regime are: Low 0.732, Normal 0.519, High 0.666. Therefore conclusions should be read as structural (state-dependent quality and robust drawdown truncation), not as point-estimate precision claims.

7 Conclusion

For U.S. equities in this sample, trend-following is best interpreted as a regime-dependent exposure controller rather than a universal crisis-alpha engine. The strongest improvement path is transition-aware and volatility-adaptive signal speed, especially around the $Low \rightarrow Normal$ state break where performance decay is most severe.

References

[1] Gary Antonacci. *Dual Momentum Investing: An Innovative Strategy for Higher Returns with Lower Risk*. McGraw-Hill, 2014.

[2] Narasimhan Jegadeesh and Sheridan Titman. Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance*, 48(1):65–91, 1993.

[3] Tobias J. Moskowitz, Yao Hua Ooi, and Lasse Heje Pedersen. Time series momentum. *Journal of Financial Economics*, 104(2):228–250, 2012.