

## Layman's README (Plain-English Summary)

This project studies S&P 500 volatility and builds a simple, rules-based strategy that changes how much stock exposure it takes based on (1) how **jumpy or calm the market is** and (2) whether prices are **trending up or down**. The goal is to **beat buy-and-hold while keeping drawdowns smaller**.

### Big Idea (In One Paragraph)

Markets move up and down, but the risk level changes over time. This project measures that risk using a volatility model, labels each day as **calm, normal, or stress**, and then adds a **trend signal** so exposure increases when prices are rising and decreases when prices are falling. **In plain terms: we buy more when things look calm and rising, and we step back when things look risky or falling.** The layered approach aims to capture upside while avoiding the worst drawdowns.

### What Data Is Used

- S&P 500 prices (to compute returns and trend)
- VIX (to compare implied volatility to realized volatility)

### How It Works (Simple Steps)

- 1) Measure daily returns from prices.
- 2) Estimate volatility with a GARCH model (how jumpy the market is).
- 3) Classify each day into **low, mid, or high** volatility regimes.
- 4) Measure trend using a 21-day price change (is the market rising or falling?).
- 5) Combine regime and trend to set **exposure** (how much of the portfolio is in stocks).

### Quick Definitions (Plain English)

- **S&P 500**: a big basket of large U.S. stocks; used as the main market.
- **VIX**: a market index that reflects expected volatility in the S&P 500.
- **Volatility**: how much prices jump around day to day.
- **Regime**: a simple label for volatility (calm, normal, stress).
- **Trend**: whether prices have been rising or falling lately.
- **Exposure**: how much of the portfolio is in stocks (1.0 = fully invested).
- **Drawdown**: how far the strategy fell from its most recent high.
- **Sharpe**: return per unit of risk (higher is better).
- **Alpha**: extra return that is not explained by market moves.
- **Beta**: how much the strategy moves when the market moves.
- **Benchmark / buy-and-hold**: holding the S&P 500 the whole time.
- **Backtest**: testing a strategy on historical data (not a guarantee).

- **Equity curve:** a line chart of how \$1 grows over time.
- **Turnover:** how much the exposure changes from day to day.
- **Cost in bps:** trading cost in basis points; 1 bp = 0.01%.
- **Annualized:** scaled to a per-year rate for comparison.
- **Rolling (1Y/3Y):** recalculated over a moving window, not fixed dates.
- **Leverage:** using more than 100% exposure (e.g., 1.2 = 120%).

## Key Results (Annualized)

Source: reports/strategy\_layered/data/summary.txt and reports/strategy\_backtest/data/summary.t

Strategy	Annual return	Volatility	Sharpe	Max drawdown	Notes
Layered (gross)	18.25%	9.51%	1.92	-9.03%	Best risk-adjusted balance
Layered (net, 5 bps costs)	17.26%	9.50%	1.82	-9.08%	Cost drag is modest
Trend-only	19.08%	10.90%	1.75	-15.27%	Higher return, more drawdown
Regime-only	6.18%	8.72%	0.71	-12.34%	Risk control, weaker return
Buy-and-hold	11.28%	17.38%	0.65	-33.92%	High return, large drawdown

Plain-English takeaway: - **Trend-only makes the most money but swings more.** - **Layered gives up a little return for much smoother risk.** - **Regime-only protects in stress but gives up too much upside.** - **Buy-and-hold has the deepest drawdowns.**

## Key Graphs (Essential Only)

All time-series graphs below use the last 12 months for easier reading, except the full-sample comparison (requested) and the cost chart.

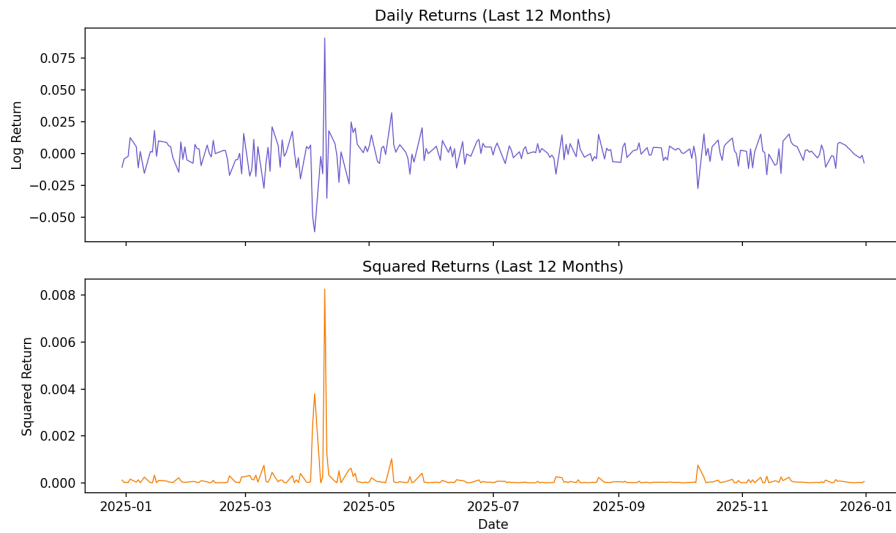


Figure 1: Returns and squared returns (last year)

### 1) Volatility shows up in clusters (last 12 months)

What to notice: - **Big spikes in squared returns mean risk comes in bursts.** - **This is why we model volatility instead of assuming risk is constant.**

### 2) Regimes over time (last 12 months)

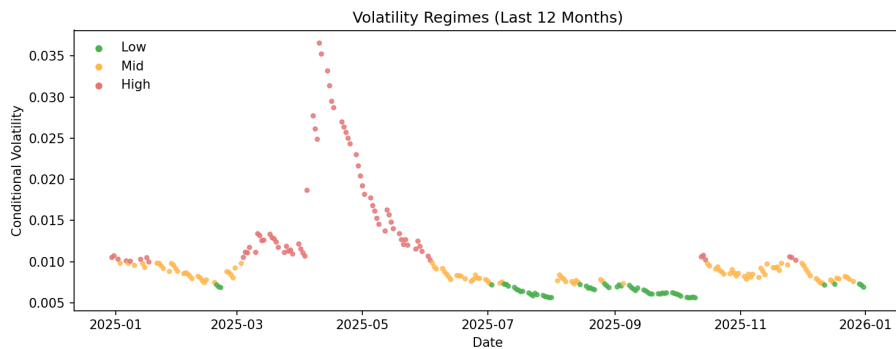


Figure 2: Regime scatter (last year)

What to notice: - **Colors show calm (low), normal (mid), and stress (high) days.** - **The strategy uses these labels to scale risk up or down.**

### 3) Last-year performance comparison (all strategies)

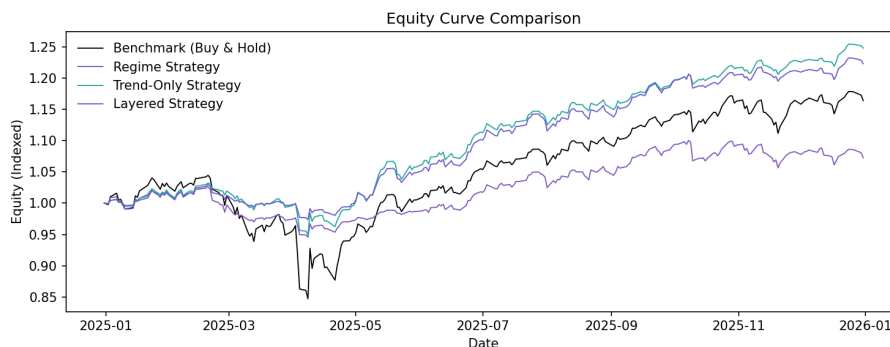


Figure 3: Equity curve comparison (last year)

What to notice: - **Trend-only is highest, but layered is close with smoother behavior.** - **Regime-only stays low (defensive but lower return).** - **Layered beats buy-and-hold while taking less risk.**

### 4) Last-year layered vs buy-and-hold (simpler view)

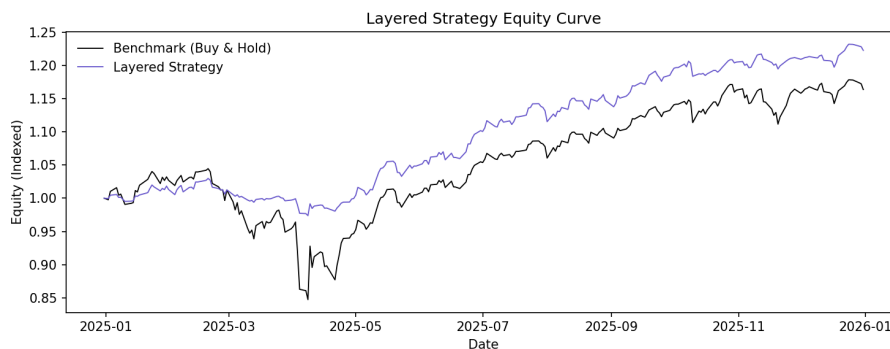


Figure 4: Equity curve (last year)

What to notice: - **Layered should dip less during drawdowns and recover faster.** - The gap shows how much risk control helps in a tough window.

### 5) Last-year exposure behavior (what the strategy is doing)

What to notice: - **Exposure drops quickly when volatility is high or trend is down.** - **Exposure rises when things are calm and trending up.** - This is the core “risk-on / risk-off” behavior in action.

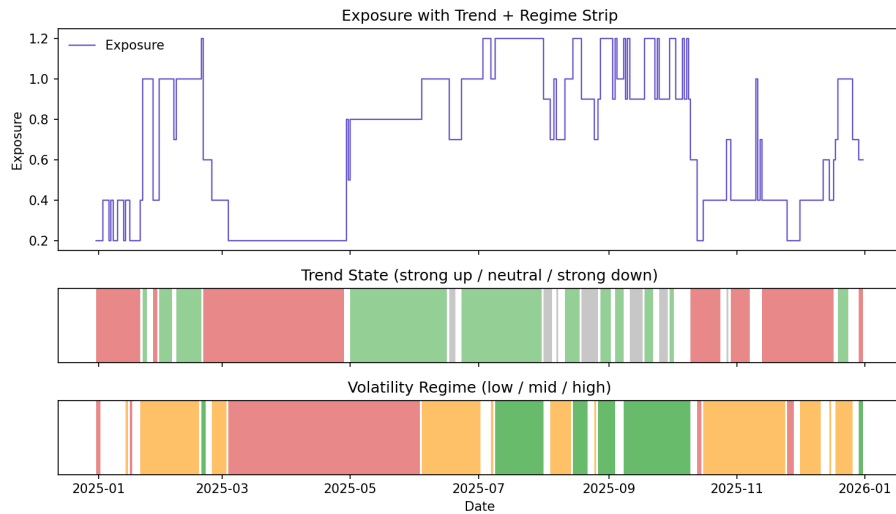


Figure 5: Exposure overlay (last year)

## 6) Full-sample performance comparison (long-run view)

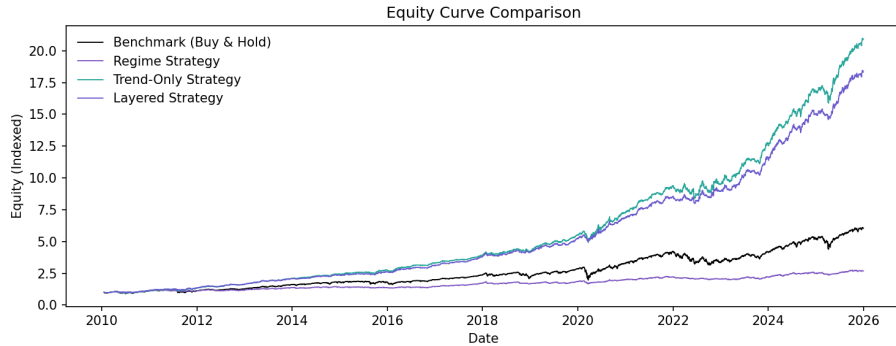


Figure 6: Equity curve comparison (full sample)

What to notice: - **Over the full history, layered stays well above buy-and-hold.** - Trend-only ends higher but takes larger drawdowns along the way.

## 7) Alpha and beta over time (last 12 months)

What to notice: - **Alpha above zero means the strategy beat what market exposure alone would explain.** - **Beta below 1.0 means the strategy takes less market risk than buy-and-hold.**

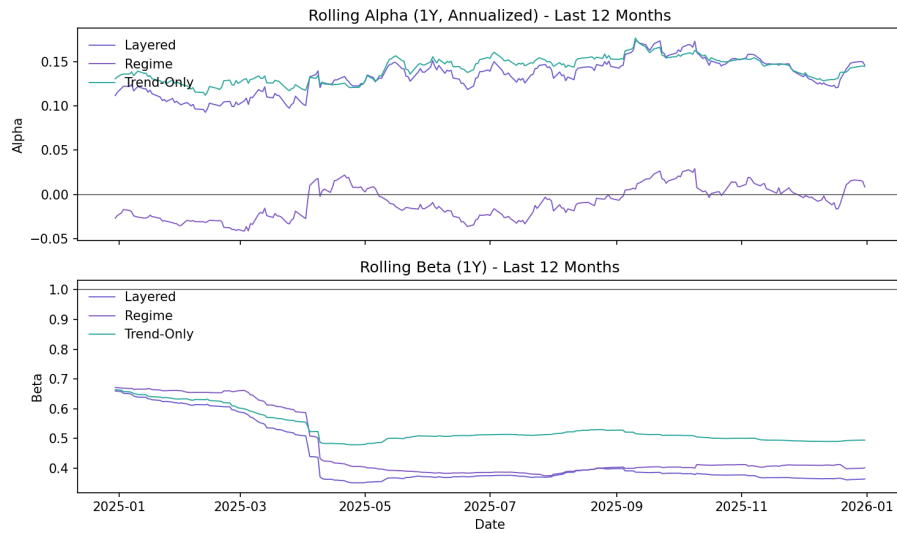


Figure 7: Rolling alpha/beta (last year)

## 8) Trading cost impact

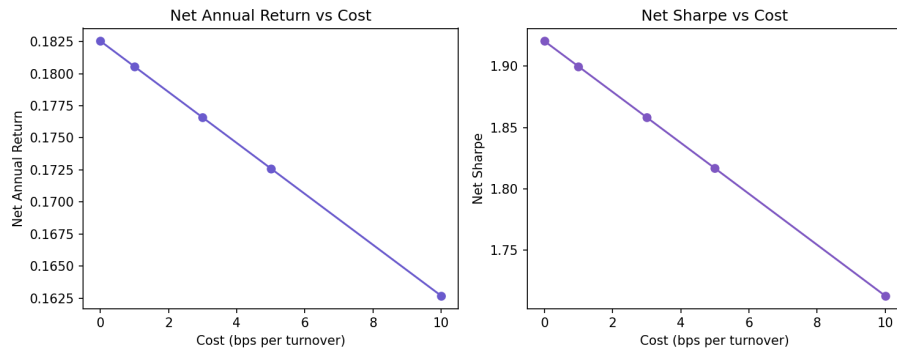


Figure 8: Cost sensitivity

What to notice: - Costs reduce returns in a roughly straight line. - Even at 10 bps per turnover, layered still holds a meaningful edge.

## 9) Simple forward-looking stress test (GBM)

What to notice: - Alpha above zero means extra return beyond simple market exposure. - More mass to the right of zero means the strategy adds value more often. - This is a rough stress test, not a real forecast.

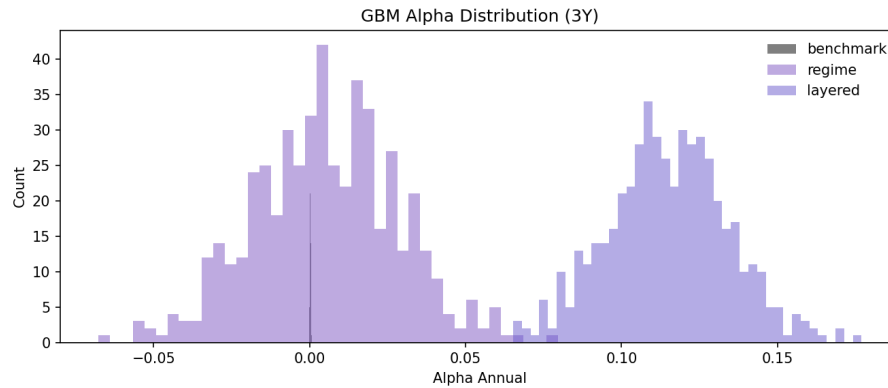


Figure 9: GBM alpha distribution (3Y)

## Alpha/Beta (Very Simple Explanation)

- **Beta** is like a volume knob for market movement.
  - **Beta 1.0:** you move with the market (same ups and downs).
  - **Beta 0.5:** you feel about half the market swings.
  - **Beta 0.0:** you are not moving with the market at all.
  - Example: **if the market rises 10% and beta is 0.45, the strategy rises about 4.5% from market exposure alone.**
- **Alpha** is the extra return **on top of** what beta would predict.
  - It is the part explained by the strategy rules, not just market movement.
  - Think of it as “skill” beyond simply being invested.

Layered strategy results (this backtest): - **Beta ~ 0.45:** the strategy takes about half the market risk. - **Alpha ~ 12.9% annualized:** performance beyond what market exposure explains.

Plain-English takeaway: - **The strategy is not just “more market.” It earns extra return while taking less market exposure than buy-and-hold.**

## If You Only Read One Thing

**The layered strategy (trend + regime) is the best balance in this sample:** it beats buy-and-hold while cutting drawdowns dramatically. Trend-only makes more money but takes more risk. Regime-only reduces risk but sacrifices too much return. **Layered is the middle ground that still wins.**