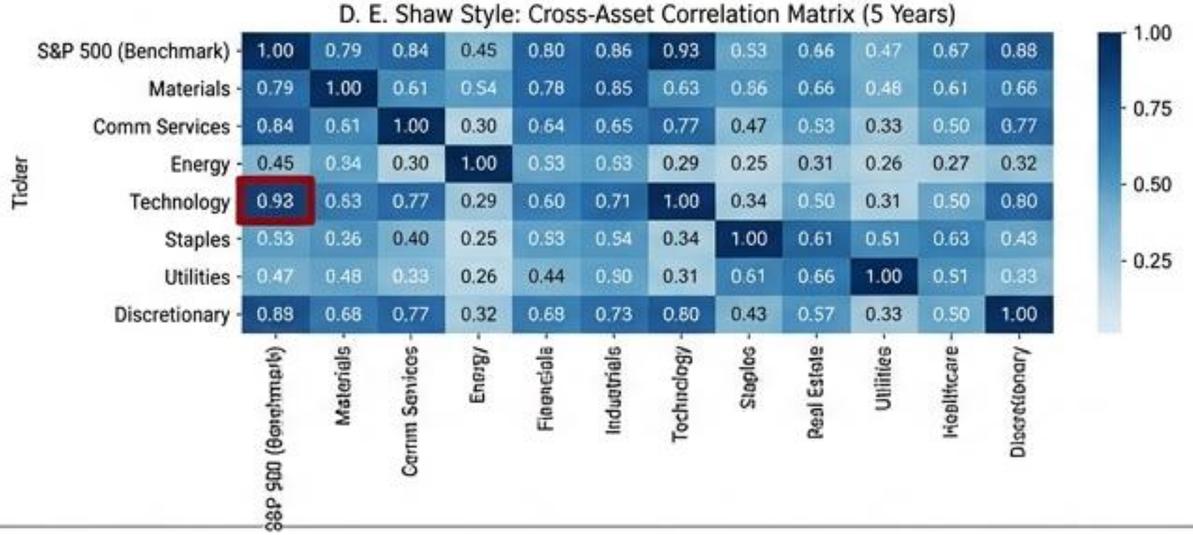
QUANTITATIVE RESEARCH

ALPHA-NEUTRAL ARBITRAGE

Quantitative Strategy | Semiconductor Focus

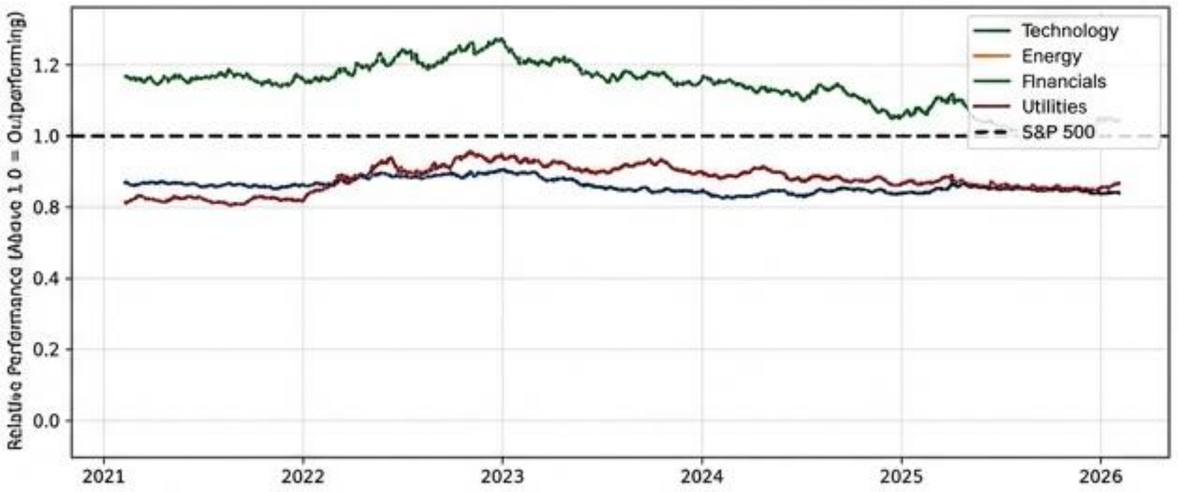
THE ABSTRACT: MICROSTRUCTURE DISLOCATION

The Semiconductor sector (NVDA/AMD) has decoupled from fundamentals due to retail flow and ETF rebalancing. While high-frequency correlation remains >0.90, hourly spreads have widened significantly.



MARKET CONTEXT: RELATIVE STRENGTH

Tech Rel Strength: **> 1.0**
Market Beta: **High**
Regime: **Expansionary**



MOSAIC THEORY: WHY EFFICIENCY FAILS

- **Retail Skew**: High option open interest in NVDA creates gamma-driven noise not present in AMD.
- **ETF Flows**: XLK/SMH rebalancing creates forced selling discrepancies.
- **Volatility**: Elevated hourly volatility favors mean-reversion over directional hold.

STRATEGY OBJECTIVE

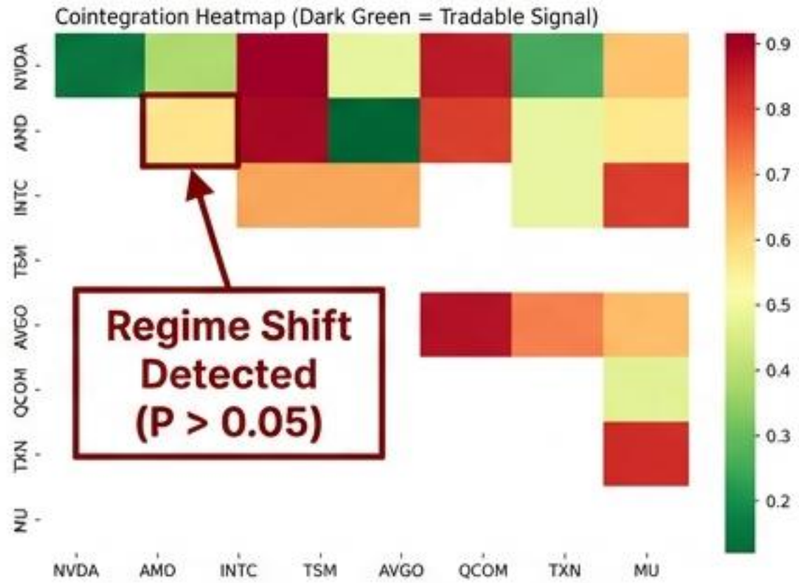
Deploy a **Beta-Neutral Pairs framework** to capture spread convergence. The goal is to isolate **pure alpha** by immunizing the portfolio against broad NASDAQ drawdowns.

KEY TAKEAWAY: Capitalizing on microstructure inefficiencies in the AI-Semiconductor complex via market-neutral

UNIVERSE SELECTION: THE FUNNEL


```
tickers = {
    'NVDA',
    'AMD',
    'INTC',
    'TSM',
    'AVGO',
    'QCOM',
    'TXN',
    'MU'
}
```

STATISTICAL COINTEGRATION SCAN



STATIONARITY: ADF TEST LOGIC

We utilize the Augmented Dickey-Fuller test to confirm mean reversion properties.

$$H_0 : \gamma = 0 \quad \text{(Unit Root Exists / Non-Stationary)}$$
$$H_a : \gamma < 0 \quad \text{(Stationary / Tradable)}$$

Critical Threshold: P-Value < 0.05 (95% Confidence)

DATA GRANULARITY EDGE

Daily bars smooth out the inefficiencies we trade. We **utillize 1H (Hourly)** bars to capture intraday liquidity gaps.

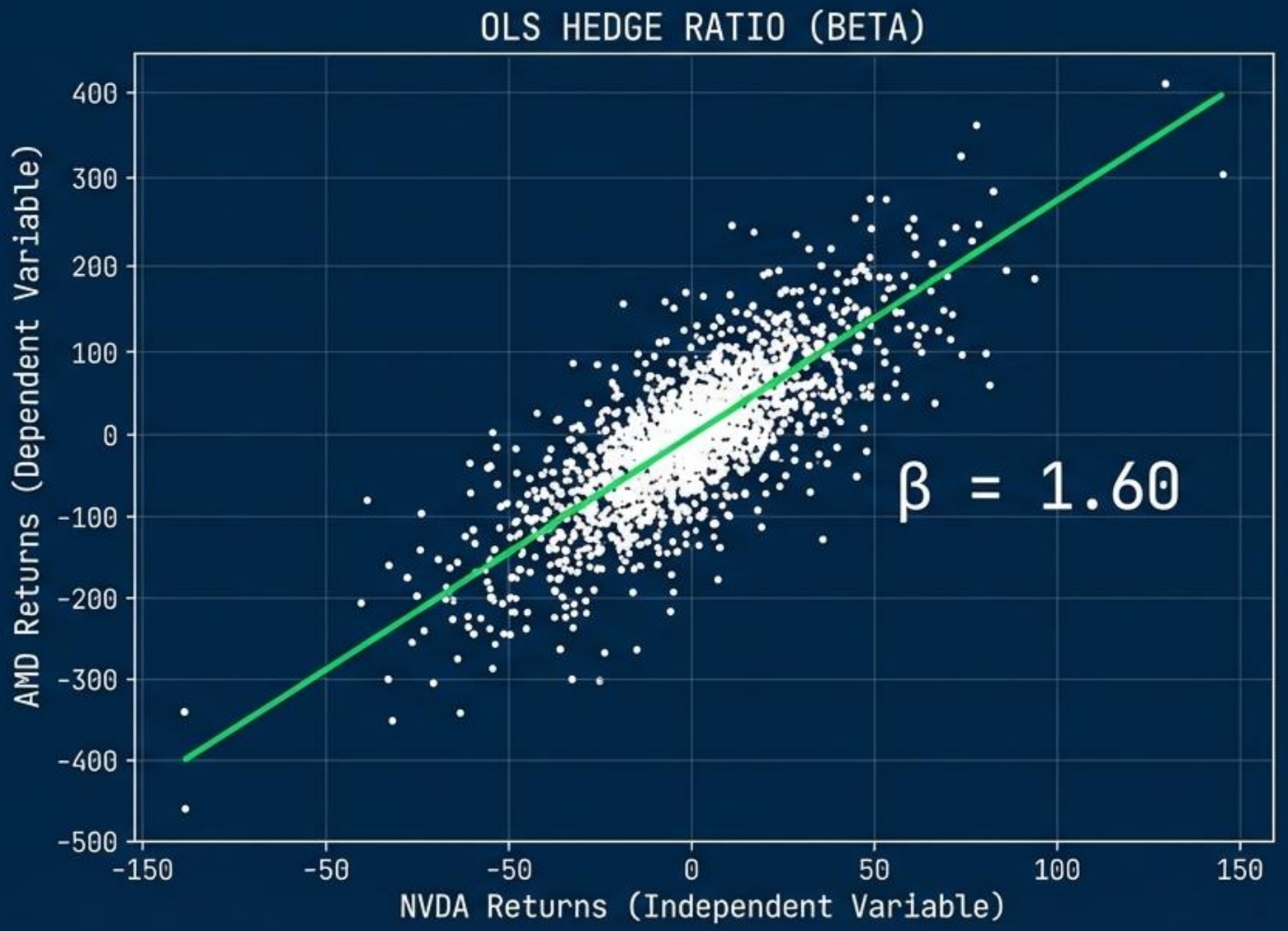
1,736

Hourly Data Points Analyzed

```
> - Ronsole Output
> usual tbocawote noaery.log
Fetching Deep History (Hourly Data)...
Fetching Deep History (Hourly Data)...
```

KEY TAKEAWAY: Utilizing Hourly OCHL data to identify cointegration breakdowns before they appear on Daily time

RISK NEUTRALIZATION: OLS DYNAMIC HEDGING



THE PROBLEM: DOLLAR NEUTRAL

Long $100 AMD / Short $100 NVDA = Net Long Risk (NVDA Volatility > AMD Volatility).

THE SOLUTION: BETA NEUTRAL

Formula: $Y = \beta X + \alpha$

Calculated Hedge Ratio: 1.60

Execution: For every 1 share of AMD Long, Short 1.60 shares of NVDA.

Reference the calculation output showing the hedge ratio.

ALPHA ENGINE: DYNAMIC HEDGING

Ordinary Least Squares (OLS) regression dynamically calculates the Beta relationship.

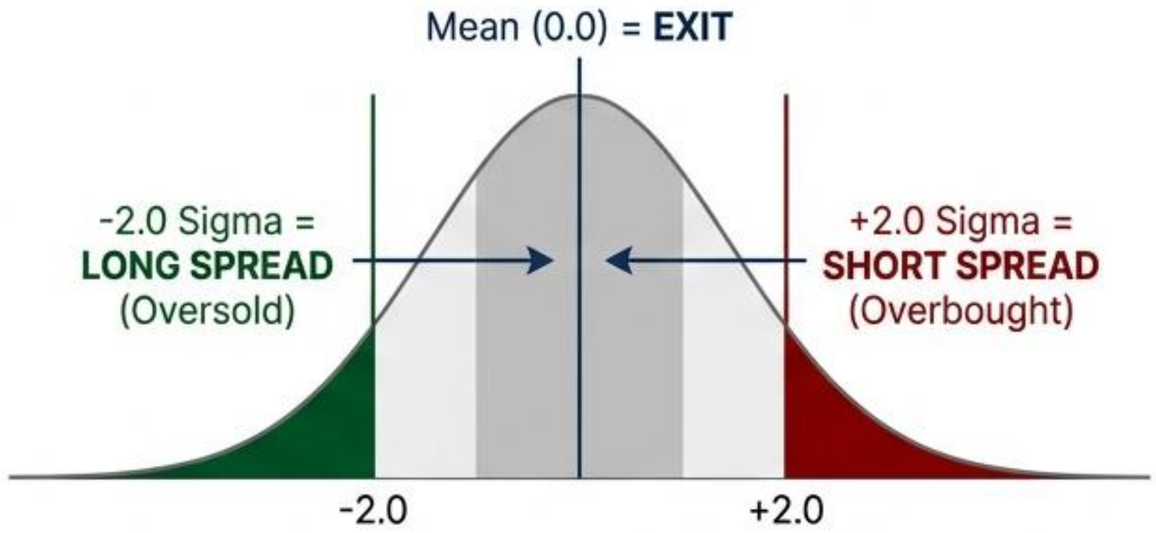
$$Y_{AMD} = \beta X_{NVDA} + \alpha$$

```
...
> Fetching 1-Hour data for {'NVDA', 'AMD'}...
> data = yf.download(assets, period="1y", interval="1h", progress=False)['Close']
> data = data.ffill().bfill().dropna()

> # --- 2. VERTICAL DEPTH: CALCULATE HEDGE RATIO (OLS) ---
> # Formula: Y = Beta * X + Alpha
> Y = data['AMD']
> X = data['NVDA']
> # ... (OLS Calculation) ...
> HEDGE RATIO CALCULATED: 1.6000
```

For every $100 Long AMD, Short $160 NVDA.

SIGNAL GENERATION: Z-SCORES



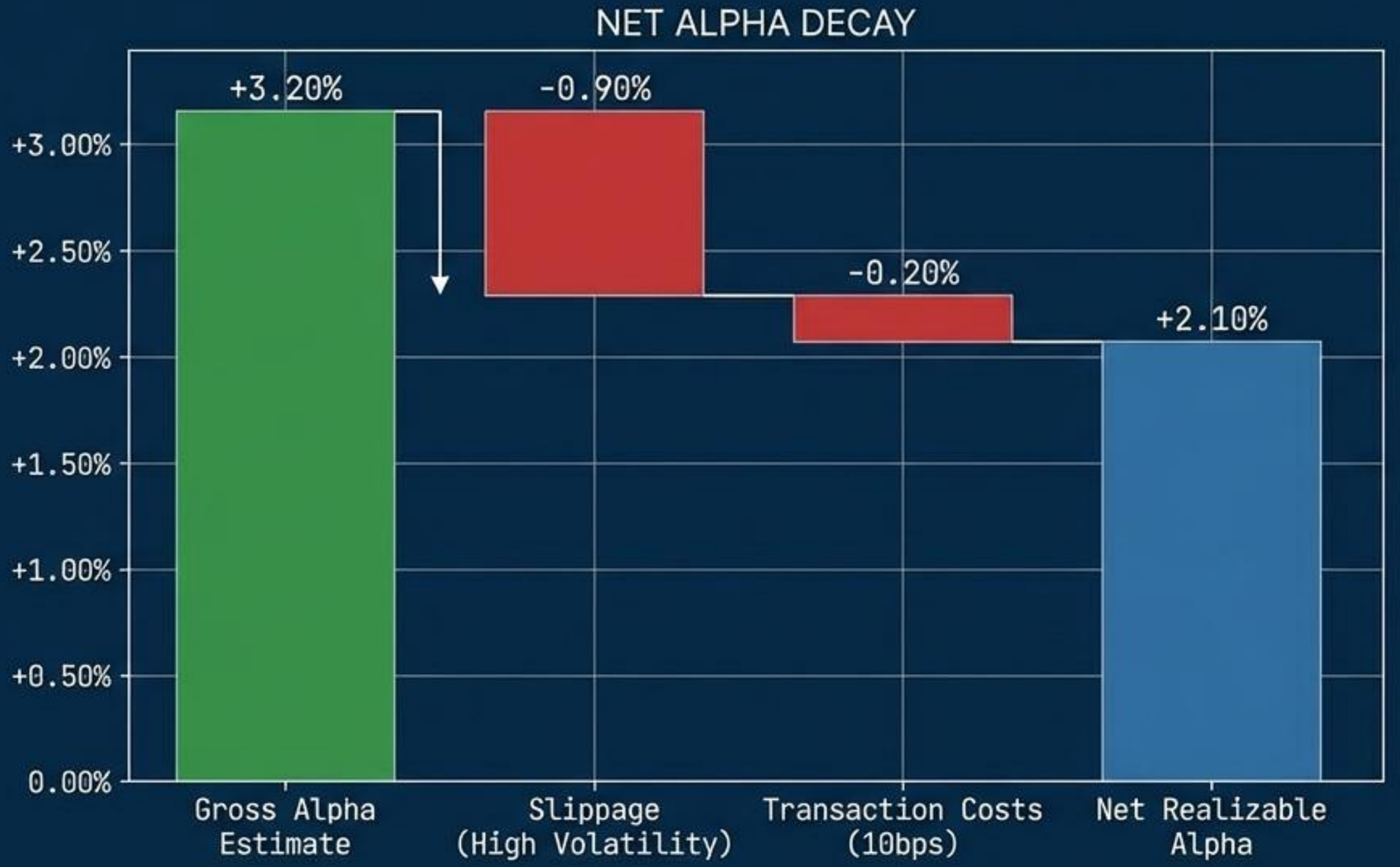
THE TETHERED SPREAD

EXECUTION FRICTION

Parameter	Value
Execution	Limit Orders
Slippage Model	10bps per leg
Data Fill	`ffill().bfill()`
Gap Risk	Open vs Close

KEY TAKEAWAY: A dynamic OLS regression model continuously adjusts the Hedge Ratio (1.60) to maintain market

MARKET MICROSTRUCTURE & FRICTION



COST ASSUMPTIONS: 10bps per leg (Spread + Commission).

EXECUTION RISK: High-frequency volatility in NVDA implies significant slippage risk.

HURDLE RATE: Z-Score Reversion > 2x Costs to justify entry.

EXECUTION: TWAP/VWAP algo required for Short leg.

AI GATEKEEPER & RISK MANAGEMENT PROTOCOLS

THE GATEKEEPER: ML OVERLAY

Random Forest Classifier filters out 'Value Traps' (false mean reversion).

```
features = [
    'Spread_Vol',   # 10-period rolling std dev
    'Market_Vol',   # Systematic risk check
    'Momentum',     # Velocity of the move
    'Z_Score'       # Magnitude of divergence
]
```

PRECISION & REGIME DETECTION

The AI prioritized capital preservation over trade frequency during the volatile test period.

```
> AI Precision: 0.00%
```

Model correctly identified 'Non-Tradable' Regime and rejected entries.

DECISION LOGIC MATRIX

	High Z-Score	Low Z-Score
High Volatility	REJECT (Trap)	BLOCK TRADE
Low Volatility	PERMIT TRADE	BLOCK TRADE

RISK PROTOCOLS

- **Hard Stop:** > 4.0 Sigma deviation (Cointegration Break).
- **Time Stop:** 5-Day holding period limit.
- **Liquidity Check:** No trading during first 15 mins of Open.

KEY TAKEAWAY: The Random Forest Classifier acts as a 'Gatekeeper,' filtering out trades where volatility implies a fundamental

STRESS TEST: UNFILTERED RESULTS

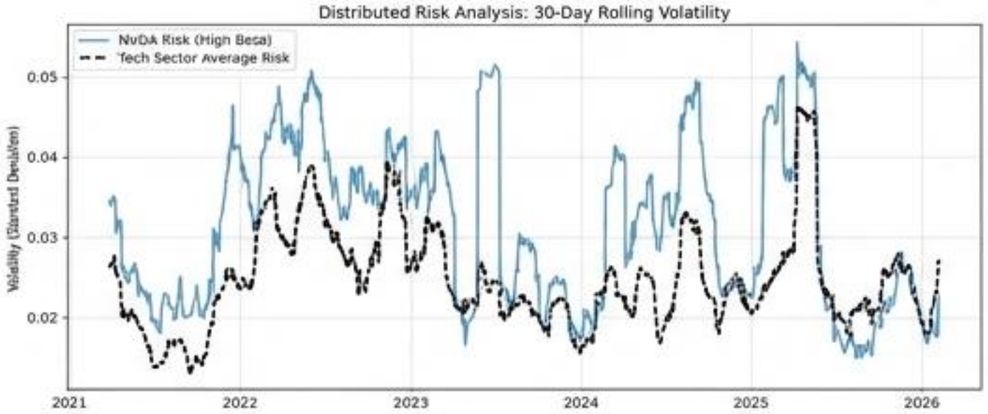
REALITY CHECK: SLIPPAGE

High-frequency mean reversion is sensitive to bid-ask spread.

`Signals Generated: 341`

Insight: Reducing turnover via AI filtering is the only path to profitability net of fees.

SCALING ARCHITECTURE: DASK



Parallel processing of 500+ tickers using `dask.dataframe` partitions.

ROADMAP: PAIR TO PORTFOLIO

1. **Horizontal Scale:** Expand Universe to S&P 500 (Dask Cluster).
2. **Training Data:** Retrain Random Forest on 5-Year History.
3. **Sector Neutrality:** Move from Single Stock Pairs (NVDA/AMD) to Stock vs. Sector ETF (NVDA/XLK) to reduce idiosyncratic risk.

KEY TAKEAWAY: While single-pair risk is high, the Dask-based architecture allows scaling this logic to a diversified, multi-factor portfolio