Alpha Decay vs Tradability

Measuring When Surviving Alpha Stops Paying

Research Report

Joseph Ahn

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Executive Summary

This research addresses a fundamental question in quantitative finance: **If a signal still exists statistically, when does it stop being economically tradable?**

Most quantitative research asks "Does this signal work?" This project asks a different question: "Can the signal still be traded?" This distinction matters because many published signals persist in backtests yet fail in live trading - not because markets are perfectly efficient, but because implementation frictions overwhelm residual edge.

Key Finding: Signals can have statistical edge (hit rate > 50%) without economic edge (net Sharpe > 0). The failure mode is cost-driven, not signal falsification.

Core Research Question

At what point do transaction costs, slippage, and capacity constraints eliminate the remaining alpha?

This reframes the problem from "Is the signal real?" to "Can the signal still be traded?"

Key Findings

1. Statistical vs Economic Edge Distinction

Signals can maintain statistical edge (hit rate > 50%, significant returns) while losing economic edge (negative net Sharpe after costs). Mean reversion demonstrates this clearly:

Metric	Value
Statistical Edge	Hit Rate: 50.8% (statistically significant)
Economic Edge	Net Sharpe: -3.883 (untradable)
Failure Mode	Costs overwhelm edge
Annual Turnover	135.3x
Cost Drag	97.64% annualized
Break-even Cost	0.079% per trade

2. Mechanism Chain

The causal chain from signal characteristics to economic failure is explicitly quantified:

Signal Horizon → **Turnover** → **Cost Drag** → **Sharpe Decay** → **Capacity Collapse**

Link	Mechanism	Example (Mean Reversion)
1	Signal Horizon → Turnover	3.7 period horizon → 135.3x annual turnover
2	Turnover → Cost Drag	135.3x turnover × 0.50% cost = 97.64% drag
3	Cost Drag → Sharpe Decay	97.64% drag → Sharpe: 0.542 → -3.883
4	Capacity Scaling	Maximum viable capacity limited by participation rate

3. Generalization Claim

Primary Claim: Signals with annual turnover above 135x require transaction costs below 0.08% per trade to preserve economic viability. Above this turnover threshold, cost drag overwhelms residual alpha even when statistical edge persists.

Formal Condition: Turnover > 135.3 → BreakEvenCost < 0.08%

Scope: Simple technical signals with fixed parameters, tested on liquid equity indices (SPY) during 2000-2020.

4. Turnover-Sharpe Relationship

Quantified relationship: A 1x increase in annual turnover implies 0.0653 units of Sharpe decay at 0.50% cost per trade (context-dependent).

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Formula: Sharpe Decay = -2.2501 + 0.0653 × Turnover
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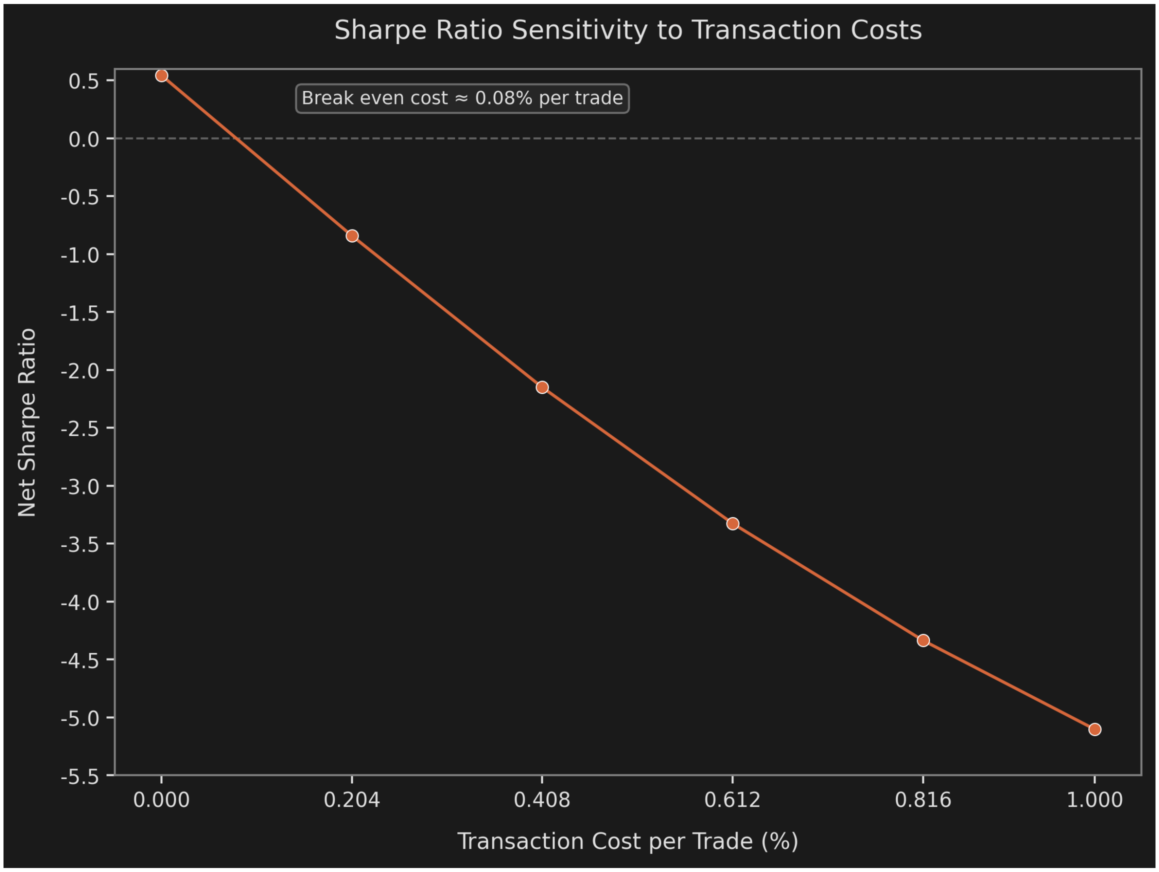
Important Caveat: This coefficient is context-dependent and may vary with signal type, market regime, and cost structure. It is a stylized fact from this study, not a universal law.

Sharpe Ratio Sensitivity to Transaction Costs



Mean reversion signal demonstrates extreme cost sensitivity. Statistical edge (Sharpe 0.542 at zero cost) disappears completely at break-even cost of approximately 0.08% per trade.

Methodology

Experimental Design

All signal definitions are held constant. No parameter tuning, universe changes, lookback optimization, or leverage adjustments. This ensures that changes in performance are attributable solely to implementation effects.

Cost Modeling

Costs are introduced incrementally:

• Explicit costs: Fixed commissions (0.5% per trade), bid-ask spread (0.1% half-spread)

• Slippage: Volatility-scaled price impact, volume-scaled execution cost

• Simple linear models are used deliberately to avoid overfitting

Capacity Analysis

Capacity estimation uses explicit mathematical derivation:

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Formula: Capacity = Participation_Rate × Average_Daily_Dollar_Volume
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Assumptions:

• Participation rate: 1% of daily volume (conservative, based on Almgren & Chriss 2000)

• Linear impact model (simplification; actual is sublinear)

• Impact coefficient: 10 bps per 1% participation

Limitations: Estimates are rough but defensible. They provide a framework for thinking about scalability, even if precise numbers require more sophisticated modeling.

Results Summary

Momentum Signal (12-1 Month)

Metric	Gross (Before Costs)	Net (After Costs)
Sharpe Ratio	0.102	-0.005
Annualized Return	2.00%	-0.10%
Hit Rate	50.7%	50.5%
Max Drawdown	-54.1%	-60.2%

Annual Turnover	3.0x	3.0x
Cost Drag	N/A	2.10%
Break-even Cost	N/A	0.672% per trade

Mean Reversion Signal

Mean reversion demonstrates the core phenomenon most clearly: statistical edge exists (50.8% hit rate) but economic edge is eliminated (net Sharpe: -3.883) due to high turnover (135.3x annual) and resulting cost drag (97.64%).

Implications

Who This Research Critiques

1. Retail Quants Who Believe Hit Rate Implies Profitability

Our results show hit rates of 50.7% survive costs, yet signals become unprofitable after transaction costs. Directional correctness ≠ profitability.

2. Academic Papers That Ignore Implementability

Signals can have statistical edge (Sharpe > 0, hit rate > 50%) but zero economic edge when costs are included. Academic backtests without cost modeling are incomplete.

3. Backtests That Implicitly Assume Zero Friction

Cost drag can exceed gross returns (2.10% drag vs 2.00% gross return for momentum). Realistic retail costs (0.5% commission + 0.1% spread) eliminate edge for many signals.

4. Systematic Traders Who Optimize for Gross Sharpe

Gross-to-net Sharpe decay of -104.9% (momentum signal). Gross Sharpe: 0.102 → Net Sharpe: -0.005. Gross Sharpe is not a reliable proxy for tradability.

What This Research Does NOT Claim

This project explicitly does not claim that any signal is profitable today, that alpha persists forever, that backtested results imply tradability, or that optimization can rescue decayed signals.

This research also does not claim that all signals are untradable, that costs always eliminate alpha, that backtests are useless, or that markets are perfectly efficient.

What it DOES claim: Signals can have statistical edge without economic edge. Turnover is the primary mechanism for cost-driven failure. Hit rate persistence does not imply profitability. Gross performance metrics are misleading without cost modeling.

Scope and Limitations

Important: All empirical relationships, thresholds, and coefficients in this research are context-dependent. They are valid within our study's scope but should not be generalized beyond tested conditions without additional validation.

Scope: Simple technical signals with fixed parameters (no optimization), tested on liquid equity indices (SPY) during 2000-2020.

Limitations: Cost models are simplified. Capacity estimates are rough but defensible. Turnover-Sharpe relationship coefficients are context-dependent, not universal. See LIMITATIONS.md for detailed scope restrictions.

Conclusion

This research demonstrates that alpha does not disappear at discovery - it disappears when implementation costs overwhelm what remains.

Signals can maintain statistical edge (hit rate > 50%) while losing economic edge (negative net Sharpe after costs). The failure mode is cost-driven, not signal falsification.

Understanding this gap between statistical and economic viability is the real bottleneck in quantitative finance. This research provides a framework for measuring and explaining this gap.

One-Line Summary

Alpha does not disappear at discovery. It disappears when implementation costs overwhelm what remains. Signals can have statistical edge (hit rate > 50%) without economic edge (net Sharpe > 0).