Automated Trading Strategy for NVDA

Programming Assignment 3

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Executive Summary

This report presents an automated trading strategy for NVIDIA Corporation (NVDA) that combines momentum and mean-reversion approaches with regime-aware filtering. The strategy achieved a 6.3% CAGR with a Sharpe ratio of 0.37 over the 2015-2025 period, demonstrating controlled risk with a maximum drawdown of 7.4% compared to NVDA buy-and-hold's 71.9% drawdown. While the strategy underperformed NVDA's exceptional 55.4% CAGR, it successfully preserved capital during volatile periods and provided superior risk-adjusted returns relative to its volatility profile.

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1. Problem Description

1.1 Objective

The goal is to develop an automated algorithmic trading system that can systematically trade NVDA while managing downside risk better than a simple buy-and-hold approach. Given NVDA's extreme volatility (48.5% annualized) and severe drawdowns, the strategy aims to participate in uptrends while avoiding major losses during market dislocations.

1.2 Strategy Components

Two-Sleeve Approach:

- **Trend Sleeve (70% weight):** Captures directional momentum using moving average filters and breakout signals
- **Mean-Reversion Sleeve (30% weight):** Exploits short-term oversold conditions using z-score analysis

Risk Management:

- Volatility-targeted position sizing using ATR
- VIX-based regime filter to avoid high-volatility environments
- Transaction costs (15 bps) and management fees (1% annual) included

1.3 Rationale

NVDA exhibits both trending behavior (during bull markets) and mean-reverting patterns (during consolidations). A hybrid approach allows the strategy to adapt to different market conditions while the regime filter prevents trading during extreme volatility when both approaches tend to fail.

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2. Data Preparation and Pipeline

2.1 Data Sources

- **Primary Asset:** NVDA daily prices (2015-2025) via Yahoo Finance
- **Benchmark:** SPY (S&P 500 ETF)
- **Volatility Proxy:** VIX Index
- **Data Points:** 2,725 trading days

2.2 Feature Engineering

Technical Indicators:

- 50-day and 200-day moving averages for trend identification
- 14-period Average True Range (ATR) for volatility measurement
- 20-day rolling z-scores for mean reversion signals
- 20-day momentum breakouts

Regime Variables:

- VIX threshold at 30 for market stress detection
- 200-day MA slope for trend quality
- 20-day realized volatility for position sizing

2.3 Data Quality

All data was validated for missing values and adjusted for corporate actions (splits, dividends). The complete dataset is stored in `data/price_data.csv` for reproducibility.

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3. Research Design

3.1 Signal Generation Logic

Trend Signals:

Long Condition = (Price > 200D MA) AND (50D MA > 200D MA) AND (20-day breakout)

Mean-Reversion Signals:

Entry: Z-score < -2.0 (oversold)
Exit: Z-score > -0.5 (return to mean)

Regime Filter:

Trade Enabled = (VIX < 30) AND (Price > 200D MA)

Final Position:

Position = [0.7 × Trend_Signal + 0.3 × MR_Signal] × Regime_OK × Vol_Scalar
Position capped between 0 (cash) and 1 (fully invested)

3.2 Risk Management

Volatility Targeting: Position sizes are scaled inversely to realized volatility to maintain a 15% target annualized volatility. This prevents over-exposure during turbulent periods.

Cost Model:

- Transaction costs: 15 basis points per trade (entry + exit)
- Management fee: 1% annually, accrued daily
- Total trades: 555 over 10 years (14.9x annual turnover)

3.3 Backtesting Methodology

The strategy was tested on out-of-sample data from 2015-2025 with no look-ahead bias. All signals use lagged (t-1) data to ensure realistic implementation. The backtest assumes:

- Market orders at close prices
- No slippage beyond modeled transaction costs
- No leverage
- Fractional share trading allowed

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4. Results

4.1 Performance Summary

Metric	Two-Sleeve Strategy	NVDA Buy&Hold	SPY Buy&Hold
CAGR	6.3%	55.4%	11.8%
Annualized Vol	6.1%	48.5%	17.9%
Sharpe Ratio (4% rf)	0.37	1.06	0.44
Sortino Ratio	0.31	1.49	0.59
Calmar Ratio	0.84	0.77	0.33
Max Drawdown	-7.4%	-71.9%	-35.7%
Hit Rate	56.6%	54.6%	54.8%

Key Findings:

- The strategy dramatically reduced drawdowns (7.4% vs 71.9%)
- Risk-adjusted returns (Sharpe 0.37) are reasonable given the conservative approach
- Calmar ratio (0.84) is superior to NVDA buy-and-hold (0.77), indicating better return per unit of drawdown

4.2 Market Exposure Analysis

- **Alpha vs SPY:** 1.84% annually
- **Beta vs SPY:** 0.06 (near-zero systematic risk)
- **Average Position:** 31.1% invested
- The strategy spent 69% of the time in cash/T-bills, explaining the lower absolute returns

4.3 Performance by Volatility Regime

VIX Regime	CAGR	Vol	Sharpe	Days
Low (<15)	13.8%	6.4%	1.54	1,024
Medium (15-25)	4.3%	5.8%	0.06	1,325
High (>25)	-6.0%	6.0%	-1.67	376

Interpretation: The strategy performs exceptionally well in calm markets (Sharpe 1.54) but struggles during extreme volatility despite the VIX filter. This suggests the 30 threshold may be too permissive—tightening to VIX < 25 could improve results.

4.4 Temporal Analysis

The monthly returns heatmap reveals:

- Consistent small gains in most months
- Few extreme losses (proper risk management)
- No obvious seasonal patterns
- Strategy avoided the major 2022 drawdown effectively

The rolling Sharpe ratio chart shows:

- Strong performance 2017-2021 (Sharpe > 1.0)
- Deterioration since 2024 as NVDA entered a persistent uptrend
- Recent underperformance (negative Sharpe in 2025) due to being under-invested during the rally

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5. Discussion

5.1 Strategy Strengths

1. **Superior Risk Control:** The 7.4% max drawdown vs 71.9% for buy-and-hold demonstrates effective downside protection
2. **Regime Awareness:** VIX filter successfully avoided the worst of market crashes
3. **Adaptability:** Two-sleeve design allows participation in both trending and ranging markets
4. **Low Beta:** Near-zero correlation to SPY provides diversification benefits

5.2 Strategy Weaknesses

1. **Opportunity Cost:** Being under-invested (31% average) meant missing NVDA's exceptional returns
2. **High Volatility Failure:** The strategy lost money during VIX > 25 periods despite the filter
3. **Recent Underperformance:** Strong NVDA uptrend in 2024-2025 was not captured
4. **High Turnover:** 14.9x annual turnover increases tax drag in taxable accounts

5.3 Comparison to Benchmarks

vs. NVDA Buy-and-Hold:

- Trade-off: Gave up 49% annual return to reduce drawdown by 64.5 percentage points
- For risk-averse investors, this trade-off may be acceptable
- Calmar ratio suggests slightly better risk-adjusted performance

vs. SPY Buy-and-Hold:

- Underperformed on absolute returns (6.3% vs 11.8%)
- Similar Sharpe ratios (0.37 vs 0.44)
- Better drawdown profile (7.4% vs 35.7%)

5.4 Practical Considerations

Implementation Feasibility:

- Strategy is fully systematic and automatable
- No manual intervention required
- All signals are based on publicly available data

Costs:

- 15 bps transaction costs are realistic for retail traders
- High turnover (555 trades) generates significant friction
- Tax implications not modeled but would further reduce returns

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6. Robustness and Limitations

6.1 Statistical Properties

The Q-Q plot reveals:

- Returns exhibit fat tails (leptokurtic distribution)
- Not normally distributed standard Sharpe ratio may underestimate risk
- Sortino ratio (0.31) is more appropriate for this distribution

6.2 Parameter Sensitivity

The strategy uses standard parameters (50/200 MA, z-score < -2) without optimization to avoid overfitting. A walk-forward analysis across different market periods would strengthen confidence, but was not implemented due to limited sample size.

6.3 Known Limitations

1. **Survivorship Bias:** NVDA was selected knowing it performed well—most stocks don't have 55% CAGRs
2. **Sample Period:** 2015-2025 was largely bullish; bear market performance uncertain
3. **Transaction Costs:** Assumed costs may be optimistic for large positions
4. **Liquidity:** Assumes perfect execution at close prices

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7. Conclusions and Future Work

7.1 Key Takeaways

This automated trading strategy successfully demonstrates:

- Systematic risk management can dramatically reduce drawdowns
- Regime-aware filtering improves risk-adjusted returns
- Hybrid approaches (trend + mean-reversion) provide flexibility

However, the fundamental tension remains: **reducing risk necessarily reduces returns in a strongly trending asset like NVDA**. The strategy is appropriate for:

- Risk-averse investors who can't tolerate 70% drawdowns
- Portfolios where NVDA is a satellite holding, not core
- Environments where preservation of capital is prioritized over maximum gains

7.2 Recommended Improvements

1. **Tighten VIX Filter:** Use VIX < 25 instead of 30 to avoid more volatile periods
2. **Add Trailing Stops:** Implement ATR-based trailing stops to lock in gains during uptrends
3. **Walk-Forward Optimization:** Test parameter stability across different market regimes
4. **Multi-Asset Extension:** Apply to a portfolio of tech stocks to diversify idiosyncratic risk
5. **Machine Learning Integration:** Use ML to predict regime shifts more accurately than simple VIX thresholds

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8. References

- Clenow, A.F. (2019). *Trading Evolved: Anyone Can Build Killer Trading Strategies in Python*. Independently Published.
- Bollinger, J. (2001). *Bollinger on Bollinger Bands*. McGraw-Hill.
- Pardo, R. (2008). *The Evaluation and Optimization of Trading Strategies*. Wiley.
- Yahoo Finance API for historical price data

Appendix: Code Repository

GitHub Repository: https://github.com/DivyankaThakur03/financial_engg_assignment3_divyanka

The repository contains:

- `assign3.py` - Main strategy implementation
- `data/` - Historical price data
- `figures/` - All performance charts
- `README.md` - Usage instructions