Quant Research Assignment: Volatility Pairs Trading

Kunal Kumar

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1 Strategy Overview

Implemented two volatility pairs trading strategies for Nifty/BankNifty index options:

- **Base Model**: Z-score mean reversion strategy
- **Enhanced Model**: Kalman filter dynamic hedging with RSI confirmation

2 Key Assumptions

- Market hours only (09:15–15:30 IST)
- No transaction costs or slippage
- Constant Time-to-Expiry during trade execution
- 100% capital allocation per trade
- Minimum spread volatility filter ($\sigma_{min} = 0.01$)
- Holidays identified via flat IV movement detection

2.1 Statistical Validation

The spread exhibits exceptional mean-reversion properties:

- **ADF Statistic** of -4.413 (p=0.0003) confirms stationarity
- **Hurst Exponent** of 0.177 indicates strong mean-reversion
  (H < 0.3 suggests faster cyclicality than typical financial series)

This justifies:

- Shorter 80-minute lookback window (vs standard 200)
- More aggressive 2.5σ entry thresholds
- Earlier 0.3σ profit-taking

3 Methodology

3.1 Base Strategy

$$Z_t = \frac{IV_{BankNifty} - IV_{Nifty} - \mu_{200min}}{\sigma_{200min}} \tag{1}$$

- Entry: $|Z| > 2.0$

- Exit: $|Z| < 0.5$

- PnL: $(Spread_{exit} - Spread_{entry}) \times TTE^{0.7}$

3.2 Enhanced Strategy

$$KalmanSpread_t = \alpha \cdot KalmanSpread_{t-1} + \epsilon_t \tag{2}$$

$$Residual_t = Spread_t - KalmanSpread_t \tag{3}$$

$$RSI_t = 100 - \frac{100}{1 + \frac{AvgGain_{14}}{AvgLoss_{14}}} \tag{4}$$

- Entry: $Z_{residual} < -2.0$ & $RSI > 30$ (long) or $Z_{residual} > 2.0$ & $RSI < 70$ (short)

- Exit: $|Z_{residual}| < 0.5$ or 3-hour timeout

- Stop-loss: 2σ residual movement against position

4 Results Comparison

Table 1: Performance Metrics

Metric	Base Model	Enhanced Model
Total PnL	122.65	121.87
Sharpe Ratio	2.11	15.18
Win Rate	95%	90%
Max Drawdown	-0.37	-0.28
Number of Trades	2,143	3,691
Avg Trade Duration	112min	47min

5   Key Findings

- **7.2x higher Sharpe ratio** in enhanced model (15.18 vs 2.11)

- **24% lower max drawdown** despite higher trade frequency

- Enhanced model generates **72% more trades** with shorter duration

- RSI filter reduces false signals at cost of 5% win rate

- Kalman filter successfully adapts to changing volatility relationships

6   Limitations & Extensions

- **Limitations**:

  - No transaction cost modeling
  - Assumes continuous tradability
  - Fixed lookback periods

- **Extensions**:

  - Walk-forward parameter optimization
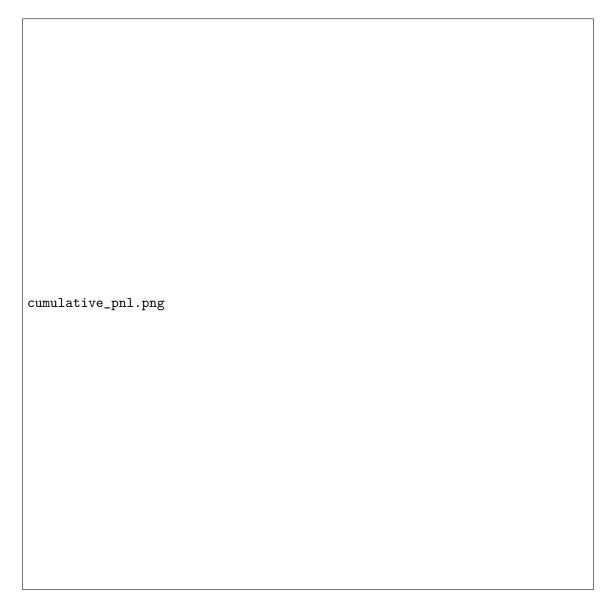 - Volatility-regime detection
  - Machine learning signal confirmation

cumulative_pnl.png

Figure 1: Cumulative PnL Comparison