REHOBOAM v2: A High-Frequency Pairs Trading Expert Advisor for MetaTrader 5

Njoroge, S.N.

EMAIL: njorogenjai11@gmail.com, TEL: +254798 937 840

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Abstract

Pairs trading is a market-neutral strategy that exploits temporary deviations in the price relationship between two correlated assets. This paper presents a detailed analysis of REHOBOAM v2, an Expert Advisor (EA) implemented in MQL5 for the MetaTrader 5 platform. The EA employs a statistical arbitrage approach using correlation as a proxy for cointegration, calculating a hedge ratio to form a synthetic spread between user-specified symbol pairs. It operates in a high-frequency trading (HFT) mode, executing decisions on every tick while incorporating risk management through position sizing, stop-loss, and take-profit mechanisms. We derive the mathematical foundations of the strategy, including hedge ratio computation, Z-score normalization, and risk-based lot sizing. The enhancements in v2 over its predecessor are highlighted, emphasizing improved responsiveness and flexibility in exit conditions.

Keywords: *pairs trading, statistical arbitrage, hedge ratio, Z-score normalization, high-frequency trading, MetaTrader 5, MQL5, Expert Advisor, cointegration proxy, risk management*

I. Introduction

Pairs trading, popularized by quantitative hedge funds in the 1980s, relies on the principle that correlated assets tend to revert to their historical price relationships after deviations. This strategy is particularly effective in volatile markets where traditional directional trades carry higher risks. REHOBOAM v2 builds on this concept by automating pairs trading for any two symbols (e.g., XAUUSD and XAGUSD) on the MetaTrader 5 platform.

The EA's core innovation lies in its use of a hedge ratio derived from historical prices to create a stationary spread, which is then monitored via Z-scores for entry and exit signals. Unlike v1, which operated on new bar formations, v2 runs on every tick for HFT compatibility, incorporates bid/ask prices for precise spread calculations, and introduces optional Z-score-based take profits. This paper elucidates the algorithmic workflow, supported by mathematical formulations, to provide a comprehensive understanding of its mechanics.

II. Background and Related Work

Pairs trading strategies typically involve identifying cointegrated pairs using tests like the Engle-Granger or Johansen methods. However, REHOBOAM v2 simplifies this by using Pearson correlation as a proxy, which is computationally efficient for real-time trading. This approach aligns with works such as Gatev et al. (2006), who demonstrated the profitability of distance-based pairs trading on equities.

In forex and commodities, pairs like AUDUSD-NZDUSD or gold-silver exhibit high correlations due to economic linkages. The EA's risk management draws from modern portfolio theory (Markowitz, 1952), sizing positions to limit exposure to a fixed percentage of account balance. Enhancements in v2 address limitations in v1, such as bar-based execution, by enabling tick-level operations akin to HFT systems described in Aldridge (2013).

III. Methodology

A. Symbol Selection and Initialization

Upon initialization, the EA validates user-input symbols (SymbolA and SymbolB) and ensures market data availability. It calculates the hedge ratio β using a lookback period of 252 bars (approximately one trading year on daily timeframes). Correlation is computed on daily returns to filter unsuitable pairs if below a minimum threshold (default 0.2 in v2, reduced from 0.8 in v1 for broader applicability).

B. Hedge Ratio and Correlation Calculation

The hedge ratio β is derived from ordinary least squares (OLS) regression, treating SymbolA prices as the dependent variable and SymbolB as the independent:

$$\beta = \frac{\mathrm{Cov}(P_A, P_B)}{\mathrm{Var}(P_B)}$$

where P_A and P_B are arrays of closing prices over the regression period.

Correlation ρ serves as a cointegration proxy, calculated on returns:

$$r_{A,i} = \frac{P_{A,i} - P_{A,i+1}}{P_{A,i+1}}, r_{B,i} = \frac{P_{B,i} - P_{B,i+1}}{P_{B,i+1}}$$

$$\rho = \frac{\mathrm{Cov}(r_A, r_B)}{\sigma_{r_A} \cdot \sigma_{r_B}}$$

If $\rho < MinCorrelation$ and not bypassed, initialization fails.

C. Spread Formation and Z-Score Normalization

The synthetic spread S is formed as:

$$S_t = P_{A,t} - \beta \cdot P_{B,t}$$

Over a lookback period (default 20), historical spreads are computed excluding the current bar:

$$\mu_S = \frac{1}{N}\sum_{i=1}^{N} S_{t-i}, \sigma_S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(S_{t-i} - \mu_S)^2}$$

The Z-score normalizes the current spread:

$$Z_t = \frac{S_t - \mu_S}{\sigma_S}$$

In v2's HFT mode, S_t uses bid/ask prices for precision:

- **Long spread:** $S_{\text{long}} = \text{Ask}_A - \beta \cdot \text{Bid}_B$
- **Short spread:** $S_{\text{short}} = \text{Bid}_A - \beta \cdot \text{Ask}_B$
- **Average:** $S_t = (S_{\text{long}} + S_{\text{short}})/2$

This accounts for transaction costs implicitly.

D. Entry Conditions

Trades are entered when $|Z_t) \geq \text{EntryZScore}$ (default 2.0), signaling deviation:

- If $Z_t \leq \text{EntryZScore}$: Long the spread (buy SymbolA, sell SymbolB).
- If $Z_t \geq \text{EntryZScore}$: Short the spread (sell SymbolA, buy SymbolB).

Positions are only opened if no existing pair trade exists and markets are open for both symbols.

E. Position Sizing

Lots for SymbolA (L_A) are sized to risk a fixed percentage (default 1%) of balance, assuming an adverse move of $2\sigma_S$ (from entry to stop):

$$\text{RiskAmount} = \begin{cases} (\text{RiskPercent}/100) \cdot B & \text{if SL\_ZScore} \\ (\text{StopLossPercent}/100) \cdot B & \text{if SL\_Percent} \end{cases}$$

where B is account balance.

The dollar risk per unit is based on tick value:

$$L_A = \frac{\text{RiskAmount}}{2\sigma_S \cdot \left(\text{TickValue}_A / \text{TickSize}_A\right)}$$

L_A is normalized to broker lot steps and capped by min/max lots (with a user-defined MaxLots in v2). Lots for SymbolB: $L_B = \beta \cdot L_A$, similarly normalized.

F. Exit Conditions

Exits occur based on stop-loss (SL) and take-profit (TP) types.

a. Z-Score Based (SL_Type = SL_ZScore)

For long spread (entry $Z_e < 0$):

- SL: $Z_t \le Z_e - \left(\text{StopZScore} - \text{EntryZScore}\right)$
- TP (TP_Type = TP_Multiple): $Z_t \ge Z_e + \text{RiskRewardRatio} \cdot \left(\text{StopZScore} - \text{EntryZScore}\right)$
- TP (TP_Type = TP_ZScore): $Zt \ge TakeProfitZScore$ (e.g., 0 for mean reversion)

Symmetric for short spread. This assumes mean reversion within a Z-score band.

b. Percentage Based (SL_Type = SL_Percent)

Monitors pair profit $\Pi = \sum \text{PositionProfit}$:

- SL: $\Pi \le \left(\text{StopLossPercent}/100\right) \cdot E$
- TP: $\Pi \ge \left(\text{StopLossPercent}/100\right) \cdot E \cdot \text{RiskRewardRatio}$

where E is equity at entry.

G. High-Frequency Enhancements in v2

Unlike v1's bar-based execution, v2 processes every tick, removing the *IsNewBar* check. This enables faster responses to market movements. Additionally, a market open check prevents trades during closures:

$$\text{MarketOpen} = \left(\text{TradeMode}_A \neq \text{DISABLED}\right) \wedge \left(\text{TradeMode}_B \neq \text{DISABLED}\right)$$

v2 also introduces TP_ZScore for flexible mean-reversion exits, absent in v1.

IV. Mathematical Validation and Assumptions

The strategy assumes the spread is stationary, validated indirectly via correlation. Under normality, Z-scores follow a standard normal distribution, with thresholds corresponding to confidence levels (e.g., $2^{\sigma} \approx 95\%$). Position sizing assumes the adverse move is linearly related to σ_S, which holds under Gaussian assumptions but may fail in fat-tailed markets.

Potential limitations include slippage in HFT mode and correlation breakdown during regime shifts. Future extensions could incorporate formal cointegration tests or adaptive lookbacks.

V. Conclusion

REHOBOAM v2 represents an advanced, user-configurable pairs trading EA optimized for high-frequency execution. By leveraging hedge ratios, Z-score signals, and risk-controlled sizing, it provides a robust framework for statistical arbitrage. The mathematical formulations outlined ensure transparency and reproducibility, making it suitable for both educational and practical applications in algorithmic trading.

References

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