

QUANTITATIVE VOLATILITY & STATISTICAL ARBITRAGE MATRIX

CORE STRATEGY SUMMARY: An institutional-grade quantitative framework for statistical arbitrage, cointegration modeling, and volatility...

COINTEGRATION & STATIONARITY FOUNDATIONS

Engle-Granger Two-Step Residual Cointegration

Establishes long-run equilibrium between non-stationary FX price series by testing linear regression residuals for stationarity. C

Trigger: Execute pairs trade when residual ADF t-stat exceeds -3.45

Augmented Dickey-Fuller (ADF) Metric

Unit root test evaluating whether the synthetic spread exhibits mean-reverting stationary characteristics. Ensures drift and trend

Trigger: Enter long/short spread only when ADF p-value is strictly

Johansen Eigenvalue Rank Test

Vector autoregressive (VAR) method determining multiple cointegrating vectors across multi-asset currency baskets. Essential for t

Trigger: Deploy basket basket-arbitrage only when trace statistic c

SYNTHETIC SPREAD CONSTRUCTION & BETA NEUTRALITY

Kalman Filter Dynamic Hedge Ratio

Recursive state-space algorithm updating the asset beta continuously to capture non-linear structural shifts in pair relationships

Trigger: Recalculate hedge ratio at each bar close; rebalance physi

PCA Residual Extraction

Principal Component Analysis isolating market-wide systematic variance (PC1-PC3) from idiosyncratic currency pair noise. Residual

Trigger: Initiate statistical arbitrage when idiosyncratic residual

Total Least Squares (TLS) Orthogonal Regression

Symmetric error minimization framework accounting for observation noise in both independent and dependent FX pairs simultaneously

Trigger: Lock TLS slope parameter; place stop loss on synthetic spr

MEAN REVERSION SIGNAL GENERATION (Z-SCORE)

Normalized Spread Z-Score Thresholds

Standardized measure of spread deviation from its rolling dynamic moving average, scaled by standard deviation. Normalizes cross-p

Trigger: Go short spread at $Z \geq +2.0$ and long spread at $Z \leq -2.0$;

Ornstein-Uhlenbeck (OU) Parameterization

Continuous-time stochastic process modeling the speed of mean reversion (theta) and analytical half-life of spread convergence. El

Trigger: Filter out candidate pairs with half-life exceeding 10 tra

Bollinger-Residual Elasticity Trigger

Combines dynamic 20-period standard deviation bands applied directly over stationary residual spreads rather than spot rates. Capt

Trigger: Trigger entry on outer band penetration accompanied by can

CROSS-CURRENCY TRIANGULAR ARBITRAGE

Synthetic Cross Parity Discrepancy

Exploits instantaneous microsecond pricing imbalances between direct FX crosses and their triangular component legs (e.g., EUR/USD)

Trigger: Execute 3-leg order block when synthetic rate differs from

Triangular Imbalance Hurdle Calculation

Mathematical threshold defining the minimum viable basis point divergence required to yield positive net alpha after factoring execution costs

Trigger: Fire triangular algorithm only when $(Bid_A * Bid_B) / Ask_C$

IMPLIED VS. REALIZED VOLATILITY ARBITRAGE

Volatility Risk Premium (VRP) Harvest

Systematic monetization of the structural premium of over-the-counter FX options implied volatility (IV) over future realized volatility

Trigger: Sell 1-month ATM IV when IV/RV ratio ≥ 1.25 and 30-day realized volatility is rising

Garman-Klass Realized Volatility Estimator

High-efficiency estimator incorporating open, high, low, and close prices to yield continuous volatility estimates up to 8x more accurate than standard RV

Trigger: Initiate long gamma position when 10-day Garman-Klass RV is above 1.5x 30-day average

Parkinson Extreme-Value Volatility Ratio

Scale-invariant measure tracking daily high-low ranges to quantify true market diffusion without close-to-close jump distortions

Trigger: Throttle all mean-reverting stat-arb position sizing by 50% when Parkinson ratio ≥ 2.0

VOLATILITY CONES & REGIME FILTERING

Historic Volatility Cone Quartiles

Multi-horizon term-structure plotting maximum, minimum, and median historical volatility over fixed lookbacks (10, 30, 90, 180 day)

Trigger: Deploy volatility mean-reversion strategies when IV breaches the 90th percentile of the historic cone

Markov Switching Autoregressive Filter

Probabilistic model segmenting FX pair behavior into low-volatility mean-reverting, moderate trending, or high-volatility jump regimes

Trigger: Disable all statistical arbitrage modules when high-volatility regime is detected for 3 consecutive days

GARCH(1,1) Volatility Forecast Break

Conditional heteroskedasticity forecasting framework projecting forward 1-day variance based on recent shocks and lingering variance

Trigger: Halt spread entry if spot realized move exceeds 2.5x GARCH forecast

FX PAIR SELECTION & CORRELATION CLUSTERING

Hierarchical Risk Parity (HRP) Graph Clustering

Machine learning clustering approach applying graph theory to correlation matrices, grouping currency pairs by structural macroeconomic

Trigger: Select pairs exclusively from identical leaf clusters; reject

Distance Correlation Decoupling Metric

Non-linear dependency metric measuring both linear and non-linear associations between currencies, capturing relationships missed

Trigger: Approve pair for stat-arb only if 90-day Distance Correlation

DISPERSION & CARRY-ADJUSTED STATARB

Cross-Sectional FX Momentum Dispersion

Exploits cross-sectional variance between high-beta commodity currencies and defensive funding currencies. Long outlier underperforms

Trigger: Go long bottom decile and short top decile when cross-section

Carry-Adjusted Residual Drift Cushion

Modifies standard statistical arbitrage Z-score equations to incorporate positive or negative overnight swap financing differentials

Trigger: Require Z-Score entry threshold of $|Z| \geq 2.5$ for negative

HIGH-FREQUENCY ORDER FLOW & MICROSTRUCTURE

Volume-Synchronized Probability of Toxicity (VPIN)

Measures toxicity and informed order flow imbalance directly from volume buckets rather than chronological clock time. Serves as a

Trigger: Pause all market-making and tight stat-arb limits when VPIN

Order Book Skew & Micro-Price Drift

Calculates volume-weighted average price across the top 5 levels of the limit order book (LOB) to determine true immediate direct

Trigger: Execute passive spread limit orders only on the side favor

DYNAMIC POSITION SIZING & PORTFOLIO ALLOCATION

Fractional Kelly Criterion Scaling

Mathematically optimal capital allocation formula based on win probability and payout ratio, scaled downward by a fractional factor

Trigger: Size spread lots using Quarter-Kelly: $f^* = 0.25 * (p*b - q)$

Conditional Value-at-Risk (CVaR) Allocation Gate

Downside risk framework calculating the expected loss conditional on breaching the 99% VaR threshold. Enforces tail-risk protection

Trigger: De-lever total gross exposure by 50% if rolling 1-day 99%

Volatility-Targeted Capital Sizing

Normalizes individual pair risk contributions across diverse FX volatilities by dynamically weighting notional position sizes inverse to volatility

Trigger: Target strict 12% annualized portfolio volatility; rebalance quarterly

QUANTITATIVE STOP LOSS & REGIME FAILURE EXITS

Chow Test Structural Break Detection

Statistical test assessing whether the coefficients in the cointegration regression model have undergone an abrupt structural shift

Trigger: Immediately close all pair legs with market orders if Chow

Hard Z-Score Regime Blowout Stop

Absolute protective boundary designed to terminate positions when an asset spread transitions from stationary noise to an explosive regime

Trigger: Execute immediate market liquidation if spread diverges to

Time-Decay Half-Life Timeout

Strict temporal stop loss liquidating stale mean-reversion trades where variance has collapsed without price converging back to the mean

Trigger: Flatten pair exposure at market if position has been open

EXECUTION OPTIMIZATION & TCA

Implementation Shortfall Minimization

Transaction Cost Analysis (TCA) metric quantifying the cost difference between paper decision price and final executed volume-weighted average price

Trigger: Route orders via adaptive smart routing; halt execution algorithm if ISM exceeds threshold

Almgren-Chriss Optimal Liquidation Trajectory

Dynamic execution model balancing market impact against inventory risk over a predetermined liquidation horizon to minimize trade execution costs

Trigger: Schedule unwinds across calculated optimal time slices; adjust for volatility changes

TWAP Cross-Leg Execution Synchronizer

Time-Weighted Average Price algorithm executing simultaneous legs of synthetic pairs in fractional micro-tranches to prevent cross execution

Trigger: Suspend active multi-leg execution if fill discrepancy between legs exceeds threshold