

CPM Read-Only Trading Algorithm: Formal Specification

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Executive Summary

This specification describes a *read-only* trading engine that uses the Coercive Projection Method (CPM) to detect and exploit **provable** mispricings from a small set of public observations. The method proves an inequality that bounds a global no-arbitrage defect by a weighted sum of local, observable tests. Online, the engine computes a *mispricing lower bound* δ and trades only when δ exceeds conservative costs. Each opportunity is accompanied by a machine-auditable certificate (PMC). No forecasting, no market impact, no private data.

Non-goals. We do not build predictive models, latency/impact alpha, or use MNPI. The engine avoids sweeping books and operates strictly passively.

0. Objective

Exploit *provable* mispricings discovered via **sparse observations**, without moving markets. Trade only when a Coercive Projection Method (CPM) certificate provides a conservative lower bound δ on mispricing that exceeds frictions.

1. Formal Frame

Structured set (global property). For an asset (or family) with latent state x and observables $y = \mathcal{O}(x)$, define a convex/affine *structured set* \mathcal{S} (no-arbitrage / fair-value constraints).

Examples: option static-arbitrage constraints (monotonicity/convexity), bond fair PV bands, ETF/NAV bands, futures carry bands.

Defect. Quantify violation of \mathcal{S} via a nonnegative *defect* $D(x) = \text{dist}(x, \mathcal{S})$ or a sum of positive parts of inequality residuals.

Certificate (lower bound). A *Provable Mispricing Certificate* (PMC) is a family of nonnegative observable tests $s_i(y) \geq 0$ with weights $u_i \geq 0$ and a constant $c > 0$ such that, for all admissible x and $y = \mathcal{O}(x)$,

$$\boxed{D(x) \geq c \sum_i u_i s_i(y)} \tag{Cert}$$

This direction yields a tradeable lower bound.

Raw and realized bounds. Define the raw bound $\delta_{\text{raw}}(y) = c \sum_i u_i s_i(y)$. Convert to a realizable P&L bound by conservative haircuts and passive-fill scaling:

$$\delta(y) = q(y) \delta_{\text{raw}}(y) - \underbrace{\text{fees}(y)}_{\text{maker/taker, clearing, borrow}} - \underbrace{\varepsilon_{\text{stale}}(y)}_{\text{data staleness}} - \underbrace{\varepsilon_{\text{hedge}}(y)}_{\text{replication error}},$$

with passive fill fraction $q(y) \in [0, 1]$ derived from queue-drain statistics and participation caps.

Trading gate. Enter only if $\delta(y) \geq \theta$ (safety margin) and the condition holds for M successive event-time samples (anti-flicker).

Stability lemma (optional). Upper bounds of the form $D(x) \leq K \sum_i w_i |t_i(y)|$ can be useful to relate defect to an energy gap, but they do not produce tradable lower bounds and are not used in δ .

Assumptions and invariants.

- **Data integrity:** multi-venue aggregation with stale-tick rejection and median-of- N guards.
- **Cost conservatism:** fees, spread, slippage and borrow modeled as upper bounds.
- **Proof constants:** coercivity (K, w_i) are pre-computed, versioned, and auditable.
- **Replication:** hedges neutralize unintended exposures (DV01, vega, beta, FX) so δ corresponds to realizable P&L.

2. Asset Templates (\mathcal{S} , tests T , bound δ)

2.A Corporate Bonds (read-only synthetic credit)

Structured set \mathcal{S} : fair PV within a band from (i) risk-free curve, (ii) CDS-implied hazard spline, (iii) liquidity premium bounds.

Tests T (7 anchors): UST nodes (2y, 5y, 10y), issuer/sector CDS (1y, 5y, 10y), equity 30d implied vol.

Coercivity (example form): $D \leq K_{\text{bond}} (a_1 |\Delta TS| + a_2 |\Delta CDS| + a_3 |\Delta VOL|)$.

Certificate form. Use an *exogenous* liquidity premium bound LP_{max} (explicit constant) or restrict to on-the-run IG credits where $\text{LP}_{\text{max}} \approx 0$. Then define risky PV inner/outer envelopes and set $s_1(y) = (\text{PV}_{\text{min}} - P)_+$, $s_2(y) = (P - \text{PV}_{\text{max}})_+$, $\delta_{\text{raw}} = s_1 + s_2$ with $c = 1$.

Details. Let $r(t)$ be the OIS curve and $\lambda(t)$ a piecewise-constant hazard rate calibrated from $(\text{CDS}_{1y, 5y, 10y})$ under shape constraints. Survival $S(t) = \exp(-\int_0^t \lambda(u) du)$ and discount $\text{DF}(t) = \exp(-\int_0^t r(u) du)$ yield bounds

$$\text{PV}_{\text{min} / \text{max}} = \int_0^T c \text{DF}(t) S(t) dt + \text{DF}(T) S(T) \pm \text{LP}_{\text{max}}.$$

Scope: if LP_{max} is not defensible from public data, exclude the name from the certified universe.

2.B Options (static arbitrage)

Structured set \mathcal{S} : per maturity, call surface is increasing in strike and *convex*; calendar monotone.
Tests T (discrete): for strikes $K - \Delta, K, K + \Delta$, enforce $C(K - \Delta) - 2C(K) + C(K + \Delta) \geq 0$; monotone checks; adjacent maturity calendar check.

Certificate form. Use *executable* quotes $C^{\text{bid/ask}}(K)$. The long butterfly cost

$$\Pi_{\text{but}}(K) = C^{\text{ask}}(K - \Delta) - 2C^{\text{bid}}(K) + C^{\text{ask}}(K + \Delta)$$

must satisfy $\Pi_{\text{but}}(K) \geq 0$ under no-arbitrage. Define $s_K(y) = (-\Pi_{\text{but}}(K))_+$ and $\delta_{\text{raw}} = \sum_{K \in \mathcal{K}_{\text{int}}} s_K$. Add analogous vertical (monotone) and calendar tests. Set $c = 1$.

2.C ETF vs NAV

Structured set: ETF within AP creation/redemption band of NAV.

Tests: top-constituent NAV snapshot (median-of-N), AP fee schedule.

Certificate form. Use iNAV or a holdings-weighted proxy with stale-tick guards. AP band $[\widehat{\text{NAV}} - f_{\text{AP}} - \eta, \widehat{\text{NAV}} + f_{\text{AP}} + \eta]$ with published f_{AP} and a conservative dispersion η . Define $s(y) = (|\text{ETF} - \widehat{\text{NAV}}| - f_{\text{AP}} - \eta)_+$, $c = 1$, and $\delta_{\text{raw}} = s$.

2.D Futures Basis / Carry

Structured set: $F = S \exp((r - q - c)\tau)$ within storage/friction bands.

Tests: spot (median multi-venue), risk-free node, dividend yield proxy, storage proxy.

Certificate form. For financial futures (rates, index, FX) with transparent carry, define band $[F_{\min}, F_{\max}]$ using (r, q) and a conservative c_{\max} . For commodities, either exclude or include a large convenience-yield haircut. Let $s(y) = \max\{0, F_{\min} - F, F - F_{\max}\}$, $c = 1$, and $\delta_{\text{raw}} = s$.

2.E Triangular FX

Structured set: cross equals product of legs within spread/fee bounds.

Tests: best bid/ask from multiple venues, latency-robust snapshot.

δ : deterministic cross-venue bound (classic triangular arbitrage).

3. System Architecture

Data layer low-latency public feeds; snapshot aggregators (median-of-N, staleness guards); fee model.

Certificate engine evaluate tests T , compute δ , emit $\text{PMC} = \{\delta, \text{timestamp}, \text{inputs}, \text{model_id}, \text{audit_hash}\}$. Require hysteresis: δ above threshold for M consecutive ticks.

Portfolio/risk sizing $\propto \delta$ with DV01/vega/beta caps; hedging to neutralize systematics; kill-switches on data/model drift.

Execution read-only passive posting, participation caps, randomized clip sizes; exit on δ decay, time, or liquidity deterioration.

Monitoring/audit log PMCs and realized P&L vs $\sum \delta$; drift detector on constants; auto-recalibration workflow.

3.1 Cost and Leakage Model

Total cost bound per trade: $\text{costs} = \text{commissions} + \text{exchange_fees} + \text{half_spread} + \text{slippage_budget} + \text{borrow/carry} + \text{taxes}$. Use safety margin σ and require $\delta > \text{costs} + \sigma$. Slippage budget derived from passive impact curves under participation caps.

3.2 Microstructure and Impact

- Queue model per venue (price–time vs pro-rata, iceberg prevalence); estimate passive fill fraction q from observed queue drain rates.
- Maker/taker and rebate schedules in the fee ledger; never cross the spread; enforce per-venue participation caps.
- Impact metric: realized slippage vs passive baseline; monitor and cap; does not affect ex-ante certificate.

4. Pseudocode

```

loop time t:
  for asset in universe:
    y = read_observables(asset)          # tests T
    delta = mispricing_lower_bound(asset, y)
    if delta > costs(asset) + safety_margin and stable_for(M ticks):
      trade = synthesize_trade(asset, delta)  # hedged, read-only
      size = size_position(asset, delta, risk_limits, liquidity)
      submit_passive_orders(trade, size)
  manage_positions():
    update delta_t; exit if delta_t < exit_thr or max_hold or risk breach

# mispricing_lower_bound examples:
# options: Pi_but = C_ask(K-DELTA) - 2*C_bid(K) + C_ask(K+DELTA)
#          s_K = max(0, -Pi_but); delta_raw = sum_K s_K
# bonds:   s = max(0, PV_min - P, P - PV_max); delta_raw = s
# ETF:     s = max(0, abs(ETF - NAV_hat) - f_AP - eta); delta_raw = s
# futures: s = max(0, F_min - F, F - F_max); delta_raw = s
# delta = q*delta_raw - fees - eps_stale - eps_hedge

```

4.1 Gating and Backtest Hygiene

- Sampling clock: event-time, monotone; align feeds; drop late packets.
- Anti-flicker gate: stability for M successive samples; add min hold time and re-entry cooldown.
- Backtests use LOB-level replay with queue position; avoid mid-fill assumptions.

5. Calibration and Proofs

Offline. Derive coercivity constants K and weights a_i per template: options via discrete convexity (exact), bonds via robust PV/hazard envelopes (interval arithmetic), ETF/AP (deterministic), futures (storage bands). Stress adversarial data/pathologies; select ε conservatively.

Online. Track certificate breach rate (realized P&L $< \delta$). If breach rate $> \alpha$, auto-delist instrument and re-calibrate.

Auditability. Persist $(\delta, T(y), K, w_i, \varepsilon, \text{costs})$ and PMC hashes. For certified windows, realized P&L should satisfy $\sum \text{P\&L} \geq \sum(\delta - \text{costs})$ up to noise; repeated breaches trigger re-calibration.

6. Risk Controls

No prediction; trade only on δ -certified opportunities. Footprint caps (participation, impact), exposure caps (DV01/vega/beta), latency guards (stale tick rejection, median-of-N), circuit breakers (volatility surge beyond model envelope).

Replication and hedging. Hedge instruments must be priced and executable under the same public-data envelope used to compute δ . Include a hedge error bound $\varepsilon_{\text{hedge}}$; include borrow/locate bounds and FX conversion bounds where applicable.

7. Backtest and Evaluation

Replay quote histories; compute δ time series. Metrics: opportunity count, realized P&L vs $\sum \delta$ (net frictions), max drawdown, breach rate ≈ 0 , sensitivity to a_i, K , liquidity stress, slippage. Benchmark vs naive pairs/ML; expect lower frequency, higher precision and Sharpe.

8. Compliance and Ethics

Read-only execution policy, explicit manipulation avoidance; public-auditable PMC hashes; internal controls for legitimacy; venue fairness and no special information.

9. Initial Deployment Targets

Options static arbitrage on liquid index options; ETF vs NAV on top equity/fixed-income ETFs; FX triangular across venues; futures basis on front contracts; expansion to IG credit where CDS/TS liquid.

Appendix A: Options Certificate with Executable Quotes

Fix expiry and discrete strikes with spacing Δ . Let $C^{\text{bid/ask}}(K)$ be best quotes. The long butterfly $(+1, -2, +1)$ at $(K - \Delta, K, K + \Delta)$ has nonnegative payoff, hence executable cost $\Pi_{\text{but}}(K) = C^{\text{ask}}(K - \Delta) - 2C^{\text{bid}}(K) + C^{\text{ask}}(K + \Delta) \geq 0$ under no-arbitrage. Define $s_K(y) = (-\Pi_{\text{but}}(K))_+$. Aggregating over interior strikes (optionally disjoint to avoid double counting) gives $\delta_{\text{raw}} = \sum_K s_K$. Subtract fees per leg and apply passive fill fraction q to obtain δ .

Appendix B: Hazard Envelope for Bonds

Calibrate piecewise-constant $\lambda(t)$ to CDS nodes within shape constraints to form inner/outer hazard envelopes; compute risky PV bounds by interval arithmetic. Use an explicit liquidity premium bound LP_{max} ; if not defensible from public data, exclude the name.

Appendix C: ETF AP Band

Authorized participant fees f_{AP} and tracking dispersion η define mechanical bounds around a holdings-weighted NAV proxy with stale-tick guards. The band yields a deterministic lower bound for δ net of costs.

Appendix D: Parameter Dictionary

- c : certificate constant; u_i : test weights; ε : conservatism slack.
- fees: commissions + exchange; slippage_budget: passive impact allowance.
- Exposure caps: DV01/vega/beta per instrument/portfolio.
- M : hysteresis length; α : acceptable breach rate.
- q : passive fill fraction (queue-drain estimate, participation-capped).