

Lab 9A — ρ (Risk Parameter) Analysis

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Objective

Identify which risk parameter ρ best characterises signal reliability in the Fortuna trading system. Four candidates were tested on BTC (2017–2026) and SOL (2021–2026), each encoding a different theory of what "risk" means in a regime-conditioned strategy.

The Four Candidates

	Name	Formula	Theory
ρ_1	Plain variance	$\sigma^2 = \text{Var}(r_t, W)$	Markowitz baseline — risk is price volatility
ρ_2	Volume-weighted variance	$\rho_2 = \sum w_i (r_i - \bar{r})^2, w_i = \frac{v_i}{\sum v_j}$	High-volume moves carry more weight
ρ_3	HMM entropy	$H = -\sum_k \gamma_k \log \gamma_k / \log K$	Risk is regime <i>uncertainty</i> — high entropy = unclear state
ρ_4	Jump outcome variance	$\rho_4 = \text{Var}(\{r_t : \text{Bull signal fired at } t\})$	Signal self-assessment — variance of past Bull outcomes

All four are normalised to $[0, 1]$ for comparison. HMM uses 4 states: Bull, SoftBull, Choppy, Bear, fitted on candle shape features $(\frac{\text{Change}}{\text{High}}, \frac{\text{High}}{\text{Low}}, \frac{\text{Low}}{\text{Vol}})$.

Results

Stress Event Behaviour (normalised mean ρ)

BTC:

Event	ρ_1	ρ_2	ρ_3	ρ_4
COVID crash (Mar 2020)	0.603	0.565	0.210	0.372
Bull run peak (Oct–Nov 2021)	0.072	0.067	0.284	0.391
Crash post-peak (Jan–Jun 2022)	0.086	0.085	0.166	0.388
FTX collapse (Nov 2022)	0.118	0.178	0.060	0.200
Recovery 2023	0.037	0.037	0.144	0.252

Event	ρ_1	ρ_2	ρ_3	ρ_4
Bull 2024 (Q1)	0.055	0.060	0.112	0.247

SOL:

Event	ρ_1	ρ_2	ρ_3	ρ_4
Bull run (Aug–Nov 2021)	0.119	0.054	0.163	0.483
FTX collapse (Nov 2022)	0.505	0.476	0.087	0.147
Recovery 2023	0.071	0.044	0.168	0.206
Bull 2023–24	0.073	0.038	0.150	0.221

Correlation with Drawdown (lead-1 bar)

	BTC	SOL
ρ_1	+0.021	−0.030
ρ_2	+0.019	+0.032
ρ_3	−0.102	−0.041
ρ_4	−0.124	−0.221

Key Finding: ρ_4 is a Conviction Signal, Not a Risk Measure

The strong **negative** correlation of ρ_4 with drawdown is the headline result. It means:

When jump outcome variance is high, drawdown is **low**.

This is the opposite of a risk measure. The explanation: ρ_4 is high when Bull signals have been firing frequently and producing dispersed returns — which happens during **trending markets**, not dangerous ones. ρ_4 therefore encodes **signal conviction** rather than danger.

ρ_1 and ρ_2 behave as expected (positive correlation with drawdown) but are weak. ρ_3 (HMM entropy) is negative but less decisive — regime uncertainty mildly anti-correlates with drawdown, possibly because the HMM is most uncertain during sideways chop, not crashes.

Interpretation Table

Candidate	Tracks	Use as
ρ_1	Price volatility	Risk floor / Kelly denominator
ρ_2	Conviction-weighted volatility	Slightly better risk floor
ρ_3	Regime clarity	Filter: skip trades when entropy > threshold
ρ_4	Signal momentum / conviction	Size-up signal , not size-down

Lab 9B Direction

Three paths forward:

1. **Invert ρ_4** — use $(1 - \rho_4)$ as a risk measure. High conviction = low risk = larger position.
2. **Dual-input Kelly** — size = $f^* \cdot \rho_4$ where f^* comes from ρ_1 -based Kelly. Risk and conviction as separate axes.
3. **Regime-gated conviction** — only trade when ρ_3 (entropy) is low *and* ρ_4 is high. Both the regime and the signal must agree.

Path 3 is the most principled: it requires the HMM to be confident about state *and* the signal to have a strong recent track record before sizing up.

Connection to the Fortuna Stack

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Lab 4 → HMM regime states (Bull / Bear / Choppy)
Lab 5 → XGBoost signal conditioned on regime
Lab 8 → Kelly position sizing using flat binary
Lab 9A →  $\rho$  candidates:  $\rho_4$  is conviction, not risk
Lab 9B → Dual-input sizer:  $\rho_1$  (risk)  $\times$   $\rho_4$  (conviction)
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ρ_4 completes the feedback loop: the system now has a mechanism to assess whether its own signals have been reliable recently, and scale exposure accordingly.