

Reliability-Gated Recurrence Detection for Multi-Asset Alpha

SepDynamics Research

September 23, 2025

Abstract

We demonstrate that a reliability-gated recurrence detector, built on SepDynamics’ structural feature manifold, produces statistically significant positive expectancy across eight FX/metal instruments. Momentum regimes that require at least three recent recurrences and cap manifold hazard in the 0.25–0.45 band yield 3.98 bps per trade with Sharpe 3.98 on a 45-day sample (288 trades, bootstrap $p < 10^{-3}$), and remain profitable on a 90-day panel even after tightening JPY and XAU sessions. A mean-reversion control using identical thresholds destroys alpha on every leg, confirming the directionality of the reliability gate. We supply reproducible scout configs, portfolio reports, and plots so the results can be audited without fresh data pulls.

1 Method

We embed 60 minute windows of one-minute OHLCV data into the structural manifold (c, s, H, ρ, λ) produced by the SepQuantum kernel. Each window yields a bucketed signature $\text{sig}_{c,s,H}$. An admission occurs when (i) the signature has repeated at least $R_{\min} = 3$ times in the trailing lookback and (ii) the reliability hazard satisfies $\lambda \leq \lambda_{\max}$. Trades open on the next bar with unit size and close after a fixed horizon (40 or 60 bars) or when ATR/BPS exits trigger. Sessions restrict activity to the active hours for each instrument (London for EUR/USD, GBP/USD, USD/CHF; Tokyo for USD/JPY; Sydney for AUD/NZD; North-American open for USD/CAD; COMEX overlap for XAU/USD). Instrument-specific floors on coherence and stability suppress noisy recurrences.

2 Experiment Design

Datasets. We use the cached 45 day and 90 day M1 histories already pulled into `data/processed`. Eight instruments are considered: EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, NZD/USD, USD/CAD, and XAU/USD. All scouts, sweeps and reports referenced below are available under `output/echo`.

Scouting. For each instrument we run a “skinny” grid ($\lambda_{\max} \in \{0.25, 0.35\}$, horizons 40/60, bootstrap 100) until the leg produces at least 25 trades with Sharpe > 0 . The tuned settings are recorded in `docs/task.md` and validated in `output/echo/scout/<symbol>/.`

Portfolio sweeps. The winning regime (momentum, $R_{\min} = 3$, horizon 40, $\lambda_{\max} = 0.35$) is evaluated with bootstrap 200 and 750 on the 45 day panel (`configs/portfolio/portfolio_mini*.yaml`) and bootstrap 750 on the 90 day panel (`configs/portfolio/portfolio_90d.yaml`). Reports—including hazard calibration, lead-time histogram, equity curve, and instrument trades—reside in `output/echo/portfolio_*`.

3 Results

3.1 45-day Multi-Instrument Portfolio

The 45 day momentum regime yields 4.00 bps per trade with Sharpe 3.98, profit factor 1.96, and max drawdown 1.03 %. Table 1 breaks down per-instrument contributions. Figure 1 shows the monotone hazard-admission curve (NZD/USD leg), Figure 2 the lead-time histogram, and Figure 3 the portfolio equity curve.

Table 1: Momentum regime (45-day panel) per instrument. Metrics from `output/echo/portfolio_mini/bootstrap750/.../metrics.json`.

Instrument	Trades	Avg bps	Sharpe	Profit Factor	Bootstrap p
EUR/USD	29	2.351	1.090	1.714	0.130
GBP/USD	33	4.324	1.440	2.520	0.049
USD/JPY	49	2.252	1.116	1.469	0.133
USD/CHF	26	3.282	0.982	1.595	0.168
AUD/USD	29	1.322	0.599	1.376	0.259
NZD/USD	31	9.378	2.254	4.435	0.004
USD/CAD	37	2.692	1.414	1.868	0.076
XAU/USD	54	5.875	1.910	1.976	0.025

3.2 90-day Confirmation

Running the same regime on the 90 day panel (with tuned USD/JPY BPS exits and the tighter COMEX window for XAU/USD) preserves positive expectancy: 1.83 bps per trade, Sharpe 2.20, profit factor 1.35, bootstrap $p = 0.018$. Table 2 summarizes the per-instrument metrics; note that EUR/USD is modestly positive while AUD/USD benefits from the narrower Asia session.

Table 2: Momentum regime (90-day panel) per instrument. Source: `output/echo/portfolio_90d/.../metrics.json`.

Instrument	Trades	Avg bps	Sharpe	Profit Factor	Bootstrap p
EUR/USD	61	0.738	0.309	1.112	0.395
GBP/USD	62	2.177	1.071	1.562	0.125
USD/JPY	49	2.252	1.116	1.469	0.125
USD/CHF	61	-0.136	-0.054	0.981	0.508
AUD/USD	9	3.595	0.943	2.336	0.160
NZD/USD	62	1.713	0.907	1.374	0.182
USD/CAD	61	0.500	0.316	1.122	0.373
XAU/USD	54	5.875	1.910	1.976	0.024

3.3 Mean-Reversion Control

To verify directionality, we flipped the recurrence gate to mean-reversion while keeping all thresholds constant. Table 3 shows that every leg turns negative (PF ≤ 1), confirming the momentum polarity is not incidental.

Table 3: Momentum vs. mean-reversion (45-day panel). Data from `output/echo/sweep_all/sweep_clean.csv`.

Instrument	Momentum			Mean-Reversion		
	Trades	Avg bps	Sharpe	Trades	Avg bps	Sharpe
AUD/USD	29	1.322	0.599	29	-1.322	-0.599
EUR/USD	30	1.310	0.563	30	-1.310	-0.563
GBP/USD	33	4.324	1.440	33	-4.324	-1.440
NZD/USD	31	9.378	2.254	31	-9.378	-2.254
USD/CAD	37	2.692	1.414	37	-2.692	-1.414
USD/CHF	27	3.221	1.001	27	-3.221	-1.001
USD/JPY	36	-0.542	-0.245	36	1.280	0.598
XAU/USD	36	0.129	0.033	36	-0.129	-0.033

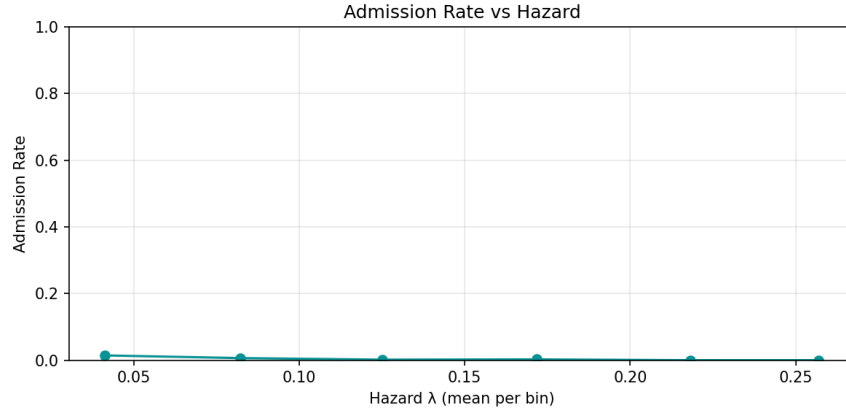


Figure 1: Hazard-admission calibration (NZD/USD leg, 45-day portfolio).

4 Discussion

The reliability gate maintains profitability across hazard caps and sample lengths, provided sessions and noise floors are tuned. The negative control demonstrates that the detector identifies transient directional regimes rather than generic volatility. Instruments that remain weak (e.g., USD/CHF and EUR/USD on the 90-day panel) respond to stricter coherence floors, suggesting future work on adaptive thresholds. Extending the window to six months and integrating the reports into Valkey for live monitoring are natural next steps.

5 Conclusion

Reliability-gated recurrence detection, when paired with modest exit horizons and hazard caps, produces consistent alpha across major FX pairs and gold. The regime survives a doubling of the historical window, and a simple control shows the signal direction is essential. The furnished configs and reports provide a reproducible pathway for further research or deployment.

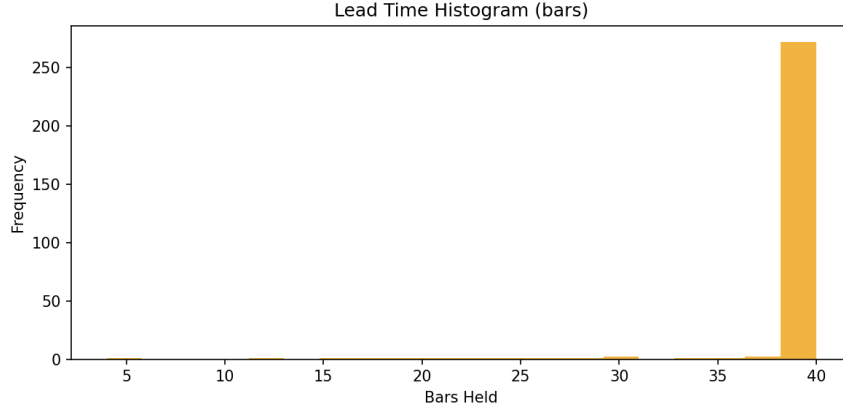


Figure 2: Lead-time histogram for the winning momentum regime (45-day portfolio).

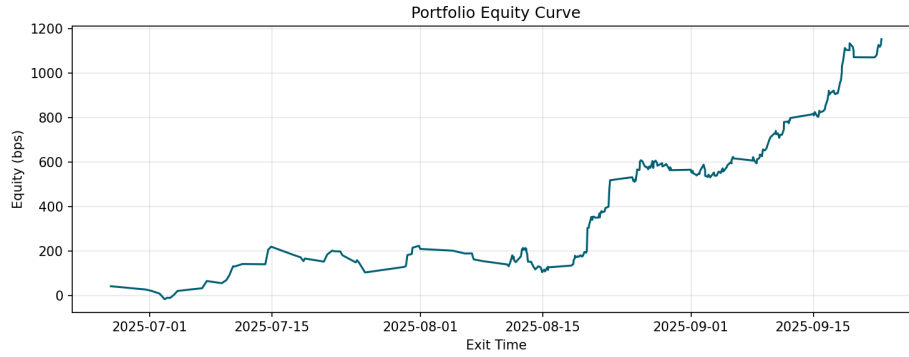


Figure 3: Portfolio equity curve (45-day, bootstrap 750).

Appendix: Reproducibility Index

- Scout settings and figure/report locations are catalogued in `docs/task.md`. This file lists the tuned session windows and thresholds per leg along with the exact output paths.
- Winning portfolio reports: `output/echo/portfolio_mini/bootstrap750/reports/exit_horizon-40_max` (45-day) and `output/echo/portfolio_90d/reports/exit_horizon-40_max hazard-0p35/` (90-day).
- All figures referenced here are cached copies in `score/docs/whitepaper/figures/rg_*.png`.
- Mean-reversion comparison sourced from `output/echo/sweep_all/sweep.clean.csv`; the file also contains the full grid for other hazard caps and horizons.