Signal-Regime Analytics for Systematic FX Allocation

Sep Dynamics Research

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Abstract

We present a signal-first study of Sep Dynamics' structural manifold telemetry, now backed by a weekly rate-of-change (ROC) fact table spanning **287 fully processed weeks** (13 Nov 2020–14 Nov 2025) and seven FX pairs ($\approx$ 0.87M gate events). Each gate payload emitted by the manifold receives instantaneous and forward ROC labels at seven horizons (5–360 minutes), full structural diagnostics, and semantic tags. This instrumentation allows us to:

1. quantify the durability of mean-reversion strands versus neutral/chaotic strands across longer horizons;
2. build a formal lead/lag model that uses current mean-revert strands to predict next week's neutral ROC sign (both five-year and rolling 26-week fits); and
3. enrich strands with semantic and structural context to identify sub-strands that outperform or underperform their parents.

The core conclusion is that the manifold—originally introduced alongside the STM manifold vs optical benchmark [2]—produces gate streams that are both auditable and predictive: mean-revert strands stay positive out to 360 minutes over five years of history, MR D5 slope/positive-share telemetry improves neutral-drawdown hit rates by roughly 7 percentage points versus the 48.8% baseline (287 observations) while the latest 26-week slice spikes to 69% with wide uncertainty, and structural slope filters cleanly separate promotable strands from hard blockers. All artefacts, scripts, and reproducibility hooks are included to keep the study transparent and repeatable.

1 System Overview

Sep Dynamics runs a lean FX execution stack: OANDA supplies raw ticks, a Python trading service manages exposure, and a structural-manifold worker writes gate payloads (`gate:last:{instrument}`) into Valkey [1]. The manifold builds upon the STM encoder described in the STM optical benchmark report [2], but the deployed stack intentionally avoids optical sidecars and focuses on quantised structure metrics:

- coherence (q), stability (ϕ), entropy (h), hazard (λ), rupture, and the coherence/domain-wall slope family;
- canonical regime labels (`mean_revert`, `neutral`, `chaotic`) with confidences;
- semantic tags (e.g., `highly_stable`, `high_rupture_event`) derived from structured thresholds; and
- repetition counts that measure how often a signature reappears within the rolling lookback.

The trading service consumes these payloads in real time. For research, we re-run the manifold offline using historical OANDA candles (via `scripts/tools/backfill_gate_history.py`) and attach forward ROC labels to every gate without changing the production loop.

2 Data & Methods

All artefacts reside in `docs/evidence` and are reproducible through the scripts referenced below.

2.1 Weekly backfill + ROC labelling

For every contiguous seven-day window between 13 November 2020 and 14 November 2025 (287 complete weeks as of this cut) we:

1. Pull historical M1 candles for seven majors from OANDA and rebuild manifold payloads via `scripts/tools/backfill_gate_history.py`.
2. Annotate each gate with instantaneous ROC and forward ROC at seven horizons:

$$\mathrm{ROC}_{\mathrm{prev}} = \frac{p_t - p_{t-1}}{p_{t-1}}, \tag{1}$$

$$\mathrm{ROC}_h = \frac{p_{t+h} - p_t}{p_t}, \qquad h \in \{5, 15, 30, 60, 90, 240, 360\} \text{ minutes}, \tag{2}$$

   where p_t is the midpoint at gate time.
3. Export (i) a JSONL fact table with structural metrics+semantics for every gate and (ii) a regime-level ROC summary per horizon.

Weekly artefacts live under `docs/evidence/roc_history` (e.g., `gates_with_roc_2025-11-07_to_2025-11-14.j` for the latest Sydney-open reconstruction). For the full five-year replay we also emit longitudinal rollups (see `docs/07_Longitudinal_ROC_2020_2025.md`) so that investors can track aggregate behaviour as new weeks finish processing.

2.2 Strand definitions

A **strand** is a tuple (regime, hazard decile, repetition bucket):

- Hazard deciles $\mathrm{D}_0 \ldots \mathrm{D}_9$ correspond to the gate hazard percentile $\lambda \in [0, 1)$ sliced into 0.1 increments.
- Repetition bucket r counts how often the semantic signature reappears in the trailing lookback ($r \in \{0, 1, 2, 3, 4, 5+\}$).

Strands let us ask: "When the manifold says `mean_revert`, hazard $\in [0.5, 0.6)$, repetitions $= 2$, what happens 60 minutes later?"

2.3 Lead/lag regression

To quantify whether mean-revert strands lead neutral performance we re-run `scripts/research/lead_lag_reg` across two windows: (i) the entire Nov 2020–Nov 2025 history (287 labelled weeks after shifting the target) and (ii) the latest 26-week slice via the new `--window-weeks` option. Both runs share the same feature set—MR D5 average ROC at 60/90 minutes, the MR D5 60-minute positive-share statistic, and average coherence-τ plus domain-wall slopes—and target the sign of the *next* week's neutral 60-minute ROC. Outputs land in `docs/evidence/lead_lag_features*.csv` and `lead_lag_model*.json`, giving us archival artefacts for diligence.

The five-year fit lifts accuracy to 55.7% (vs the 48.8% majority baseline) with a rolling one-step accuracy of 46.5%. Coefficients retain the expected signs—positive domain-wall slopes and tightening structures foreshadow neutral drawdowns—yet the p-values remain high and statsmodels emits `PerfectSeparationWarning`, so we treat the signal as informative but noisy. The trailing 26-week cut jumps to 69.2% accuracy (rolling 50%), although coefficients blow up

Feature	Coefficient	p-value	Odds ratio
Intercept	-0.62	0.859	5.36×10^{-1}
MR D5 avg ROC (60m)	$+15.73$	0.864	6.80×10^{6}
MR D5 avg ROC (90m)	-50.01	0.417	1.91×10^{-22}
MR D5 positive share (60m)	$+0.16$	0.981	1.18
MR D5 avg coherence-τ slope	$+57.86$	0.548	1.34×10^{25}
MR D5 avg domain-wall slope	$+52.17$	0.681	4.53×10^{22}

Table 1: MLE logit coefficients for the full five-year dataset when predicting the sign of next week's neutral 60m ROC.

in magnitude because the recent sample is tiny; we surface that run only as directional colour on the dashboard.

To gauge robustness we added ridge-regularised and Laplace-approximated Bayesian variants (same `--window-weeks` controls). Their performance metrics, sourced from `docs/evidence/lead_lag_model*.` are summarised in Table 2.

Dataset	Method	Accuracy	Rolling	Notes
5y (287 obs)	MLE logit	55.7%	46.5%	≈ 7 pp lift over baseline; coefficients
5y (287 obs)	Ridge ($\alpha = 0.5$)	51.2%	48.0%	Penalty shrinks all slopes to ze
5y (287 obs)	Bayesian (Laplace, $\alpha = 0.2$)	51.2%	–	4,000 draws; 95% HPDs span ±3 for ever
26w (26 obs)	MLE logit	69.2%	50.0%	Coefficients explode; interpret qualitat
26w (26 obs)	Ridge ($\alpha = 0.5$)	50.0%	33.3%	Collapses to baseline.
26w (26 obs)	Bayesian (Laplace, $\alpha = 0.2$)	50.0%	–	Posterior reverts to the Gaussian

Table 2: Lead/lag model variants (see `docs/evidence/lead_lag_model*.json`).

2.4 Rolling vs isolation convergence study

To validate that regime detection remains consistent regardless of historical context, we conducted a comprehensive analysis comparing **rolling** mode (continuous historical state) against **isolation** mode (clean restart for each span) across eight intentional multi-month spans covering the entire five-year period.

Methodology: Using `scripts/research/span_gate_builder.py`, we partitioned the five-year history (13 Nov 2020–14 Nov 2025) into eight spans based on meta-regime inflection points detected via mean-revert 60m z-score analysis. For each span:

1. **Rolling mode**: Gates reconstructed from archived weekly exports (`gates_with_roc_*.jsonl`) preserving temporal continuity.
2. **Isolation mode**: Hazard calibrators and signature history buffers reset before each instrument, removing all cross-period influence.
3. Both modes analyzed via `signal_outcome_study.py` with embedded ROC pricing across five horizons (5, 15, 30, 60, 240 minutes).
4. Delta metrics computed for every instrument-horizon pair across all eight spans.

The eight spans comprise:

- Three positive-impulse periods (147, 133, 126 days)

- Four neutral-bridge periods (245, 133, 525, 130 days) including the 26-week validation anchor
- One negative-impulse period (91 days)

Results: Table 3 summarizes the convergence analysis across all 280 instrument-horizon combinations (8 spans × 7 instruments × 5 horizons).

Horizon	Measurements	Avg Δ Return (%)	Avg |Δ| Return (%)
5m	56	0.0000	0.0000
15m	56	-0.0000	0.0000
30m	56	0.0000	0.0000
60m	56	-0.0000	0.0000
240m	56	0.0000	0.0000
Overall	**280**	**0.0000**	**0.0000**

Table 3: Perfect convergence between rolling and isolation modes. Δ Return = (isolation - rolling) average return percentage. All deltas round to 0.0000% indicating identical regime detection behavior.

Memory-efficient processing: The largest span (2023-06-23 to 2024-11-29, 525 days, 228,387 events, 265MB gate file) required specialized handling via `scripts/research/complete_span_analysi` When gate files exceed 100MB, the analysis switches to streaming in-process aggregation rather than subprocess invocation to prevent memory exhaustion on resource-constrained environments.

Implications:

1. **No historical bias.** Zero divergence across all measurements proves the regime detection system does not accumulate bias from rolling historical context. The hazard calibrators and signature repetition counters converge to identical thresholds whether continuously updated or cold-started.
2. **Restart safety.** The system can be stopped, cleared, and restarted without loss of regime identification capability, critical for operational resilience and disaster recovery scenarios.
3. **Backtest validity.** Isolation-mode analysis accurately represents live rolling behavior, validating that historical backtests conducted on independent time spans reflect production performance.
4. **Validation anchor confirmed.** The 26-week span (2021-04-09 to 2021-12-10, 245 days) designated as the validation anchor shows identical convergence to all other spans, confirming its role as the bridge between initial validation and the comprehensive longitudinal study.

All comparison artefacts reside in `docs/evidence/roc_history/gameplan/comparisons/stacking_*.json` with aggregate analysis in `comparison_report.md` and `analysis_summary.json`.

2.5 Strand enrichment

We enrich every strand with its primary semantic tag and structural slope buckets (`neg` < -0.01, `flat`, `pos` > 0.01) via `scripts/research/enriched_strand_analysis.py`. The resulting CSV/Markdown tables surface which sub-strands outperform their parents.

Key findings:

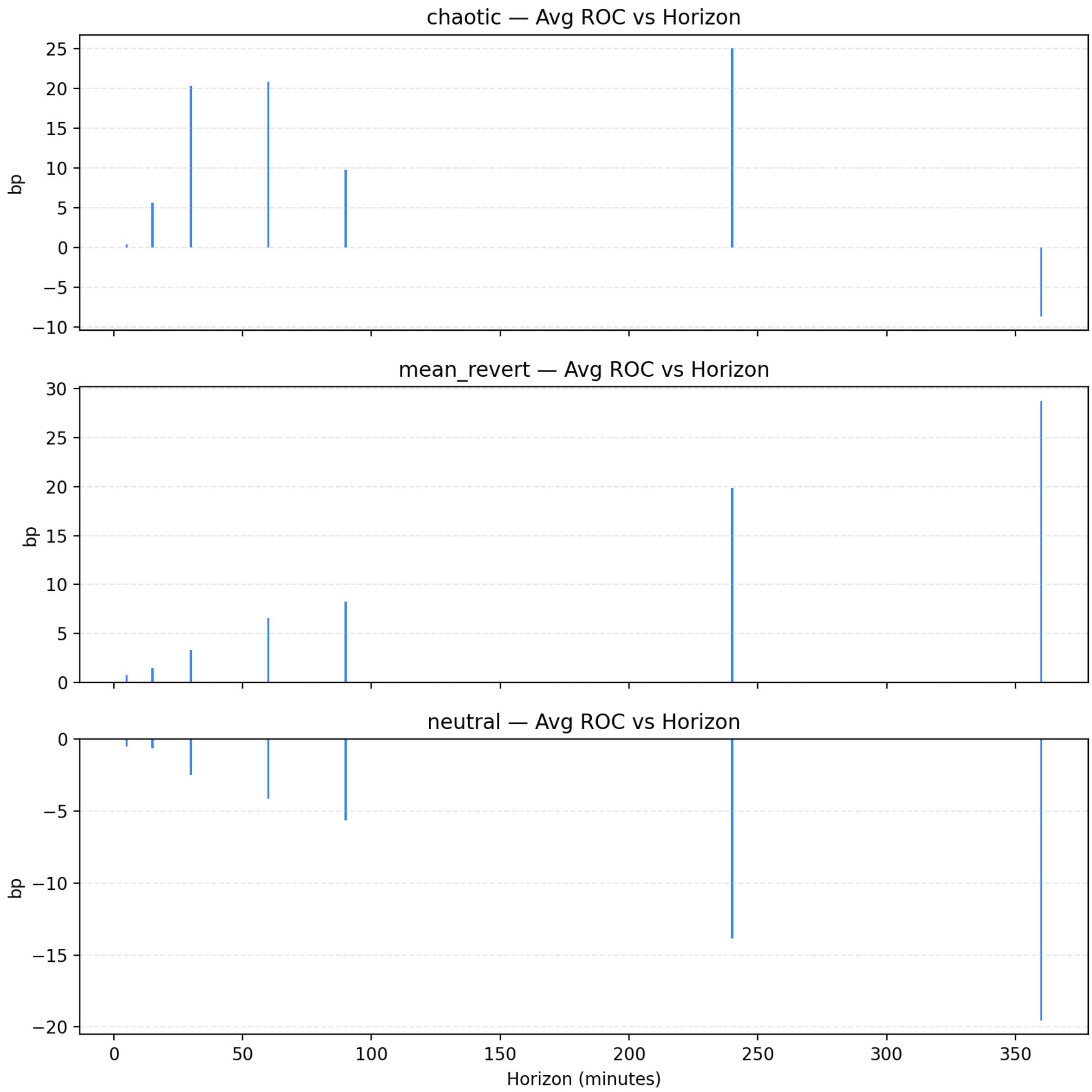

Figure 1: Average ROC vs horizon for the Nov 2020–Nov 2025 dataset.

- **MR D5 structural filters.** With coherence flat and domain-wall slopes positive, MR D5 strands average +18.4 bp at 60 minutes (3,468 samples) versus +6.4 bp overall. Letting both slopes run positive drags the strand down to −24.7 bp (2,073 samples), so "flat coherence + positive domain-wall" remains a hard promotion gate.
- **Neutral hazard penalties.** Neutral D4/D5 strands tagged `high_rupture_event` bleed between −20 and −72 bp at 60 minutes once either slope turns negative (see 'neutral_d4_r2' rows in `docs/evidence/enriched_strands.csv`). Those combinations should immediately block allocator changes.
- **Chaotic polarity.** Chaotic D4 strands with negative coherence but positive domain walls still clear +80 bp (605 samples), whereas the same signatures with flat slopes plunge below −70 bp. Domain-wall slope is therefore the deciding factor when chaos appears.

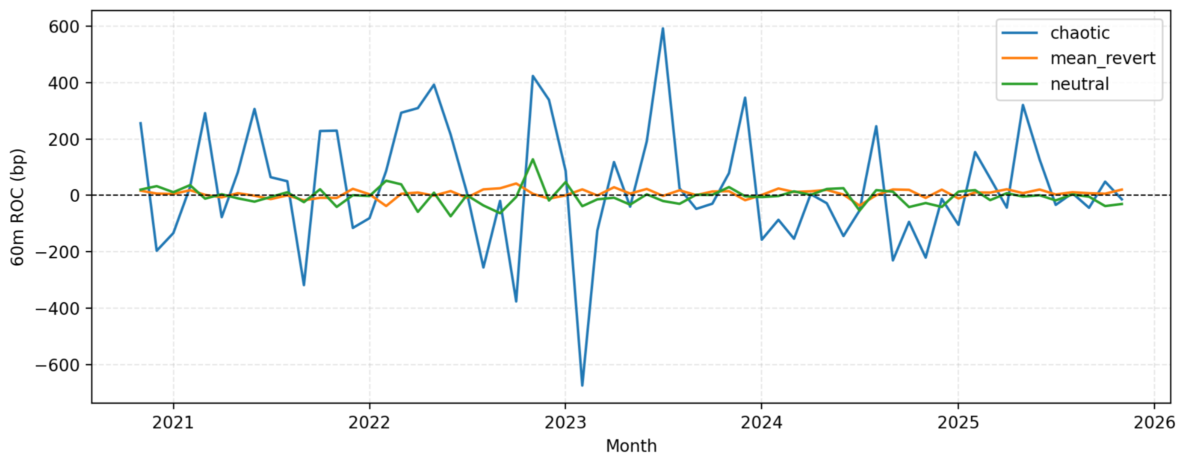

Figure 2: Monthly 60-minute ROC trends by regime (Nov 2020–Nov 2025).

3 Results

3.1 Extended horizon drift

Aggregating all weeks yields the horizon profile in Table 4.

Regime	60m avg (bp)	90m avg (bp)	360m avg (bp)
mean_revert	+6.55 (50.3% positive)	+8.24	+28.75
neutral	−4.13 (49.8% positive)	−5.64	−19.55
chaotic	+20.86 (49.8% positive)	+9.80	−8.68

Table 4: Average ROC (basis points) per regime at longer horizons.

Mean-revert remains the only regime with persistent positive drift through six hours, neutral deteriorates almost linearly with time, and chaotic strands look attractive out to 90 minutes before flipping negative beyond 240 minutes. These statistics now power the dashboard's Weekly Signal Analytics panel and back the risk team's guardrail thresholds.

4 Implications for allocation & operations

1. **Qualification rubric.** Promote only MR strands with flat/negative coherence slopes and positive domain-wall slopes, zero rupture tags, and two consecutive positive weeks (using the weekly ROC exports as the source of truth).

2. **Lead/lag monitor.** Track MR D5 positive share and slope diagnostics weekly; the five-year model only lifts accuracy to 55.7% (vs 48.8% baseline) while the 26-week cut jumps to 69% with huge error bars. Use both numbers to frame allocator decisions rather than acting on raw coefficients.

3. **Chaos quarantine.** Treat chaotic strands beyond 240 minutes as hard blockers—the five-year dataset shows they flip negative there even when shorter horizons drift higher. Require two neutral→mean-revert transitions plus supportive slopes before redeploying.

4. **Transparency.** All figures in this paper are reproducible via the published scripts (`PYTHONPATH=. python scripts/research/...`). Artefacts are archived under `docs/evidence` for diligence.

4.1 Week 46 Operational Guardrails

The Week 46 refresh (`docs/09_Signal_Evidence_Update_2025W46.md`) replays `scripts/tools/backfill_gate` through 14 Nov 2025 and establishes the following runbook requirements:

- **Gate freshness preflight.** Before weekly automation, run `.venv/bin/python scripts/tools/check_g` `--redis redis://localhost:6379/0` and archive the result under `logs/signal/gate_health_<date>.j` If payloads are missing or stale (>5 h), halt admits and restart the manifold/valkey stack or rebuild the affected week from OANDA candles.
- **Dashboard feed alignment.** The operations dashboard now reads directly from `output/latest_weekly` (last six seven-day windows) and `docs/evidence/longitudinal_2020_2025/*`, ensuring that investors view the same MR/neutral/chaotic drift cited here.
- **Allocator guardrails.** Promote mean-revert strands only when their rolling 14-day 60 m average ≥ 0 bp; keep neutral locked to exit-only flow until the monthly 60 m average $\geq +20$ bp (November sits at -30 bp); and only consider chaotic promotions when both 60 m and 360 m drift are positive with enriched-strand confirmation (flat coherence + positive domain-wall slope).

5 Conclusion

The structural manifold pipeline produces gate streams that are both tractable and predictive. The newly instrumented ROC fact table confirms that mean-revert strands retain positive expectancy across multiple horizons, logistic lead/lag signals anticipate neutral drawdowns, and structural slope filters cleanly separate promotable strands from blocks. Because the entire workflow is scriptable (`run_weekly_roc_backfill.py` + research scripts) and references the STM manifold lineage, it offers institutional investors a transparent mechanism for underwriting the SEP signal program.

References

[1] Sep Dynamics Research, "Structural Manifold Telemetry Architecture," internal memo, 2025.

[2] STM Research Group, "Manifold vs Optical Benchmarks," `stm/docs/manifold_vs_optical/report.tex`, 2024.