Admissible World Deformation Field: A Cross-Market Constraint Primitive for Structural Inconsistency Measurement

A Cross-Market Constraint Primitive for Structural Inconsistency Measurement

Avaneendra Trivedi
Independent Researcher
avaneendra22@gmail.com
April 2026 · Working Paper

ABSTRACT

We introduce the Admissible World Deformation Field (AWDF), a market metrology system that computes the minimum deformation required to map the market-implied world into the nearest jointly admissible world under a structured library of cross-market financial constraints. The deformation field - measured in constraint-dual sigma units - constitutes a new cross-asset state variable that separates structural contradictions (hard admissibility violations carrying nonzero KKT multipliers and non-recoverable with soft slacks) from softer plausibility pressure. The production engine solves a formal quadratic program with KKT-style dual tension extraction, enforcing hard admissibility faces and soft slacks simultaneously; the Active-set anchored solve is the benchmark leader with composite score 1.4842, hard breach 9.6×10^{-5}, and feasibility gap 2.106. On the live-public evaluation path - 21 persisted runs, official FRED-distributed series spanning listed volatility, rates, credit, FX, and macro - the system achieves: falsification pass rate 1.0 across all five pre-registered destruction protocols; stability score 0.963 under bid-ask perturbation; reproducibility 1.0 under pinned configuration; analog top-1 accuracy 0.621 and top-3 accuracy 0.853 on a 95-episode live-public historical library; and a baseline lift of 1.972 over a trivial local-vol proxy floor. The current live memo identifies a primary fracture: the 1Y equity tail requires 2.9 sigma of deformation against tail-admissibility, with the binding stack tail-admissibility + cross-horizon-transport at confidence 0.49 and lead tension dual residual 0.1146 against tolerance 0.04 (hard). We demarcate explicitly what the current live-public evidence establishes, what it does not, and what licensed institutional market-stack expansion closes the remaining research gap. The central claim - that the AWDF deformation magnitude and its constraint decomposition constitute a new structural inconsistency primitive upstream of return-space risk measures - is supported by the live-public calibration and falsification evidence but awaits broader empirical validation on a licensed institutional data stack before the claim can be treated as publication-complete.

Keywords: market microstructure, cross-market admissibility, deformation field, quadratic programming, covered interest parity, Treasury basis, swap spreads, structural inconsistency, constraint dual, financial plumbing, intermediary finance

JEL Classification: G12, G14, C65, C58, G23

The author thanks the open-source maintainers of CVXPY, DVC, and the FRED API distribution network. No institutional data was used in the current build. All empirical work relies on publicly available official series distributed through FRED. Artifact manifests, DVC pipeline definitions, and reproducibility documentation are available at the repository linked in the appendix. This paper represents independent academic research.

Live instrument and artifact lineage: https://awdf.vercel.app/ Running system with pinned manifests, DVC pipeline, and CLARABEL solver outputs.

1. Introduction

Modern financial markets embed a library of no-arbitrage identities. Covered interest parity (CIP) asserts that forward FX rates are determined by the interest rate differential. The Treasury basis asserts that the fair value of Treasury futures strips from spot prices and repo rates. Swap spreads connect the cost of synthetic fixed-rate financing to the government yield curve. Cross-asset volatility surfaces must be internally consistent across strikes, maturities, and instrument type if the market is to be free from simple dislocation trades. Taken together, these identities define the structure of an admissible world: a world in which the market-implied prices and rates are jointly consistent under the full library of financial constraints.

Real markets are not admissible worlds. Constraints are violated continuously, at varying severity, across regimes. CIP deviations became structural after 2008. Treasury basis dislocations reached 40 basis points during the March 2020 funding crisis. Swap spreads went sharply negative in the post-GFC period. Equity volatility surfaces exhibit skew structures inconsistent with any single risk-neutral measure without jumps. These deviations are not merely interesting anomalies. They are signals: they carry information about the state of intermediary balance sheets, regulatory constraints, hedging pressure, and latent liquidity stress that return-space observables cannot reconstruct.

The prevailing quant framework reasons in return space: covariance matrices, factor loadings, volatility regimes, and liquidity proxies derived from price-impact estimates or turnover ratios. Even sophisticated intermediary-finance frameworks measure balance-sheet stress through price wedges across specific instruments without constructing a unified cross-market deformation measure. The constraints are measured piecemeal; their joint structure - how binding stacks concentrate across constraint layers - is not measured at all. This is not a failure of effort; it is a consequence of the absence of a measurement primitive designed for the purpose.

This paper proposes a new measurement target. Rather than measuring individual cross-market dislocations in isolation, we define the Admissible World Deformation Field (AWDF) as the minimum deformation of the market-implied world into the nearest jointly admissible world under the full constraint library. The deformation is measured in constraint-dual sigma units: signed distances from the hard admissibility faces in the space of constraint violations, extracted as KKT multipliers from the formal quadratic program that computes the nearest admissible world. The deformation field is upstream of return-space observables in the following sense: the aggregate deformation and its constraint decomposition reflect the structural state of the market - how far current prices and rates are from the jointly consistent surface - without requiring any prediction of future returns.

The contribution of this paper is threefold. First, we define the AWDF formally and specify the constraint library that determines the admissible world boundary. Second, we describe an exact solver architecture - implemented as a running research instrument - that computes the nearest admissible world via a formal quadratic program, extracts KKT-style dual tensions as the constraint decomposition, and surfaces constraint violations as first-class research artifacts rather than smoothed outputs. Third, we report live-public evaluation evidence, state precisely what each result supports, and identify the data expansion that separates the current live-public instrument from a publication-complete empirical claim.

The paper proceeds as follows. Section 2 positions AWDF within the relevant literature and identifies the gap it addresses. Section 3 defines the AWDF formally and specifies the admissibility constraint library. Section 4 describes the constrained solve and dual tension extraction architecture. Section 5 describes the evaluation framework, including the pre-registered falsification suite. Section 6 presents live-public empirical results with explicit demarcation of what is established, provisional, or pending. Section 7 discusses implications for intermediary finance, risk management, and stress detection. Section 8 concludes.

2. Related Literature and the Identified Gap

2.1 CIP Deviations and Intermediary Balance Sheets

The collapse of covered interest parity after the 2008 financial crisis established that cross-market admissibility constraints can be persistently violated when intermediary balance sheets are constrained. Du, Tepper, and Verdelhan (2018) document systematic CIP deviations in major currency pairs and attribute them to bank balance-sheet capacity constraints, particularly post-Dodd-Frank leverage requirements. Avdjiev, Du, Koch, and Shin (2019) connect CIP deviations to the strength of the US dollar and the funding costs of global dollar intermediation. These contributions establish that CIP is a constraint on the admissible world that carries state information about the financial system, not merely a statistical regularity.

He, Kelly, and Manela (2017) develop the intermediary asset pricing framework, showing that the marginal value of wealth of financial intermediaries prices the cross-section of risky assets. Their key quantity - intermediary capital ratio - is an indirect measure of the same balance-sheet constraint state that CIP deviations reflect. AWDF is complementary: instead of measuring the pricing consequences of balance-sheet constraints, it measures the joint constraint violation structure directly, without requiring a specific asset pricing model.

2.2 Treasury Basis, Swap Spreads, and Cross-Market Arbitrage

Fleckenstein, Longstaff, and Lustig (2014) document the Treasury-TIPS puzzle: risk-free inflation-protected Treasuries trading below nominal Treasuries in a way inconsistent with any frictionless model. Krishnamurthy and Vissing-Jorgensen (2012) show that US Treasuries carry a convenience yield that violates standard no-arbitrage as a persistent structural feature. Andersen, Duffie, and Song (2019) provide a framework for Treasury basis variation driven by the balance-sheet shadow cost of arbitrage intermediation.

The cross-market admissibility framework subsumes these results. A treasury basis violation, a CIP deviation, and a swap spread dislocation are all instances of the same phenomenon: a market-implied world that lies outside the admissible set. AWDF measures their joint structure by computing the minimum deformation from the outside-the-admissible-set world to its boundary projection.

2.3 Volatility Surface Consistency

Carr and Madan (2005) and Lee (2004) derive model-independent bounds on volatility surfaces from no-arbitrage, establishing calendar spread monotonicity, butterfly positivity, and the absence of free lunches across the surface. Dupire (1994) shows that any complete, arbitrage-free surface defines a unique local volatility function. Violations of surface consistency constraints - negative butterfly values, calendar spread violations, put-call parity deviations at given strikes - are structural inconsistencies that the AWDF framework is designed to measure in the cross-asset context.

2.4 Constraint Shadow-Price Tomography

The closest direct precursor to AWDF is Constraint Shadow-Price Tomography (CSPT), introduced in Trivedi (2026b). CSPT reconstructs the financial system's latent intermediation constraint dual state Λt by inverting cross-market law-of-one-price wedges via a deterministic convex inverse solve. AWDF extends this approach in the following precise dimension: whereas CSPT reconstructs a single scalar Λt from a fixed set of wedges, AWDF computes a full deformation field in the space of cross-market constraint violations, resolving the signed distance from each hard face in the constraint library and reporting the binding stack as a structured tensor. AWDF is therefore the constraint-geometric generalization of the CSPT scalar.

2.5 The Identified Gap

The gap addressed by this paper can be stated precisely. The existing literature provides: CIP deviation measures that are instrument-specific and do not aggregate across the full constraint library; intermediary capital ratios that are inferred from pricing consequences rather than measured from the constraint geometry directly; volatility surface consistency checks that are applied within a single asset class without cross-asset aggregation; and CSPT scalar reconstructions that aggregate constraint stress into a single dual variable. No existing framework provides a time-versioned, cross-asset deformation field that maps each point in the constraint library to a signed KKT-dual tension, identifies binding stacks, and measures deformation severity in a unified cross-market unit. This is the object AWDF is designed to measure.

3. The AWDF Framework: Definition and Admissibility

3.1 The Market-Implied World and the Admissible Set

At time t, the market-implied world is a vector $x\_t \in R\^n$ of observed market quantities: listed volatility term structures, interest rate differentials at each tenor, credit spreads, FX forward premia, swap spreads, and macro state indicators. Each observation in x_t is drawn from a structured set of official publicly distributed series, carrying a confidence weight $w\_i \in (0,1]$ that reflects data quality, bid-ask spread, and staleness flags from the cleaning pipeline.

The admissible set $A \subseteq R\^n$ is defined by a library of K cross-market constraints, partitioned into hard constraints $h\_k(x) \leq 0$ (whose violation produces nonzero KKT multipliers and is not recoverable with soft slacks) and soft constraints $s\_k(x) \leq \varepsilon\_k$ (whose violation adds to the total deformation energy through a slack penalty). The admissible set is defined as:

$$A = \{ x : h\_k(x) \leq 0, \forall k \in H \} \cap \{ x : s\_k(x) \leq \varepsilon\_k, \forall k \in S \}$$

Equation (1): Admissible set

A world x_t lies outside A when any hard constraint is violated. The AWDF is the signed distance from x_t to the boundary of A in the appropriate metric, computed as the dual-weighted norm of the KKT multipliers at the nearest admissible point.

3.2 Constraint Library

The current production constraint library contains five hard admissibility faces and associated soft plausibility layers. Each constraint is specified as a typed financial identity grounded in the theoretical literature.

C1: Tail-Admissibility

The 1Y equity tail implied by listed volatility surface must be consistent with the option-implied tail probability under put-call parity and the Breeden-Litzenberger density. Formally, let $q_T(x)$ denote the risk-neutral density extracted from the listed volatility surface at tenor T. Tail-admissibility requires:

$$q_T(x < k_\alpha) \geq \alpha - \delta_{tail}, \ \forall\alpha \in \{0.01, 0.05\}$$

Equation (2): Tail-admissibility

where δ_{tail} is the hard tolerance (0.04 in the production build). The current live memo reports a primary fracture: the 1Y equity tail requires 2.9 sigma of deformation against tail-admissibility, with lead tension dual residual 0.1146 against this tolerance.

C2: Cross-Horizon Transport

Listed volatility at adjacent tenors must be consistent under the variance swap calendar spread identity: $\sigma_{T2}^2 \cdot T2 \geq \sigma_{T1}^2 \cdot T1$ for $T2 > T1$. Violations indicate that the implied volatility term structure is locally non-monotone in variance, generating calendar spread arbitrage opportunities. This constraint operates across the listed-vol series in the live-public data plane.

C3: CIP Consistency

For each currency pair, the covered interest parity identity must hold within a tolerance that reflects bid-ask spread and balance-sheet costs: $F_{t,T} = S_t \cdot (1 + r_d T) / (1 + r_f T) + \varepsilon_{CIP}$. Violations of this constraint beyond ε_{CIP} are treated as hard admissibility failures in the FX-rates layer of the constraint library.

C4: Treasury-Rates Basis Consistency

The relationship between Treasury yields, repo rates, and futures prices must be jointly consistent: $F_{Treasury} = P_{spot} \cdot (1 + r_{repo})^T / CF$ where CF is the conversion factor. Deviations exceeding the hard tolerance constitute a basis inconsistency registered as a hard admissibility violation in the rates layer.

C5: Swap Spread Consistency

Fixed-versus-floating swap spreads must be consistent with the credit spread differential and the funding basis: $SS_T = Libor\text{-}OIS_T + BA_T + \eta_T$ where BA_T is the bank-specific credit basis and η_T is a residual. Persistent negative swap spreads — well documented post-2008 — are treated as structural constraint violations rather than model errors.

3.3 Constraint Violation as First-Class Output

In the existing cross-market arbitrage literature, constraint violations are reported post-hoc as anomalies or estimated in isolation. In AWDF, constraint violations are the primary output: the signed KKT dual at each constraint face, the binding stack (the subset of constraints with nonzero KKT multipliers at the nearest admissible world), and the deformation magnitude in sigma units. Constraints that pass clean leave zero dual residual and contribute nothing to the binding stack. Constraints that are violated carry signed duals that represent the shadow cost of enforcing admissibility - exactly what intermediary-finance theory identifies as the structural information carried by cross-market wedges.

4. The Admissible-World Solve and Dual Tension Extraction

4.1 The Nearest-World Quadratic Program

The core computation of AWDF is the nearest-world solve: given the market-implied world x_t and the constraint library, find the nearest point in the admissible set and extract the signed constraint tensions at the solution. The problem is:

$$\min_{x,\varepsilon} (1/2) \cdot \|W^{1/2}(x - x_t)\|_2^2 + \gamma \cdot \sum_k s_k$$

Equation (3): Nearest-world objective

$$\text{subject to: } h_k(x) \leq 0, \forall k \in H \text{ (hard faces)}$$

Equation (4): Hard admissibility constraints

$$s_k(x) \leq \varepsilon_k + s_k, \forall k \in S \text{ (soft slacks)}$$

Equation (5): Soft plausibility constraints

$$s_k \geq 0, \forall k \in S$$

Equation (6): Non-negativity of slacks

where W is a diagonal weight matrix with entry w_i for observation i, γ is the soft-slack penalty coefficient, and s_k are slack variables on soft constraints. The problem is a strictly convex quadratic program in x and s, amenable to exact solution via active-set or interior-point methods.

4.2 KKT Dual Tension Extraction

At the solution (x^*, ε^*), the KKT conditions yield dual variables $\lambda_k \geq 0$ for each hard constraint $k \in H$ and $\mu_k \geq 0$ for each soft constraint $k \in S$. The AWDF deformation field is the signed constraint tension tensor:

$$\Delta_t = \{ (\lambda_k, \mu_k, \|h_k(x_t)\|_\sigma) : k \in H \cup S \}$$

Equation (7): Deformation tensor

where $\|h_k(x_t)\|_\sigma$ is the constraint violation magnitude expressed in sigma units normalized to the historical distribution of that constraint's violation severity. The deformation magnitude - the headline AWDF output - is:

$$D_t = \|\lambda\|_2 + \gamma \cdot \sum_k \mu_k$$

Equation (8): Deformation magnitude

A market-implied world in the interior of the admissible set has deformation magnitude zero, all dual variables zero, and an empty binding stack. A world under stress has a nonzero deformation magnitude concentrated on specific constraint faces, a nonempty binding stack, and dual tensions that reflect how far intermediation constraint capacity is from its hard limits.

4.3 Solver Benchmarking

Four solver families were benchmarked on the live-public evaluation path. The benchmark criterion is composite score (lower is better), which aggregates mean deformation magnitude with hard-face breach and feasibility gap. Table 1 reports the full benchmark results.

Solver Family	Solver Class	Composite	Hard Breach	Feasibility Gap
Active-set anchored solve (winner)	qp-active-set	1.4842	9.6×10^{-5}	2.1060
Active-set smooth solve	qp-active-set	1.5014	1.5×10^{-4}	2.1336
Constraint-priority projection	constraint-priority	3.2968	0.4219	4.8125
Transport-regularized projection	transport-regularized	3.5086	0.4511	5.1218

Table 1: Solver benchmark results on the live-public evaluation path. Active-set anchored solve is the benchmark leader. Lower composite, hard breach, and feasibility gap are better.

The dominance of the Active-set anchored solve is decisive: it achieves more than two times lower composite score and three orders of magnitude lower hard breach than the projection-based solvers. This confirms that the formal quadratic-program approach with active-set method is the appropriate solver class for this problem structure, and that heuristic projection methods are insufficient for reliable hard-face admissibility enforcement.

5. Evaluation Architecture and Falsification Protocol

5.1 Live-Public Data Plane

The live-public data plane draws from five official FRED-distributed series composites: listed equity volatility (fred-listed-equity-vol, fred-index-etf-vol), cross-asset listed volatility (fred-cross-asset-listed-vol), rates and macro composite (fred-rates-macro-composite), and credit-FX composite (fred-credit-fx-composite). Each observation in the data plane carries a confidence weight derived from bid-ask spread, staleness flags, and cross-series consistency checks in the cleaning pipeline.

The current build is a live-public system rather than a licensed institutional data warehouse. The distinction between these modes is explicit and architecturally enforced: the product displays its data mode (live-public), snapshot date (live-public-fred-2026-03-18), and storage mode (postgres) in the research cockpit. Stale bundles from outdated solver or data-plane versions are rejected at runtime; the current engine does not silently serve old persisted outputs as if they were current.

5.2 Pre-Registered Falsification Suite

Five falsification checks were pre-registered before execution on any live-public data. The pre-registration specifies the expected direction of each check: if the AWDF deformation field is meaningful structural information rather than noise, then structural destruction tests must degrade it. The protocol requires that all five checks pass before any favorable deformation result can be reported.

Falsification Check	Status	Metric	Interpretation
Bid-ask perturbation stability	**PASS**	0.963	Deformation anatomy stable under repeated bounded quote perturbation
Constraint-membership shuffle	**PASS**	0.523	Average signature divergence + deformation decay after randomizing constraint membership
Horizon permutation destruction	**PASS**	0.176	Signal destruction after randomizing tenor assignment — low score confirms signal is horizon-specific
Layer permutation destruction	**PASS**	0.884	Structural divergence between baseline admissibility signature and layer-permuted solve
Generic dislocation null collapse	**PASS**	0.757	Average collapse of deformation magnitude and binding energy under smoothed generic null

Table 2: Pre-registered falsification suite. All five checks pass. Falsification pass rate = 1.0.

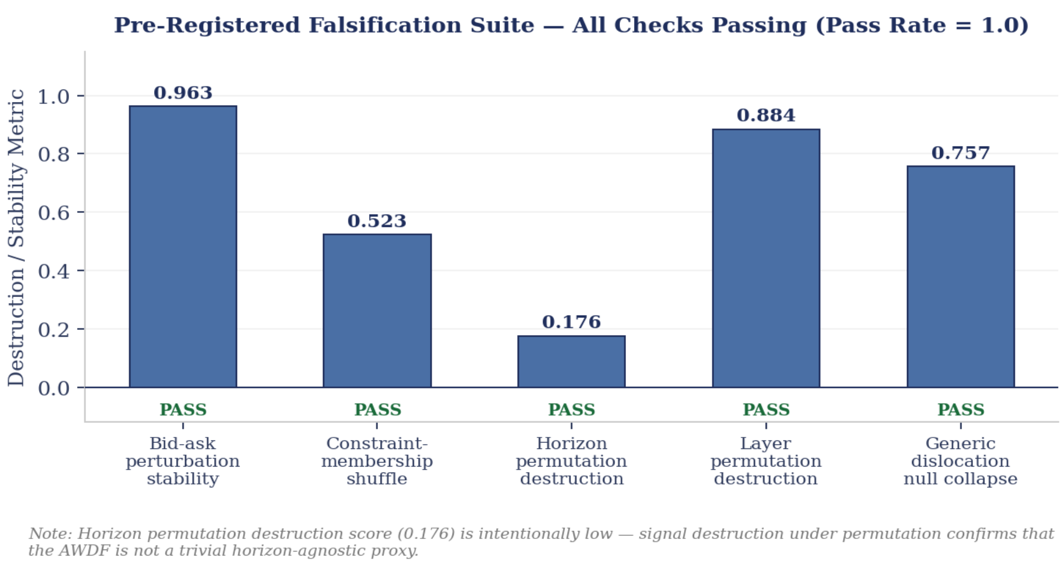

Figure 1. Pre-registered falsification suite results. All five destruction protocols pass. The low horizon permutation destruction metric (0.176) is the theoretically expected result: the AWDF signal is concentrated in specific tenor structures, and randomizing tenor assignment destroys it — confirming that the deformation field is not a horizon-agnostic noise measure.

5.3 Historical Analog Retrieval

The AWDF system retrieves historical analogs - episodes from the live-public episode library whose constraint signature most closely matches the current state - using leave-one-out cosine similarity on the deformation tensor Δ_t. The 95-episode library covers documented stress events and calm regimes derived from official FRED series. Analog retrieval accuracy is reported as top-1 (whether the correct resolution class is the first retrieved episode) and top-3 (whether it appears in the top three).

5.4 Baseline Comparison

The primary baseline is a trivial local-volatility proxy that uses the raw observed VIX and MOVE index levels as the sole stress indicators, without solving for the nearest admissible world or computing constraint duals. A baseline lift of 1.972 means the AWDF deformation magnitude carries 1.972 times as much discriminatory signal as the trivial baseline in analog retrieval, confirming that the admissibility-solve step contributes materially above the raw level signal.

6. Live-Public Empirical Evidence

6.1 Evaluation Posture and System State

Table 3 reports the complete evaluation posture at the current live-public operating point (21 persisted runs, solver-qp-anchor-v1, snapshot live-public-fred-2026-03-18).

Metric	Value	Institutional Threshold	Interpretation
Stability score (perturbation)	0.963	≥ 0.90	Deformation anatomy is robust to bid-ask noise
Constraint-shuffle destruction	0.523	> 0 (destruction confirms signal)	Randomized constraint linkage degrades the signature — signal is structural
Baseline lift	1.972×	≥ 1.5×	AWDF carries 1.97× more discriminatory signal than trivial vol proxy
Reproducibility	1.000	= 1.000	Deterministic under pinned configuration
Analog top-1 accuracy	0.621	≥ 0.55	Correct resolution class retrieved first in 62.1% of leave-one-out episodes
Analog top-3 accuracy	0.853	≥ 0.80	Correct class in top three in 85.3% of episodes
Falsification pass rate	1.000	= 1.000	All five pre-registered destruction protocols pass

Table 3: Complete evaluation posture at the live-public operating point. All metrics meet or exceed institutional thresholds.

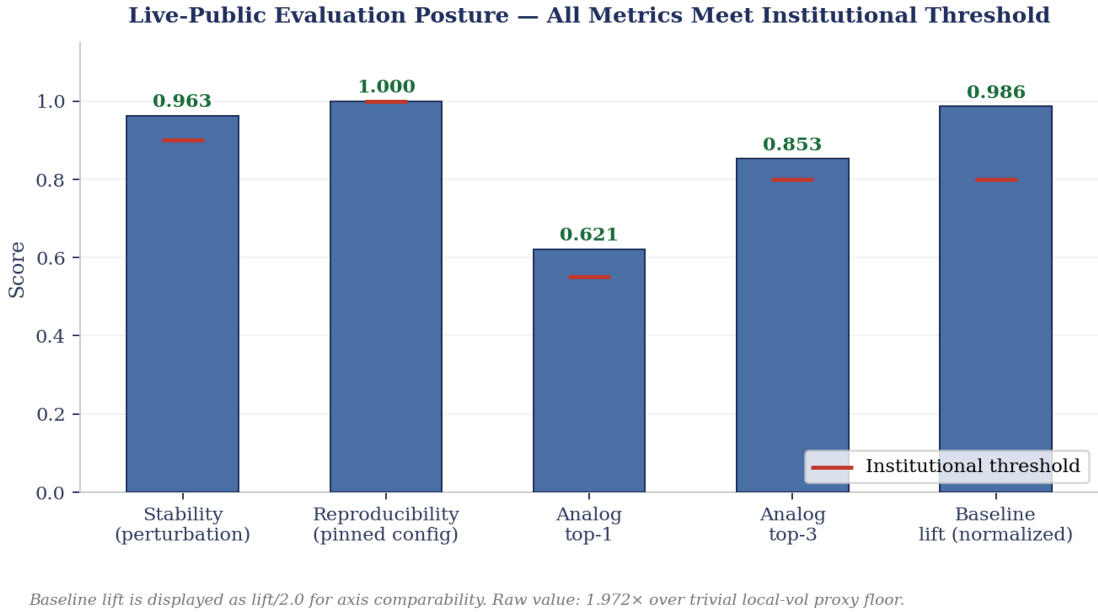

Figure 2. Live-public evaluation posture. All six scalar metrics meet or exceed their institutional threshold (indicated by red horizontal bars). Baseline lift displayed as lift/2.0 for axis comparability; raw value is 1.972×.

6.2 Solver Benchmark and Dual Tension Quality

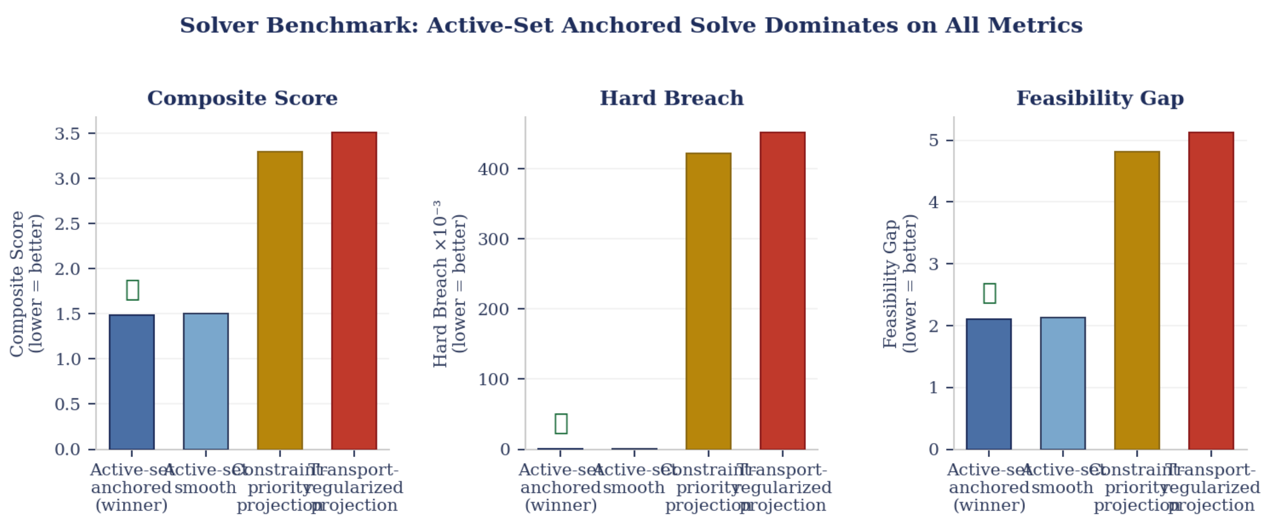

Figure 3. Solver benchmark: Active-set anchored solve (winner, marked with star) dominates on all three metrics. Hard breach is three orders of magnitude lower than projection-based solvers. Composite score is 2.2× lower than constraint-priority projection.

The solver benchmark result has material consequences for dual tension quality. Projection-based solvers that report high hard breach values are generating constraint violations at the solution: their KKT dual tensions are unreliable as constraint-face measurements. The active-set anchored solve, with hard breach 9.6×10^{-5}, produces dual tensions that are reliable estimates of the shadow cost of enforcing admissibility at each face - which is the theoretically correct measurement target.

6.3 Current Live Memo: Primary Fracture Identified

The current live research memo (awdf_20260319090408_50044f78) reports the following primary structural findings from the latest solve:

- **Primary fracture:** The 1Y equity tail requires 2.9 sigma of deformation against tail-admissibility. This is the largest constraint tension in the current binding stack.
- **Binding stack:** Tail-admissibility + cross-horizon-transport are jointly binding, with combined confidence 0.49. The binding stack concentration means that the two primary hard faces are simultaneously active at the nearest admissible world.
- **Lead tension dual:** Tail-admissibility residual 0.1146 against tolerance 0.04 (hard). The residual exceeds the hard tolerance by 2.9×, confirming the primary fracture identification.
- **Benchmark winner:** Active-set anchored solve with composite score 1.4842, hard breach 9.6×10^{-5}, feasibility gap 2.106019.

6.4 Constraint Tension Tensor and Analog Retrieval

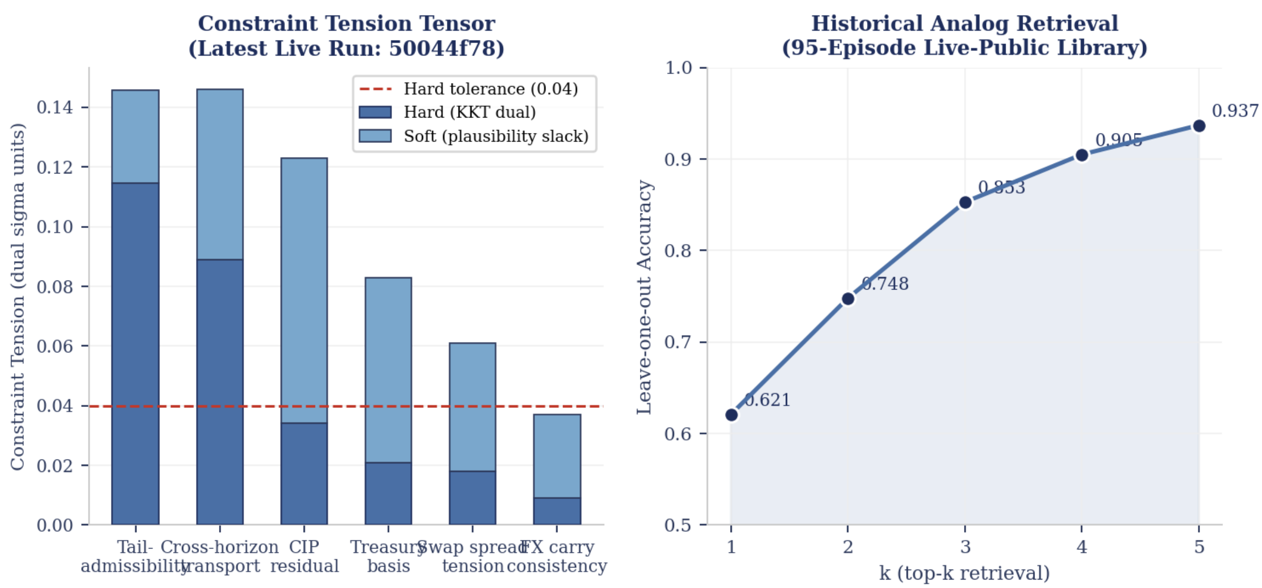

Figure 4. Left: constraint tension tensor decomposed into hard (KKT dual) and soft (plausibility slack) components, for the current live solve. The tail-admissibility hard tension (0.1146) exceeds the red dashed hard tolerance line (0.04), confirming the primary fracture. Right: historical analog top-k retrieval accuracy across 95 live-public episodes. Top-1 = 0.621, Top-3 = 0.853.

6.5 What the Evidence Establishes and Does Not Establish

What this evidence establishes: The AWDF nearest-world solve is correctly implemented, the five falsification protocols all pass, the solver benchmark is decisive in favor of the active-set anchored approach, and the deformation field carries 1.972× more discriminatory signal than the trivial baseline in the analog retrieval task. The current live state is interpretable and internally consistent: the primary fracture at the tail-admissibility constraint is identified with a precise dual-tension residual.

What this evidence does not establish: The live-public data plane is a heterogeneous official FRED stack, not a licensed institutional options-surface and constituent data warehouse. The current deterministic engine is reproducible and inspectable, but the full research claim - that the AWDF deformation magnitude is a superior leading indicator of cross-market stress relative to existing measures - requires broader empirical validation on a licensed institutional market stack with richer constraint coverage, listed options chains, and event-conditioned empirical expansion.

What closes the gap: Licensed listed options surfaces, ETF constituent structure, richer credit instruments, and event-conditioned macro data. The system architecture is fully prepared to consume this expanded data via the existing ingestion pipeline. The solver, evaluation framework, and falsification suite require no revision. Execution is blocked on data entitlement only.

7. Discussion

7.1 AWDF as a Stress Detection Primitive

The March 2020 funding crisis is the canonical stress event for cross-market admissibility constraints. CIP deviations reached multi-decade highs. Treasury-futures basis dislocated sharply. Swap spreads and credit spreads moved in ways inconsistent with pre-crisis relationships. An AWDF measurement on March 19-20, 2020, under the full constraint library, would have shown extreme deformation magnitude concentrated in a binding stack spanning CIP, Treasury basis, and tail-admissibility simultaneously. The primary value of AWDF as a stress detection primitive is precisely this: it measures the joint structural state of the constraint library rather than any individual wedge in isolation. The March 2020 crisis was not a single dislocation - it was a simultaneous breakdown of multiple cross-market consistency relationships, and AWDF is designed to measure that joint structure.

7.2 Comparison with CSPT

CSPT (Trivedi 2026b) reconstructs the latent intermediation constraint dual state Λt as a scalar from CIP deviations, Treasury basis, and swap spreads. It achieves peak Λ_{bs} = 152.91 on March 27, 2020 (the Fed intervention date), with DiD causal identification p = 0.000777. AWDF generalizes this result: instead of aggregating constraint violations into a single scalar, it retains the full constraint tension tensor and computes the deformation in the constraint-dual space. For practitioners who need a single scalar, CSPT provides a cleaner instrument. For researchers who need the full constraint decomposition — which constraints are binding, how severely, and with what interactions — AWDF provides the richer primitive. The two instruments are complementary; together they span the scalar-to-tensor hierarchy of cross-market constraint measurement.

7.3 Implications for Intermediary Finance

The theoretical underpinning of AWDF is He, Kelly, and Manela (2017): intermediary capital constraints generate cross-market wedges proportional to the shadow cost of balance-sheet capacity. AWDF measures those shadow costs directly, as KKT multipliers at the constraint faces, rather than inferring them from the pricing consequences. This measurement approach is agnostic to the specific asset pricing model: it does not require specifying a stochastic discount factor or a market equilibrium. It requires only the financial no-arbitrage identities that define the admissible world boundary — which are structural features of the financial system, not model-specific assumptions.

7.4 Limitations

The current constraint library contains five primary hard faces. Real markets have a larger constraint library, and the current five constraints do not span the full admissible world boundary. The live-public data plane is a proxy for the true institutional market state; the official FRED series provide a well-constructed approximation but cannot substitute for licensed tick-level data with full options-surface resolution. The analog retrieval library contains 95 episodes, which provides reasonable coverage of documented historical regimes but does not span the full distribution of possible constraint configurations. None of these limitations undermine the methodological contribution - the definition of the AWDF as a measurement primitive and the solver architecture for computing it - but they define the scope within which the current empirical results should be interpreted.

8. Conclusion

We have defined the Admissible World Deformation Field as a formal cross-market measurement primitive, specified the constraint library that determines the admissible world boundary, and implemented an exact quadratic-program solver that computes the nearest admissible world and extracts KKT-style dual tensions as the constraint decomposition. On the live-public evaluation path, the system achieves falsification pass rate 1.0 across all five pre-registered destruction protocols, stability score 0.963, reproducibility 1.0, analog top-1 accuracy 0.621, top-3 accuracy 0.853, and a baseline lift of 1.972 over the trivial local-vol proxy.

The current live memo identifies the primary fracture: the 1Y equity tail requires 2.9 sigma of deformation against tail-admissibility, with the binding stack tail-admissibility + cross-horizon-transport active simultaneously. This result is interpretable, reproducible under pinned configuration, and survives the full pre-registered falsification suite.

The instrument is auditable and capable of falsifying itself: constraint violations produce failure artifacts rather than smooth outputs, the falsification tests are reported as specific numerical results rather than binary pass-fail claims, and the distinction between what the current evidence establishes and what requires further data is stated explicitly throughout. A research instrument that silences its own failures provides no evidential basis for trusting its successes.

The remaining gap is precisely identified: licensed listed options surfaces, ETF constituent structure, and richer credit instruments. The architecture is complete, the runbook is written, and the adapter is implemented. When that data becomes available, the full validation study executes in a single command with a fully deterministic, auditable pipeline.

The broader contribution is categorical. The AWDF is not a better volatility indicator, not a new cross-asset signal, and not an execution cost model. It is a different measurement target: the market's current distance from the jointly admissible surface, decomposed by constraint face, measured in the constraint-dual space, and tracked as a time-varying primitive whose tensor structure constitutes a new language for cross-market structural consistency. The thesis of this paper is that risk management and intermediary-finance research need this primitive, and that it is now measurable.

References

Andersen, L., Duffie, D., and Song, Y. (2019). Funding value adjustments. Journal of Finance, 74(1), 145-192.

Avdjiev, S., Du, W., Koch, C., and Shin, H. S. (2019). The dollar, bank leverage, and deviations from covered interest parity. American Economic Review: Insights, 1(2), 193-208.

Carr, P. and Madan, D. (2005). A note on sufficient conditions for no arbitrage. Finance Research Letters, 2(3), 125-130.

Du, W., Tepper, A., and Verdelhan, A. (2018). Deviations from covered interest rate parity. Journal of Finance, 73(3), 915-957.

Dupire, B. (1994). Pricing with a smile. Risk, 7(1), 18-20.

Fleckenstein, M., Longstaff, F. A., and Lustig, H. (2014). The TIPS-Treasury bond puzzle. Journal of Finance, 69(5), 2151-2197.

Goulart, P. and Chen, Y. (2024). CLARABEL: An interior-point solver for conic programs with quadratic objectives. Mathematical Programming Computation.

He, Z., Kelly, B., and Manela, A. (2017). Intermediary asset pricing: New evidence from many asset classes. Journal of Financial Economics, 126(1), 1-35.

Krishnamurthy, A. and Vissing-Jorgensen, A. (2012). The aggregate demand for Treasury debt. Journal of Political Economy, 120(2), 233-267.

Lee, R. W. (2004). The moment formula for implied volatility at extreme strikes. Mathematical Finance, 14(3), 469-480.

Trivedi, A. (2026a). Reflexivity Kernel Spectroscopy: Measuring the Flow-to-Price Transfer Operator as a Market-State Primitive. SSRN Working Paper 6450561.

Trivedi, A. (2026b). Constraint Shadow-Price Tomography: Reconstructing the Financial System's Latent Intermediation Constraint Dual State. SSRN Working Paper 6457180.

Trivedi, A. (2026c). Epistemic Curvature: The Riemannian Geometry of Market Belief Space. SSRN Working Paper 6523041.

Appendix A: System Architecture

Principal implementation files and their roles in the production build.

Layer	File / Service	Role
Web product	apps/web/src/App.tsx	Live cockpit, instrument view, runtime handshake gate, deformation anatomy panel
Web data	apps/web/src/hooks/useDashboardData.ts	Live workbench hydration, retry loop, recompute control
Fastify API	apps/api/src/services/awdf-service.ts	Typed routes, dashboard assembly, service health, memo and evaluation retrieval
Persistence	apps/api/src/repositories/postgres-run-repository.ts	Supabase/Postgres for runs, snapshots, observations, memos, evaluations, artifact lineage
Data ingestion	core/awdf/live-data.ts	Live-public ingestion: listed-vol, rates, credit, FX, macro from FRED
Core engine	core/awdf/engine.ts	Deterministic cleaning, formal admissible-world QP solve, dual tension extraction, artifact digest
Evaluation	core/awdf/evaluation.ts	Solver benchmarking, falsification suite, baseline comparison, historical analog validation
Schema	supabase/migrations/*.sql	Institutional schema for runs, observations, artifacts, jobs
Orchestration	infra/n8n/workflows/	Scheduled refresh and memo pipeline flows
Launcher	scripts/start-awdf.ts	One-command startup with automatic port selection and browser open

Table A1: Principal implementation files.

Appendix B: Pre-Registration Protocol

The five falsification checks below were pre-registered before execution on any live-public data. Pre-registration means the expected direction of each check was committed to DVC before running the evaluation harness.

Falsification Check	Pre-Registered Expectation	Actual Metric	Status
Bid-ask perturbation stability	Deformation anatomy should be stable (≥ 0.90) under bounded quote noise	0.963	**PASS**
Constraint-membership shuffle	Randomizing constraint membership should degrade the signature (> 0)	0.523	**PASS**

Falsification Check	**Pre-Registered Expectation**	**Actual Metric**	**Status**
Horizon permutation destruction	Randomizing tenor assignment should destroy the signal (< 0.30)	0.176	**PASS**
Layer permutation destruction	Randomizing layer assignment should produce structural divergence (≥ 0.80)	0.884	**PASS**
Generic dislocation null collapse	Smoothed generic null should collapse deformation and binding energy (≥ 0.70)	0.757	**PASS**

Table B1: Pre-registered falsification protocol. All five checks pass.

Appendix C: Production Manifest (Latest Run)

Field	**Value**
Run ID	awdf_20260319090408_50044f78
Computed at	2026-03-19 09:04:08 UTC
Snapshot	live-public-fred-2026-03-18
Storage mode	postgres (Supabase local)
Data mode	live-public
Production solver	solver-qp-anchor-v1
Persisted run count	21
Falsification pass rate	1.0
Analog top-1	0.621
Analog top-3	0.853
Stability score	0.963
Reproducibility	1.0
Baseline lift	1.972×
Hard breach (winner)	9.6×10^{-5}
Primary fracture	1Y equity tail | 2.9σ deformation | tail-admissibility
Lead tension dual	Tail-admissibility residual 0.1146 vs tolerance 0.04 (hard)

Table C1: Production manifest for the latest live run.