Wave Liquidity Redistribution Theory (WLRT)

Technical Appendix

Version 1.2

Author: Petr Popov

Affiliation: Independent Researcher

Date: December 2025

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This technical appendix accompanies the Wave Liquidity Redistribution Theory (WLRT) White Paper v1.2 and provides formal definitions, conceptual schematics, and analytical clarifications of the liquidity-based framework introduced therein.

Status: pre-release. Not yet published.

Appendix A — Liquidity as a Spatio-Temporal Field

In the Wave Liquidity Redistribution Theory (WLRT), liquidity is formalized as a spatio-temporal field defined over price space. This formulation departs from traditional treatments of liquidity as a local, instantaneous, or purely microstructural quantity and instead elevates it to a global state variable that governs market dynamics.

Let $p \in \mathcal{P} \subset \mathbb{R}$ denote the price coordinate and $t \in \mathbb{R}^+$ denote time. The liquidity field is represented by a scalar function

$L : \mathcal{P} \times \mathbb{R}^+ \rightarrow \mathbb{R}^+,$

where $L(p,t)$ encodes the market's capacity to absorb trading activity at price level p and time t without inducing large or unstable price displacements.

The quantity L(p,t) should not be interpreted as a directly observable order book depth or quoted volume. Rather, it represents an effective and aggregated measure of liquidity that includes both visible and latent components. In centralized limit order book markets, L(p,t) reflects the collective liquidity-provision intentions of market participants, including hidden orders, strategic reserve liquidity, and delayed supply. In decentralized or automated market maker environments, L(p,t) corresponds to the effective liquidity encoded in protocol-defined mechanisms and agent strategies.

WLRT explicitly allows liquidity to exist and evolve away from the current transaction price. Liquidity located far from the prevailing price may remain inactive for extended periods while still exerting a structural influence on future price dynamics through delayed activation, propagation, or redistribution. This nonlocal perspective is essential for capturing regime transitions and large price movements that cannot be explained by local liquidity conditions alone.

The liquidity field is treated as a partially latent object. Observable quantities such as order book snapshots, executed volumes, spreads, or transaction prices provide only incomplete and localized information about L(p,t). As a result, the full spatio-temporal structure of liquidity must be inferred indirectly, framing empirical analysis within WLRT as an inverse reconstruction problem rather than a direct measurement task.

Within this framework, price is not modeled as an independent stochastic process. Instead, the observed price trajectory emerges as a constrained path determined by the configuration and evolution of the liquidity field. Liquidity gradients, asymmetries, and redistributions across price space shape the direction, persistence, and volatility of price movements.

This field-based formulation provides the conceptual foundation for the dynamical processes introduced in subsequent appendices, where liquidity is allowed to propagate, dissipate, and interact under internal dynamics and external forcing.

Appendix A.1 — Dimensional Interpretation and Normalization

To avoid ambiguity and overinterpretation, WLRT deliberately refrains from assigning a unique physical dimension to the liquidity field $L(p,t)$. Instead, liquidity is treated as an effective quantity whose interpretation depends on market structure, trading conventions, and the scale of analysis.

In centralized limit order book markets, $L(p,t)$ can be loosely interpreted as having units proportional to traded volume per unit price, aggregated across visible and latent supply and demand. In decentralized or automated market maker environments, $L(p,t)$ may instead reflect protocol-defined reserves or liquidity coefficients, normalized by price sensitivity. These interpretations are not assumed to be universal and are intentionally kept flexible.

For analytical clarity, WLRT allows the liquidity field to be rescaled without loss of generality. Let

$$\tilde{L}(p,t) = \frac{L(p,t)}{L_0},$$

where L_0 is a characteristic liquidity scale defined over a relevant price range and time window.

Similarly, price and time variables may be rescaled as

$$\tilde{p} = \frac{p - p_0}{\Delta p}, \quad \tilde{t} = \frac{t}{\tau},$$

where p_0 denotes a reference price level, Δp a characteristic price scale, and τ a characteristic time scale associated with liquidity redistribution or replenishment.

Under such transformations, WLRT focuses on dimensionless combinations that govern market behavior, such as relative liquidity gradients, redistribution rates, and external flow intensities. Market stability, regime persistence, and volatility patterns are therefore interpreted as properties of scale-free ratios rather than absolute liquidity magnitudes.

Appendix B — Liquidity Dynamics

Within WLRT, the liquidity field L(p,t) evolves through the interaction of several distinct but coupled processes.

B.1 Liquidity Consumption

Liquidity consumption refers to the depletion of the liquidity field resulting from executed trades. Transactions act as localized sinks that reduce liquidity in the vicinity of execution. The magnitude and impact of consumption depend on both order flow intensity and the local structure of the liquidity field.

B.2 Liquidity Replenishment

Liquidity replenishment describes the restoration of liquidity through strategic or algorithmic provision. Replenishment may be delayed, asymmetric, or spatially extended, leading to persistent gradients and regime-dependent price responses.

B.3 Liquidity Propagation

Propagation captures the redistribution of liquidity across price space over time. Liquidity may migrate toward anticipated price regions or retreat from areas of heightened risk, enabling nonlocal interactions within the liquidity field.

B.4 Liquidity Dissipation

Dissipation represents the gradual decay or withdrawal of liquidity that is not actively maintained. This process operates on longer time scales and contributes to regime transitions by eroding stabilizing liquidity structures.

B.5 External Forcing and Order Flow

Order flow acts as an external forcing term that reshapes the liquidity field through repeated consumption and induced redistribution. Identical order flow statistics may produce different outcomes depending on the prior liquidity configuration.

B.6 Emergent Market Regimes

Trends, consolidations, volatility expansions, and abrupt transitions emerge as qualitatively distinct patterns of interacting liquidity dynamics rather than as exogenous shocks.

Appendix C — Hidden and Latent Liquidity

WLRT distinguishes between observable liquidity and a broader latent liquidity field that includes hidden, deferred, or conditional trading intentions.

Observable liquidity reflects explicit commitments, while latent liquidity includes strategic reserves, hidden orders, discretionary participation, and protocol-responsive mechanisms.

Local latent liquidity models focus on the immediate neighborhood of the current price. WLRT generalizes this view by embedding latent liquidity within a global spatio-temporal field, allowing distant liquidity structures to shape future market behavior.

Activation of latent liquidity is treated as a gradual and regime-dependent process. Delayed revelation and hysteresis effects play a central role in market stability and regime persistence.

WLRT positions latent liquidity models as local or limiting cases of the broader liquidity field framework rather than as competing theories.

Appendix D — Shareholder Stabilization: Formal View

Within WLRT, price stabilization is interpreted as a structural property of the liquidity field rather than as direct price control.

Shareholders and strategic holders operate on long horizons and influence the slow components of the liquidity field. Stabilization is achieved through redistribution of liquidity across price space to suppress extreme gradients and reduce destabilizing feedback loops.

Effective stabilization requires coherence between the spatial, temporal, and intensity scales of redistribution and the dominant liquidity dynamics. WLRT emphasizes dimensionless stability considerations based on ratios of redistribution, consumption, and dissipation processes.

WLRT distinguishes liquidity-based stabilization from market making and explicit price targeting, highlighting its global and structural nature.

Appendix E — Empirical Reconstruction and Measurement

WLRT frames empirical analysis as an inverse problem: inferring the latent liquidity field from observable market data.

Observable proxies include prices, volumes, order book states, order flow statistics, and on-chain liquidity measures. None provides a complete representation of the liquidity field.

In centralized markets, reconstruction must integrate limited order book visibility with price dynamics and liquidity recovery patterns. In decentralized and AMM environments, protocol-defined liquidity offers partial transparency but remains influenced by latent agent behavior.

Empirical reconstruction is inherently scale-dependent and regime-sensitive.

WLRT emphasizes falsifiability through the ability to reproduce regime transitions, volatility clustering, and asymmetric price responses under comparable conditions.

This empirical outline defines a research agenda rather than a finalized methodology and establishes the foundation for future quantitative validation of WLRT.