# Wave Liquidity Redistribution Theory (WLRT)

## Version 1.2 — Full English Text

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Author: Petr Popov

Affiliation: Independent Researcher

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## Abstract

This paper introduces the Wave Liquidity Redistribution Theory (WLRT), a theoretical framework for analyzing financial market dynamics through the spatio-temporal evolution of liquidity across price space. Unlike price-centric, equilibrium-based, or purely microstructural models, WLRT treats liquidity as the primary state variable and interprets price dynamics as an emergent consequence of liquidity gradients, redistribution, and interaction.

Within WLRT, liquidity is formalized as a continuous dynamical field defined over the entire price domain. Market regimes such as trends, consolidations, volatility clustering, and abrupt transitions arise naturally as different classes of liquidity wave behavior. This approach provides a unified interpretation of market dynamics across time horizons, asset classes, and market architectures, including both centralized order book markets and decentralized automated liquidity mechanisms.

WLRT builds on and generalizes latent liquidity models by extending their local perspective to a global spatio-temporal framework. The theory is positioned as complementary to existing microstructure and information-based models, offering a higher-level structural description of market behavior driven by liquidity redistribution rather than price adjustment alone. The paper also discusses the current limitations of the framework and outlines directions for empirical reconstruction, calibration, and future development.

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# 1. Introduction

Classical financial market models predominantly treat price as the central dynamical variable, while liquidity enters implicitly or as a secondary constraint. In such frameworks, price movements are modeled directly, and liquidity is often assumed to be either abundant, locally adaptive, or instantly replenished. While these assumptions simplify analysis, they obscure the structural role that liquidity plays in shaping market behavior.

The Wave Liquidity Redistribution Theory adopts the opposite perspective. Liquidity is treated as the fundamental state variable of the market, while price trajectories emerge as dependent outcomes constrained by the evolving liquidity field. From this viewpoint, market instability, volatility regimes, and large price movements are not anomalies or exogenous shocks, but structural consequences of how liquidity is distributed, propagated, and depleted across price space.

WLRT is not a microstructure model in the traditional sense, nor does it rely on equilibrium or representative-agent assumptions. Instead, it provides a mesoscopic and macroscopic dynamical framework within which microstructural mechanisms, order flow statistics, and informational effects can be interpreted as local or regime-specific manifestations of broader liquidity dynamics.

The objective of this paper is to formalize this perspective, position it relative to existing literature, and outline a coherent theoretical framework for liquidity-driven market dynamics.

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# 2. Conceptual Framework

WLRT models liquidity as a continuous field defined over price space and time. This field represents the capacity of the market to absorb trading activity without inducing large price displacements. Liquidity is allowed to propagate, concentrate, dissipate, and interact across price levels under internal dynamics and external forcing.

Price is not modeled as an independent stochastic process. Instead, it is treated as an emergent trajectory constrained by the local and global structure of the liquidity field. Liquidity gradients, asymmetries, and redistribution flows determine the direction, persistence, and volatility of price movements.

Within this framework, different market regimes correspond to qualitatively distinct configurations and dynamics of the liquidity field.

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# 3. Liquidity as a Spatio-Temporal Field

In WLRT, liquidity is defined over the entire price domain rather than being confined to the immediate vicinity of the current price. This global perspective allows the theory to capture delayed effects, nonlocal interactions, and regime transitions driven by liquidity dynamics far from the transaction price.

Liquidity evolves over time through:

- local consumption by trades,
- replenishment through strategic or algorithmic provision,
- propagation across price levels,
- dissipation due to inactivity or strategic withdrawal.

These processes collectively define a spatio-temporal liquidity field whose evolution governs market behavior.

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# 4. Emergent Price Dynamics and Market Regimes

Market regimes such as trends, range-bound behavior, volatility clustering, and abrupt transitions emerge naturally within WLRT as different classes of liquidity wave dynamics.

Sustained trends correspond to persistent liquidity gradients across price space. Consolidation regimes arise when liquidity is symmetrically distributed and rapidly replenished. Volatility expansions occur when liquidity is locally depleted faster than it can be redistributed, while abrupt transitions reflect delayed liquidity adjustments across distant price levels.

Price behavior is thus interpreted as a manifestation of underlying liquidity dynamics rather than as a primary driver.

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# 5. Related Work: Bouchaud et al. and Latent Liquidity Models

A central conceptual foundation of the Wave Liquidity Redistribution Theory (WLRT) is closely related to the body of work developed by Jean-Philippe Bouchaud and collaborators on market microstructure, order flow, and latent liquidity [1-4]. These contributions have played a pivotal role in shifting the focus of market modeling away from equilibrium-based price dynamics toward the structural and dynamical properties of liquidity itself.

### Latent Liquidity and the Local Structure of Markets

Latent liquidity models, including the latent order book (LOB) framework, were introduced to capture the discrepancy between visible order book depth and the true, underlying supply and demand present in the market. In this approach, liquidity is treated as a hidden, slowly evolving field that reflects traders' intentions, which become revealed only when prices approach specific levels.

A key insight of this line of research is that price impact and volatility are not primarily driven by exogenous information shocks, but rather by the interaction between order flow and the spatial distribution of latent liquidity around the current price. Within this framework, the market price emerges as a dynamical object constrained by the local shape, slope, and replenishment rate of latent liquidity near the transaction price.

These models successfully explain several empirical regularities, including:

- the concave form of market impact,
- long memory in order flow,
- slow liquidity recovery after large trades,
- the absence of a stable equilibrium price in continuous trading.

However, latent liquidity models are primarily formulated as local descriptions, centered on the vicinity of the current price and calibrated to short- to medium-term microstructural dynamics.

## From Local Latent Structure to Global Liquidity Dynamics

WLRT builds directly on these insights while extending their scope along two key dimensions: spatial generality and temporal propagation.

Whereas latent order book theory focuses on the immediate neighborhood of the current price, WLRT treats liquidity as a continuous field defined over the entire price space, not merely as a local reservoir surrounding the transaction price. In this sense, WLRT can be viewed as a dynamical and spatial generalization of latent liquidity models.

More specifically:

- Latent liquidity models characterize the local structure of liquidity.
- WLRT describes the global evolution, propagation, and redistribution of liquidity across price space.

In WLRT, liquidity is not only revealed or consumed locally but can propagate, accumulate, dissipate, and interact across distant price levels over time. Market regimes such as trends, consolidations, volatility expansions, and abrupt transitions are interpreted as different classes of spatio-temporal liquidity wave dynamics rather than as outcomes of local equilibrium shifts.

### Conceptual Continuity and Distinction

WLRT does not contradict or replace latent liquidity models; instead, it provides a higher-level dynamical framework within which they naturally embed as a limiting or local case. In the limit where liquidity dynamics are slow, spatial gradients are small, and interactions are confined to a narrow price region, WLRT reduces conceptually to a latent liquidity description centered around the current price.

Conversely, when liquidity distributions evolve asymmetrically, propagate across wide price ranges, or interact nonlocally, WLRT captures phenomena that lie beyond the descriptive reach of local latent order book models. This includes:

- large-scale liquidity migrations preceding major price moves,
- delayed regime transitions driven by liquidity accumulation far from the current price,
- stabilization or destabilization effects caused by intentional liquidity redistribution.

### Positioning of WLRT

From a methodological standpoint, WLRT follows the same guiding principle emphasized in Bouchaud's work: price is not the fundamental variable of market dynamics; liquidity is. The price trajectory is treated as an emergent object constrained and driven by the evolving liquidity field.

WLRT extends this principle by explicitly formalizing liquidity as a spatio-temporal dynamical field, enabling the analysis of market behavior across time horizons and market structures within a unified framework. As such, WLRT should be understood as a complementary and natural continuation of latent liquidity research, rather than as a competing microstructural theory.

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## 6. Microstructure Theories and WLRT: Comparative Positioning

WLRT is not intended to replace or subsume existing theories of market microstructure. Instead, it introduces a complementary analytical layer that operates at a different level of abstraction. To clarify this positioning, it is useful to contrast WLRT with several established theoretical frameworks.

## Order Flow–Centered Approaches

Order flow models emphasize the statistical properties and temporal correlations of buy and sell orders as the primary drivers of price dynamics. A central insight of this literature is that persistent order flow imbalance can coexist with diffusive prices due to adaptive liquidity provision.

WLRT is fully compatible with this view but shifts the analytical focus from order flow itself to the liquidity field that absorbs and reshapes it. In WLRT, order flow acts as an input or forcing term, while price dynamics depend on how this flow interacts with the spatial distribution and dynamics of liquidity. As a result, WLRT can accommodate identical order flow statistics leading to different price outcomes under different liquidity configurations.

## Kyle and Glosten–Milgrom Frameworks

Canonical models such as those introduced by Albert Kyle and Lawrence Glosten with Paul Milgrom focus on price formation under asymmetric information [5,6]. In these frameworks, prices adjust to balance informed trading against liquidity provision, often converging toward an informationally efficient benchmark.

WLRT does not rely on informational equilibrium or representative-agent assumptions. Instead of modeling how prices reveal information, WLRT models how liquidity redistributes in response to trading activity, strategic behavior, and external constraints. Information asymmetry may influence liquidity dynamics, but it is not the organizing principle of the theory.

In this sense, WLRT operates at a structural level that is orthogonal to information-based price discovery models.

## Stochastic Volatility and Reduced-Form Models

Stochastic volatility models treat volatility as a latent process driving observed price fluctuations. While successful in capturing empirical regularities, these models typically do not specify the underlying mechanisms that generate volatility regimes.

WLRT offers a mechanistic interpretation: volatility regimes emerge from the configuration and evolution of the liquidity field. Liquidity depletion, concentration, or delayed redistribution naturally give rise to volatility clustering, regime persistence, and abrupt transitions without introducing volatility as an independent exogenous variable.

## Positioning Summary

The distinctions above can be summarized as follows:

- Traditional microstructure theories primarily explain how prices respond to trades, information, or order flow.
- WLRT explains why those responses vary across time, regimes, and market structures by modeling the underlying liquidity dynamics.

WLRT therefore should be viewed as a higher-level dynamical framework that can coexist with, and provide context for, microstructural and reduced-form models. In appropriate limits, these models can be embedded within WLRT as local or regime-specific approximations

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# 7. Liquidity-Based Price Stabilization: The Shareholder Case

Within the framework of the Wave Liquidity Redistribution Theory (WLRT), price stabilization is naturally interpreted not as direct price control, but as a consequence of deliberate liquidity redistribution across price space. This perspective is particularly relevant for large long-term holders, shareholders, or strategic participants whose objective is not short-term trading profit, but the mitigation of excessive price fluctuations and destabilizing market regimes.

### Stabilization as Liquidity Redistribution

In WLRT, price dynamics emerge from gradients, imbalances, and flows within the liquidity field. From this viewpoint, attempts to stabilize prices through direct intervention at the transaction price are structurally fragile, as they address symptoms rather than underlying causes.

A shareholder acting within a WLRT-consistent strategy does not seek to pin the price to a specific level. Instead, stabilization is achieved by reshaping the liquidity landscape in a way that reduces extreme gradients and suppresses runaway liquidity depletion or accumulation. This can involve:

- reinforcing liquidity in regions where depletion would otherwise amplify volatility,
- redistributing liquidity across price ranges to smooth sharp spatial discontinuities,
- dampening feedback loops between order flow and local liquidity scarcity.

Price stabilization thus appears as an emergent outcome of a more regular and resilient liquidity configuration, rather than as an externally imposed constraint.

### Distinction from Market Making and Price Targeting

It is important to distinguish the shareholder stabilization perspective from traditional market making and explicit price targeting.

Market makers typically operate at short time horizons, providing liquidity close to the current price in exchange for spread capture and inventory management. Their actions primarily affect local liquidity and short-term microstructure.

Price targeting strategies, by contrast, attempt to defend or enforce specific price levels through aggressive order placement or intervention. Such approaches often generate sharp liquidity gradients and can exacerbate instability once intervention capacity is exhausted.

In WLRT terms, shareholder-driven stabilization operates at a broader spatial and temporal scale. The objective is not to dominate local price formation, but to influence the global liquidity field in a manner that reduces the likelihood of extreme price excursions.

### Stability Metrics and Dimensionless Considerations

WLRT naturally suggests the introduction of dimensionless stability measures that relate liquidity gradients, redistribution rates, and external flow intensity. While specific formulations are left for future empirical work, the conceptual role of such measures is clear: stability depends on the relative strength of liquidity redistribution mechanisms compared to the forces that deplete or concentrate liquidity.

From this perspective, stabilization fails not because intervention is insufficient in absolute terms, but because it is mismatched to the characteristic scales of liquidity dynamics. Effective stabilization requires coherence between the spatial reach, temporal persistence, and intensity of liquidity redistribution.

### Applicability and Scope

The shareholder case illustrates a broader principle within WLRT: stabilization is a property of the liquidity field, not of the price process itself. This insight applies across centralized and decentralized markets, including environments where liquidity provision is algorithmic or protocol-driven.

At the same time, WLRT does not imply that stabilization is always achievable or desirable. Structural market conditions, asymmetric information, and external shocks may overwhelm any feasible redistribution strategy. WLRT provides a framework for analyzing these limits, not for guaranteeing stabilization outcomes

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## 8. Limitations and Open Problems

While the Wave Liquidity Redistribution Theory (WLRT) provides a unified conceptual and dynamical framework for analyzing market behavior through liquidity dynamics, it is important to clearly delineate its current limitations and open challenges. These limitations are not shortcomings of the approach itself but rather define the boundary between the present theoretical formulation and future empirical and methodological developments.

## Empirical Identification of Liquidity Fields

A central challenge for WLRT lies in the empirical identification and reconstruction of the underlying liquidity field. Unlike price or traded volume, liquidity in WLRT is a partially latent object that is only indirectly observable through transactions, order book updates, and market responses to order flow.

Inferring the full spatio-temporal liquidity distribution from observable data remains a nontrivial inverse problem. While centralized limit order book markets provide partial visibility into local liquidity, large portions of the liquidity field remain hidden, particularly away from the current price. In decentralized or automated market maker environments, liquidity is formally specified but aggregated across heterogeneous agents and strategies.

Developing robust empirical proxies, reconstruction techniques, and filtering methods for liquidity fields is therefore an open research direction and a prerequisite for systematic empirical validation of WLRT.

## Calibration and Parameter Stability

WLRT introduces dynamical parameters governing liquidity propagation, redistribution, dissipation, and interaction across price space. The stability and universality of these parameters across assets, market regimes, and time scales remain open questions.

In particular, parameter values inferred from one market or period may not be directly transferable to another without accounting for structural differences such as market design, participant composition, or regulatory constraints. This limits the immediate applicability of WLRT as a fully calibrated predictive model and positions it, in its current form, as a structural and explanatory framework rather than a ready-to-use forecasting tool.

Future work must address the conditions under which WLRT parameters exhibit robustness, regime dependence, or scale invariance.

## Boundary Conditions and Market Microstructure Dependence

WLRT deliberately abstracts away from many microstructural details in order to focus on the global dynamics of liquidity. However, real markets impose boundary conditions that shape liquidity behavior, including:

- discrete tick sizes,
- minimum order sizes,
- latency and execution constraints,

- market-specific matching rules.

These factors can influence liquidity propagation and redistribution, especially at short time scales. While WLRT is designed to remain valid at a mesoscopic or macroscopic level, its interaction with fine-grained microstructural effects requires further investigation.

Understanding how WLRT interfaces with specific market architectures is an important step toward extending the theory's applicability without sacrificing its generality.

### Interpretation and Overextension Risks

As a unifying framework, WLRT is intentionally broad. This generality carries the risk of overextension, where diverse market phenomena are retrospectively interpreted in liquidity-wave terms without sufficient empirical discrimination.

To avoid this, WLRT must be accompanied by falsifiable criteria, operational definitions, and quantitative benchmarks that distinguish genuine liquidity-driven dynamics from coincidental or price-driven patterns. Establishing such criteria is essential for maintaining the theory's scientific rigor and preventing interpretative ambiguity.

### Open Directions

The limitations outlined above naturally define several promising directions for future research, including:

- empirical reconstruction of liquidity fields from high-frequency and on-chain data,
- regime-dependent calibration of liquidity dynamics,
- controlled experiments in automated market maker environments,
- integration of WLRT with agent-based and microstructural models,
- systematic testing of liquidity-based stabilization strategies.

These directions reflect the current frontier of WLRT and emphasize its role as an evolving theoretical framework rather than a closed or finalized model

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## 9. Discussion

WLRT provides a unifying lens through which diverse market phenomena can be interpreted consistently. By elevating liquidity to the role of primary dynamical variable, the theory connects microstructural behavior, regime dynamics, and stabilization mechanisms within a single conceptual framework.

At the same time, WLRT deliberately refrains from offering immediate predictive prescriptions. Its primary contribution lies in structural understanding rather than short-term forecasting performance.

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# 10. Conclusion

The Wave Liquidity Redistribution Theory provides a unified conceptual framework for understanding financial market dynamics through the lens of liquidity rather than price. By formalizing liquidity as a spatio-temporal dynamical field defined over price space, WLRT offers an alternative interpretation of market regimes, volatility, and instability as emergent properties of liquidity redistribution processes.

WLRT does not seek to replace established theories of market microstructure, information-based price discovery, or reduced-form modeling. Instead, it complements these approaches by addressing a different level of description: the global organization and evolution of liquidity that constrains and shapes local price formation. In appropriate limits, traditional models naturally embed within the WLRT framework as local or simplified approximations.

The theory highlights that price stabilization, regime persistence, and abrupt transitions are fundamentally liquidity phenomena. From this viewpoint, effective market intervention and stabilization strategies operate through reshaping liquidity distributions rather than imposing direct price control.

At the same time, WLRT remains an open theoretical framework. Challenges related to empirical identification, calibration, and interaction with specific market microstructures define clear directions for future research. Addressing these challenges will be essential for transforming WLRT from a unifying explanatory model into a quantitatively testable and empirically grounded theory.

By shifting the analytical focus from price to liquidity, WLRT provides a coherent foundation for further theoretical, empirical, and practical exploration of market dynamics across diverse trading environments.

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