What Drives Liquidity on Decentralized Exchanges? Evidence from the Uniswap Protocol

CAAW'25

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Motivation

- Liquidity plays a fundamental role in financial markets, affecting efficiency, stability, and execution costs.
- Decentralized exchanges (DEXs) introduce novel liquidity mechanisms via automated market makers (AMMs), distinct from traditional limit order books.
- Liquidity provision in DEXs is influenced by factors not yet fully understood—especially with the rise of concentrated liquidity and DEX aggregators.
- Understanding what drives DEX liquidity is essential for protocol designers, liquidity providers (LPs), and users in the evolving DeFi ecosystem.

Research Qs

- What are the key on-chain and off-chain factors that drive liquidity on DEXs?
  - ⇒ Gas prices, token pair returns and volatilities, and in-pool fee revenue and markout have significant explanatory power on future market depth.
- Through what channels—TVL vs. concentration—do these factors affect market depth?
  - ⇒ Gas price and returns act through liquidity concentration only.
  - ⇒ Volatility, fee revenue, and markout act through both channels.
- How does external liquidity (from competing DEXs and DEX aggregators) impact on-chain liquidity?
  - ⇒ Competitor share reduces liquidity via less concentration.
  - ⇒ Internalization by aggregators has no significant negative impact on market depth.

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Takeaway

- **Liquidity $\neq$ just TVL — concentration matters.**
- **Volatility, fees, and informed trading shape depth.**
- **Competition between DEXs fragments liquidity.**
- **Aggregators don't kill DEXs — they can coexist.**

Literature

- **Liquidity Provision in DEXs**
  - Losses to arbitrageurs and cream-skimming:
    Lehar & Parlour (2024); Capponi & Jia (2025); Capponi, Jia & Zhu (2024)
  - Concentrated liquidity:
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  - *Our work:* Multiple factors, broader scope (longer time, cross-chain coverage)

- **Informed Trading on DEXs**
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  - *Our work:* Use markout as proxy for adverse selection — shows negative effect on depth

- **Off-Chain Liquidity and Aggregators**
  - Aggregators improve execution (Bachu, Wan & Moallemi 2024)
  - Theory suggests harm (Chitra et al. 2024), but...
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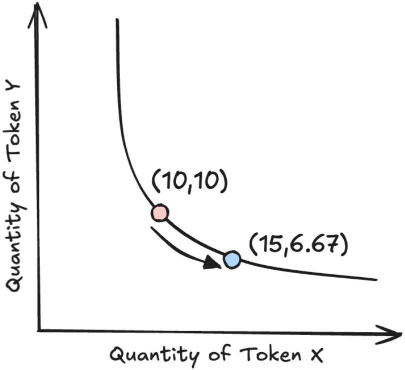
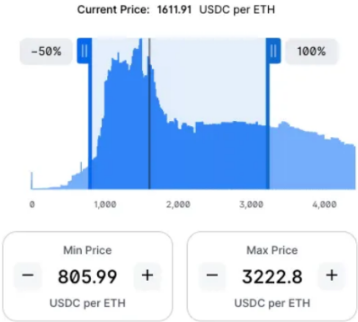
Constant Function Market Makers (Uniswap v2)

- Post-trade pool reserves must preserve level set of pricing function F (e.g. $F(x, y) = xy$)
- Example: $(10 + 5) \times (10 - 3.33) = 10 \times 10 \rightarrow$ can trade in 5 tokens X for 3.33 tokens Y



Concentrated Liquidity (Uniswap v3)

- v2: liquidity is "active" at all prices — can be capital inefficient
- v3: LPs choose in which price ranges to provide liquidity — improves capital efficiency
- v3 pools track *current pool price* (black) and *total active liquidity* at each price (blue)



Liquidity Pools Coverage

Uniswap v3 data from May 5, 2021 to July 31, 2024 from the following pools:

Pair \ Network	Ethereum (L1)	Arbitrum (L2)	Optimism (L2)	Polygon (L2)
CRV–WETH	30 bps	30 bps	30 bps	30 bps
DAI–WETH	30 bps	30 bps	30 bps	30 bps
LDO–WETH	30 bps	30 bps	30 bps	30 bps
LINK–WETH	30 bps	30 bps	30 bps	30 bps
USDC–WETH	5, 30 bps	5, 30 bps	5, 30 bps	5, 30 bps
WBTC–WETH	5, 30 bps	5, 30 bps	5, 30 bps	5, 30 bps
WETH–USDT	5, 30 bps	5, 30 bps	5, 30 bps	5, 30 bps

Liquidity Pools Included in Sample by Pair, Network, and Fee Tier.

Liquidity Metrics

Effective Spread

- Difference in quoted price between buying and selling a fixed amount Δ of WETH
- Quoted prices obtained via quoter contracts

Total Value Locked

- Dollar value of a liquidity pool's token reserves

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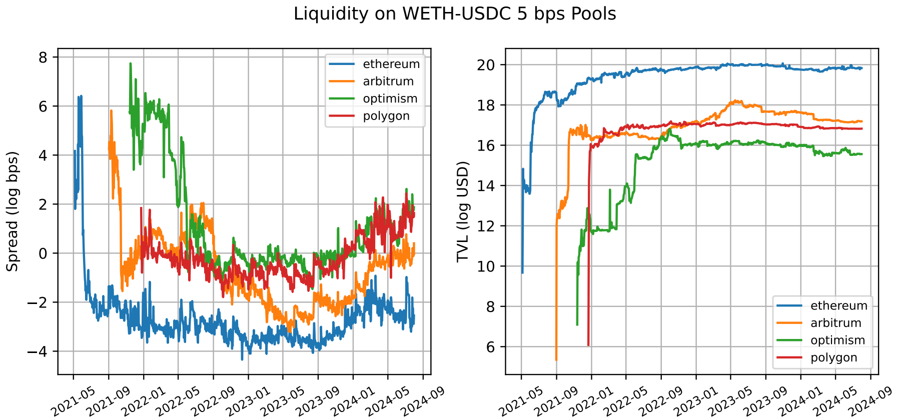
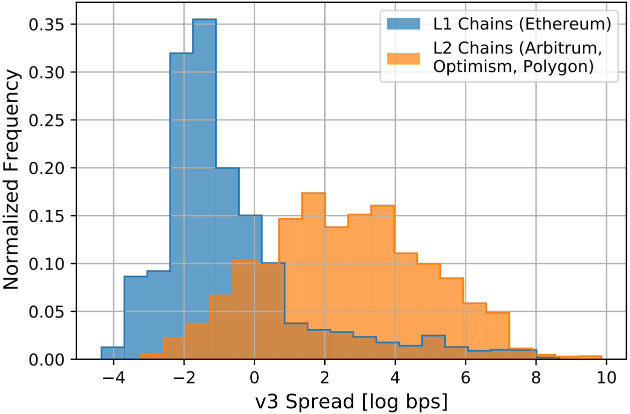


Time series of liquidity metrics for $\Delta = 1$ WETH in selected WETH-USDC pools.

Liquidity Metrics



Histogram of effective spreads for $\Delta = 1$ WETH (full sample; split by blockchain type).

Decomposing Spread in Uniswap v3

Counterfactual v2 Spread (Cv2S)

- What if the capital is in a V2 pool?

$$\mathsf{Cv2S}_t^{pool} = 10^4 \times \frac{4p_t^{WETH}}{\mathsf{TVL}_t^{pool}} \Delta_{WETH}$$

Derivation

- Note: this does not correspond to any actual pool on Uniswap v2

Spread Quotient (SQ)

- The quotient between the actual v3 and counterfactual v2 spreads

$$\mathsf{SQ}_t^{pool} := \frac{\mathsf{v3S}_t^{pool}}{\mathsf{Cv2S}_t^{pool}}$$

- Proxy for how well-concentrated the pool is around its mid-price

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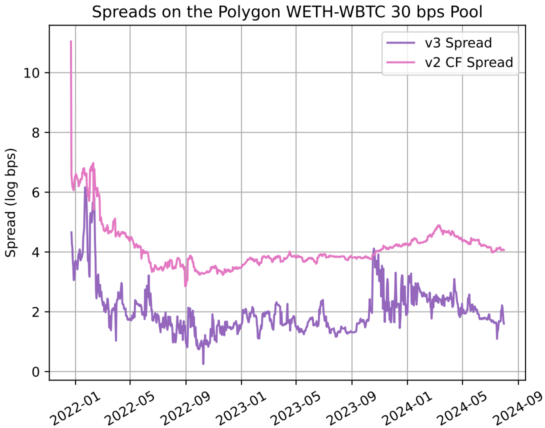
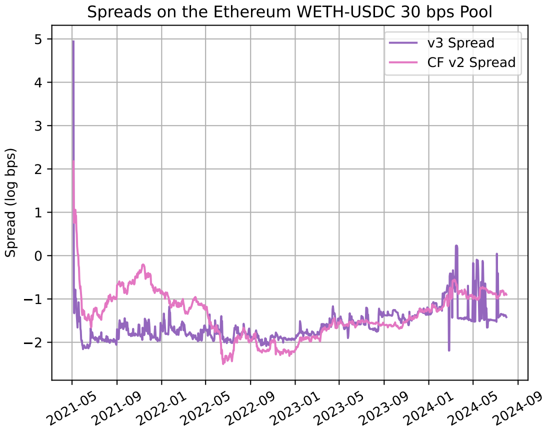
Decomposing Spread in Uniswap v3

Well-concentrated pool — actual spread *consistently below* counterfactual v2 spread



Decomposing Spread in Uniswap v3

Poorly concentrated pool — actual spread *often similar to* counterfactual v2 spread



Decomposing Spread in Uniswap v3

Take logarithms:

$$\log \text{v3S} = \log \text{Cv2S} + \log \text{SQ}$$

Which motivates our regression models:

$$\begin{aligned}\log \text{v3S}_{t+1}^{pool} = \beta_0 &+ \beta_1 \log \text{GasPrice}_t^{chain} + \beta_2 \text{LogReturns}_t^{pair} + \beta_3 \text{Volatility}_t^{pair} \\ &+ \beta_4 \log \text{FeeRevenue}_t^{pool} + \beta_5 \text{Markout}_t^{pool} + \gamma^{pool+\delta_t+\varepsilon_{t+1}^{pool}}\end{aligned} \tag{1}$$

$$\begin{aligned}\log \text{Cv2S}_{t+1}^{pool} = \beta_0 &+ \beta_1 \log \text{GasPrice}_t^{chain} + \beta_2 \text{LogReturns}_t^{pair} + \beta_3 \text{Volatility}_t^{pair} \\ &+ \beta_4 \log \text{FeeRevenue}_t^{pool} + \beta_5 \text{Markout}_t^{pool} + \gamma^{pool+\delta_t+\varepsilon_{t+1}^{pool}}\end{aligned} \tag{2}$$

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Main Analysis Parameters

- Trade size of $\Delta = 1$ WETH for spreads.
- Return horizon h_r of 1 day.
- Markout horizon h_m of 5 minutes.

Robustness Check

Main Result

	(1) log v3S	(2) log Cv2S	(3) log SQ	(4) log TVL
log GasPrice				
LogReturns				
Volatility				
log FeeRevenue				
Markout				
Observations				
N. of groups				
R^2				

Baseline Regression Model

Main Result

	(1) log v3S	(2) log Cv2S	(3) log SQ	(4) log TVL
log GasPrice	0.213			
	(0.132)			
LogReturns	-0.033***			
	(0.008)			
Volatility	0.401***			
	(0.053)			
log FeeRevenue	-0.928***			
	(0.117)			
Markout	-0.086***			
	(0.028)			
Observations	38440			
N. of groups	40			
R^2	0.313			

Baseline Regression Model

Main Result

	(1) log v3S	(2) log Cv2S	(3) log SQ	(4) log TVL
log GasPrice		0.085	0.128***	
		(0.126)	(0.048)	
LogReturns		-0.009	-0.024***	
		(0.006)	(0.005)	
Volatility		0.101**	0.300***	
		(0.044)	(0.027)	
log FeeRevenue		-0.237***	-0.690***	
		(0.074)	(0.086)	
Markout		-0.169***	0.083***	
		(0.019)	(0.021)	
Observations		38440	38440	
N. of groups		40	40	
R^2		0.078	0.435	

Baseline Regression Model

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N. of groups	40	40	40	40
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Baseline Regression Model

Extension: External Liquidity

Competitors' Market Share

- Volume of swaps taking place on other DEXs

$$\mathsf{CompetitorShare}_t^{chain,pair} = 1 - \frac{v_t}{\sum_{D \in \mathcal{D}} v_t^D}$$

Internalization Ratio

- Volume of swaps filled by private liquidity due to aggregator routing

$$\mathsf{Internalization}_t^{chain,pair} = \frac{\sum_{A \in \mathcal{A}} v_t^A}{\sum_{D \in \mathcal{D}} v_t^D + \sum_{A \in \mathcal{A}} v_t^A}$$

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Extended Regression Model

$$
\begin{aligned}
y_{t+1}^{pool} = \beta_0 &+ \beta_1 \log \mathsf{GasPrice}_t^{chain} + \beta_2 \, \mathsf{LogReturns}_t^{pair} + \beta_3 \, \mathsf{Volatility}_t^{pair} \\
&+ \beta_4 \log \mathsf{FeeRevenue}_t^{pool} + \beta_5 \, \mathsf{Markout}_t^{pool} + \beta_6 \, \mathsf{CompetitorShare}_t^{chain,pair} \\
&+ \beta_7 \, \mathsf{Internalization}_t^{chain,pair} + \gamma^{pool+\delta_t+\varepsilon_{t+1}^{pool}}
\end{aligned}
$$

where $y \in \{\log \mathsf{v3Spread},\ \log \mathsf{cfv2Spread}, \log \mathsf{v3S}/\mathsf{cfv2S}\}$

Extended Regression Result

	(1) log v3Spread	(2) log cfv2Spread	(3) log v3S/cfv2S	(4) log TVL
log GasPrice				
LogReturns				
Volatility				
log FeeRevenue				
Markout				
CompetitorShare				
Internalization				
Observations				
N. of groups				
R^2				

Model with External Liquidity Variables

Extended Regression Result

	(1) log v3Spread	(2) log cfv2Spread	(3) log v3S/cfv2S	(4) log TVL
log GasPrice	0.178	0.083	0.095**	-0.083
	(0.126)	(0.120)	(0.047)	(0.120)
LogReturns	-0.033***	-0.009	-0.024***	0.009
	(0.008)	(0.006)	(0.006)	(0.006)
Volatility	0.379***	0.089**	0.290***	-0.089**
	(0.052)	(0.045)	(0.026)	(0.045)
log FeeRevenue	-0.869***	-0.201**	-0.668***	0.201**
	(0.119)	(0.079)	(0.079)	(0.079)
Markout	-0.088***	-0.169***	0.081***	0.169***
	(0.026)	(0.019)	(0.020)	(0.019)
CompetitorShare	0.222***	0.088	0.134***	-0.088
	(0.065)	(0.056)	(0.031)	(0.056)
Internalization	0.062	0.113***	-0.051	-0.113***
	(0.082)	(0.027)	(0.070)	(0.027)
Observations	38440	38440	38440	38440
N. of groups	40	40	40	40
R^2	0.327	0.093	0.447	0.093

Model with External Liquidity Variables

Extended Regression Result

	(1) log v3Spread	(2) log cfv2Spread	(3) log v3S/cfv2S	(4) log TVL
log GasPrice				
LogReturns				
Volatility				
log FeeRevenue				
Markout				
CompetitorShare				
Internalization	0.062			
	(0.082)			
Observations				
N. of groups				
R^2				

Model with External Liquidity Variables

Summary

- **Liquidity on DEXs is driven by both capital (TVL) and concentration.**
- **Key drivers:** gas prices, volatility, returns, fee revenue, and markout.
- Different factors operate through different channels:
    - Gas price and returns ⇒ affect liquidity *concentration*.
    - Volatility, fees, markout ⇒ affect both *TVL and concentration*.
- **External liquidity matters:**
    - Competition from other DEXs reduces concentration.
    - Aggregator internalization does *not* harm overall market depth.

And more in the paper

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Derivation

- Token X = WETH, Token Y = Other Token
- Ask price (buying WETH) on v2:

$$(X - \Delta_X)(Y + \Delta_Y) = XY \implies \frac{\Delta_Y}{\Delta_X} = \frac{Y}{X - \Delta_X} := Ask$$

- Bid price (buying WETH) on v2:

$$(X + \Delta_X)(Y - \Delta_Y) = XY \implies \frac{\Delta_Y}{\Delta_X} = \frac{Y}{X + \Delta_X} := Bid$$

- DEX price aligned to outside price: $Y = p^{WETH} X$

$$\mathsf{Cv2S}_t^{pool} = 10^4 \times \frac{Ask - Bid}{\frac{1}{2}(Ask + Bid)} = 10^4 \times \frac{4p^{WETH}\Delta_X}{p^{WETH}X + Y}$$

Back

Robustness checks

- Small trade size ($\Delta = 0.1$ WETH)
- Large trade size ($\Delta = 10$ WETH)
- Weekly return horizons (h_r of 1 week)
- Hourly markout horizons (h_m of 1 hour)

Back