

# Decentralized Exchanges

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# Introduction

- Most modern exchanges are operated as a variant of an open electronic limit order book.
- It is viewed as an most efficient way of providing liquidity.
- Key assumption are perfectly competitive market makers, obtaining zero profit
- Investments into high frequency trading, co-location
- Liquidity traders try to carve out a competitive niche and extract rents
  
- We examine a new form of liquidity provision - liquidity pools

# Main finding

- Liquidity pools can dominate limit order markets when
  - There are many uninformed traders
  - Prices do not move by much
  - Incentives to invest in high frequency trading are strong
- Liquidity pools
  - track limit order market prices
  - can have lower price impact
  - have lower variation in price impact

# The Uniswap system

- Uniswap is a large, decentralized finance swap facility.
- Part of the new “Decentralized Finance” or DeFi
  
- Daily Trading Volume is over 3 billion USD.
- Posted Liquidity is over 7.5 billion USD
  
- Uniswap comprises tens of thousands of liquidity pools.
- Anyone can be a liquidity provider
- Trading: send token A to the pool, receive token B

# Setup and Players

- Asset
  - current value  $p_0$
  - With probability  $\alpha$  innovation:  $p_0 + \sigma$  or  $p_0 - \sigma$
- Traders
  - Liquidity trader: trades for exogenous motive quantity  $q$ : arrives when there is no innovation
  - Arbitrageur: Learns about innovation and trades on it
  - Liquidity providers: unaware which type of trader they face

# Limit order market

- Competitive liquidity providers
  - gain from selling to liquidity trader
  - lose from trading with arbitrageur post innovation
  - break even on average
  - narrower spread
- Liquidity providers can invest in a technology that gives them a chance for a market niche where they have market power
  - High frequency trading
  - Learn if an institutional trader is placing a large order
  - Learning information faster than others
- Monopolist liquidity provider
  - charges high spread
  - either  $p_0 + \sigma$  or  $p_0 - \sigma$
- Technology is wasteful and costly (cost  $a$ )

# Uniswap – Liquidity Provision

## A Pool with Ether “E” and a token “T”

- Suppose that there is a pool with E and T
- The exchange rate is E/T
- Liquidity demanders pay a fixed, proportional fee.
- Price impact: Trading will move the price in a deterministic fashion
- The exchange rate is determined by a “bonding curve.”
- This mechanically relates Eth to the Token, so that

$$(E + \Delta_E)(T + \Delta_T) = k$$

- An infinitesimal small trader pays E/T

# UniSwap-Price Impact

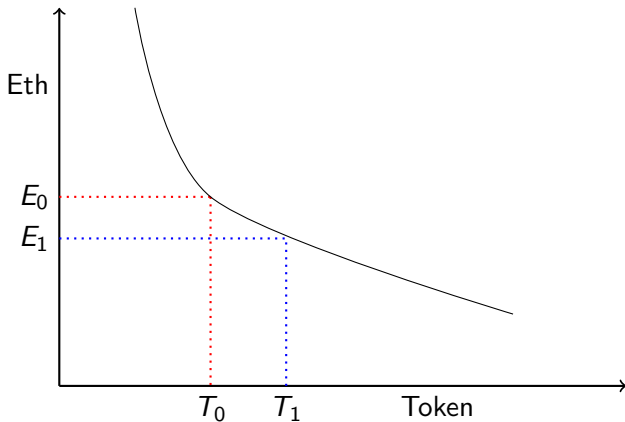


Figure: A bonding curve



# Framework - Uniswap markets

- Liquidity providers earn a fee  $\tau$  per trade
- Liquidity trader - no change in 'true price'
  - Pushes price from  $p_0 = E_0/T_0$  to  $E_1/T_1$
  - An arbitrageur arrives and pushes price back from  $E_1/T_1$  to  $E_0/T_0$
  - No change in value for liquidity providers except collecting  $2 \times$  fee
- Arbitrageur - change in 'true price'
  - Liquidity pool quotes price  $p_0$
  - assume true price is  $p_0 \pm \sigma$
  - Price is stale
  - arbitrageur will take advantage of mispricing
  - pool gets picked off
  - Liquidity providers lose out

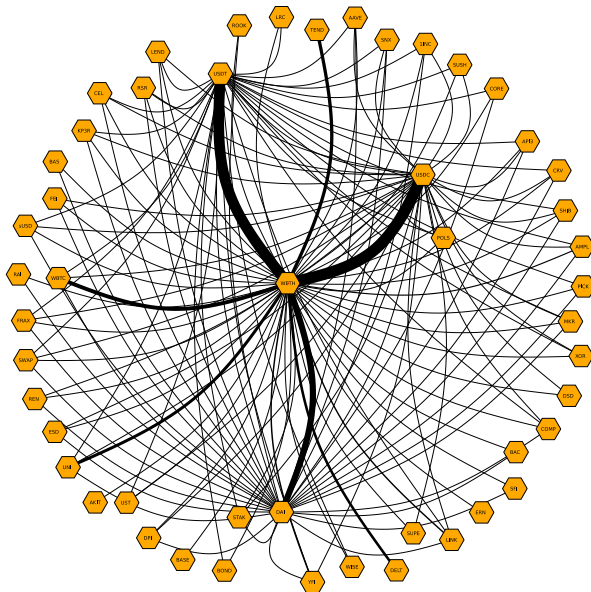
# Types of Transactions

- List of all UniSwap V1 and V2 liquidity pools from factory contract transactions.
- 36,958 individual liquidity pools, consisting of 3,937 V1 pools and 33,021 V2 pools.
- We have 47,204,920 transactions on Uniswap from its inception on November 2, 2018 until May 20, 2021.
- 1,084,581 liquidity injections
- 582,063 withdrawals of liquidity
- 45,481,500 trades of tokens.
- rest complex transactions or flash swaps.

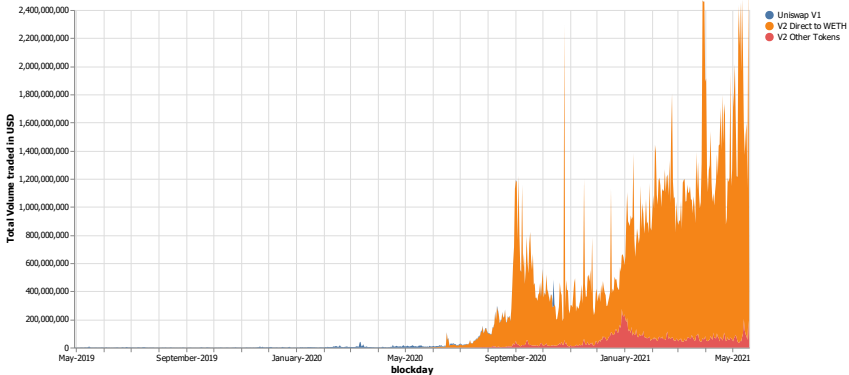
# Largest Exchanges

Token 1		Token 2		Number Transactions	Volume (ETH)	Volume (USD)	Pool size (ETH)
Panel A: Uniswap V2							
Wrapped Ether	WETH	Tether USD	USDT	7,516.2	83,445	72,383,925	211,915
USD Coin	USDC	Wrapped Ether	WETH	5,757.4	81,018	71,535,793	197,864
Dai Stablecoin	DAI	Wrapped Ether	WETH	3,008.9	46,683	36,897,989	162,671
Uniswap	UNI	Wrapped Ether	WETH	2,429.9	31,156	26,624,652	53,511
Wrapped BTC	WBTC	Wrapped Ether	WETH	957.9	29,277	23,932,848	284,151
Fei USD	FEI	Wrapped Ether	WETH	288.6	26,780	68,605,073	374,990
yearn.finance	YFI	Wrapped Ether	WETH	872.1	19,994	9,318,935	27,322
Tendies Token	TEND	Wrapped Ether	WETH	144.3	16,260	24,569,585	724
SushiToken	SUSHI	Wrapped Ether	WETH	894.5	14,860	6,750,425	77,097
Wrapped Ether	WETH	Truebit	TRU	3,680.3	14,171	43,746,104	1,647
Panel B: Uniswap V1							
Ether	ETH	Dai Stablecoin	DAI	540.6	2,681	524,088	9,226
Ether	ETH	HEX	HEX	219.4	1,801	378,702	22,300
Ether	ETH	USD Coin	USDC	258.0	1,274	287,165	6,858
Ether	ETH	Maker	MKR	118.3	1,101	217,221	11,010
Ether	ETH	LoopringCoin V2	LRC	20.5	983	365,065	794
Ether	ETH	Sai Stablecoin v1.0	SAI	166.4	770	153,078	5,030
Ether	ETH	Synthetix Network Token	SNX	124.8	700	130,702	3,480
Ether	ETH	Synth sETH	sETH	44.1	576	110,465	26,579
Ether	ETH	UniBright	UBT	108.0	279	58,212	635
Ether	ETH	Pinakion	PNK	40.7	197	59,877	1,544

# Network of largest pools

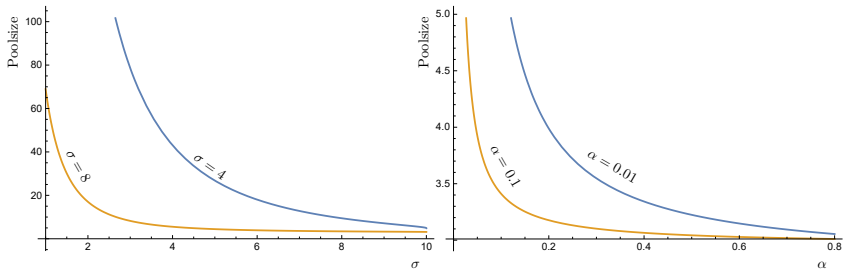


# Volume



# Optimal poolsize - Theory

- Fee revenue = Losses from quoting stale prices
- Fee revenues get shared among liquidity providers
- As losses increase pool shrinks to increase revenue per unit of liquidity provided



# Optimal poolsize - Empirical

	(1)	(2)	(3)	(4)	(5)
Volatility	-14646277.8*** (1907118.6)		-14193779.4*** (1742450.0)	-13976232.8*** (1615636.4)	-15986481.5*** (2208943.9)
Volume (USD)		0.255*** (0.0739)	0.255*** (0.0739)		
Number trades				3051.9** (1521.2)	
Reversals					18963.9** (9073.6)
R <sup>2</sup>	0.000925	0.0498	0.0507	0.0338	0.0264
Observations	263,750	279,040	263,750	263,750	263,750

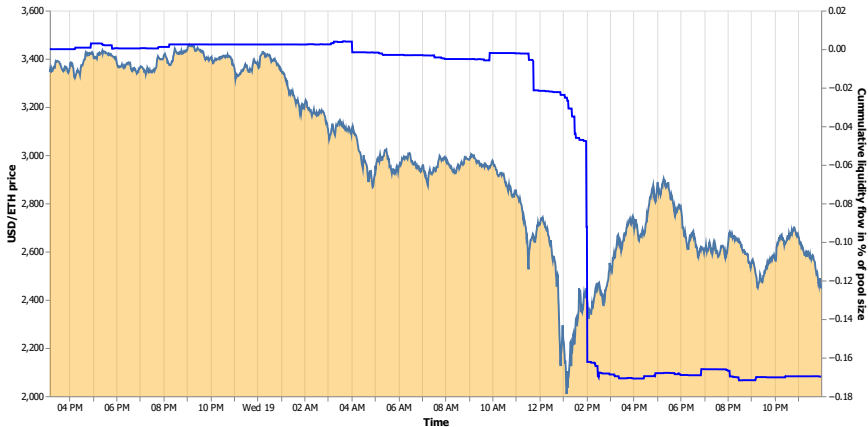
- Poolsize decreasing in innovation and
- increasing in uninformed trading

# Stability in liquidity provision

- No short term evaporation of liquidity
- Only 1.17% of sample are liquidity withdrawals
- Only 1,801 events where the same address added and withdrew liquidity within 50 blocks. Median size USD 146.75
- Only 18 observations where
  - deposit and withdrawal over USD 1,000
  - within 5 blocks



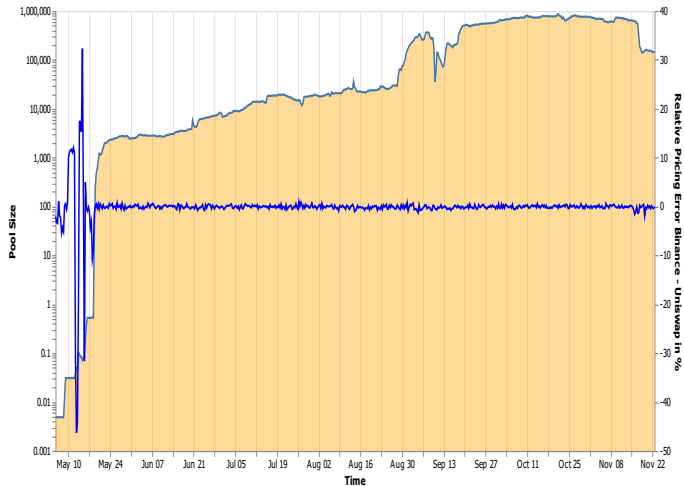
# Liquidity provision - May 19, 2021



# Comparison to a limit order market

- Liquidity pools
  - track limit order market prices
  - can have lower price impact
  - have lower variation in price impact
- We collect minute interval data from Binance, the largest crypto exchange
- Identify 384 tokens that trade on both
- Eliminate pairs with small trading volume and end up with 27 cross listed tokens.

# Minimal Pricing difference for pools above 700 Eth



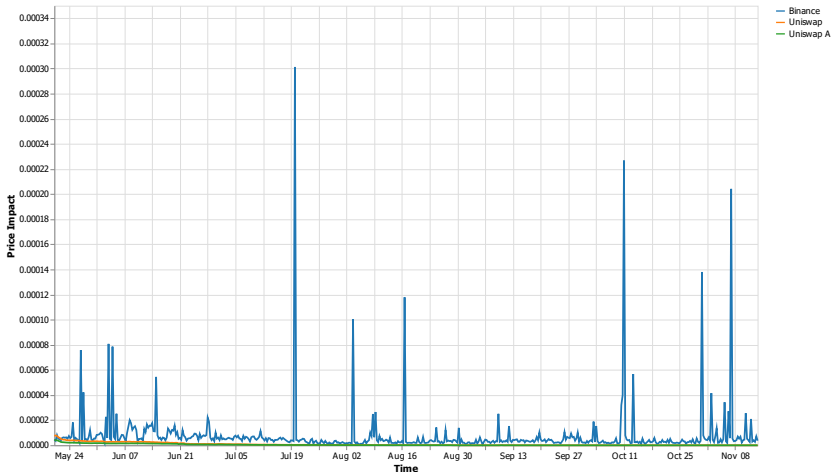
**Figure:** Pricing error and pool size Pricing difference for the USDC/ETH pair when comparing Binance to Uniswap in percent of the Binance price (blue line, right axis) and pool size of the Uniswap USDC/ETH pool (orange, log-scale, left axis).

# Intraday Prices



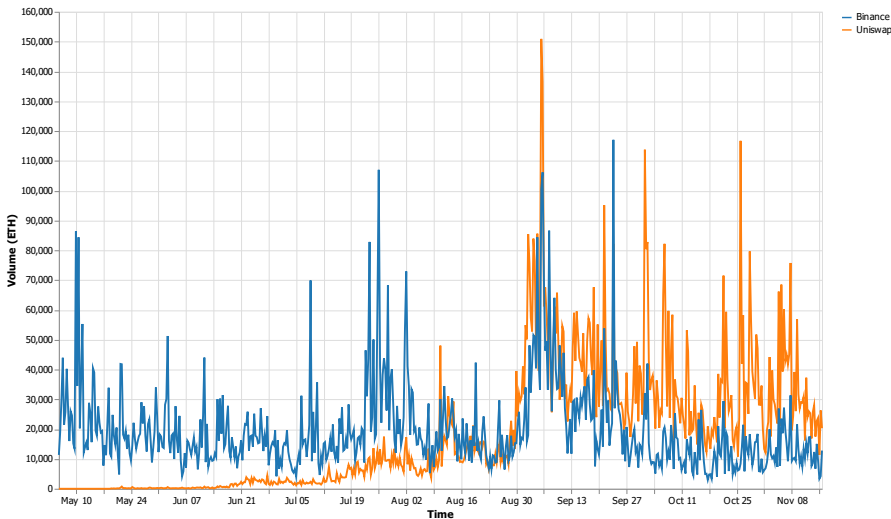
**Figure:** Intraday prices for the USDC/ETH pair on October 21, 2020 The graph shows minute-by-minute

# Price Impact



**Figure:** Price Impact of USDC/ETH on Uniswap (orange, green) and Binance (blue). Price impact is computed as change in price over volume (green and blue lines) as well as analytically as the price change for a marginal unit bought using the bonding curve formula (green line).

# Trading Volume



**Figure:** Trading volume of USDC/ETH on Uniswap (orange) and Binance (blue). The graph shows the

# Conclusion

- Presented evidence on the efficacy of a new model of liquidity provision.
- Liquidity providers in limit order markets have an incentive to invest in wasteful technology to carve out a competitive advantage
- In a pool, an automated market maker, adverse selection costs are mutualized, which reduced the cost to posting liquidity.
- Liquidity pools can dominate limit order markets
- Liquidity pools can have lower price impact and variation in price impact