Decentralized Exchanges For Near-Money Assets

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Introduction

- Decentralized exchanges (DEXs) are a key pillar of DeFi.
- A DEX is a platform for *automated* trading of cryptoassets.
- DEX applications in traditional markets are so far limited.
- However, the novel design of DEX may play a bigger role in trading of tokenised financial assets.

We study DEXs designed for stablecoins and explores their potential applications for near-money assets.

This paper:

- Analyzes transaction-level data *on stablecoins* from decentralized (DEXs) and centralized (CEXs) exchanges.
- Develops a model of stablecoin trading on a CEX and a DEX.
- Shows that:
  - The introduction of a DEX can reduce stablecoin price variation.
  - The main benefit of the DEX for assets with (relatively) stable values is the reduction of the price impact of large traders.
  - DEXs are not economically viable in competitive and liquid markets (i.e., when the number of liquidity providers in the CEX is large).

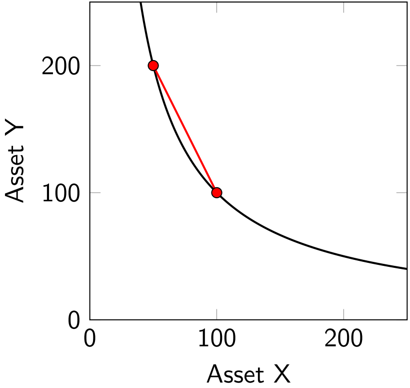
How does our paper differ from other papers on DEXs?

- **DEXs literature**: Aoyagi and Ito (2024), Barbon and Ranaldo (2024), Capponi and Jia (2024), Foley et al. (2024), Hasbrouck et al. (2022), Lehar and Parlour (2024), Lehar et al. (2024), Malinova and Park (2024), among others.
- **Empirical part:** focus on the Curve DEX designed for assets with (relatively) stable values.
- **Theoretical part:** in the model, stablecoin traders differ in trade size; the analysis of the optimal design of the DEX for stablecoins.

How does trading in the DEXs work?

Pricing Function: $xy = C$

$C = 10^4$



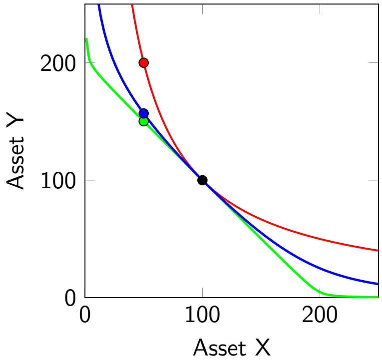
Initial Pool State
Asset X: 100
Asset Y: 100

Trade: Buy 50 X, paying Y

Post-Trade Pool State
Asset X: 50
Asset Y: 200

Pricing in the Curve Exchange

Trade: Buy 50 X for Y
Initial Pool State: (100,100)



$xy = 10^4$

Asset X: 50
Asset Y: 200
Price(X) = 2 Y

Curve ($A = 2$)

Asset X: 50
Asset Y: 156.87
Price(X) = 1.137 Y

Curve ($A = 100$)

Asset X: 50
Asset Y: 150.17
Price(X) = 1.002 Y

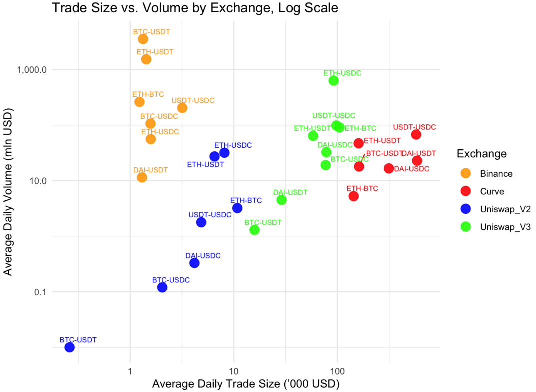
Data

- Transaction-level data (January 1, 2020 - March 30, 2023)
- Traditional exchange (CEX): Binance (Limit Order Book)
- Blockhain-based exchanges (DEXs):
  - Curve.fi
  - Uniswap V2
  - Uniswap V3
- Focus on the largest stablecoins: DAI, USDC, USDT
- Changes in parameter A (the convexity of the pricing function) and liquidity pool fees over time for stablecoin pairs.

Empirical Facts (1/3)

The average trade size is larger on DEXs than on Binance (CEX).

Among DEXs, Curve has the largest trade size.



Time period: May 5, 2021 - March 30, 2023

Empirical Facts (2/3) - Price variations of DAI, USDT, USDC decreased after the introduction of Curve Exchange

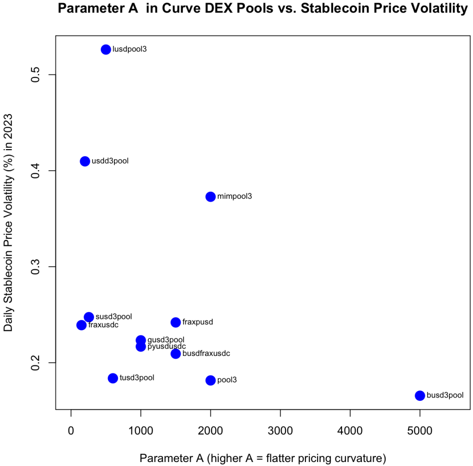
Diff-in-diff: DAI/USDT/USDC have been traded on Curve since its launch, while BUSD - only from April 2021.

	σ_t	σ_t	$abs(1-p_t)$	$abs(1-p_t)$
Curve × T	-4.932***	-5.017***	-27.293***	-27.558***
	(1.405)	(1.272)	(5.661)	(5.340)
Curve	-1.576	1.174	-4.408	22.210***
	(1.158)	(1.144)	(4.664)	(4.802)
T	2.665**	2.697***	12.532***	12.639***
	(1.041)	(0.942)	(4.193)	(3.955)
Controls	NO	YES	NO	YES
R^2	0.17	0.32	0.34	0.42
N. obs	1582	1582	1582	1582
Period	02/20-03/21	02/20-03/21	02/20-03/21	02/20-03/21

Dependent variable: the mean daily absolute price deviation $abs(1-p_t)$ or the intraday price volatility σ_t (in bp) on CEXs. Curve dummy: equals 1 if the date is after Sep 6, 2020. Daily Frequency. T equals 1 for the treatment group (DAI,USDC,USDT) and 0 for BUSD.

Empirical Facts (3/3)

The parameter A, which defines the "flatness" of the AMM pricing function, is heterogeneous across stablecoin pairs in Curve DEX.



Model: Timeline

$t = 0$	$t = 1$	$t = 2$
• N_C liquidity providers in the CEX choose liquidity supply functions $x^i_C(s)$ • N_D liquidity providers in the DEX deposit x^i_D stablecoins	• With prob. λ there is a shock to the fundamental value of the stablecoin v • If no shock: the liquidity trader chooses the venue to sell $Q \sim U[0, \bar{Q}]$ stablecoins • If shock happened: the informed trader chooses the venue to sell $Q \sim U[0, \bar{Q}]$ stablecoins	• If no shock: the arbitrageur brings the price back to 1 (if the trade happened in the DEX) • If shock happened: the arbitrageur trades s.t. the marginal price in the pool is v • Payoffs realize If shock happened, DEX LPs experience the impermanent loss

Trader's problem

- A trader sells Q stablecoins, $Q \sim U(Q)$
- Cost of trading in the CEX: $s_C(Q)Q$, $s_C(Q)$ - spread in the CEX
- Cost of trading in the DEX:

$$\underbrace{fQ}_{\text{DEX pool fee}} + \underbrace{(1 - P(Q, X_D, A))Q}_{\text{price impact}}$$

The average selling price $P(Q, X_D, A)$ in the DEX is determined by the AMM pricing function (parameter A), liquidity pool size X_D, trade size Q.

- The trader sells in the DEX iff:

$$s_C(Q) > f + (1 - P(Q, X_D, A))$$

Centralized Exchange (CEX)

- N_C liquidity providers (LPs) quote in a limit order book
- $t = 0$: A liquidity provider submits their liquidity supply function x_C to maximize:

$$\pi_C = \underbrace{s_C x_C}_{\text{gain from spread}} - \underbrace{\frac{\rho}{2} x_C^2}_{\text{inventory cost}} - \underbrace{\lambda x_C (1 - v)}_{\text{exp. loss if the shock occurs}}$$

where $s_C = 1 - P_C$ is the spread they earn and P_C is the price of the stablecoin in the CEX.

- In the equilibrium, $N_C x_C(s_C) = Q$.
- The expected profit of a LP at $t = 0$:

$$E_0[U^{LP_C}] = \int_{\Omega_C} \frac{1}{\bar{Q}} \pi_C(Q) dQ$$

where Ω_C is the set of traders that choose to trade in the CEX.

Decentralized Exchange (DEX)

- Automated Market Maker (AMM) with a per-unit transaction fee f and a deterministic pricing curve:

$$((1-A)X + AX_D)((1-A)Y + AX_D) = X_D^2$$

where $A \in (0,1)$ is the curvature parameter, X and Y are the token amounts, X_D is the initial pool size.

- The average price P_D of selling Q units of stablecoins in the DEX is

$$P_D = \frac{X_D}{(1-A)Q + X_D}$$

- Denote the price impact of a trade in DEX as $s_D = 1 - P_D$.

$$\frac{\partial s_D}{\partial A} < 0, \qquad \frac{\partial s_D}{\partial X_D} < 0, \qquad \frac{\partial s_D}{\partial Q} > 0.$$

Decentralized Exchange (DEX)

- N_D liquidity providers deposit stablecoins in the pool. A DEX LP chooses x_D^i to maximize:

$$E_0[\pi_D] = \underbrace{f \frac{x_D^i}{X_D} \int_{\Omega_D} \frac{1}{\bar{Q}} V_D(Q) dQ}_{fees} - \underbrace{\frac{\rho}{2} {x_D^i}^2}_{inv.cost} - \lambda \underbrace{\frac{x_D^i}{1-A}(1 + v - 2\sqrt{v})}_{imp.loss}$$

where Ω_D is the set of traders that choose to trade in the DEX, $V_D(Q)$ - trading volume in the DEX.

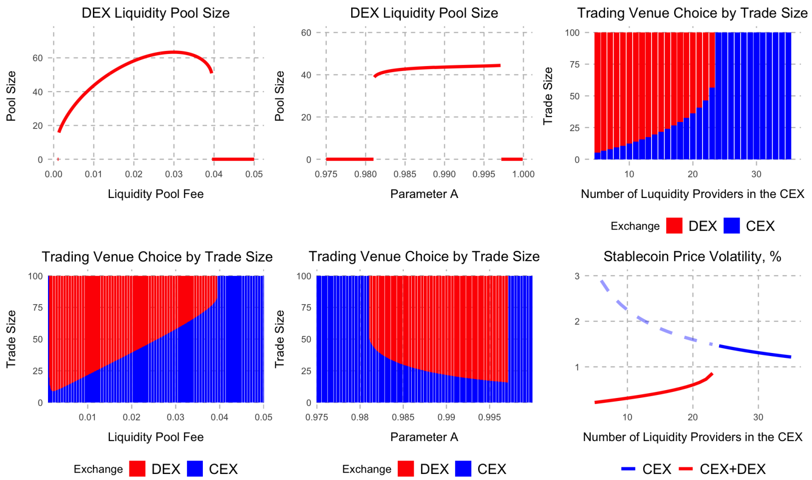
- The size of impermanent loss of DEX liquidity providers is increasing in X_D and A and decreasing in v.

CEX vs DEX

Main differences between the CEX and DEX in the model:

- Pricing mechanism: Dealer Market (CEX) vs AMM (DEX)
- Passive liquidity provision in the DEX vs active liquidity provision in the CEX
- The DEX requires to pre-commit capital
  - Inventory costs are incurred even if no trades occur in the DEX

Comparative statics: A, f, N_C



Parameters: $f = 0.01$, $\rho = 0.01$, $N_C = 15$, $N_D = 10$, $\bar{Q} = 100$, $\lambda = 0.01$, $v = 0.95$, $A = 0.99$.

Conclusion

- DEX can improve market quality for assets with stable values.
- A flatter DEX pricing curve (i.e., higher A) enables a lower impact of inventory costs on prices, reducing trading costs of large trades ...
- ... but resulting in higher adverse selection costs.
- For more volatile assets, the optimal A is lower, and to compensate DEX LPs, the optimal pool fee f needs to be higher.
- The DEX design could potentially be useful for the trading of near-money assets, such as short-term government bonds.

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