Blockchain Currency Markets

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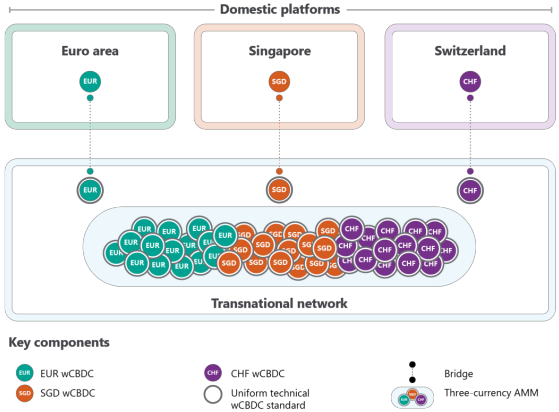
Motivation: Blockchain Currency Markets

- **Decentralized Finance (DeFi):** A transformative shift in global finance, leveraging blockchain technology to enable access without traditional intermediaries.
- **Decentralized Exchanges (DEXs):** Peer-to-peer markets leveraging smart contracts and automated market maker (AMM) algorithms to set prices and execute trades.
- On DEXs, stablecoins—cryptocurrencies pegged to fiat currencies—are actively traded. Examples include:
  - **USDC**: A stablecoin pegged to the U.S. dollar.
  - **EURC**: A stablecoin pegged to the Euro.
- These transactions form the foundation of a **Blockchain Currency Market**.
- The blockchain currency market offers a unique laboratory for testing the feasibility of DEXs in pricing currencies.

Motivation: Project Mariana

- A collaboration between the BIS Innovation Hub, the Bank of France, the Monetary Authority of Singapore, and the Swiss National Bank.
- The project explores the potential of DEXs for foreign exchange (FX) trading and employs an AMM design for currency pricing.

Mariana high-level architecture — Graph 1



Source: BIS

This paper

- This paper provides the first comprehensive study of blockchain currency markets (USDC/EURC)
- The paper addresses three key research questions:
  1. Can blockchain currency markets be efficient?
  2. How are blockchain currency markets connected to traditional currency markets?
  3. Do blockchain currency markets exhibit asymmetric information?
- **Contribution:** Leveraging rich transaction-level blockchain data, this paper examines the informational role of blockchain transactions in the traditional EUR/USD currency market.

Preview of Findings I: Stylized Facts

1. **Price Efficiency:** EURC/USDC prices on DEXs closely follow EUR/USD prices, with an average deviation of 24 basis points due to blockchain-specific factors (e.g., gas fees, market risk).
2. **Arbitrage Efficiency:** Only 1% of EURC/USDC transactions exceed arbitrage limits after considering transaction costs.
3. **Information Efficiency:** EURC/USDC prices respond quickly to macroeconomic news (e.g., FOMC meetings), demonstrating efficient incorporation of fundamental information.

Preview of Findings II: Information Content

1. **Market Linkage:** EURC/USDC trading volume systematically aligns with EUR/USD volume in traditional currency markets, particularly in interbank segments.
2. **Feedback Trading:** EURC/USDC order flow on DEXs responds to price deviations between EURC/USDC and EUR/USD.
3. **Information Advantage:** Sophisticated traders and participants with access to the primary market have informational advantages in trading.

Related Literature I

- **Stablecoins:** Connections to traditional markets, arbitrage mechanisms, price dynamics, and risks of speculative attacks (e.g. Adams et al. 2023; Eichengreen, T Nguyen, and Viswanath-Natraj 2023; Lyons and Viswanath-Natraj 2023; Kozhan and Viswanath-Natraj 2021; Ma, Zeng, and Zhang 2023; Liu, Makarov, and Schoar 2023).
  This paper highlights the potential role of stablecoins in forming a blockchain currency market.
- **Decentralized Exchanges:** Research on market efficiency, liquidity provision, and their potential to replace traditional limit order book exchanges.(e.g. Capponi and Jia 2021; Aoyagi and Ito 2021; Hasbrouck, Rivera, and Saleh 2022; Lehar and Parlour 2021; Foley, O'Neill, and Putniņš 2023; Malinova and Park 2023; Fang 2022; Lehar, Parlour, and Zoican 2023; Hansson 2023; Klein et al. 2023).
  This paper examines the efficiency of the AMM algorithm in facilitating FX transactions.

Related Literature II

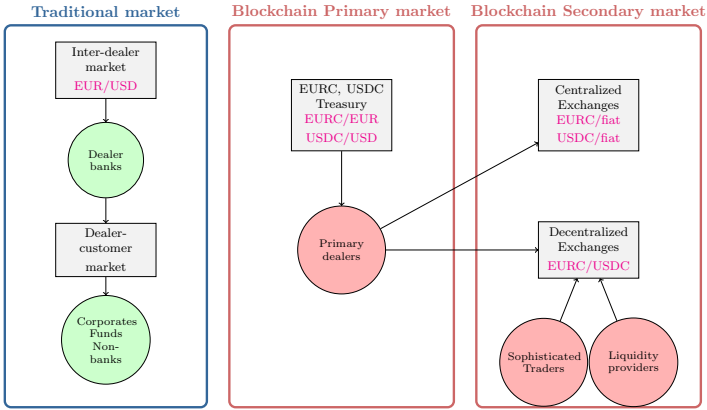
- **Microstructure:** Traditional market microstructure (e.g. Evans and Lyons 2002; Andersen et al. 2003; Berger et al. 2008; Rime, Sarno, and Sojli 2010; Kozhan and Salmon 2012; Ranaldo and Somogyi 2021; Huang et al. 2021; Krohn, Mueller, and Whelan 2022).
  This paper bridges the stablecoin literature with traditional market microstructure literature by examining the heterogeneous price impact of order flows in DEXs on traditional currency markets.

Roadmap of Talk

1. Institutional Details and Data
2. Stylized Facts
3. Empirical Evidence

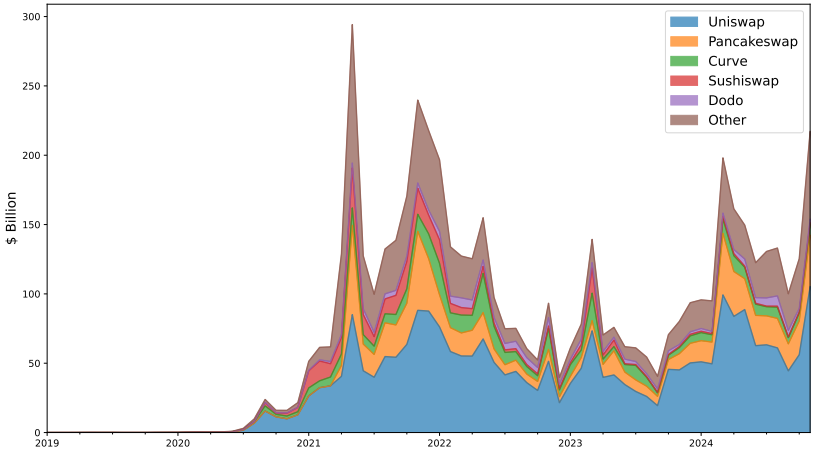
Market Structure: Traditional vs Blockchain

- **Traditional currency market**: inter-dealer and dealer-customer segments.
- **Blockchain currency market**:
  - Primary dealers deposit traditional currencies with stablecoin treasury to mint EURC and USDC.
  - Prices determined in centralized or decentralized exchanges.



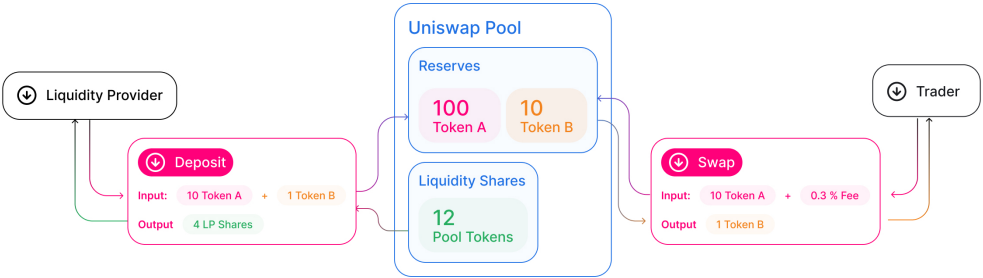
Blockchain Market: Decentralized Exchanges

Figure Trading Volumes Across Different DEXs



Blockchain Market: Uniswap

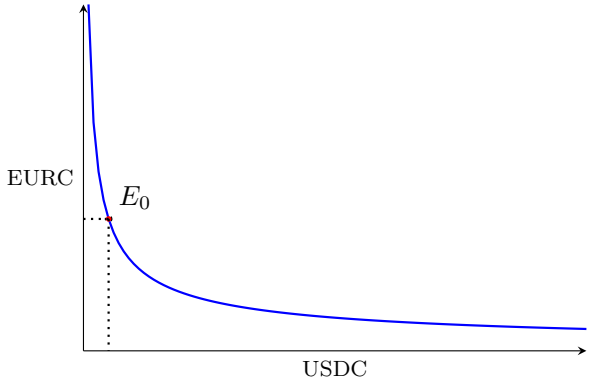
- Use AMM matching and price setting algorithm.
- The price is determined based on the constant product function $k = xy$.
- Orders:
  - Swap orders (liquidity demanders)
  - Liquidity providers can deposit ('mint') or withdraw ('burn') liquidity from the pool.



Source: Uniswap

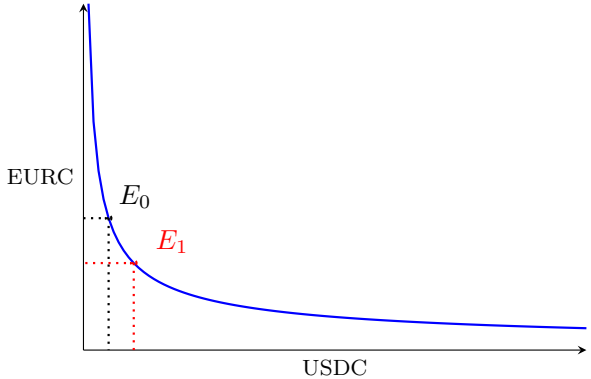
EURC/USDC Bonding Curve

- The bonding curve represents the set of liquidity $[x, y]$ that satisfies the constant product function ($k = xy$).
- For example, if a pool contains 100 EURC and 110 USDC, the constant k is $100 \times 110 = 11,000$, represented as E_0 with $k_0 = x_0 y_0$.
- The exchange rate (slope of the point) is 1.10 USDC per EURC.



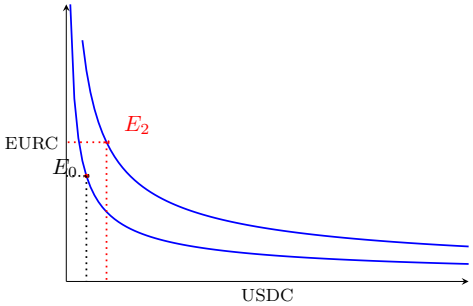
EURC/USDC Bonding Curve: Swap

- A swap order: Buy EURC from the pool by selling USDC ($E_0 \rightarrow E_1$).
- To maintain the constant product formula, at point E_1, the constant $k_1 = x_1 y_1$, where $x_1 > x_0$ and $y_1 < y_0$, with $k_1 = k_0$. This results in an increase in the relative price of EURC.



EURC/USDC Bonding Curve: Liquidity Provision

- A liquidity provision: Deposit (mint) both tokens into the pool ($E_0 \rightarrow E_2$).
- The depth of the pool increases as $k_2 > k_0$, $x_2 > x_0$, and $y_2 > y_0$. The relative price of EURC remains unchanged.

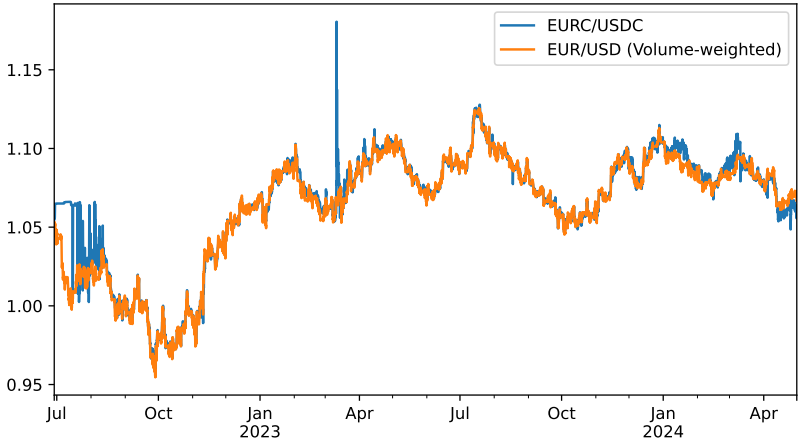


- **Uniswap V2:** Liquidity providers supply both tokens based on the constant product formula, providing liquidity over the entire price range $[0, \infty)$.
- **Uniswap V3:** Liquidity providers can specify a price range $[p_L, p_U]$ for minting and burning tokens, enabling concentrated liquidity within that range.

Data Sources

- **DEX Transaction Data:** EURC/USDC Uniswap V3 (0.05%) pool data, including all swaps (trades) and liquidity provision activities (mints/burns).
- **Traditional Market Price and Volume:** EUR/USD 5-minute interval prices and hourly volumes from CLS, the largest international FX volume dataset. It disaggregates flows into interbank, bank-fund, bank-non-bank, and bank-corporate segments.
- **Supplementary Data:** Macroeconomic variables and cryptocurrency price data from centralized exchanges.

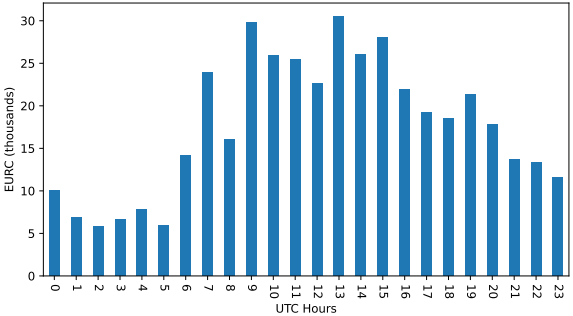
EURC/USDC and EUR/USD Prices



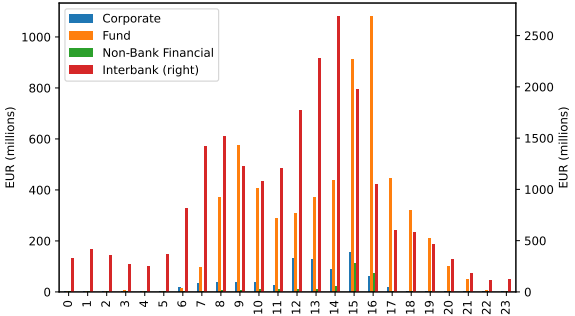
- Average (absolute) deviations of 24 basis points from 08/22-04/24.

EURC/USDC and EUR/USD Volume

Panel (a): EURC/USDC



Panel (b): EUR/USD



- Average daily volume: 28.42 EUR billion in CLS EUR/USD vs. 0.423 EURC million in Uniswap EURC/USDC.
- Traditional markets trade primarily between 13:00 and 16:00 UTC, while DEX trading is more evenly distributed throughout the day.

Roadmap of Talk

1. Institutional Details and Data
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Fact 1: Peg efficiency is driven by blockchain factors

Table Determinants of EURC-USDC Peg Deviations

	|EURC/USDC-EUR/USD| Peg Deviations					
	(1)	(2)	(3)	(4)	(5)	(6)
σ^{IV}_{ETH}	0.1328***				0.1608***	
	(0.0454)				(0.0479)	
σ^{IV}_{BTC}		0.3605***				0.3568***
		(0.0816)				(0.0801)
gasfee			0.4054**		0.4624**	0.3982**
			(0.1992)		(0.2036)	(0.1923)
R_{ETH}				0.0036	0.0041	0.0039
				(0.0041)	(0.0039)	(0.0038)
constant	0.0015***	0.0002	0.0019***	0.0024***	0.0008*	-0.0002
	(0.0003)	(0.0005)	(0.0002)	(0.0001)	(0.0004)	(0.0005)
R-squared	0.0104	0.0284	0.0160	0.0019	0.0328	0.0457
No. observations	625	625	625	624	624	624

- Market volatility heightens risk for traders holding wealth in risky cryptocurrencies, reducing arbitrage activity.
- High gas fees increase transaction costs, hindering arbitragers from closing price divergences with traditional markets.

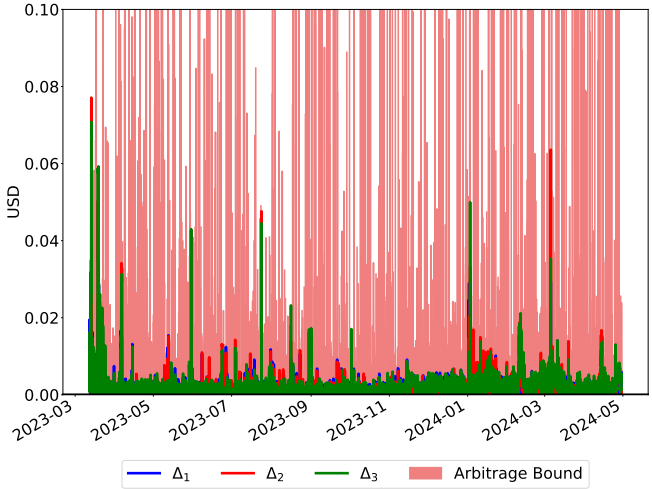
Fact 2: Peg Deviations Are Within Arbitrage Bounds

Triangular arbitrage measures:

$$\Delta_1 = \left| 1 - \frac{p_{\text{EURC/USDC}} \cdot p_{\text{USDC/USD}}}{p_{\text{EURC/USD}}} \right|,$$
$$\Delta_2 = \left| 1 - \frac{p_{\text{EUR/USD}} \cdot p_{\text{EURC/EUR}}}{p_{\text{EURC/USD}}} \right|, \tag{1}$$
$$\Delta_3 = \left| 1 - \frac{p_{\text{EUR/USD}} \cdot p_{\text{EURC/EUR}}}{p_{\text{EURC/USDC}} \cdot p_{\text{USDC/USD}}} \right|.$$

Arbitrage bounds: actual gas fees, liquidity fees (0.05%), and slippage (0.5%, based on Uniswap's default setting).

Fact 2: Peg Deviations Are Within Arbitrage Bounds

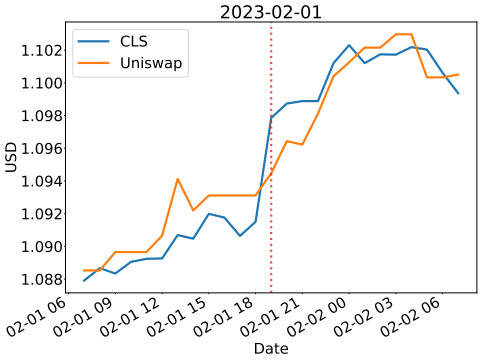


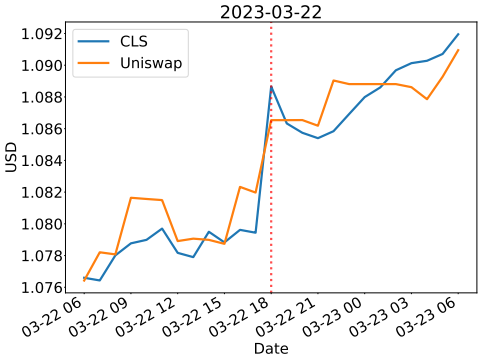
- Arbitrage bound violations occur in approximately 1% of transactions.
- Note: Additional costs from intermediation fees on centralized exchanges are excluded.

Fact 3: Peg Prices React to Macro News Intra-Day

- EURC/USDC closely follows EUR/USD during macroeconomic news events.
- Peg prices exhibit clear reactions to FOMC announcements from July 2022 to April 2024.

Example: Reactions to FOMC announcements:





Roadmap of Talk

1. Institutional Details and Data
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Heterogeneous Market Participants

Blockchain data allows us to classify wallets into following groups.

- **Sophisticated traders**
  - Top 10 wallets by trading volume.
  - 52% of aggregate trading volume.
- **Primary dealers**
  - Wallets transacting with EURC/USDC Treasury.
  - Hold traditional EUR and USD deposits with stablecoin treasury.
  - Deposit 1 EUR (USD) to mint 1 EURC (USDC) token.
  - 7% of aggregate trading volume.
- **Liquidity providers**
  - Wallets providing liquidity in EURC/USDC pools.
  - 7% of aggregate trading volume.

Trader Classification

Groups include sophisticated traders (Top10), Primary Dealers (PM), Liquidity Providers (LP), and their intersections.

Group	top10	PrimaryDealer	LP	$N_{addresses}$	Tx	$Tx/N_{addresses}$
Top10	✓	×	×	76	4447	58.51
PM	×	✓	×	68	363	5.34
LP	×	×	✓	90	446	4.96
Top10 ∩ PM	✓	✓	×	6	534	89.00
Top10 ∩ LP	✓	×	✓	7	254	36.29
PM ∩ LP	×	✓	✓	3	6	2.00
$\notin \{Top10, PM, LP\}$	×	×	×	2342	9137	3.90

Volume

Research Hypothesis: Market Linkage

H1: *DEX trading volume has a systematic connection with traditional market volume, particularly with the interbank segment that drives the price discovery process.*

$$V_{N_{DEX},t} = \alpha_{N_{DEX}} + \sum_{i \in N_{CLS}} V_{N_{CLS},t} + \epsilon_{N_{DEX},t} \tag{2}$$

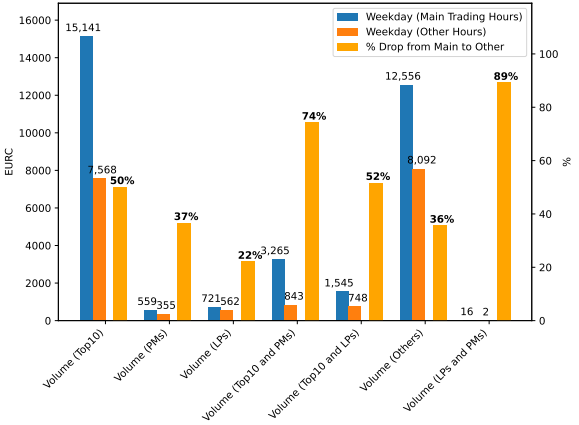
- $V_{N_{DEX},t}$ represents EURC/USDC hourly trading volumes for sophisticated traders, primary dealers, liquidity providers, and wallets that overlap across these categories.
- $V_{N_{CLS},t}$ captures hourly trading volumes in the traditional EUR/USD market, using disaggregated CLS data by sector. This includes interbank volumes, corporate-bank volumes, fund-bank volumes, and non-bank financial-bank volumes.

Research Hypothesis: Market Linkage

	V_{top10}	V_{PM}	V_{LP}	$V_{top10 \cap PM}$	$V_{top10 \cap LP}$	$V_{LP \cap PM}$	$V_{\notin top10, PM, LP}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Interbank	4.3478***	0.1984***	0.3286**	0.8337***	0.4106*	-0.0001	3.2545***
	(0.6874)	(0.0408)	(0.1295)	(0.0859)	(0.2462)	(0.0006)	(0.5365)
Corporate-Bank	1.5545	-0.0026	0.3532	0.5860	-0.4185**	-0.0018	2.2923
	(1.6186)	(0.1902)	(0.3012)	(0.3777)	(0.1643)	(0.0013)	(1.9664)
Fund-Bank	1.1120***	0.0353	0.0166	0.2303***	0.0369	0.0017	0.9016***
	(0.3915)	(0.0285)	(0.0392)	(0.0613)	(0.0734)	(0.0017)	(0.3031)
Non-Bank Financial-Bank	2.3239	0.3554	-0.0312	0.7064	0.0518	-0.0002	6.8670
	(3.7023)	(0.3001)	(0.1766)	(0.7246)	(0.0985)	(0.0002)	(7.7152)
constant	3261.9288***	113.7215***	190.3928**	111.9940*	379.6192***	2.7742	4390.3679***
	(494.1829)	(35.6057)	(91.4735)	(60.5383)	(135.9636)	(2.3514)	(428.4421)
R-squared	0.017	0.005	0.005	0.028	0.001	0.000	0.018
No. observations	14,999	14,999	14,999	14,999	14,999	14,999	14,999

- There is a significant correlation between blockchain and traditional market volumes, particularly in interbank activity.
- In column (1), a 1 EUR million increase in interbank trading volume corresponds to a 4.35 EURC increase in DEX activity for sophisticated traders.

Weekday Trading: Main Trading Hours vs. Other Hours



- Trading volumes are significantly higher during main trading hours (13:00 to 16:00 UTC) across all participant groups.
- The most pronounced decline is observed among primary dealers and sophisticated investors.

Research Hypothesis: Feedback Trading

H2: *Blockchain order flow on DEX is responsive to deviations between DEX and traditional market prices, indicating feedback trading behavior.*

$$OF_{i,t} = \alpha_i + \beta_i(p_{EURC/USDC,t-1} - p_{EUR/USD,t-1}) + controls_{i,t} + \epsilon_{i,t} \tag{3}$$

- We examine whether DEX traders adjust their strategies in response to price differences between the DEX reference rate and the CLS benchmark rate.
- $OF_t = \sum_{k=1}^{N} \left(\mathbb{1}[T_k = Buy] - \mathbb{1}[T_k = Sell] \right) \times V_{t_k}$
- $controls_t$ include the lagged DEX (EURC/USDC) return and DEX order flows.

Research Hypothesis: Feedback Trading

	$OF_{top10,t}$	$OF_{PM,t}$	$OF_{LP,t}$	$OF_{top10 \cap PM,t}$	$OF_{top10 \cap LP,t}$	$OF_{LP \cap PM,t}$	$OF_{\notin top10,PM,LP,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$P_{DEX,t-1} - P_{CLS,t-1}$	-0.1454***	-0.0097	-0.0207	-0.1374***	-0.0032	-0.0003	-0.2247***
	(0.0474)	(0.0071)	(0.0126)	(0.0196)	(0.0074)	(0.0002)	(0.0488)
DEXReturn_{t-1}	-0.0077**	-0.0002	0.0003	-0.0012	0.0002	-0.0000	-0.0008
	(0.0032)	(0.0002)	(0.0005)	(0.0010)	(0.0002)	(0.0000)	(0.0019)
$OF_{i,t-1}$	✓	✓	✓	✓	✓	✓	✓
R-squared	0.042	0.001	0.000	0.012	0.008	0.000	0.020
No. observations	14,998	14,998	14,998	14,998	14,998	14,998	14,998

- In columns (1) and (4), a unit increase in the lagged hourly price difference between DEX and CLS rates corresponds to a sell blockchain order flow of 0.15 and 0.14 million EURC for sophisticated traders and those who are both sophisticated and primary dealers, respectively.
- The order flow for primary dealers and LPs, shown in columns (2) and (3), is not statistically significant.

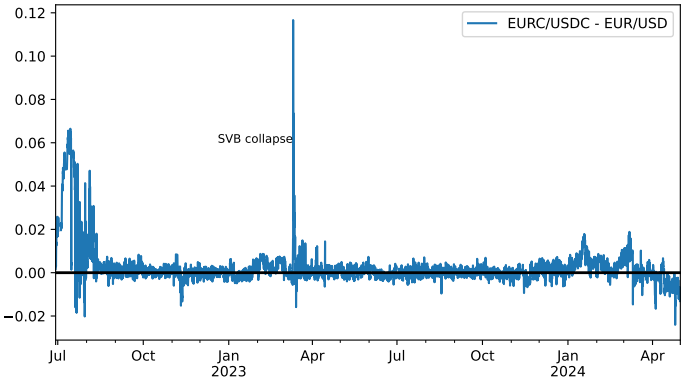
Research Hypothesis: Information Advantage

- **H3a:** *Sophisticated traders and primary dealers have informational advantages in the EUR/USD market.*
  - They leverage arbitrage opportunities.
  - Higher permanent price impact of order flow.
- **H3b:** *LPs are uninformed regarding the EUR/USD market.*
  - Manage inventory without market information.
  - Hedging trades have low permament price impact of order flow.

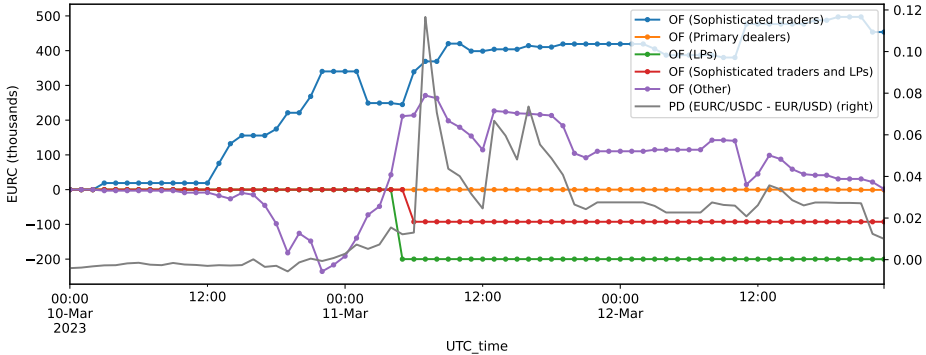
USDC De-Pegging Event I

Event Overview:

- On March 11, 2023, USDC de-pegged to 87 cents after Silicon Valley Bank (SVB), which held $3.3 billion of Circle's reserves backing USDC, declared bankruptcy.
- Confidence was restored on March 13, following FDIC's guarantee of all SVB deposits.



USDC De-Pegging Event II



- **Sophisticated Traders:** Positive pre-depegging inflows indicate informational advantage.
- **LPs and Smaller Traders:** Negative order flow, reflecting limited access to information.

USDC De-Pegging Event: Arbitrage Activity by Sophisticated Traders

Wallet '1c37' exploited arbitrage opportunities by selling USDC to acquire EURC during the de-pegging event.

Date (UTC)	Hash	From	To	USDC	From Name	To Name
2023-03-10 04:06:11	46f0	3e43	1c37	16666666666.6666	Coinbase	trader
...	...	...	...	...	...	...
2023-03-10 13:30:11	cfa9	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 13:34:59	3601	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 13:43:35	5de7	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 14:11:11	ae67	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 14:24:47	6aa6	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 14:29:11	5102	3e43	1c37	16666666666.6666	Coinbase	trader
2023-03-10 14:29:59	b043	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 14:36:59	ebaf	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 14:43:35	021d	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
2023-03-10 15:03:47	3c82	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
...	...	...	...	...	...	...
2023-03-10 22:57:11	f239	3e43	1c37	16666666666.6666	Coinbase	trader
2023-03-10 22:59:11	9bb9	1c37	73d6	3333333333.33333	trader	Uniswap V3: EURC-USDC
...	...	...	...	...	...	...

Contemporaneous Price Impact

$$\Delta p_t = \alpha + \sum_{i \in N_k} \beta_i \mathrm{OF}_{i,t} + controls_{t-1} + \epsilon_t \tag{4}$$

- We test whether different participant categories have distinct effects on blockchain-based and traditional FX rates.
- Δp_t is the hourly log spot exchange return for either the EURC/USDC or EUR/USD pair
- OF_i is the hourly order flow for each subgroup.
- $controls_{t-1}$ control for the lag of log spot exchange return for either the EURC/USDC or EUR/USD pair

Aggregate Order Flows

Contemporaneous Price Impact

	DEXReturn (EURC/USDC)	CLSReturn (EUR/USD)
OF_{top10}	6.6094***	2.2984***
	(0.4929)	(0.1798)
OF_{PM}	7.5372***	2.9974***
	(0.4370)	(0.5617)
OF_{LP}	6.5598***	1.8161***
	(0.4440)	(0.2317)
$OF_{top10 \cap PM}$	6.6047***	3.2516***
	(0.2858)	(0.2998)
$OF_{top10 \cap LP}$	5.2599***	0.8859**
	(0.7113)	(0.3789)
$OF_{LP \cap PM}$	9.6165***	-0.2970
	(0.7925)	(0.4060)
$OF_{\notin top10, PM, LP}$	7.2696***	1.9088***
	(0.4741)	(0.1516)
controls	✓	✓
R-squared	0.472	0.132
No. observations	14,998	14,998

- Column (1): Trader groups show similar price effects on EURC/USDC returns, consistent with the AMM design, where contemporaneous price impact follows the constant product function.
- Column (2): Sophisticated traders and primary dealers demonstrate informational advantages.

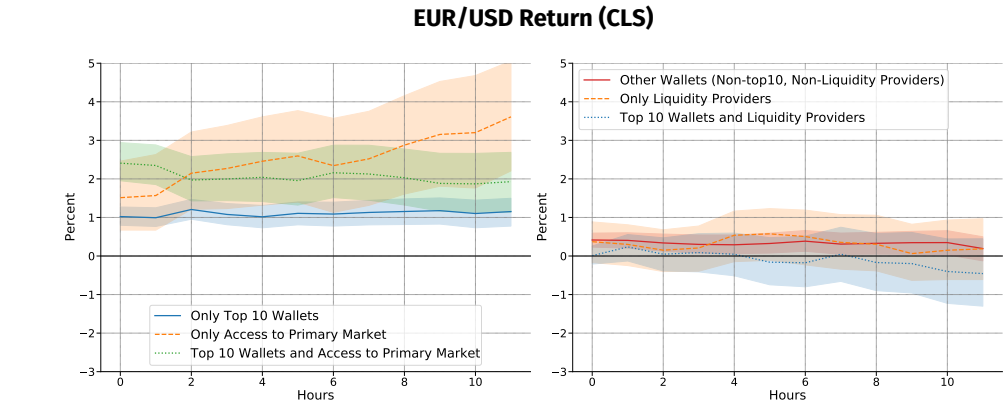
Permanent Price Impact

$$\Delta p_t = \alpha_1 + \sum_{k=1}^{L} \gamma_{1,k} \Delta p_{t-k} + \sum_{k=0}^{L} \beta_{1,k} OF_{t-k} + \epsilon_{1,t} \tag{5}$$

$$OF_t = \alpha_2 + \sum_{k=1}^{L} \gamma_{2,k} \Delta p_{t-k} + \sum_{k=1}^{L} \beta_{2,k} OF_{t-k} + \epsilon_{2,t} \tag{6}$$

- We test for dynamic relationships using a structural VAR framework (Hasbrouck 1991)
- **Identification Assumptions:** Contemporaneous shocks to blockchain order flow impact price immediately, while price shocks influence blockchain order flow only with a lag.
- This assumption aligns with the causality direction proposed by Evans and Lyons (2002).

Permanent Price Impact



- Trading by sophisticated traders and primary dealers shows significant permanent price impacts.
- LPs and other groups show insignificant price impacts.

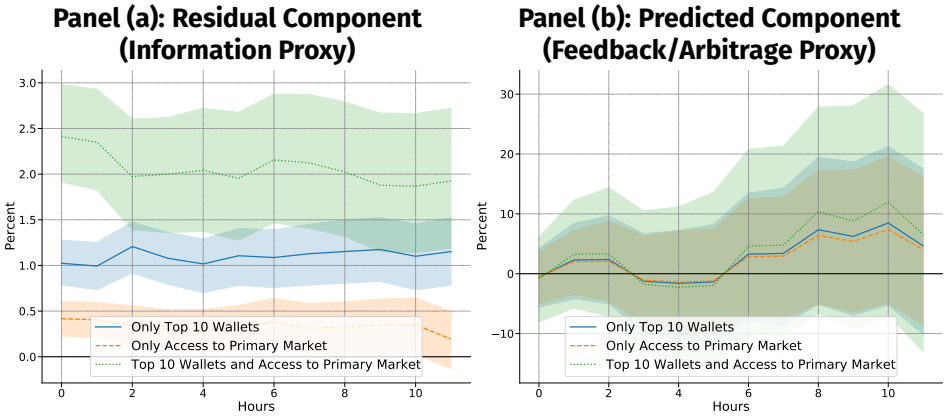
Permanent Price Impact: Feedback Trading vs. Information I

- Persistent price impact on EUR/USD returns indicates arbitrage or informational trading.
- DEX order flow is split into:

$$OF_{i,t} = \underbrace{\alpha_i + \beta_i(p_{EURC/USDC,t-1} - p_{EUR/USD,t-1})}_{\text{Predicted Component}} + \underbrace{\epsilon_{i,t}}_{\text{Residual Component}} \tag{7}$$

1. **Predicted Component:** Proxy for feedback-driven order flow
2. **Residual Component:** Proxy for informational order flow

Permanent Price Impact: Feedback Trading vs. Information II



- Only the residual component exhibits permanent price impacts.
- The feedback-driven component does not significantly influence traditional market returns.
- Price impacts stem from informational order flow rather than mechanical trading dynamics.

Additional Tests

- **Liquidity Provision:** Permanent price impact remains robust after controlling for net liquidity minted for each token in the pool. Link
- **Traditional Order Flow:** Permanent price impact persists when including CLS order flow controls, both aggregate and sectoral. Link
- **Intra-Day Price Impact:** Hourly analysis shows stronger effects for sophisticated investors and primary dealers during main trading hours. Link
- **Blockchain Characteristics:** No systematic relationship exists between blockchain characteristics (such as the number of tokens traded, transaction frequency, and wallet age) and the price impact of blockchain order flow.

Conclusion

- We evaluate the efficiency and asymmetric information in blockchain currency markets.
- **Market Efficiency:** Peg deviations arise from gas fees and market risk, while prices respond efficiently to macroeconomic news.
- **Trader Heterogeneity:** Informed traders exploit arbitrage, while LPs currently act as hedgers but may become more active as markets scale.
- **Policy implications**:
  - Blockchain traders have fundamental information on the underlying and can contribute to price discovery process.
  - DEXs with AMM trading algorithms could serve as alternative trading venues to currency markets.

Thank You!

Slide Appendix

Volume per transaction (EURC)

Group	mean	std	min	25%	50%	75%	max
Top10	25,256	48,853	1	7,818	13,693	27,525	1,040,295
PM	12,528	18,558	3	991	8,000	18,596	183,500
LP	16,752	25,887	1	1,149	8,079	24,260	289,800
Top10 ∩ PM	26,373	10,664	100	20,000	25,000	30,000	95,990
Top10 ∩ LP	43,786	62,026	100	4,131	30,754	50,000	343,333
PM ∩ LP	7,537	9,931	352	2,394	4,556	6,262	27,256
$\notin \{Top10, PM, LP\}$	12,585	21,311	0	1,061	5,055	15,126	557,076

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Determinants of EURC-USDC and EUR-USD Returns

	Panel (a): DEX Return		Panel (b): CLS benchmark return	
	(1)	(2)	(3)	(4)
OF	4.9558***	4.7939***	4.1538***	3.8618***
	(0.1423)	(0.1492)	(0.1676)	(0.1738)
$i_{EUR} - i_{USD}$		0.0003		0.0001
		(0.0002)		(0.0003)
HKM		3.3564***		5.8713***
		(0.9645)		(1.1233)
constant	-0.0050	0.0501	-0.0015	0.0186
	(0.0103)	(0.0456)	(0.0121)	(0.0531)
R-squared	0.6609	0.6684	0.4970	0.5185
No. observations	624	624	624	624

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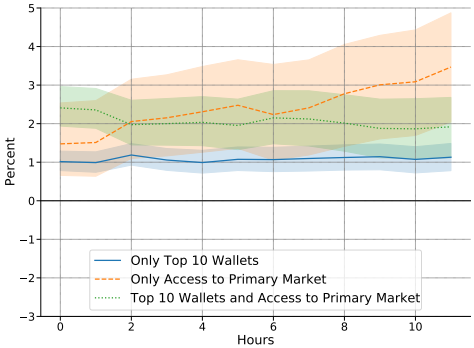
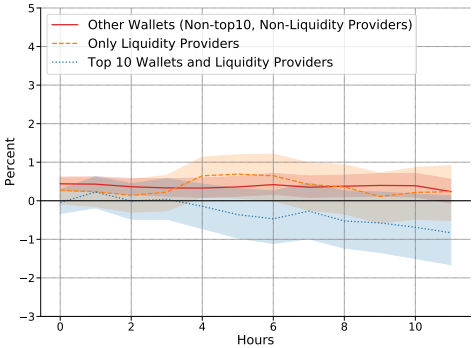
Permanent Price Impact: Liquidity Provision

EUR/USD Return (CLS):





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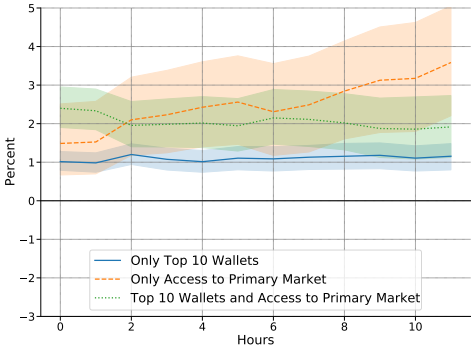
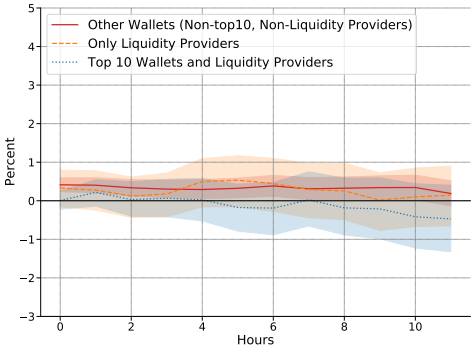
Permanent Price Impact: Aggregate Order Flow

EUR/USD Return (CLS):





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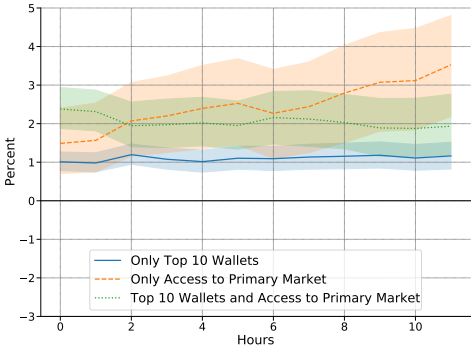
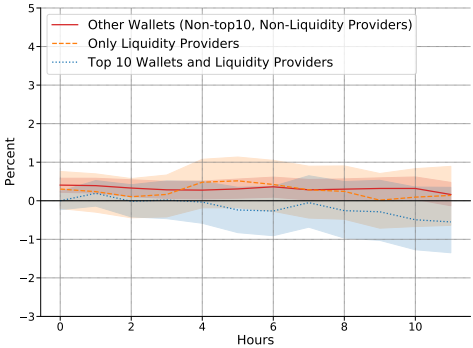
Permanent Price Impact: Sectoral Order Flow

EUR/USD Return (CLS):





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Intra-Day Price Impact

EUR/USD Return (CLS):