Money in Motion: Micro-Velocity and Usage of Ethereum's Liquid Staking Tokens

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Motivation & Background

1

Proof-of-Stake

Validators **stake** native tokens to **verify transactions** (skin in the game).
Staking rewards include transaction fees and incentives.

But when tokens are staked, they are often **locked** and cannot be used elsewhere.

Liquid staking solves this by giving people a **token that represents the staked token**, so they can still use it in DeFi.

Related Work

Micro-velocity: Extends monetary velocity to the **address level**, revealing behavioural diversity on blockchains.

—Wealthier accounts and intermediaries transact disproportionately more.

—Highlights latent **centralisation** in “decentralised” networks.

Macro-structures:

—Bitcoin & other chains dominated by a few large players.

—Persistent hierarchical patterns; wealth inequality confirmed (e.g., Gini).

—On-chain governance studies show concentration of power.

Related Work

Liquid Staking Protocols (LSPs):

—Taxonomies, risk maps, and market analyses exist.

—Yet little focus on **address-level dynamics** or turnover behaviour.

Gap:

—There is no systematic application of **behavioural analysis to liquid staking tokens**.

—Our work bridges this by combining velocity metrics with address-level balance analysis for *stETH* and *wstETH*.

Scope and Content

Do People use Liquid Stake Tokens (LSTs) actively as money in motion, or passively as savings?

1. Velocity of Money: from macro to micro and digital currencies
2. Methodological challenges and data collection
3. Empirical results on *stETH* and *wstETH*

Methodology & Data Set

2

Velocity

In classical monetary theory, the **Fisher equation** $M \cdot V = P \cdot Q$ links money supply M, its velocity V, and nominal economic activity.

Unfortunately, cash does not allow to measure the velocity in the system directly. Cryptocurrencies allow this analysis due to distributed (and accessible) ledgers.

Micro-velocity measure applies this principle at the **address level**, showing how often balances turn over and aggregate into on-chain usage.

Defining Micro-Velocity

Consider an ERC-20 token account i holding tokens at time t.

Holding-time distribution:

$$P_i^t(\tau) = \frac{w_i^t(\tau)}{M_i(t)}$$

—$w_i^t(\tau)$:tokens held with age τ.

—$M_i(t) = \sum_\tau w_i^t(\tau)$:total tokens held by i.

Micro-velocity of account i:

$$V_i(t) = \sum_\tau \frac{1}{\tau} P_i^t(\tau)$$

Defining Micro-Velocity

Aggregate velocity of token:

$$M(t)V(t) = \sum_i M_i\,(t)V_i(t)$$

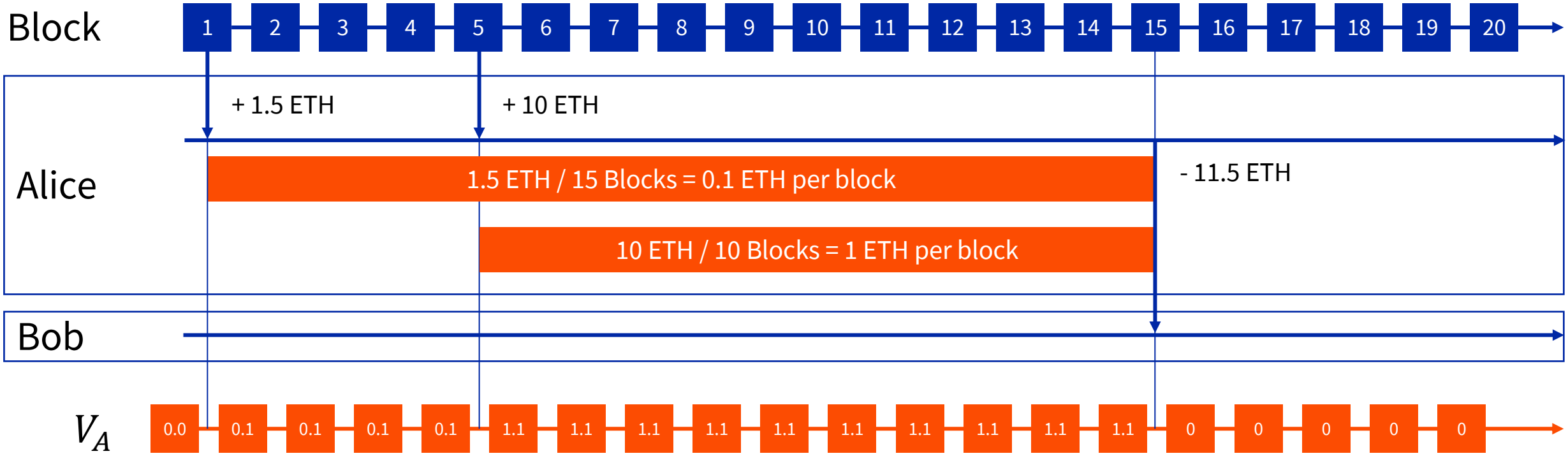
Computation (Ethereum):

—Apply **LIFO spending policy**: most recent balances are spent first.

—Captures distinction between **liquid balances** and **illiquid savings**.

—Results robust to FIFO or random mixing assumptions.

Defining Micro-Velocity



Liquid Staking in Lido

Lido platform: lets users stake ETH in a liquid, fractionalized way.

—Deposit ETH → receive **stETH** (rebasing) or **wstETH** (wrapped, ERC-20).

—Removes 32 ETH validator threshold & operational duties.

stETH (rebasing):

—Balances increase daily to reflect staking rewards.

—Requires interpreting contract state for accurate balances.

wstETH (non-rebasing):

—Fixed balances; rewards accrue via rising exchange rate.

—Fully ERC-20 compatible and widely integrated in DeFi.

Rebasing (stETH)

Rewards accrue and stETH balances **are recalculated daily**.

Formula:

$$\text{balanceOf(account)} = \mathit{shares[account]} \times \frac{\mathit{totalPooledEther}}{\mathit{totalShares}}$$

Key variables:

—**shares:** fractional ownership (per user).

—**totalShares:** sum across all users.

—**totalPooledEther:** total ETH (buffered + transient + beacon).

Triggered by **handleOracleReport,** emits TokenRebased.

Minting & Burning & Transfer Events (stETH)

- **Minting:** New stETH minted when ETH is deposited. Records initial adoption and inflows of new users. On-chain pattern: Mint = transfer from **zero address** to user.
- **Burning:** Burning shares = redeeming ETH (post-Shappella, May 2023). Burning address introduced (Lido 2.0). Not relevant for velocity.
- Transfers:
  - **Transfer (ERC-20):** logs stETH token transfers.
  - **TransferShares:** logs share transfers (needed for rebasing).

Table 1: Summary of recorded events, highlighting that TransferShares events began later than Transfer events.

Token	Event	# Records	First Block	Last Block
stETH	Transfer	2,792,968	11,480,187	21,145,533
stETH	TransferShares	2,519,615	14,860,275	21,145,533
wstETH	Transfer	1,420,359	11,888,810	21,145,533

wstETH Mechanics

Wrapped stETH non-rebasing version of stETH.

—Rewards via **rising exchange rate** to ETH (not balance changes).

—Fully ERC-20 compatible for DeFi integration.

—Tracking is straightforward: only **standard Transfer events**.

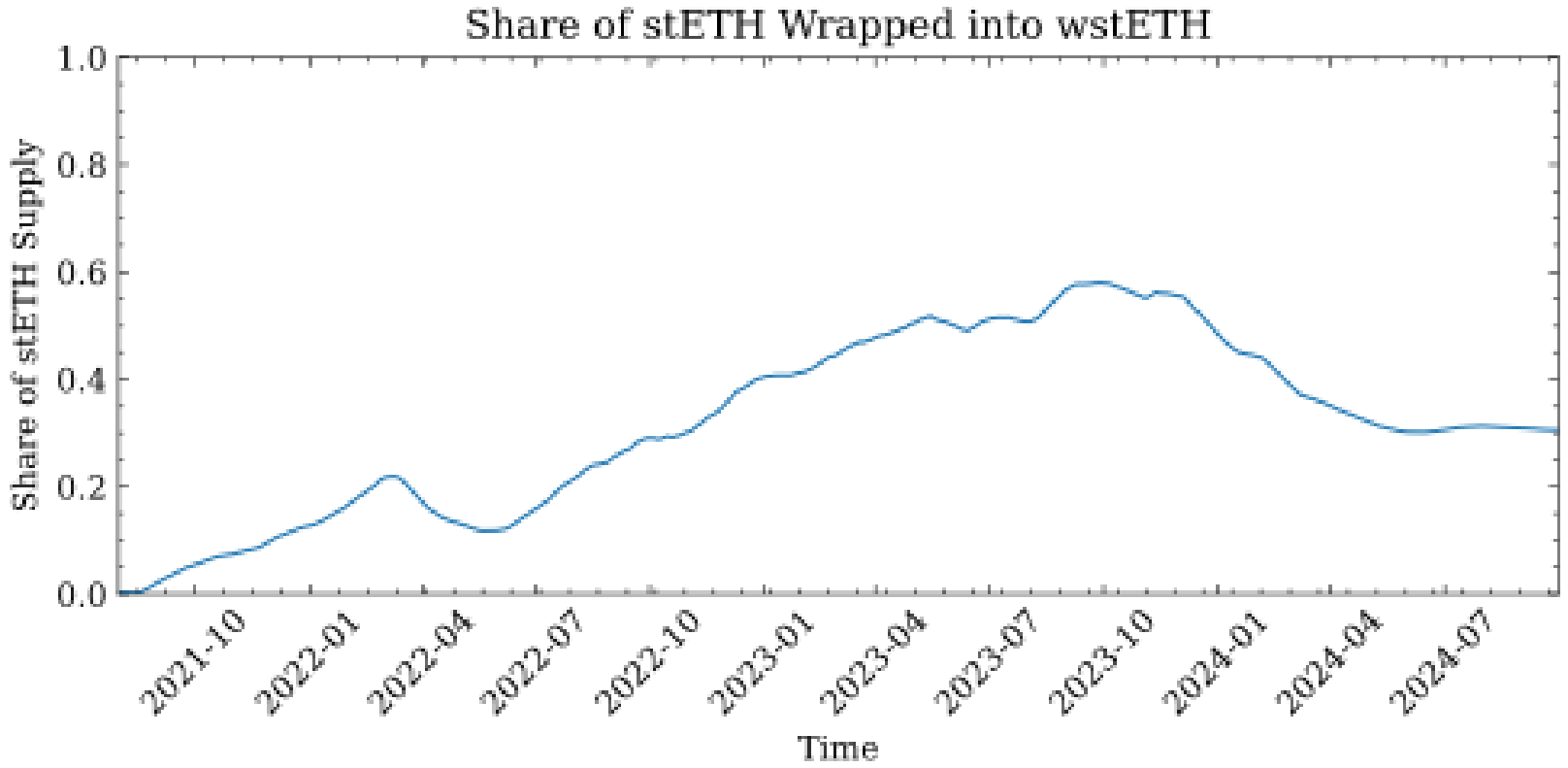


Figure 2: Evolution of the share of stETH wrapped into wstETH over time. The line represents the 30-day moving average of the proportion of total stETH supply held by the wstETH contract.

Data Collection & Processing

Challenge: stETH is **rebasing** i.e. not fully ERC-20 compliant. Need to reconstruct balances in **shares** to measure velocity. TransferShares events introduced late (after LIP-11) offer only incomplete early history.

Tools Developed

1. ethereum-event-tracker: extracts on-chain events.
2. ethereum-variable-tracker: retrieves contract state variables (e.g. totalShares, beaconBalance, bufferedEther).

Processing Steps:

—Reconstructed early **share-denominated transfers** from contract state.

—Built a longitudinal dataset for stETH (shares) and wstETH (tokens).

Results

3

Global Velocity of stETH and wstETH

Key findings:

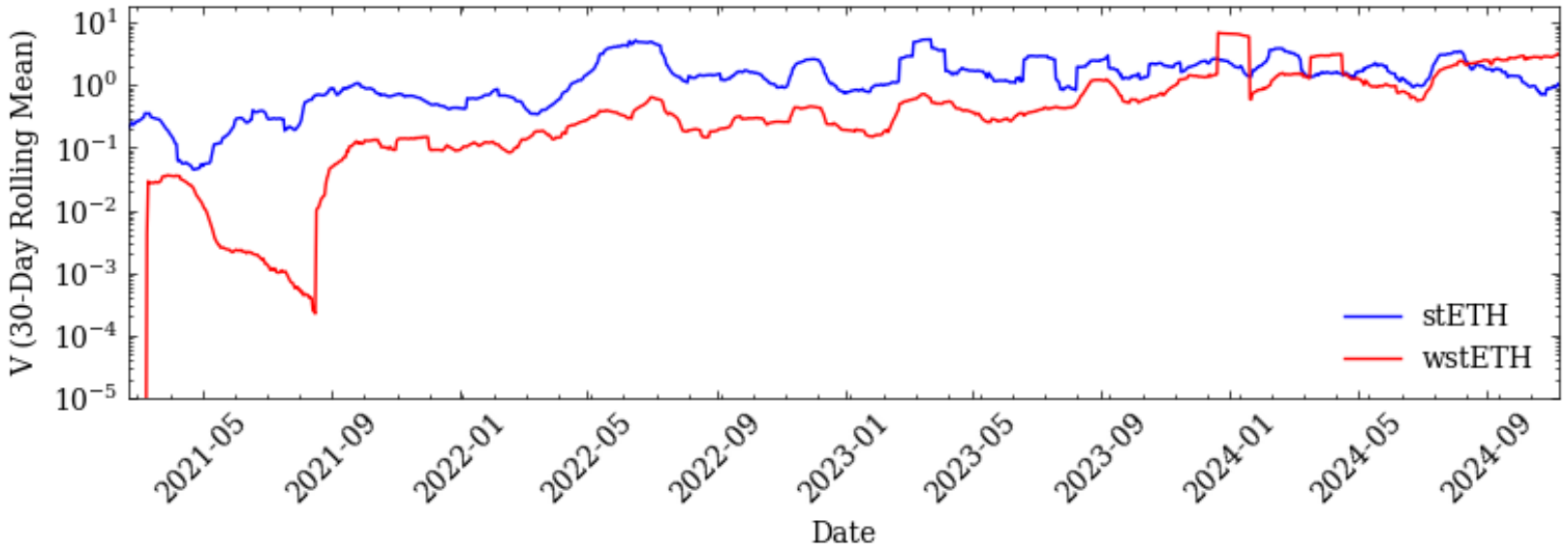
— Consistently high values (vs PoW/ERC-20 tokens).

— Two phases: early growth (2020–H1 2022 reflects adoption & Lido's rising role) to mature regime.

wstETH trends upwards:

— Rising velocity, converging with stETH in 2023.

— Eventually surpasses stETH, suggesting role as "smart money" in DeFi



Holder Distribution in stETH & wstETH

Both tokens show extreme concentration; whales dominate activity.

stETH: Whales (≥10k): 1,011 addresses (0.25%), hold 141.7M.

wstETH: Whales (≥10k): 780 addresses, hold 149.3M. Small holders' share much lower (≈476k vs 2.1M in stETH).

Table 2: Summary of address categories by received *stETH*.

Category (stETH)	Threshold (stETH)	Total Received (stETH)	# Addresses
Whale	≥ 10,000	141,703,560	1,011
Orca	3,000 – 9,999	6,981,034	1,278
Dolphin	1,000 – 2,999	4,074,250	2,378
Fish	100 – 999	4,547,189	14,441
Shrimp	10 – 99	1,636,948	49,982
Krill	1 – 9	416,862	113,749
Plankton	< 1	68,469	307,188

Table 3: Summary of address categories by received *wstETH*.

Category (wstETH)	Threshold (wstETH)	Total Received (wstETH)	# Addresses
Whale	≥ 10,000	149,285,851	780
Orca	3,000 – 9,999	4,618,320	850
Dolphin	1,000 – 2,999	2,457,660	1,401
Fish	100 – 999	2,084,329	6,224
Shrimp	10 – 99	413,353	11,285
Krill	1 – 9	54,466	14,063
Plankton	< 1	8,030	56,518

Velocity Distribution in stETH & wstETH

In both stETH & wstETH:

—**Whales dominate velocity**. Smaller categories contribute little.

—Strong asymmetry mirrors wealth concentration in blockchain economies.

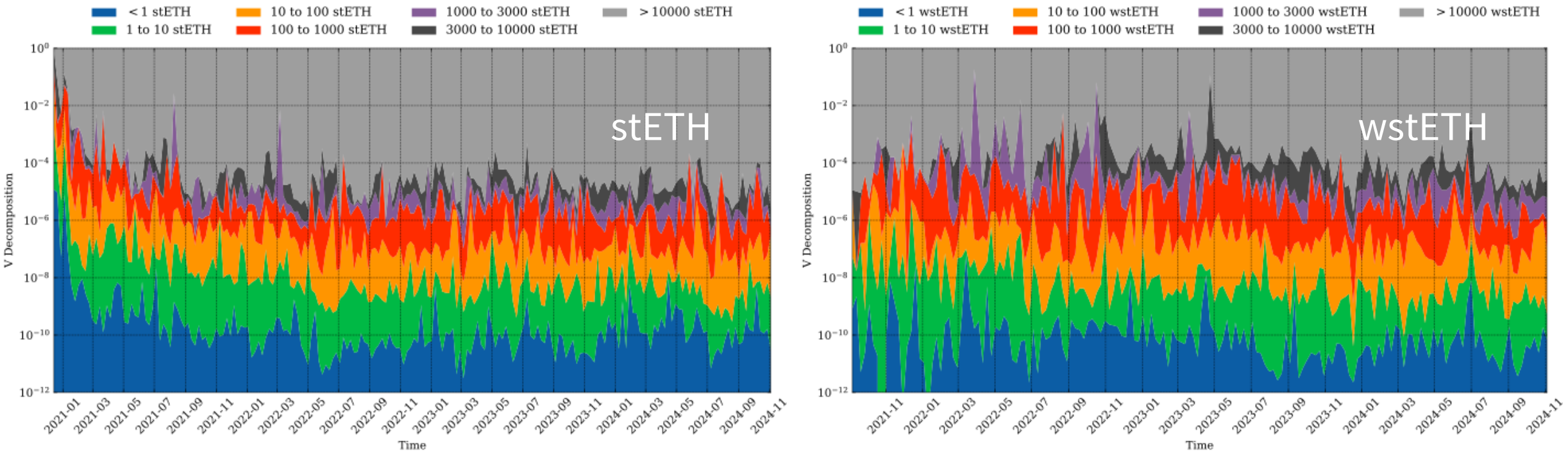


Figure 4. Micro velocity shares decomposition for *stETH* (left) and *wstETH* (right), by categories defined in Table 2. Expressed in log scale.

Two User Typologies

1. **High-capacity accounts**

   A few addresses transact large volumes.

   Integrated into DeFi infrastructures (lending, liquidity pools, collateral).

2. **Smaller accounts**

   Many addresses, low activity.

   Passive holders collecting staking rewards.

Top DeFi Holders of wstETH

Largest non-CEX holders are **Aave, Spark, SkyMoney, Balancer**.
Examples:

—**Balancer Vault**: holds pool assets, executes swaps.

—**Aave/Spark**: issue interest-bearing receipt tokens (lending protocol).

—**SkyMoney**: accepts wstETH collateral via join adapters.

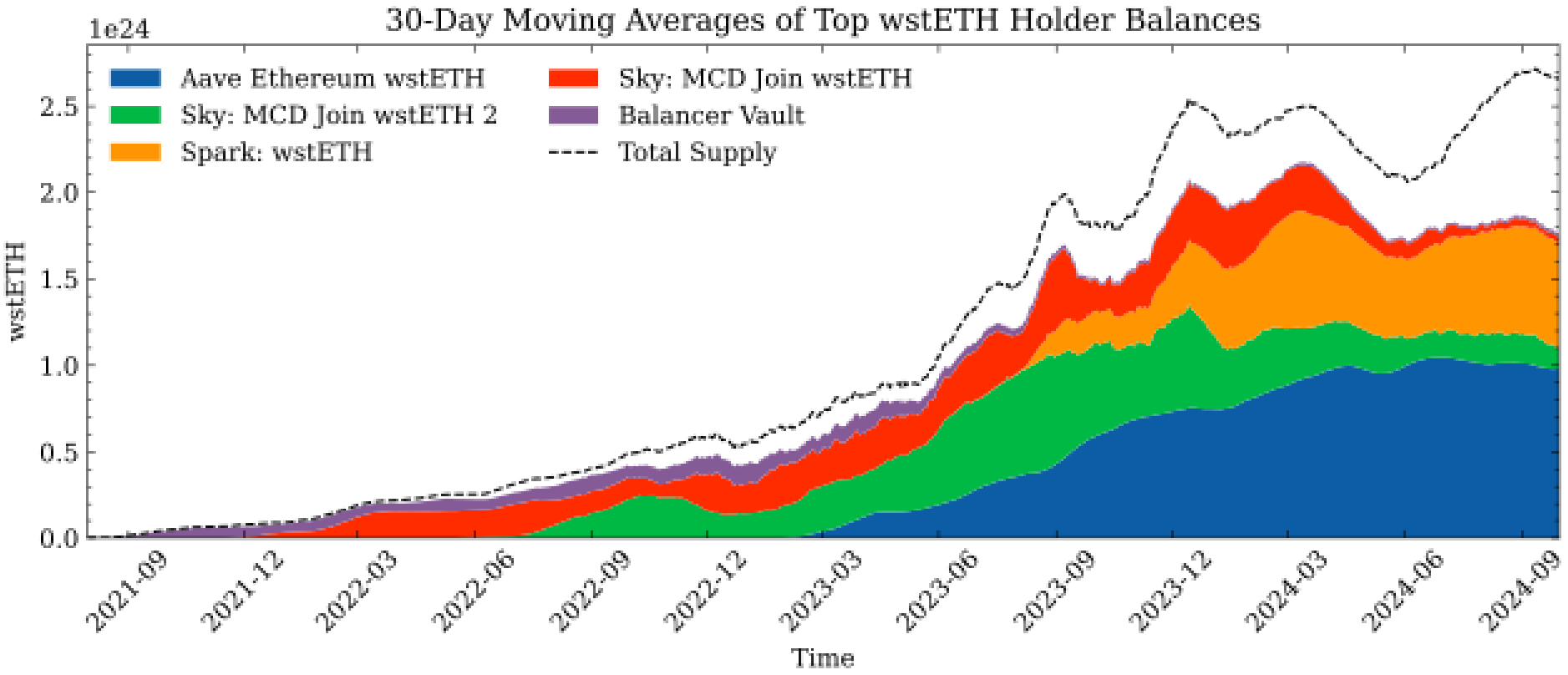


Figure 5: 30-day moving averages of w*stETH* balances for the top five holder addresses.

Results Summary

—**High turnover:** stETH & wstETH show **much higher velocity** than typical ERC-20 tokens.

—**Two phases:** early growth (2020–22), mature phase post-Merge (2022–24).

—**Event-driven spikes:** e.g., Shappella upgrade (Apr 2023), Lido 2.0 (Jun 2023).

—**Concentration:** Whales dominate both stETH and wstETH activity.

—**DeFi integration:** Major protocols (Aave, Balancer, Spark, SkyMoney) drive wstETH velocity.

—**Token velocity:** Velocity of stETH and wstETH approach each other, with wstETH overtaking stETH, indicating a more active role (away from a passive savings instrument)

4

Future Work & Outlook

Contributions

—**Methodology:** Novel framework to compute velocity on rebasing tokens.

—**Empirical analysis:** First address-level study of LST circulation.

—**Findings:** Evidence of DeFi integration and user asymmetries in LSTs.

—**Data & Tools Availability:**

—All datasets and software from this study are **open-source**.

—Publicly accessible at:

github.com/LucaPennella/money-in-motion-lsts

Future Work with in Staking

Extend scope beyond Lido:

—Apply micro-velocity to other LSTs (e.g., cbETH, rETH) and PoS chains.

—Build cross-token comparison, classify assets by behavioural archetype.

Enhance risk monitoring:

—Use micro-velocity as an early-warning metric for shifts in user behaviour.

—Track systemic risks in staking ecosystems.

Recursive Leverage in Ethereum LSTs:

—Analyze yield farming & restaking of LSTs.

—Quantify effects on leverage and monetary dynamics.

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github.com/LucaPennella/money-in-motion-lsts

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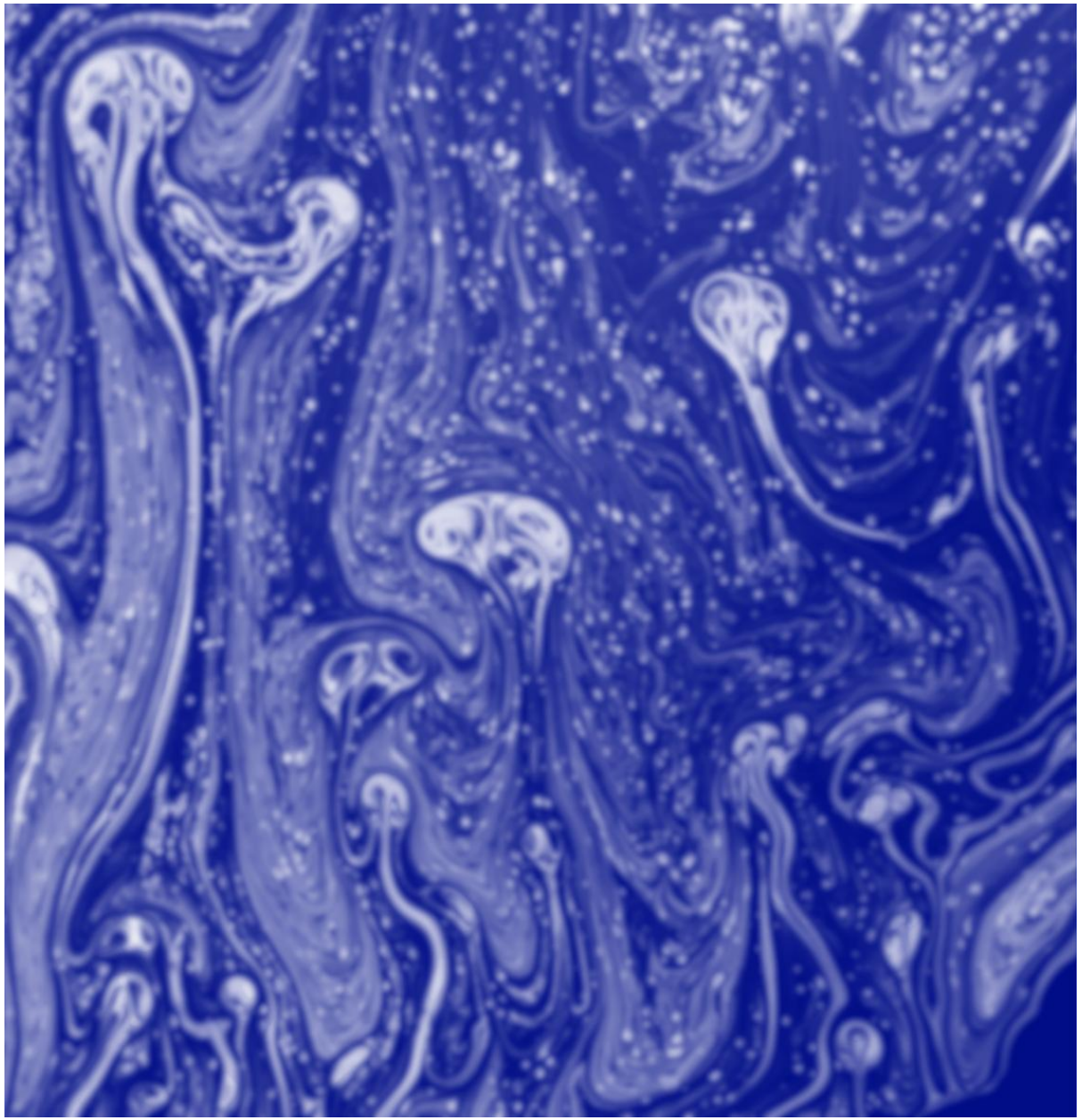
Paper:



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References (1/2)

[1] Ziqiao Ao, Lin William Cong, Gergely Horvath, and Luyao Zhang. *Is decentralized finance actually decentralized?* A social network analysis of the Aave protocol on the Ethereum blockchain. CoRR, abs/2206.08401, 2022. arXiv:2206.08401, doi:10.48550/arXiv.2206.08401.

[2] Vitalik Buterin, Diego Hernandez, Thor Kamphefner, Khiem Pham, Zhi Qiao, Danny Ryan, Juhyeok Sin, Ying Wang, and Yan X. Zhang. *Combining GHOST and Casper.* CoRR, abs/2003.03052, 2020. URL: https://arxiv.org/abs/2003.03052, arXiv:2003.03052, doi:10.48550/arXiv.2003.03052.

[3] Carlo Campajola, Raffaele Cristodaro, Francesco Maria De Collibus, Tao Yan, Nicolò Vallarano, and Claudio J. Tessone. *The evolution of centralisation on cryptocurrency platforms.* CoRR, abs/2206.05081, 2022. arXiv:2206.05081, doi:10.48550/arXiv.2206.05081.

[4] Carlo Campajola, Marco D'Errico, and Claudio J. Tessone. *Microvelocity: rethinking the velocity of money for digital currencies,* 2023. arXiv:2201.13416.

[5] Tarun Chitra and Alex Evans. *Why stake when you can borrow?* CoRR, abs/2006.11156, 2020. URL: https://arxiv.org/abs/2006.11156, arXiv:2006.11156, doi:10.48550/arXiv.2006.11156.

[6] Francesco Maria De Collibus. *The Ethereum ecosystem from a transaction network perspective.* PhD thesis, University of Zurich, Zürich, April 2024. doi:10.5167/uzh-260608.

[7] Francesco Maria De Collibus, Carlo Campajola, and Claudio J. Tessone. *The microvelocity of money in Ethereum.* EPJ Data Sci., 14(1):11, 2025. doi:10.1140/epjds/s13688-024-00518-6.

[8] Mikel Cortes-Goicoechea, Tarun Mohandas-Daryanani, Jose Luis Muñoz-Tapia, and Leonardo Bautista-Gomez. *Autopsy of Ethereum's post-merge reward system.* In IEEE International Conference on Blockchain and Cryptocurrency, ICBC 2023, Dubai, UAE, May 1–5, 2023, pages 1–9. IEEE, 2023. doi:10.1109/ICBC56567.2023.10174942.

[9] Francesco Maria De Collibus, Carlo Campajola, Guido Caldarelli, and Claudio J. Tessone. *Patterns and centralisation in Ethereum-based token transaction networks.* Frontiers in Physics, 12, 2024. doi:10.3389/fphy.2024.1305167.

[10] Ethereum Foundation. *The risks of LSD.* https://notes.ethereum.org/@djrtwo/risks-of-lsd, 2022. Accessed: 2025-08-06.

[11] Krzysztof Gogol, Benjamin Kraner, Malte Schlosser, Tao Yan, Claudio J. Tessone, and Burkhard Stiller. *Empirical and theoretical analysis of liquid staking protocols.* CoRR, abs/2401.16353, 2024. arXiv:2401.16353, doi:10.48550/arXiv.2401.16353.

[12] Krzysztof Gogol, Yaron Velner, Benjamin Kraner, and Claudio J. Tessone. *SoK: Liquid staking tokens (LSTs) and emerging trends in restaking,* 2024. arXiv:2404.00644, doi:10.48550/arXiv.2404.00644.

References (2)

[13] Igor Makarov and Antoinette Schoar. *Blockchain analysis of the Bitcoin market.* SSRN Electronic Journal, October 2021. doi:10.2139/ssrn.3942181.
[14] Kelsie Nabben and Primavera De Filippi. *Accountability protocols? On-chain dynamics in blockchain governance.* Internet Policy Rev., 13(4):1–22, 2024. doi:10.14763/2024.4.1807.
[15] Ashish Rajendra Sai, Jim Buckley, and Andrew Le Gear. *Characterizing wealth inequality in cryptocurrencies.* Frontiers Blockchain, 4:730122, 2021. doi:10.3389/fbloc.2021.730122.
[16] Stefan Scharnowski and Hossein Jahanshahloo. *The economics of liquid staking derivatives: Basis determinants and price discovery.* Journal of Futures Markets, 45(2):91–117, 2025. doi:10.1002/fut.22556.
[17] Apostolos Tzinas and Dionysis Zindros. *The principal-agent problem in liquid staking.* In Financial Cryptography and Data Security, FC 2023 Workshops, Croatia, May 5, 2023, LNCS vol. 13953, pages 456–469. Springer. doi:10.1007/978-3-031-48806-1_29.
[18] Nicolò Vallarano, Claudio J. Tessone, and Tiziano Squartini. *Bitcoin transaction networks: An overview of recent results.* Frontiers in Physics, 8:286, 2020. doi:10.3389/fphy.2020.00286.
[19] Yougui Wang, Ning Ding, and Li Zhang. *The circulation of money and holding time distribution.* Physica A, 324(3):665–677, 2003. doi:10.1016/S0378-4371(03)00074-8.
[20] Tao Yan, Shengnan Li, Benjamin Kraner, Luyao Zhang, and Claudio J. Tessone. *A data engineering framework for Ethereum beacon chain rewards: From data collection to decentralization metrics.* Scientific Data, 12(1):519, 2025. doi:10.1038/s41597-025-04623-7.
[21] Peilin Zheng, Zibin Zheng, Jiajing Wu, and Hong-Ning Dai. *Xblock-eth: Extracting and exploring blockchain data from Ethereum.* IEEE Open J. Comput. Soc., 1:95–106, 2020. doi:10.1109/OJCS.2020.2990458.

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