Journal of International Money and Finance 158 (2025) 103404

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

DeFi: Mirage or reality? Unveiling wealth centralization risk in Decentralized Finance☆

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HIGHLIGHTS

- This study analyzes 586 DeFi tokens to assess risk from wealth centralization.
- Smart contracts and governance tokens exhibit notable resilience to such risk.
- Stablecoins stabilize DeFi absorbing shocks, while oracle tokens cause spillovers.
- DAO tokens are highly sensitive to their internal wealth concentration.

ARTICLE INFO

JEL classification:
G10
G11
G12
G14
G23

Keywords:
Decentralized finance
Layer-3 tokens
Wealth centralization risk
Value at risk
Conditional value at risk
Time-varying parameter vector autoregression

ABSTRACT

This study examines centralization risk in decentralized finance (DeFi), with a focus on the impact of wealth concentration on risk exposure across its key components. An analysis of the top 58,600 wallet addresses from 586 projects among the top 1,000 DeFi tokens reveals significant centralization, particularly within layer-3 tokens. Using value at risk and expected shortfall measures, the analysis reveals heightened risk for stablecoins and decentralized autonomous organization (DAO) tokens, while oracles, smart contracts, and governance tokens remain largely unaffected by wealth centralization. Further analysis with the standard GARCH model and time-varying parameter vector autoregression (TVP-VAR) scaled by the wealth concentration ratio (WCR) reveals that DAOs generate much of their risk internally. Stablecoins, serving as critical stabilizing agents within DeFi, absorb systemic risk without transmitting it back, unlike oracle tokens. This reliance on stablecoins during volatile conditions underscores their unique risk absorber role. The internal risk dynamics of DAOs, driven by the wealthiest stakeholders, amplify vulnerabilities within DeFi and extend their influence to Bitcoin. These findings challenge the traditional understanding of DeFi, showing how wealth concentration reshapes risk exposure beyond the DeFi ecosystem, with far-reaching consequences.

1. Introduction

In an era of growing economic disparities, the rise of decentralized finance (DeFi) offers hope for a more equitable financial system. Bitcoin, introduced in 2008 by the anonymous Satoshi Nakamoto (Nakamoto, 2008), marked the beginning of this revolution as the

☆ I gratefully acknowledge the Project Research Grants (Grant Nos. 220290, 210248, and 230391) awarded by the Foundation for Economic Education (LIIKESIVISTYSRAHASTO), Finland. I am thankful to the participants of the 7th Cryptocurrency Research Conference, Zayed University, Dubai, UAE (September 23-24, 2024), and the discussant at the 13th International Conference of the Financial Engineering and Banking Society, Paris School of Business, Paris, France (June 20-22, 2024), for their useful and encouraging comments. I am grateful to the participants of the Mission Possible Event 2023 and the Powered by Blockchain Education Day, Seminar, and Workshop for Companies 2023 at the University of Vaasa for the valuable discussions and feedback.

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https://doi.org/10.1016/j.jimonfin.2025.103404

Available online 9 August 2025

first decentralized, peer-to-peer digital currency.[1] However, nearly seventeen years later, Bitcoin remains far from achieving true decentralization, as evidenced by the concentration of wealth among a small number of holders. Recent research (Sai et al., 2021b) highlights this centralization, showing that 0.01 % of Bitcoin addresses hold over 50 % of its wealth, further exacerbating inequality. This issue is compounded by the proof-of-work (PoW) consensus mechanism, which is dominated by a small number of influential Bitcoin miners (Capponi et al., 2023). Consequently, the concentration of wealth within the Bitcoin ecosystem is likely to intensify over time. As an early miner, Satoshi Nakamoto holds approximately 1.1 million Bitcoins, placing him among the top 20 wealthiest individuals globally during Bitcoin's peak at $92,000.[2] Optimistic investors predict Bitcoin could reach $1 million per unit by 2025,[3] potentially propelling Satoshi and other early miners into the ranks of the world's wealthiest individuals, further exacerbating wealth inequality (Sapkota, 2022b). As of November 13, 2024, Satoshi Nakamoto's net worth is approximately $100 billion USD, ranking him among the top 20 richest people in the world on paper. If Bitcoin reaches $300,000, he could become the wealthiest individual globally. Should Bitcoin hit $1 million per unit, he would become the first trillionaire.

The issue of centralization in wealth distribution extends beyond native layer-1 tokens (cryptocurrencies) and is also present in other blockchain layers. Native tokens, such as Ether (ETH) for Ethereum, are directly tied to their respective blockchain networks. In contrast, layer-2 tokens are issued on protocols designed to enhance scalability and functionality on top of layer-1 blockchains. For example, the Lightning Network for Bitcoin and Polygon for Ethereum enhance the functionality of their respective base blockchain layers. DeFi tokens, representing decentralized financial services, typically operate within layer-3, also known as the application layer, where decentralized applications (DApps) and protocols such as DeFi and GameFi reside. Schär (2021) introduces a multi-layered framework for understanding DeFi's architecture, with each layer serving a distinct purpose, including aggregation, application, and protocol layers. Similarly, Gogel (2021) identifies nine foundational technologies for DeFi that leverage blockchain to create an open, transparent, and inclusive financial system. This study examines centralization risk in layer-3 assets, specifically the following DeFi components:

1. *Blockchain*: The distributed ledger system (DLS) that serves as the settlement layer, ensuring immutability, transparency, and security (Lipton and Treccani, 2021).
2. *Digital wallets*: Secure gateways that store crypto assets and enable interaction with DeFi protocols (Kitzler et al., 2023).
3. *Crypto assets*: Tokens representing value on blockchain networks, essential for payments, lending, borrowing, and governance (Moringiello and Odinet, 2022).
4. *Stablecoins*: Tokens designed to maintain stable value, providing liquidity and reducing volatility in DeFi (Grobys et al., 2021).
5. *Smart contracts*: Self-executing contracts that automate processes, reducing reliance on intermediaries and transaction costs (Dimitropoulos, 2020).
6. *Oracles*: Connect blockchains to external data, enabling real-time feeds for pricing, derivatives, and smart contract execution (Liu et al., 2021).
7. *Decentralized autonomous organizations (DAOs)*: Community-governed entities playing a vital role in protocol governance (Bellavitis et al., 2023).
8. *Governance protocols*: Mechanisms enabling token holders to vote on proposals that impact protocol development (Kiayias and Lazos, 2022).
9. *DApps*: Decentralized applications powering a range of financial services such as lending, trading, and asset management using the components listed above.

While a handful of earlier studies have explored the token distributions of a few DeFi projects (e.g., Nadler and Schär (2020); Gramlich et al. (2022)), this study examines 586 DeFi projects from the top 1000 with accessible richlists to investigate the concentration of token supply within the DeFi ecosystem. The analysis focuses on the top 100 wealthiest wallet addresses within each project to evaluate wealth distribution. The findings reveal a pronounced concentration of wealth: on average, only 0.23 % of DeFi wallet addresses hold 92.29 % of the total token supply. This concentration surpasses even that of Bitcoin, indicating a significant lack of decentralization within the blockchain-based DeFi landscape. Sai et al. (2021a) define centralization in public blockchains as the restriction of broad participation due to constraints such as high resource requirements, network control, and governance influence, identifying 13 centralization aspects across six architectural layers. In this study, we focus on wealth concentration as the common unifying measure of centralization across different DeFi components, aiming to assess how it shapes risk exposure across layers. These observations lead to the central research question of this study: How does wealth concentration among the top DeFi holders influence risk within DeFi components, and what are its implications beyond the DeFi ecosystem?

Cong et al. (2023) analyze 433 Ethereum-based DeFi applications, highlighting structural challenges such as high transaction fees, volatile token returns, and concentrated mining power and Ether ownership, which tend to disadvantage smaller or less experienced users. While their study offers valuable insights into the limitations of Ethereum-based DeFi, our research takes a broader approach by examining wealth distribution across DeFi tokens on all available platforms, regardless of their underlying blockchain. This allows us to move beyond an Ethereum-centric perspective and assess wealth concentration across a more diverse and expansive DeFi

[1] Bitcoin was introduced in 2008 with the publication of the whitepaper by Satoshi Nakamoto, titled *"Bitcoin: A Peer-to-Peer Electronic Cash System"*. It was officially launched on January 3, 2009, with the mining of the genesis block (Block 0), containing the embedded text: *"The Times 03/Jan/2009 Chancellor on brink of second bailout for banks."*.

[2] Source: https://beincrypto.com/increase-in-cpi-and-bitcoin-reaches-all-time-high/ (November 2024).

[3] Source: x.com (November 12, 2024).

ecosystem. The purpose of this study is to investigate the impact of wealth concentration on financial risk exposure within DeFi, with a focus on how centralization affects various components such as stablecoins, DAOs, governance tokens, and smart contracts. This paper makes four distinct contributions toward the DeFi literature.

Firstly, *(i)* unlike previous studies that focus primarily on centralization in prominent cryptocurrencies such as Bitcoin and Ethereum (for example, (Kondor et al., 2014; Beikverdi and Song, 2015; Kusmierz and Overko, 2022)), this study shifts the focus toward a broad universe of DeFi tokens. It covers 586 tokens that support decentralized financial applications across a wide range of use cases, thereby offering a more comprehensive understanding of token ownership in emerging decentralized ecosystems. Secondly, *(ii)* this study systematically examines wealth concentration across all eight essential components of the DeFi ecosystem. Rather than analyzing a single category of tokens, it investigates stablecoins, DAOs, lending protocols, DEXs, and others in parallel, allowing for comparisons in how decentralization varies across different segments of the market. Thirdly, *(iii)* the study does not merely document the extent of wealth concentration but further explores its implications for financial risk. By using non-parametric measures such as Value at Risk (VaR) and Conditional Value at Risk (CVaR) along with different categorizations of concentration levels (high, medium, and low), it evaluates how these levels affect downside risk. Fourthly, *(iv)* the study investigates how centralization within one DeFi component may influence risk dynamics in others. Using a refined interconnectedness framework based on Antonakakis et al. (2020), it identifies directional spillover effects between components.

The results indicate that DAO tokens and stablecoins are especially concentrated and more exposed to tail risks, while governance and infrastructure tokens appear more resilient. Interestingly, stablecoins with medium concentration show greater stability than those with either low or high concentration. Furthermore, the findings reveal that DAO tokens are not only internally fragile but also susceptible to external risk transmission, highlighting the systemic vulnerabilities posed by centralization in certain segments of DeFi. This interconnectedness raises important considerations for protocol design, risk management, and regulatory oversight in decentralized financial markets.

To fully leverage blockchain technology, it is critical to address centralization, as it undermines the goal of decentralization. Although blockchain presents challenges (Sodhi et al., 2022), it adds operational value (Hastig and Sodhi, 2020; Chod et al., 2020; Pun et al., 2021; Vitasek et al., 2022). Chen and Bellavitis (2019) argue that DeFi offers potential for innovation; however, decentralization often remains elusive, with many projects relying on centralized components that expose users to risks (Amler et al., 2021). The rapid growth of DeFi presents significant challenges (Makridis et al., 2023), including over 3 billion USD in losses from various incidents (Zhou et al., 2023). Thus, recognizing the limits and risks of DeFi's decentralization is crucial for investors. This paper contributes by highlighting the risks of wealth centralization in DeFi, aiding regulators and practitioners in implementing precautionary measures.

The next section provides a literature review. The third section presents the data and methodologies. Furthermore, the fourth section documents the results and discussions, and the final section concludes.

2. Literature review

Previous research on blockchain-based decentralized finance (DeFi) can be grouped into five categories. The first group of studies (i) focuses on measuring decentralization (Kusmierz and Overko, 2022; Lin et al., 2021; Chen and Bellavitis, 2020). Lin et al. (2021) use a sliding window approach for Bitcoin and Ethereum to reveal decentralization trends, while Kusmierz and Overko (2022) extend this analysis to 14 projects using Zipf and Gini coefficients. Chen and Bellavitis (2020) explore the broader role of blockchain in reducing costs and enabling decentralized platforms. Gramlich et al. (2022) provide insights into DeFi token distributions, while Nadler and Schär (2020) examine token distribution changes over time, criticizing prior overestimates of ownership concentration caused by custodial and escrow addresses. Cong et al. (2023) argue that while Web3 and DeFi promote inclusion and decentralization, Ethereum remains concentrated in mining, ownership, and transaction activity, often dominated by exchanges and large users, thereby reproducing traditional inequalities. High gas fees, volatility, and technical barriers further marginalize smaller participants, and reforms like EIP-1559 offer only partial relief. Similarly, Gencer et al. (2018) find centralization in both Bitcoin and Ethereum, citing node clustering, mining inefficiencies, and reward variance. They propose relay networks to ease Ethereum's pressure, while Bitcoin's centralization may persist. In contrast, Sai et al. (2021a) offer a more nuanced view, noting that centralization's impact varies by blockchain layer. For instance, Ethereum is more affected by storage and governance centralization, including reliance on figures like Vitalik Buterin. They argue that some centralization may improve efficiency and responsiveness. Overall, the literature emphasizes consensus power, exchange dominance, and wallet concentration, while wealth concentration remains relatively underexplored.

The centralization issue extends beyond governance and permeates wealth distribution and transaction dynamics within the DeFi ecosystem. Alamsyah and Muhammad (2024) conduct large-scale network analysis of transaction data from Ethereum-based DeFi protocols such as DAI, UNI, and WBTC, revealing significant clustering and centrality of wallet addresses. Their results show that a small number of highly connected nodes dominate transaction flows, acting as de facto intermediaries in a system that aspires to eliminate them. This structural concentration of activity mirrors wealth centralization patterns, often observed in traditional finance. Together with the functional resemblance to TradFi highlighted by Aquilina et al. (2024), these patterns challenge the narrative of DeFi as inherently more democratized. As such, DeFi may risk replicating the very inequities and systemic vulnerabilities it was designed to disrupt, unless these forms of centralization are actively addressed through both technical and policy interventions.

The second group (ii) studies governance and organizational aspects of DeFi (Heo and Yi, 2023; Jensen et al., 2021; Zetzsche et al., 2020). Jensen et al. (2021) highlight the duality between decentralized technological components and centralized organizational governance. Zetzsche et al. (2020) examine regulatory implications, proposing "embedded regulation" to balance decentralization and oversight, while warning of re-concentration risks in less regulated financial segments. Heo and Yi (2023) explore governance across various blockchain systems, revealing that certain consensus algorithms introduce centralizing effects despite technological decentralization.

Despite its name and foundational promise, DeFi exhibits several features that challenge the very notion of decentralization. Aquilina et al. (2024) emphasize that while DeFi disintermediates traditional financial services through smart contracts, it often replicates many functions and risks inherent to traditional finance (TradFi), including those arising from economic externalities and information asymmetries. The purported decentralization is further undermined by structural centralization embedded within DeFi applications, particularly in governance mechanisms. Sun et al. (2024) empirically demonstrate that the MakerDAO protocol, despite being governed through token-based voting, exhibits centralized power concentration. Their findings suggest that a small subset of token holders effectively controls decision-making processes, highlighting a trade-off between decentralization and the operational efficiency or performance of DeFi protocols. This governance centralization raises critical concerns about the DeFi sector's capacity to remain trustless and community-driven as it scales.

The third group of articles (*iii*) examines financial applications of DeFi. Bartoletti et al. (2021) analyze automated market makers (AMMs), providing a theoretical framework and fundamental properties. DeFi lending protocols, which replicate traditional financial services without intermediaries, have also been extensively studied (Kitzler et al. 2023; Bartoletti et al. 2022, etc.). Gudgeon et al. (2020) report that DeFi lending protocols held a 76 % market share as of April 2020. Kitzler et al. (2023) highlight strong connectivity and centrality among decentralized exchange and lending protocol nodes, while Bartoletti et al. (2022) discuss lending pools and research challenges in DeFi.

The fourth group of articles (*iv*) explores challenges and risks in DeFi. Corbet et al. (2023) examine bubbles in conventional and DeFi cryptocurrencies, emphasizing the importance of risk management in the ecosystem. Carter and Jeng (2021) categorize risks across multiple dimensions, including connections with traditional finance, operational risks, smart contract vulnerabilities, governance, regulatory concerns, and scalability. These findings underscore the need for robust regulatory frameworks to ensure DeFi's long-term sustainability. Bartoletti et al. (2022) discuss how DeFi risks impact financial stability, while Chen and Bellavitis (2019) evaluate challenges, limitations, and business models in decentralized finance.

The fifth group of articles (*v*) examines the interconnectedness between DeFi tokens, cryptocurrencies, non-fungible tokens (NFTs), and traditional assets, with a focus on DeFi's role in risk transmission and diversification. Qiao et al. (2023) use wavelet-based analysis to demonstrate that yield farming tokens contribute to downside risks but serve as hedges in the medium term. Ugolini et al. (2023) identify strong return spillovers within and between DeFi and cryptocurrency markets, largely influenced by prevailing financial conditions. Karim et al. (2022) show that DeFi tokens are key drivers of risk transmission, particularly under conditions of extreme volatility, while NFTs tend to remain relatively disconnected. Yousaf and Yarovaya (2022), employing TVP-VAR models, suggest that DeFi assets act as net transmitters of return and volatility spillovers, providing diversification benefits during periods of market stress. Assaf et al. (2025) highlight that the connectedness between DeFi tokens and cryptocurrencies is shaped by factors such as economic policy uncertainty and geopolitical risks, offering valuable insights for risk management and portfolio optimization.

While DeFi seeks to democratize finance, it also presents risks related to centralization. The risks and opportunities in blockchain-based financial markets have been widely studied (Brauneis et al., 2022; Sapkota, 2022a,b, 2025; Dimpfl and Peter, 2021; Makarov and Schoar, 2020). As DeFi solutions span from algorithmic dominance to increased human interaction (Grassi et al., 2022), concerns about centralization within DeFi and its broader ecosystem have emerged. This study provides insights into decentralization, risk exposure, and interconnectedness within and beyond the essential components of DeFi.

3. Data and methodologies

3.1. Preparing the data set

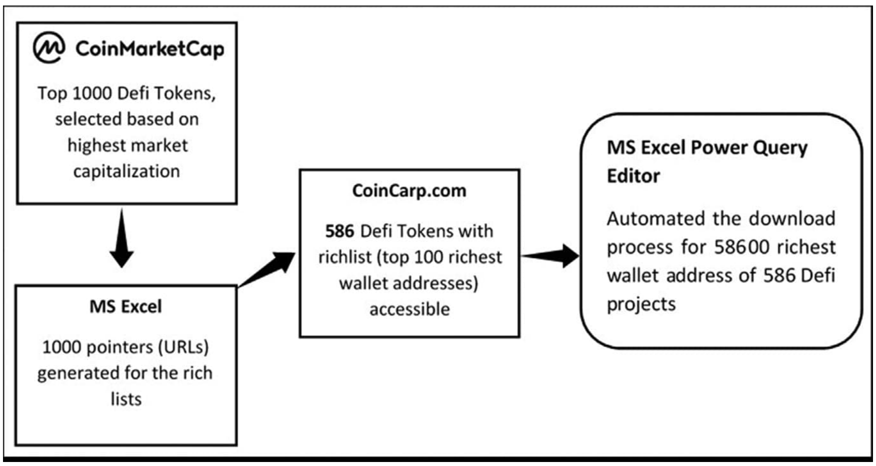

Fig. 1. DeFi top 100 richlist data accumulation process for top 1000 DeFi projects. **Note**: This figure shows the data generation process of top 1000 DeFi tokens with the top 100 wealthiest wallet addresses as of 10.10.2022.

We obtained the list of the top 1000 DeFi tokens by market capitalization from CoinMarketCap.com as of October 10, 2022. Using Excel's Power Query Editor, we accessed the top 100 richest wallet addresses for each of the 1000 highest market capitalization DeFi tokens from the rich list tracking website CoinCarp.com. However, the Power Query Editor retrieved the rich list for only 586 DeFi projects. Consequently, the final dataset comprises the 58,600 richest wallet addresses holding DeFi tokens.

Fig. 1 illustrates the steps to automate and download the rich list of the DeFi tokens used in this study. For example, Table A.1 in Appendix shows the top 100 richest wallet addresses holding DeFiChain (DFI) tokens. This study uses a similar rich list for 586 DeFi tokens listed in Table A.2 in Appendix. The daily closing price of the selected tokens is downloaded, spanning from each token's initial listing on the website until May 13, 2024.[4]

3.2. Measures of inequality

We employ three widely used measures of inequality; the coefficient of variation (CV), the generalized entropy measure (Theil index), and the Gini coefficient; to assess the concentration of wealth and the degree of inequality within the DeFi ecosystem.

The CV is a straightforward measure of dispersion that quantifies the variability of a distribution relative to its mean. It is particularly useful for comparing distributions across different periods or across different DeFi protocols. In the context of wealth distribution in DeFi, the CV is calculated using the formula:

$$CV = \frac{\sigma_{\text{tokens}}}{\mu_{\text{tokens}}} \tag{1}$$

where σ_{tokens} is the standard deviation of token holdings and μ_{tokens} is the mean token holdings.

The CV quantifies the relative variability in the distribution of wealth among token holders in the DeFi ecosystem. A higher CV indicates a greater relative variability, suggesting a more uneven distribution of tokens among addresses.

The Theil index, on the other hand, is a more nuanced measure that considers not only the variability of the distribution but also the relative distribution of wealth (Theil, 1967). It is particularly sensitive to situations where wealth is concentrated among a small number of individuals. The Theil index (T) is calculated using the formula:

$$T = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{X_i}{\bar{X}}\ln\frac{X_i}{\bar{X}}\right) \tag{2}$$

where n is the number of wallet addresses, X_i is the wealth of the i-th address, and $\bar{X}$ is the mean wealth across all addresses.

The Gini coefficient is another widely used measure of inequality that captures the overall inequality in a distribution. It ranges from zero, indicating perfect equality, to one, indicating perfect inequality. Developed by Italian statistician Corrado Gini (Gini, 1912), it is often used to measure income or wealth inequality in a population. The Gini coefficient ($Gini$) is calculated using the formula:

$$Gini = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|X_i - X_j|}{2n\sum_{i=1}^{n}X_i} \tag{3}$$

where X_i and X_j represent the wealth of the i-th and j-th wallet addresses. The term $\sum_{i=1}^{n}\sum_{j=1}^{n}|X_i - X_j|$ is the sum of the absolute differences between all pairs of wallets' wealths. Here, n is the total number of wallet addresses, and $\sum_{i=1}^{n}X_i$ is the sum of the wealth of all wallet addresses.

3.3. Centralization and value at risk

This study examines the risks associated with wealth concentration in various DeFi tokens using non-parametric tests. By analyzing the wealth distribution among the top groups of token holders, the study aims to evaluate the potential influence of wealth concentration on the risk exposure of DeFi tokens.

In the context of financial risk measurement, VaR and CVaR are essential metrics for understanding potential losses in investments. This study applies these tools to three groups of tokens categorized by their level of wealth concentration: highly wealth-concentrated tokens, medium wealth-concentrated tokens, and low wealth-concentrated tokens. The analysis is conducted at three standard confidence intervals, 95 %, 99 %, and 99.9 % across different groups of token holders, including the Top1, Top10, Top20, Top50, Top100, and the remaining token holding groups.

The mean VaR and CVaR approach for risk measurement and portfolio optimization has been widely applied by researchers in the past (for example, Banihashemi and Navidi 2017; Lwin et al. 2017; Guo et al. 2019). The calculations are based on the daily returns derived from the daily closing prices of each token.

The daily return R_t for a token is calculated as:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{4}$$

Where P_t is the closing price at time t and P_{t-1} is the closing price at time $t-1$.

[4] The `crypto2` R-package is utilized to download the daily closing price of the tokens.

VaR is defined as the maximum potential loss over a given time period at a certain confidence level. Mathematically, for a confidence level α, VaR is the threshold loss value such that:

$$P(L \leq \text{VaR}_\alpha) = \alpha \tag{5}$$

Where L represents the loss of an investment.

CVaR (or ES), is the expected loss given that the loss is beyond the VaR threshold. For a confidence level α, CVaR is defined as:

$$\text{CVaR}_\alpha = E[L \mid L > \text{VaR}_\alpha] \tag{6}$$

This measure provides an average of the losses in the tail of the loss distribution, offering a more comprehensive view of risk in extreme scenarios. By calculating the daily returns from the daily closing prices for each token in the groups of highly wealth-concentrated, medium wealth-concentrated, and low wealth-concentrated tokens, we compute the VaR and CVaR for each top token holding group. The mean differences in VaR and CVaR between different groups provide valuable insights into the risk profiles of these groups.

To create these groups, we sort the tokens within each holding group in descending order and equally divide the sample into three groups: high, medium, and low. The top group is classified as high, the middle group as medium, and the lowest holding group as low.

For each group, the mean VaR and CVaR values are calculated by taking the mean of the individual VaR and CVaR values of the tokens within that group:

$$\text{Mean VaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{VaR}_{\alpha,i} \tag{7}$$

$$\text{Mean CVaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{CVaR}_{\alpha,i} \tag{8}$$

Where n is the number of tokens in the group, and i indexes the individual tokens.

$\text{Mean VaR}_{\text{group}}$ and $\text{Mean CVaR}_{\text{group}}$ represent the average VaR and CVaR for a particular group, respectively. Then, the mean differences in VaR and CVaR between the groups ($\Delta\text{VaR}_{\text{group}}$ and $\Delta\text{CVaR}_{\text{group}}$) are calculated as follows:

$$\Delta\text{VaR}_{\text{group}} = \begin{cases} \text{VaR}_{\text{CI,H}} - \text{VaR}_{\text{CI,M}}, & \text{for high-medium} \\ \text{VaR}_{\text{CI,M}} - \text{VaR}_{\text{CI,L}}, & \text{for medium-low} \\ \text{VaR}_{\text{CI,H}} - \text{VaR}_{\text{CI,L}}, & \text{for high-low} \end{cases} \tag{9}$$
$$\text{at CI (95 \%, 99 \%, and 99.9 \%)}$$
$$\text{for the Top (1, 10, 20, 50, 100, Rest) Token Holding Groups.}$$

$$\Delta\text{CVaR}_{\text{group}} = \begin{cases} \text{CVaR}_{\text{CI,H}} - \text{CVaR}_{\text{CI,M}}, & \text{for high-medium} \\ \text{CVaR}_{\text{CI,M}} - \text{CVaR}_{\text{CI,L}}, & \text{for medium-low} \\ \text{CVaR}_{\text{CI,H}} - \text{CVaR}_{\text{CI,L}}, & \text{for high-low} \end{cases} \tag{10}$$
$$\text{at CI (95 \%, 99 \%, and 99.9 \%)}$$
$$\text{for the Top (1, 10, 20, 50, 100, Rest) Token Holding Groups.}$$

Furthermore, to determine whether the mean differences in $\Delta\text{VaR}_{\text{group}}$ and $\Delta\text{CVaR}_{\text{group}}$ between different combinations of high, medium, and low groups are statistically significant, we perform a two-tailed t-test. The two-tailed t-test compares the means of two groups and assesses whether they are significantly different from each other. The difference in VaR between these groups indicates which group has a higher or lower threshold for potential losses at a given confidence level. Similarly, the difference in CVaR shows which group, on average, experiences greater losses in worst-case scenarios. If the level of wealth centralization does not influence the differences in risk exposure across high, medium, and low wealth concentration categories, then the mean differences in VaR and CVaR among these categories should not be statistically significant.

3.4. Risk and interconnectedness

This study adopts the approach suggested by Antonakakis et al. (2020) to analyze the interconnectedness between essential DeFi components. This method builds on the foundational work of Diebold and Yilmaz (2009, 2012, 2014) and Primiceri (2005). Furthermore, the study explores the interconnectedness of Bitcoin and the native tokens of the blockchains upon which layer-3 tokens (assets) are developed.

We first compute the returns using two different approaches: equally weighted and value-weighted portfolio returns. Then, the volatility is estimated using the sGARCH model for each approach.

For an equally weighted portfolio of N_t assets, the return is calculated as:

$$R_t^{EW} = \frac{1}{N_{t-1}} \sum_{i=1}^{N_{t-1}} R_{i,t} \tag{11}$$

Where:

- N_{t-1} is the number of tokens in the portfolio at time $t-1$,
- $R_{i,t}$ is the return of asset i at time t, and
- the portfolio is dynamically rebalanced only when a new token enters. No further interventions are made at fixed intervals.

Whenever a new token j enters the portfolio at time $t+1$, the portfolio is rebalanced by updating N_t to $N_{t+1} = N_t + 1$, and the weight of each token is recalculated as:

$$w_{i,t+1} = \frac{1}{N_{t+1}}, \quad \forall i \in \{1, \ldots, N_{t+1}\} \tag{12}$$

Where:

- $w_{i,t+1}$ represents the weight of each token after rebalancing,
- N_{t+1} is the updated number of tokens in the portfolio at time $t+1$.

This dynamic rebalancing ensures equal weighting across all tokens in the portfolio without further manual intervention. Furthermore, for a value-weighted portfolio, where the weights are based on market capitalization, the return is:

$$R_t^{VW} = \sum_{i=1}^{N_{t-1}} w_{i,t-1} R_{i,t} \tag{13}$$

Where $w_{i,t-1} = \frac{MC_{i,t-1}}{\sum_{i=1}^{N_{t-1}} MC_{i,t-1}}$ is the weight of asset i based on its market capitalization $MC_{i,t-1}$ at time $t-1$.

To ensure stationarity in the return series, the Augmented Dickey–Fuller (ADF) test is employed. The null hypothesis of the ADF test posits the presence of a unit root, indicating non-stationarity. Rejecting the null hypothesis confirms that the series is stationary. For further details on the test, see Dickey and Fuller (1981).

After obtaining the returns for both equally weighted and value-weighted portfolios, we estimate the volatility using the sGARCH(1,1) model. The sGARCH model is specified as:

$$R_t = \mu + \epsilon_t \tag{14}$$

$$\epsilon_t = \sigma_t z_t \tag{15}$$

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{16}$$

where R_t is the return (either equally weighted or value-weighted) at time t, σ_t^2 is the conditional variance, and $z_t \sim N(0,1)$ is a white noise process.

Thus, two sets of volatilities σ_t^{EW} and σ_t^{VW} are obtained corresponding to equally weighted and value-weighted portfolio returns, respectively.

This study uses the Wealth Concentration Ratio (WCR) in place of traditional inequality measures such as the Gini coefficient or Theil index for several conceptual and practical reasons. Conventional measures like Gini and Theil are designed to capture inequality across the entire distribution of holders. However, in the context of crypto assets, the distribution often includes a long tail of wallets with negligible balances, which can obscure the influence of large holders who are most relevant for assessing systemic risk. In addition, the total number of wallet addresses varies substantially across assets, making such indices less suitable for meaningful cross-asset comparisons. By contrast, the WCR offers a more focused and comparable metric by concentrating on the distribution of wealth among a fixed subset of top wallet addresses (e.g., the top 100 holders). This approach more effectively captures the structural concentration of economic power that is most relevant in decentralized financial systems, regardless of the total address count. As such, the WCR provides a more accurate and consistent representation of wealth dominance across heterogeneous DeFi assets. While the WCR does not fully account for variations in the lower and middle segments of the distribution and may overlook more nuanced shifts in overall inequality, these limitations are relatively minor in the context of this study. Given the high relevance of top-100-holder dominance in DeFi ecosystems, the WCR remains a suitable and practically informative metric.

To examine the impact of wealth concentration on interconnectedness, we modify the time-varying parameter vector autoregressive (TVP-VAR) model by introducing wealth concentration as the scaling factor. This scaling reflects how the concentration of wealth in each asset modulates its influence on the system. The wealth concentration ratio (WCR) can be expressed as:

$$k = \frac{P_w}{P_{\text{wealth}}} \tag{17}$$

where k is the ratio representing the fraction of wallets controlling the wealth, P_w is the percentage of wallets, and P_{wealth} is the percentage of wealth.

This means that for every percentage point of wealth, only $k\%$ of wallets hold that wealth. It highlights the small fraction of wallets controlling significant wealth, serving as an indicator of the concentration of wealth among a limited group of wallets. For each asset i, we scale its volatility ($\sigma_{i,t}$) by its corresponding wealth concentration ratio (WCR_i), creating a wealth-adjusted volatility series.

The wealth-adjusted equally weighted volatility is given by:

$$Y_t^W = \sigma_t^{EW} \odot WCR \tag{18}$$

where:

- σ_t^{EW} is the equally weighted volatility at time t,
- WCR is the wealth concentration ratio vector, and
- $\odot$ denotes element-wise multiplication.

Similarly, for value-weighted volatility, the scaling is done by:

$$Y_t^W = \sigma_t^{VW} \odot WCR \tag{19}$$

where:

- σ_t^{VW} is the value-weighted volatility at time t,

3.4.1. Modified TVP-VAR-WCR model

The modified TVP-VAR model incorporating wealth concentration is represented as:

$$Y_t^W = A_{0,t} + \sum_{i=1}^{p} A_{i,t} Y_{t-i}^W + \epsilon_t \tag{20}$$

where:

- Y_t^W is the $N \times 1$ vector of asset volatilities adjusted for wealth concentration at time t,
- $A_{0,t}$ is the $N \times 1$ vector of time-varying intercepts,
- $A_{i,t}$ is the $N \times N$ matrix of time-varying coefficients for lag i,
- $\epsilon_t \sim N(0, \Sigma_t)$ is the vector of errors, and
- Σ_t is the time-varying covariance matrix of residuals.

After estimating the TVP-VAR model using the wealth-adjusted volatilities, the generalized forecast error variance decomposition (FEVD) is used to compute the connectedness measures. The connectedness index for each pair of assets is calculated as:

$$C_{ij}(t) = \frac{\theta_{ij}(t)}{\sum_{j=1}^{N} \theta_{ij}(t)} \times 100 \tag{21}$$

where:

- $\theta_{ij}(t)$ represents the portion of the H-step ahead forecast error variance of asset i due to shocks in asset j at time t,
- N is the total number of assets.

The total connectedness, which captures the overall interconnectedness between the assets, is defined as:

$$TC(t) = \frac{\sum_{i \neq j} \theta_{ij}(t)}{N} \times 100 \tag{22}$$

This modification allows us to study how wealth concentration affects the dynamic interconnectedness among the assets over time.

4. Results and discussions

To further analyze the wealth distribution within DeFi, we decompose it into eight fundamental components: blockchain, assets, wallets, stablecoins, smart contracts, oracles, DAOs, and governance. This analysis evaluates the degree of decentralization within each category. To assess the level of wealth centralization risk among the top holders of layer-3 tokens, we estimate the mean difference in VaR and CVaR among different top-level holders, as well as among the rest of the token holders, within stablecoins, smart contracts, oracles, DAO, and governance tokens. Additionally, since blockchain tokens are native layer-1 tokens, this study does not calculate the risk exposure of these coins. The primary objective is to examine the risk associated with layer-3 DeFi tokens.

4.1. Blockchain

Centralization can occur in a decentralized blockchain when a small number of individuals or entities hold a significant portion of the wealth within that blockchain. This concentration of wealth can lead to several negative consequences for the blockchain ecosystem, including reduced decentralization, unfair distribution of wealth, diminished innovation, and increased risk of manipulation.

Table A.3 in the Appendix provides an overview of the distribution of wealth in the top six DeFi blockchains based on their market capitalization, along with the number of wallet addresses and the percentage of wealth held by the top 1 to top 100 wallet addresses. It shows a significant concentration of wealth in the hands of a small number of participants. For instance, on Ethereum, the top 1 wallet holds 23.37 % of the wealth, while the top 100 wallets hold 46.24 %. This means that a mere 0.000102 % of wallets control almost 46 % of the wealth in the Ethereum blockchain. This concentration of wealth is not unique to Ethereum; it is a common trend across all the top six DeFi blockchains. In fact, the average percentage of wealth held by the top 1 to top 100 wallets is 39.39 %. However, the Polygon blockchain exhibits a more decentralized distribution of wealth, with the top 100 wallets holding less than 5 % of its wealth. Conversely, the Polkadot blockchain has a highly centralized wealth distribution, with the top 100 wallets holding almost three-fourths of the wealth.

Table A.4 in the Appendix shows the average concentration of wealth in the top 100 wallet addresses for the top six DeFi blockchains. It indicates that the top 100 wealthiest addresses hold an average of 39.39 % of the wealth in these blockchains, while the remaining addresses hold 60.61 %. This demonstrates that a very small fraction of the overall addresses in these blockchains control a significant portion of the wealth, highlighting a highly centralized distribution of wealth. To address the issue of wealth concentration in blockchains, several measures can be implemented, including fair launch distribution, community governance, protocol fee redistribution, and education and awareness. By adopting these measures, DeFi protocols can work toward creating a more decentralized and equitable ecosystem that benefits all participants.

4.2. Assets

Table 1
Descriptive statistics of assets and wealth distribution in DeFi.

Statistics	Top1	Top10	Top20	Top30	Top40	Top50
Mean	44.3601	79.9893	84.5983	86.839	88.1602	89.1521
Standard Error	1.1361	0.9724	0.8842	0.8358	0.8111	0.7917
Median	41.6250	86.8300	91.2250	93.6500	94.7800	95.5700
Mode	25	84.7900	99.9100	93.0900	94.5800	95.5700
Std Dev	24.5250	20.9685	19.0473	17.9841	17.3586	16.9243
Variance	601.4735	439.6783	362.7998	323.4279	301.3193	286.4318
Kurtosis	−0.5277	1.8611	3.9990	5.7921	7.2549	8.5188
Skewness	0.4971	−1.4532	−1.9089	−2.2172	−2.4286	−2.5719
Minimum	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
Maximum	99.9100	100	100	100	100	100
#DeFi	586	586	573	573	558	557
Statistics		Top60	Top70	Top80	Top90	Top100
Mean		90.4593	91.0378	91.5425	91.9652	92.2904
Standard Error		0.7132	0.7035	0.6947	0.6879	0.6861
Median		96.2000	96.5400	96.9100	97.1100	97.2900
Mode		99.4900	96.8300	97.1800	97.4800	99.8900
Std Dev		14.9091	14.6728	14.4882	14.3474	14.2764
Variance		222.2821	215.2918	209.9073	205.8489	203.8152
Kurtosis		10.0151	11.3158	12.6557	13.9911	15.2593
Skewness		−2.4908	−2.4874	−2.4469	−2.3907	−2.3088
Minimum		0.0200	0.0200	0.0200	0.0200	0.0200
Maximum		100	100	100	100	100
#DeFi		537	535	535	535	533

Note: This table reports the summary statistics of the percentage of wealth distribution of 586 DeFi tokens among the top 1 to top 100 wallet addresses.

Table 1 above shows the descriptive statistics of the wealth distribution in 586 crypto assets used in this study. On average, the top wallet holder controls almost half of the wealth in DeFi, with values ranging from a minimum of 2 % to a maximum of 99.91 %. The top 10 wallet holders, on the other hand, control nearly 80 % of the wealth on average, with values ranging from a minimum of 2 % to a maximum of 100 %. This raises serious concerns about the decentralization objectives and democratic practices in DeFi. The top 50 wallet addresses, on average, hold 90 % of the wealth in DeFi, and this pattern remains consistent when examining the top 60 to top 100 wallet addresses. This finding clearly illustrates that, in each DeFi market, approximately 50 wallets capture nearly 90 % of the total wealth, highlighting a highly centralized wealth distribution within the ecosystem. In Table 1, the discrepancies in the number of DeFi projects across the top wallet categories beyond the Top 10 holders arise because some projects have wealth holding information for fewer than 20 wallet addresses within the Top 100. Moreover, CoinCarp does not report data for all Top 100 wallet addresses for every DeFi project. Wallet addresses with no wealth holdings statistics are excluded from the Top 100 rich list.

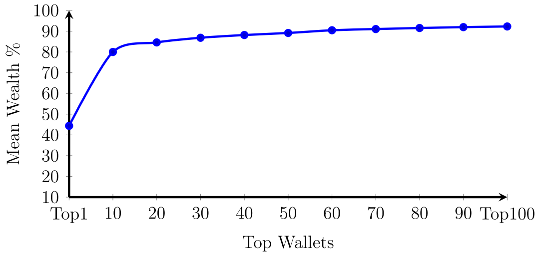

Fig. 2. Mean wealth for the top wallet categories. **Note**: This figure shows the aggregate wealth of the 586 DeFi tokens held by Top1 to Top100 wallet categories (as of 10.10.2022).

Fig. 2 above illustrates a notable disparity in average wealth across the Top1 to Top100 wallet categories, with a substantial jump in wealth observed from the top 1 wallet to the top 10 wallets. Following this initial surge, the subsequent Top20 to Top100 categories exhibit a relatively steady increase in mean wealth. This pattern suggests a concentration of wealth among the top 10 wallets, contributing to a distinct wealth gap between the highest-ranking wallets and the subsequent tiers. The chart provides a visual representation of the distribution of wealth across different wallet rankings, further highlighting the disproportionate concentration of wealth within the top wallet classes.

Table A.5 in the Appendix shows that the concentration of wealth in the DeFi ecosystem is exceptionally high. On average, the top 100 wealthiest addresses hold 92.29 % of the wealth, while the remaining addresses collectively hold just 7.71 %. This indicates that a small number of individuals or institutions control a significant portion of the wealth in the DeFi ecosystem. The high concentration of wealth in DeFi can be attributed to several factors, including initial token distribution mechanisms, early adoption, market speculation, and the structural design of some DeFi protocols. Early adopters who received large allocations of tokens through airdrops or token sales have often benefited from significant price appreciation. Market speculation has further contributed to wealth concentration, as individuals or entities with substantial capital reserves have been able to accumulate more tokens during periods of high market volatility. Additionally, some DeFi protocols incentivize large token holdings through yield farming mechanisms, which exacerbates the concentration of wealth.

4.2.1. Lorenz curve of inequality

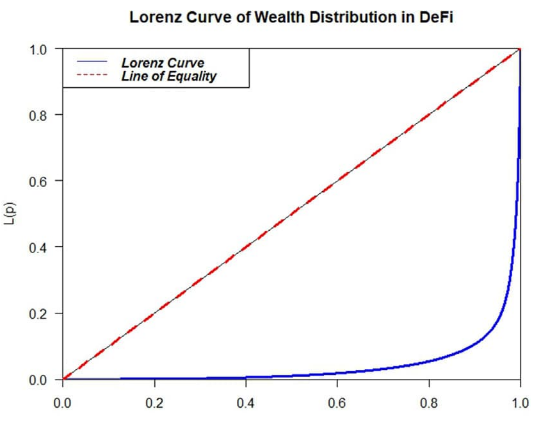

Fig. 3. Lorenz curve of wealth distribution of overall 586 DeFi tokens in 58600 richest wallet addresses. **Note**: The red dotted line represents the line of equality, while the blue solid line represents the Lorenz curve. The closer the Lorenz curve is to the line of equality, the more equal the distribution of wealth. The further the Lorenz curve is from the line of equality, the more unequal the distribution of wealth (as of 10.10.2022). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

A Lorenz curve, developed by American economist Max Lorenz (Lorenz, 1905), is a graphical representation of income or wealth inequality. The graph plots percentiles of the population on the horizontal axis according to income or wealth and plots cumulative income or wealth on the vertical axis.[5]

$$L(p) = \frac{1}{\mu} \int_0^p q(x)\, dx \tag{23}$$

where:

[5] The Lorenz curve in this study is derived using the `ineq` R-package.

- P is the cumulative percentage of wallet addresses, ranging from 0 % to 100 %.
- $L(p)$ is the cumulative percentage of total wealth held by the corresponding percentage of wallet addresses.
- μ is the total wealth in DeFi.
- $q(x)$ is the cumulative distribution function (CDF) of the wealth distribution.

Fig. 3 illustrates the Lorenz curve for wealth distribution in DeFi, plotting the cumulative proportion of token holdings against the cumulative proportion of wallet addresses. The curve reveals an extremely unequal distribution of wealth, where a very small proportion of wallet addresses holds a disproportionately large share of the total token holdings. This concentration of wealth undermines the ideals of decentralization and accessibility in DeFi, as the majority of wallet addresses hold minimal tokens while a small group reaps most of the gains. This imbalance can lead to increased centralization, with wealthiest participants exerting greater influence over protocol governance and decision-making, while discouraging participation from less affluent individuals and limiting diversity within the DeFi community. Addressing this issue requires efforts to promote equitable wealth distribution through mechanisms like airdrops or staking incentives targeted at smaller wallet addresses, as well as fostering an inclusive financial environment to empower participants from diverse backgrounds. Notably, an analysis of the top 100 richest wallet addresses across 586 DeFi tokens further reveals that even within this elite group, a very small number of addresses control the majority of token holdings, raising concerns about potential market manipulation risks.

4.2.2. Other measures of wealth inequality

Table 2 shows the basic statistics for three different inequality indices across 586 DeFi tokens: the coefficient of variation (CV), the generalized entropy measure (Theil index), and the Gini coefficient. The results reveal significant wealth inequality in the DeFi ecosystem. The CV ranges from 0.0000 to 9.9960, with a mean value of 5.0501, indicating a highly heterogeneous wealth distribution. A mean CV of 5.0501 reflects a wide disparity in token holdings among wallet addresses, with a large standard deviation relative to the mean. This highlights a substantial concentration of tokens among a small number of addresses, undermining decentralization and fairness in DeFi. The Theil index ranges from 1.7150 to 4.3900, with a mean of 2.28, further confirming the unequal distribution of wealth. Similarly, the Gini coefficient has a mean value of 0.8628, which aligns with the observed patterns of significant variations in token holding distributions. These findings suggest that a small group of individuals holds disproportionate influence over protocol development and decision-making, raising concerns about the decentralization and sustainability of the DeFi ecosystem.

Table 2
Assets and wealth distribution inequality in DeFi.

Statistics	Coefficient of Variation (CV)	Theil Index	Gini Coefficient
Minimum	0.0000	0.0000	0.0881
1st Quarter	3.4507	1.7150	0.8224
Median	4.8265	2.3490	0.9113
Mean	5.0501	2.2800	0.8628
3rd Quarter	6.5041	2.9120	0.9514
Maximum	9.9960	4.3900	0.9900
NA's	4	1	1
Length	586	586	586

Note: This table reports the basic statistics for three different inequality indices for the 586 DeFi tokens used in this study. The calculation methods are presented in Eqs. (1), (2), and (3).

4.3. Wallets

Centralization concerns in DeFi may stem from one of its fundamental components: wallets. The active participation of a few wallet addresses across multiple DeFi projects concentrates influence, creates interconnected risks, and distorts liquidity and capital allocation. This concentration of power may result in governance decisions that prioritize the interests of a select few, undermining the decentralized nature of DeFi and discouraging broader participation. Furthermore, the involvement of these addresses in multiple projects increases systemic vulnerabilities through interconnected risks.

In Table 3, the null/dead/burn address is identified as the most active wallet address among 116 DeFi tokens out of the 586 analyzed in this study. These addresses are commonly used by projects to burn tokens and reduce the total supply. In many cases, when the soft or hard capital (minimum or maximum capital required to launch a project) is reached, developers transfer the remaining token supply to null addresses. These addresses typically hold a large percentage of tokens; therefore, they are excluded from the rich list in this study. Examples of null addresses include:

```
0x000000000000000000000000000000000000dead
0x1111111111111111111111111111111111111dead
0x22222222222222222222222222222222222222dead
0xdeadbeefdeadbeefdeadbeefdeadbeefdeadbeef
...
```

Table 3
Wallets active in multiple DeFi projects.

S.No.	Wallets	Max	Average%	S.No.	Wallets	Max	Average%	S.No.	Wallets	Max	Average%
1	116 DeFi	84.49	21.8807	15	32 DeFi	1.88	0.3869	29	14 DeFi	4.60	0.3164
2	112 DeFi	30.65	1.3858	16	30 DeFi	26.30	1.5113	30	13 DeFi	48.72	0.8488
3	73 DeFi	63.23	3.6419	17	28 DeFi	14.68	3.3818	31	12 DeFi	44.78	1.566
4	72 DeFi	61.16	10.0054	18	27 DeFi	42.08	5.3119	32	11 DeFi	15.30	0.874
5	70 DeFi	19.73	0.7252	19	26 DeFi	1.01	0.3263	33	10 DeFi	31.14	0.8748
6	64 DeFi	30.82	2.4055	20	25 DeFi	0.43	0.072	34	9 DeFi	78.04	3.026
7	62 DeFi	1.83	0.3996	21	24 DeFi	3.30	0.5606	35	8 DeFi	89.38	1.0164
8	56 DeFi	97.27	3.6162	22	21 DeFi	0.30	0.0805	36	7 DeFi	98.99	5.0104
9	47 DeFi	99.91	4.8623	23	20 DeFi	30.91	2.354	37	6 DeFi	98.94	3.8989
10	44 DeFi	14.64	1.8636	24	19 DeFi	28.37	0.7216	38	5 DeFi	84.67	1.0961
11	38 DeFi	9.39	0.8855	25	18 DeFi	6.21	0.8174	39	4 DeFi	27.37	0.4689
12	37 DeFi	0.73	0.1581	26	17 DeFi	52.84	1.891	40	3 DeFi	21.66	0.3879
13	36 DeFi	1.20	0.1936	27	16 DeFi	1.58	0.3044	41	2 DeFi	97.55	0.861
14	33 DeFi	5.63	0.6321	28	15 DeFi	3.19	0.7347	42	1 DeFi	99.10	0.8412

Note: This table reports the maximum and the average wealth accumulated in single wallet address that holds the wealth of multiple DeFi tokens. Table A.6 in the appendix provides the details about the holder's information on some of these wallet addresses. The first wallet includes all the null addresses.

The second most active wallet address is associated with tokens from 112 out of 586 DeFi projects, with the highest concentration at 30.65 % in a single project and an average holding of 1.3858 % across these 112 projects. Similarly, the fourth most active wallet is linked to tokens from 72 projects, with a maximum stake of 61.16 % in one project and an average holding of 10.0054 % across these 72 projects. Remarkably, wallets exclusively holding tokens from a single DeFi project, on average, possess 0.8412 % of the total wealth. In contrast, within a specific DeFi ecosystem, wallets exclusively engaged in that particular project command a substantial 99.10 % of the overall wealth. This highlights that the risk of centralization arises not only from addresses holding tokens across multiple DeFi projects but also from addresses exerting significant control over a large portion of the wealth within individual DeFi projects.

An analysis of wallets active in multiple DeFi projects reveals that while some wallets hold significant portions of individual tokens, their average holdings across projects are much lower except for the largest centralized crypto exchange Binance. For instance, it has a wallet with a maximum holding of 61.16 % in a single project but an average holding of only 10.00 % across 72 projects and another wallet with average holding of 3.64 % across 73 DeFi projects. This suggests that centralization risks may be more pronounced at the project level as well as across the DeFi ecosystem as a whole. However, considering both maximum and average holdings provides a more balanced assessment of DeFi's decentralization, as wealth distribution appears more dispersed when viewed across multiple projects.

Out of 58,600 wallet addresses, 6,771 wallets are active in more than two projects. Most of these wallet addresses belong to centralized exchanges such as Binance, Gate.io, etc. There are also a few wallets from decentralized exchanges (DEX), DEX bridges and vaults. A DEX bridge enables the transfer of assets across different blockchains by using smart contracts and relayers, allowing users to move tokens like USDC or ETH from one chain to another without relying on centralized exchanges. In contrast, a DEX vault is a smart contract that automates yield-generating strategies such as liquidity provision or farming, enabling users to earn passive income on their assets. While bridges focus on cross-chain mobility, vaults optimize asset productivity within or across chains, with both playing critical roles in the decentralized finance ecosystem. One particular wallet address belongs to institutional market making (MM). Institutional MM wallets typically provide liquidity and facilitate smoother market transactions, enhancing market efficiency and stability. Nevertheless, even a small fraction of wealth concentration in centralized exchanges poses a substantial risk, given the potential for bankruptcy, defaults due to poor management, regulatory issues, scams, and other factors. A recent study by Sapkota (2025) reveals that the log odds of default among cryptocurrency exchanges are significantly higher for centralized exchanges compared to decentralized ones. Specifically, the odds of default for decentralized exchanges are only 27.5 % of those for centralized exchanges, indicating that decentralized exchanges are approximately 72.5 % less likely to default. Given the historical precedent of over 500 cryptocurrency exchanges having already gone bankrupt or disappeared from the market, the concentration of assets in certain wallets of centralized platforms poses a substantial threat to investor security and systemic stability. For example, the recent Baybit exchange hacking involved the theft of more than a billion dollars worth of Ethereum from an offline (cold) wallet. Hackers exploited the typically uniform transfer-time window from cold wallets to hot wallets to orchestrate this theft.[6]

4.4. Stablecoins

The concentration of wealth in stablecoins within a few wallet addresses can significantly affect the operation of DeFi protocols. Such concentration disrupts liquidity and stability, leading to abrupt changes in asset prices and lending rates as large holders move substantial amounts of stablecoins. It also increases market manipulation risks, enabling these entities to artificially influence prices

[6] Source: https://www.bbc.com/news/articles/c2kgndwwd7l.

Table 4
Value at risk and the expected shortfall for different top holder groups for stablecoins.

Group	CI	Full sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
Top1	VaR_95	−0.0263	−0.0129	−0.0446	−0.0134	0.0317*	0.0183	−0.0235	−0.0056	−0.0448	−0.0179*	0.0392**	0.0213
					(−1.14)	(1.98)	(0.96)				(−2.03)	(2.12)	(1.05)
	VaR_99	−0.0595	−0.0308	−0.0978	−0.0287	0.0669*	0.0383	−0.0663	−0.0120	−0.0949	−0.0543**	0.0829**	0.0286
					(−1.43)	(2.03)	(1.05)				(−2.74)	(2.08)	(0.65)
	VaR_99.9	−0.1344	−0.0776	−0.2492	−0.0568	0.1715**	0.1148*	−0.1446	−0.0336	−0.1890	−0.1110**	0.1554**	0.0443
					(−1.65)	(2.74)	(1.85)				(−2.26)	(2.27)	(0.55)
	CVaR_95	−0.0496	−0.0258	−0.0862	−0.0238	0.0604**	0.0367	−0.0516	−0.0112	−0.0801	−0.0404**	0.0689**	0.0285
					(−1.44)	(2.34)	(1.27)				(−2.46)	(2.16)	(0.81)
	CVaR_99	−0.0978	−0.0499	−0.1754	−0.0478*	0.1254***	0.0776	−0.1063	−0.0236	−0.1454	−0.0827**	0.1218**	0.0390
					(−1.89)	(2.89)	(1.66)				(−2.48)	(2.17)	(0.62)
	CVaR_99.9	−0.1741	−0.1118	−0.4149	−0.0623	0.3031***	0.2408**	−0.1697	−0.0366	−0.2068	−0.1331**	0.1702**	0.0371
					(−1.38)	(3.32)	(2.50)				(−2.19)	(2.36)	(0.41)
Top10	VaR_95	−0.0238	−0.0300	−0.0316	0.0062	0.0016	0.0078	−0.0191	−0.0250	−0.0318	0.0059	0.0067	0.0126
					(0.35)	(0.08)	(0.46)				(0.37)	(0.32)	(0.69)
	VaR_99	−0.0523	−0.0665	−0.0729	0.0141	0.0064	0.0205	−0.0514	−0.0574	−0.0689	0.0060	0.0115	0.0175
					(0.44)	(0.17)	(0.63)				(0.18)	(0.25)	(0.43)
	VaR_99.9	−0.1162	−0.1518	−0.2006	0.0356	0.0488	0.0844	−0.1220	−0.1057	−0.1467	−0.0163	0.0410	0.0247
					(0.73)	(0.67)	(1.30)				(−0.25)	(0.52)	(0.31)
	CVaR_95	−0.0435	−0.0580	−0.0634	0.0145	0.0054	0.0199	−0.0411	−0.0474	−0.0580	0.0063	0.0106	0.0170
					(0.54)	(0.18)	(0.77)				(0.22)	(0.29)	(0.52)
	CVaR_99	−0.0838	−0.1096	−0.1356	0.0259	0.0260	0.0519	−0.0870	−0.0849	−0.1095	−0.0021	0.0246	0.0226
					(0.64)	(0.49)	(1.14)				(−0.04)	(0.38)	(0.37)
	CVaR_99.9	−0.1557	−0.2438	−0.3146	0.0881	0.0708	0.1588*	−0.1446	−0.1126	−0.1634	−0.0320	0.0507	0.0188
					(0.93)	(0.60)	(1.80)				(−0.42)	(0.61)	(0.21)
Top20	VaR_95	−0.0369	−0.0158	−0.0314	−0.0211	0.0156	−0.0055	−0.0318	−0.0115	−0.0312	−0.0203	0.0198	−0.0006
					(−1.32)	(1.19)	(−0.20)				(−1.42)	(1.16)	(−0.06)
	VaR_99	−0.0774	−0.0433	−0.0687	−0.0342	0.0254	−0.0087	−0.0768	−0.0296	−0.0685	−0.0471	0.0388	−0.0083
					(−1.18)	(0.85)	(−0.20)				(−1.55)	(0.99)	(−0.12)
	VaR_99.9	−0.1551	−0.1333	−0.1783	−0.0218	0.0450	0.0232	−0.1629	−0.0692	−0.1386	−0.0936	0.0694	−0.0242
					(−0.44)	(0.65)	(0.33)				(−1.58)	(1.00)	(−0.24)
	CVaR_95	−0.0651	−0.0381	−0.0596	−0.0269	0.0215	−0.0054	−0.0625	−0.0250	−0.0568	−0.0375	0.0318	−0.0058
					(−1.10)	(0.93)	(−0.10)				(−1.50)	(1.03)	(−0.10)
	CVaR_99	−0.1169	−0.0875	−0.1224	−0.0294	0.0348	0.0054	−0.1218	−0.0504	−0.1058	−0.0714	0.0554	−0.0160
					(−0.75)	(0.76)	(0.10)				(−1.61)	(0.99)	(−0.22)
	CVaR_99.9	−0.1940	−0.2562	−0.2651	0.0623	0.0088	0.0711	−0.1865	−0.0778	−0.1528	−0.1087	0.0750	−0.0337
					(0.61)	(0.07)	(0.80)				(−1.57)	(1.00)	(−0.33)
Top50	VaR_95	−0.0254	−0.0293	−0.0307	0.0040	0.0013	0.0053	−0.0231	−0.0242	−0.0285	0.0011	0.0043	0.0054
					(0.23)	(0.07)	(0.30)				(0.07)	(0.22)	(0.26)
	VaR_99	−0.0583	−0.0658	−0.0675	0.0075	0.0017	0.0092	−0.0609	−0.0563	−0.0604	−0.0046	0.0041	−0.0005
					(0.24)	(0.05)	(0.26)				(−0.14)	(0.10)	(−0.05)
	VaR_99.9	−0.1313	−0.1903	−0.1509	0.0590	−0.0394	0.0196	−0.1344	−0.1389	−0.1044	0.0045	−0.0346	−0.0300
					(0.94)	(−0.55)	(0.32)				(0.06)	(−0.46)	(−0.36)

(*continued on next page*)

Table 4 (*continued*)

Group	CI	Full sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
	CVaR_95	−0.0492	−0.0591	−0.0567	0.0099	−0.0024	0.0075	−0.0482	−0.0498	−0.0488	0.0016	−0.0010	0.0005
					(0.38)	(−0.09)	(0.26)				(0.06)	(−0.03)	(0.02)
	CVaR_99	−0.0947	−0.1269	−0.1091	0.0321	−0.0177	0.0144	−0.0996	−0.0983	−0.0849	−0.0012	−0.0135	−0.0147
					(0.75)	(−0.36)	(0.30)				(−0.02)	(−0.22)	(−0.20)
	CVaR_99.9	−0.1673	−0.3341	−0.2217	0.1667	−0.1124	0.0543	−0.1535	−0.1539	−0.1173	0.0004	−0.0366	−0.0362
					(1.55)	(−0.96)	(0.72)				(0.00)	(−0.45)	(−0.41)
Top100	VaR_95	−0.0263	−0.0282	−0.0307	0.0019	0.0024	0.0043	−0.0250	−0.0221	−0.0285	−0.0029	0.0064	0.0035
					(0.11)	(0.14)	(0.25)				(−0.19)	(0.33)	(0.17)
	VaR_99	−0.0622	−0.0615	−0.0675	−0.0007	0.0060	0.0053	−0.0690	−0.0473	−0.0604	−0.0217	0.0131	−0.0086
					(−0.02)	(0.17)	(0.15)				(−0.66)	(0.31)	(−0.20)
	VaR_99.9	−0.1697	−0.1476	−0.1509	−0.0220	0.0032	−0.0188	−0.1732	−0.0958	−0.1044	−0.0774	0.0086	−0.0688
					(−0.36)	(0.05)	(−0.26)				(−1.03)	(0.12)	(−0.82)
	CVaR_95	−0.0540	−0.0537	−0.0567	−0.0003	0.0030	0.0027	−0.0548	−0.0478	−0.0488	−0.0069	0.0009	−0.0060
					(−0.01)	(0.11)	(0.09)				(−0.25)	(0.03)	(−0.19)
	CVaR_99	−0.1128	−0.1067	−0.1091	−0.0061	0.0024	−0.0037	−0.1151	−0.0918	−0.0849	−0.0232	−0.0070	−0.0303
					(−0.14)	(0.05)	(−0.07)				(−0.41)	(−0.11)	(−0.42)
	CVaR_99.9	−0.2203	−0.2752	−0.2217	0.0549	−0.0536	0.0013	−0.1750	−0.1340	−0.1173	−0.0409	−0.0167	−0.0576
					(0.49)	(−0.48)	(0.01)				(−0.49)	(−0.21)	(−0.59)
Rest	VaR_95	−0.0307	−0.0282	−0.0263	−0.0024	−0.0019	−0.0043	−0.0307	−0.0282	−0.0263	−0.0024	−0.0019	−0.0043
					(−0.14)	(−0.11)	(−0.25)				(−0.14)	(−0.11)	(−0.20)
	VaR_99	−0.0675	−0.0615	−0.0622	−0.0060	0.0007	−0.0053	−0.0675	−0.0615	−0.0622	−0.0060	0.0007	−0.0053
					(−0.17)	(0.02)	(−0.15)				(−0.17)	(0.02)	(−0.10)
	VaR_99.9	−0.1509	−0.1476	−0.1697	−0.0032	0.0220	0.0188	−0.1509	−0.1476	−0.1696	−0.0032	0.0220	0.0188
					(−0.05)	(0.36)	(0.26)				(−0.05)	(0.36)	(0.26)
	CVaR_95	−0.0567	−0.0537	−0.0540	−0.0030	0.0003	−0.0027	−0.0567	−0.0537	−0.0540	−0.0030	0.0003	−0.0027
					(−0.11)	(0.01)	(−0.09)				(−0.11)	(0.01)	(−0.00)
	CVaR_99	−0.1091	−0.1067	−0.1128	−0.0024	0.0061	0.0037	−0.1091	−0.1067	−0.1128	−0.0024	0.0061	0.0037
					(−0.05)	(0.14)	(0.07)				(−0.05)	(0.14)	(0.07)
	CVaR_99.9	−0.2217	−0.2752	−0.2203	0.0536	−0.0549	−0.0013	−0.2217	−0.2752	−0.2203	0.0536	−0.0549	−0.0013
					(0.48)	(−0.49)	(−0.01)				(0.48)	(−0.49)	(−0.00)

Note: This table reports the mean VaR and CVaR for different top holder groups of stablecoin tokens with high (H), medium (M), and low (L) levels of wealth concentration for the full sample period and the year 2022. Calculations are based on the daily returns derived from daily closing prices. Each token's daily closing price data spans from its initial listing until May 13, 2024. For each top token holding group, the mean VaR and mean CVaR values are calculated as follows: Mean $\text{VaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n}\text{VaR}_{\alpha,i}$ and Mean $\text{CVaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n}\text{CVaR}_{\alpha,i}$, where n is the number of tokens in the group, and i indexes the individual tokens. The mean differences in VaR and CVaR between groups are calculated at three confidence levels (95 %, 99 %, and 99.9 %) across top holder groups: Top (1, 10, 20, 50, 100) and the Rest of the token holding group. The mean differences are computed between high-medium (H-M), medium-low (M-L), and high-low (H-L) groups. The top 100 rich list for each token used in this study is downloaded as of October 10, 2022. Table A.4 shows the wealth distribution among the top 100 richest wallet addresses holding 33 stablecoins.
t-statistics are reported in parentheses.
*, **, and *** denote significance at the 10 %, 5 %, and 1 % levels, respectively.

and distort market behaviors, eroding trust in DeFi markets. Additionally, collateral shortages may occur if these holders withdraw or lock up their stablecoins, potentially triggering liquidation events and disrupting lending and borrowing activities. This inequality of access and reduced innovation could hinder the broader adoption and growth of DeFi.

Table A.7 in the Appendices lists the top 33 stablecoins with the highest market capitalization, number of wallet addresses, and the percentage of wealth held by the top 1 to top 100 wallet addresses. Table A.8 shows the average concentration of wealth among the top 100 wealthiest wallet addresses for these stablecoins. The table indicates that the top 100 wealthiest addresses hold an average of 92.23 % of the wealth across all stablecoins, while the remaining 99.79 % of addresses hold an average of just 6.77 %. To explore the potential risks associated with this significant disparity in wealth distribution, the analysis is extended to investigate the daily returns of the selected stablecoins. These returns are then sorted to estimate the mean VaR and CVaR for each top-tier token holding group and the remaining token holders.

Table 4 presents the VaR and CVaR for stablecoin top holder groups categorized by wealth concentration (high, medium, low). High-concentration groups exhibit the least negative values, indicating lower potential losses compared to medium and low groups. This suggests that wealth concentrated among fewer holders leads to more stable and less risky behavior. Significant differences are particularly evident for Top1 holders, where the Top1 CVaR_99.9 shows a 30.31 % difference between medium and low groups, indicating enhanced stability with a more concentrated wealth distribution. For other groups (Top10 to Rest), the differences are less pronounced and largely insignificant, implying that smaller holders' wealth concentration has minimal impact on risk profiles. These findings confirm that wealth concentration at the topmost level (Top1 holders) plays a critical role in the stability of stablecoins. Analysis for 2022 further supports these results, showing significant differences in risk metrics across wealth concentration levels, especially for high-concentration groups, which exhibit lower risk exposure.

Stablecoins differ significantly from most other crypto tokens due to their primary use cases, which include trading, liquidity provision, yield farming, and custodial operations. These distinctive functions lead to a unique distribution profile across wallets. To appropriately reflect these differences, we categorized wallets holding these stablecoins into exchange-held and custodial wallets (see Table A.9 for details on wallet classification). Our analysis indicates that major centralized exchanges, such as Binance, Coinbase, and Kraken, typically hold relatively modest proportions of stablecoins, often comprising less than 5 % of the total circulating supply per wallet. However, Bitfinex notably diverges from this pattern, single-handedly accounting for approximately 18.56 % of all stablecoin holdings in our dataset. Bitfinex's substantial share is primarily attributed to its deep operational integration with Tether Ltd., the issuer of USDT, the largest stablecoin by market capitalization. Both entities share the same parent company, iFinex, resulting in newly minted USDT frequently being routed through Bitfinex first, thus inflating its visible on-chain stablecoin balance. Additionally, Bitfinex has played a pioneering role in launching and supporting other stablecoins, such as Tether Gold (XAUT), CNHT (offshore yuan-pegged), and EURT (euro-pegged), and has also been an early advocate of prominent alternatives like USDC and DAI. Further enhancing its dominance is Bitfinex's function as a major liquidity provider, its prominent OTC trading operations, and the transparency of its wallet structures. The exchange was also among the earliest to list innovative stablecoins like EURQ and USDQ[7] Nonetheless, despite these operational justifications, concentrating a significant volume of stablecoins within a single entity such as Bitfinex introduces noteworthy centralization risks. Events such as governance breakdowns, legal disputes, or technical vulnerabilities could propagate systemic shocks across the broader cryptocurrency ecosystem. Consequently, we argue that operational concentration must still be recognized as a critical measure of centralization risk.

4.5. Smart contracts

While governance tokens empower the community to shape the future of a project, smart contract tokens facilitate its core functionality and value proposition. Both types of tokens are essential to the DeFi ecosystem. However, when a small number of wallet addresses hold a significant share of smart contract tokens, they may influence the allocation of resources within the DeFi protocol to benefit themselves, potentially at the expense of the broader community.

Table A.10 in the Appendices shows the distribution of wealth among the top holders of the 50 most valuable smart contract tokens. Furthermore, Table A.11 shows, on average, the top 100 wealthiest addresses in the top 50 smart contract tokens hold 77.04 % of the wealth, while the remaining addresses hold 22.96 %. This indicates that a very small number of participants control a large majority of the wealth in the smart contracts ecosystem. One potential way to address centralization is by implementing mechanisms within smart contracts that discourage large holdings, such as increasing gas fees for large transactions or enforcing a maximum holding limit.

Table 5 shows minimal and statistically insignificant differences in risk exposure between wealth levels of smart contract token holders, as measured by VaR and CVaR. For instance, the CVaR_95 for Top1 holders is −0.1652 (H), −0.1660 (M), and −0.1707 (L), with minor differences of 0.0007 (H-M) and 0.0047 (M-L), and t-statistics of 0.06 and 0.33, respectively. This indicates no significant variation in potential losses across different wealth concentrations. However, the robustness check for 2022 highlights that medium wealth concentration holders face slightly lower risk, with a significant difference of 0.0192 at the 10 % level between medium and low VaR_95 values. These findings suggest a relatively uniform risk landscape for smart contract token holders, where medium concentration holders may benefit from slightly better risk management practices.

[7] See more at; https://blog.bitfinex.com/tag/stablecoin/.

Table 5
Value at risk and the expected shortfall for different holder groups for smart contract tokens.

Group	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
Top1	VaR_95	−0.1102	−0.1115	−0.1141	0.0013	0.0026	0.0040	−0.0934	−0.0862	−0.1054	−0.0071	0.0192*	0.0121
					(0.17)	(0.30)	(0.53)				(−0.89)	(1.78)	(1.06)
	VaR_99	−0.1938	−0.1899	−0.1935	−0.0039	0.0035	−0.0003	−0.1664	−0.1568	−0.1784	−0.0095	0.0216	0.0121
					(−0.30)	(0.23)	(−0.03)				(−0.57)	(1.07)	(0.57)
	VaR_99.9	−0.3658	−0.3399	−0.3664	−0.0259	0.0265	0.0006	−0.2992	−0.2462	−0.3254	−0.0530	0.0791	0.0261
					(−0.66)	(0.63)	(0.01)				(−1.40)	(1.60)	(0.44)
	CVaR_95	−0.1652	−0.1660	−0.1707	0.0007	0.0047	0.0055	−0.1426	−0.1306	−0.1593	−0.0120	0.0287	0.0167
					(0.06)	(0.33)	(0.47)				(−0.94)	(1.65)	(0.88)
	CVaR_99	−0.2701	−0.2592	−0.2759	−0.0109	0.0167	0.0059	−0.2340	−0.2092	−0.2542	−0.0248	0.0449	0.0201
					(−0.43)	(0.65)	(0.23)				(−1.00)	(1.43)	(0.55)
	CVaR_99.9	−0.4494	−0.4041	−0.4667	−0.0453	0.0626	0.0173	−0.3366	−0.2640	−0.3629	−0.0726	0.0989	0.0263
					(−0.88)	(1.01)	(0.27)				(−1.53)	(1.67)	(0.37)
Top10	VaR_95	−0.1115	−0.1111	−0.1131	−0.0004	0.0020	0.0016	−0.0939	−0.0934	−0.0972	−0.0005	0.0038	0.0032
					(−0.05)	(0.22)	(0.21)				(−0.06)	(0.33)	(0.28)
	VaR_99	−0.1942	−0.1882	−0.1950	−0.0060	0.0069	0.0009	−0.1634	−0.1632	−0.1745	−0.0002	0.0113	0.0111
					(−0.45)	(0.46)	(0.07)				(−0.01)	(0.55)	(0.52)
	VaR_99.9	−0.3666	−0.3353	−0.3705	−0.0313	0.0352	0.0039	−0.2932	−0.2577	−0.3192	−0.0355	0.0615	0.0260
					(−0.78)	(0.85)	(0.09)				(−0.92)	(1.21)	(0.44)
	CVaR_95	−0.1665	−0.1647	−0.1709	−0.0017	0.0061	0.0044	−0.1413	−0.1385	−0.1521	−0.0027	0.0136	0.0109
					(−0.13)	(0.43)	(0.39)				(−0.21)	(0.76)	(0.56)
	CVaR_99	−0.2720	−0.2546	−0.2788	−0.0174	0.0242	0.0068	−0.2308	−0.2155	−0.2506	−0.0153	0.0351	0.0198
					(−0.68)	(0.95)	(0.27)				(−0.60)	(1.10)	(0.54)
	CVaR_99.9	−0.4439	−0.3980	−0.4787	−0.0459	0.0807	0.0348	−0.3255	−0.2830	−0.3536	−0.0424	0.0705	0.0281
					(−0.86)	(1.33)	(0.56)				(−0.88)	(1.15)	(0.39)
Top20	VaR_95	−0.1115	−0.1119	−0.1124	0.0004	0.0005	0.0009	−0.0945	−0.0911	−0.0990	−0.0034	0.0079	0.0045
					(0.05)	(0.06)	(0.12)				(−0.38)	(0.70)	(0.40)
	VaR_99	−0.1937	−0.1932	−0.1901	−0.0005	−0.0031	−0.0036	−0.1637	−0.1607	−0.1768	−0.0030	0.0161	0.0131
					(−0.04)	(−0.21)	(−0.26)				(−0.17)	(0.79)	(0.63)
	VaR_99.9	−0.3673	−0.3449	−0.3595	−0.0224	0.0146	−0.0077	−0.3017	−0.2477	−0.3213	−0.0541	0.0737	0.0196
					(−0.54)	(0.35)	(−0.12)				(−1.41)	(1.45)	(0.34)
	CVaR_95	−0.1665	−0.1677	−0.1676	0.0012	−0.0000	0.0011	−0.1424	−0.1354	−0.1544	−0.0071	0.0190	0.0119
					(0.09)	(−0.00)	(0.10)				(−0.52)	(1.07)	(0.64)
	CVaR_99	−0.2734	−0.2611	−0.2705	−0.0123	0.0093	−0.0030	−0.2356	−0.2086	−0.2533	−0.0270	0.0447	0.0177
					(−0.47)	(0.36)	(−0.11)				(−1.06)	(1.41)	(0.50)
	CVaR_99.9	−0.4429	−0.4127	−0.4639	−0.0302	0.0512	0.0210	−0.3364	−0.2712	−0.3553	−0.0651	0.0841	0.0189
					(−0.54)	(0.83)	(0.34)				(−1.37)	(1.37)	(0.27)
Top50	VaR_95	−0.1096	−0.1170	−0.1088	0.0074	−0.0082	−0.0008	−0.0939	−0.0961	−0.0943	0.0022	−0.0018	0.0004
					(1.01)	(−0.94)	(−0.10)				(0.25)	(−0.15)	(0.03)
	VaR_99	−0.1873	−0.2045	−0.1845	0.0172	−0.0200	−0.0028	−0.1614	−0.1698	−0.1695	0.0084	−0.0003	0.0081
					(1.37)	(−1.32)	(−0.20)				(0.47)	(−0.02)	(0.39)
	VaR_99.9	−0.3410	−0.3831	−0.3449	0.0421	−0.0382	0.0039	−0.2930	−0.2703	−0.3059	−0.0227	0.0356	0.0129
					(1.06)	(−0.82)	(0.11)				(−0.55)	(0.68)	(0.23)

(*continued on next page*)

Table 5 (*continued*)

Group	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
	CVaR_95	−0.1606	−0.1776	−0.1629	0.0169	−0.0146	0.0023	−0.1400	−0.1436	−0.1481	0.0036	0.0045	0.0081
					(1.39)	(−1.00)	(0.21)				(0.26)	(0.25)	(0.43)
	CVaR_99	−0.2565	−0.2852	−0.2615	0.0287	−0.0237	0.0050	−0.2301	−0.2238	−0.2425	−0.0063	0.0187	0.0124
					(1.15)	(−0.82)	(0.25)				(−0.23)	(0.58)	(0.35)
	CVaR_99.9	−0.4236	−0.4475	−0.4460	0.0239	−0.0014	0.0224	−0.3291	−0.2947	−0.3374	−0.0344	0.0427	0.0083
					(0.43)	(−0.02)	(0.38)				(−0.67)	(0.68)	(0.12)
Top100	VaR_95	−0.1098	−0.1168	−0.1088	0.0071	−0.0080	−0.0009	−0.0936	−0.0964	−0.0943	0.0027	−0.0020	0.0007
					(0.98)	(−0.91)	(−0.11)				(0.31)	(−0.18)	(0.06)
	VaR_99	−0.1874	−0.2034	−0.1845	0.0160	−0.0189	−0.0029	−0.1595	−0.1715	−0.1695	0.0120	−0.0021	0.0099
					(1.27)	(−1.22)	(−0.20)				(0.67)	(−0.10)	(0.48)
	VaR_99.9	−0.3421	−0.3829	−0.3436	0.0408	−0.0393	0.0016	−0.2905	−0.2726	−0.3059	−0.0179	0.0333	0.0154
					(1.03)	(−0.85)	(0.05)				(−0.43)	(0.64)	(0.27)
	CVaR_95	−0.1618	−0.1769	−0.1631	0.0151	−0.0138	0.0014	−0.1392	−0.1443	−0.1481	0.0050	0.0038	0.0088
					(1.25)	(−0.95)	(0.12)				(0.36)	(0.21)	(0.47)
	CVaR_99	−0.2588	−0.2838	−0.2628	0.0251	−0.0211	0.0040	−0.2284	−0.2253	−0.2425	−0.0031	0.0172	0.0141
					(1.03)	(−0.72)	(0.19)				(−0.11)	(0.53)	(0.40)
	CVaR_99.9	−0.4251	−0.4544	−0.4450	0.0293	−0.0106	0.0188	−0.3254	−0.2982	−0.3374	−0.0272	0.0392	0.0121
					(0.51)	(−0.18)	(0.32)				(−0.52)	(0.63)	(0.17)
Rest	VaR_95	−0.1088	−0.1168	−0.1098	0.0080	−0.0071	0.0009	−0.0943	−0.0964	−0.0936	0.0020	−0.0027	−0.0007
					(0.92)	(−0.96)	(0.12)				(0.18)	(−0.31)	(−0.06)
	VaR_99	−0.1845	−0.2043	−0.1874	0.0199	−0.0169	0.0030	−0.1695	−0.1715	−0.1595	0.0021	−0.0120	−0.0099
					(1.31)	(−1.34)	(0.25)				(0.10)	(−0.67)	(−0.48)
	VaR_99.9	−0.3449	−0.3837	−0.3403	0.0388	−0.0434	−0.0046	−0.3059	−0.2726	−0.2905	−0.0333	0.0179	−0.0154
					(0.83)	(−1.09)	(−0.10)				(−0.64)	(0.43)	(−0.27)
	CVaR_95	−0.1629	−0.1774	−0.1608	0.0145	−0.0166	−0.0021	−0.1481	−0.1443	−0.1392	−0.0038	−0.0050	−0.0088
					(0.98)	(−1.35)	(−0.10)				(−0.21)	(−0.36)	(−0.47)
	CVaR_99	−0.2615	−0.2855	−0.2562	0.0240	−0.0293	−0.0053	−0.2425	−0.2253	−0.2284	−0.0172	0.0031	−0.0141
					(0.83)	(−1.18)	(−0.20)				(−0.53)	(0.11)	(−0.40)
	CVaR_99.9	−0.4460	−0.4466	−0.4245	0.0006	−0.0222	−0.0216	−0.3374	−0.2982	−0.3254	−0.0392	0.0272	−0.0121
					(0.01)	(−0.40)	(−0.32)				(−0.63)	(0.52)	(−0.17)

Note: This table reports the mean VaR and CVaR for different top holder groups of smart contract tokens with high (H), medium (M), and low (L) levels of wealth concentration for the full sample period and the year 2022. Calculations are based on the daily returns derived from daily closing prices. Each token's daily closing price data spans from its initial listing until May 13, 2024. For each top token holding group, the mean VaR and mean CVaR values are calculated as follows: Mean $\text{VaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{VaR}_{\alpha,i}$ and Mean $\text{CVaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{CVaR}_{\alpha,i}$, where n is the number of tokens in the group, and i indexes the individual tokens. The mean differences in VaR and CVaR between groups are calculated at three confidence levels (95 %, 99 %, and 99.9 %) across top holder groups: Top (1, 10, 20, 50, 100) and the Rest of the token holding group. The mean differences are computed between high-medium (H-M), medium-low (M-L), and high-low (H-L) groups. The top 100 rich list for each token used in this study is downloaded as of October 10, 2022. Table A.5 shows the wealth distribution among the top 100 richest wallet addresses holding these tokens.
t-statistics are reported in parentheses.
*, **, and *** denote significance at the 10 %, 5 %, and 1 % levels, respectively.

4.6. Oracles

Oracles play a critical role in providing accurate and reliable data to DeFi applications (Liu et al., 2021). However, when a small number of addresses hold a large majority of oracle tokens, these powerful holders can potentially manipulate the data underpinning DeFi protocols. Table A.12 in the Appendices lists the 27 oracle tokens analyzed in this study. Table A.13 summarizes the wealth centralization among the top 100 wealthiest addresses for 27 leading oracle tokens, showing that these addresses hold an average of 83.59 % of the wealth, leaving just 16.41 % for the remaining 99.85 % of addresses. This extreme centralization raises concerns about the decentralization and resilience of oracle networks. Monolithic oracle chains and Chainlink, in particular, have been criticized for centralization risks, with the former relying on a few nodes and the latter on a limited number of trusted nodes, increasing vulnerability to manipulation. Such wealth concentration could impair DeFi operations by enabling data manipulation, leading to incorrect asset pricing and eroding trust in the ecosystem. To evaluate the risk impact of this concentration, we calculated the mean VaR and CVaR for top-tier and remaining holders of oracle tokens, using returns illustrated in Figure A.3 in the Appendices.

Table 6 presents the VaR and CVaR metrics for different oracle token holder groups, providing insights into potential losses. For instance, Top1 holders in the high wealth concentration group show a VaR_95 of −0.1283, indicating a 5 % chance of losing at least 12.83 % of value. The differences between groups are small and statistically insignificant, suggesting that wealth concentration does not significantly impact risk exposure. For example, Top1 holders have a VaR_99.9 of −0.3703 (high concentration) compared to −0.4137 (medium) and −0.4098 (low), with insignificant t-statistics (for example, 0.56 for H - M). This indicates that wealth distribution is not a major factor in determining the risk profile of oracle tokens. A robustness check for 2022 data reveals a significant difference in VaR_95 between high and medium concentration for Top1 holders, but no major differences for Top10 and Top20 groups. The Rest group shows a significant difference in VaR_99 between high and medium concentration. Overall, risk differences are more pronounced at the 95 % confidence level, especially for Top1 holders, with less variation observed for larger holder groups.

4.7. DAOs

Unlike conventional organizations with centralized leadership, DAOs operate on a decentralized model of collective decision-making. They are governed by a consensus-based system where token holders vote on proposals that shape the DAO's direction. DAOs utilize smart contracts to automate governance and ensure transparency. While this decentralized model offers advantages over traditional hierarchies, it also presents risks, such as the centralization of token ownership, which can lead to governance manipulation, unethical decisions, and security threats (Wright, 2020). Implementing clear conflict-of-interest policies is essential to prevent abuse of voting power. Table A.14 in the Appendices presents the top 40 DAO tokens in the DeFi ecosystem, detailing their market capitalization distribution and the concentration of ownership among holders.

Table A.15 in the Appendix shows that, in the top 40 DAO tokens, the wealthiest 100 addresses hold 82.85 % of the wealth, while 99.76 % of addresses collectively hold only 17.15 %. This highlights significant wealth centralization in DAOs. To assess whether this impacts risk, daily returns of selected DAO tokens were calculated to estimate the mean VaR and CVaR for top holders and the rest.

Table 7 shows that top 1 % of holders with high wealth concentration have lower risk metrics (VaR, CVaR) compared to those with medium or low concentrations. Positive (H - M) and (H - L) differences indicate that top holders face less risk, potentially due to better risk management. Conversely, lower wealth concentration is associated with higher risk for other groups, as reflected in negative (H - M) and (H - L) differences. Significant results at higher confidence levels suggest that wealth concentration influences risk exposure.

The 2022 analysis reveals distinct risk profiles based on wealth concentration. For Top1 holders, high concentration tokens have a VaR of −0.2279 at the 99 % confidence level, significantly lower than Medium at −0.3544, with similar trends observed at the 99.9 % level. Significant differences are also observed in the Top10 and Top20 groups across confidence levels, indicating higher risk for those with concentrated wealth. For Top50, Top100, and Rest groups, the Top50 shows significant VaR differences at the 99.9 % level, while the Top100 exhibits differences at the 95 % VaR and 99.9 % CVaR levels. The Rest group shows higher risks for lower concentration levels, particularly at the 95 % and 99 % VaR levels.

These findings highlight the influence of wealth concentration on risk exposure. In Table 7, for the Top10, VaR difference at 99.9 % (H - M) is 0.1646 (5 % significance), while the Top50's VaR_99 difference (H - L) is 0.1534 (10 %), and the Top100's is 0.1622 (5 %). Although the Rest group shows lower VaR and CVaR, particularly in CVaR_99.9, these differences are not statistically significant. However, CVaR_95 and CVaR_99 differences are significant at the 10 % level, suggesting that lower concentration groups may face reduced extreme risk exposure.

4.8. Governance

Token voting is the most common governance mechanism in DeFi, where participants use governance tokens to influence protocol decisions based on their holdings. However, variations in governance structures and token distribution raise concerns about centralization. Table A.16 in the Appendices highlights significant wealth centralization among the top 33 DeFi governance tokens, with the top 1 % of wallets holding a substantial share. On average, the top wallet holds 34.05 % of tokens, while the top 100 wallets hold 84.35 %. Tokens like Aragon (ANT) and Ribbon Finance (RBN) exhibit extreme concentration, with the top wallet holding over 69 %. This level of concentration challenges the decentralization of governance tokens and DeFi's democratizing potential.

Wealth concentration in governance tokens presents a complex challenge. High concentration allows a few entities to heavily influence protocol decisions, posing governance risks. Tokens like Uniswap (UNI) and Internet Computer (ICP), which have more holders, exhibit lower concentration and greater decentralization. In contrast, tokens with fewer holders often experience higher

Table 6
Value at Risk and the expected shortfall for different holder groups of oracle tokens.

Top	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
Top1	VaR_95	−0.1283	−0.1197	−0.1304	−0.0086	0.0107	0.0021	−0.1162	−0.0965	−0.1192	−0.0197**	0.0227	0.0030
					(−1.06)	(0.87)	(0.18)				(−2.04)	(0.99)	(0.13)
	VaR_99	−0.2174	−0.2148	−0.2383	−0.0026	0.0235	0.0209	−0.2049	−0.1715	−0.1936	−0.0334	0.0221	−0.0112
					(−0.13)	(0.70)	(0.64)				(−1.54)	(0.66)	(−0.30)
	VaR_99.9	−0.3703	−0.4137	−0.4098	0.0434	−0.0040	0.0395	−0.3339	−0.3129	−0.3752	−0.0210	0.0623	0.0414
					(0.56)	(−0.04)	(0.62)				(−0.29)	(0.60)	(0.46)
	CVaR_95	−0.1914	−0.1853	−0.2010	−0.0061	0.0157	0.0096	−0.1795	−0.1468	−0.1774	−0.0327	0.0305	−0.0022
					(−0.31)	(0.57)	(0.38)				(−1.61)	(0.94)	(−0.02)
	CVaR_99	−0.2959	−0.3100	−0.3195	0.0140	0.0095	0.0236	−0.2803	−0.2462	−0.2878	−0.0341	0.0416	0.0075
					(0.29)	(0.16)	(0.49)				(−0.75)	(0.65)	(0.13)
	CVaR_99.9	−0.4087	−0.4583	−0.5245	0.0496	0.0662	0.1158	−0.3516	−0.3480	−0.4229	−0.0037	0.0749	0.0713
					(0.66)	(0.64)	(1.38)				(−0.04)	(0.59)	(0.67)
Top10	VaR_95	−0.1222	−0.1304	−0.1258	0.0082	−0.0046	0.0036	−0.1045	−0.1276	−0.0998	0.0231	−0.0278	−0.0047
					(0.70)	(−0.35)	(0.49)				(1.01)	(−1.22)	(−0.50)
	VaR_99	−0.2241	−0.2399	−0.2065	0.0158	−0.0334	−0.0175	−0.1920	−0.2149	−0.1632	0.0228	−0.0517	−0.0289
					(0.47)	(−1.00)	(−1.00)				(0.64)	(−1.58)	(−1.49)
	VaR_99.9	−0.3695	−0.4641	−0.3601	0.0946	−0.1040	−0.0094	−0.3285	−0.3980	−0.2955	0.0695	−0.1025	−0.0330
					(1.17)	(−1.20)	(−0.10)				(0.84)	(−1.05)	(−0.40)
	CVaR_95	−0.1907	−0.2065	−0.1806	0.0158	−0.0259	−0.0100	−0.1675	−0.1886	−0.1476	0.0211	−0.0411	−0.0199
					(0.58)	(−0.95)	(−0.60)				(0.64)	(−1.30)	(−0.91)
	CVaR_99	−0.2974	−0.3508	−0.2772	0.0534	−0.0736	−0.0202	−0.2672	−0.3133	−0.2338	0.0461	−0.0795	−0.0334
					(0.93)	(−1.32)	(−0.60)				(0.80)	(−1.34)	(−0.66)
	CVaR_99.9	−0.4345	−0.5102	−0.4467	0.0758	−0.0635	0.0123	−0.3572	−0.4435	−0.3219	0.0863	−0.1216	−0.0353
					(0.90)	(−0.61)	(0.15)				(0.86)	(−1.02)	(−0.39)
Top20	VaR_95	−0.1181	−0.1345	−0.1258	0.0164	−0.0087	0.0077	−0.1027	−0.1294	−0.0998	0.0267	−0.0296	−0.0029
					(1.49)	(−0.70)	(1.03)				(1.19)	(−1.32)	(−0.32)
	VaR_99	−0.2205	−0.2435	−0.2065	0.0229	−0.0369	−0.0140	−0.1883	−0.2186	−0.1632	0.0303	−0.0554*	−0.0251
					(0.68)	(−1.14)	(−0.70)				(0.86)	(−1.74)	(−1.21)
	VaR_99.9	−0.3742	−0.4594	−0.3601	0.0852	−0.0993	−0.0141	−0.3362	−0.3903	−0.2955	0.0541	−0.0947	−0.0407
					(1.05)	(−1.13)	(−0.20)				(0.65)	(−0.96)	(−0.50)
	CVaR_95	−0.1872	−0.2099	−0.1806	0.0227	−0.0293	−0.0066	−0.1653	−0.1908	−0.1476	0.0255	−0.0432	−0.0177
					(0.84)	(−1.11)	(−0.40)				(0.78)	(−1.39)	(−0.81)
	CVaR_99	−0.2979	−0.3502	−0.2772	0.0523	−0.0730	−0.0207	−0.2691	−0.3113	−0.2338	0.0421	−0.0775	−0.0354
					(0.91)	(−1.31)	(−0.60)				(0.73)	(−1.30)	(−0.74)
	CVaR_99.9	−0.4382	−0.5065	−0.4467	0.0682	−0.0597	0.0085	−0.3685	−0.4322	−0.3219	0.0637	−0.1103	−0.0466
					(0.81)	(−0.57)	(0.11)				(0.63)	(−0.91)	(−0.47)
Top50	VaR_95	−0.1181	−0.1345	−0.1258	0.0164	−0.0087	0.0077	−0.1027	−0.1294	−0.0998	0.0267	−0.0296	−0.0029
					(1.49)	(−0.70)	(1.03)				(1.19)	(−1.32)	(−0.32)
	VaR_99	−0.2205	−0.2435	−0.2065	0.0229	−0.0369	−0.0140	−0.1883	−0.2186	−0.1632	0.0303	−0.0554*	−0.0251
					(0.68)	(−1.14)	(−0.70)				(0.86)	(−1.74)	(−1.21)
	VaR_99.9	−0.3742	−0.4594	−0.3601	0.0852	−0.0993	−0.0141	−0.3362	−0.3903	−0.2955	0.0541	−0.0947	−0.0407
					(1.05)	(−1.13)	(−0.20)				(0.65)	(−0.96)	(−0.50)

(*continued on next page*)

Table 6 (*continued*)

Top	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
	CVaR_95	−0.1872	−0.2099	−0.1806	0.0227	−0.0293	−0.0066	−0.1653	−0.1908	−0.1476	0.0255	−0.0432	−0.0177
					(0.84)	(−1.11)	(−0.40)				(0.78)	(−1.39)	(−0.81)
	CVaR_99	−0.2979	−0.3502	−0.2772	0.0523	−0.0730	−0.0207	−0.2691	−0.3113	−0.2338	0.0421	−0.0775	−0.0354
					(0.91)	(−1.31)	(−0.60)				(0.73)	(−1.30)	(−0.74)
	CVaR_99.9	−0.4382	−0.5065	−0.4467	0.0682	−0.0597	0.0085	−0.3685	−0.4322	−0.3219	0.0637	−0.1103	−0.0466
					(0.81)	(−0.57)	(0.11)				(0.63)	(−0.91)	(−0.47)
Top100	VaR_95	−0.1181	−0.1345	−0.1258	0.0164	−0.0087	0.0077	−0.1027	−0.1294	−0.0998	0.0267	−0.0296	−0.0029
					(1.49)	(−0.70)	(1.03)				(1.19)	(−1.32)	(−0.32)
	VaR_99	−0.2205	−0.2435	−0.2065	0.0229	−0.0369	−0.0140	−0.1883	−0.2186	−0.1632	0.0303	−0.0554*	−0.0251
					(0.68)	(−1.14)	(−0.70)				(0.86)	(−1.74)	(−1.21)
	VaR_99.9	−0.3742	−0.4594	−0.3601	0.0852	−0.0993	−0.0141	−0.3362	−0.3903	−0.2955	0.0541	−0.0947	−0.0407
					(1.05)	(−1.13)	(−0.20)				(0.65)	(−0.96)	(−0.50)
	CVaR_95	−0.1872	−0.2099	−0.1806	0.0227	−0.0293	−0.0066	−0.1653	−0.1908	−0.1476	0.0255	−0.0432	−0.0177
					(0.84)	(−1.11)	(−0.40)				(0.78)	(−1.39)	(−0.81)
	CVaR_99	−0.2979	−0.3502	−0.2772	0.0523	−0.0730	−0.0207	−0.2691	−0.3113	−0.2338	0.0421	−0.0775	−0.0354
					(0.91)	(−1.31)	(−0.60)				(0.73)	(−1.30)	(−0.74)
	CVaR_99.9	−0.4382	−0.5065	−0.4467	0.0682	−0.0597	0.0085	−0.3685	−0.4322	−0.3219	0.0637	−0.1103	−0.0466
					(0.81)	(−0.57)	(0.11)				(0.63)	(−0.91)	(−0.47)
Rest	VaR_95	−0.1262	−0.1362	−0.1275	0.0100	−0.0087	0.0013	−0.0998	−0.1294	−0.1027	0.0296	−0.0267	0.0029
					(0.89)	(−0.74)	(0.20)				(1.32)	(−1.19)	(0.33)
	VaR_99	−0.2282	−0.2523	−0.2215	0.0241	−0.0308	−0.0067	−0.1632	−0.2186	−0.1883	0.0554*	−0.0303	0.0251
					(0.74)	(−1.00)	(−0.35)				(1.74)	(−0.86)	(1.21)
	VaR_99.9	−0.3683	−0.4512	−0.3662	0.0829	−0.0850	−0.0020	−0.2955	−0.3903	−0.3362	0.0947	−0.0541	0.0407
					(1.03)	(−1.04)	(−0.03)				(0.96)	(−0.65)	(0.50)
	CVaR_95	−0.1928	−0.2168	−0.1840	0.0240	−0.0328	−0.0088	−0.1476	−0.1908	−0.1653	0.0432	−0.0255	0.0177
					(0.90)	(−1.24)	(−0.55)				(1.39)	(−0.78)	(0.81)
	CVaR_99	−0.3043	−0.3622	−0.2914	0.0579	−0.0707	−0.0128	−0.2338	−0.3113	−0.2691	0.0775	−0.0421	0.0354
					(1.01)	(−1.26)	(−0.37)				(1.30)	(−0.73)	(0.74)
	CVaR_99.9	−0.4521	−0.5225	−0.4715	0.0704	−0.0510	−0.0194	−0.3219	−0.4322	−0.3685	0.1103	−0.0637	0.0466
					(0.83)	(−0.51)	(−0.25)				(0.91)	(−0.63)	(0.47)

Note: This table reports the mean VaR and CVaR for different top holder groups of oracle tokens with high (H), medium (M), and low (L) levels of wealth concentration for the full sample period and the year 2022. Calculations are based on the daily returns derived from daily closing prices. Each token's daily closing price data spans from its initial listing until May 13, 2024. For each top token holding group, the mean VaR and mean CVaR values are calculated as follows: Mean $\text{VaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{VaR}_{\alpha,i}$ and Mean $\text{CVaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n} \text{CVaR}_{\alpha,i}$, where n is the number of tokens in the group, and i indexes the individual tokens. The mean differences in VaR and CVaR between groups are calculated at three confidence levels (95 %, 99 %, and 99.9 %) across top holder groups: Top (1, 10, 20, 50, 100) and the Rest of the token holding group. The mean differences are computed between high-medium (H-M), medium-low (M-L), and high-low (H-L) groups. The top 100 rich list for each token used in this study is downloaded as of October 10, 2022. Table A.6 shows the wealth distribution among the top 100 richest wallet addresses holding these oracle tokens.
t-statistics are reported in parentheses.
*, **, and *** denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Table 7
Value at Risk and the expected shortfall for different holder groups of DAO tokens.

Top	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
Top1	VaR_95	−0.1314	−0.1725	−0.1362	0.0411	−0.0362	0.0049	−0.1049	−0.1356	−0.1483	0.0307	0.0128	0.0435
					(1.42)	(−1.25)	(0.28)				(1.03)	(0.30)	(1.32)
	VaR_99	−0.2279	−0.3544	−0.2560	0.1265*	−0.0984	0.0281	−0.1832	−0.2989	−0.2640	0.1157	−0.0348	0.0808
					(1.91)	(−1.47)	(0.72)				(1.63)	(−0.41)	(1.61)
	VaR_99.9	−0.3874	−0.5668	−0.4431	0.1794**	−0.1237	0.0557	−0.3631	−0.4615	−0.3589	0.0985	−0.1027	−0.0042
					(2.03)	(−1.36)	(0.74)				(1.12)	(−1.14)	(−0.05)
	CVaR_95	−0.1949	−0.2826	−0.2120	0.0877*	−0.0706	0.0171	−0.1627	−0.2373	−0.2187	0.0746	−0.0187	0.0559
					(1.84)	(−1.47)	(0.58)				(1.46)	(−0.29)	(1.32)
	CVaR_99	−0.2999	−0.4680	−0.3395	0.1682**	−0.1286	0.0396	−0.2737	−0.3973	−0.3254	0.1236	−0.0719	0.0518
					(2.24)	(−1.68)	(0.78)				(1.67)	(−0.81)	(0.80)
	CVaR_99.9	−0.4450	−0.6164	−0.5227	0.1714*	−0.0936	0.0778	−0.4091	−0.4856	−0.3734	0.0765	−0.1122	−0.0357
					(1.72)	(−0.94)	(0.80)				(0.78)	(−1.21)	(−0.38)
Top10	VaR_95	−0.1109	−0.1885	−0.1394	0.0776***	−0.0491*	0.0285*	−0.1000	−0.1518	−0.1356	0.0518	−0.0162	0.0356
					(3.07)	(−1.78)	(1.85)				(1.68)	(−0.39)	(1.18)
	VaR_99	−0.2017	−0.3576	−0.2787	0.1559**	−0.0788	0.0771*	−0.1830	−0.2903	−0.2735	0.1073	−0.0168	0.0905*
					(2.59)	(−1.14)	(2.00)				(1.53)	(−0.20)	(1.73)
	VaR_99.9	−0.3502	−0.5532	−0.4951	0.2030**	−0.0581	0.1449*	−0.3040	−0.4686	−0.4102	0.1646**	−0.0585	0.1062
					(2.56)	(−0.63)	(1.81)				(2.18)	(−0.60)	(1.37)
	CVaR_95	−0.1700	−0.2909	−0.2277	0.1209***	−0.0632	0.0577**	−0.1549	−0.2402	−0.2234	0.0853*	−0.0167	0.0686
					(2.87)	(−1.30)	(2.03)				(1.69)	(−0.26)	(1.66)
	CVaR_99	−0.2690	−0.4552	−0.3843	0.1862***	−0.0709	0.1153**	−0.2498	−0.3839	−0.3638	0.1341*	−0.0201	0.1141*
					(2.82)	(−0.89)	(2.03)				(1.98)	(−0.22)	(1.71)
	CVaR_99.9	−0.3772	−0.6380	−0.5670	0.2608***	−0.0710	0.1898**	−0.3241	−0.5119	−0.4298	0.1877**	−0.0820	0.1057
					(3.09)	(−0.70)	(2.14)				(2.30)	(−0.78)	(1.28)
Top20	VaR_95	−0.1147	−0.1849	−0.1394	0.0702**	−0.0455	0.0247	−0.1055	−0.1467	−0.1356	0.0412	−0.0111	0.0301
					(2.68)	(−1.60)	(1.60)				(1.31)	(−0.26)	(1.00)
	VaR_99	−0.2070	−0.3526	−0.2787	0.1456**	−0.0739	0.0717*	−0.1895	−0.2843	−0.2735	0.0948	−0.0108	0.0840
					(2.38)	(−1.05)	(1.88)				(1.34)	(−0.12)	(1.61)
	VaR_99.9	−0.3658	−0.5388	−0.4951	0.1731**	−0.0437	0.1293	−0.3278	−0.4467	−0.4102	0.1189	−0.0365	0.0824
					(2.11)	(−0.46)	(1.63)				(1.51)	(−0.36)	(1.08)
	CVaR_95	−0.1761	−0.2853	−0.2277	0.1092**	−0.0576	0.0516*	−0.1620	−0.2335	−0.2234	0.0715	−0.0101	0.0614
					(2.52)	(−1.16)	(1.82)				(1.40)	(−0.16)	(1.50)
	CVaR_99	−0.2815	−0.4436	−0.3843	0.1621**	−0.0593	0.1028*	−0.2651	−0.3697	−0.3638	0.1046	−0.0059	0.0987
					(2.37)	(−0.72)	(1.82)				(1.50)	(−0.06)	(1.49)
	CVaR_99.9	−0.4133	−0.6047	−0.5670	0.1914**	−0.0377	0.1537	−0.3488	−0.4891	−0.4298	0.1402	−0.0592	0.0810
					(2.08)	(−0.36)	(1.67)				(1.64)	(−0.54)	(1.00)
Top50	VaR_95	−0.1147	−0.1620	−0.1642	0.0473**	0.0021	0.0494*	−0.1055	−0.1190	−0.1656	0.0135	0.0466	0.0601
					(2.46)	(0.07)	(1.86)				(0.76)	(1.09)	(1.50)
	VaR_99	−0.2070	−0.3009	−0.3348	0.0938*	0.0340	0.1278**	−0.1895	−0.2203	−0.3429	0.0308	0.1226	0.1534*
					(1.99)	(0.46)	(2.18)				(0.76)	(1.42)	(1.98)

(*continued on next page*)

Table 7 (*continued*)

Top	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
	VaR_99.9	−0.3658	−0.4809	−0.5579	0.1151	0.0770	0.1921**	−0.3278	−0.3855	−0.4764	0.0577	0.0909	0.1486*
					(1.54)	(0.81)	(2.23)				(0.88)	(0.89)	(1.69)
	CVaR_95	−0.1761	−0.2484	−0.2677	0.0723**	0.0193	0.0916**	−0.1620	−0.1853	−0.2757	0.0233	0.0904	0.1137*
					(2.12)	(0.37)	(2.16)				(0.88)	(1.41)	(1.90)
	CVaR_99	−0.2815	−0.3854	−0.4474	0.1039*	0.0621	0.1659**	−0.2651	−0.3070	−0.4318	0.0419	0.1247	0.1666*
					(1.86)	(0.74)	(2.34)				(0.89)	(1.38)	(2.03)
	CVaR_99.9	−0.4133	−0.5496	−0.6267	0.1363	0.0772	0.2134**	−0.3488	−0.4292	−0.4948	0.0803	0.0656	0.1459
					(1.54)	(0.73)	(2.26)				(1.06)	(0.59)	(1.60)
Top100	VaR_95	−0.1147	−0.1709	−0.1663	0.0561***	−0.0146	0.0415*	−0.1055	−0.1057	−0.1800	0.0002	0.0743*	0.0745*
					(3.01)	(−0.51)	(1.83)				(0.02)	(1.79)	(1.81)
	VaR_99	−0.2070	−0.3164	−0.3301	0.1094**	−0.0137	0.0957*	−0.1895	−0.2121	−0.3517	0.0226	0.1396	0.1622**
					(2.36)	(−0.20)	(1.93)				(0.62)	(1.64)	(2.07)
	VaR_99.9	−0.3658	−0.4890	−0.5481	0.1233	0.0591	0.1824*	−0.3278	−0.3995	−0.4613	0.0717	0.0618	0.1335
					(1.69)	(0.68)	(1.91)				(1.04)	(0.61)	(1.56)
	CVaR_95	−0.1761	−0.2598	−0.2718	0.0837**	0.0118	0.0955**	−0.1620	−0.1781	−0.2835	0.0161	0.1054	0.1215*
					(2.45)	(0.25)	(2.36)				(0.72)	(1.67)	(2.01)
	CVaR_99	−0.2815	−0.4032	−0.4544	0.1217**	0.0511	0.1728**	−0.2651	−0.3134	−0.4249	0.0483	0.1115	0.1598*
					(2.21)	(0.62)	(2.43)				(0.97)	(1.22)	(1.96)
	CVaR_99.9	−0.4133	−0.5749	−0.6345	0.1616*	0.0596	0.2212**	−0.3488	−0.4479	−0.4745	0.0990	−0.0266	0.1257
					(1.89)	(0.54)	(2.35)				(1.23)	(−0.24)	(1.44)
Rest	VaR_95	−0.1757	−0.1514	−0.1147	−0.0242	−0.0367*	−0.0609**	−0.1800	−0.1057	−0.1055	−0.0743*	−0.0002	−0.0745*
					(−0.79)	(−1.85)	(−2.30)				(−1.79)	(−0.02)	(−1.81)
	VaR_99	−0.3498	−0.2871	−0.2070	−0.0627	−0.0800*	−0.1428**	−0.3517	−0.2121	−0.1895	−0.1396	−0.0226	−0.1622**
					(−0.86)	(−1.70)	(−2.40)				(−1.64)	(−0.62)	(−2.07)
	VaR_99.9	−0.5528	0.4856	−0.3658	−0.0672	−0.1198	−0.1870**	−0.4613	−0.3995	−0.3278	−0.0618	−0.0717	−0.1335
					(−0.70)	(−1.59)	(−2.10)				(−0.61)	(−1.04)	(−1.56)
	CVaR_95	−0.2806	−0.2365	−0.1761	−0.0440	−0.0604*	−0.1044**	−0.2835	−0.1781	−0.1620	−0.1054	−0.0161	−0.1215*
					(−0.85)	(−1.77)	(−2.50)				(−1.67)	(−0.72)	(−2.01)
	CVaR_99	−0.4572	−0.3763	−0.2815	−0.0809	−0.0948*	−0.1757**	−0.4249	−0.3134	−0.2651	−0.1115	−0.0483	−0.1598*
					(−0.98)	(−1.77)	(−2.50)				(−1.22)	(−0.97)	(−1.96)
	CVaR_99.9	−0.6136	−0.5618	−0.4133	−0.0518	−0.1485	−0.2003**	−0.4745	−0.4479	−0.3488	−0.0266	−0.0990	−0.1257
					(−0.49)	(−1.67)	(−2.10)				(−0.24)	(−1.23)	(−1.44)

Note: This table reports the mean VaR and CVaR for different top holder groups of DAO tokens with high (H), medium (M), and low (L) levels of wealth concentration for the full sample period and the year 2022. Calculations are based on the daily returns derived from daily closing prices. Each token's daily closing price data spans from its initial listing until May 13, 2024. For each top token holding group, the mean VaR and mean CVaR values are calculated as follows: Mean $\text{VaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n}\text{VaR}_{\alpha,i}$ and Mean $\text{CVaR}_{\text{group}} = \frac{1}{n}\sum_{i=1}^{n}\text{CVaR}_{\alpha,i}$, where n is the number of tokens in the group, and i indexes the individual tokens. The mean differences in VaR and CVaR between groups are calculated at three confidence levels (95 %, 99 %, and 99.9 %) across top holder groups: Top (1, 10, 20, 50, 100) and the Rest of the token holding group. The mean differences are computed between high-medium (H-M), medium-low (M-L), and high-low (H-L) groups. The top 100 rich list for each token used in this study is downloaded as of October 10, 2022. Table A.7 shows the wealth distribution among the top 100 richest wallet addresses holding these DAO tokens.
t-statistics are reported in parentheses.
*, **, and *** denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Table 8
Value at Risk and the expected shortfall for different holder groups for governance tokens.

Top	CI	Full Sample						2022					
		H	M	L	H - M	M - L	H - L	H	M	L	H - M	M - L	H - L
Top1	VaR_95	−0.12596	−0.10826	−0.11141	−0.0177	0.0032	−0.0145	−0.09319	−0.09551	−0.09701	0.0023	0.0015	0.0038
					(−0.71)	(0.32)	(−0.60)				(0.16)	(0.15)	(0.30)
	VaR_99	−0.22527	−0.17782	−0.18951	−0.0474	0.0117	−0.0358	−0.16562	−0.15694	−0.16464	−0.0087	0.0077	−0.0010
					(−1.04)	(0.66)	(−0.70)				(−0.37)	(0.57)	(−0.03)
	VaR_99.9	−0.36566	−0.32780	−0.30872	−0.0379	−0.0191	−0.0569	−0.24727	−0.26630	−0.23248	0.0190	−0.0338	−0.0148
					(−0.52)	(−0.46)	(−0.70)				(0.54)	(−1.15)	(−0.51)
	CVaR_95	−0.19244	−0.15861	−0.16198	−0.0338	0.0034	−0.0305	−0.13834	−0.13800	−0.13664	−0.0003	−0.0014	−0.0017
					(−0.88)	(0.23)	(−0.81)				(−0.02)	(−0.12)	(−0.15)
	CVaR_99	−0.29621	−0.25145	−0.24925	−0.0448	−0.0022	−0.0470	−0.21251	−0.21505	−0.20170	0.0025	−0.0134	−0.0108
					(−0.76)	(−0.08)	(−0.82)				(0.09)	(−0.68)	(−0.42)
	CVaR_99.9	−0.41560	−0.40404	−0.40637	−0.0116	0.0023	−0.0092	−0.26605	−0.29072	−0.24846	0.0247	−0.0423	−0.0176
					(−0.13)	(0.04)	(−0.11)				(0.60)	(−1.19)	(−0.52)
Top10	VaR_95	−0.13165	−0.10226	−0.11172	−0.0294	0.0095	−0.0199	−0.09737	−0.08878	−0.09956	−0.0086	0.0108	0.0022
					(−1.22)	(1.08)	(−0.84)				(−0.64)	(1.10)	(0.16)
	VaR_99	−0.23501	−0.17559	−0.18200	−0.0594	0.0064	−0.0530	−0.17409	−0.15090	−0.16221	−0.0232	0.0113	−0.0119
					(−1.30)	(0.44)	(−1.12)				(−1.01)	(0.91)	(−0.51)
	VaR_99.9	−0.39581	−0.30718	−0.29919	−0.0886	−0.0080	−0.0966	−0.25987	−0.25995	−0.22623	0.0001	−0.0337	−0.0336
					(−1.25)	(−0.21)	(−1.43)				(0.00)	(−1.26)	(−1.04)
	CVaR_95	−0.20121	−0.15311	−0.15871	−0.0481	0.0056	−0.0425	−0.14368	−0.13266	−0.13664	−0.0110	0.0040	−0.0070
					(−1.27)	(0.43)	(−1.15)				(−0.61)	(0.36)	(−0.43)
	CVaR_99	−0.31637	−0.24042	−0.24012	−0.0759	−0.0003	−0.0762	−0.22066	−0.21067	−0.19793	−0.0100	−0.0127	−0.0227
					(−1.32)	(−0.01)	(−1.34)				(−0.36)	(−0.70)	(−0.95)
	CVaR_99.9	−0.47135	−0.35868	−0.39598	−0.1127	0.0373	−0.0754	−0.27675	−0.28628	−0.24220	0.0095	−0.0441	−0.0345
					(−1.24)	(0.63)	(−0.81)				(0.23)	(−1.31)	(−0.94)
Top20	VaR_95	−0.13165	−0.10226	−0.11172	−0.0294	0.0095	−0.0199	−0.09737	−0.08878	−0.09956	−0.0086	0.0108	0.0022
					(−1.22)	(1.08)	(−0.84)				(−0.64)	(1.10)	(0.16)
	VaR_99	−0.23501	−0.17559	−0.18200	−0.0594	0.0064	−0.0530	−0.17409	−0.15090	−0.16221	−0.0232	0.0113	−0.0119
					(−1.30)	(0.44)	(−1.12)				(−1.01)	(0.91)	(−0.51)
	VaR_99.9	−0.39581	−0.30718	−0.29919	−0.0886	−0.0080	−0.0966	−0.25987	−0.25995	−0.22623	0.0001	−0.0337	−0.0336
					(−1.25)	(−0.21)	(−1.43)				(0.00)	(−1.26)	(−1.04)
	CVaR_95	−0.20121	−0.15311	−0.15871	−0.0481	0.0056	−0.0425	−0.14368	−0.13266	−0.13664	−0.0110	0.0040	−0.0070
					(−1.27)	(0.43)	(−1.15)				(−0.61)	(0.36)	(−0.43)
	CVaR_99	−0.31637	−0.24042	−0.24012	−0.0759	−0.0003	−0.0762	−0.22066	−0.21067	−0.19793	−0.0100	−0.0127	−0.0227
					(−1.32)	(−0.01)	(−1.34)				(−0.36)	(−0.70)	(−0.95)
	CVaR_99.9	−0.47135	−0.35868	−0.39598	−0.1127	0.0373	−0.0754	−0.27675	−0.28628	−0.24220	0.0095	−0.0441	−0.0345
					(−1.24)	(0.63)	(−0.81)				(0.23)	(−1.31)	(−0.94)
Top50	VaR_95	−0.12952	−0.11038	−0.10573	−0.0191	−0.0047	−0.0238	−0.09705	−0.09782	−0.09084	0.0008	−0.0070	−0.0062
					(−0.77)	(−0.48)	(−1.01)				(0.05)	(−0.69)	(−0.54)
	VaR_99	−0.22477	−0.19250	−0.17533	−0.0323	−0.0172	−0.0494	−0.16855	−0.16009	−0.15856	−0.0085	−0.0015	−0.0100
					(−0.69)	(−0.95)	(−1.11)				(−0.36)	(−0.11)	(−0.41)
	VaR_99.9	−0.38819	−0.32121	−0.29278	−0.0670	−0.0284	−0.0954	−0.26338	−0.26074	−0.22193	−0.0026	−0.0388	−0.0415
					(−0.95)	(−0.71)	(−1.30)				(−0.07)	(−1.54)	(−1.31)
	CVaR_95	−0.19587	−0.16426	−0.15290	−0.0316	−0.0114	−0.0430	−0.14226	−0.14066	−0.13006	−0.0016	−0.0106	−0.0122
					(−0.81)	(−0.78)	(−1.16)				(−0.09)	(−0.96)	(−0.70)

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Table 8 (*continued*)

Top	CI	Full Sample H	M	L	H - M	M - L	H - L	2022 H	M	L	H - M	M - L	H - L
	CVaR_99	−0.30626	−0.25940	−0.23125	−0.0469	−0.0282	−0.0750	−0.21902	−0.21842	−0.19182	−0.0006	−0.0266	−0.0272
					(−0.80)	(−1.08)	(−1.34)				(−0.02)	(−1.49)	(−1.11)
	CVaR_99.9	−0.44582	−0.41144	−0.36875	−0.0344	−0.0427	−0.0771	−0.28306	−0.28201	−0.24016	−0.0010	−0.0418	−0.0429
					(−0.38)	(−0.67)	(−0.90)				(−0.03)	(−1.30)	(−1.14)
Top100	VaR_95	−0.12952	−0.11038	−0.10573	−0.0191	−0.0047	−0.0238	−0.09723	−0.09293	−0.09314	−0.0043	0.0002	−0.0041
					(−0.77)	(−0.48)	(−1.01)				(−0.29)	(0.02)	(−0.25)
	VaR_99	−0.22477	−0.19250	−0.17533	−0.0323	−0.0172	−0.0494	−0.16358	−0.15618	−0.15949	−0.0074	0.0033	−0.0040
					(−0.69)	(−0.95)	(−1.11)				(−0.30)	(0.22)	(−0.14)
	VaR_99.9	−0.38819	−0.32121	−0.29278	−0.0670	−0.0284	−0.0954	−0.24674	−0.25477	−0.22810	0.0080	−0.0267	−0.0187
					(−0.95)	(−0.71)	(−1.30)				(0.20)	(−1.00)	(−0.62)
	CVaR_95	−0.19587	−0.16426	−0.15290	−0.0316	−0.0114	−0.0430	−0.13908	−0.13622	−0.13141	−0.0029	−0.0048	−0.0076
					(−0.81)	(−0.78)	(−1.16)				(−0.16)	(−0.40)	(−0.42)
	CVaR_99	−0.30626	−0.25940	−0.23125	−0.0469	−0.0282	−0.0750	−0.21512	−0.21210	−0.19562	−0.0030	−0.0164	−0.0194
					(−0.80)	(−1.08)	(−1.34)				(−0.10)	(−0.86)	(−0.69)
	CVaR_99.9	−0.44582	−0.41144	−0.36875	−0.0344	−0.0427	−0.0771	−0.27807	−0.28424	−0.23871	0.0062	−0.0455	−0.0394
					(−0.38)	(−0.67)	(−0.90)				(0.15)	(−1.34)	(−0.97)
Remaining	VaR_95	−0.10573	−0.11038	−0.12952	0.0047	0.0191	0.0238	−0.09721	−0.09389	−0.09429	−0.0033	0.0004	−0.0029
					(0.48)	(0.77)	(1.01)				(−0.22)	(0.03)	(−0.18)
	VaR_99	−0.17533	−0.19250	−0.22477	0.0172	0.0323	0.0494	−0.16338	−0.15778	−0.16105	−0.0056	0.0033	−0.0023
					(0.95)	(0.69)	(1.11)				(−0.23)	(0.23)	(−0.08)
	VaR_99.9	−0.29278	−0.32121	−0.38819	0.0284	0.0670	0.0954	−0.24667	−0.25518	−0.23074	0.0085	−0.0244	−0.0159
					(0.71)	(0.95)	(1.35)				(0.21)	(−0.91)	(−0.52)
	CVaR_95	−0.15290	−0.16426	−0.19587	0.0114	0.0316	0.0430	−0.13929	−0.13666	−0.13197	−0.0026	−0.0047	−0.0073
					(0.78)	(0.81)	(1.16)				(−0.14)	(−0.39)	(−0.40)
	CVaR_99	−0.23125	−0.25940	−0.30626	0.0282	0.0469	0.0750	−0.21553	−0.21286	−0.19641	−0.0027	−0.0164	−0.0191
					(1.08)	(0.80)	(1.34)				(−0.09)	(−0.86)	(−0.68)
	CVaR_99.9	−0.36875	−0.41144	−0.44582	0.0427	0.0344	0.0771	−0.27880	−0.28516	−0.23996	0.0063	−0.0452	−0.0389
					(0.67)	(0.38)	(0.90)				(0.15)	(−1.33)	(−0.96)

Note: This table reports the mean VaR and CVaR for different top holder groups of governance tokens with high (H), medium (M), and low (L) levels of wealth concentration for the full sample period and the year 2022. Calculations are based on the daily returns derived from daily closing prices. Each token's daily closing price data spans from its initial listing until May 13, 2024. For each top token holding group, the mean VaR and mean CVaR values are calculated as follows: Mean $VaR_{group} = \frac{1}{n}\sum_{i=1}^{n} VaR_{\alpha,i}$ and Mean $CVaR_{group} = \frac{1}{n}\sum_{i=1}^{n} CVaR_{\alpha,i}$, where n is the number of tokens in the group, and i indexes the individual tokens. The mean differences in VaR and CVaR between groups are calculated at three confidence levels (95 %, 99 %, and 99.9 %) across top holder groups: Top (1, 10, 20, 50, 100) and the Rest of the token holding group. The mean differences are computed between high-medium (H-M), medium-low (M-L), and high-low (H-L) groups. The top 100 rich list for each token used in this study is downloaded as of October 10, 2022. Table A.8 shows the wealth distribution among the top 100 richest wallet addresses holding these governance tokens.
t-statistics are reported in parentheses.
*, **, and *** denote significance at the 10 %, 5 %, and 1 % levels, respectively.

concentration, leading to centralization risks. These findings highlight that, despite some resilience through structured governance, centralization remains a concern for DeFi. Addressing this issue requires equitable token distribution strategies and governance mechanisms that limit the influence of large holders. Broader participation is essential for DeFi platforms to achieve their promise of a more inclusive financial system.

Table A.17 in the Appendix reveals that 0.00089 % of the top addresses hold 84.35 % of the wealth in major governance tokens, indicating significant wealth centralization. In contrast, the remaining 99.911 % of addresses collectively hold only 15.65 %, suggesting that a small group controls governance, challenging DeFi's decentralization ideals. To mitigate this, some protocols adopt mechanisms such as quadratic voting, which impose quadratic costs to limit the accumulation of large voting power. Delegated voting also enhances inclusivity by enabling participants to delegate their voting power to trusted members. Additionally, community-based governance prioritizes collective decision-making over token ownership, fostering broader participation and consensus (Barbereau et al., 2023).

To assess whether wealth concentration impacts risk, daily returns of selected governance tokens were calculated to estimate the mean VaR and CVaR for top holders and the rest. Over the full sample period, Table 8 shows minor variations in VaR and CVaR across high, medium, and low wealth concentrations. For Top1 holders, VaR_95 is −0.12596 for high and −0.11141 for low concentrations, with insignificant t-statistics, suggesting minimal risk variation due to wealth concentration. In 2022, Top1 holders show slight VaR_95 differences, ranging from −0.09319 to −0.09701, with insignificant H-L differences across groups. Similar patterns are observed for Top10, Top20, and Top50 groups, indicating that wealth concentration does not significantly affect governance token risk levels. Comparing both time periods, t-statistics remain insignificant, suggesting stable risk profiles regardless of wealth concentration across holder groups and over time.

The wealth distribution statistics for the top 100 wallet addresses in 586 DeFi projects reveal that DeFi is far from achieving its decentralization objectives. Further investigation into its essential components highlights even greater centralization across all major elements, raising concerns about proper democratization and the potential for market manipulation.

Table 9
DeFi essentials and wealth centralization.

S.No.	Tokens	Assets	MeanHolders	Wealth (%)	Aaddresses_Top100 (%)
1	Blockchains	6	97656367	39.39	0.000102
2	Governance	33	111988	84.35	0.00089
3	Stablecoins	33	47174	93.23	0.21
4	Smart Contracts	50	4669214	77.04	0.002
5	Oracles	27	64933	83.59	0.15
6	DAOs	40	41707	82.85	0.24
7	Overall Assets	586	9059149	92.29	0.23

Note: This table reports the level of centralization for top 100 wallet addresses in 7 DeFi essentials of 586 DeFi projects.

Table 9 compares the wealth concentration in the top 100 wallet addresses across eight DeFi essential categories, revealing a striking contrast in wealth distribution. While blockchains in DeFi appear to have better wealth distribution, with 39.39 % of wealth held by the top 100 wallets, these wallets represent only 0.000102 % of the average number of wallets in a decentralized blockchain. Similar distribution patterns are observed in other DeFi essentials, such as governance, oracles, and smart contracts. As the DeFi industry continues to grow, it is crucial to monitor wealth distribution and develop mechanisms to mitigate potential centralization risks.

4.9. Interconnectedness and risk spillovers

Table 10 provides insights into the interconnectedness among key DeFi categories, focusing on wealth concentration and portfolio dynamics. The findings confirm that smart contracts (37.10 %) and governance tokens (47.61 %) are the least affected among DeFi essentials by their internal market dynamics. This aligns with wealth interaction results, where both categories exhibit minimal impact from wealth concentration. In contrast, DAO tokens (81.86 %) and stablecoins (72.31 %) are significantly influenced by their internal market dynamics.

When wealth concentration is considered, the results remain consistent for DAO tokens. Notably, DAO tokens emerge as the largest net transmitters of market volatility, with a net transmission rate of 18.95 %, while stablecoins act as the largest net receivers, with a net receipt of −14.33 %. This indicates that stablecoins function as shock absorbers in the DeFi ecosystem, mitigating the impact of market fluctuations. However, factoring in wealth concentration, DAO tokens shift to become the largest net receivers of risk, with a value of −12.81 %. The network plot in Fig. 4 suggests that this risk primarily originates from the internal market dynamics of the DAO itself.

These findings suggest that while stablecoins stabilize the DeFi ecosystem by absorbing shocks, DAO tokens are more vulnerable to significant internal market fluctuations. This dual role underscores the complexity of interactions within DeFi markets, where tokens can alternately function as transmitters or receivers of risk depending on market conditions and wealth distribution. Understanding these dynamics is essential for investors and policymakers seeking to navigate the volatile landscape of decentralized finance effectively.

The interconnectedness network plot in Fig. 4 for the equally weighted portfolio illustrates the relationships and interaction strengths among different DeFi essentials. Larger nodes, such as those representing DAOs and stablecoins, indicate sectors of greater

Table 10
Dynamic interconnectedness among DeFi essentials (equally weighted).

	BTC	Layer1	StableC	SmartC	Oracles	DAO	GovT	BTC_W	Layer1_W	StableC_W	SmartC_W	Oracles_W	DAO_W	GovT_W	FROM
BTC	**41.56**	12.91	1.17	15.40	6.06	3.65	12.38	0.91	0.79	0.82	0.86	1.38	1.24	0.86	58.44
Layer1	13.32	**39.84**	1.86	17.04	4.75	2.47	12.96	0.94	2.88	1.04	0.64	0.96	0.64	0.65	60.16
StableC	2.64	3.45	**72.31**	3.21	2.62	2.63	6.15	0.62	0.54	2.29	0.45	1.43	0.91	0.77	27.69
SmartC	14.32	15.58	2.15	**37.10**	6.95	3.42	12.82	1.02	0.85	1.26	0.89	1.55	1.36	0.73	62.90
Orcles	6.81	6.78	1.16	10.16	**52.68**	2.02	6.25	1.40	0.93	1.30	1.11	6.02	2.31	1.08	47.32
DAO	1.74	1.29	1.98	2.95	1.66	**81.86**	2.34	0.56	0.50	0.67	0.44	0.73	2.70	0.57	18.14
GovT	11.64	11.36	2.30	13.30	4.57	4.92	**47.61**	0.37	0.66	0.45	0.51	0.86	0.69	0.75	52.39
BTC_W	0.63	0.50	0.15	0.66	0.68	0.38	0.24	**17.29**	15.39	11.84	16.03	11.09	9.55	15.57	82.71
Layer1_W	0.50	1.38	0.12	0.53	0.49	0.42	0.36	15.86	**17.88**	11.65	15.61	10.96	8.80	15.43	82.12
StableC_W	0.40	0.68	1.63	0.95	1.02	0.58	0.29	13.96	13.45	**20.85**	13.64	10.21	8.08	14.27	79.15
SmartC_W	0.63	0.54	0.14	1.18	0.68	0.40	0.42	16.11	15.23	11.69	**17.36**	10.75	9.16	15.69	82.64
Oracles_W	0.73	0.53	0.22	1.14	6.32	0.85	0.48	12.85	12.34	9.85	12.33	**22.24**	7.59	12.54	77.76
DAO_W	0.52	0.30	0.29	0.57	0.74	14.72	0.32	11.22	9.97	7.78	10.68	7.20	**25.01**	10.69	74.99
GovT_W	0.57	0.44	0.20	0.58	0.57	0.63	1.06	15.64	15.05	12.18	15.69	10.87	9.16	**17.38**	82.62
TO	54.45	55.74	13.37	67.67	37.10	37.09	56.07	91.45	88.58	72.82	88.88	74.02	62.18	89.61	**889.03**
Inc.Own	96.01	95.58	85.67	104.77	89.78	118.95	103.69	108.74	106.46	93.67	106.24	96.26	87.19	106.99	**cTCI/TCI**
NET	−3.99	−4.42	−14.33	4.77	−10.22	18.95	3.69	8.74	6.46	−6.33	6.24	−3.74	−12.81	6.99	**68.39/63.50**
NPT	3.00	2.00	0.00	6.00	2.00	9.00	5.00	13.00	10.00	7.00	10.00	6.00	8.00	10.00	

Note: These values represent the interconnectedness of key DeFi components, with wealth concentration ratio (WCR) used as a scaling factor for the volatility series. The data is based on equally weighted portfolios over the analyzed period (Table A.18). This table is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name indicates the wealth-concentrated scaling.

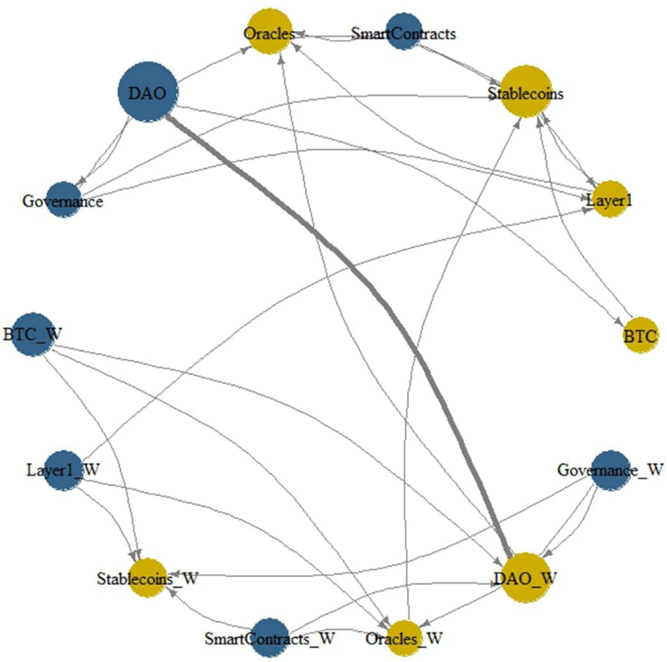


Fig. 4. TVP-VAR volatility interconnectedness network plot (equally weighted). **Note**: The node sizes represent the relative importance of each category, while the thickness of the connecting lines indicates the intensity of interactions or risk spillovers between components. Blue nodes indicate transmitters, while yellow nodes indicate receivers of the spillovers. This network plot is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name denotes the wealth-concentrated setting. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

importance within the portfolio. DAOs are central to the network, exhibiting strong connections, particularly with their own internal market dynamics in the wealth-concentrated setting. The thick edges indicate a significant level of interaction.

The stablecoin sector is also highly interconnected, with strong links to most DeFi components, including Bitcoin and layer-1 tokens, underscoring its pivotal role in liquidity provision and stability within the broader DeFi ecosystem. Layer-1 blockchains, such as Ethereum, exhibit moderate connections with other sectors, particularly DAOs, oracles, and governance, emphasizing their foundational importance in enabling decentralized applications.

Other essentials, such as smart contracts and oracles, exhibit moderate interaction levels with the core sectors, suggesting that while these components are vital, their impact is somewhat secondary to that of stablecoins and DAOs. Governance tokens display significant connections with DAOs, highlighting the importance of decentralized decision-making in protocol management. The equally weighted portfolio indicates that risk is distributed relatively evenly across sectors; however, certain sectors, particularly DAOs and stablecoins, serve as key nodes for transmitting risk or market shocks across the network. The thickness of the connections between these sectors suggests potential pathways for contagion.

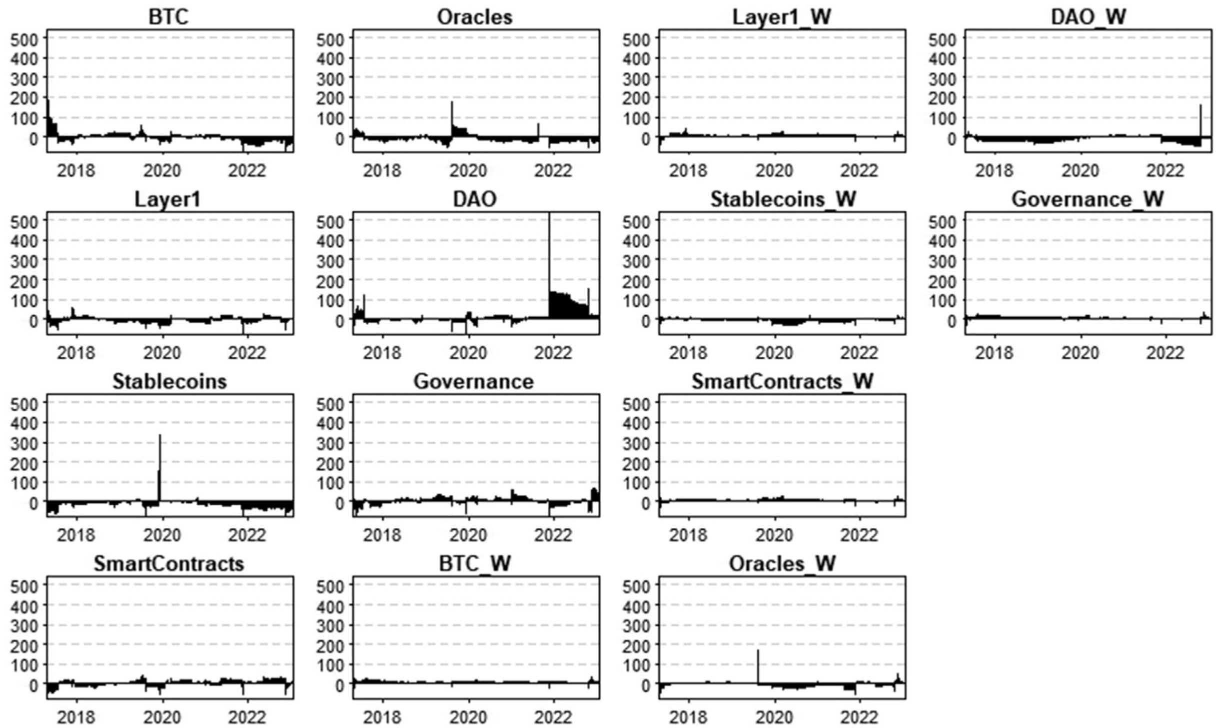


Fig. 5. TVP-VAR volatility net interconnectedness plot (equally weighted). **Note**: This net interconnectedness plot is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name denotes the wealth-concentrated setting.

The net interconnectedness plot for the equally weighted portfolio illustrates significant trends from 2017 to 2023 across various sectors, as shown in Fig. 5. Bitcoin and its related metrics remain stable with low values, reflecting its steady yet dominant role in the network. In contrast, oracles exhibit a notable spike in 2021, highlighting their increasing importance in the decentralized finance (DeFi) ecosystem. Stablecoins also show an uptick during the same period, emphasizing their growing significance. The DAO sector experiences a substantial surge in 2022, underscoring the rise of DAOs within the portfolio. However, stablecoins maintain consistent metrics throughout the observed period, reinforcing their role as liquidity providers and volatility hedges. Governance tokens and smart contracts display low and stable metrics, indicating a contained and consistent influence within the network.

Table 11 provides insights into the interconnectedness among key DeFi categories within a value-weighted portfolio context. The results indicate that, among the DeFi essentials, smart contracts (33.91 %) and governance tokens (36.07 %) are least impacted by their internal market dynamics, excluding layer-1 blockchain tokens. This pattern aligns with wealth interaction findings, suggesting that both categories exhibit resilience against the effects of wealth concentration. In contrast, DAO tokens (66.93 %) and stablecoins (56.45 %) display significant sensitivity to their internal market dynamics, highlighting their greater vulnerability to market fluctuations.

Oracle tokens and stablecoins appear to receive the highest risk spillovers from other assets. However, when wealth concentration is factored into the analysis, DAO tokens and stablecoins show the highest sensitivity, emerging as the largest net receivers of risk, with values of −9.68 % and −9.43 %, respectively. Notably, DAO tokens also exhibit substantial risk transmission, with a net transmission rate of −9.68 %, while stablecoins absorb 56.45 % of market volatility. This suggests that stablecoins serve as critical stabilizers within the DeFi ecosystem, effectively mitigating the adverse effects of market fluctuations. When wealth concentration is considered, DAO tokens also emerge as significant net transmitters of risk. The network plot in Fig. 4 indicates that this risk primarily originates from the internal market dynamics of the DAO itself.

As previously observed in the equally weighted scenario, these findings suggest that while stablecoins play a crucial role in stabilizing the DeFi ecosystem by absorbing shocks, DAO tokens face substantial risks due to their internal dynamics. This complexity highlights the intricate interactions within DeFi markets, where tokens function variably as transmitters and receivers of risk, depending on market conditions and wealth distribution. Understanding these relationships is vital for investors and policymakers seeking to navigate the volatile landscape of decentralized finance effectively.

Table 11
Dynamic interconnectedness among DeFi essentials (value weighted).

	BTC	Layer1	StableC	SmartC	Oracles	DAO	GovT	BTC_W	Layer1_W	StableC_W	SmartC_W	Oracles_W	DAO_W	GovT_W	FROM
BTC	**36.98**	16.12	3.88	13.07	8.68	5.24	10.65	0.84	0.80	0.76	0.83	0.75	0.56	0.85	63.02
Layer1	13.94	**31.41**	4.12	14.44	9.76	6.14	13.01	1.03	1.20	1.10	0.99	0.95	0.76	1.15	68.59
StableC	5.51	4.84	**56.45**	4.96	3.40	2.59	4.83	2.38	2.33	4.39	1.88	2.69	1.09	2.65	43.55
SmartC	12.80	14.11	6.17	**33.91**	9.38	7.48	10.76	0.87	0.82	0.95	0.69	0.82	0.36	0.90	66.09
Oracles	7.84	10.76	4.12	12.72	**38.18**	5.64	11.94	1.17	1.25	1.47	1.11	1.47	0.85	1.47	61.82
DAO	3.97	5.52	2.68	6.34	5.47	**66.93**	5.19	0.57	0.55	0.53	0.53	0.56	0.60	0.56	33.07
GovT	10.23	13.57	3.39	11.76	10.46	6.44	**36.07**	1.04	1.22	1.17	1.11	1.06	1.09	1.37	63.93
BTC_W	0.47	0.53	1.18	0.26	0.74	0.31	0.47	**15.52**	15.13	10.19	14.86	14.57	11.10	14.69	84.48
Layer1_W	0.37	0.66	1.17	0.28	0.79	0.30	0.55	15.01	**15.41**	9.97	14.93	14.59	11.15	14.84	84.59
StableC_W	0.51	0.71	4.38	0.48	1.07	0.46	0.68	12.41	12.20	**19.59**	12.14	12.68	10.01	12.68	80.41
SmartC_W	0.43	0.57	1.03	0.50	0.78	0.36	0.57	14.90	15.09	9.97	**15.56**	14.52	11.07	14.65	84.44
Oracles_W	0.31	0.48	1.33	0.24	1.01	0.31	0.49	14.64	14.77	10.47	14.55	**15.62**	11.14	14.62	84.38
DAO_W	0.35	0.56	0.97	0.26	0.85	3.76	0.68	12.67	12.78	9.67	12.58	12.66	**19.28**	12.93	80.72
Gov_W	0.40	0.58	1.31	0.33	0.91	0.36	0.83	14.57	14.83	10.34	14.48	14.43	11.26	**15.39**	84.61
TO	57.12	69.01	35.71	65.65	53.30	39.39	60.64	92.10	92.97	70.98	90.68	91.74	71.04	93.36	**983.70**
Inc.Own	94.10	100.43	92.16	99.55	91.48	106.32	96.71	107.62	108.38	90.57	106.24	107.36	90.32	108.75	**cTCI/TCI**
NET	−5.90	0.43	−7.84	−0.45	−8.52	6.32	−3.29	7.62	8.38	−9.43	6.24	7.36	−9.68	8.75	**75.67/70.26**
NPT	1.00	4.00	3.00	4.00	2.00	6.00	3.00	11.00	12.00	7.00	10.00	9.00	6.00	13.00	

Note: These values represent the interconnectedness of key DeFi components, with wealth concentration ratio (WCR) used as a scaling factor for the volatility series. The data is based on value weighted portfolios based on market capitalization over the analyzed period (Table A.18). This table is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name indicates the wealth-concentrated scaling.

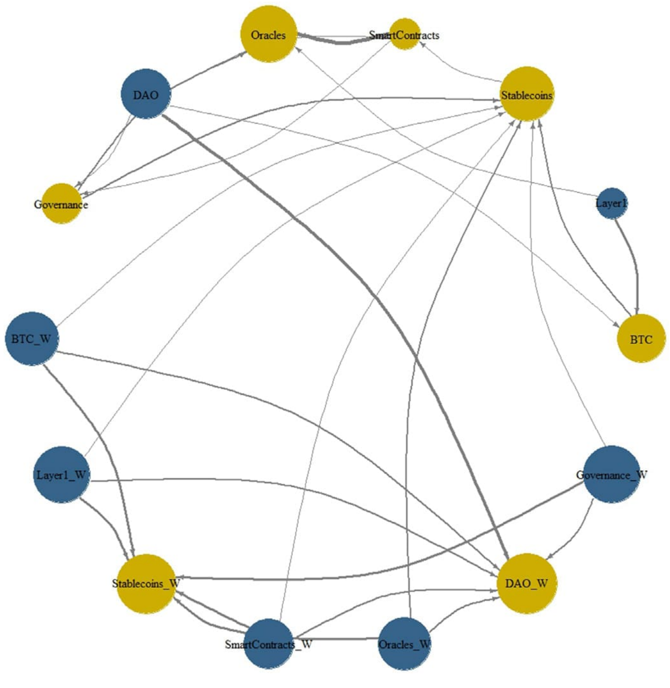


Fig. 6. TVP-VAR volatility interconnectedness network plot (value weighted). **Note**: The node sizes represent the relative importance of each category, while the thickness of the connecting lines indicates the intensity of interactions or risk spillovers between components. Blue nodes indicate transmitters, while yellow nodes indicate receivers of the spillovers. This network plot is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name denotes the wealth-concentrated scaling. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The interconnectedness network plot in Fig. 6 for the value-weighted portfolio highlights the relative importance of each sector based on market value. Stablecoins and DAOs remain prominent, underscoring their critical roles within the portfolio. Stablecoins exhibit extensive connections with multiple sectors, including DAOs, smart contracts, and oracles, emphasizing their pivotal function in providing liquidity and stability across the network. The thickness of these connections reflects the high intensity of their interactions with other sectors.

DAOs maintain strong ties with key sectors, notably governance and stablecoins, emphasizing their crucial governance role within decentralized finance. They serve as hubs for both decision-making and liquidity distribution. The solid connections with other sectors suggest that DAOs exert significant influence across the network. Bitcoin and layer-1 sectors exhibit somewhat reduced centrality compared to the equally weighted portfolio, although they still maintain moderate interactions with other sectors. Layer-1 blockchains display links with smart contracts, DAOs, and oracles, reinforcing their foundational role in powering decentralized infrastructure. Other sectors, such as smart contracts and oracles, show varying degrees of connectedness, indicating that while they contribute to the portfolio's functionality, their influence remains secondary to the dominant stablecoins and DAOs. The value-weighted portfolio suggests that risk and returns are concentrated around the most prominent sectors, with potential disruptions in stablecoins or DAOs posing systemic risks that could propagate across the entire network.

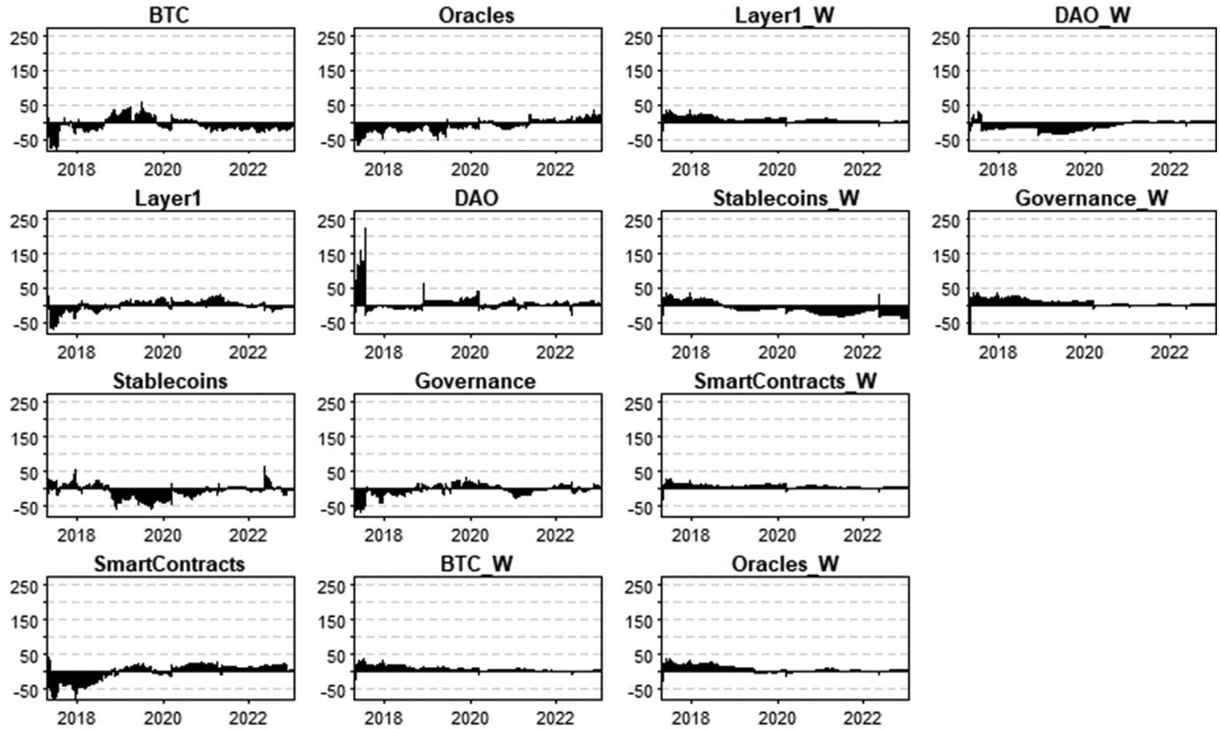


Fig. 7. TVP-VAR volatility net interconnectedness plot (value weighted). **Note**: This net interconnectedness plot is generated using the `ConnectednessApproach` R-package, as recommended by Antonakakis et al. (2020). The suffix "_W" at the end of the token name denotes the wealth-concentrated scaling.

The plots in Fig. 7 display the network interaction metrics for various cryptocurrency groups (e.g., Bitcoin, oracles, layer-1, DAOs, stablecoins, governance, smart contracts) and their wealth-concentrated counterparts (denoted by "_W") for value-weighted portfolios. Overall, the value-weighted portfolio interactions show higher volatility in the early years for Bitcoin and DAO tokens, followed by stabilization over time. Wealth concentration appears to amplify interaction strength across all categories, as evidenced by the generally larger magnitudes in the "_W" plots. Notably, stablecoins and smart contracts exhibit subdued network volatility compared to other tokens, while Bitcoin and oracle tokens display more pronounced fluctuations, particularly in their wealth-concentrated versions. This suggests that wealth concentration in these tokens may amplify network interactions and contribute to increased volatility.

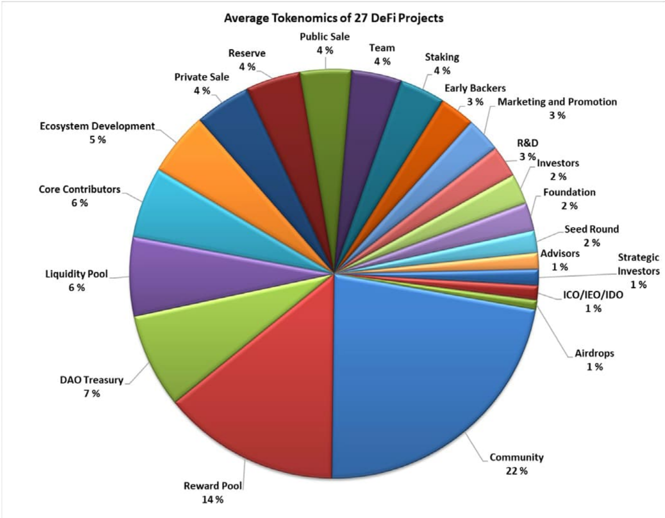
4.10. Exploratory consistency checks

To assess the robustness and internal consistency of our centralization findings, we conducted a series of exploratory checks using complementary data sources and analytical approaches. These checks aimed to validate whether the patterns of wealth concentration observed in DeFi tokens persist across different samples, tokenomic structures, and time periods, thereby strengthening the reliability of our main results.

4.10.1. Tokenomics and centralization

To better understand the relationship between token allocation and decentralization, we analyzed the tokenomics of two distinct sets of DeFi projects. In categorizing the tokenomics into 21 common categories, we excluded certain miscellaneous headings that were project-specific and not common across multiple tokens; such as, emission control or for opening a store, adventure park etc. The first set includes 27 DeFi projects for which complete tokenomics data were available under full market dilution (i.e., where circulating supply equals maximum supply) which are part of the richlist evaluated in this study. The second set includes 30 DeFi projects, added to expand the coverage of our analysis. These 30 DeFi projects were initially not included because the richlist in the website CoinCarp was not available or because these DeFi projects were launched after 2022.[8]

A: 27 DeFi projects (part of original datasets from 586 DeFi projects)



B: Tokenomics of 30 DeFi projects (not part of the original datasets)

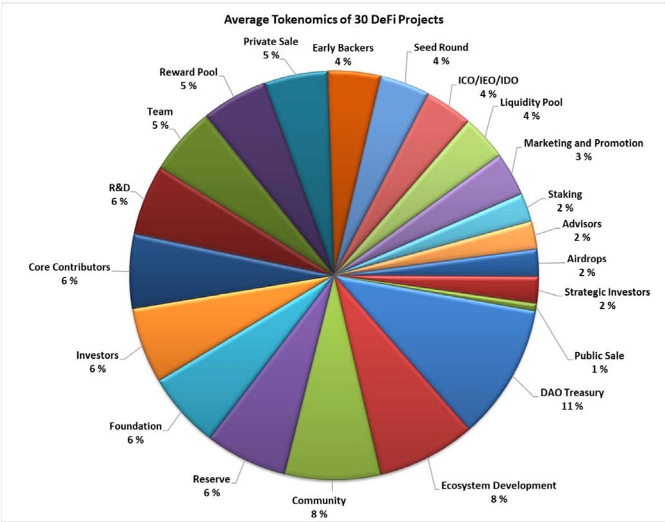


Fig. 8. Tokenomics of DeFi projects (fully diluted supply).

Fig. 8 displays the average token allocation across two DeFi samples. Both charts clearly indicate a high concentration of tokens among internally affiliated stakeholders, such as the DAO Treasury, Core Contributors, Foundation, Team, and Investors. In the first group (**A**) of 27 projects, the largest allocations include the Reward Pool (14 %), DAO Treasury (7 %), Core Contributors (6 %), and Liquidity Pool (6 %). While the Community category shows a large share (22 %), this label often refers to governance-controlled wallets that remain under the influence of founding teams or DAOs, rather than reflecting widespread individual ownership. In contrast, public-facing allocations such as Airdrops (1 %), Public Sale (4 %), and Staking (4 %) remain comparatively small. In the second group of 30 DeFi projects (**B**), internal concentration remains similarly high. DAO Treasury alone accounts for 11 % of the token supply, followed by Foundation, Core Contributors, Investors, and Reserve; each receiving around 6 %. Public allocations continue to be limited, with the Public Sale representing just 1 %, and Airdrops and Staking each accounting for 2 %.

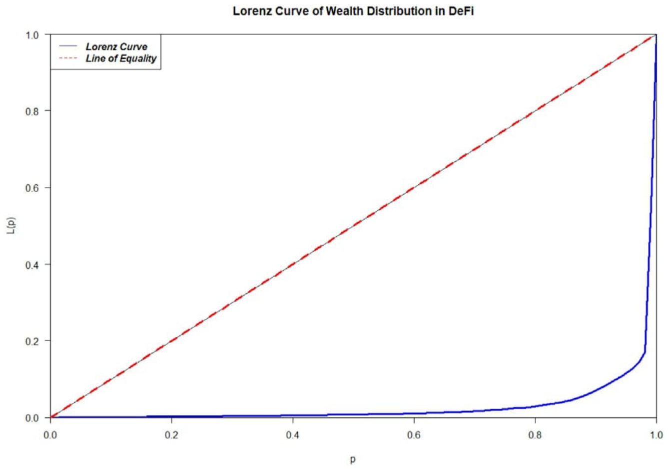
These findings highlight a consistent pattern: despite the narrative of decentralization, token ownership in DeFi projects remains largely centralized. Internal entities maintain significant control over token supply and governance rights, limiting genuine community

[8] Table A.19 in the Appendix presents an example of the tokenomics for a fully diluted DeFi token.

Table 12
Wealth distribution inequality in DeFi: Group-wise summary statistics.

Group	Statistics	CV	Theil	Gini
27 Tokens (fully minted/diluted)	Minimum	1.811	1.054	0.6852
	1st Quarter	3.204	1.580	0.7453
	Mean	4.596	2.105	0.8055
	3rd Quarter	5.989	2.631	0.8656
	Maximum	7.382	3.157	0.9257
27 fully minted tokens (excluding CEXs wallets)	Minimum	0.2623	0.02268	0.1152
	1st Quarter	0.7979	0.33194	0.2770
	Mean	1.3334	0.64121	0.4387
	3rd Quarter	1.8689	0.95047	0.6005
	Maximum	2.4044	1.25974	0.7622

Note: This table presents grouped summary statistics for CV, Theil, and Gini indices across three groups of DeFi tokens: the full 586-token sample, 28 tokens with the maximum supply in circulation, and 28 tokens excluding the centralized exchange custodial wallets. The calculation methods are presented in Eq. (1), Eq. (2), and Eq. (3).



(a) 27 DeFi tokens with fully diluted supply

(b) 27 DeFi with fully diluted supply (excluding CEX wallets)

Fig. 9. Lorenz curve of wealth distribution for DeFi tokens. **Note**: The red dotted line represents the line of equality, while the blue solid line represents the Lorenz curve. The closer the Lorenz curve is to the line of equality, the more equal the distribution of wealth. The further the Lorenz curve is from the line of equality, the more unequal the distribution of wealth. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

participation. This centralization is a structural outcome of how tokens are allocated during early-stage funding, development, and governance setup, and underscores the importance of tokenomics in assessing the decentralization claims of DeFi protocols. This distribution structure highlights an inherent contradiction in DeFi: while protocols promote decentralized finance, token ownership remains concentrated in governance bodies, development teams, and private investors. As a result, the decision-making power and economic benefits remain disproportionately in the hands of a select group, challenging the narrative of full decentralization within the DeFi ecosystem.

Table 12 presents summary statistics on wealth distribution inequality across three groups of DeFi tokens, measured using the CV, Theil index, and Gini coefficient. The first group, includes 27 tokens with a fully diluted supply, which also shows substantial inequality, though slightly lower on average than the full sample (mean Gini: 0.8055, Theil: 2.105). The second group excludes top CEX wallets from the same set of 27 tokens, significantly reducing observed inequality (mean Gini: 0.4387, Theil: 0.6412), highlighting the concentration effects of custodial wallets. These findings suggest that centralized holdings, such as those in CEX wallets, substantially inflate inequality metrics in DeFi token distributions.

Fig. 9 presents Lorenz curves depicting the wealth distribution across three different groups of DeFi tokens. The first panel, which includes 27 fully diluted tokens, shows slightly reduced but still pronounced inequality, suggesting that even with full supply in circulation, ownership remains highly concentrated. The second panel, which excludes CEX wallets from the same set of fully diluted tokens, shows a modest improvement, but the Lorenz curve remains substantially bowed and far from the line of equality. This implies that while CEX wallets contribute to observed concentration, severe inequality persists even after removing these custodial holdings, reflecting the inherently skewed nature of token ownership in many DeFi projects.

4.10.2. DeFi life span, centralization and survival

To understand the extent of wealth concentration in the DeFi ecosystem, we analyze the distribution of token holdings among top wallet addresses. Examining how ownership is spread across different types of tokens provides insight into patterns of decentralization and their potential link to token performance and longevity. Specifically, we re-examined wallet activity 2.5 years after the initial data collection to assess token longevity, distinguishing between tokens that remain active and those no longer available on CoinCarp. Additionally, we analyzed the distribution of fully diluted token supplies for the DeFi projects considered in this study, including those introduced after 2022. While the present work does not adopt an event-study or behavioral finance framework, we acknowledge the potential impact of major market events and investor sentiment on token performance and ownership dynamics. These factors, while not directly addressed in the present study, offer promising avenues for future research.

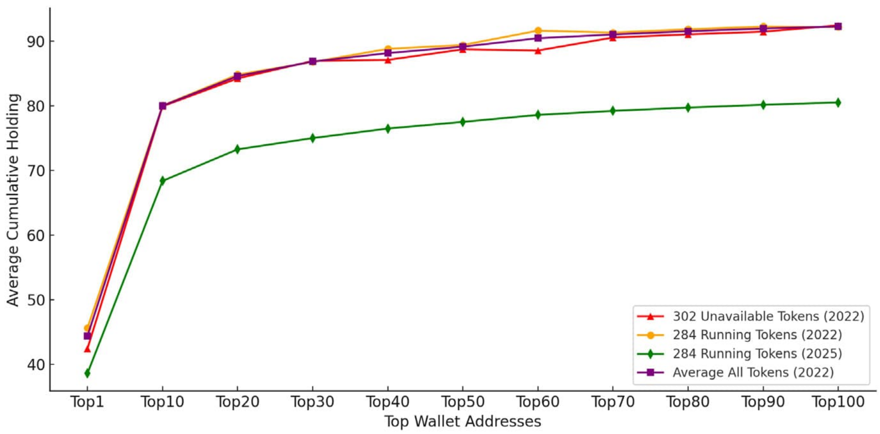


Fig. 10. Mean wealth of the top wallet categories for DeFi tokens for running and defunct tokens.

Fig. 10 presents the average cumulative holdings of the top wallet addresses across four categories of DeFi tokens. In all groups, the top ten wallets hold a significant share of the total token supply, indicating a high level of wealth concentration. Tokens that became unavailable by 2025 display slightly higher concentration among top holders compared to the other groups, particularly from the top ten to the top one hundred wallets. This pattern suggests that greater concentration of token ownership may be associated with a higher likelihood of project failure. In contrast, the 284 tokens that remained active in 2025 exhibit a more gradual increase in cumulative holdings, reflecting a relatively more even distribution. The 2022 data for the same running tokens and the average across all tokens in 2022 lie between these two extremes. The observed differences become more pronounced beyond the top ten addresses, suggesting that a broader distribution of token ownership may be linked to greater project resilience and longevity.

To complement the graphical analysis of wealth concentration, we conduct a more formal statistical examination to evaluate whether centralization levels differ meaningfully across token categories and over time. This allows us to test whether ownership concentration is merely incidental or systematically associated with token survival and decentralization dynamics.

Table 13 provides insights into the evolution of centralization risk in DeFi by comparing the mean token holdings of top wallets across two groups of tokens; those that are no longer available (MU2022) and those still actively traded (MR2022 and MR2025). The analysis is based on pooled-variance two-sample t-tests of mean differences in wallet concentration across top addresses (Top1 to Top100). The first set of comparisons (MU2022 – MR2022) assesses whether tokens that eventually disappeared from the market exhibited higher centralization at the time of observation in 2022. Although most of these differences are statistically insignificant, the signs are predominantly negative, indicating that unavailable tokens tended to have slightly lower concentration among the most

Table 13
Mean differences, two-sample *t*-test.

Group	Mean Holdings			Mean Difference	
	MU2022	MR2022	MR2025	MU2022 - MR2022	MR2022 - MR2025
Top1	0.4240	0.4558	0.3856	−0.0318 (−1.59)	0.0702*** (3.23)
Top10	0.7992	0.8003	0.6836	−0.0011 (−0.06)	0.1167*** (5.52)
Top20	0.8424	0.8483	0.7325	−0.0059 (−0.38)	0.1158*** (5.60)
Top30	0.8693	0.8678	0.7500	0.0015 (0.10)	0.1178*** (6.01)
Top40	0.8710	0.8882	0.7648	−0.0172 (−1.16)	0.1234*** (6.62)
Top50	0.8874	0.8941	0.7750	−0.0067 (−0.47)	0.1191*** (6.43)
Top60	0.8856	0.9163	0.7858	−0.0307 (−2.31)	0.1305*** (7.13)
Top70	0.9056	0.9133	0.7921	−0.0077 (−0.58)	0.1212*** (6.94)
Top80	0.9106	0.9185	0.7972	−0.0079 (−0.60)	0.1213*** (6.99)
Top90	0.9147	0.9227	0.8015	−0.0080 (−0.61)	0.1212*** (6.98)
Top100	0.9245	0.9219	0.8052	0.0026 (0.20)	0.1167*** (6.69)
DeFi	302	284	284		
			DF	584	566

Note: This table reports group-wise means for MD2022, ML2022, and ML2025, and the corresponding mean differences. Each difference is followed by the t-statistic in parentheses. All t-statistics are computed using the pooled-variance two-sample *t*-test:
MU2022 represents 302, now unavailable tokens and their top wallet holdings in 2022.
MR2022 represents 284, now running tokens and their top wallet holdings in 2022.
MR2025 represents 284, now running tokens and their top wallet holdings in 2025.
Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

of the top holders, however, the Top100 is positive. This pattern hints at a potential association between early centralization and project discontinuation, though the results are not conclusive. The second set of comparisons (MR2022 – MR2025) captures changes in wallet concentration over time for tokens that have remained active. Across all groups from Top1 to Top100, we observe statistically significant decreases in concentration at the 1 % level. For instance, the Top10 wallets' mean holding declined from 0.8003 in 2022 to 0.6836 in 2025, with a highly significant mean difference of 0.1167. This consistent and significant reduction across all wallet brackets implies a gradual dilution of ownership concentration over time, reflecting increasing decentralization as tokens mature and circulate more widely among users.

Analyzing the centralization risk perspective, the results are twofold. First, tokens that disappeared from the market tend to start with slightly more concentrated ownership, suggesting that initial centralization might be a vulnerability factor for project longevity. Second, for projects that survive over time, a meaningful decline in top wallet holdings indicates reduced centralization risk as DeFi ecosystems mature. This dynamic supports the argument that decentralization in DeFi is an evolving process, and the age of the token plays a crucial role in shaping ownership structure and associated governance risks. However, it is important to note a critical limitation in how concentration is measured here. These wallet brackets (Top1, Top10, Top100) are based on absolute wallet rankings rather than proportions of the total holder base. As such, they provide no insight into the distribution among the long tail of smallholders. Despite the observed improvements, the fact that the top 100 wallets; regardless of total holder count, still control more than 80 % of the total token supply on average remains deeply concerning. This high level of concentration underscores that, even among projects that survive, DeFi token ownership continues to be heavily centralized. Hence, the decentralization narrative should be approached with caution, as control over economic and governance power is often retained by a relatively small elite within the ecosystem.

From the initial stages of token issuance to the point at which the maximum supply is reached, the distribution pattern appears to be highly concentrated, with a small number of dominant holders, which may indicate the presence of internal control mechanisms. Empirical evidence shows that the top 100 richest wallet addresses continue to hold, on average, more than 80 % of the tokens in circulation in March 2025 from 92 % on average in October 2022. This observation does not necessarily imply that the earlier dominant holders, who previously held approximately 92 % of the supply, are actively distributing their tokens. Rather, it is plausible that newly minted tokens are being acquired by new participants, thereby maintaining or even increasing the absolute token holdings of the wealthiest addresses. As a result, although the proportional share held by these addresses may appear to decline, the actual number of tokens they control could be higher than before. In contrast to the broader cryptocurrency market, DeFi tokens typically receive limited public attention and exist within a highly fragmented ecosystem. Consequently, conventional proxies for investor attention, such as the Google Search Trend Index, which are frequently employed in prior literature (e.g., Yao et al. (2024); Nguyen et al. (2023)), are less applicable in the context of DeFi. This study, therefore, focuses on the empirical measurement of wealth concentration across various components of the DeFi ecosystem, rather than investigating its potential drivers, such as investor attention or user familiarity. Although behavioral dimensions are undoubtedly relevant and merit future investigation, they fall outside the scope of the present analysis. The findings suggest that inherent flaws in the initial and ongoing token distribution processes may be a key factor contributing to the persistent centralization of wealth within DeFi ecosystems.

The core objective of decentralization cannot be fully achieved if the ecosystem continues to rely heavily on centralized entities such as CEXs and custodial wallet providers. While traditional banks also hold user deposits, their operations are typically confined to national or regional levels. In contrast, blockchain technology facilitates seamless cross-border transactions. However, the rising dominance of centralized cryptocurrency exchanges introduces new systemic risks. Unlike traditional financial institutions, the failure of a large, globally active centralized platform could have far-reaching consequences. If decentralized finance continues to depend largely on centralized exchanges and custodial services, we risk compromising its foundational principles. Such reliance may unintentionally reinforce centralization and magnify its associated vulnerabilities. Interestingly, some centralized exchanges appear to recognize this contradiction. For instance, Binance, despite being a centralized platform, has recently launched its own Web3 wallet, aiming to promote greater user control and self-custody. Unlike custodial wallets, where the exchange retains control of private keys, the Binance Web3 wallet allows users to manage their own keys and interact directly with dApps across multiple blockchains. This marks a notable shift toward a more decentralized user experience, even within a centralized exchange ecosystem, and may reflect a broader trend toward hybrid solutions that promote decentralization.

5. Conclusion

DeFi emerges as a beacon of hope for a more equitable and accessible financial system. However, recent studies reveal a troubling reality: DeFi may not be as decentralized as it is often portrayed (Nadler and Schär, 2020; Gramlich et al., 2022). A stark concentration of wealth exists in the hands of a few large players, mirroring the wealth inequality of traditional financial systems. This research finds that a mere 0.23 % of DeFi wallet addresses hold an overwhelming 92.29 % of the total wealth in the ecosystem. To assess centralization tendencies, this study analyzes the wealth distribution across 586 DeFi projects, examining the top 100 richest wallet addresses in each project. An analysis of 58,600 wallet addresses reveals that centralization pervades various aspects of DeFi protocols, including oracles, governance, smart contracts, and DAOs. The Gini coefficient, a measure of inequality, averages 0.8628, indicating severe wealth concentration. Other measures such as the coefficient of variation, Theil index, and Lorenz curve corroborate these findings. Some wallet addresses hold tokens from numerous DeFi projects (for example, 112, 73, and 72 projects), centralizing influence and heightening interconnected risks. This raises concerns about governance favoring a select few, undermining DeFi's decentralized nature, and discouraging broader participation.

A notable finding is the significant centralization in layer-3 tokens, which are designed to enhance scalability and reduce transaction costs. Wealth concentration also impacts risk exposure, with stablecoins and DAO tokens demonstrating substantial changes in their risk profiles. Stablecoins risk losing reliability if dominated by a few large holders, while DAO tokens face governance centralization, affecting decision-making processes. Oracles are similarly affected by wealth concentration, while governance tokens and smart contracts show greater resilience, indicating more robust decentralization mechanisms. Using VaR, CVaR, and TVP-VAR methodologies, this study demonstrates that wealth concentration exacerbates systemic risks, particularly for stablecoins and DAO tokens. Stablecoins serve as stabilizing forces with their broad connections and low risk metrics, mitigating market volatility. However, DAO tokens face significant vulnerabilities due to wealth concentration, acting as both risk transmitters and receivers. The interconnectedness analysis confirms that stablecoins and DAOs are central to the network, influencing risk transmission, while governance tokens and smart contracts play secondary roles with lower risk profiles.

This study highlights a few key limitations. It focuses on the top 100 wallet addresses, which cover, on average, 92.29 % of the wealth distribution across 586 DeFi projects. While the analysis does not fully account for the dynamic nature of DeFi, where wallet holdings can fluctuate due to market movements and new participants, significant changes in holdings remain rare, especially among large wallet holders. This stability makes it reasonable to rely on static wealth concentration data for this analysis. Additionally, the reliance on public blockchain data excludes off-chain activities that may impact wealth distribution and risk exposure. Future research should expand the scope to include a broader range of wallet addresses, integrate off-chain activities, and monitor changes in wealth distribution over time. In addition to wealth inequality, the role of centralized and decentralized exchanges further shapes the evolution of DeFi. Many token holders rely on centralized exchanges for access and liquidity, which can obscure the actual distribution of holdings and increase systemic vulnerabilities. Moreover, tokenomics designs often favor early investors or insiders through mechanisms such as pre-mines and vesting schedules, further exacerbating wealth concentration. These design choices can create long-lasting imbalances in governance power and utility access.

Distinguishing between active and dormant wallets remains a critical yet underexplored area in wealth concentration studies within decentralized finance. The current rich list data only provide aggregated snapshots such as token holdings and 7-day changes, which are insufficient to confidently infer wallet activity. Future research could benefit from incorporating transaction level data to capture wallet behaviors over time. By analyzing patterns such as transaction frequency, volume, and interwallet transfers, researchers could develop more robust classifications of wallet activity. Such an approach would enable a deeper understanding of wealth dynamics, the persistence of wealth concentration, and the identification of systemic actors versus passive holders in decentralized finance ecosystems. Furthermore, based on varying levels of wealth concentration among the top wallet holders, future studies could examine whether the centralization of wealth is a significant factor influencing the lifespan of a decentralized finance token. This could be explored in conjunction with other tokenomics characteristics discussed in this paper. Additionally, the finding that a large proportion of DeFi tokens become defunct within a short period further emphasizes the need to investigate whether highly centralized tokens are more prone to failure. As a future research direction, a DeFi token bankruptcy prediction model could be developed similarly to the cryptocurrency default prediction model by Grobys and Sapkota (2020) and the cryptocurrency exchange failure prediction model by Sapkota (2025), incorporating tokenomics, socioeconomic, and other technical features.

The economic implications of these findings are far-reaching. Concentrated wealth and governance power may distort market signals and reduce the efficiency of capital allocation in DeFi ecosystems. Investors may be deterred by high centralization, perceiving it as a sign of manipulation or lack of long-term sustainability. Moreover, network effects in token governance and liquidity provision may be disproportionately influenced by a handful of actors, undermining market competition. If DeFi continues to mirror the wealth dynamics of traditional finance without sufficient corrective mechanisms, it risks losing its appeal as an inclusive financial alternative. The asymmetric power structure may also disincentivize participation from smaller investors and developers, thus stifling innovation and diversity.

Appendix A

Table A.1
Top 100 richest wallet addresses with DeFiChain (DFI) tokens.
Note: This research study uses similar richlist for 586 DeFi projects listed in the Table A.2. in the appendix.

#	Address	Quantity	Percentage
1	0xb5e2d774c4672aa4297272f62d61e8a041175cb5	2,340,112	26.06 %
2	0xb079d6be3faf5771e354586dbc47d0a3d37c34fb	1,620,403	18.04 %
3	0x9e251daeb17981477509779612dc2ffa8075aa8e	708,390	7.89 %
4	0x5bdf85216ec1e38d6458c870992a69e38e03f7ef	593,117	6.60 %
5	0xc5a0a17eabbb0e64dcd567b5670c8c5d5c34128c	453,296	5.05 %
6	0xf89d7b9c864f589bbf53a82105107622b35eaa40	411,336	4.58 %
7	0x23ef8015b0e62a4cee0bd1d2536b4801ee0c060f	175,689	1.96 %
8	0xdc694a7b67bb088cf251c5dd6e17e59718b70860	149,221	1.66 %
9	0x1a4f25f0afaa48b9fd2a0ff1f0d31028c1b7f7ce	142,594	1.59 %
10	0x2a4f8a68f1835887d08dd61efd8ff5a557caf28b	129,563	1.44 %
11	0x8207172f0976d786d9045ba867f774360849d190	100,803	1.12 %
12	0xee5b5b923ffce93a870b3104b7ca09c3db80047a	77,319	0.86 %
13	0xb55cac1e610505c547a79412d444787f7b41a6fc	70,000	0.78 %
14	0x88d2ab2ccfa3719953c43bbcf3dd8361b6c5eb35	61,556	0.69 %
15	0x3e6cb675f53a9c724ed5edacb2cd838a654bf5d3	60,112	0.67 %
16	0x189ff06a4cf9339124a0f950e6123182cef3ca71	58,990	0.66 %
17	0x11ca122eaadb38d787142bb5e1b62684393ae523	57,415	0.64 %
18	0xc4807a590fcd501d9a92fa7055f60f06262fad57	55,418	0.62 %
19	0x291701b2a6f64b1637dda68d1bb65c5c41d47728	41,312	0.46 %
20	0x637f535013c443667cae9712d900e5667fa597a7	40,226	0.45 %
21	0x8027cb1d747800ab4612a81bcdaf4f868058a3b1	38,145	0.42 %
22	0x6628cb4b7ca58bc6a75bc38ffb3069ee613e73bc	36,795	0.41 %
23	0xfa0f6f23d5c977c37b86b2fbec71be1d4b860e74	36,124	0.40 %
24	0xd3d390ac956a3c29cb887683feba4e35e68e5d24	31,798	0.35 %
25	0x54346d39976629b65ba54eac1c9ef0af3be1921b	30,230	0.34 %
26	0xeef9c1b8442a2fc9f0ec1dcde3f90a966c7bcae4	30,212	0.34 %
27	0xfaf45c45a9a59525f9687529f03331b58a22c867	29,833	0.33 %
28	0x4697cd5c90a480d004a2dd33dc592ba0e043ba90	28,832	0.32 %
29	0x9ca62bf261e0d25b6b056d190bd1be3dd4f0b338	28,604	0.32 %
30	0x8c7a0ab6a47c16e4f791147da6c85b104dbe7faf	24,715	0.28 %
31	0x3ab28ecedea6cdb6feed398e93ae8c7b316b1182	24,348	0.27 %
32	0xbde6e7adc3cfd94e54575289770a968b7ebcfa6a	23,972	0.27 %
33	0x456325f2ac7067234dd71e01bebe032b0255e039	22,879	0.25 %
34	0x66fd00831e1973dd505370ac69710c0bc81f5f4f	21,347	0.24 %
35	0x1e7efbaf8dcfd4316134bb3c752fe3c8c84afabd	20,662	0.23 %
36	0x11c4b9d2c090d54cff9da4c4649beb50ef022037	20,272	0.23 %
37	0x9d01224c05a9a2ea14cb7253839ccdcc6ca151dd	20,093	0.22 %
38	0x0d0707963952f2fba59dd06f2b425ace40b492fe	19,359	0.22 %
39	0x7c1a8e910686fe820ad9097989cab878553e3e9e	18,464	0.21 %
40	0x547ee178eeb931751e36e92636cabbaa49cf1ac7	16,941	0.19 %
41	0x38a4312bb7007b4543647ef2d2fcf875c4af7ece	16,186	0.18 %
42	0x433e28c5f8c14b6b72ab8975c20ffa94ef066373	15,851	0.18 %
43	0x9e88a038fa98cbf3c9606fd44c5319595bb60b8d	15,457	0.17 %
44	0xaac6c3baf004e73e33600fcfd486657e7258778a	15,217	0.17 %
45	0x9ffea55184645a6db001cc28ef55fd9670979067	15,023	0.17 %
46	0xbcb8c9baa9f6a8de86b4151874b57b4479265e88	13,192	0.15 %
47	0x0b0c3a28c543e7964e94626fd0aa430bc2b9a5d0	13,127	0.15 %
48	0x935d688deece042ce8eaa45475f6bf458e236aad	12,773	0.14 %
49	0xeeafd41d17d164b3068bfa157ddd865b7a42b43e	12,709	0.14 %
50	0xe18be2ab2dde24bd1d4c1fe0e0574e2508d1f88d	12,701	0.14 %
51	0xf7460857ffbafce3a6752018365816fd0cb32a4e	12,169	0.14 %
52	0xb2df3b19333f7bd8d3880f415950f497b2f77165	11,988	0.13 %
53	0xd2e1cbbe20d4d870467c9661afc1058a11ccc7e6	11,463	0.13 %
54	0x709519577caa14c60a69700f902b441697e0e335	11,434	0.13 %
55	0xd5cd415a1693b7861563ec50c79e4bba8aaacfe1	11,199	0.12 %
56	0xad4a6ba3b7d1d614e1d3bc397a02560bffd3577a	10,308	0.11 %
57	0xe8f433140d3409fb9a0b71834e95ada774946996	10,115	0.11 %
58	0xf3e71e71e54e653965e15236e086e8b355d52c5d	10,037	0.11 %
59	0xf5c03fd36015f8c657a34b503352fc3471c73815	10,005	0.11 %
60	0xdd4cd7e82d4be5bb81043fe37fd2616cf75f03c6	9,994	0.11 %
61	0xf16e9b0d03470827a95cdfd0cb8a8a3b46969b91	9,926	0.11 %
62	0xd239216ac7e44a09da67d6852cd757fc5e829fe2	9,740	0.11 %
63	0xdee5674d723936cc34a7165befc01cd6016f190d	9,714	0.11 %
64	0x82308abc17077b6fc68d2d5823d32f705e40cd7b	9,347	0.10 %
65	0xd896074337dfdadcf53fa757deb52cf556a692eb	9,290	0.10 %

(*continued on next page*)

Table A.1 (*continued*)

#	Address	Quantity	Percentage
66	0x1689c94072919b39abbc7201e246adae13315866	9,212	0.10 %
67	0x6496e1fb0d1616109b9e7f40536fb0b3a0a67ed9	9,155	0.10 %
68	0x4a6538a167ae93bdd1ea1183513c27ff81c7f8f9	8,725	0.10 %
69	0x8686f9f8f12c3702631b44d2da9ac47af962852f	8,699	0.10 %
70	0x743c5b2f134290741b6de9c330d5a2ff43c773d3	8,380	0.09 %
71	0x5f93d3d64e416c3e3e63db631072bcfa8321a0ad	8,346	0.09 %
72	0x3441ba016c915f5d6095125e9328fbd3478361e2	8,192	0.09 %
73	0x250bfab47e7b4e7021b0fda032cc0276f5166d43	7,590	0.08 %
74	0x018d6aeb2b14c168afb09c692e0f246fe34091b0	7,577	0.08 %
75	0x02a6525ae78d00bd1ee187d9c989ff85009ebe20	7,547	0.08 %
76	0xd5baba6d324a5ce6ec92df6e3a331d3f00c3e107	7,244	0.08 %
77	0x004856f4b09a11d72649f4f4491643ce060e6a14	7,207	0.08 %
78	0x5868ea549e4543ffcec670d8676240d041338f94	6,979	0.08 %
79	0xbf09a462a383c83e8c4903b6703a00770e35891b	6,117	0.07 %
80	0x83dd0a73f9ccc6e79d52972358731cc6345ab272	6,057	0.07 %
81	0xc13a1f46b58fce16c3a583df8e26bbef1a497ad2	5,992	0.07 %
82	0xbf09c6d899159d81c2702a002ef98e2753cf2abe	5,973	0.07 %
83	0xf7e20abc5e4b9ef68d34bf3eeea39e496e875405	5,895	0.07 %
84	0xce36b8d3d1ea7a8eeddb5adfc2fec26ad27182cc	5,635	0.06 %
85	0x0de17de8ea4ee075c2d1602243dad81d5efb2643	5,580	0.06 %
86	0x33aafc3cac782abef765a0e1559e04f89e62639d	5,292	0.06 %
87	0xebb0325f30295f8559e1dbc740df88a7a411e067	5,288	0.06 %
88	0xfc47b956036545b440febe9d77319c9a764921db	5,143	0.06 %
89	0x88c9b76f53e9ba9e9e46f87b8e59311c9a0d7d83	4,965	0.06 %
90	0x78cab78565a5d7e4be48386642e8dc2ed66b0505	4,908	0.05 %
91	0x03ee15456299df9b66fa434167d73303a1298dc4	4,865	0.05 %
92	0x7764b9e89c907f4f2e8b9495d3871cb01f88c412	4,809	0.05 %
93	0xf9d2154e19969a01eb46bb1750b5ad4822524c6f	4,797	0.05 %
94	0x617d4baa136e92eaf4b1ee04279d8ea2dc466599	4,796	0.05 %
95	0x380ecdbcd504db32a86d6bb5df13a6424fc967b6	4,689	0.05 %
96	0xf9db4a52a4ea598dd31093fbedb0e03751f23a80	4,648	0.05 %
97	0x8d9d80692867c7cb7ec793e91168fbb726677c91	4,595	0.05 %
98	0x11bc5501c0350ce440b1cb314e358e4c960acdd3	4,537	0.05 %
99	0x98f1c0c58f1af9f34a0c3bafdca945f5d88788c6	4,398	0.05 %
100	0xbd609b73b105fa5320fd7a44000179cb0e3655e3	4,340	0.05 %

Table A.2
List of DeFi projects used in this study.
Note: This table reports the list of 586 DeFi projects used in this study.

S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi
1	0x ZRX	31	arc	61	bitgoo	91	convex-finance	121	defrost-finance
2	1inchtoken	32	arcane-token	62	bitlocus	92	coredao	122	Dego Finance DEGO
3	1sol	33	Ares Protocol ARES	63	Bitlocus BTL	93	corn	123	depo
4	aave-new	34	AstroSwap	64	bitshiba-token	94	Cosmos	124	despace
5	acalanetwork	35	atlas-dex	65	black-whale	95	coti	125	deus-finance-v2
6	adalend	36	auction	66	blockbank	96	Cream CREAM	126	deversifi
7	ADAM oracle ADAM	37	avalanche	67	boda-token	97	creamfinance	127	dexigas
8	adapad	38	awrttoken	68	bonfida	98	credefi	128	dexsport
9	aelf	39	babylon-finance	69	BOSAGORA	99	creditcoin	129	df
10	Aeternity	40	baby-lovely-inu	70	brokoli-network	100	credmark	130	DFI.Money YFII
11	airswap	41	baby-saitama	71	bumper	101	CropBytes	131	DIA
12	AirSwap AST	42	babyswap	72	cairo-finance	102	cross-chain-bch	132	Digix Gold Token
13	alchemix	43	badger-dao	73	cakeswap	103	cryptertoken	133	dinoswap
14	aldrin	44	bakeryswap	74	calamarinetwork	104	cryptex	134	dmg
15	Algorand	45	balancer	75	Cardano	105	Crypto Global United	135	dodo
16	alpaca-finance	46	bancor	76	ChainGPT	106	CryptoFranc XCHF	136	dogebonk
17	alphafinancelab	47	Band Protocol BAND	77	ChainLink LINK	107	crystal	137	dogefood
18	american-shiba	48	Bankless DAO BANK	78	chargedefi	108	cudos	138	doken
19	amp	49	barnbridge	79	CheckDot	109	curve	139	dollarneutrino
20	ampleforth	50	bedrock	80	chedda-token	110	cVault.finance CORE	140	domi-online
21	ancient-kingdom	51	bepay	81	cheesus	111	Dai DAI	141	don-key
22	aniverse	52	Berry Data BRY	82	choise	112	daolaunch	142	Dora Factory DORA
23	ankr	53	betswirl	83	chromia	113	DAOstack GEN	143	DOS Network DOS
24	anpanswap-token	54	BIDR	84	circuits-of-value	114	dappradar	144	Drep DREP
25	antex	55	bifi	85	clean	115	darkshield	145	duelist-king
26	antimatterfinance	56	Binance USD BUSD	86	clearpool	116	day	146	duelnetwork

(*continued on next page*)

Table A.2 (*continued*)

S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi
27	anyswap	57	Bird.Money BIRD	87	coinerr	117	Decentralized USD	147	dumpbuster
28	API3	58	BitDAO BIT	88	coinstox	118	Decred	148	DXDao DXD
29	aragon	59	bitgatti	89	Compound COMP	119	decredit	149	eco-defi
30	Arbitrum ARB	60	Bitgert	90	Conflux	120	defiChain	150	elastos
151	elitheum	181	for	211	gunstar-metaverse	241	infinitypad	271	kryxivia
152	ellipsis	182	forta	212	GYEN	242	injectiveprotocol	272	kyber-network
153	elongate	183	fountain	213	gyro	243	insure	273	Kylin Network KYL
154	elvantis	184	Frax FRAX	214	HairDAO HAIR	244	insuredao	274	laeeb
155	emptysetdollar	185	FreeRoss DAO FREE	215	Hakka Finance	245	integralresistance	275	launchblock
156	Enigma	186	frenchie-network	216	handy	246	Internet_ICP	276	lend-flare
157	EOS	187	function-x	217	HAPI.one HAPI	247	IOI Token IOI	277	lgcynetwork
158	Ethereum	188	funfi	218	harvestfinance	248	ix-swap	278	lido
159	EthereumClassic	189	Fusion	219	hecoyearnfinance	249	izumi-finance	279	life
160	Etherparty	190	Gains	220	Hector Network HEC	250	Jigstack STAK	280	lillion
161	ethichub	191	gamespad	221	hector-dao	251	jpool	281	linearfinance
162	euler-tools	192	gamestar-exchange	222	hegic	252	jupiter	282	liquidefi
163	evergrow-coin	193	gamingshiba	223	helena-financial	253	JUST JST	283	Liquity USD LUSD
164	everrise	194	gamma-strategies	224	hellsing-inu	254	JUST Stablecoin USDJ	284	lite-usd
165	evrynet	195	Gas DAO Gas	225	hero-inu	255	justgov	285	livetrade-token
166	ezillion	196	Gather	226	Hifi	256	juststablecoin	286	lobis
167	FaceDAO FACE	197	Gemini Dollar GUSD	227	hnb-protocol	257	kabosu	287	logitron
168	fantohm	198	genshiro	228	hoppy	258	kainet	288	Loom
169	fantom	199	ginza-network	229	hubble-protocol	259	kakashi-sensei	289	loopnetwork
170	farmbit	200	gnosis	230	hundred-finance	260	kangaroo	290	loopring
171	Fei USD FEI	201	goat-token	231	hunt	261	kawaii	291	lovelace-world
172	ferrumnetwork	202	gogeta-inu	232	HUSD	262	keep3rv1	292	luca
173	filda	203	goji-crypto	233	hydro	263	keeperdao	293	lumerin
174	FirmaChain	204	goldfarm	234	ichi	264	keepnetwork	294	lunar
175	fitness-instructor	205	goldminer	235	idex	265	keyfi	295	maker
176	flokimooni	206	golff	236	Idle IDLE	266	keys-token	296	maplefinance
177	flokipad	207	gotem	237	iExec RLC	267	kirobo	297	Marinade MNDE
178	flurry	208	graph	238	Illuvium ILV	268	kittyshiba	298	mars
179	fndz-token	209	gridzone	239	impactx	269	kleekai	299	marsrise
180	fodl-finance	210	gscarab	240	infinite	270	kromatika	300	marsx
301	marx	331	Neo	361	Parachute PAR	391	qredo	421	Rupiah Token IDRT
302	mdex	332	NEST Protocol NEST	362	paraswap	392	Qtum	422	safuu
303	melo-token	333	Neutrino USD USDN	363	parsiq	393	quai-dao	423	saketoken
304	merchant-token	334	NFT Protocol NFT	364	Pax Dollar USDP	394	QuarkChain	424	sandclock
305	meta	335	nft-art-finance	365	peakdefi	395	quickswap	425	save-your-assets
306	metadoctor	336	nftlaunch	366	pearl	396	quickswap-new	426	scientia
307	metadog-racing	337	nft-royal-token	367	perifinance	397	ramp	427	sealem-token
308	metalswap	338	nftx	368	perp	398	raydium	428	secret
309	metaplay	339	niftypays	369	pibble	399	Razor network	429	seesaw
310	metaufo	340	numeraire	370	picipo	400	rbx	430	sekuya
311	metavpad	341	obortech	371	picklefinance	401	rebaseapy	431	serum
312	metawars	342	oceanland	372	PieDAO DOUGH v2	402	recast1-coin	432	shibadoge
313	meter	343	ocean-protocol	373	Pillar Pillar PLR	403	redfox-labs	433	shiba-interstellar
314	metfi	344	Odin Protocol ODIN	374	pochi-inu	404	reef	434	shibrobi
315	meverse	345	olympus	375	Polkadot	405	Reflexer	435	Shiden
316	mine-network	346	Omax	376	polkaex	406	renbtc	436	shiryo-inu
317	mirror	347	Ontology	377	polkastarter	407	republic-protocol	437	Shroom.Finance
318	Modefi MOD	348	ooki-token	378	Polygon	408	request-network	438	Shyft
319	monopolon	349	OpenDao SOS	379	polygonum-online	409	Reserve RSV	439	Signum
320	monox-finance	350	opsmen	380	polypad	410	retreeb	440	silo-finance
321	mooni-defi	351	OptionRoom ROOM	381	polysports	411	reu-earth	441	Silva
322	moontoken	352	Oraichain Token	382	polytrade	412	revolotto	442	silva-token
323	moonway	353	Orakuru ORK	383	poorquack-com	413	revoluzion	443	sipher
324	moonwell	354	Origin Dollar OUSD	384	pornrocket	414	rgt	444	SKALE
325	moonwolf	355	origintoken	385	portify	415	ringfi	445	skate-metaverse-coin
326	mrhb-defi	356	OriginTrail	386	position-exchange	416	rlc	446	Skey
327	mrweb-finance	357	orionprotocol	387	Prism PRISM	417	rocketfi	447	smartcoin-farm-smrtr
328	MultiversX	358	oryx	388	probittoken	418	rome	448	smartkey
329	muslim-coins	359	pancake-hunny	389	propel	419	rsr	449	Solana

(*continued on next page*)

Table A.2 (*continued*)

S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi	S.No.	DeFi
330	my-master-war	360	pancakeswap	390	pros	420	rtn-coin	450	solanyx
451	solar	481	superb	511	tokemak	541	vulture-peak	571	zombie-inu
452	solareum	482	sUSD SUSD	512	tokenlon	542	walletnow	572	zuna
453	solberg	483	sushi	513	ton-crystal	543	wallstreetbets-dapp	573	ZUSD
454	solend	484	swaptracker	514	torum	544	weave	574	Cartesi
455	solid-protocol	485	sway-social-protocol	515	tranchess	545	whale	575	HOPR
456	sologenic	486	swerve	516	tribe	546	wiggly-finance	576	Avegotchi
457	solrise-finance	487	swipe	517	TRON	547	wing	577	Index Cooperative
458	sonarwatch	488	switcheo	518	TrueFi	548	WINkLink WIN	578	Mask Network
459	space-hamster	489	synthetify	519	TrueUSD TUSD	549	Wirex	579	Internet Computer
460	spell-token	490	synthetix-network-token	520	twoge-inu	550	wonderland	580	Decubate
461	spherium	491	taitoken	521	UMA UMA	551	wrapped-bitcoin	581	Adventure Gold
462	spookyshiba	492	talkado	522	Umbrella Network	552	wrappednxm	582	Bone ShibaSwap
463	spookyswap	493	tdex-token	523	Unbound UNB	553	wrapped-pkt	583	Ribbon Finance
464	sports-2k75	494	tellor	524	unclemine	554	xcarnival	584	Merit Circle
465	Squid Game SQUID	495	Telos TLOS	525	unfederalreserve	555	xDai STAKE	585	Ethereum Name Service
466	squid-game	496	TemDAO TEM	526	Unidef U	556	Xend	586	IceCream Finance
467	stafi	497	templedao	527	unifi	557	XFUND		
468	Stakeborg DAO	498	ten	528	uniswap	558	xpredictmarket		
469	Star Atlas DAO	499	TerraUSD USTC	529	uquid-coin	559	XSGD		
470	stash-capital	500	Tether EURt	530	USD Coin USDC	560	xy-finance		
471	STASIS EURO EURS	501	Tether Gold XAUt	531	USDK	561	yamv3		
472	stobox-token	502	Tether USDT	532	USDX	562	yearnfinance		
473	strategyx	503	tetu	533	vai	563	yfii		
474	strike	504	Tezos	534	vegaprotocol	564	yoda-coin-swap		
475	strips-finance	505	theos	535	Velas	565	yoshi-exchange		
476	stronghold-token	506	thrupenny	536	velaspad	566	zamio		
477	Sui	507	tia	537	venus	567	ZAP		
478	sun	508	tidalfinance	538	Victoria VR	568	zebec-protocol		
479	sunny-side-up	509	tigerfinance	539	viralup	569	Zilliqa		
480	supe	510	titano	540	vr-blocks	570	zktube		

Table A.3
Blockchains and wealth distribution in DeFi.

S.No.	Name	Market Cap ($)	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	Ethereum	224.48B	240,650,364	23.37	33.47	36.05	40.89	46.24
2	Solana	9.95B	9,154,449	3.14	10.84	15.97	25.41	33.42
3	Cardano	10.37B	3,577,963	3.67	8.82	10.58	15.04	20.36
4	Polygon	6.85B	331,297,573	1.67	3.04	3.51	4.18	4.67
5	Polkadot	6.42B	1,139,305	5.32	28.80	38.77	57.85	73.27
6	Avalanche	4.32B	118,550	14.67	39.74	46.69	53.54	58.35
		Average	97,656,367	8.64	20.79	25.26	32.82	39.39

Note: This table reports the top six DeFi blockchains by market capitalization (as of 10.10.2022), the number of wallet addresses, and the percentage of wealth held by the top 1 to top 100 wallet addresses.

Table A.4
Blockchains and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.000102	99.9999
% of Wealth	39.39	60.61

Note: This table reports the wealth centralization among top 100 wallet addresses in average for top 6 blockchains.

Table A.5
Assets and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.23	99.77
% of Wealth	92.29	7.71

Note: This table reports the wealth centralization among top 100 wallet addresses in average for 586 DeFi tokens.

Table A.6
CEX and DEX wallets active in multiple DeFi projects and their average wealth holdings.

S.No.	Address	Holder	Type	#DeFi	AvgHolding %
1	0x0d0707963952f2fba59dd06f2b425ace40b492fe	Gate.io	CEX	112	1.3858
2	0x28c6c06298d514db089934071355e5743bf21d60	Binance 14	CEX	73	3.6419
3	0xf977814e90da44bfa03b6295a0616a897441acec	Binance 20	CEX	72	10.0054
4	0x75e89d5979e4f6fba9f97c104c2f0afb3f1dcb88	MEXC 1	CEX	70	0.7252
5	0xd6216fc19db775df9774a6e33526131da7d19a2c	KuCoin 6	CEX	64	2.4055
6	0xdfd5293d8e347dfe59e90efd55b2956a1343963d	Binance 16	CEX	62	0.3996
7	0x6cc5f688a315f3dc28a7781717a9a798a59fda7b	OKX	CEX	56	3.6162
8	0x40ec5b33f54e0e8a33a975908c5ba1c14e5bbbdf	Polygon (Matic) ERC20 Bridge	DEX/Bridge	47	4.8623
9	0x2faf487a4414fe77e2327f0bf4ae2a264a776ad2	FTX	CEX	44	1.8636
10	0xe93381fb4c4f14bda253907b18fad305d799241a	HTX 10	CEX	38	0.8855
11	0xa910f92acdaf488fa6ef02174fb86208ad7722ba	Poloniex 4	CEX	37	0.1581
12	0x562680a4dc50ed2f14d75bf31f494cfe0b8d10a1	Hobit	CEX	36	0.1936
13	0xfbb1b73c4f0bda4f67dca266ce6ef42f520fbb98	Bitrex	CEX	33	0.6321
14	0xcffad3200574698b78f32232aa9d63eabd290703	Crypto.com 5	CEX	32	0.3869
15	0x3cc936b795a188f0e246cbb2d74c5bd190aecf18	MEXC 3	CEX	30	1.5113
16	0xbe0eb53f46cd790cd13851d5eff43d12404d33e8	Binance 7	CEX	28	3.3818
17	0xc7029e939075f48fa2d5953381660c7d01570171	Hobit 8	CEX	27	5.3119
18	0x5f65f7b609678448494de4c87521cdf6cef1e932	Gemini 4	CEX	26	0.3263
19	0x4bba5f077a8fcfaf8d6d07c6cfbce553e2d94c9c	Gate.io Dep	CEX	25	0.072
20	0x8d6f396d210d385033b348bcae9e4f9ea4e045bd	Gemini 6	CEX	24	0.5606
21	0x46340b20830761efd32832a74d7169b29feb9758	Crypto.com 2	CEX	21	0.0805
22	0xba12222222228d8ba445958a75a0704d566bf2c8	Balancer: Vault	DEX/Vault	20	2.354
23	0x1522900b6dafac587d499a862861c0869be6e428	Bitstamp 2	CEX	19	0.7216
24	0xa3a7b6f88361f48403514059f1f16c8e78d60eec	Arbitrum One: L1 ERC20 Gateway	DEX/Bridge	17	1.891
25	0x124d9bf2fecbc16b54ec4accdb14d44c2144f012	Lbank: Hot Wallet 5	CEX	16	0.3044
26	0x4f3a120e72c76c22ae802d129f599bfdbc31cb81	Wintermute: Multisig	Institutional/MM	15	0.7347
27	0x6cc8dcbca746a6e4fdefb98e1d0df903b107fd21	Bitrue	CEX	14	0.3164
28	0x50be13b54f3eebbe415d20250598d81280e56772	Phemex	CEX	13	0.8488
29	0x06fed18718975d9e178e0c0fea35c18eac794c3f	Unknown	Unknown	12	1.566
30	0x47ac0fb4f2d84898e4d9e7b4dab3c24507a6d503	Binance: Binance-Peg Tokens	CEX	11	0.874
31	0xd0be1fded5d964619b92b3672c08c43305529be0	Gate.io Dep	CEX	10	0.8748

Table A.7
Stablecoins and wealth distribution in DeFi.

S.No.	Name	Market Cap	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	Tether (USDT)	83,462,515,471	433,784	37.97	60.70	67.80	74.24	77.99
2	USD Coin (USDC)	26,158,103,693	47,182	16.86	59.20	66.29	74.88	80.43
3	Dai (DAI)	5,251,749,431	107,655	34.60	73.26	81.06	86.56	90.03
4	Binance USD (BUSD)	3,381,609,840	170,055	36.40	91.35	92.41	93.95	95.24
5	TrueUSD (TUSD)	2,965,416,299	51,509	37.78	85.27	88.66	93.31	95.50
6	Frax (FRAX)	811,737,496	8,023	42.93	82.71	90.19	96.24	98.41
7	Decentralized USD	738,181,085	999	36.25	99.58	99.91	99.97	99.98
8	Pax Dollar (USDP)	507,354,621	109,779	18.32	69.81	79.26	86.17	90.36
9	Tether Gold (XAUt)	473,029,961	1,063	37.93	97.94	99.13	99.68	99.87
10	Gemini Dollar (GUSD)	354,684,876	9,306	82.80	96.63	97.57	98.56	99.16
11	JUST Stablecoin (USDJ)	300,784,411	19,524	70.25	99.83	99.96	99.97	99.98
12	Liquity USD (LUSD)	297,428,503	7,934	58.09	76.17	80.94	87.66	92.10
13	JUST (JST)	202,172,164	440,694	10.14	47.95	52.32	55.43	60.43
14	TerraUSD (USTC)	148,537,765	46,812	27.92	69.65	74.89	81.23	85.99
15	STASIS EURO (EURS)	136,362,734	4,974	68.75	95.90	97.20	98.85	99.52
16	USDX (Kava)	104,041,838	2,743	30.42	85.76	91.67	95.73	97.87
17	Vai (VAI)	56,887,105	14,798	53.77	93.02	95.45	96.98	97.72
18	XSGD	51,749,023	2,361	58.99	88.69	93.34	95.40	96.78
19	sUSD (SUSD)	41,049,306	14,946	19.14	64.51	72.85	83.64	89.77

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Table A.7 (*continued*)

S.No.	Name	Market Cap	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
20	Tether EURt	39,942,757	1,007	90.90	97.92	99.05	99.63	99.90
21	Fei USD (FEI)	33,361,989	3,810	48.43	94.96	97.60	98.53	99.06
22	Reserve (RSV)	28,782,996	441	32.14	74.80	81.30	84.55	85.61
23	USDK	28,033,932	3,844	58.30	88.54	91.45	95.46	97.69
24	Origin Dollar (OUSD)	19,000,146	3,123	18.12	76.29	86.15	93.49	96.79
25	GYEN	18,914,144	9,488	23.48	61.81	86.46	93.03	94.27
26	BIDR	14,804,280	8,662	46.01	95.00	97.94	98.92	99.07
27	HUSD	11,573,932	9,462	58.49	98.83	99.20	99.35	99.46
28	Rupiah Token (IDRT)	7,980,849	10,049	10.45	41.42	46.29	55.08	65.93
29	CryptoFranc (XCHF)	3,653,502	589	16.73	57.75	72.59	91.40	98.46
30	Neutrino USD (USDN)	2,150,275	2,068	66.85	93.06	96.30	98.66	99.29
31	xDai (STAKE)	1,499,013	8,846	75.03	92.86	93.40	93.96	94.40
32	ZUSD	1,471,396	626	71.30	99.76	99.94	99.96	99.97
33	Unbound (UNB)	1,328,804	588	25.00	85.80	95.42	98.66	99.46
Average		3,807,754,353	47,174	43.05	81.72	86.79	90.88	93.23

Note: This table reports the top 33 stablecoins by market capitalization (as of 10.10.2022), along with the number of wallet addresses and the percentage of wealth held by the top 1 to top 100 wallet addresses.

Table A.8
Stablecoins and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.21	99.79
% of Wealth	92.23	6.77

Note: This table reports the wealth centralization among top 100 wallet addresses in average for top 33 Stablecoins.

Table A.9
Distribution and classification of wallet addresses holding stablecoins (sorted by holdings %).

S.N.	Exchange	Wallets	Holdings (%)	Type	S.N.	Exchange	Wallets	Holdings (%)	Type
1	Bitfinex	11	18.5636	CEX	16	BingX	1	0.1000	CEX
2	Binance	34	3.0565	CEX	17	OkCoin	2	0.0850	CEX
3	Bybit	5	2.9240	CEX	18	BitMEX	1	0.0800	CEX
4	gate.io	13	2.8592	CEX	19	Indodax	1	0.0500	CEX
5	Coinlist	1	2.5400	CEX	20	BigONE	1	0.0400	CEX
6	Coinbase	4	2.5025	CEX	21	WhiteBIT	1	0.0400	CEX
7	Gemini	4	1.7900	CEX	22	AscendEX	1	0.0100	CEX
8	HTX (Huobi)	8	1.4450	CEX	23	Binance.US	1	0.0100	CEX
9	Unknown	2864	0.7670	Unknown	24	Exmo	1	0.0100	CEX
10	Crypto.com	6	0.7600	CEX	25	IDEX	1	0.0100	DEX
11	Kraken	2	0.7000	CEX	26	MXC	2	0.0100	CEX
12	HCEX	1	0.3600	CEX	27	Hotbit	3	0.0067	CEX
13	MEXC	4	0.3175	CEX	28	Coinbene	1	< 0.0001	CEX
14	Kucoin	10	0.3130	CEX	29	FameEX	1	< 0.0001	CEX
15	Bitget	3	0.1900	CEX					

Table A.10
Smart contracts and wealth distribution in DeFi.

S.No.	Name	Market cap	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	TRON	7038286090	183034351	17.83	28.91	30.23	36.48	39.86
2	Cosmos	2485544798	2520268	5.76	26.06	36.87	45.61	53.07
3	Internet_ICP	1472291014	1517718	5.15	14.61	20.36	30.3	39.71
4	Algorand	747001581	32256553	5.95	21.91	28.57	44.55	60.94
5	Tezos	653836242	20668	13.33	56.2	61.08	67.25	70.71
6	EOS	640939519	5976123	21.85	78.17	86.4	91.14	95.14
7	MultiversX	639582278	35344	36.76	62.16	65.06	68.48	71.15
8	Neo	518856346	135358	37.77	88.77	91.79	93.19	93.78
9	Conflux	420092564	17434	47.94	67.23	76.76	88.99	93.99
10	Sui	380131845	6265407	5.36	13.55	14.62	15.49	15.84
11	Zilliqa	259041349	45426	13.83	50.17	55.38	62.97	68.06
12	Qtum	225437418	1543	31.5	71.81	79.63	91.13	97.38
13	aelf	202293158	50967	17.82	83.68	97.47	99.13	99.39
14	Ontology	143623176	173005	24.45	69.08	82.46	93.82	97.11
15	SKALE	104347342	23383	6.94	34.93	46.95	60.88	74.66
16	UMA	102499291	20856	30.14	79.57	88.81	95.59	98.13
17	Gains	97871040	1093	30.96	88.09	90.54	95.45	98.25
18	OriginTrail	95596379	18416	19	38.22	48.13	61.7	69.12
19	Amp	77145239	94581	23.83	62.69	71.98	83.72	89.26
20	Bitgert	73963869	184930	3.18	16.13	27.36	32.11	33.31
21	Unifi	61614630	908	8.42	42.8	63.51	84.05	92.75
22	Hifi	57597207	3314	18.32	77.17	84.99	90.97	94.58
23	QuarkChain	48155230	10057	19.25	38.26	39.87	40.55	41.04
24	Loom	47154198	5155	53.88	86.35	93.61	97.36	98.2
25	Wirex	39906149	901	76.98	98.87	99.52	99.8	99.91
26	TrueFi	33522464	7729	22.53	58.69	71.92	86.38	93.62
27	FirmaChain	32441721	12634	65.95	99.82	99.92	99.93	99.99
28	Elastos	31899571	833	43.2	84.89	87.53	91.31	94.89
29	Shiden	15796412	642934	7.29	30.43	30.74	30.75	30.76
30	Fusion	14989727	9458	2.82	5.61	6.43	7.32	7.98
31	Velas	14414567	2980	74.65	83.21	85.21	88.3	90.91
32	Aeternity	8977295	130328	9.64	48.21	71.48	82.94	87.24
33	Ooki	8588033	2559	59.67	89.05	94.96	96.9	97.93
34	ChainGPT	4968479	14749	39.94	78.89	90.51	97.54	98.08
35	Shyft	4806485	2691	13.2	61.53	79.7	91.53	95.93
36	Signum	3165554	502	50	99.55	99.72	99.89	99.96
37	CropBytes	3037485	8142	42.74	93.54	97.08	98.96	99.62
38	Skey	3030657	9540	12.96	73.6	82.18	84.88	86.33
39	BOSAGORA	2869069	1435	28.9	91.52	96.45	98.34	99.22
40	Omax	2783413	28823	39.19	89.33	90.18	91.31	92.36
41	Reflexer	2531050	3650	24.12	55.92	66.84	77.52	83.55
42	Xend	2206573	5551	37.43	87.65	92.38	95.57	97.04
43	CheckDot	1878759	4997	21.54	45.89	54.16	64.65	72.81
44	Gather	226470	3783	35.16	70.54	76.81	82.83	88.06
45	ODIN	210340	7138	12.81	18.08	18.85	19.67	20.28
46	Etherparty	206482	62536	26.75	72.45	76.41	81.62	85.65
47	AstroSwap	163684	30454	57.5	92.65	93.59	95.05	96.3
48	Hydro	131962	74	74.92	99.29	99.64	99.97	100
49	Enigma	131676	10944	5.64	17.54	18.64	18.96	19.42
50	Silva	130477	42508	10.97	21.03	23.8	25.98	28.56
	Average	336518327.1	4669214	27.91	61.29	67.74	73.58	77.04

Note: This table reports the top 50 smart contract tokens based on market capitalization along with number of holders and the percentage of wealth held by the top 1 to top 100 wallet addresses.

Table A.11
Smart contracts and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.002	99.998
% of Wealth	77.04	22.96

Note: This table reports the wealth centralization among top 100 wallet addresses in average for the top 50 Smart Contracts tokens.

Table A.12
Oracles and wealth distribution in DeFi.

S.No.	Name	Market cap	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	ChainLink LINK	4062278103	669406	3	30	53.95	64.35	71.88
2	Band Protocol BAND	157387543	34519	62.39	84.08	91.3	95.88	97.3
3	UMA UMA	118655112	20700	30.23	79.62	88.91	95.65	98.25
4	API3	102703878	21089	54.46	82.25	86.79	92.53	94.82
5	iExec RLC	93199769	23375	14.07	47.26	57.78	74.05	82.34
6	WINkLink WIN	64676833	820619	22.38	69.27	81.76	89.6	91.15
7	NEST Protocol NEST	53470272	6708	29.37	87.65	94.85	98.41	99.17
8	Tellor TRB	27560916	6920	25.72	68.38	81.8	90.87	93.18
9	DIA	26692028	22257	31.81	77.45	84.25	90.59	93.9
10	AirSwap AST	17779464	13170	64.4	86.34	89.87	93.24	95.05
11	Drep DREP	12772885	2564	55.18	86.77	89.71	92.9	95.78
12	HAPI.one HAPI	6673251	5241	11.32	45.96	57.3	68.23	75.47
13	xFund XFUND	5640000	2132	4.49	23.94	34.45	53.35	68.06
14	Oraichain Token	4143639	10028	0.57	1.74	1.98	2.22	2.39
15	Modefi MOD	3101208	6456	14.52	58.04	65.93	74.83	80.02
16	Umbrella Network	2691448	9741	20.55	63.14	71.92	80.09	85.18
17	Kylin Network KYL	2371904	692	92.54	94.85	95.67	97.02	98.17
18	ADAM oracle ADAM	1450611	4013	41.65	87.04	92.24	95.03	95.97
19	Razor network	1204989	6328	34.82	83.57	87.89	91.87	94
20	Bird.Money BIRD	1033510	3739	26.64	62.4	66.87	74.31	79.91
21	OptionRoom ROOM	554868	9244	26.08	71.17	75.57	81.13	85.86
22	ZAP	538409	5755	36.21	59.1	65.18	74.53	82.2
23	Odin Protocol ODIN	270976	7136	12.8	18.08	18.85	19.67	20.27
24	DOS Network DOS	160816	9296	36.01	70.47	82.51	90.79	93.32
25	Ares Protocol ARES	124302	5683	20	85.19	90.92	94.52	96.58
26	Berry Data BRY	39730	19395	27.55	97.02	99	99	99
27	Orakuru ORK	12669	6973	16	71.08	75.26	81.71	87.65
	Average	176562560.5	64933	30.18	66.37	73.43	79.87	83.59

Note: This table reports the top 27 Oracles with highest market capitalization (as of 10.10.2022), number of wallet addresses, and the percentage of wealth held by the top 1 to top 100 wallet addresses.

Table A.13
Oracles and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.15	99.85
% of Wealth	83.59	16.41

Note: This table reports the wealth centralization among top 100 wallet addresses in average for the top 27 Oracle tokens.

Table A.14
DAOs and wealth distribution in DeFi.

S.No.	Name	Market cap	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	Arbitrum ARB	1,473,390,000	633302	35.26	62.78	67.65	79.47	90.03
2	BitDAO BIT	1,012,227,040	25333	30.44	46.3	49.64	51.51	52.01
3	Compound COMP	432,003,558	213565	14.61	49.28	58.75	75.18	88
4	0x ZRX	179,075,916	195252	9.94	49.13	56.66	67.07	73.81
5	Illuvium ILV	178,731,600	38936	41.01	82.97	86.41	90.24	92.82
6	cVault.finance CORE	58,520,000	3909	4.14	8.74	10.49	12.86	13.96
7	DXDao DXD	37,191,226	1311	13.17	26.83	27.54	28.21	28.59
8	DFI.Money YFII	28,429,428	10839	29.25	78.99	88.65	94.15	95.99
9	Unidef U	25,429,011	47992	33	88.55	96.9	99.94	99.95
10	Cream CREAM	25,219,334	8975	5.31	24.69	29.73	31.84	32.17
11	Telos TLOS	24,897,278	1994	20.82	59.96	78.39	91.25	94.72
12	Dego Finance DEGO	21,091,067	297	77.79	98.12	99.63	99.91	99.96
13	Star Atlas DAO	18,880,922	51544	31.64	78.1	81.6	85.75	86.76
14	Victoria VR	11,693,627	10088	50	93.04	97.2	98.52	98.93
15	Dora Factory DORA	8,892,797	3261	21.45	76.68	87.67	96.43	98.46
16	Hector Network HEC	7,913,648	525	75.54	99.23	99.48	99.79	99.93
17	Squid Game SQUID	4,842,100	98352	16.97	54.03	60.65	67.03	71.9
18	Digix Gold Token	2,987,195	2112	9.98	39.46	54.69	73.3	82.71
19	HairDAO HAIR	2,851,414	156	61.73	87.18	94.33	99.34	99.99
20	OpenDao SOS	1,888,163	182759	33.31	73.71	82.78	88.31	90.71
21	Prism PRISM	1,734,274	5633	89.28	98.48	98.66	98.71	98.71
22	Idle IDLE	1,621,826	3717	20	62.65	73.95	87.72	93.52
23	Pillar Pillar PLR	1,552,977	22124	11.24	30.68	32.64	35.98	38.56
24	Bankless DAO BANK	1,428,562	6058	20.09	60.56	69.47	74.92	79.8
25	Shroom.Finance	1,338,761	3827	6.99	21.38	29.76	42.73	51.73
26	Marinade MNDE	1,188,370	31826	67.12	87.63	91.71	95.59	95.59
27	Hakka Finance	1,042,485	4353	27.58	73.86	84.23	91.88	95.21
28	Unbound UNB	674,237	592	25	85.75	95.36	98.62	99.44
29	PieDAO DOUGH v2	597,016	2761	32.02	46.43	47.74	48.25	48.48
30	NFT Protocol NFT	531,386	3184	33.75	71.09	78.03	86.51	91.15
31	FreeRoss DAO FREE	448,763	3700	25.81	58.75	67.76	81.81	88.14
32	Jigstack STAK	407,597	9297	22.88	74.65	77.96	82.43	85.36
33	FaceDAO FACE	395,970	18998	80	87.93	88.43	88.84	89.16
34	IOI Token IOI	276,010	1813	35.57	82.07	93.33	96.84	98.31
35	DAOstack GEN	263,826	7411	18.28	51.16	60.72	71.83	78.58
36	Stakeborg DAO	240,894	540	29.55	95.06	99.05	99.77	99.92
37	Parachute PAR	190,929	6444	18.08	58.37	69.18	77.6	82.02
38	Gas DAO Gas	129,212	45103	38.07	83.52	85.91	89.42	91.84
39	Bitlocus BTL	28,075	12	97.52	100	100	100	100
40	TemDAO TEM	18,427	2099	31	97.13	98.38	99.36	99.78
		Average	41707.2	35.25	68.41	74.42	79.97	82.85

Note: This table reports the number of wallet addresses, and the percentage of wealth held by the top 100 wallet addresses of the all available DAO tokens (as of 10.10.2022).

Table A.15
DAOs and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.24	99.76
% of Wealth	82.85	17.15

Note: This table reports the wealth centralization among top 100 wallet addresses in average for the top 40 DAO tokens.

Table A.16
Governance tokens and wealth distribution in DeFi.

S.No.	Name	Symbol	Market Cap($)	Holders	Top 1	Top 10	Top 20	Top 50	Top 100
1	Uniswap	UNI	7150930067	382129	38.33	50.73	59.76	73.86	83.65
2	Internet Computer	ICP	5611714278	1621256	5.29	14.56	20.51	30.71	40.38
3	Maker	MKR	2389140381	100452	15.27	41.09	50.55	64.23	74.92
4	Aave	AAVE	1502800105	167986	17.15	55.29	65.53	75.52	81.43
5	Ethereum Name Servic	ENS	786114644	65523	54.26	80.66	83.33	87.21	90.16
6	PancakeSwap	CAKE	712254131	13609	35.66	72.15	76.29	82.16	87.01
7	Aragon	ANT	381363410	12142	81.26	91.26	93.28	95.43	96.57
8	Amp	AMP	380858086	97223	39.07	75.57	80.16	86.95	90.98
9	Frax Share	FXS	369730866	17324	44.83	78.01	83.57	89.39	93.15
10	Mask Network	MASK	337631372	13682	32.82	81.38	85.96	92.01	96.60
11	Decred	DCR	311925369	575869	3.60	7.41	8.59	9.88	10.86
12	UMA	UMA	260998436	21920	34.01	89.89	92.99	94.84	97.89
13	Tribe	TRIBE	235319034	14519	44.33	87.91	90.65	95.49	98.80
14	yearn.finance	YFI	232177810	52363	9.46	42.87	56.32	72.32	82.80
15	Balancer	BAL	225771092	47939	18.74	35.30	42.41	51.22	56.67
16	Sushi	SUSHI	214250937	122624	16.97	58.94	69.54	82.54	94.51
17	TokenFi	TOKEN	201660799	27590	48.11	91.59	93.29	94.63	95.60
18	Cartesi	CTSI	199771118	21002	32.63	70.28	79.11	88.02	93.63
19	Ribbon Finance	RBN	161414894	5911	82.79	91.22	93.88	96.75	98.72
20	Bone ShibaSwap	BONE	156477862	96201	9.15	43.60	52.37	61.11	65.69
21	inSure DeFi	SURE	134581343	2062	69.62	97.51	98.74	99.00	99.83
22	Adventure Gold	AGLD	125064097	14547	32.85	78.08	83.92	92.88	96.07
23	Cream	CREAM	120088070	9049	10.66	86.57	88.72	89.58	89.64
24	Hifi Finance	HIFI	102347248	2453	49.01	89.21	93.36	97.30	98.48
25	Aavegotchi	GHST	90124740	8576	72.58	82.68	88.04	94.85	96.78
26	Decubate	DCB	62627405	13352	60.84	93.24	95.92	97.95	98.56
27	Merit Circle	MC	57630017	8151	30.42	62.62	73.41	81.80	86.53
28	Ampleforth Governanc	FORTH	47429775	26227	19.77	63.35	75.18	89.27	93.49
29	Voxies	OXEL	45247662	103706	31.74	82.52	88.67	94.62	96.47
30	Harvest Finance	FARM	45033643	15303	3.80	9.63	11.26	13.21	13.58
31	HOPR	HOPR	44824561	6937	21.48	71.10	80.88	91.08	93.92
32	Frax Price Index Sha	FPIS	34970565	2240	30.14	97.58	99.01	99.67	99.77
33	Index Cooperative	INDEX	32548694	5763	27.01	57.05	69.58	83.20	90.30
		Average	689843100	111988	34.05	67.60	73.48	80.26	84.35

Note: This table reports the top 33 Governance Tokens with highest market capitalization along with the number of wallet addresses and the percentage of wealth held by the top 1 to top 100 wallet addresses.

Table A.17
Governance tokens and wealth centralization.

Average	Top 100 Wealthiest Addresses	Remaining Addresses
% of Addresses	0.00089	99.911
% of Wealth	84.35	15.65

Note: This table reports the wealth centralization among the top 100 wallet addresses in average for top 33 Governance tokens.

Table A.18
Descriptive statistics, equally weighted and value weighted portfolios.

Assets	nobs	Min	Max	1st.Qrt	3rd.Qrt	Mean	Median	Stdev	Skew	Kurt
Bitcoin	3553	−0.3717	0.4297	−0.0138	0.0183	0.0023	0.0016	0.0413	0.2195	10.0688
ew_return_Layer1	3553	−0.7283	0.6756	−0.0256	0.0327	0.0057	0.0017	0.0674	0.6386	14.5805
vw_return_Layer1	3553	−0.7283	0.5073	−0.0230	0.0291	0.0045	0.0009	0.0612	0.1215	14.4920
ew_return_stableC	3553	−0.4970	0.6495	−0.0025	0.0025	0.0004	0.0000	0.0191	9.5890	648.7367
vw_return_stableC	3553	−0.4970	0.6495	−0.0004	0.0004	0.0001	0.0000	0.0159	13.1133	1300.4921
ew_return_smartC	3553	−0.3832	1.2586	−0.0236	0.0303	0.0058	0.0034	0.0728	3.4137	44.8381
vw_return_smartC	3553	−0.4133	1.2586	−0.0252	0.0305	0.0065	0.0026	0.0767	3.4627	41.2571
ew_return_oracles	3553	−0.4541	2.7709	−0.0291	0.0358	0.0087	0.0036	0.1063	12.7299	293.9694
vw_return_oracles	3553	−0.4598	0.5750	−0.0327	0.0380	0.0052	0.0030	0.0727	0.7313	6.2149
ew_return_DAO	3553	−0.8350	15.5534	−0.0335	0.0447	0.0528	0.0038	0.6262	17.0149	338.6068
vw_return_DAO	3553	−0.8350	11.5383	−0.0366	0.0406	0.0327	0.0012	0.4628	17.8420	379.6212
ew_return_GovT	3553	−0.4942	1.0665	−0.0255	0.0305	0.0057	0.0012	0.0709	2.5137	27.9768
vw_return_GovT	3553	−0.5059	0.5514	−0.0277	0.0306	0.0049	0.0014	0.0685	1.3733	10.7538

Note: This table reports the descriptive statistics of the equally and value weighted portfolios of different DeFi essentials including Bitcoin and Layer-1 tokens.

Table A.19
ZND token (ZND) allocations, max (total) supply: 700,000,000 ZND.

S.No.	Category	Percentage	Total	Description
1	Seed Sale	9.8 %	68,600,000 ZND	TGE unlock 12 %, Cliff 8 months, Vesting 12 months
2	Private	11.9 %	83,300,000 ZND	TGE unlock 14 %, Cliff 6 months, Vesting 10 months
3	KOL's Round	1 %	7,000,000 ZND	TGE unlock 20 %, Cliff 2 months, Vesting 10 months
4	Public Sale Stage 1	0.8 %	5,600,000 ZND	TGE unlock 16 %, Cliff 3 months, Vesting 7 months
5	Public Sale Stage 2	0.9 %	6,300,000 ZND	TGE unlock 17 %, Cliff 3 months, Vesting 7 months
6	Public Sale Stage 3	0.9 %	6,300,000 ZND	TGE unlock 18 %, Cliff 2 months, Vesting 6 months
7	Public Sale Stage 4	0.9 %	6,300,000 ZND	TGE unlock 19 %, Cliff 1 month, Vesting 5 months
8	Launchpool	0.8 %	5,600,000 ZND	TGE unlock 20 %, Cliff 1 month, Vesting 7 months
9	Partners	8 %	56,000,000 ZND	TGE unlock 10 %, Cliff 3 months, Vesting 24 months
10	Treasury	29 %	203,000,000 ZND	TGE unlock 0 %, Cliff 24 months, Vesting 60 months
11	Liquidity	8 %	56,000,000 ZND	TGE unlock 20 %, Cliff 0 months, Vesting 6 months
12	Marketing	5 %	35,000,000 ZND	TGE unlock 16 %, Cliff 0 months, Vesting 24 months
13	Team	8 %	56,000,000 ZND	TGE unlock 0 %, Cliff 8 months, Vesting 36 months
14	Eco Incentives	15 %	105,000,000 ZND	TGE unlock 2 %, Cliff 0 months, Vesting 48 months

Data availability

Data will be made available upon request.

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